



Short-Circuiting Short-Term Funding

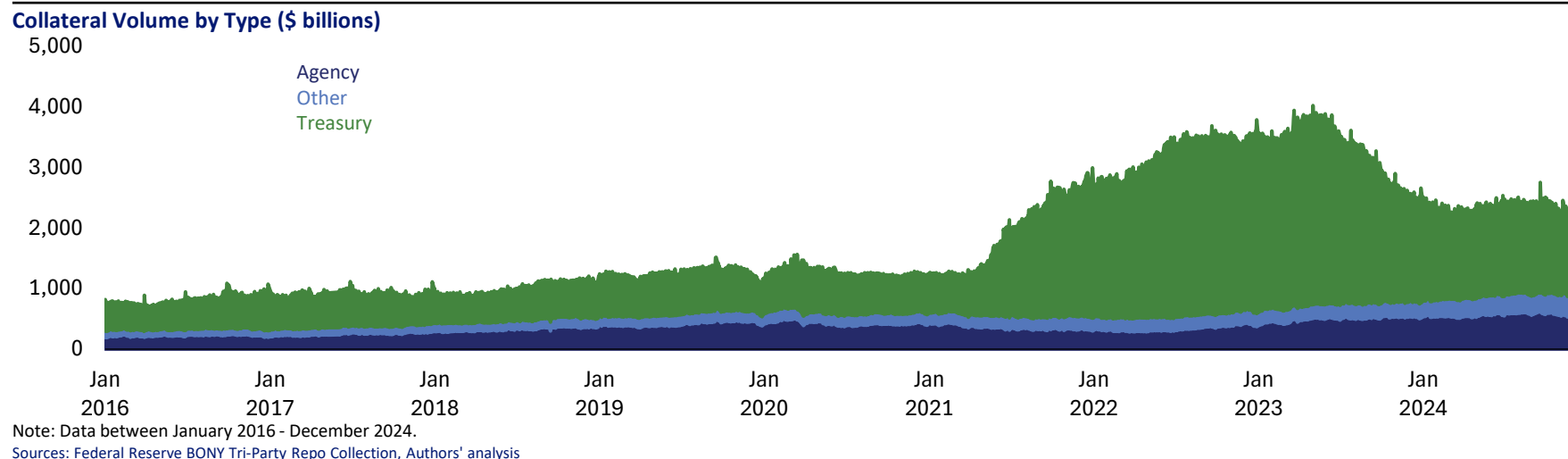
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EBA Workshop 2025

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Views and opinions expressed are those of the authors and do not necessarily represent official positions or policy of the Office of Financial Research, the U.S. Department of the Treasury, or the Board of Governors of the Federal Reserve System.

Motivation



- **The repo market provides trillions of dollars of funding every day to facilitate trading in Treasury and fixed-income markets**
 - **The market has many frictions:**
 - Most of the trading is done bilaterally through long-standing relationships.
 - Often conducted over the phone, concentrated in a small window of time.
 - **Operational outages in repo could be meaningful:**
 - Industrial and Commercial Bank of China ransomware attack in 2023 disrupted trades in the Treasury market.
 - September 2019 saw major spike in repo rates due to concern that the demand for funding would outweigh supply.

How resilient is the repo market to an operational outage?

- Combine transaction-level data for Tri-Party repo and firm-level cybersecurity rating.
- How would security risks, if realized, impact the demand for borrowing and lending?
 - We find the consequences of disruption are dominated by a few lenders with substantive volumes.
 - At the extreme high end, disruptions can reach \$200 billion.
 - On average, **5 borrowers** are impacted by the average lender's absence.
 - At the extreme more than **20 borrowers** can be impacted.
 - We estimate a larger lender's disruption could cause the repo rates to increase by roughly **20 basis points**.
 - In simulations that include the security scores of participants, the expected daily disruption due to attack on a lender is between \$2-4 billion in volume.
- Risks vary by counterparty type, time of day, and recovery speed:
 - Among the worst performing institutions are **Municipality lenders** and **Bank borrowers**.
 - However, improving scores for **Asset Managers** (mostly Money Market Funds), may be a priority.
 - 9 AM and 2 PM are the most disruptive hours by volume for an outage, though lower resiliency/longer recovery times can make attacks that start at 7 AM-8 AM more disruptive.

Literature Review

- **Tri-Party Repo Market**

- Copeland, A., Duffie, D., Martin, A., & McLaughlin, S. (2012). Key Mechanics of the US Tri-Party Repo Market. *Economic Policy Review* (19320426), 18(3).
- Gorton, G. & Metrick, A. (2012) Securitized Banking and the Run on Repo. *Journal of Financial Economics*, 104(3), 425-451.
- Hu, G. X., Pan, J., & Wang, J. (2021). Tri-party repo pricing. *Journal of Financial and Quantitative Analysis*, 56(1), 337-371.
- Paddrik, M. E., Ramírez, C. A., & McCormick, M. J. (2021). The dynamics of the US Overnight Triparty Repo Market. OFR Brief 21-3.

- **Short-Term Funding Market Disruptions**

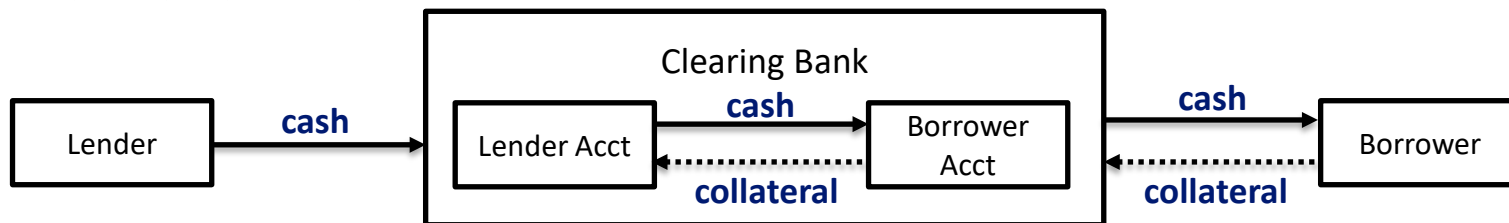
- López-Espinosa, G., Moreno, A., Rubia, A., & Valderrama, L. (2012). Short-term wholesale funding and systemic risk: A global CoVaR approach. *Journal of Banking & Finance*, 36(12), 3150-3162.
- Copeland, A., Martin, A. & Walker, M. (2014) Repo Runs: Evidence from the Tri-party Repo Market. *The Journal of Finance* 69(6) 2343-2380.
- Gorton, G. B., Metrick, A., & Ross, C. P. (2020). Who Ran on Repo?. In *AEA Papers and Proceedings* 110, 487-492.
- Paddrik, M. E., Young, H. P., Kahn, R. J., McCormick, M., & Nguyen, V. (2023). Anatomy of the Repo Rate Spikes in September 2019. *Journal of Financial Crises*, 5(4).

- **Operational Risks and Cybersecurity**

- Eisenbach, T. M., Kovner, A., & Lee, M. J. (2022). Cyber risk and the US financial system: A pre-mortem analysis. *Journal of Financial Economics*, 145(3), 802-826.
- Aldasoro, I., Gambacorta, L., Giudici, P., & Leach, T. (2022). The drivers of cyber risk. *Journal of Financial Stability*, 60, 100989.
- Kotidis, A., & Schreft, S. (2022). Cyberattacks and financial stability: Evidence from a natural experiment. Federal Reserve Board of Governors 2022-025.
- Eisenbach, T. M., Kovner, A., & Lee, M. J. (2023). When It Rains, It Pours: Cyber Vulnerability and Financial Conditions. *Federal Reserve Bank of New York Staff Reports*, 1022.

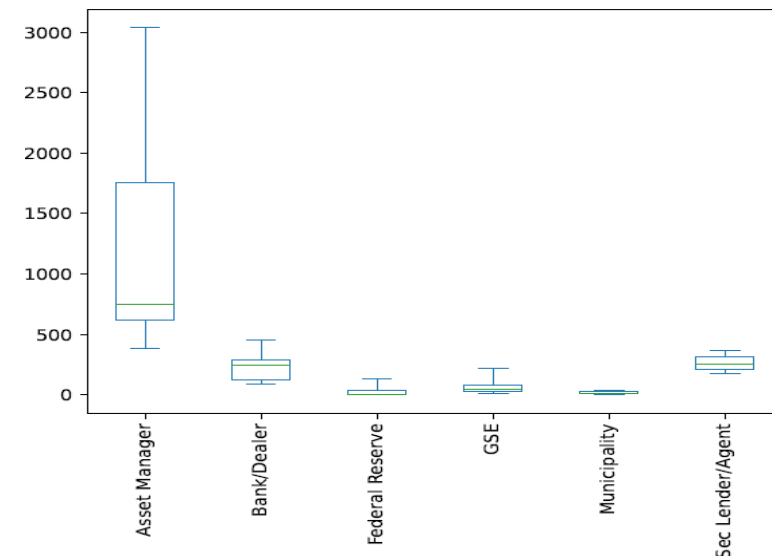
We focus on the tri-party repo market:

Opening Repo Example



- **Tri-party: general collateral funding market where collateral is matched through BNYM.**
 - Mostly cash-rich MMFs and banks lending to dealers and Federal Reserve.
 - Over \$2T (including the Federal Reserve) in daily funding, \$1.6T is overnight.
- **Tri-party transaction and settlement data from New York Fed and BNY Mellon**
 - Date, counterparties, rates, maturity, haircut, collateral for each transaction.
- **Over 8 million transactions between 8,512 cash lender and 192 cash borrowers from 2016-2024.**

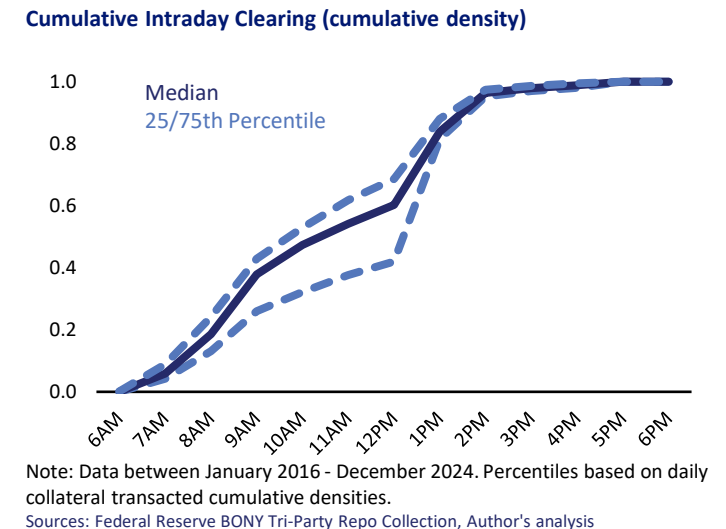
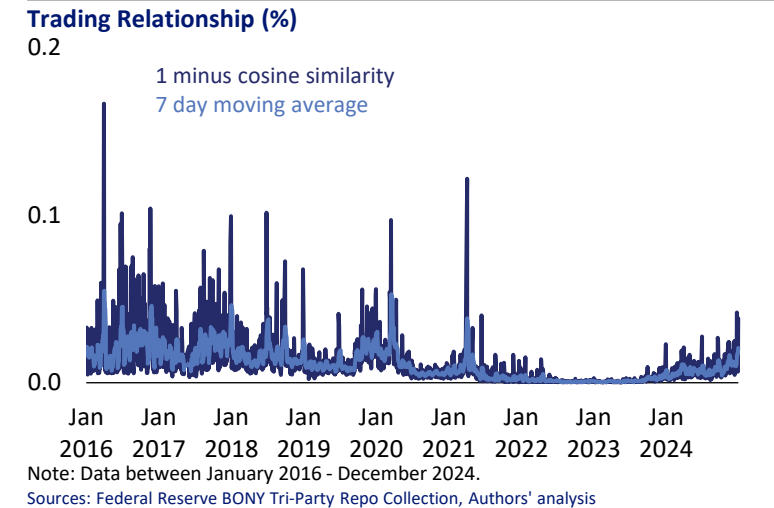
Daily Collateral Volume Transacted by Lender Type (\$ billions)



Note: Data between January 2016 - December 2024.
Sources: Federal Reserve BONY Tri-Party Repo Collection, Authors' analysis

Transactions in tri-party face substantial frictions

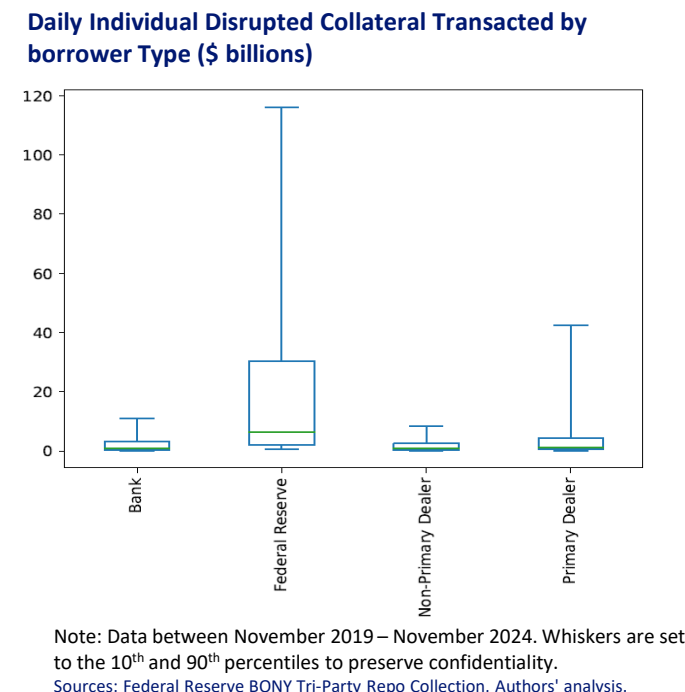
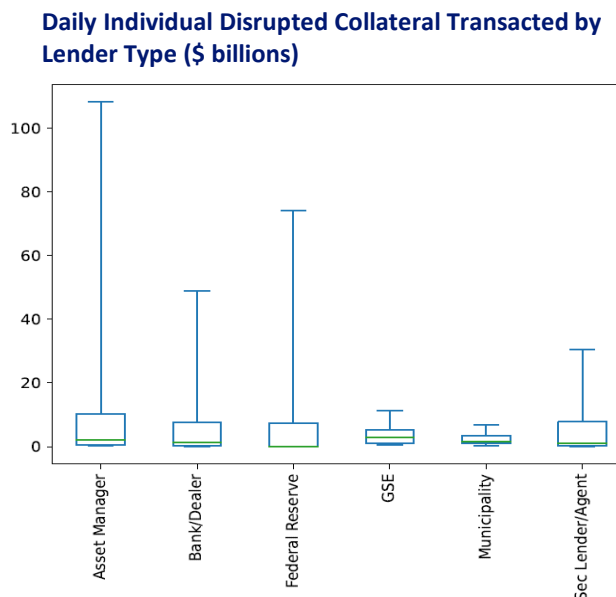
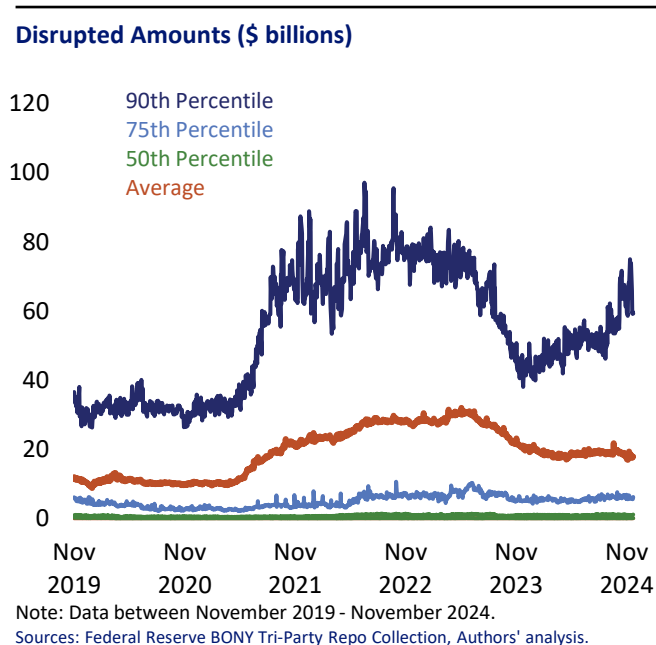
- **Relationships are important to how daily funding is distributed.**
 - Cosine similarity shows same counterparties transact with nearly the same volume day over day.
 - *Consistent with Han et al. (2022), Huber (2023), Paddrik et al. (2021).*
- **Majority of repo is agreed to bilaterally in the morning, though a substantial portion is not settled at BONY until later in the day.**
 - Closing occurs at 3:30 PM. Firms relying on roll over funding subsequently need to find a new repo to pair against.



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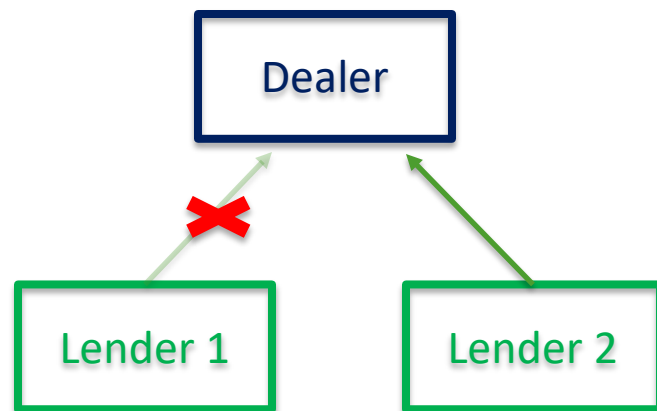
First, we examine the impact of an isolated outage

- Assume *one* institution is unable to transact for a day. What volume is impacted?



- Most of the disruption is concentrated among a few large volume lenders.
- On average, 7 borrowers are disrupted by a lender outage, although >20 can be disrupted by a single lender's outage.
 - Asset Managers have most disrupted volume of lenders, primary dealers most disrupted of (private) borrowers.

What is the economic impact of an outage?

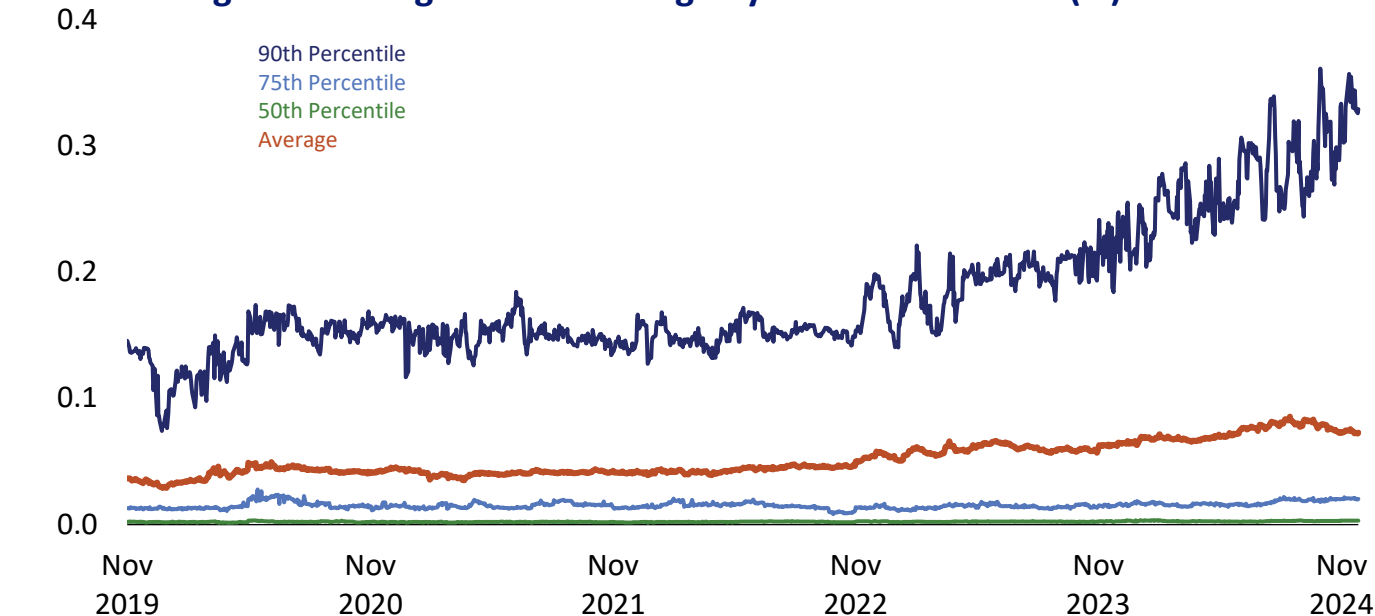


	Weighted average rate (BPs)			
	OLS		2SLS	
Chg. In Principal (\$B) x ON RRP Volume	0.668**	-6.109***	-6.706***	-2.692*
			2.421*	
x High repo spread day				-10.013***
First stage				
Bartik instrument		0.761**	0.585**	1.031**

- **Persistent relationships create a rigidity to the search for liquidity, but how much of an economic impact does an outage have?**
 - Need to estimate the extent to which lenders can substitute away and ultimate impact on rates.
- **Use Bartik-style instrument to look at what happens to dealers who usually borrow from MMFs that face redemptions (Crane data).**
 - First stage tells us how much dealers are able to substitute away (only about 24 cents on the dollar on average).
 - Second stage tells us about how the withdrawal of funds effects willingness to pay.
 - Use this second-stage estimate for the effect of an outage on rates.

What is the economic impact of an outage?

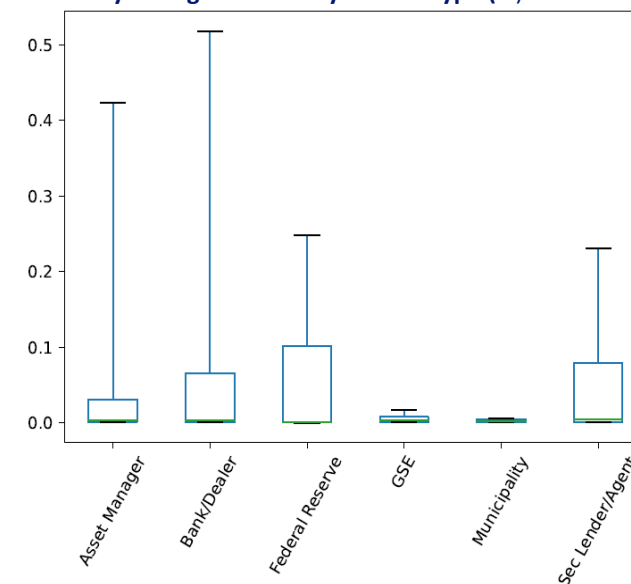
Market Weighted Average Rate of Change by Individual Lender (%)



Note: Data between November 2019 - November 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Authors' analysis.

Daily Change in Rates by Lender Type (%)



Note: Data between November 2019 – November 2024. Whiskers are set to the 5th and 95th percentiles to preserve confidentiality.

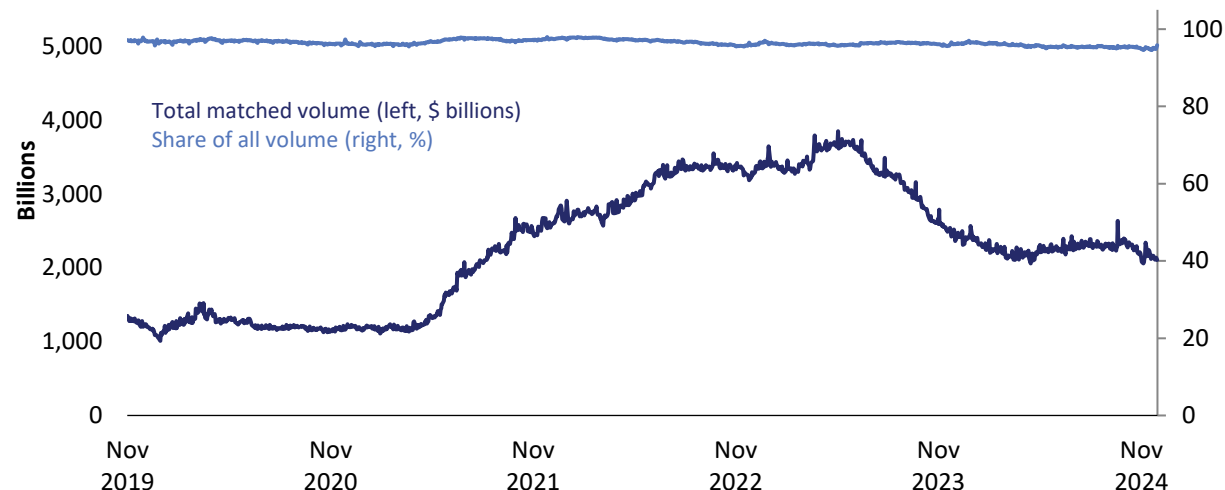
Sources: Federal Reserve BONY Tri-Party Repo Collection, Authors' analysis.

- **<20 BP on the high end from 2019-2022, but increasingly costly as private repo has expanded.**
- **Average consequences are highest for asset managers, but consequences can be higher for lending from banks and dealers.**
 - Reflects large inter-affiliate transactions through tri-party (Hempel et al, 2023; Bai et al, 2025).

We now step from general outages to the impact of cyber attacks

- **Bitsight Security Ratings:** include publicly observable data on security configurations and events.
 - Ratings range from 250-900, but effective range in practice is 300-820. Average rating is 720.
 - Ratings are updated daily, and new findings can be incorporated within 48 hours.
 - Used for e.g. underwriting cyber insurance policies (totals more than \$5 billion in premiums).
- **Match to tri-party institutions**
 - Among market participants there is wide variation in security ratings.

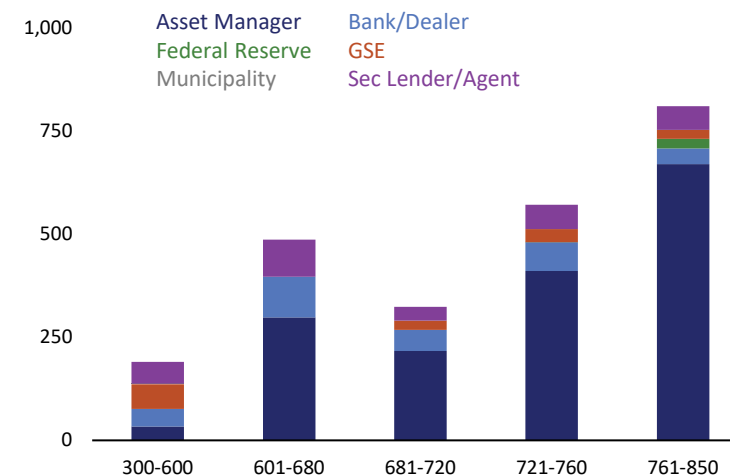
Bitsight Coverage of Tri-Party Institutions



Note: Data between November 2019 - November 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Authors' analysis.

Average Daily Collateral Volume by Lender Risk Type (\$ billions)



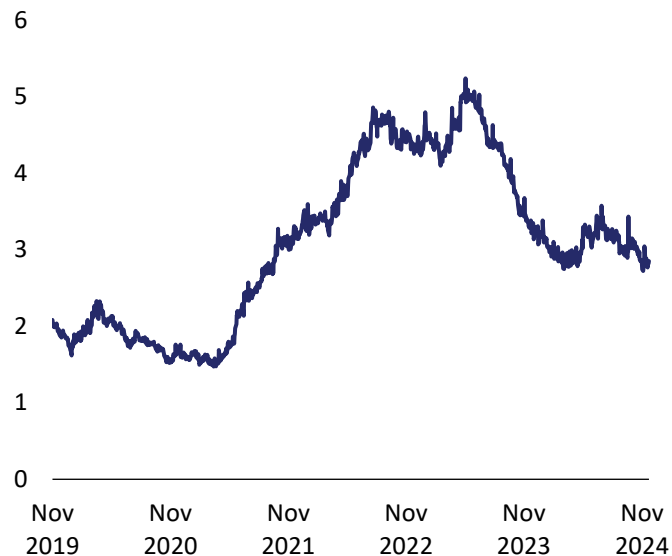
Note: Data between November 2019-November 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Author's analysis

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Use ratings to form a distribution over outages from cyberattacks

Expected Value for Total Collateral Disrupted (\$ billions)



Note: Data between November 2019 - November 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Authors' analysis.

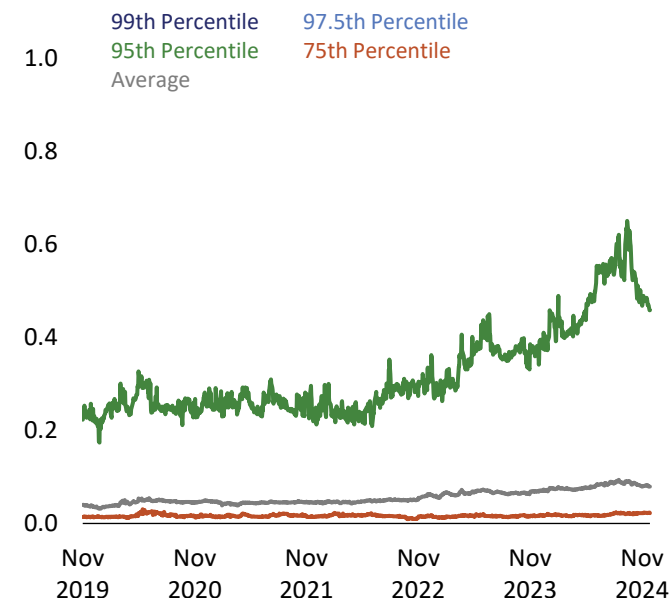
Expected Impact on Rate Increase (%)



Note: Data between November 2019 - November 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Authors' analysis.

Percentiles for Rate Impact (%)



Note: Data between November 2019 - November 2024.

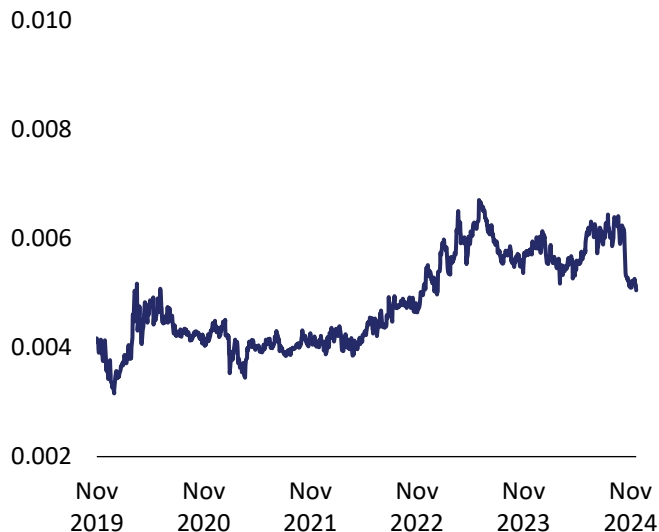
Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Authors' analysis.

- Use an arbitrary baseline probability of attack of 1/1000 (*results scale linearly*).
- Produce Monte Carlo estimates assuming attacks are independent and consequences last the entire day.
- Examine means and distribution of impact.

Impact can vary by type of attack

Patching Cadence

Expected Impact on Rate Increase (%)

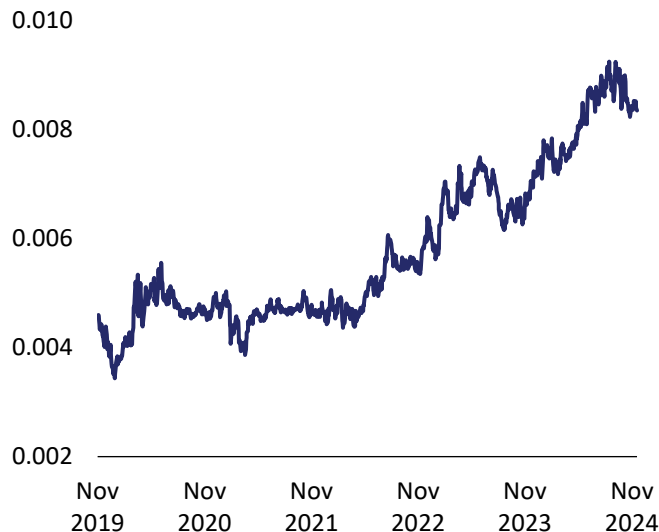


Note: Data between November 2019 - November 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Authors' analysis.

Desktop Software

Expected Impact on Rate Increase (%)

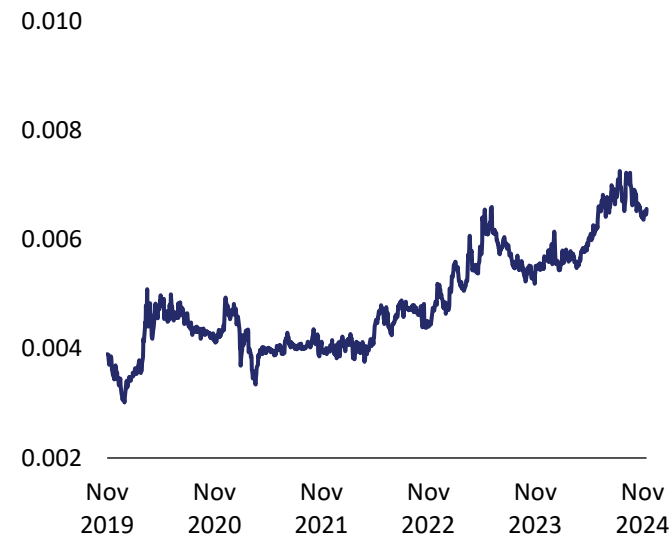


Note: Data between November 2019 - November 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Authors' analysis.

Open Ports

Expected Impact on Rate Increase (%)



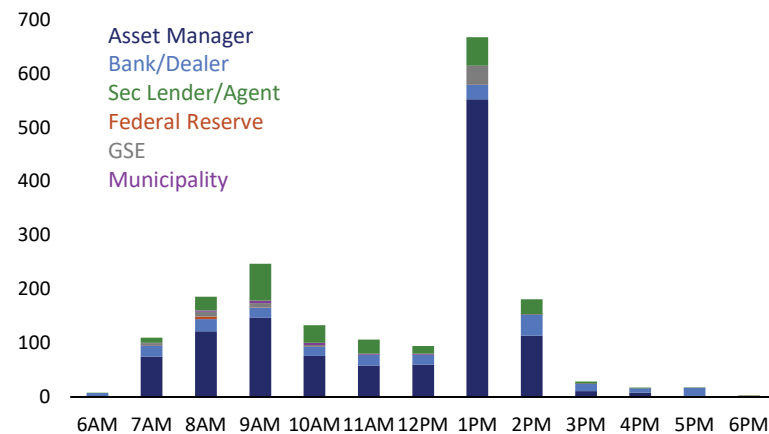
Note: Data between November 2019 - November 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Bitsight, Authors' analysis.

- **Desktop Software** risk vector has higher expected impact than the other two types of attacks.
- Expected impact of **Desktop Software** attack rose over the sample period, in contrast to the other two risk vectors.

What if attacks do not last the entire day?

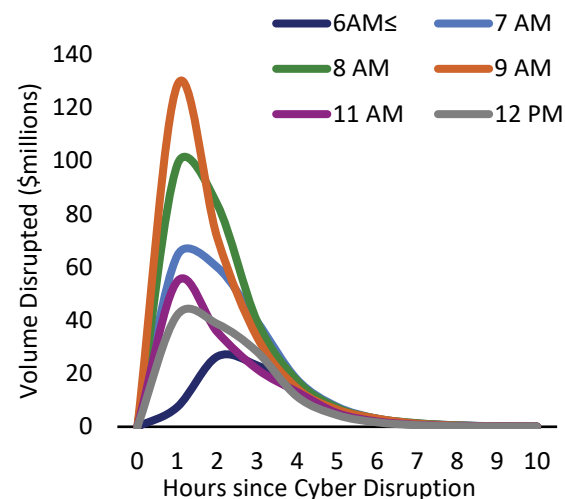
Average Daily Collateral Volume by Lender Type (\$ billions)



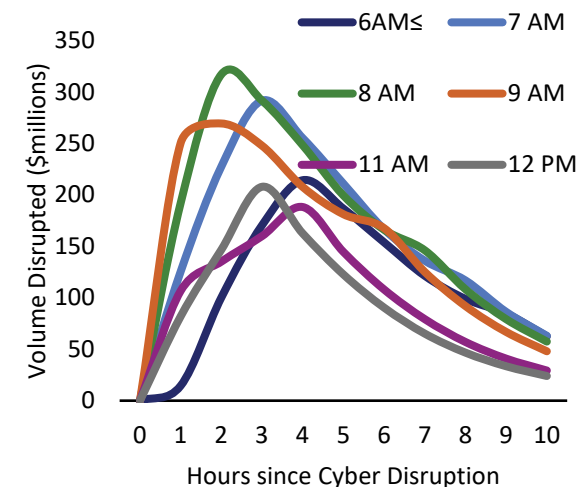
Note: Data between January 2016 - December 2024.

Sources: Federal Reserve BONY Tri-Party Repo Collection, Author's analysis

1 Hour Expected Recovery



3 Hours Expected Recovery



- **Since timing is so important to the repo market, it matters when an attack hits and how long it lasts.**
 - The number of lenders offering funding early in the morning and the end of the day is also concentrated.
- **Run Monte Carlo focused on resiliency, assuming recovery time follows a Poisson distribution.**
 - Peak vulnerability depends on recovery time.
 - If lenders recover quickly, 9 AM or 2 PM is the most vulnerable since this is when the volume is highest.
 - Longer recovery times mean that greater vulnerability occurs earlier in the day.
 - Emphasizes the role of **resiliency** in limiting the impact of attacks.

Conclusion

- **We performed several different types of tests to assess the relationship between cybersecurity and Tri-Party repo transactions.**
 - Using Bitsight cybersecurity ratings to estimate probability of attack, we find expected daily disruptions are around \$2-4 billion and expected rate impact is 0.1 basis points.
 - Improving the cyber ratings of asset managers can have big positive impact on the market.
 - In our analysis of market resilience, we find that 9AM and 2PM are the most disruptive at lower resiliency levels.