Discount Window Stigma and the Term Auction Facility

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MSU Theory/Macro Brown Bag

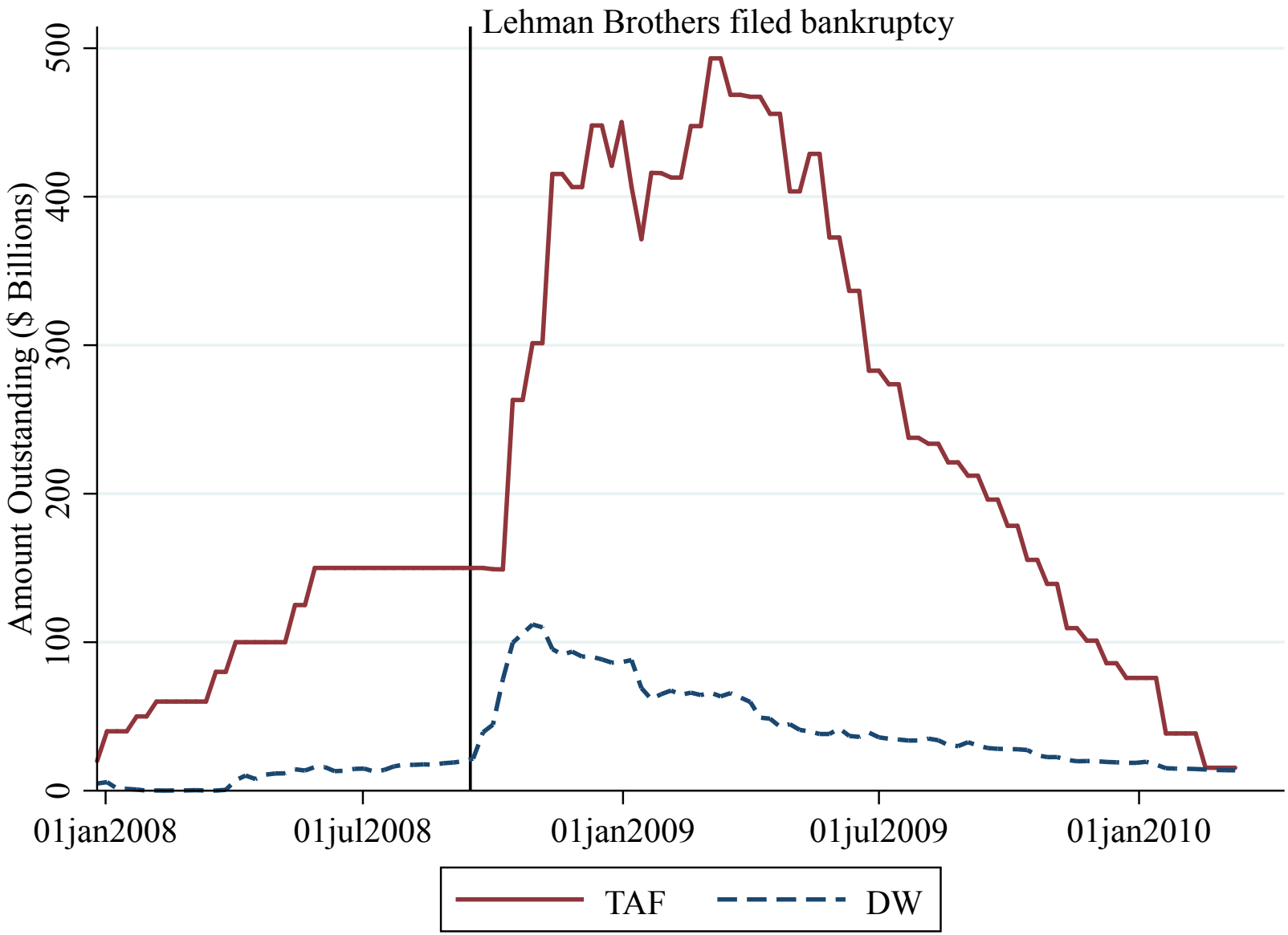
Discount Window Stigma

- 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.
  - Evidence: banks regularly paid higher interest rates for loans on the interbank market than the discount rate (Peristiani, 1998; Furfine, 2001; Armantier et al., 2015).

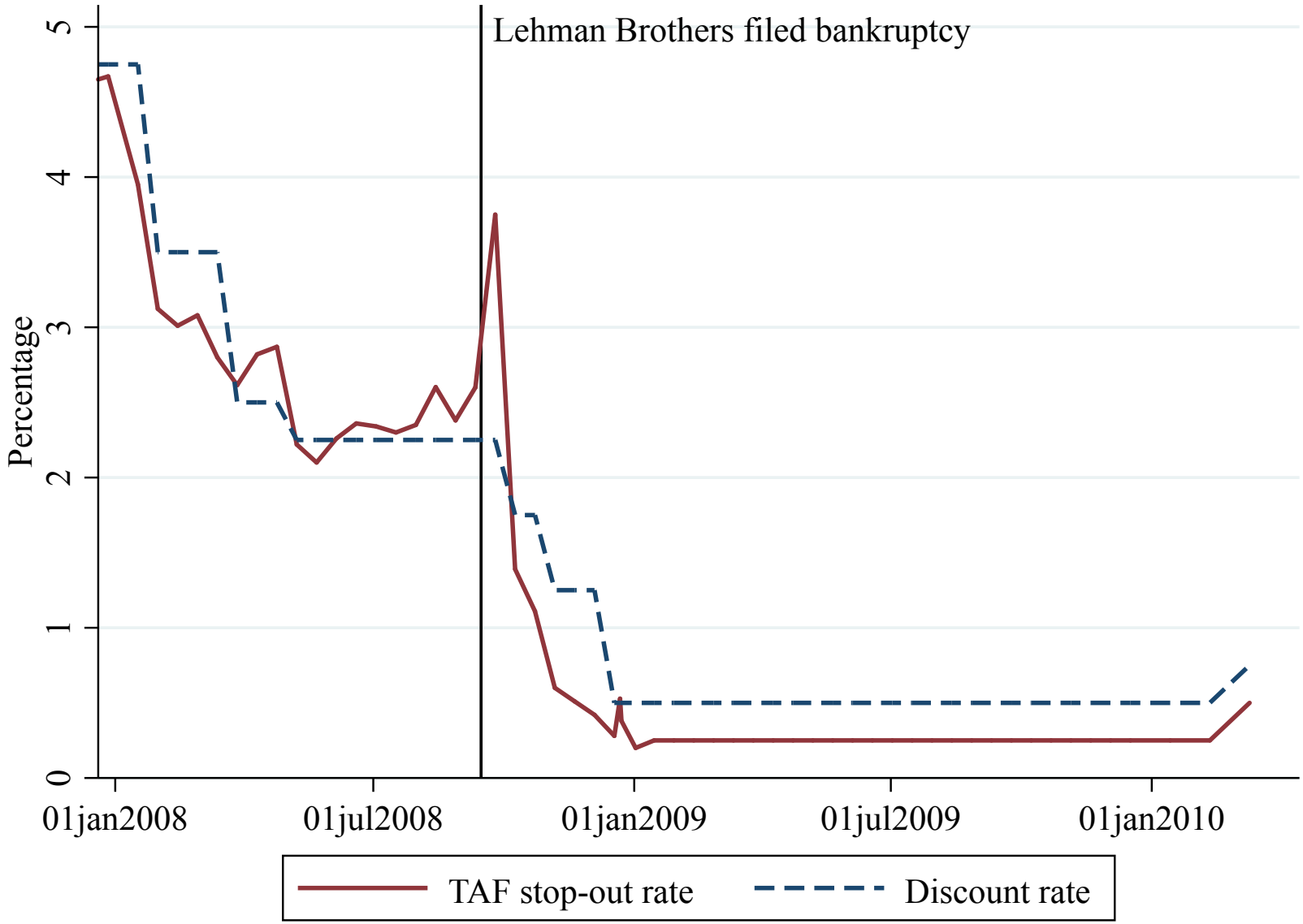
Term Auction Facility

- In response to the lack of discount window borrowing, Fed created the **Term Auction Facility** (TAF) in December 2017.
- TAF ran sixty auctions every two weeks between December 2017 and February 2010 to lend a pre-announced set of 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 discount window borrowing
- explain how TAF could encourage participation and borrowing
- explain how TAF bids could be higher than the discount rate
- predict and empirically verify that
  - worse banks borrow from DW and better banks borrow from TAF
  - TAF winners worse than TAF losers
- derive comparative statics for policy implications

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 $b(\theta)$, $b' < 0$.
  - 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 θ that the liquidity shock hits a type-θ bank.

Discount Window

- DW offers a loan at interest rate, called **discount rate**, r_D.
- A bank who takes the loan gets $b(\theta) - r_D - pk_D - (1-p)k_\emptyset$.
- **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

$$b(\theta) - r_D - pk_D - (1-p)k_\emptyset \geq -pk_N - (1-p)k_\emptyset.$$

- Cutoff θ_1: banks $[0, \theta_1]$ borrow

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

Stigma

- Borrowing from DW

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

- No borrowing

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

- No detection

$$G_\varnothing = F$$

- 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, G_N, and $G_\emptyset$.
- Beliefs G_D, G_N, and $G_\emptyset$ are consistent with aggregate borrowing behavior.

Equilibrium in DW-Only Economy

Any θ_1 that satisfies

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

characterizes an equilibrium. There is a unique equilibrium if

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

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.

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 θ_2: banks $[0, \theta_2]$ borrow from DW2,

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

DW1

- A bank borrows from DW1 iff

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

- Slope is

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

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 θ_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 τ

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

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Corner Case: TAF+DW, $\delta = 1$

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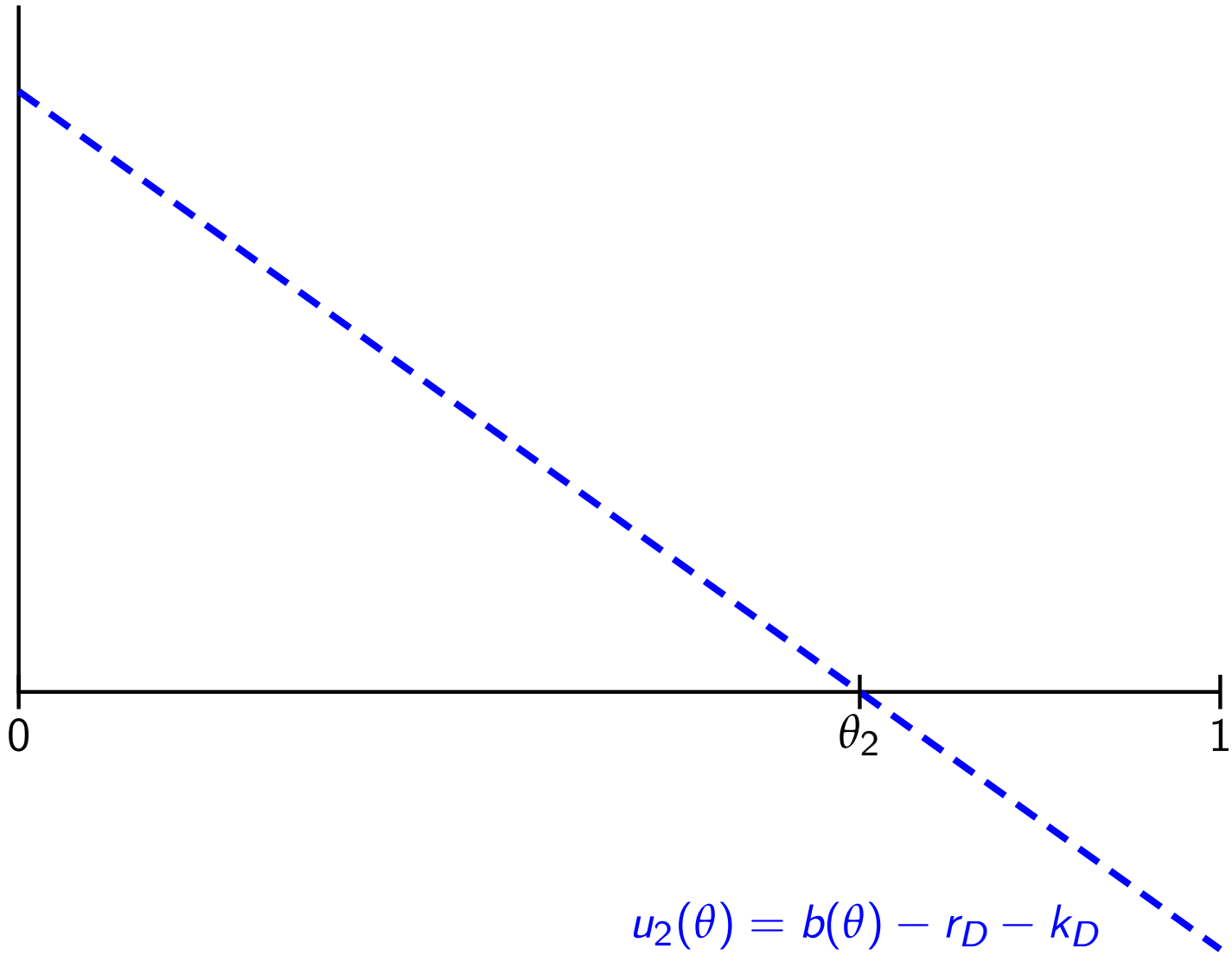

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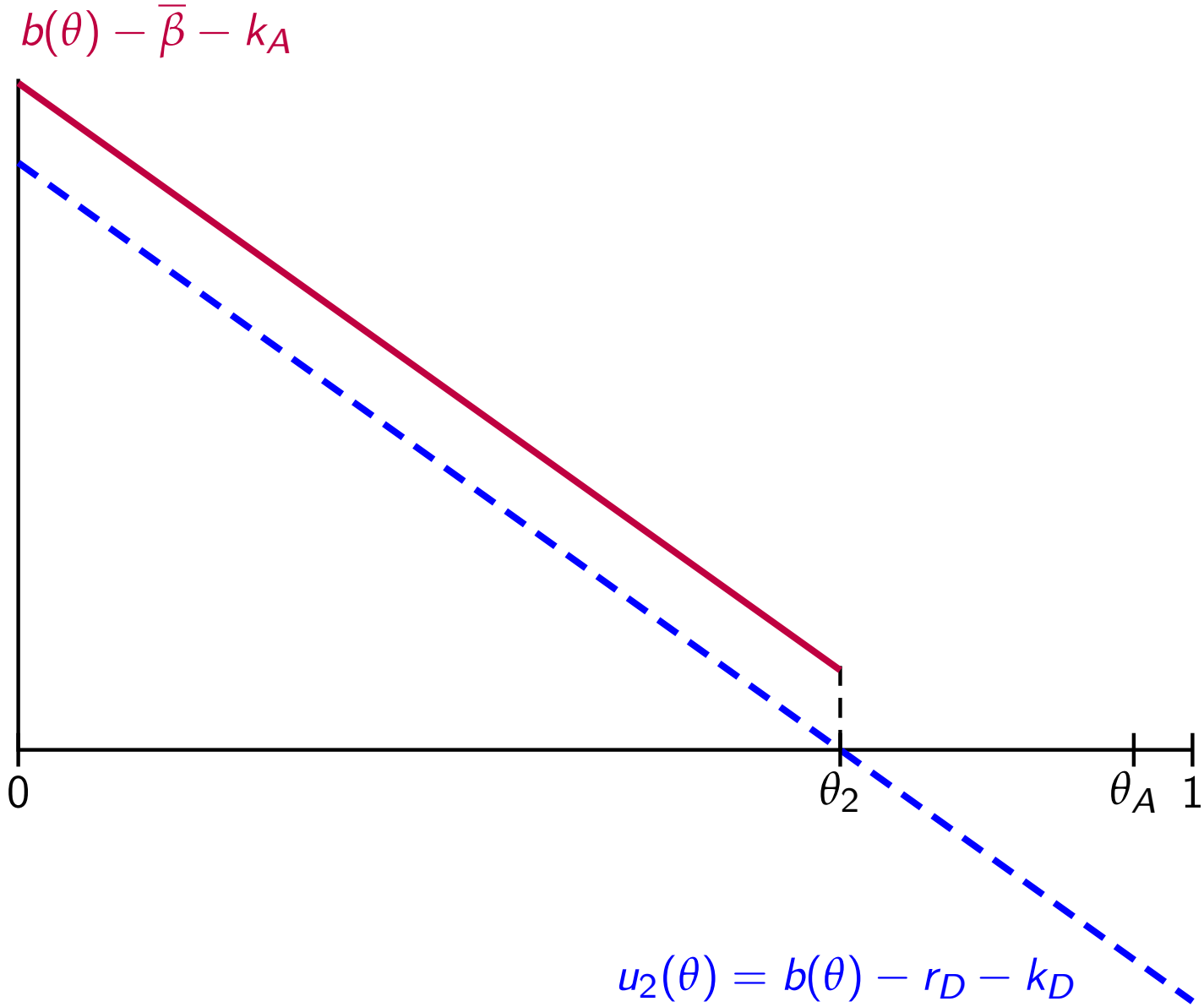

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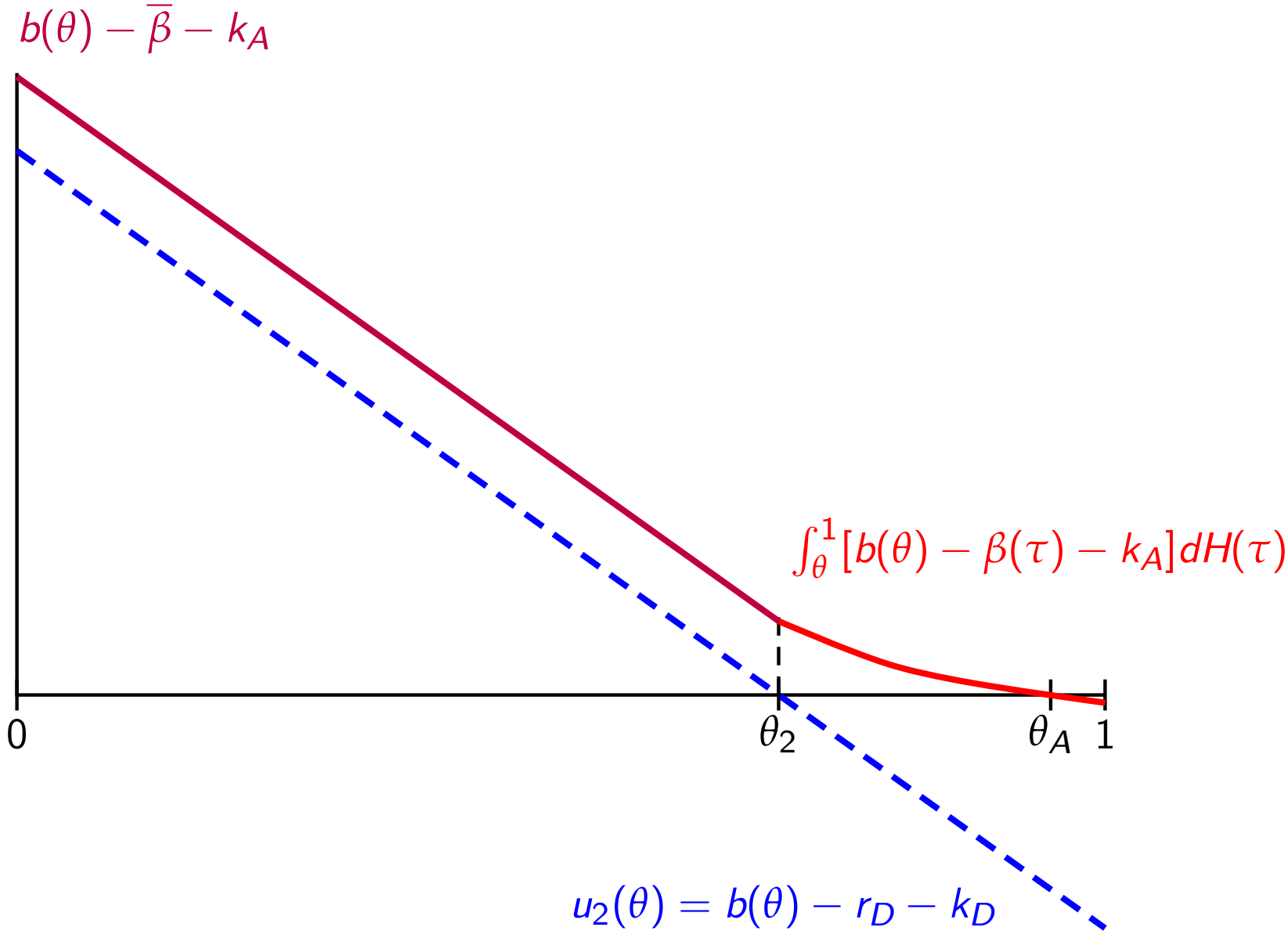

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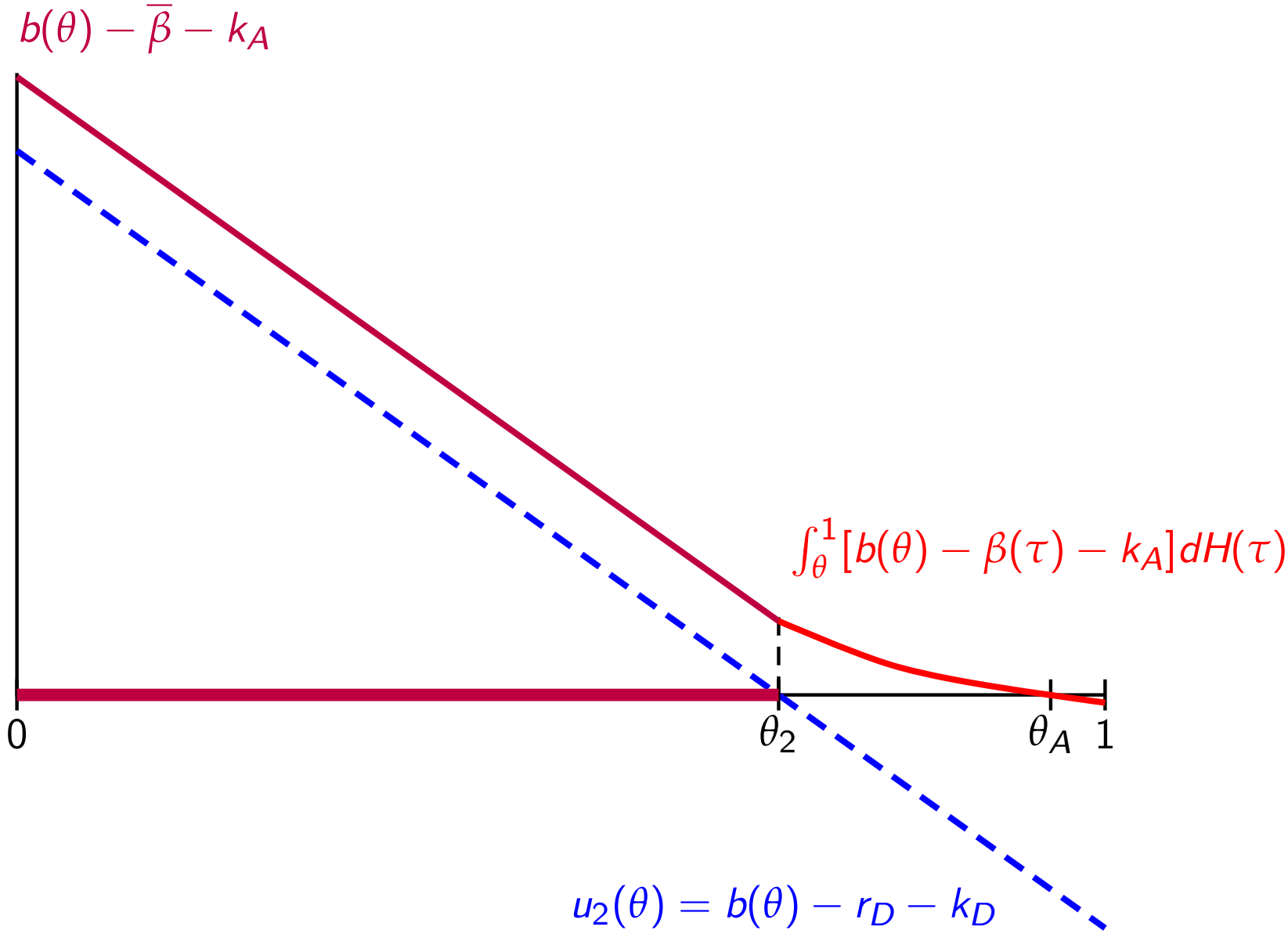

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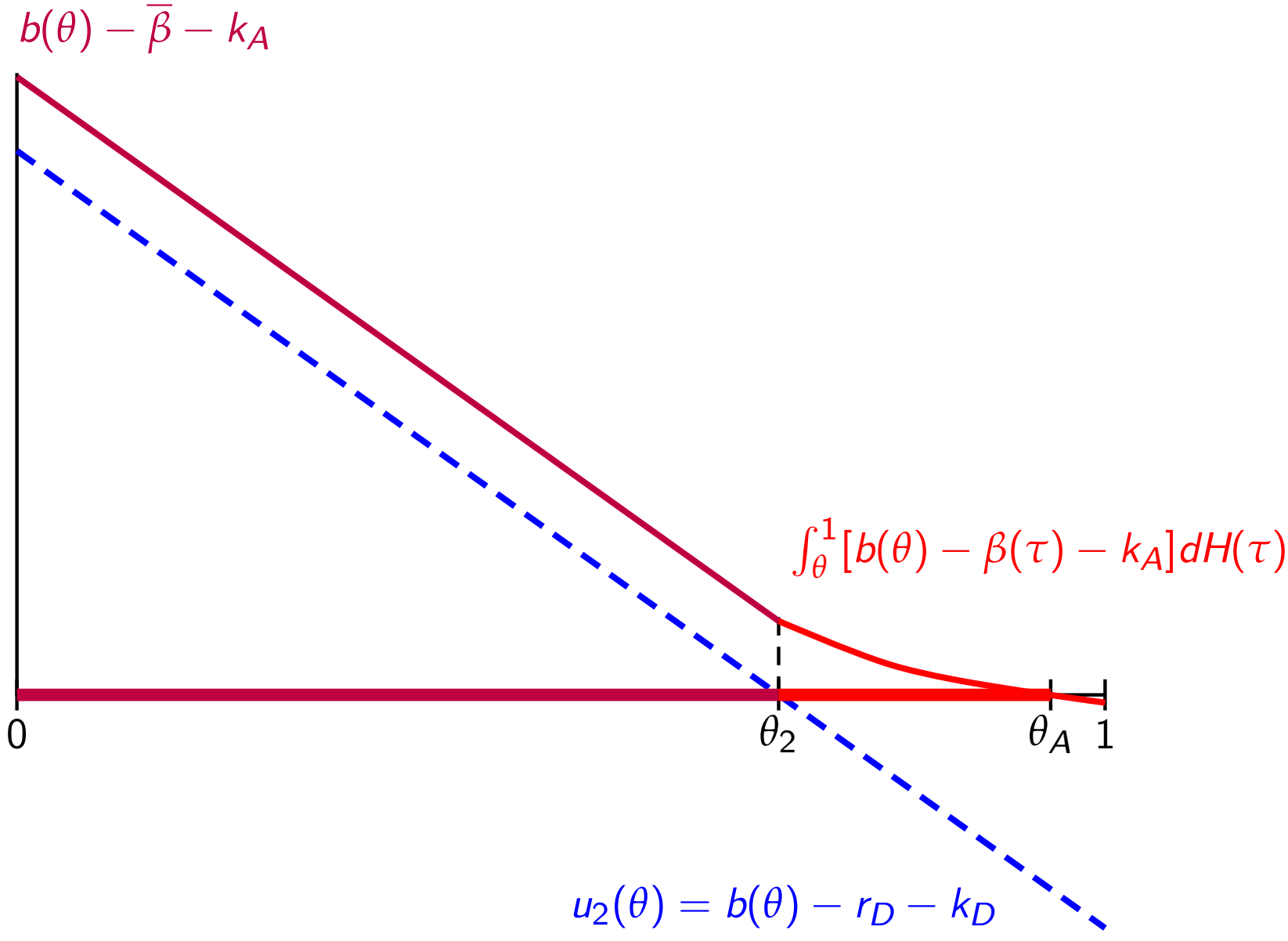

Equilibrium Case 1: DW+TAF+DW

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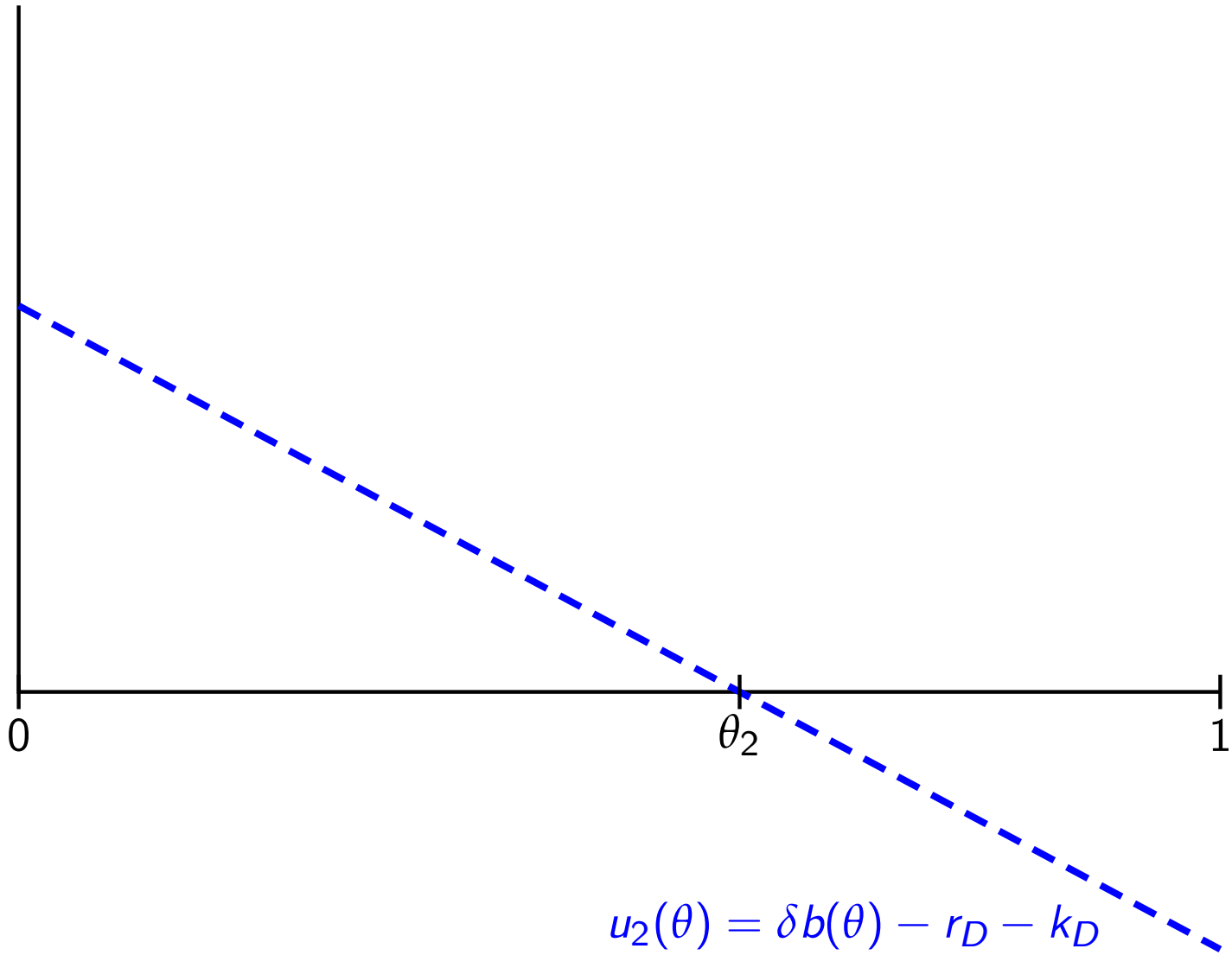

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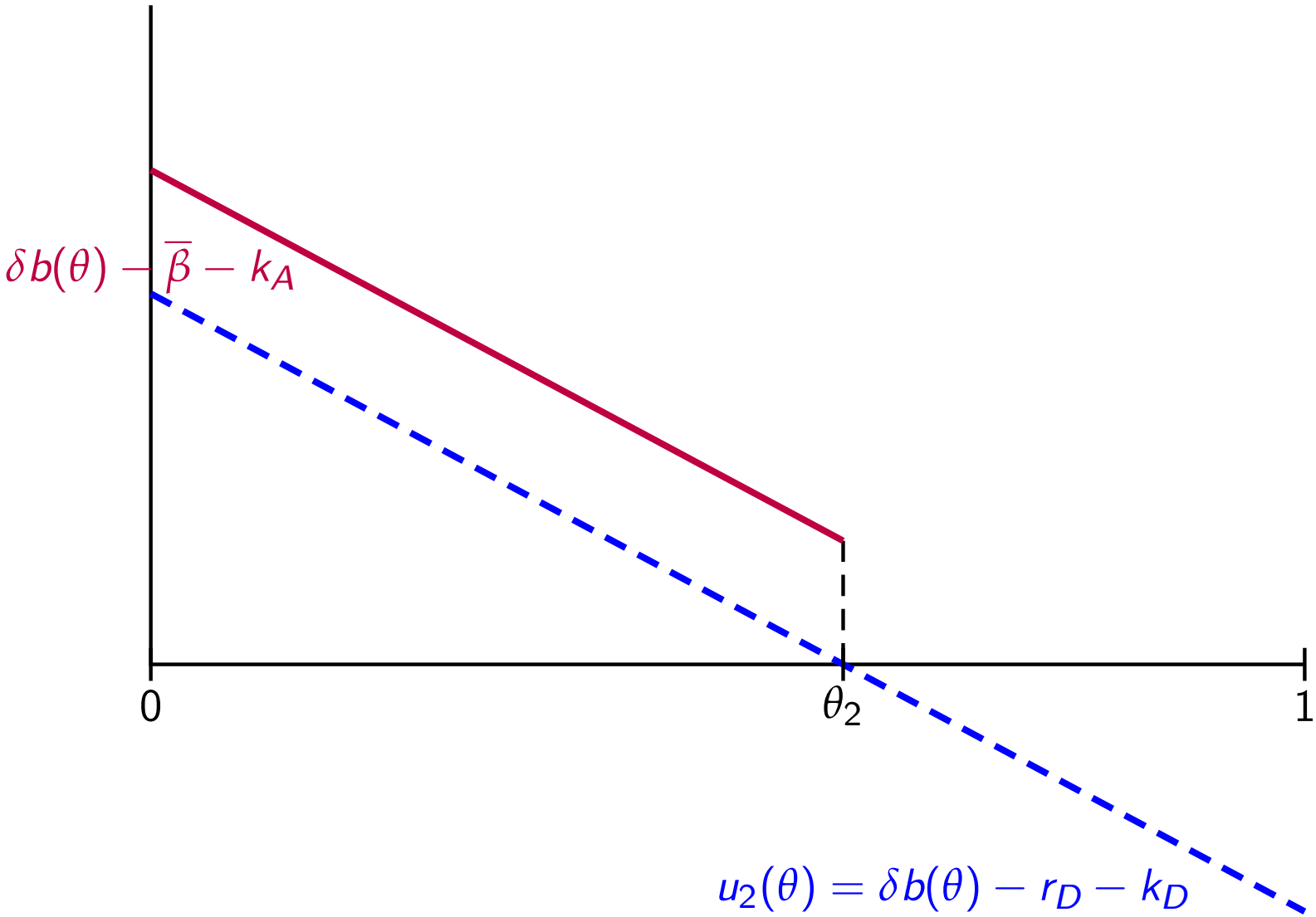

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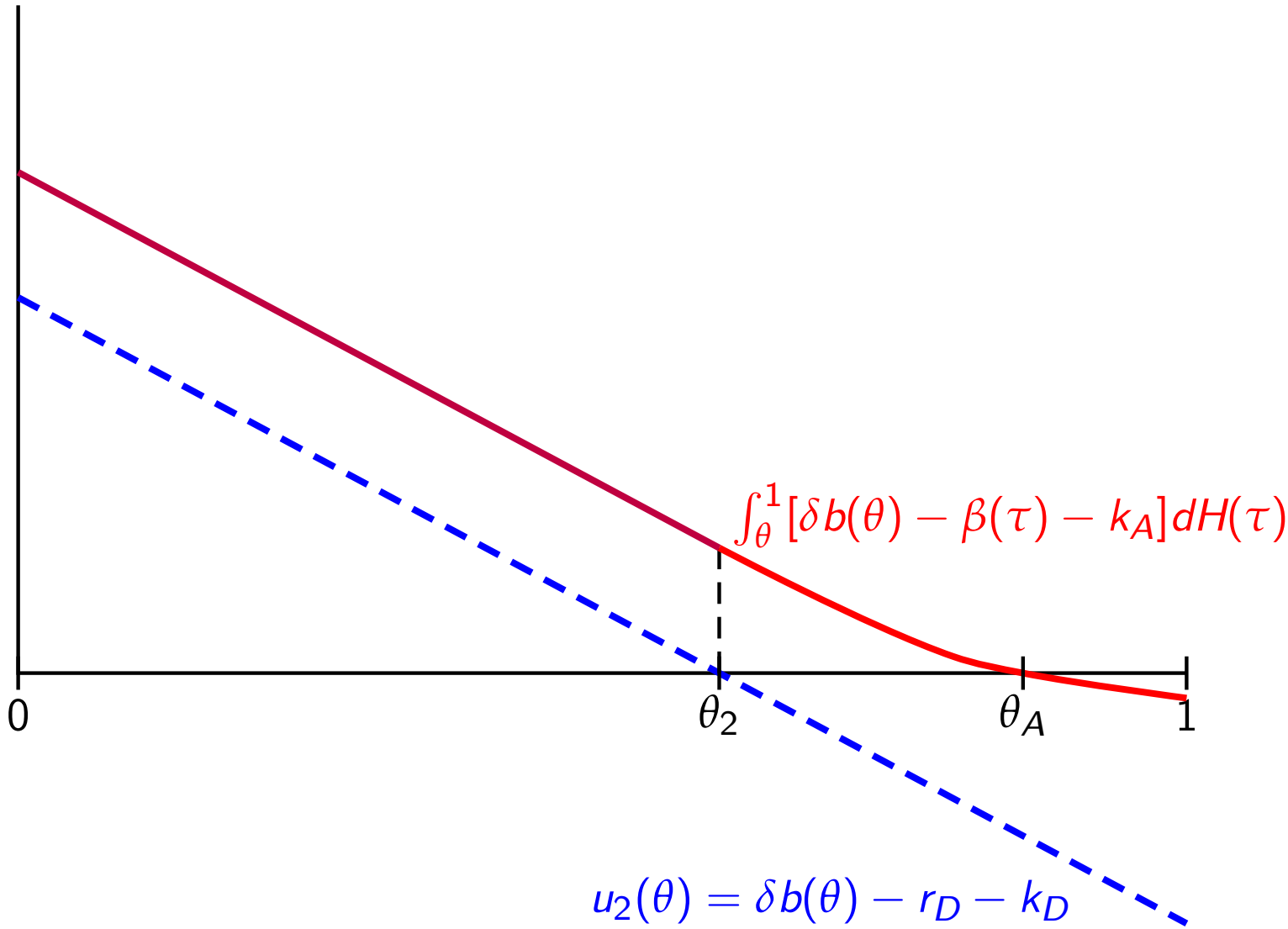

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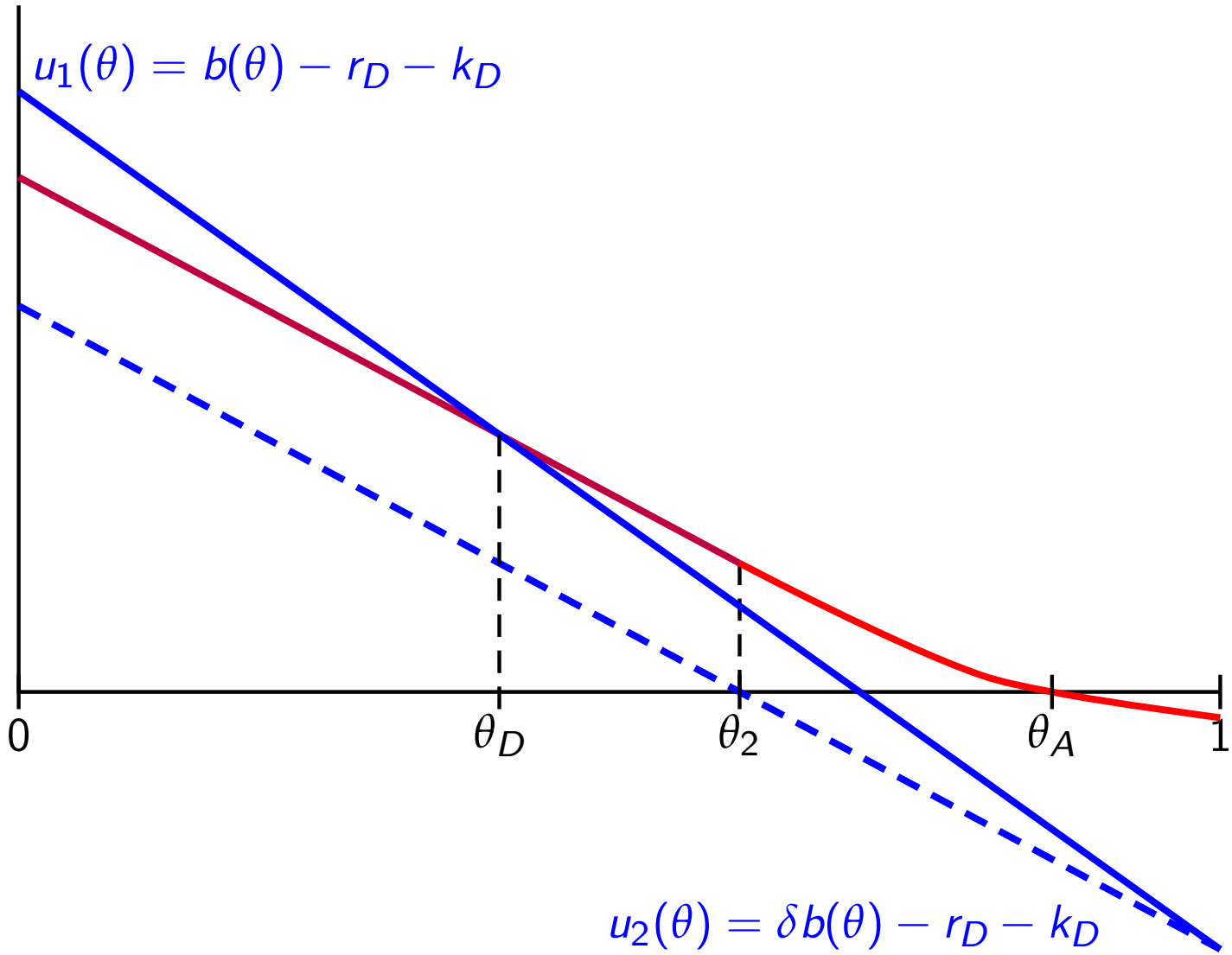

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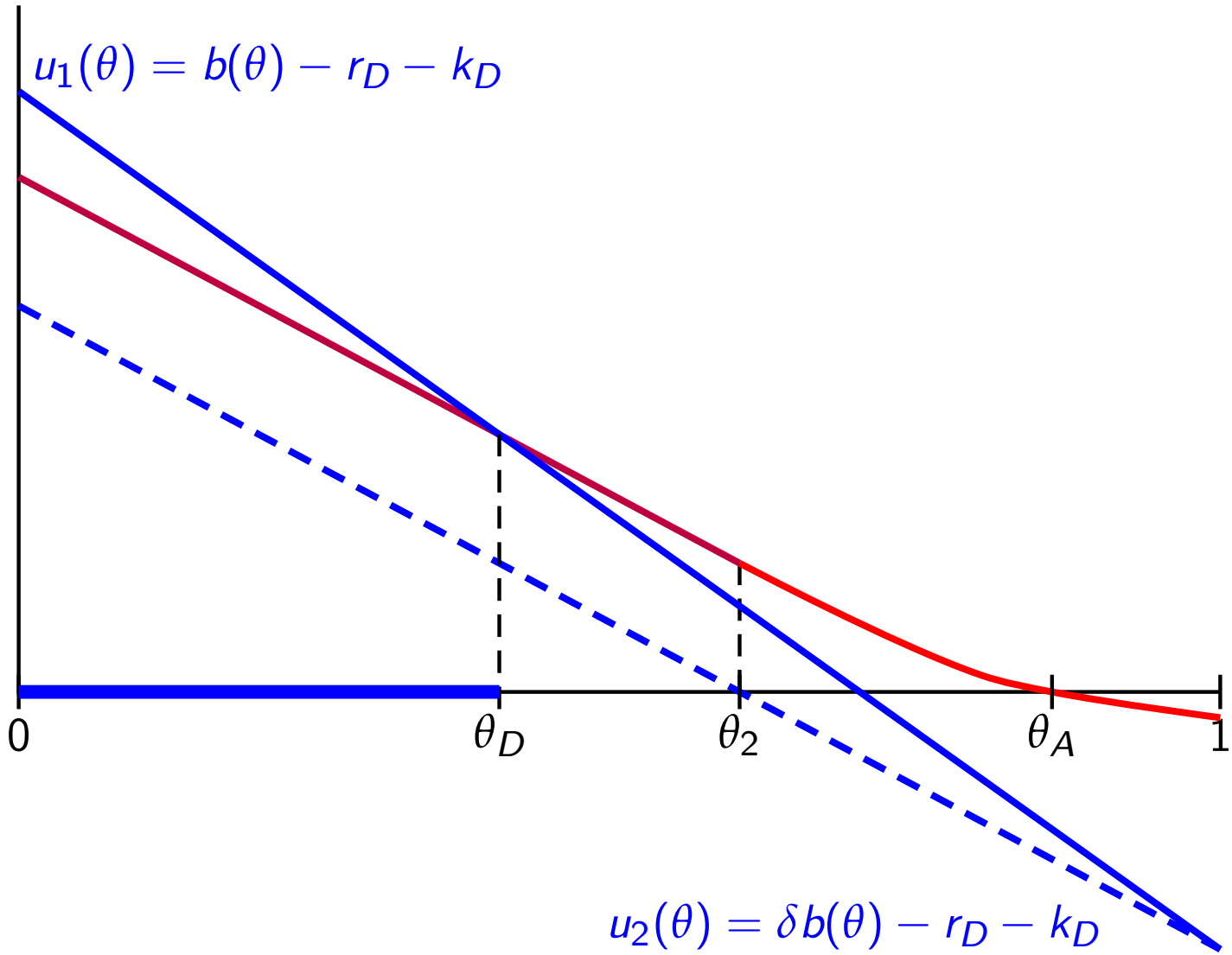

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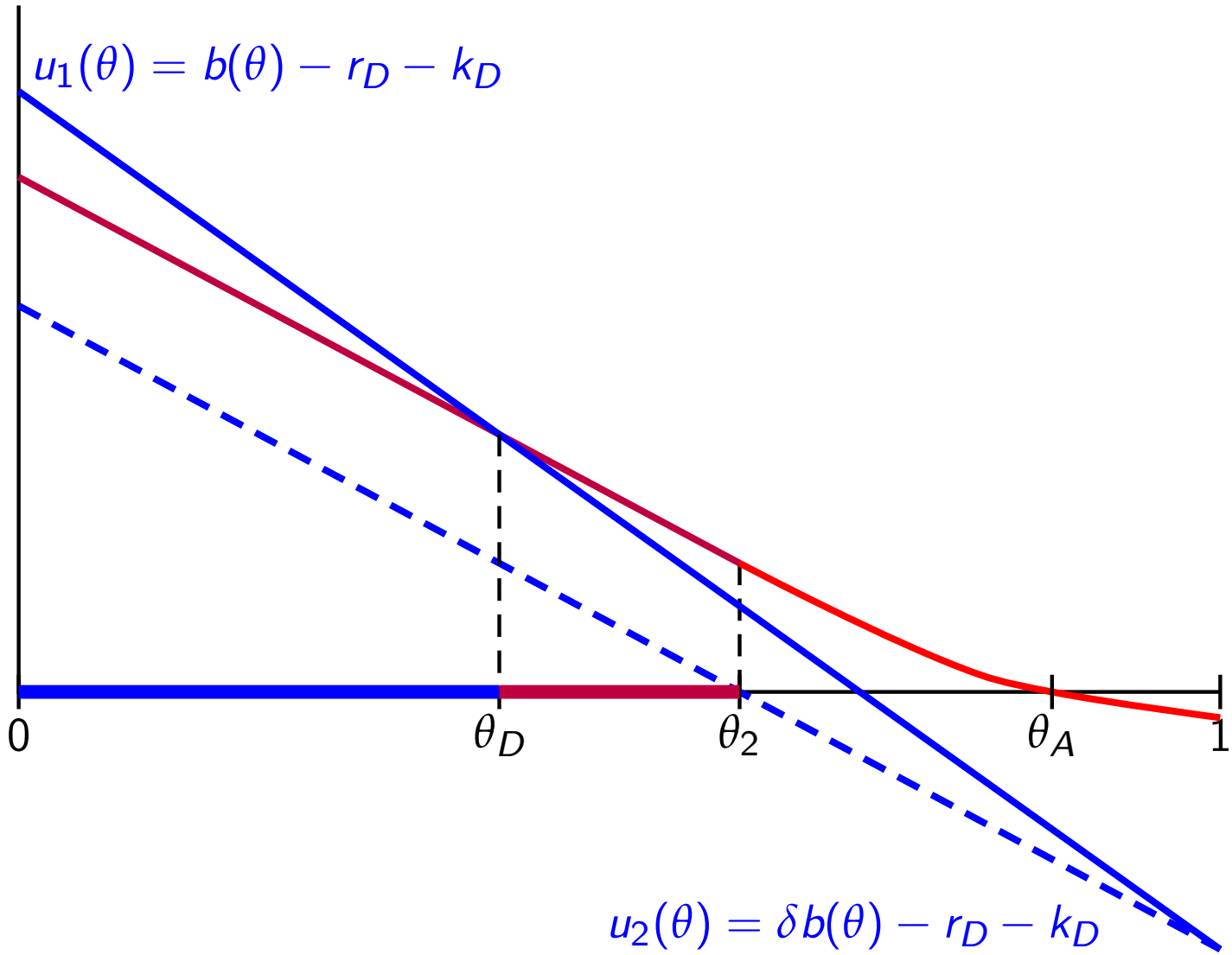

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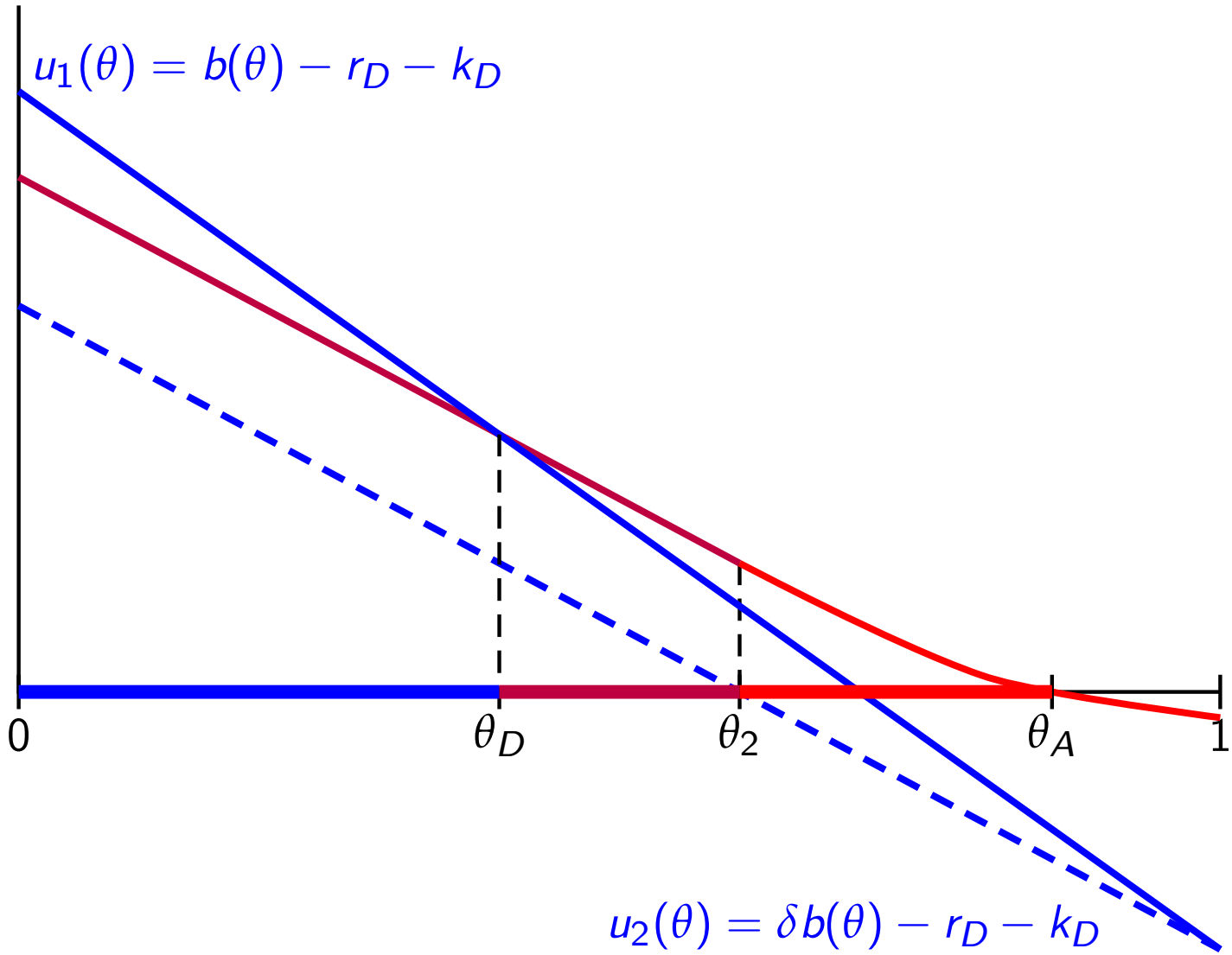
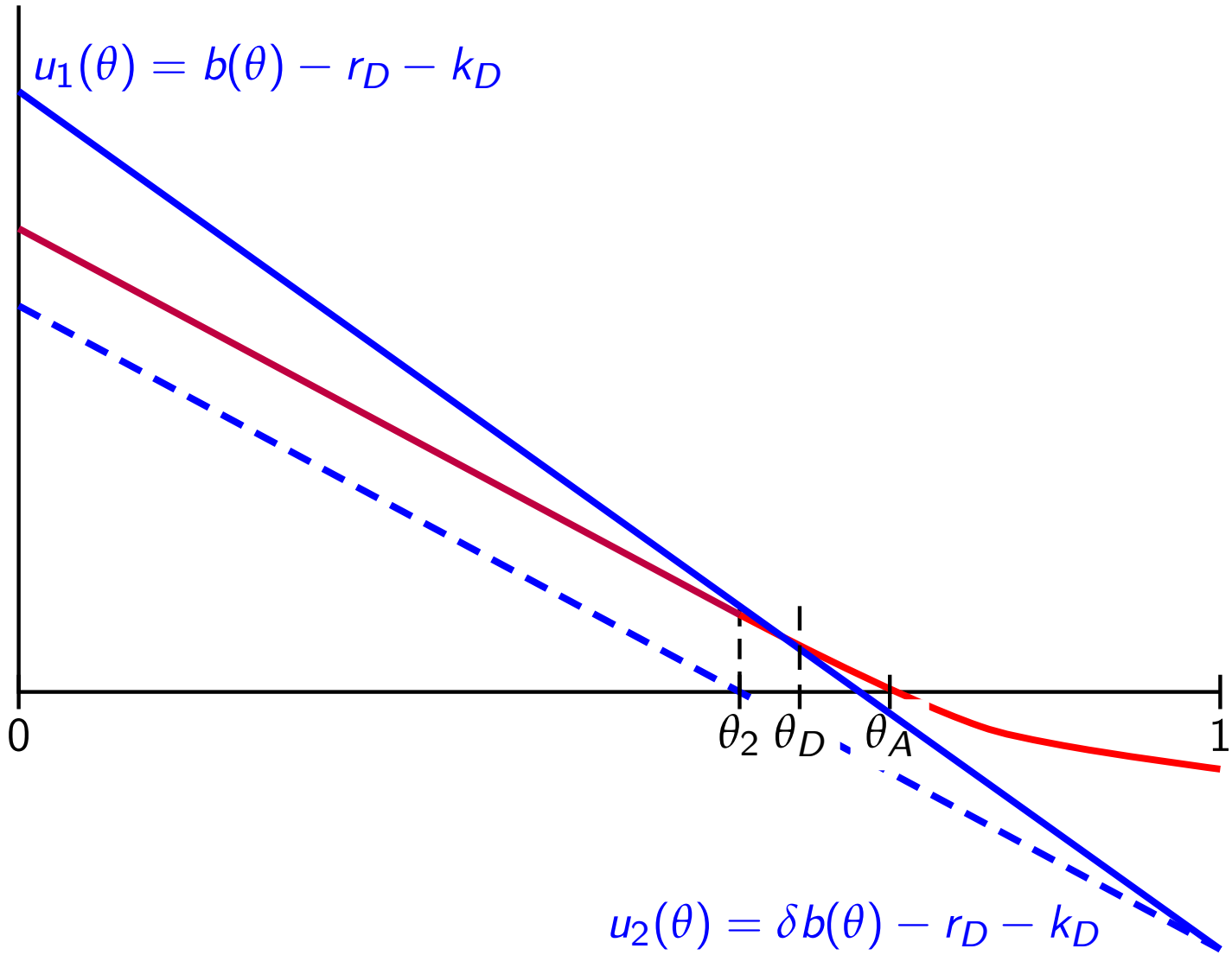


Equilibrium Case 2: DW + TAF



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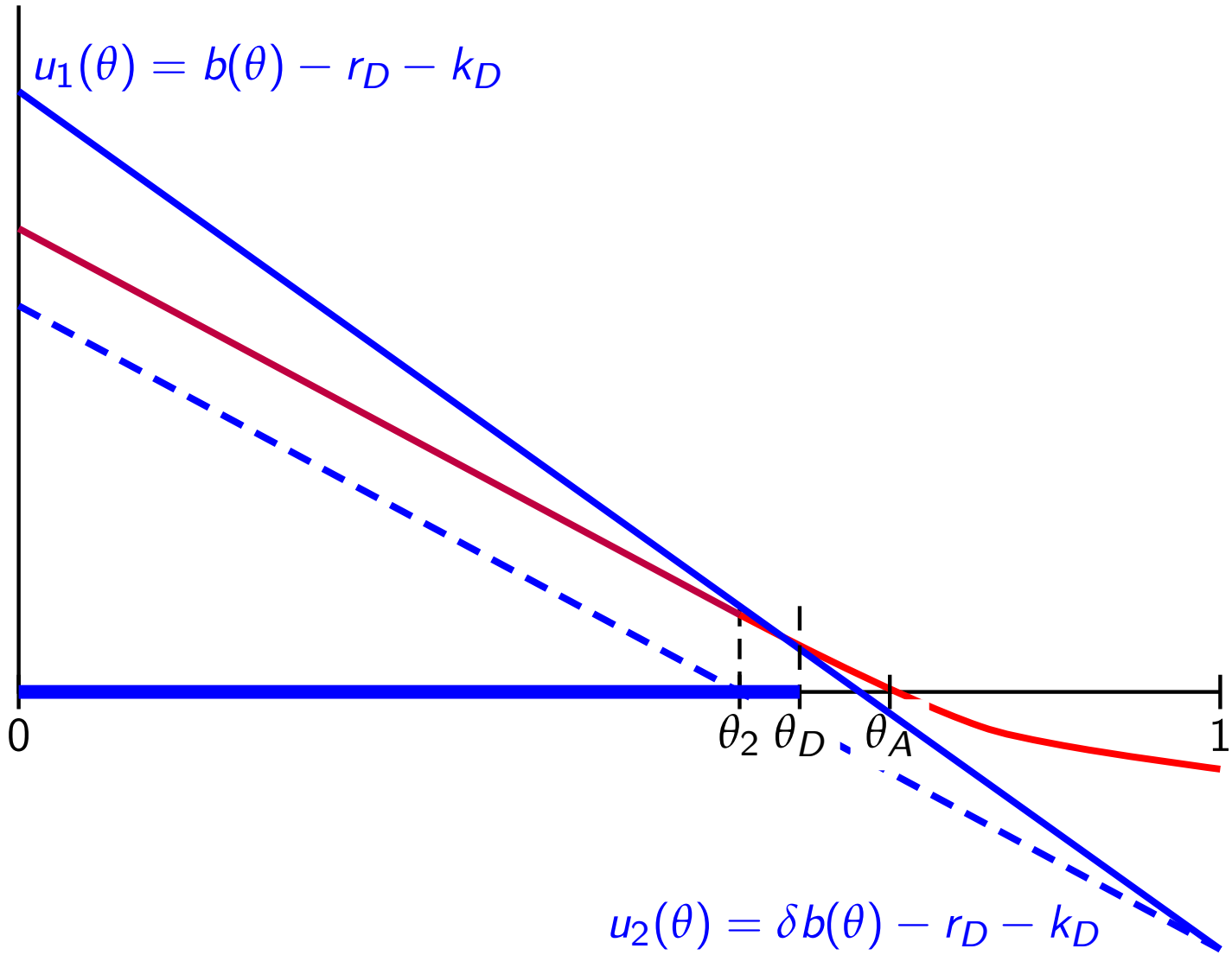

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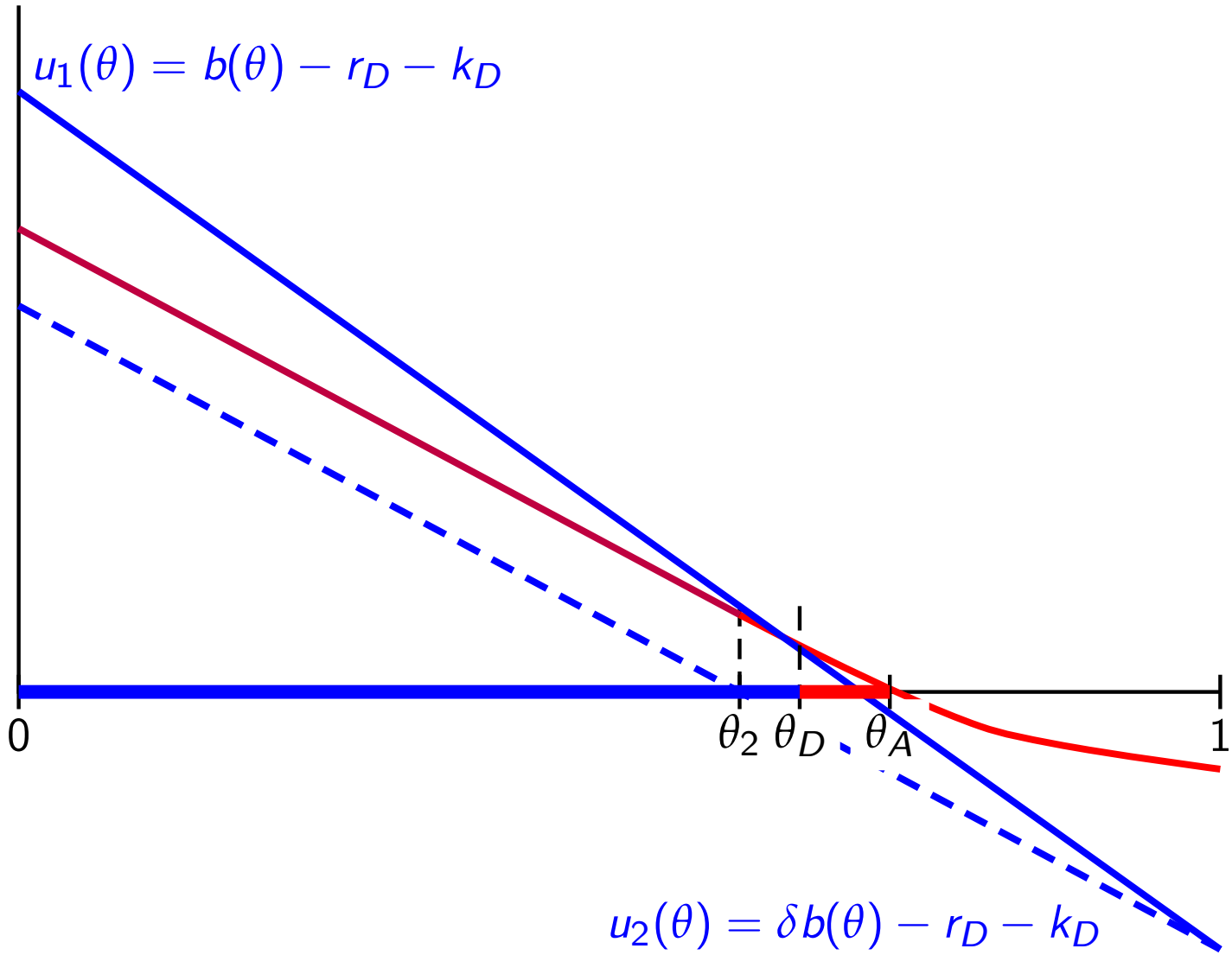
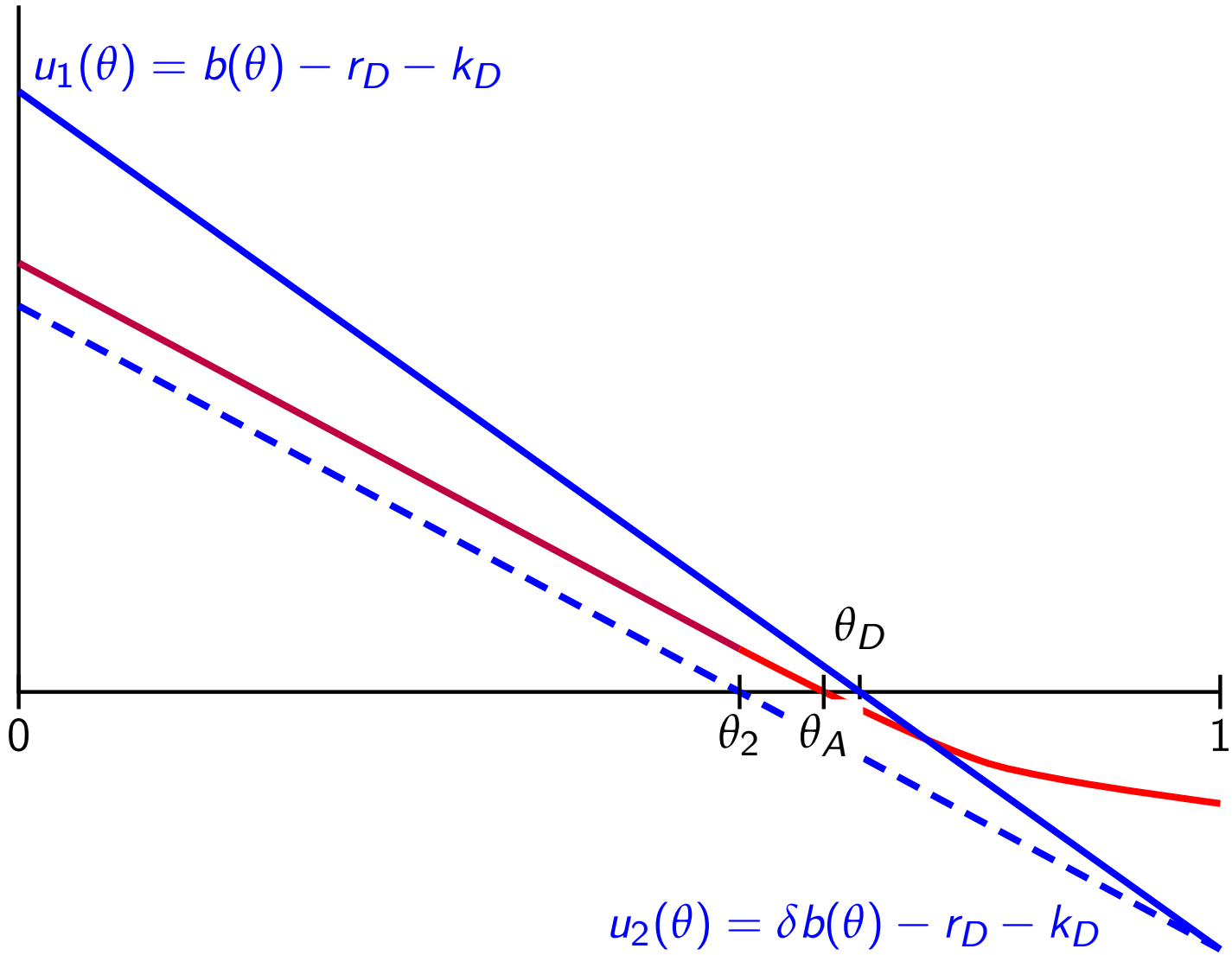


Corner Case: DW Only, δ small



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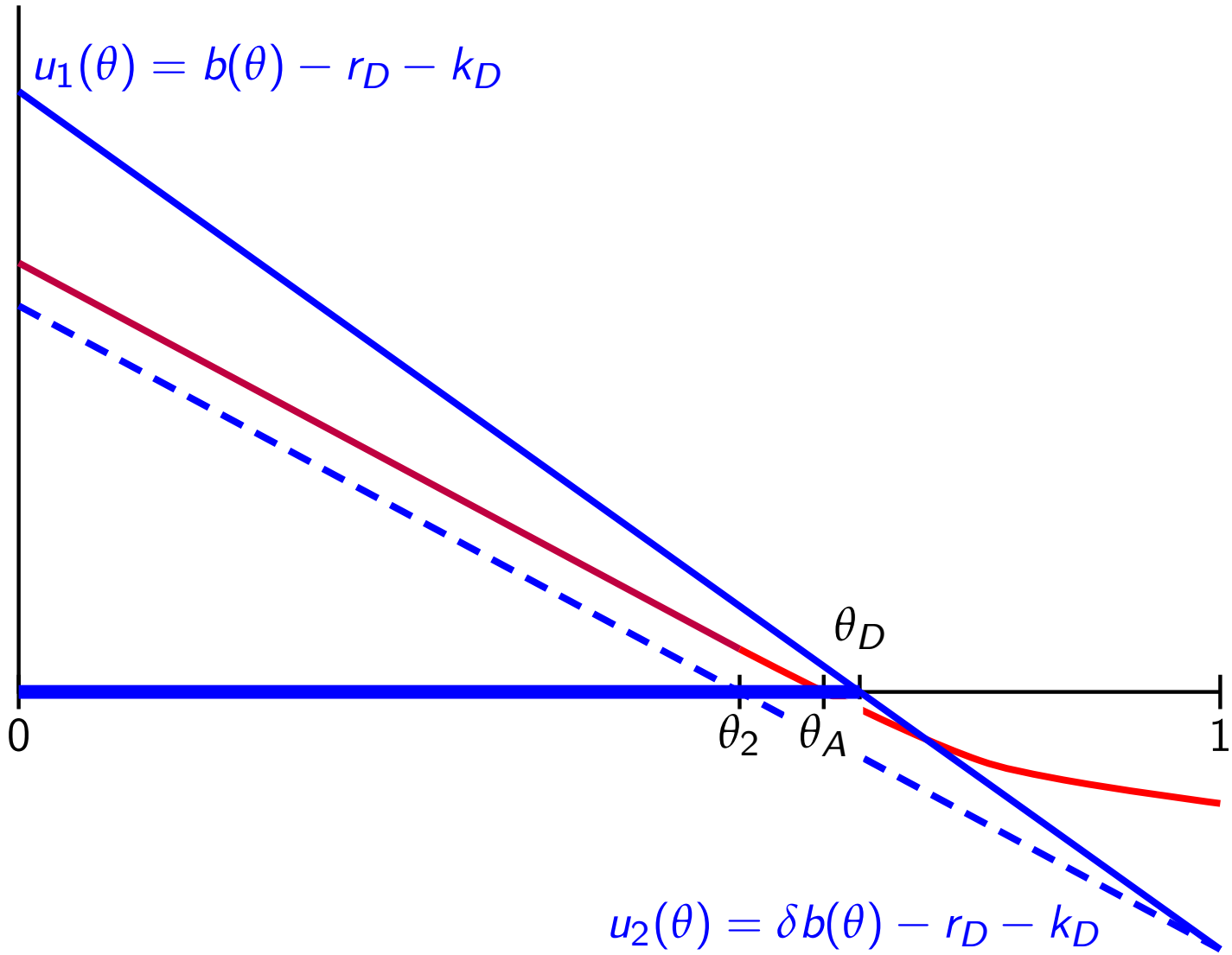


PBE

If they have not borrowed, banks $[0, \theta_D]$ borrow from DW1, banks $[0, \theta_A]$ bid in TAF, and banks $[0, \theta_2]$ borrow from DW2, where

$$\delta b(\theta_2) - r_D - k_D(\theta_D, \theta_2) = 0 \qquad \text{(DvN)}$$

$$\delta b(\theta_A) - r_A - k_A(\theta_D, \theta_2, \theta_A) = 0 \qquad \text{(AvN)}$$

$$b(\theta_D) - r_A - k_D(\theta_D, \theta_2) = \delta b(\theta_D) - \delta B(\theta_D, \theta_2, \theta_A) \qquad \text{(DvA)}$$

where $B(\theta_D, \theta_2, \theta_A) =$

$$\begin{cases} \int_{\theta_D}^{\theta_2} b(\theta_2) dH(\tau; \theta_D) + \int_{\theta_2}^{\theta_A} b(\tau) dH(\tau; \theta_D) + \int_{\theta_A}^{1} b(\theta_A) dH(\tau; \theta_D) & \theta_2 > \theta_D \\ \int_{\theta_D}^{\theta_A} b(\tau) dH(\tau; \theta_D) + \int_{\theta_A}^{1} b(\theta_A) dH(\tau; \theta_D) & \theta_2 \leq \theta_D \end{cases},$$

and

$$h(\tau; \theta_D) = (n-1) f(\tau) \binom{n-2}{m-1} [F(\tau) - F(\theta_D)]^(m-1)[1 - F(\tau) + F(\theta_D)]^{n-m-1}.$$

Unique PBE

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 the following monotonicity conditions hold:

$$\delta b'(\theta_2) - k_{D2}(\theta_D, \theta_2) < 0 \quad \forall \theta_D, \theta_2 \tag{Mon-DW2}$$

$$\delta b'(\theta_A) - k_{AA}(\theta_D, \theta_2, \theta_A) < 0 \quad \forall \theta_D, \theta_2, \theta_A \tag{Mon-TAF}$$

$$\delta b'(\theta_D) - k_{DD}(\theta_D, \theta_2) < 0 \quad \forall \theta_D, \theta_2 \tag{Mon-DW1}$$

$$(1-\delta) b'(\theta_D) + \delta B_D - \frac{\delta b'(\theta_2)(1 - H_2(\theta_2; \theta_D))}{\delta b'(\theta_2) - k_{D2}(\theta_D, \theta_2)} k_{DD}(\theta_D, \theta_2) < 0 \quad \forall \theta_D, \theta_2. \tag{Mon-D}$$

Empirical Design

- Key testable predictions
  - DW banks worse than TAF banks
  - TAF winners worse than TAF losers
  - DW1 banks worse than DW2 banks
- Our tests center around two main ideas:
  1. Compare banks' fundamentals (θ) 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

Table 1: Summary Statistics of Bloomberg

	N	Mean	Max	Min	SD	50^{th}
No. of Borrowers	407					
No. of Foreign Banks	92					
Frequency: DW		12	242	0	28.7	2
Frequency: DW before TAF		2	42	0	4.5	0
Frequency: DW after TAF		2	57	0	5.7	0
Frequency: TAF		5	28	0	5.1	3
Total DW amt (MM)		1529	190155	0	10393.8	20
Total TAF amt (MM)		3174	100167	0	10727.5	58
No. of days in debt		323	814	28	196.8	306

Table 2: Summary Statistics of TAF Bidders

	N	Mean	Max	Min	SD	50^{th}
No. of Banks	434					
No. of G-SIBs	22					
No. of Foreign Banks	82					
All Banks: no. of bids		13	95	1	13.9	8
G-SIBs		27	95	1	24.5	25
Foreign Banks		25	95	1	18.5	23
All: high-haircut collateral		0.185	1	0.000	0.314	0.000
G-SIBs		0.354	1	0.000	0.363	0.221
Foreign		0.401	1	0.000	0.370	0.340

Figure 1: Auction rates

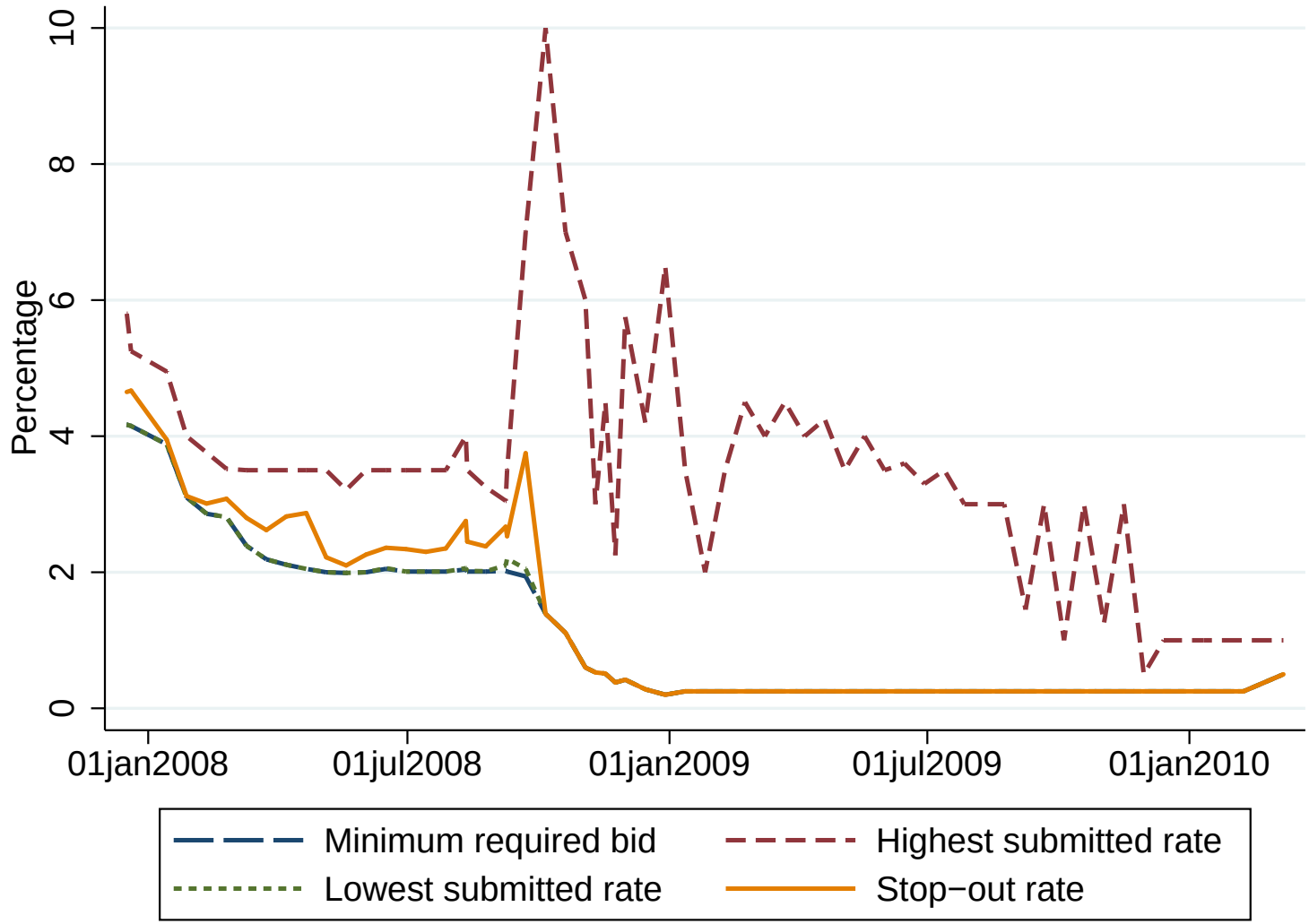
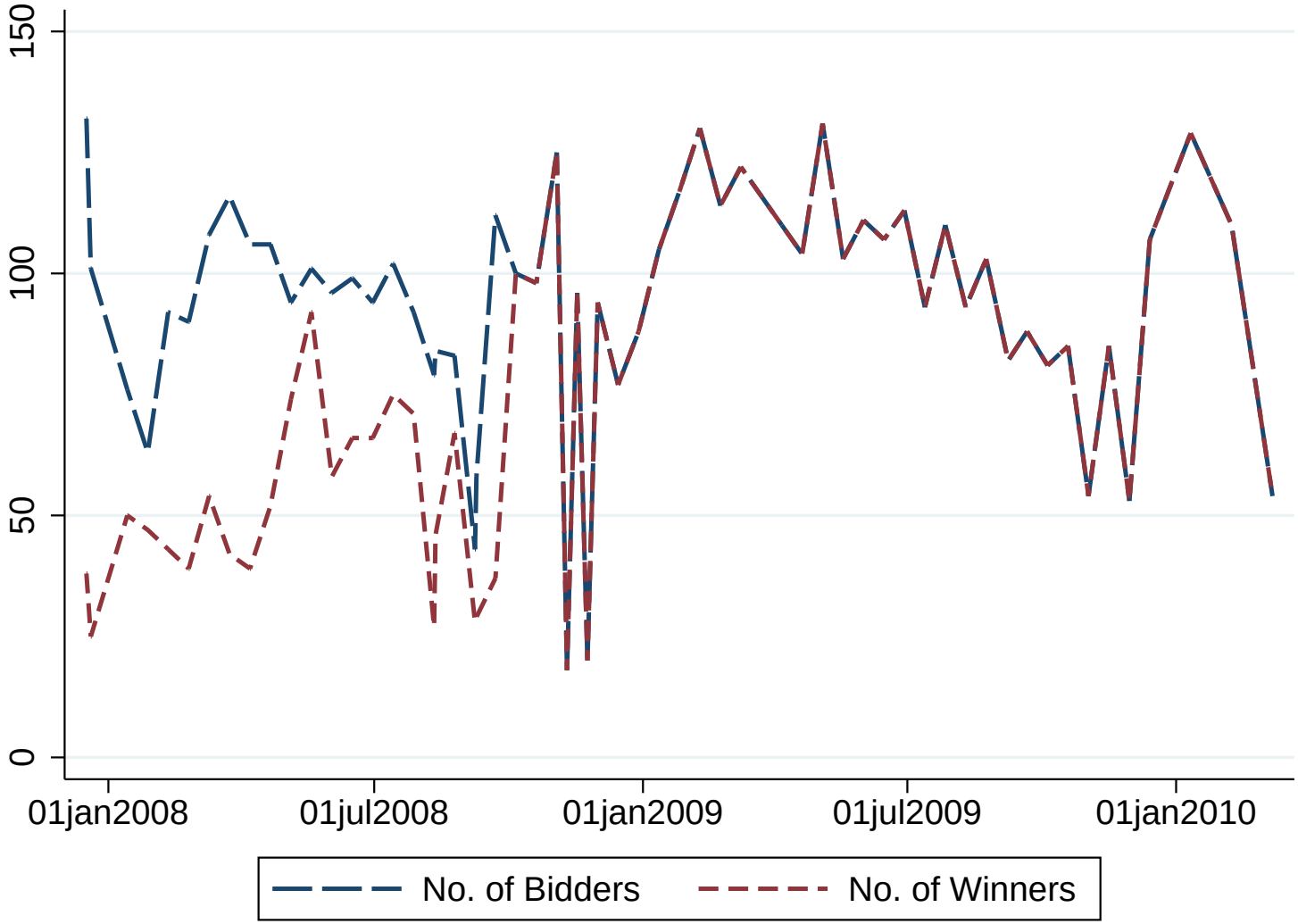


Figure 2: Auction participants



DW vs TAF: Tier 1 Capital

Tier 1 capital is the core measure of a bank's financial strength from a regulator's point of view. It is composed of core capital, which consists primarily of common stock and disclosed reserves (or retained earnings), but may also include non-redeemable non-cumulative preferred stock.

- Prediction: Higher tier 1 capital ratio predicts lower percent in DW borrowing.

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***	-2.720*	-2.496**
	(1.047)	(1.524)	(1.058)
(mean) size	-0.061***	-0.790***	-0.064***
	(0.009)	(0.193)	(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^2	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***	-2.105*	-2.069**
	(0.772)	(1.170)	(0.804)
(mean) size	-0.059***	-0.747***	-0.062***
	(0.009)	(0.194)	(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^2	0.116	0.558	0.152

Within TAF: Collaterals

A haircut is the difference between the market value of an asset used as loan collateral and the value ascribed to that asset when used as collateral for that loan (i.e. an ascribed (nominal) reduction to the value of that asset, when it is used as collateral). The amount of the haircut reflects the perceived risk of the asset falling in value or being sold in a fire sale; the larger the risk is perceived to be, the larger the haircut will be.

- Prediction: Banks who bid higher rates in TAF pledged more collaterals with high haircuts.

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***	0.122***	0.026***
	(0.009)	(0.009)	(0.009)
Constant	0.134***	0.202***	0.049
	(0.006)	(0.053)	(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^2	0.051	0.087	0.345

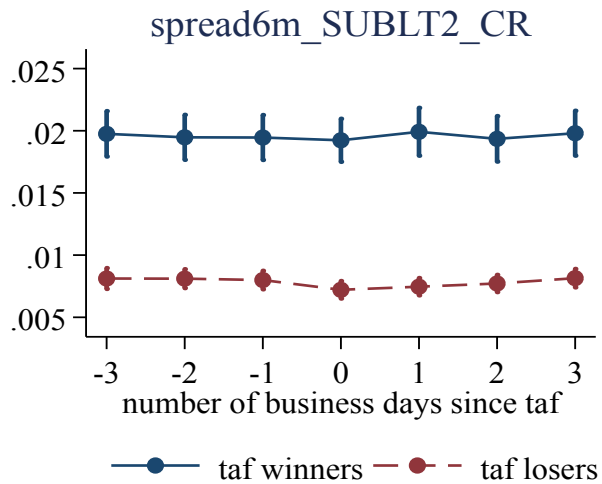
Within TAF: Subsequent Borrowing

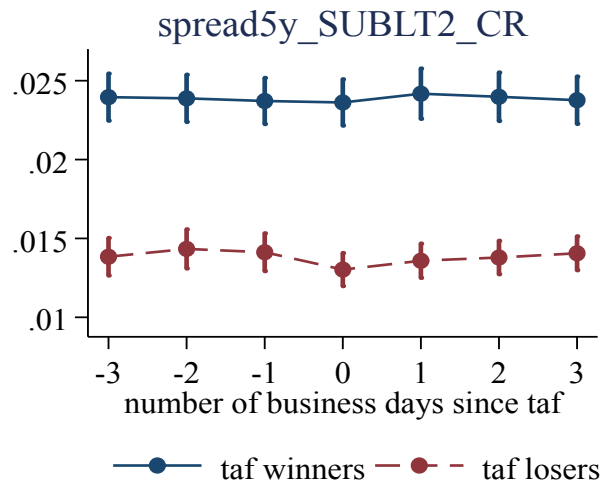
Winners were more likely to bid in the next two auctions.

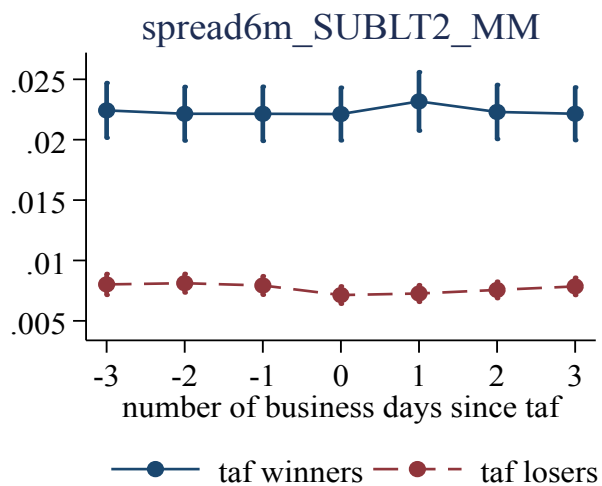
	(1)	(2)	(3)
Winner	0.032**	0.078***	0.059***
	(0.016)	(0.019)	(0.019)
Constant	0.822***	0.722***	0.690***
	(0.015)	(0.046)	(0.046)
auction FE	No	Yes	Yes
G-SIB FE	No	No	Yes
Foreign FE	No	No	Yes
Sample	Full	Full	Full
N	4855	4855	4855
R^2	0.001	0.085	0.095

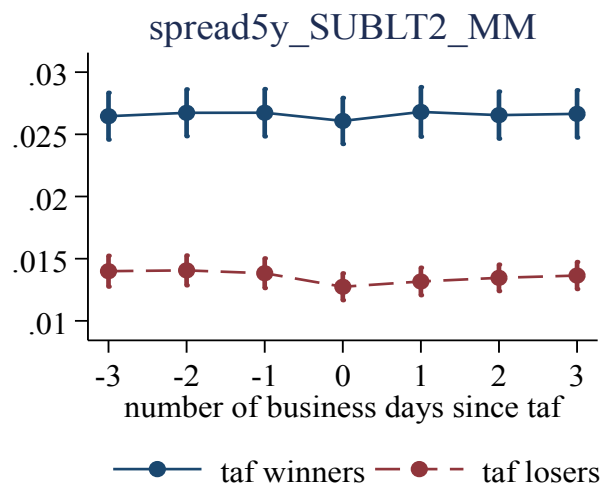
Within TAF: CDS Spreads

TAF winners worse than TAF losers.



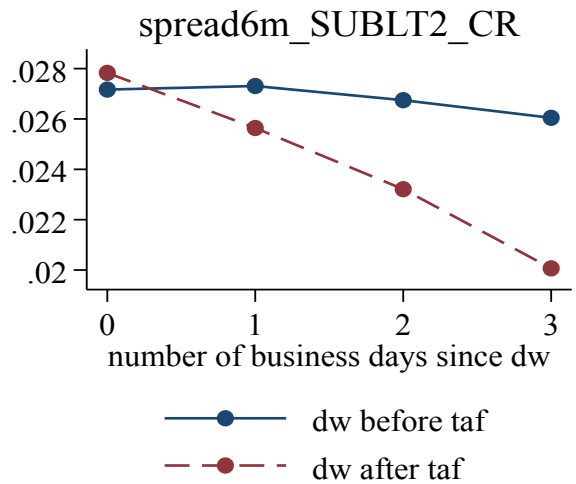


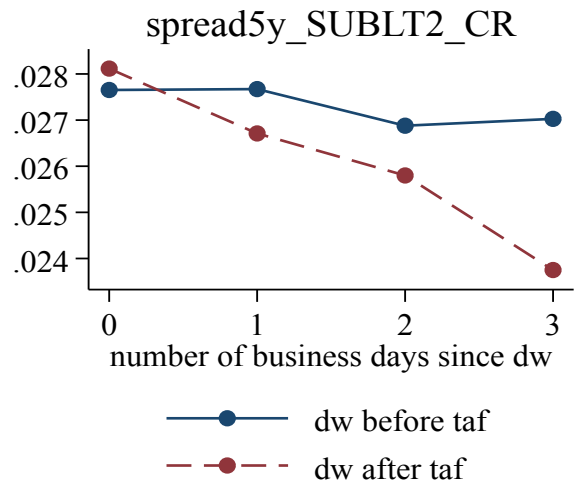


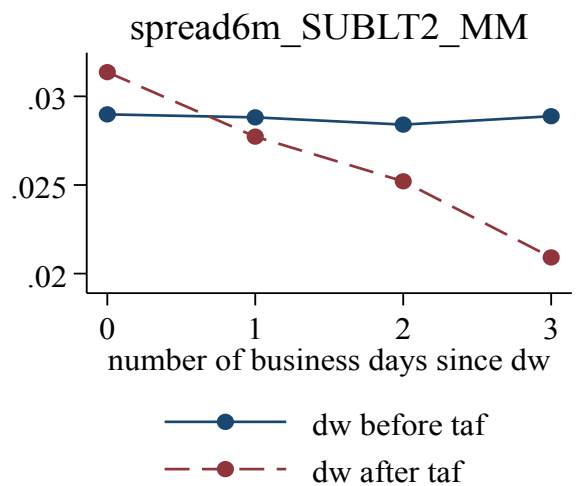


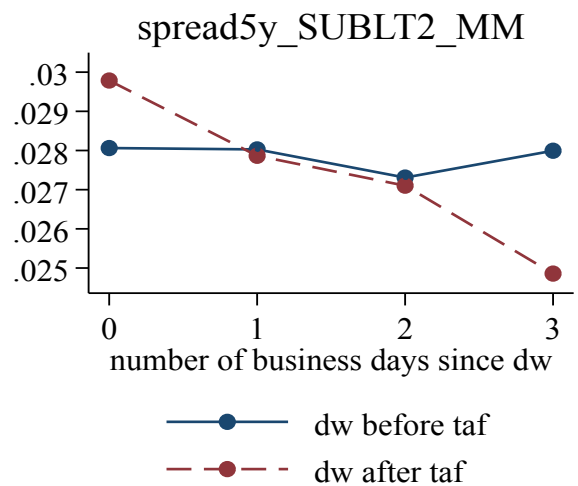
DW1 vs DW2: CDS spreads

DW1 banks worse than DW2 banks.









Market Reaction k to DW and TAF Borrowing

Event-study approach

- Estimation window: Jan 3, 2005 to Aug 1, 2007
- Events:
  - DW within three-day window before TAF
  - DW after three-day window before TAF
  - TAF borrowing
  - DW borrowing
- Event window: 5 trading days after the event
- Market model

Market Reaction k 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***	-0.015*	0.004	-0.005
	(0.002)	(0.008)	(0.007)	(0.004)
N	2948	209	257	720

Market Reaction k to DW and TAF Borrowing

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

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

Note: the coefficients are multiplied by 10^3.

Comparative Statics: More TAF Funds m

- θ_D decreases.
  1. Reduced auction payment due to more funds.
  2. Reduced TAF stigma because more $[\theta_D, \theta_A]$ banks win.
  3. Increases DW stigma because more $[\theta_D, \theta_2]$ banks borrow in TAF.
- θ_2 decreases.
  1. Type-θ_D banks switch to TAF from DW1, so worse banks borrow from DW1, so DW stigma increases.
  2. Fewer $[\theta_D, \theta_2]$ banks borrow from DW2, so DW stigma increases.
- θ_A ambiguous.
  1. Type-θ_D banks switch to TAF from DW1, so TAF stigma increases.
  2. Reduced TAF stigma because more $[\theta_D, \theta_A]$ banks win.

Comparative Statics: Lower Discount Rate r_D

- θ_D increases.
  - Reduced DW payment.
  - Reduced DW stigma because more borrow from DW2.
- θ_2 increases.
  - Reduced DW payment.
  - Reduced DW stigma because more borrow from DW1.
- θ_A increases.
  - Reduced TAF stigma because θ_D banks switch to DW1, so TAF stigma decreases.

Comparative Statics

- Higher minimum bid r_A.
- Higher discount δ.
- Higher detection p.
- Higher return $R \cdot b$.

Summary

- Constructed a model with endogenous DW and TAF stigma.
- Explained why TAF encouraged participation and high borrowing rates.
- Verified that DW banks worse than TAF banks, and TAF winners worse than TAF losers, DW1 banks worse than DW2 banks.
- Derived comparative statics.

Thank you!