Too Big to Diversify: A Stress Test on Collateralized Loan Obligations

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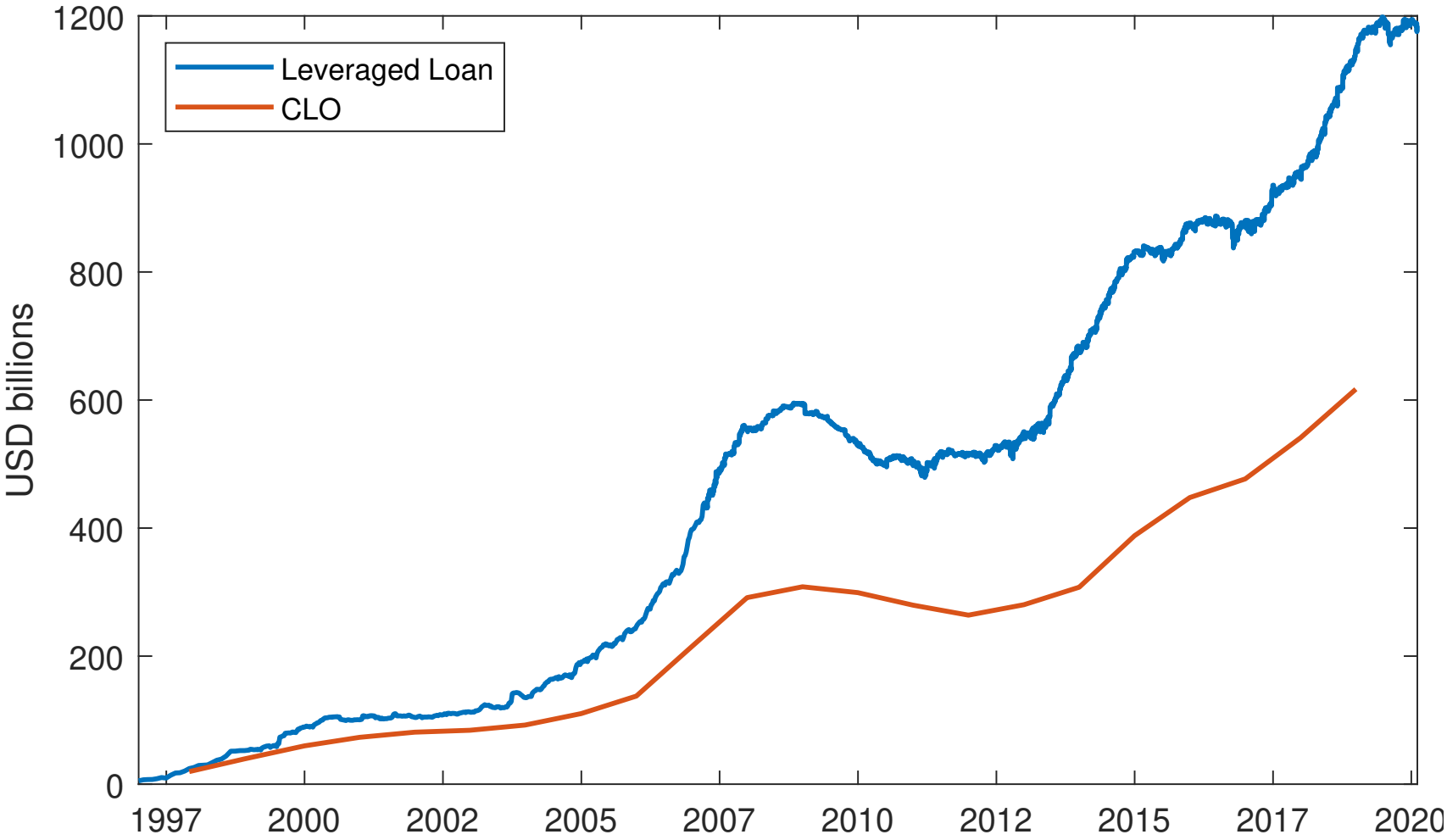
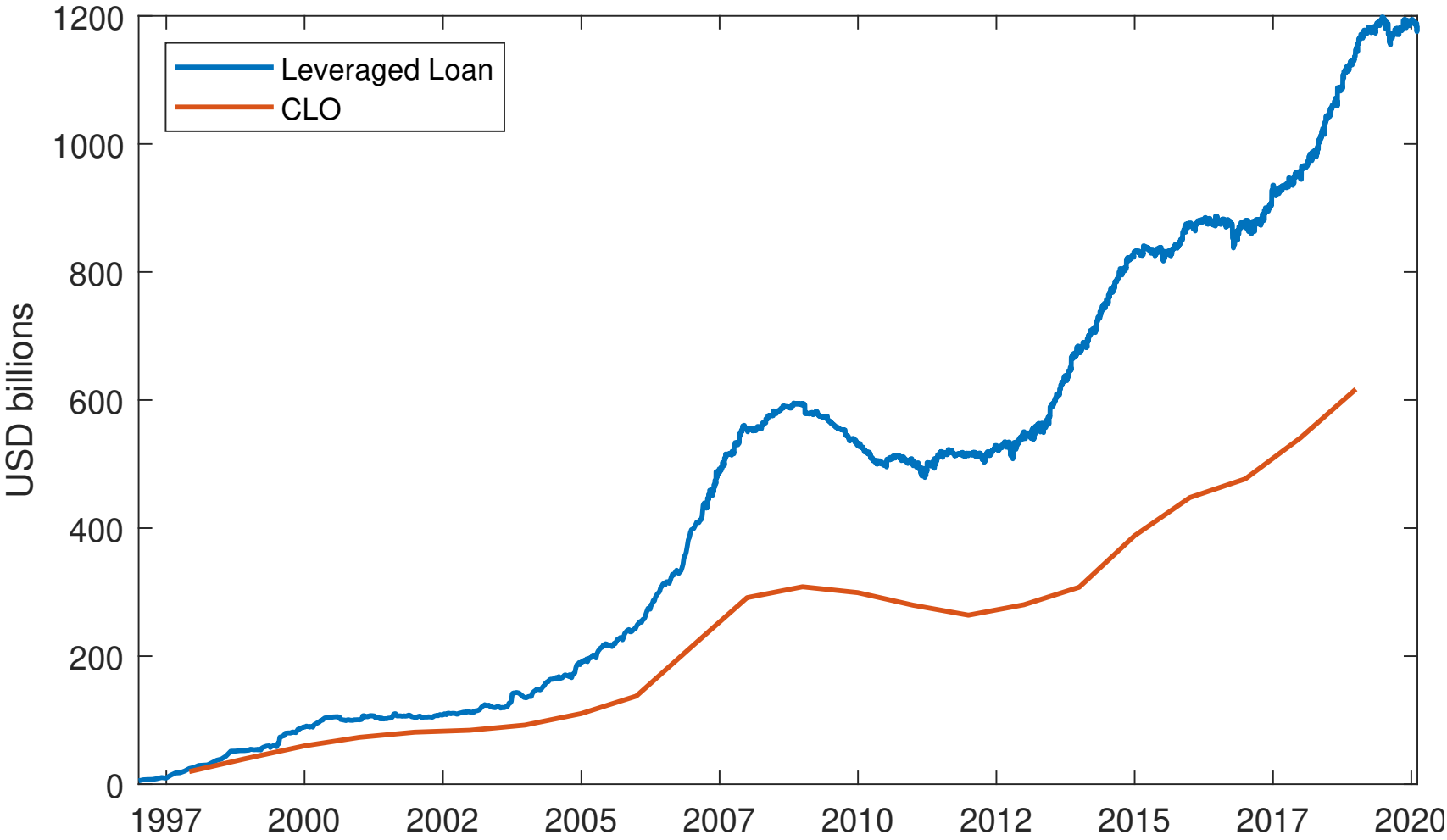
Growth of Collateralized Loan Obligations and Leveraged Loan Market



Source: Refinitive Leveraged Loan Monthly (Leveraged Loan) and SIFMA (CLO)

Growth of Collateralized Loan Obligations and Leveraged Loan Market

Shocks to some leveraged loan borrowers ⇒ CLOs ⇒ Other borrowers.



Source: Refinitive Leveraged Loan Monthly (Leveraged Loan) and SIFMA (CLO)

What We Do

1. Stress tests on CLOs:
   - What happens if large borrowers default for idiosyncratic reasons?
   - Use CLO's loan holdings data to examine how this hypothetical shock spreads across CLOs.
   - Study the effect of the shocks on CLO's leverage.

2. Fire sale by constrained CLOs
   - To relax leverage constraints, CLOs sell loans downgraded to CCC.
   - Collective action to sell inflicts price impact on CCC-rated loans.

$\Rightarrow$ Systemic risk on the leverage loan market

Data

CLO-i data from Acuris company:

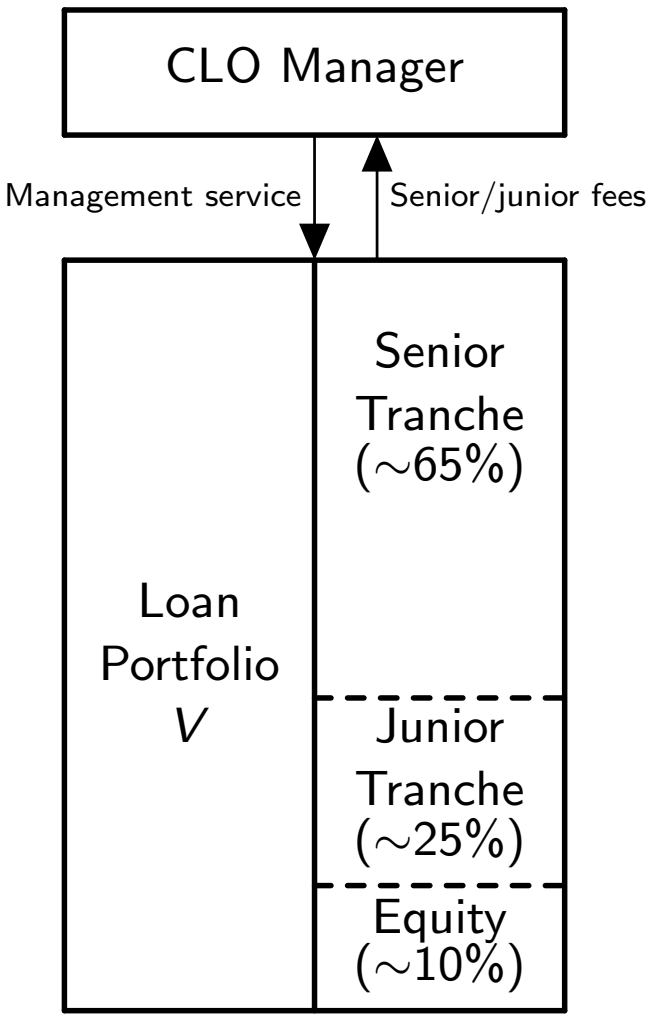
- Gather information in monthly trustee reports from January 2007 to March 2020.
- Loan-level holdings data including borrower's credit rating.
- CLO's transaction data including price and volume.
- Constraints imposed on CLOs (OC test results).
- Data coverage (in terms of asset under management) is about 80% in 2018.

Part I:

Stress Tests on CLOs

Structures and Constraints on CLOs

1. Diversification requirements [ASSET]
2. Leverage constraints [LIABILITY]



- Leverage of a CLO is measured by the Overcollateralization (OC) ratio.
- Senior OC ratio:

$$OC(S) = \frac{V}{D(S)}$$

e.g.

$$OC(S) = \frac{100}{65} \approx 154\%$$

- Junior OC ratio:

$$OC(J) = \frac{V}{D(S) + D(J)}$$

e.g.

$$OC(J) = \frac{100}{65 + 25} \approx 111\%$$

Overcollatralization Ratio

Determinants of the OC ratio:

- Shocks to asset value V
- Initial leverage and repayment of CLO's debt

Shocks to CLO's asset

- CLOs evaluate their loan holdings at book value unless:
  - A loan is in default
  - Total holdings of CCC loans (rated CCC or below, but not in default) are more than 7.5% of assets
    $\Rightarrow$ The excess is evaluated at fair value.

OC ratio test: Test if the OC ratio remains above the pre-specified threshold.
$\Rightarrow$ If a CLO fails the OC ratio test, then it must take actions:

- If the CLO is in the reinvestment period, the CLO has to divert cash flows from equity / junior tranches to purchase more collaterals or pay down senior tranches.
- If the CLO is in the amortization period, the CLO has pay down senior tranches.

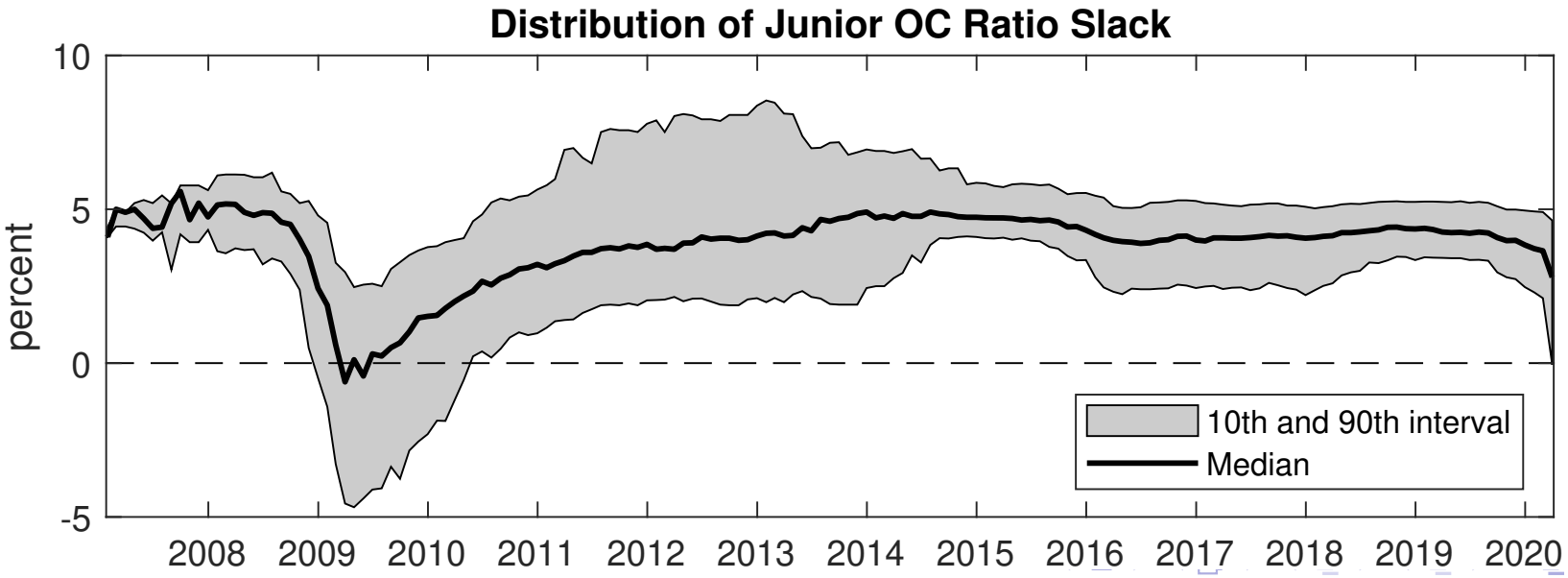
Failing an OC Ratio Test

Failure in an OC ratio test leads to negative consequences on the CLO manager:

- No junior management fee
- Downgrading for CLO senior/junior tranches, lower returns on equity tranches
  $\Rightarrow$ Hurt reputation of the manager, making it more difficult to launch new CLOs in the future.

In practice, failing OC ratio tests has been rare since 2011.

Hypothesis: A CLO manager with a low OC ratio may take pre-emptive actions to prevent the OC ratio from falling.



Stress Test on the Aggregate CLO Market

We consider three stress scenarios on the aggregate CLO market.

1. Top 10 borrowers (defined by the total borrowing from the CLOs as a whole) default
2. The 95% Value-at-Risk
3. The 99% Value-at-Risk

Assumptions:

- LGD=50% (the average recovery for senior secured loan (1st lien) during recessions (1992, 2002, 2008, and 2009) is 56.8%)
- Rise of covenant-lite loans

Additional assumptions for VaR:

- Asset returns for borrower b follows a one-factor model:

$$R_b = \sqrt{\rho} W + \sqrt{1-\rho} Z_b$$

  where W and Z_b are normal random variables, and $\rho = 0.24$.
- Loss for CCC excess loans upon downgrading is 11.25% (the average market price).
- The borrower defaults if $R_b < \underline{R}$, where $\underline{R}$ is backed out from Moody's historical default probability.

Summary Statistics for the Overall CLO Market

Year	N(CLO)	N(B)	Total Holdings ($ bil.)	Avg. N(CLO) per brwrs	Avg. N(CLO) (Top 10)	Avg. N(B) per CLO
2007	19	1,076	6.8	4.2	14.9	237.0
2008	143	2,123	54.6	13.3	106.6	196.8
2009	163	2,193	62.4	13.8	136.6	186.2
2010	219	2,340	84.5	17.1	183.0	182.8
2011	235	2,310	91.1	18.1	196.7	178.3
2012	221	2,222	85.7	16.9	173.0	169.6
2013	244	2,270	91.8	17.3	175.7	161.2
2014	354	2,303	133.1	24.8	228.4	161.2
2015	428	2,273	159.0	32.0	299.7	170.0
2016	421	2,100	154.0	38.4	289.7	191.4
2017	493	2,089	223.4	56.2	380.2	238.0
2018	535	1,695	259.6	83.0	441.4	262.9
2019	607	1,641	262.5	98.8	479.5	267.1

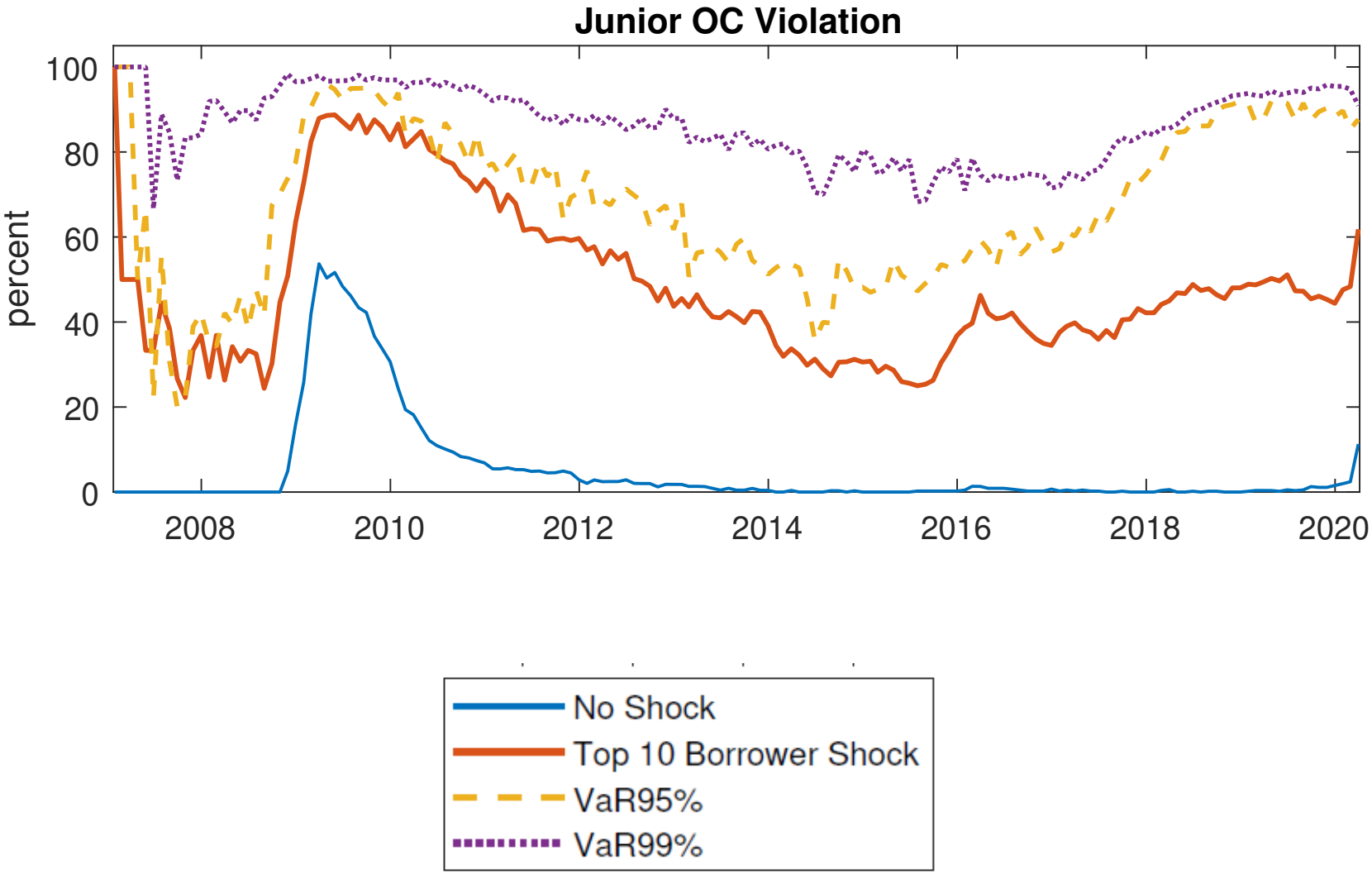
Summary Statistics of CLO Loan Holdings

	Mean	Percentiles				
		5%	25%	50%	75%	95%
Diversification across industry:						
Top 1 industry share (%)	12.9	8.2	10.0	11.8	13.7	22.0
Top 3 industry share (%)	29.8	21.8	25.3	28.9	32.0	43.1
Herfindahl index $\times 100$	6.9	4.4	5.2	5.9	6.7	12.8
Exposure to 10 largest borrowers (%)	8.1	1.2	5.6	8.2	10.6	14.5
Share of loans by credit ratings (%):						
IG	3.7	0.0	0.6	1.7	5.1	12.3
BB	19.0	4.8	14.4	19.1	24.3	31.2
B	64.4	38.7	58.7	67.8	73.3	79.9
CCC	7.3	1.9	4.4	6.2	8.5	16.2
Monthly loan turnover (%)	6.2	0.3	2.2	4.3	7.0	17.9

Results of the Stress Tests

$\Delta Slack/V$	Mean	Percentiles					$\%(<0)$
		5%	25%	50%	75%	95%	
Panel A. Slack without shocks							
$OC(J)$	3.5	0.5	2.5	3.3	4.0	7.7	3.1
$OC(S)$	9.3	4.3	5.9	6.5	9.2	25.5	0.0
Def	21.1	13.6	18.3	20.3	22.0	33.0	0.0
Panel B. Top 10 borrowers default							
$OC(J)$	0.0	-4.2	-1.4	0.0	1.3	4.5	46.0
$OC(S)$	5.7	-0.2	2.3	3.7	5.8	20.6	5.4
Def	17.6	9.4	14.5	16.9	19.0	29.2	0.0
Panel C. VaR95% shock							
$OC(J)$	-3.5	-7.8	-5.2	-3.7	-2.0	1.8	81.2
$OC(S)$	1.8	-4.3	-1.9	-0.2	2.7	16.9	47.0
Def	13.8	6.4	10.9	12.9	15.4	25.1	0.0
Panel D. VaR99% shock							
$OC(J)$	-11.2	-17.1	-14.0	-11.8	-8.7	-3.8	88.7
$OC(S)$	-6.0	-13.8	-10.7	-8.0	-3.7	10.4	77.8
Def	6.0	-2.0	2.3	4.8	8.4	18.7	9.3

Fraction of CLOs (%) That Would Fail the OC Tests Under Stress



Summary of Stress Test Results

Idiosyncratic default of large borrowers can increase the fraction of constrained CLOs from 3.1% to 46.2%.

Diversification requirement on CLOs causes them to choose similar loans to each other.

$$\Rightarrow \textbf{“Too big to diversify”}.$$

The original shocks are not as large as a “tail event” as quantified by VaR.

- Our VaR results depend on normally-distributed shocks, and likely underestimate the true tail risk.
- The magnitude of shocks from top 10 borrower default is even smaller.

Next question: What happen to constrained CLOs?

Part II:

Systemic Risk of the Underlying Leveraged Loan Market

OC Ratio and Sales of Loans

Consider a CLO with $OC^{Pre} = A/D$ sells its loan holdings, and repay senior tranches with the proceeds.

1. The loan is valued at the book value (i.e. loans rated B or above).
2. The loan is marked-to-market (excess CCC loans, defaulted loans).

Case I: The OC ratio after the transaction changes to,

$$OC^{Post} = \frac{A - 100}{D - P}. \tag{1}$$

and the OC ratio improves upon transactions (i.e. $OC^{Post} > OC^{Pre}$) if and only if,

$$OC^{Pre} > \frac{100}{P}. \tag{2}$$

Case II: The OC ratio changes to,

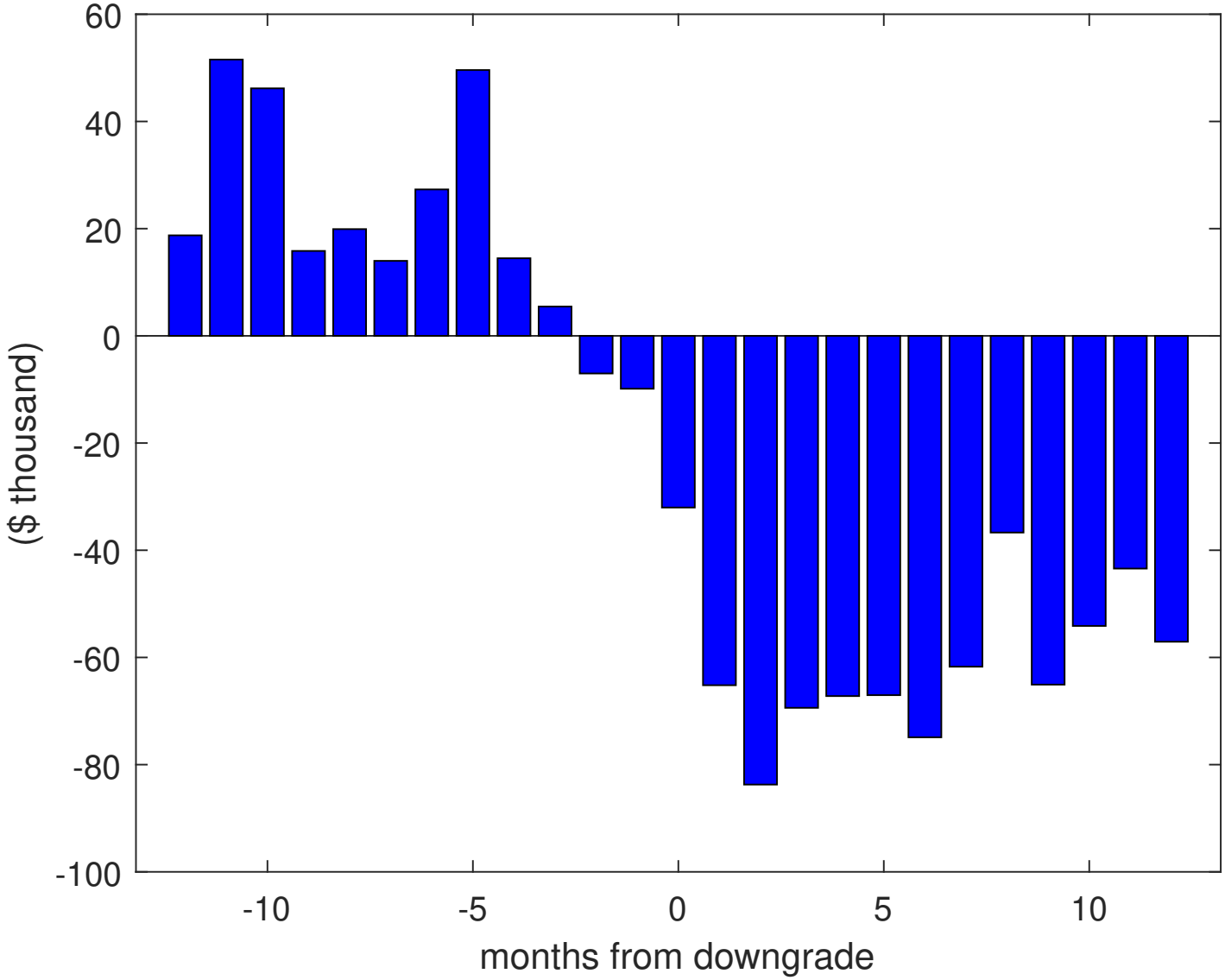
$$OC^{Post} = \frac{A - P}{D - P}. \tag{3}$$

and the OC ratio improves upon sale if and only if,

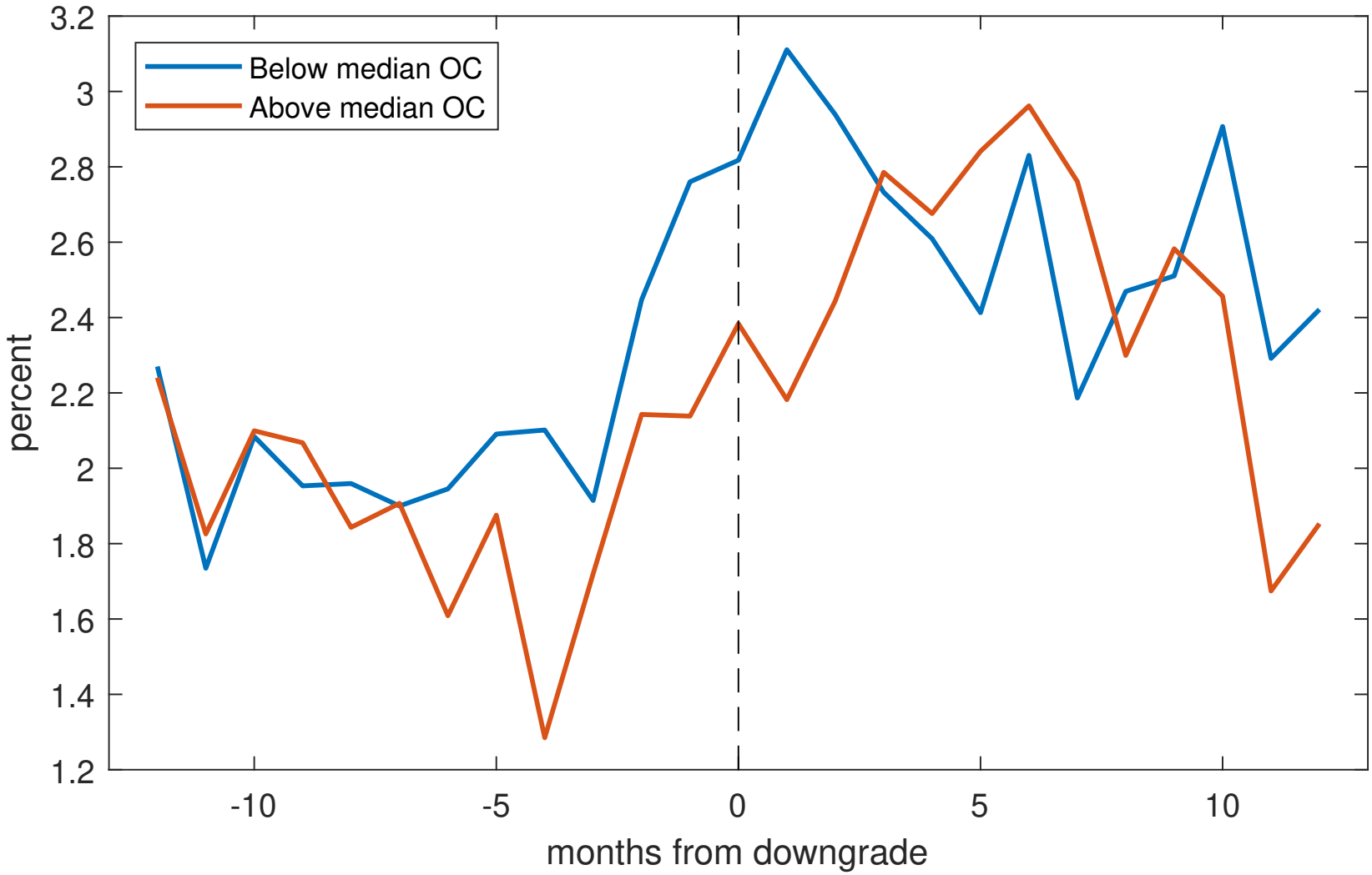
$$OC^{Pre} > 1. \tag{4}$$

Net Purchases of Loans Downgraded to CCC or Below by CLOs

CCC-Rated loans above threshold level are marked to market.



Average Probability of Selling Downgraded Loans Around Downgrading Months



Logit Regression of Loan Sales on OC Ratio Slack

Do constrained CLOs sell downgraded loans more than unconstrained CLOs do, after controlling for loan/CLO characteristics?

Use a dummy variable for CLO i's sale for loan j between months m_0 and m_1.

$$D^{SELL}_{i,j,m_0 \to m_1} = f\left(b \frac{Slack(J)_{i,m_0-1}}{A_{i,m_0-1}} + \gamma_0 X_{j,m_0-1} + \gamma_1 Y_{i,m_0-1} + \gamma_2 FE_{q_1} + \varepsilon_{i,j,m_0 \to m_1} \right).$$

- X_{j,m_0-1}: Rating before downgrade, loan time to maturity.
- Y_{i,m_0-1}: CLO time to reinvestment date, log CLO size, CLO manager's age, log CLO manager's size, CCC loan ratio.

Determinants of Sales of Downgraded Loans

	Months -1 to 1		Months -3 to -2		Months 2 to 3	
	b	$m(b)$	b	$m(b)$	b	$m(b)$
$Slack(J)/A$	-5.72	-0.41	-6.71	-0.27	-3.24	-0.18
	(-3.25)	(-3.26)	(-2.58)	(-2.59)	(-1.54)	(-1.54)
Rtg	3.09	0.22	4.16	0.17	-7.10	-0.38
	(2.03)	(2.03)	(2.01)	(2.01)	(-3.66)	(-3.68)
$LoanMat$	4.27	0.31	-8.85	-0.35	4.34	0.23
	(0.94)	(0.94)	(-1.93)	(-1.94)	(0.90)	(0.90)
$CLOMat$	1.12	0.08	3.08	0.12	-1.43	-0.08
	(0.71)	(0.71)	(1.46)	(1.46)	(-0.75)	(-0.75)
log $CLOSize$	17.55	1.26	7.26	0.29	-9.63	-0.52
	(1.95)	(1.95)	(0.60)	(0.60)	(-0.90)	(-0.90)
$MgrAge$	-4.55	-0.33	-3.92	-0.16	-8.74	-0.47
	(-5.63)	(-5.66)	(-3.82)	(-3.84)	(-8.09)	(-8.28)
log $MgrSize$	16.84	1.21	18.41	0.74	45.66	2.47
	(4.26)	(4.29)	(3.61)	(3.64)	(9.02)	(9.40)
$CCCRatio$	0.29	0.02	0.35	0.01	0.48	0.03
	(0.48)	(0.48)	(0.43)	(0.43)	(0.71)	(0.71)
Time FE	Yes		Yes		Yes	
$\bar{R}^2$	2.86		3.61		3.75	
N	25,225		21,494		19,769	

Cumulative Abnormal Returns Upon Downgrade

Sale of a downgraded loan by an individual CLO may not affect the loan price.

However, collective action of many constrained CLOs may matter.

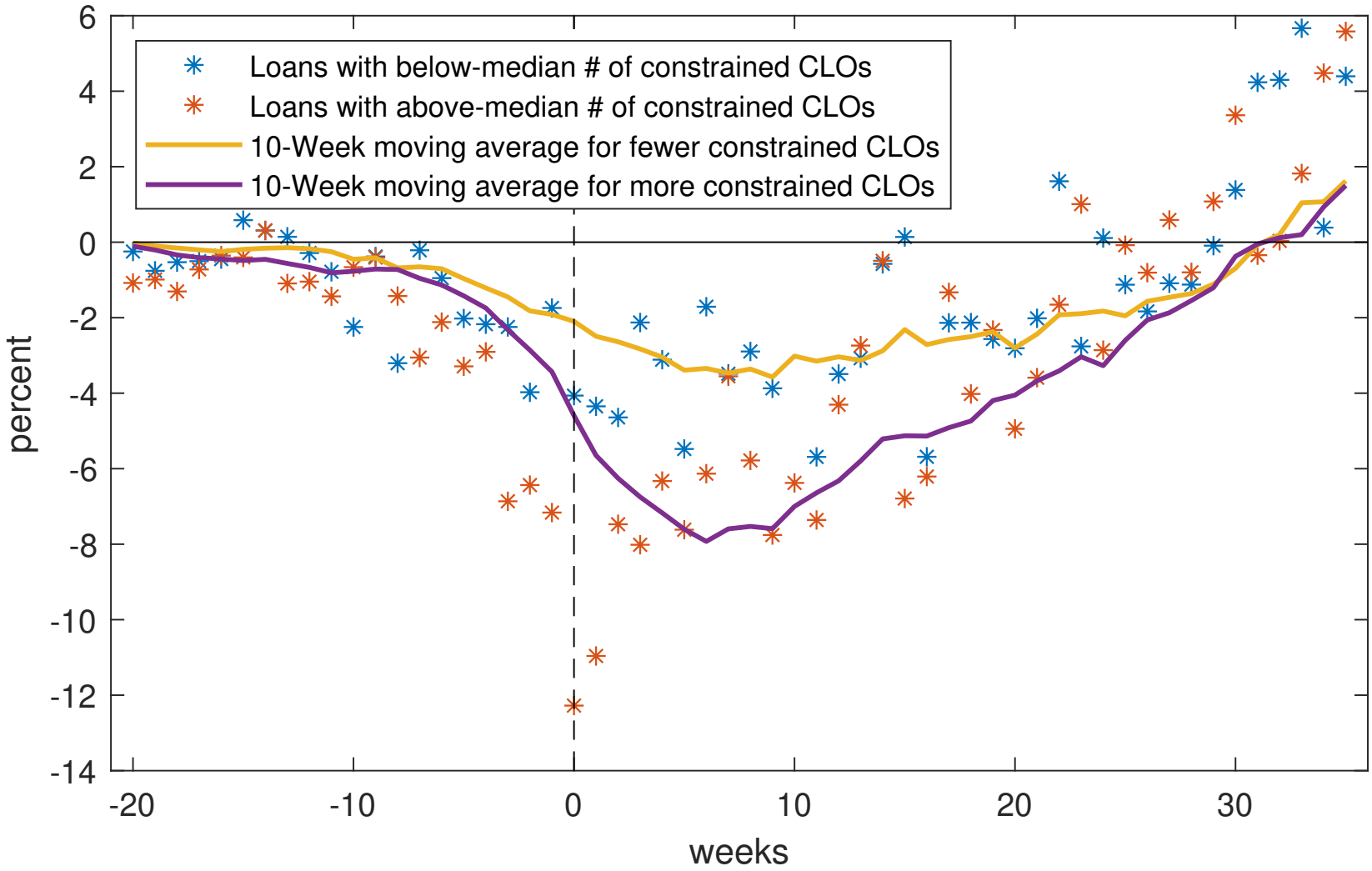
Abnormal returns on downgraded loan:
We run regressions of weekly returns on loan i:

$$\Delta \log P_{i,w+1} = \alpha + \beta IDX_{w+1} + \gamma_1 (S_{i,w+1} - S_{i,w}) + \gamma_2 (S_{i,w+1} \log Q_{i,w+1} - S_{i,w} \log Q_{i,w}) + \varepsilon_{i,w+1}.$$

- IDX_{w+1} is a vector of benchmark returns (S&P LSTA Leveraged Loan Index, SPX, T-bill).
- $S_{i,w}$ is an indicator variable which is 1 (-1) when a CLO buys (sells) loan i.
- $Q_{i,w}$ is dollar volume of the transaction.
- Run separately for 4 groups based on i) rating before downgrade / ii) maturity.

Cumulate ε from 20 weeks before the downgrade week.

Moving-Average of Mean Cumulative Abnormal Returns Around the Downgrade Event



Placebo Tests: Number of Unconstrained CLOs

$$CAR_{i\tau} = b_0 + b_1 N(CLO_{LowOC})_i + b_2 N(CLO_{HighOC})_i + \gamma Ctrl_i + u_i.$$

τ	$N(CLO_{LowOC})$	$N(CLO_{HighOC})$	Maturity	Rating before downgrade	Year FE	$\bar{R}^2$
-16	-0.01	0.01	-0.23	-0.15	YES	0.02
	(-0.15)	(0.46)	(-2.99)	(-0.75)		
-1	-0.25	0.05	-0.70	-0.52	YES	0.07
	(-2.44)	(0.54)	(-3.02)	(-0.83)		
0	-0.26	0.05	-0.83	-0.36	YES	0.11
	(-2.26)	(0.53)	(-3.31)	(-0.55)		
5	-0.21	0.07	-0.52	-0.89	YES	0.13
	(-1.85)	(0.67)	(-1.67)	(-1.17)		
35	-0.21	0.17	-0.10	-0.57	YES	0.14
	(-1.19)	(1.10)	(-0.19)	(-0.53)		

Conclusion: Increased Risk Amid the Pandemic

The impact of fire sale could be larger during the COVID-19 pandemic.

- Borrowers have difficulty refinancing.
- Banks are major investors in CLO senior tranches.
- Risk of downgrades and lower market prices.