# Redesigning Over-the-Counter Financial Markets

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Based in part on work with Leif Andersen, Antje Berndt, Piotr Dworczak, Yang Song, Haoxiang Zhu, and Yichao Zhu

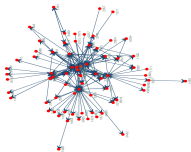# A dealer-intermediated bilateral OTC market
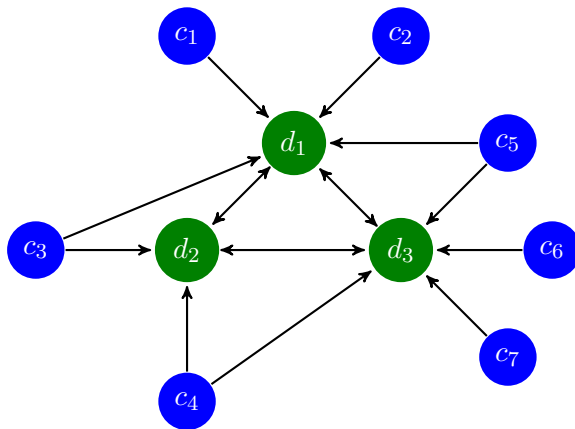
Example: The core-periphery European CDS market

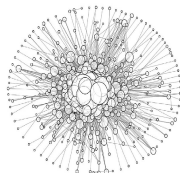Source: European Systemic Risk Board.
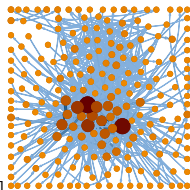
Examples of core-periphery dealing networks

Li-Schüerhoff: munis]

Hollifield-Neklyudov-Spatt: ABS]

Bech-Atalay: Fed Funds]

ESRB: IR swaps]

ESRB: CDS]

ESRB: FX forwards]

Frictions in dealer-intermediated OTC markets

1. Search, relationship, and switching costs. Schultz (2001), Green-Hollifield-Schürhoff (2007), Osler-Bjonnes-Kathitziotis (2016), O'Hara-Wang-Zhou (2018), Hau-Hoffman-Langfield-Timmer (2018).

2. Relative lack of price transparency to dealer customers. Bessembinder-Maxwell-Venkataraman (2006), Goldstein-Hotchkiss-Sirri (2006), Edwards-Harris-Piwowar (2007), Asquith-Covert-Pathak (2013), Duffie-Dworczak-Zhu (2018).

3. Dealer balance sheet costs. Adrian-Etula-Muir (2014), Adrian-Fleming-Goldberg-Lewis-Natalucci-Wu (2013), He-Kelly-Manela (2016), Andersen-Duffie-Song (2018).

4. For CDS and corporate bonds, asymmetric information about the referenced default risk. Biswasy-Nikolovaz-Stahe (2015), Collin-Dufresne-Trolle (2017).

Dealer balance sheet
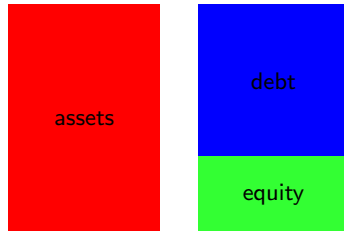
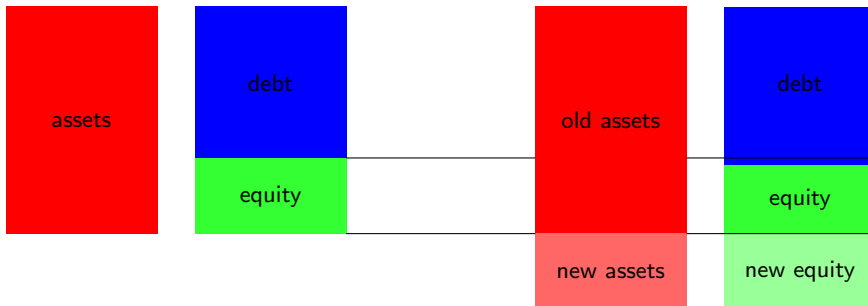# More equity to fund more assets
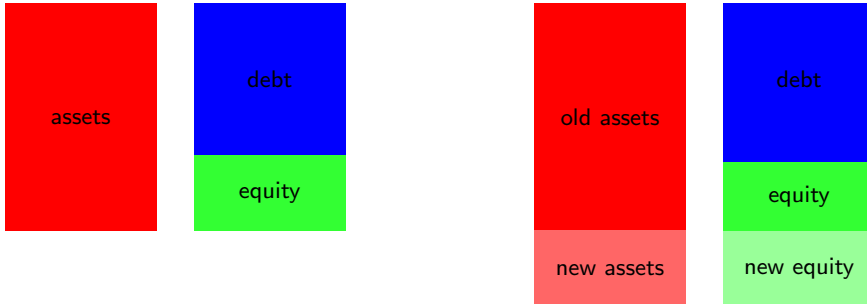
Legacy shareholders have subsidized creditors

Higher capitalization implies a value transfer from legacy shareholders to creditors.

Debt overhang
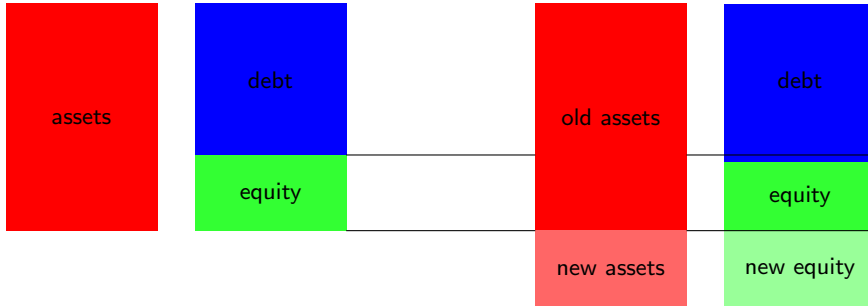
For shareholders to break even, the new assets must be purchased at a profit that exceeds the value transfer to creditors.

Dealer funds swap collateral with debt

Where FVA should appear on the balance sheet

Dealer Funding Costs Determine Cost of Balance Sheet Space
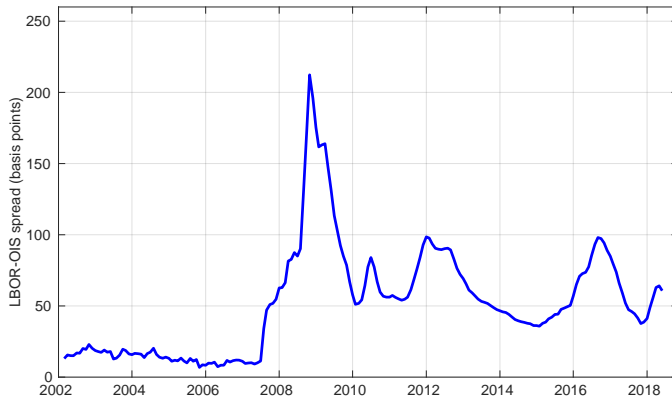
One-year LIBOR-OIS. Data source: Bloomberg

Funding value adjustments of swap dealers

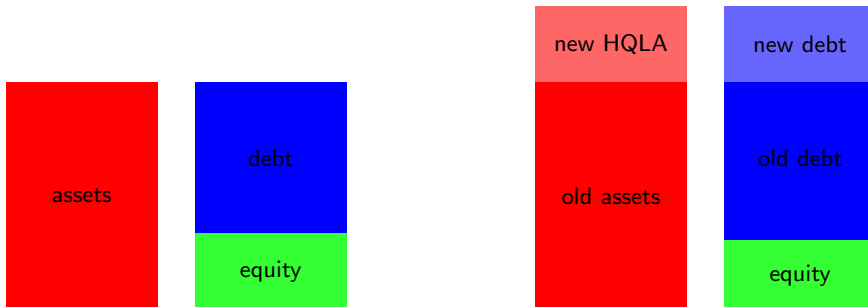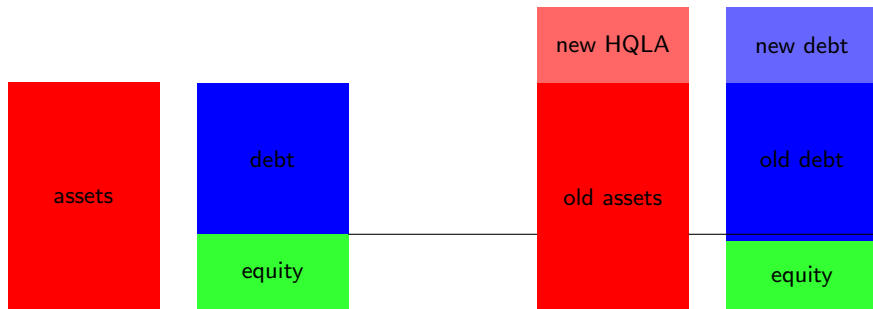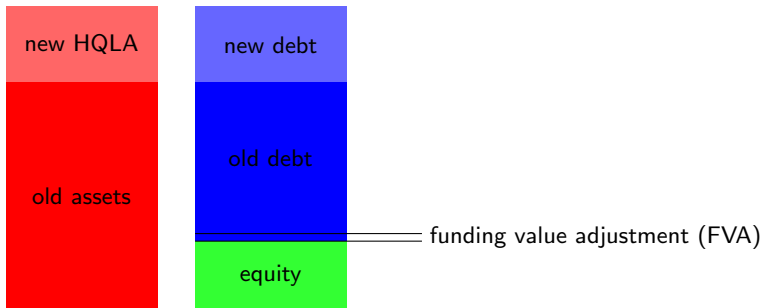|	Amount (millions)	Date Disclosed
Bank of America Merrill Lynch	$497	Q4 2014
Morgan Stanley	$468	Q4 2014
Citi	$474	Q4 2014
HSBC	$263	Q4 2014
Royal Bank of Canada	C$105	Q4 2014
UBS	Fr267	Q3 2014
Crédit Suisse	Fr279	Q3 2014
BNP Paribas	€166	Q2 2014
Crédit Agricole	€167	Q2 2014
J.P. Morgan Chase	$1,000	Q4 2013
Deutsche Bank	€364	Q4 2012
Royal Bank of Scotland	$475	Q4 2012
Barclays	£101	Q4 2012
Lloyds Banking Group	€143	Q4 2012
Goldman Sachs	Unknown	Q4 2011

Sources: Supplementary notes of quarterly or annual financial disclosures.

Unsecured swap
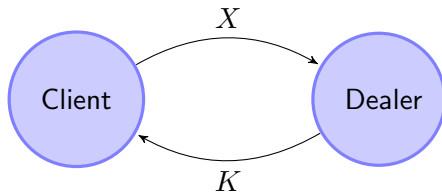
Financing

- Upfront cash payment by dealer.

Back-to-back swap trades
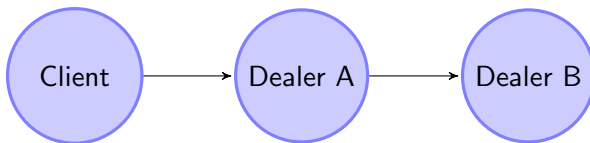
Dealers hedge the market risk of client swaps in the inter-dealer market.

Collateralization
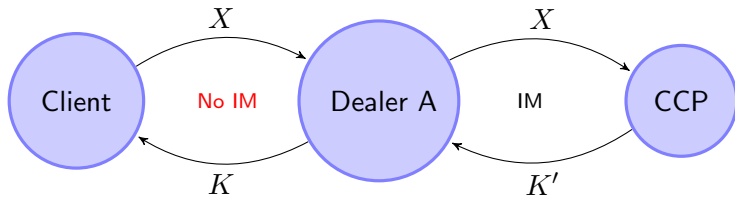
Initial margin exchanged between dealer A and dealer B (or CCP).

Variation margin as swap value changes over time.

Collateralization: Case 2
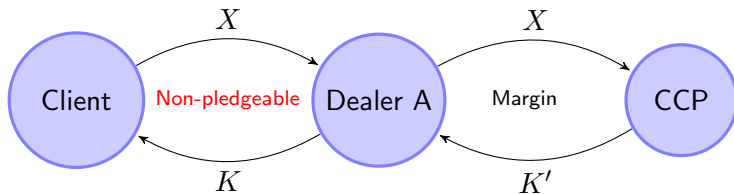
CCPs require dealers to post collateral
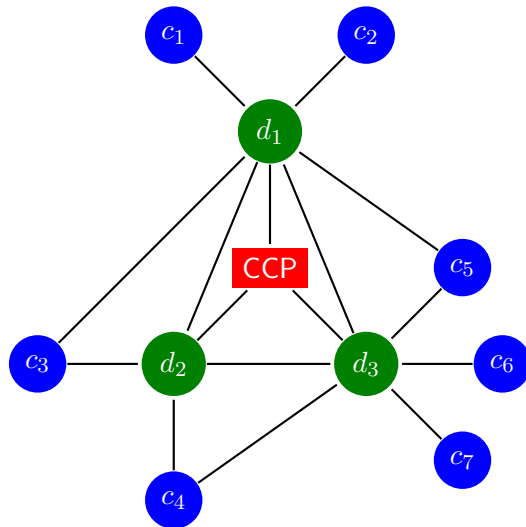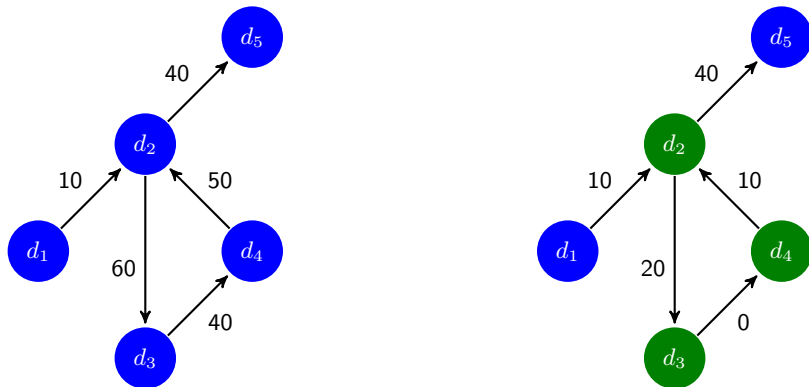
Figure: A compression trade that eliminates a redundant circle of positions of size 40 (counterclockwise, involving dealers 2, 3, and 4) with a circle of clockwise trades of size 40. Counterparty exposures and initial margin are reduced without changing market exposures. Example service providers: TriOptima (over $1 quadrillion notional eliminated, largely interest-rate swaps).

Reducing swap exposures, especially from compression trading
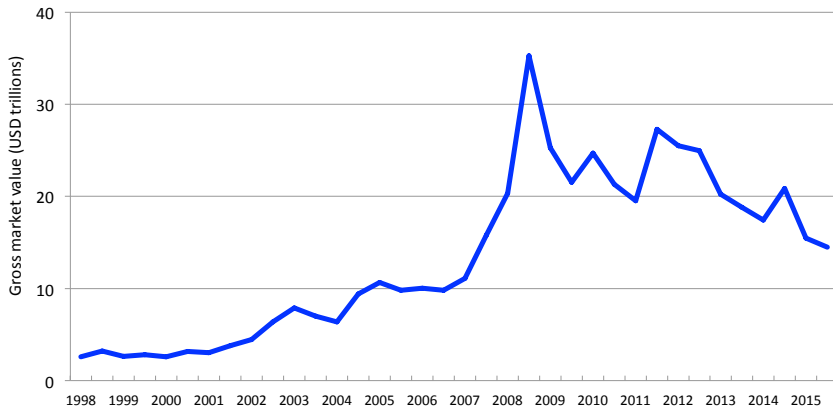
Valuation setting

From "Funding Value Adjustments," with Leif Andersen and Yang Song

▶ Two periods: 0 and 1, with a one-period risk-free discount of $\delta = 1/R$.

▶ Coherent market valuation functional $V(\,\cdot\,)$ for contingent claims.

- Linear: $V(\alpha X + \beta Y) = \alpha V(X) + \beta V(Y)$.
- Increasing: For $X \geq Y$ and $X \neq Y$, we have $V(X) > V(Y)$.

▶ These coherency axioms imply a stochastic discount factor $\lambda \gg 0$ such that, for any claim Y, we have $V(Y) = E(\lambda Y)$.

▶ This implies we can represent values with a "risk-neutral" probability measure P^*, so that $V(Y) = \delta E^*(Y)$.

Dealer model

- At time 1, the dealer's assets pay A, and it's liabilities claim L.

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▶ Base case: The dealer funds the trade with new unsecured debt.

Technical assumptions

1. There is a finite number of states and $P(A = L) = 0$.

   OR

2. Under the risk-neutral measure P^*
   - A, L, and Y have finite expectations.

   - Either A and L have a continuous joint probability density, or A has a continuous density and L is constant.

The new dealer balance sheet

If the dealer finances a position of size q by issuing new debt, then its total assets are

$$\mathcal{A}(q) = A + qY$$

and total liabilities are

$$\mathcal{L}(q) = L + U(q)(R + s(q)),$$

where $s(q)$ is the dealer's credit spread to finance the position.

The limit spread $\lim_{q \downarrow 0} s(q)$ is

$$S = \frac{E^*(\phi)R}{1 - E^*(\phi)},$$

for a fractional loss to creditors in the default event $D = \{A < L\}$ of

$$\phi = \frac{L - \kappa A}{L} \mathbf{1}_D.$$

Marginal value of the trade to dealer shareholders

The marginal increase in the value of the firm's equity, per unit investment, is

$$G = \left. \frac{\partial E^*[\delta(A + qY - L - U(q)(R + s(q)))^+]}{\partial q} \right|_{q=0}.$$

The Funding Value Adjustment

Proposition

The marginal increase in equity value is well defined and given by

$$G = p^*\pi - \delta\text{cov}^*(1_D, Y) - \Phi,$$

where

- $p^* = 1 - P^*(D)$ *is the risk-neutral survival probability.*
- $\pi = \delta E^*(Y) - u$ *is the marginal profit on the trade to a hypothetical risk-free dealer.*
- $\Phi = p^*\delta u S$ *is the funding value adjustment (FVA).*

Wider credit spreads leave wider FVA bounds on the CIP basis
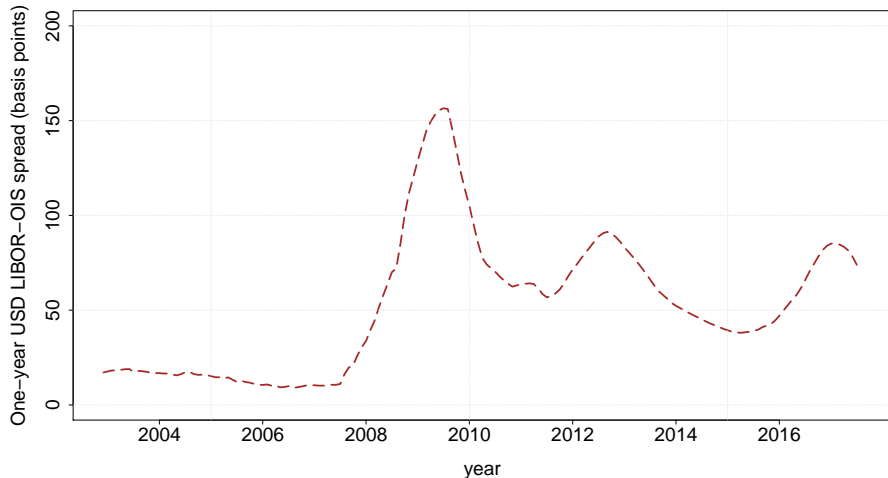
Five-Year Cross-Currency Basis: G10 Currencies
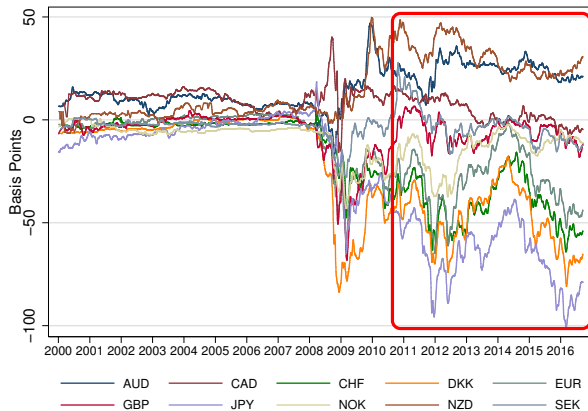
Figure: from Du, Tepper, and Verdelhan (2017)

5-year CDS Rates of Major Dealers
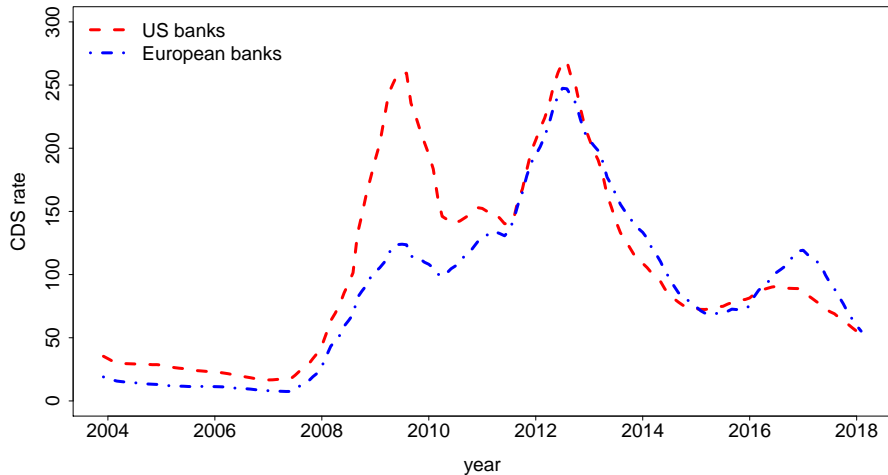
Bank funds synthetic dollars with dollar debt
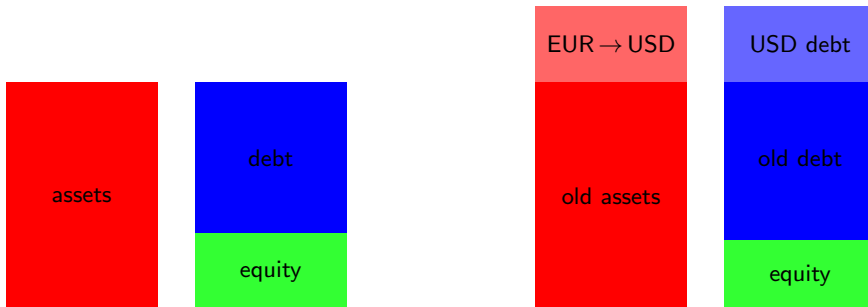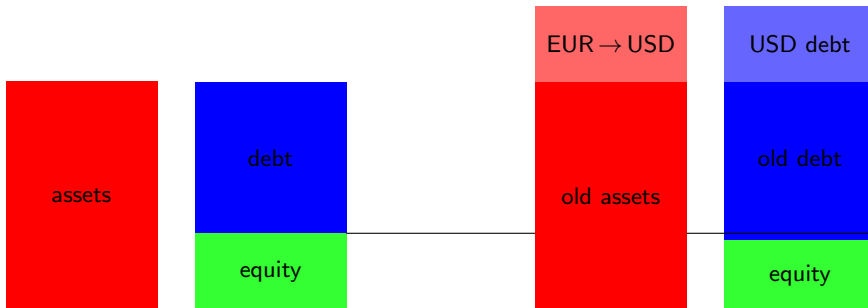
Funding cost to shareholders
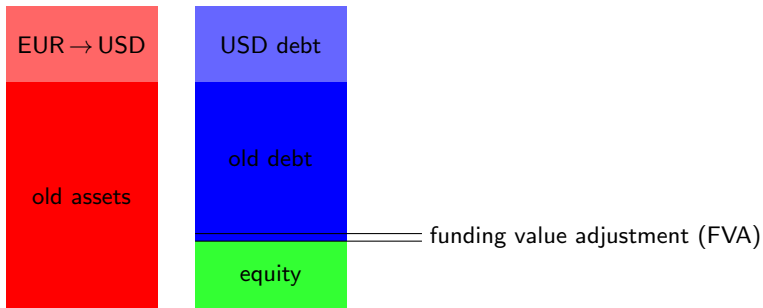
Increased dealer credit spreads imply a larger funding-cost wedge
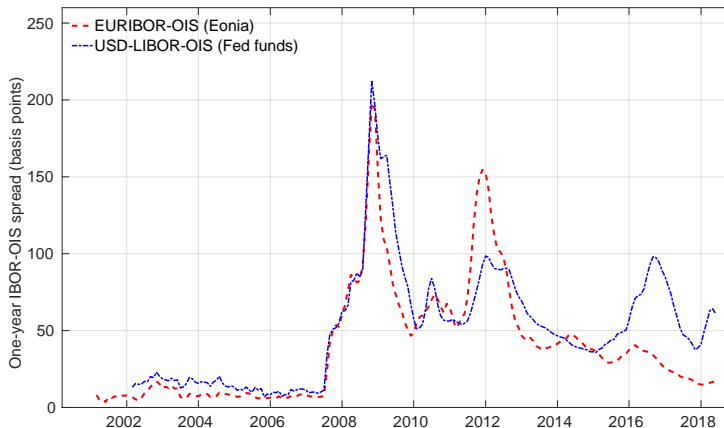
Spreads between one-year IBOR and OIS rates. Data source: Bloomberg.

But the biggest dealer-banks now have much bigger capital buffers
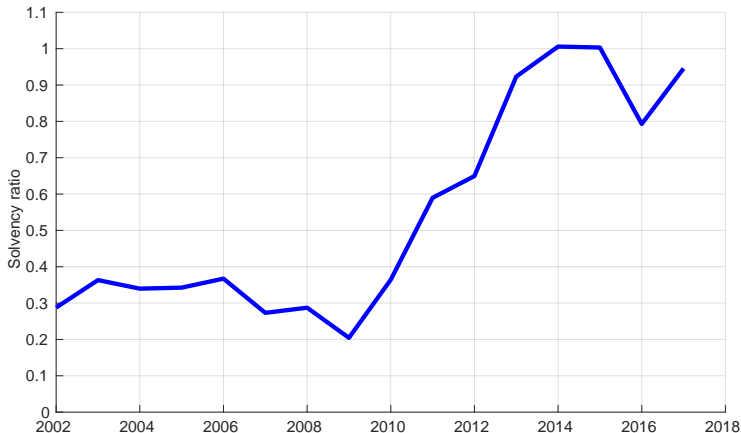
Solvency ratio: tangible equity divided by an estimate of the standard deviation of the annual change in asset value. Nine largest US bank holding companies, asset weighted. Source: Berndt, Duffie, and Zhu (2018).

G-SIB credit ratings no longer include sovereign uplifts
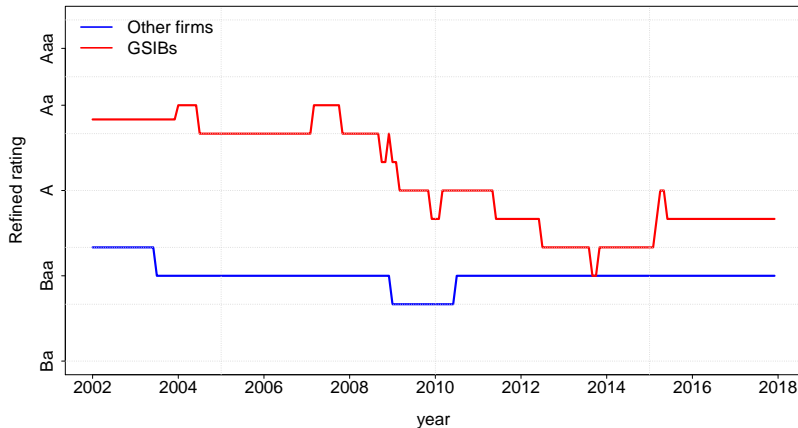
Median refined credit ratings. Data source: Moody's Investors Service.

G-SIB 5-year credit spreads at a fixed distance to default

From a panel regression of log 5-year CDS rates on distance to default, for 1.6 million observations, 855 firms, 2002-2017, with interacted time and G-SIB fixed effects. Source: Berndt-Duffie-Zhu (2018).

Example sources of OTC price transparency

- ▶ Post-trade transactions reporting (TRACE, swap data repositories).

- ▶ Pre-trade platform-based price quotations.

- ▶ Benchmark price reporting.

Common OTC price benchmarks

- LIBOR, EURIBOR, TIBOR, . . .

- SONIA, EONIA, . . .

- WM/Reuters foreign exchange fixings.

- Gold, Silver, Palladium, Platinum, . . .

- Oil (Brent, WTI), Natural Gas, Iron Ore (IODEX), . . .

- Pharmaceuticals (Average Wholesale Price).

Selected LIBOR and EURIBOR Dependencies

(amounts in billions of USD equivalent notional)

	U.S.	LIBOR fraction	Eurozone	EURIBOR fraction
Syndicated loans	3400	97%	535	90%
Bilateral corporate loans	1650	$\simeq$40%	4322	60%
Retail mortgages	9608	15%	5073	28%
Floating rate notes	1470	84%	2645	70%
Interest rate swaps	106700	65%	137553	high
Exchange-traded derivatives	32900	93%	17300	100%

Source: Market Participant Group Report (2014)

Welfare roles of benchmark price transparency in OTC markets

From "Benchmarks in Search Markets," with Piotr Dworczak and Haoxiang Zhu

1. Increasing the volume of beneficial trade through:
   - Signaling when there are high gains from trade.
   - Improving the share of gains offered to traders.

2. Reducing total search costs.

3. Facilitating more efficient trade matching between dealers and customers, through:
   - Improving the ability of traders to detect when quotes are from high-cost dealers.
   - The use of benchmarks by low-cost dealers as a "price transparency weapon."

Related work on search-market transparency

- Benabou and Gertner (1993) analyze the influence of inflationary uncertainty on welfare and the split of surplus between consumers and two firms.

- Precursor search theory: Janssen, Pichler, and Weidenholzer (2011).

- Empirical work on TRACE and post-trade price transparency: Bessembinder, Maxwell, and Venkataraman (2006), Edwards, Harris, and Piwowar (2007), Goldstein, Hotchkiss, and Sirri (2007), Bessembinder and Maxwell (2008), Green, Hollifield, and Schürhoff (2007), Asquith, Covert, and Pathak (2013).

- Related theory on transparency in dealer markets: Madhavan (1995); Pagano and Roell (1996); Asriyan, Fuchs, and Green (2017).

Dealers post quotes on platforms

The cost of dealer i is $c_i = c + \epsilon_i$, where c is common, ϵ_i is idiosyncratic.

There is a benchmark if the common cost component c is published.

The quote p_i of dealer i has an equilibrium probability distribution F that depends on c and ϵ_i, and whether there is a benchmark.

The payoff of dealer i is $(p_i - c_i)Q_i$, where Q_i is the total volume of trades.

Fast traders pick the minimum offer

All traders value the asset at trader at some constant value v.

A fraction μ of traders are "fast," that is, have no search cost.
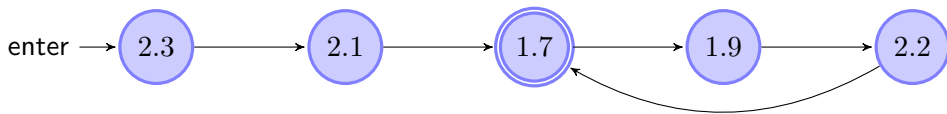
In this example, the payoff of the fast trader is $v - 1.7$.

Feasible search path of an entering slow trader

Slow traders incur a search or delay cost of s for each dealer platform visited.
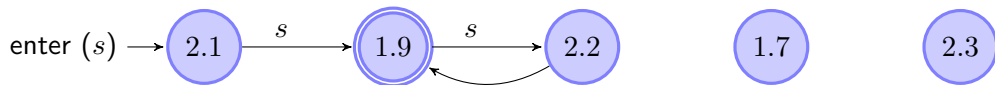
The net payoff of this path is $v - 1.9 - 3s$

Outline of results

▶ A welfare comparison of market equilibria with and without a benchmark.

▶ With heterogeneous-cost dealers, how benchmarks improve matching efficiency.

▶ The incentives of homogeneous-cost dealers to introduce a benchmark.

▶ The strategic introduction of benchmarks by low-cost dealers to increase market share.

▶ Benchmark manipulation incentives for dealers.

Equilibrium search of a slow trader with a benchmark

Enter with a probability λ_c that depends on the observed benchmark c.

Immediately accept the first offer below an optimal reservation price r_c.

The net payoff of this path is $v - 1.9 - 2s$.

Simple case: dealers with the same cost

The support of the distribution of c is $[\underline{c}, \overline{c}]$.

We examine behavior on the event $\{c < v - s\}$. (Otherwise, slow traders don't enter and dealers compete à la Bertrand, offering to sell for c.)

The unique equilibrium probability distribution F of offer quotes has no atoms and has upper support limit r_c.

Dealer quote strategy

For a dealer, the probability that a quote-observing trader is fast is

$$q(\lambda_c) = \frac{\mu}{\mu + \frac{1}{N}\lambda_c(1-\mu)}.$$

Dealers are indifferent between all price offers in the support of F, so

$$\left[1 - q(\lambda_c) + q(\lambda_c)\left(1 - F(p)^{N-1}\right)\right](p-c) = \left[1 - q(\lambda_c)\right](r_c - c).$$

Solving,

$$F(p) = 1 - \left[\frac{\lambda_c(1-\mu)}{N\mu}\frac{r_c - p}{p - c}\right]^{\frac{1}{N-1}}.$$

Slow trader strategy

Pandora solution of Weitzman (1979): Indifference to search when observing the quote r_c implies that

$$v - r_c = v - s - \mathbb{E}_F(p).$$

Solving,

$$r_c = c + \frac{1}{1 - \alpha(\lambda_c)} s,$$

where

$$\alpha(\lambda_c) = \int_0^1 \left(1 + \frac{N\mu}{\lambda_c(1-\mu)}\, z^{N-1}\right)^{-1} dz < 1.$$

An interior entry probability λ_c solves

$$s = (1 - \alpha(\lambda_c))(v - c).$$

Equilibrium search of entering slow traders with no benchmark

Enter with probability λ.

Accept the offer on the first platform visited if it is below v.

Then exit.

enter $(s) \longrightarrow$ (2.1) (1.9) (2.2) (1.7) (2.3)

Because $v < 2.1$, this path has net payoff $-s$.

When does a benchmark improve welfare?

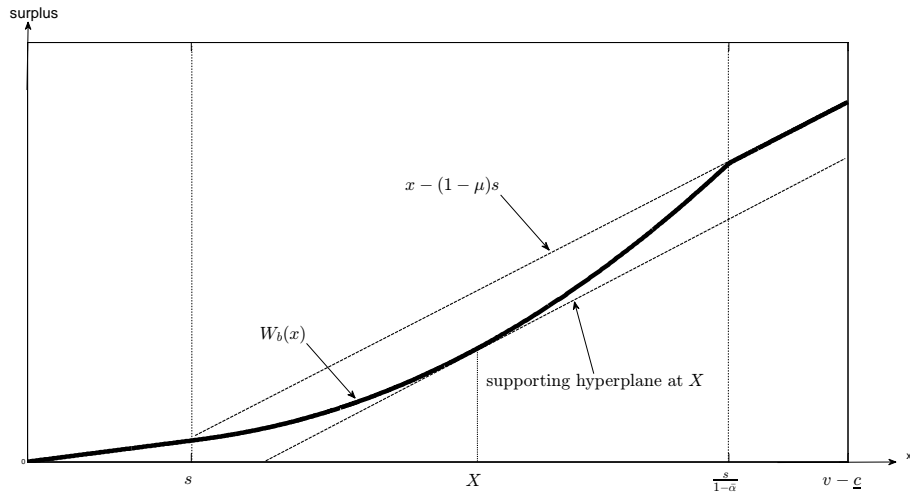- Change variables to gain from trade $x = \max(v - c, 0)$.

- Letting $\Lambda(x) = \lambda_c$, the social surplus with a benchmark is

$$W(x) = \mu x + \Lambda(x)(1 - \mu)(x - s).$$

- The total social surplus with no benchmark is $W(\mathbb{E}(x))$.

- If μ is small enough or s is at least a given fraction of $\mathbb{E}(x)$, then $W(\cdot)$ is sub-differentiable at $\mathbb{E}(x)$, leaving

$$\mathbb{E}(W(x)) \geq W(\mathbb{E}(x)).$$

Welfare: $W_b(x) = \mu x + \Lambda(x)(1-\mu)(x-s)$

Benchmarks do not always improve welfare!

▶ If the expected gain from trade of slow traders is sufficiently large relative to search costs, then even without the benchmark all of the slow traders may enter.

▶ In the presence of the benchmark, however, slow-trader entry may be low in the event of a high realization of c (still allowing gains from trade).

▶ Thus, adding a benchmark could *reduce* welfare if the entry of slow traders is already nearly efficient without the benchmark.

Matching efficiency

Proposition. Suppose the search cost is sufficiently low and there is always a gain from trade $(v > \bar{c} + \Delta)$. Then, with a benchmark:

- All trade is with low-cost dealers.

- If, in addition, the search cost is not too low, then slow traders always trade with the first encountered low-cost dealer.

Theorem. If the search cost is within a specified interval and if $\bar{c} > \underline{c} + \Delta$, then the expected social surplus is strictly greater in the equilibrium with a benchmark than in any equilibrium without a benchmark.

Incentive for dealers to introduce a benchmark

Theorem. Suppose all dealers have the same cost, and the search cost is high enough. Then dealer profits are higher with a benchmark than without.

Whenever dealers would opt for the benchmark in this sense, it must be the case that the introduction of the benchmark raises social surplus. The converse is not true.

# Low-cost dealers can use benchmarks strategically

- A slight change in the cost distribution, so that the number L of low-cost dealers is zero or at least two.

- Any non-trivial coalition of dealers can commit to a benchmark (by voting).

- Dealers enter if and only if their expected profit is strictly positive.

- The number of entering dealers is publicly observed.

Proposition. Suppose that the dealer cost difference Δ is sufficiently large and the search cost s is not too high. Then:

- There exists an equilibrium of the extended game in which low-cost dealers always vote in favor of the benchmark, and high-cost dealers always vote against it. Moreover, there are no profitable group deviations in the voting stage.

- If the environment is competitive (that is, $L \geq 2$), the benchmark is introduced, all high-cost dealers stay out of the market, all low-cost dealers enter the market, and all traders enter the market.

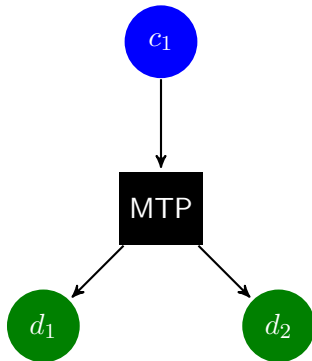- If the environment is uncompetitive ($L = 0$), the benchmark is not introduced, and all dealers enter the market.

Improving trade competition

Example objective: Migration of active products to all-to-all trade platforms
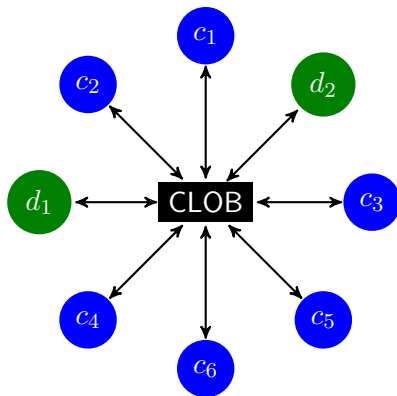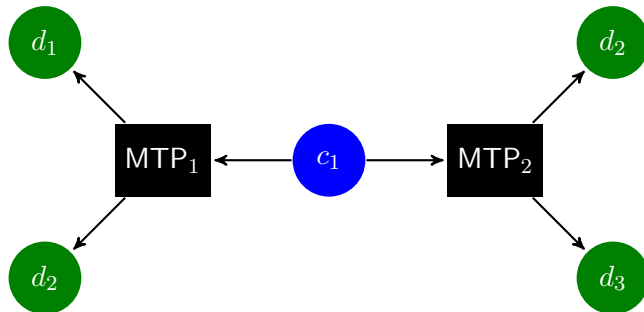
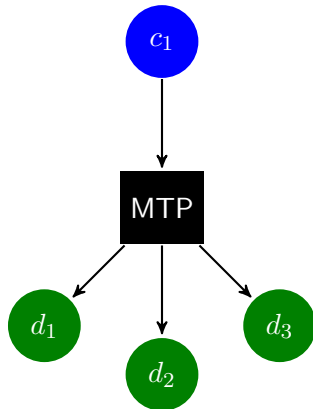# Typical response of regulators to market design

Buy-side firms request quotes at multilateral trading platforms

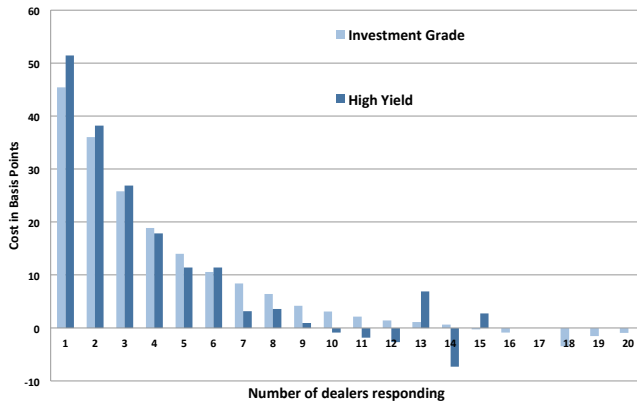# But with excessive fragmentation across platforms
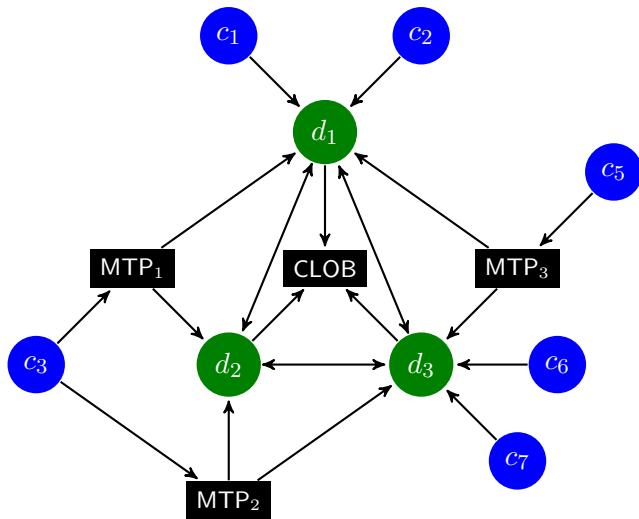
Reducing fragmentation improves competition

At corporate bond platforms
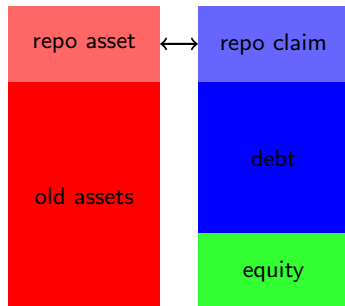# Dealer competition lowers buy-side trade costs

Now typical fragmented two-tiered OTC markets
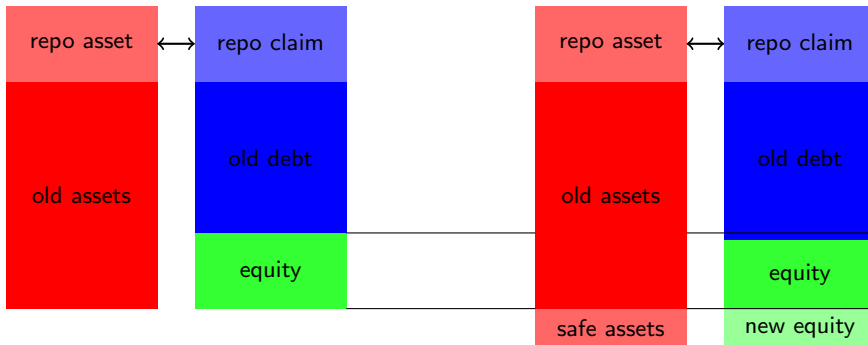
Appendix

Impact of supplementary leverage ratio rule on repo markets

Debt overhang dampens repo intermediation incentives, widening bid-offer spreads

Impact of the leverage-ratio regulation
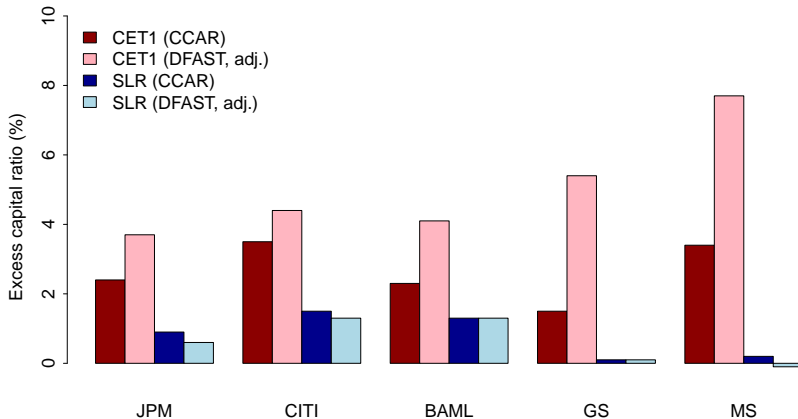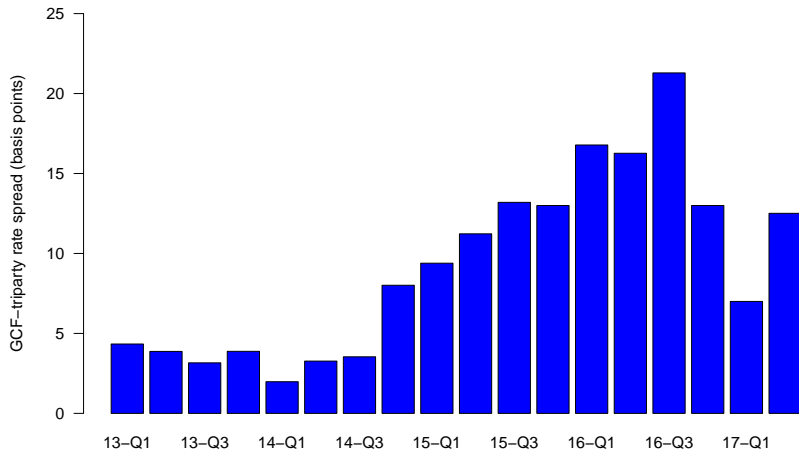# on repo intermediation costs to legacy shareholders

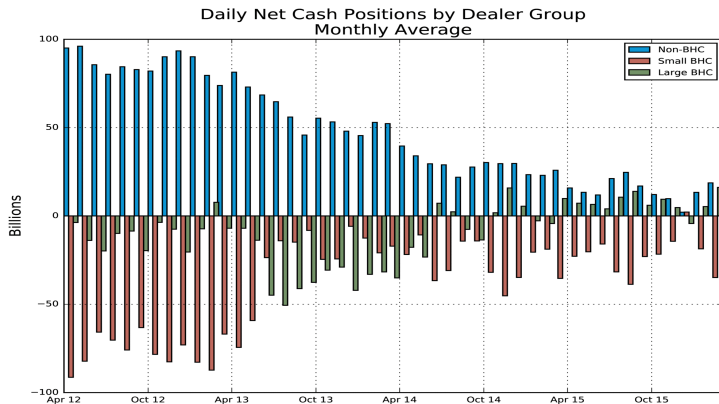# SLR is more binding than risk-based capital regulation

Results of the Fed's 2017 stress tests for the largest US dealer banks

Estimated impact of SLR on USD repo-rate bid-ask spread

Decline in GCF repo net lending volume

Daily Net Cash Positions by Dealer Group
Monthly Average

Source: Martin, FRBNY (2016)

European Banks Delever as Reporting Days Approach

Daily collateral outstanding in the tri-party repo market and the Federal Reserve's overnight reverse repo (ON RRP) facility
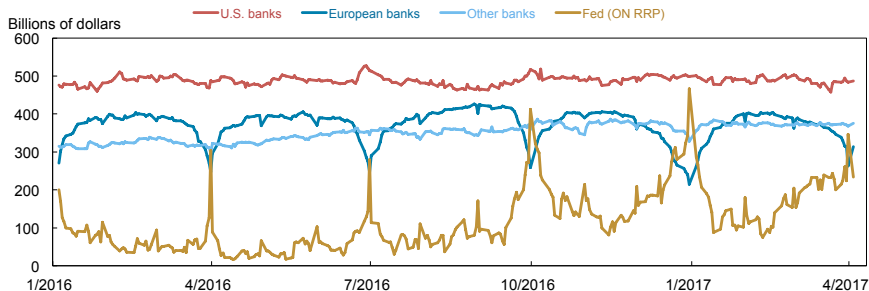
Figure Source: Egelhov, Martin, Zinsmeister, Federal Reserve Bank of New York, August, 2017.

Notes: Banks headquartered in the euro area and Switzerland report leverage ratios as a snapshot of their value on the last day of each quarter, while their U.S. counterparts report quarterly averages. Totals only include trades backed by Fedwire-eligible securities–that is, U.S. Treasury and agency securities.

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▶ Suppose the one-year USD risk-free rate is zero.

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- We have a new liability worth $100 and a new asset worth approximately $100.25, for a trade profit of approximately $0.25.
- However, the marginal value of the trade to our shareholders is

$$0.993\bigg(\$100.60\big(0.993 + 0.0035\big) - \$100.35\bigg) \simeq -\$0.10.$$

Pecking order of financing sources

▶ The pecking order of financing sources, in order of lowest marginal cost to equity value: (1) existing cash on the balance sheet, (2) unsecured debt, (3) equity.

▶ Relative to debt financing, the extra marginal cost to dealer shareholders when a fraction α of the funding must be equity is $\alpha(1 - p^* - \Phi)$, which annualizes to roughly αS, assuming a loss given default of 0.5.

▶ For the purchase of safe assets, the shareholder breakeven "arbitrage" yield is the total annualized funding cost to shareholders of roughly $(1 + \alpha)S$.

When should a dealer arbitrage the USD-JPY CIP basis?
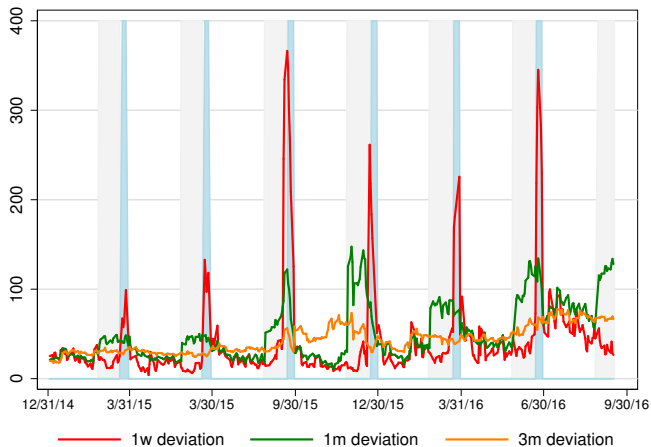
Source: Du, Tepper, and Verdelhan (2016).