Scarcity channel of Quantitative Easing : Examining the Overnight Treasury Repo Market in the US

Master's Thesis

Submitted in partial fulfillment of the requirements for the degree of Master of Arts in Economics and Business Administration

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Zurich, 1 February 2022

Project Definition for the Master Thesis in
Banking and Finance

Subject:
Scarcity channel of Quantitative Easing:
Examining the Overnight Treasury Repo Market in the US

It is plausible that quantitative easing (QE) programs, by decreasing the supply of Treasuries, increase the scarcity of these securities in financial markets, especially in the repo market. This effect is labelled as the scarcity effect of QE. Repo markets are a key component of the financial system and they rates have been focus of research (see e.g. Duffie, 1996, and Nyborg, 2019). Some research has found evidence of the scarcity effect of QE by studying the relationship between central bank asset purchases a special repo rates in the U.S. (D'Amico et al., 2014) and the EU (Arrata et al., 2020). Over the past years the FED has significantly increased their holdings of US Treasuries, especially in response to Covid-19.

The objective of this Thesis is to investigate the scarcity effect of QE on US Treasuries using new data from Treasury repo markets. As a result, your Thesis should be able to answer the following questions: (1) What are drivers of the supply and demand of US Treasuries (see e.g. Krishnamurthy et al., 2012)? (2) Do you find evidence for a scarcity effect of QE on US Treasury repo rates, and thereby can you confirm findings of the existing literature? (2) How did the FED's response to Covid-19 impact Treasury repo markets?

The first part of the Thesis should consist of a literature review. The second part would be dedicated to the data presentation. The third part consists of the empirical analysis. As a last part you should include a detailed discussion of results and a general assessment.

Preferably the analysis is implemented using STATA, MATLAB, R or a comparable software upon discussion with the supervisor.

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Since this Thesis relies on careful data collection and empirical analysis, included tables should be very thoroughly designed and clearly captioned.

As data source we recommend using Refinitiv Eikon, Datastream or Bloomberg. Bloomberg has limits on the amounts of data that can be downloaded in a given month while Eikon and Datastream do not have such limits. Further helpful data sources for your thesis are the websites of the Depository Trust & Clearing Corporation (DTCC) and the Federal Reserve Economic Data (FRED).

Sincerely,

University of Zurich
Department of Banking and Finance

Prof. Dr. Kjell G. Nyborg
Chair Corporate Finance

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Course of your thesis:

If you have questions you can ask your supervisor for an appointment. However, the goal is to acquire the knowledge on your own and to try to solve problems on your own, but to discuss your own solution to a problem with your supervisor.

Formal criteria and submission:

- You compose the thesis in English (students may write in German. However, we strongly recommend writing in English since this is a good first exercise to learn it).
- The structure of the thesis might roughly be the following one:
  1. Front page
  2. This Project Definition
  3. Executive Summary
  4. Introduction, where you
     a. say what your topic is about and why it is important,
     b. present your main findings,
     c. give an overview to related literature and in which sense your topic is related to this literature,
     d. show how you proceed throughout the thesis.
  5. Main part
  6. Conclusion, where you
     a. summarize and present your findings,
     b. evaluate the results in order to provide an answer to the research question
     c. give a perspective on possible extensions and open questions.
- Quality comes before quantity. Be brief and compact in writing. Your thesis should not be longer than 40 pages, counting from the introduction to the conclusion and including the graphs and tables referred to in the thesis but excluding the list of references and any appendix.
- Pay attention on writing correctly and watch out for a scientifically, concise, but a fluent writing style. Do also pay attention on a correct use of citation (in the text not full information, only author and year), like commonly used in Journal of Finance or Journal of Financial Economics. Also in other formal aspects use the layout of these two Journals. Only use sufficiently described black-white graphs. Graphs and tables should be self-explanatory and understandable also without reading the whole thesis.
- At the beginning of the thesis you write a short abstract (question, results) like in JFE or JF. This abstract is short and even more concise than an Executive Summary and comprises not more than 100 words.
- Create a maximally four-sided Executive Summary (question, procedure, results and general evaluation), which typically is similar to the introduction of the thesis.

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- Please upload your thesis to OLAT before the deadline has passed. Upload a zip file to OLAT containing following files:
  - Cover page of your thesis (PDF-document)
  - Executive summary (PDF-document)
  - Whole thesis (LaTex- or Word-file as well as PDF-document)
  - Full data material which has been used for the paper
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Executive Summary

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Scarcity channel of Quantitative Easing: Examining the Overnight Treasury Repo Market in the US

Hubert Mrugala

Abstract

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JEL classification: E4, E5

Keyword: Collateral, Scarcity, Treasury, Monetary Policy, Repo Market

1 Introduction

The COVID-19 pandemic has caused the deepest US recession since the Great Depression and induced the biggest monetary stimulus since the Global Financial Crisis. One of the monetary policy tools that was activated during the pandemic was an additional round of quantitative easing.[1] In the time of 4 months, the Fed's balance sheet exploded from \$4.2 to \$7.1 trillion, and then kept growing. As of April 2022, total assets of the Fed reached almost \$9 trillion. Central bank asset purchases are used in normal times as a unconventional policy that helps achieving ultimate goals of the Fed, which are maximum employment and inflation level at 2% over the longer run.

There are many theoretical transmission channels of quantitative easing, however almost all of those channels focus on positive effects of asset purchases. Negatives are very rarely analysed. Nyborg (2015) showed that collateral frameworks of ECB distort financial markets' efficiency by

[1] It was actually an acceleration of already present QE that was sparked by 2019 repo rumble.

making bad collateral look better then it really is. What about a high-quality collateral? Can draining fist-class collateral out of the markets have an adverse impact on the economy?

There is one channel of quantitative easing that is rarely mentioned and insuffitiently studied.[2]. It is the scarcity channel (or scarcity effects). While most channels on QE focus on abundance of reserves, central bank liquidity, the scarcity effect, puts emphasis on the collateral-side of the swap, which is the public sector liquidity. There are only two academic papers that study the scarcity channel of asset purchases programmes. D'Amico et al. (2014) find that there was a scarcity premium of US Treasury securities traded in the repo market during the time of LSAP programs. Likewise, Arrata et al. (2018) determine a similar relationship in the **Euro zone market for repo contracts**. Both papers prove the existence of the scarcity effects in the US and EU markets, however, those investigations look only at specific special repo markets and don't take into account the mechanics of the collateral intermediation complex. Furthermore, there hasn't been any research done about the scarcity premium of US Treasuries in over eight years, despite an almost constant QE during that period.

This research fills the subject gap, the time gap, and the context gap in the narrow literature on scarcity effects. I use a General Collateral Financing Treasury Repo rate weighted index in a timespan of the last 15 years to test a connection between the level of US Treasury securities on the Fed's balance sheet and the index. Additionally, to focus completely on the collateral-side of a repo transaction, I use a collateral spread as the dependent variable. Nyborg and Rösler (2019) **find ...**

[**Findings**]

I control for [**...**] and emphasize the importance of high-quality collateral by describing its dynamics and economic function. Moreover, I add an innovative proxy for the re-use rate of collateral in the banking system as an extension of the base model.

The research connects three different strains of literature, which are research on collateral scarcity, US Treasury markets and collateral intermediation.

Apart from already mentioned academic papers on scarcity effects, there is also one investigation of the Japanse JGB market that contributes to the literature on collateral scarcity. Han and Seneviratne (2018) have documented that BoJ purchases of Japanese Government Bonds in QE and then QQE programs have negative impact on market liquidity, which suggest scarcity effects.

The second stain is the literature on repo market rates and cash market rates of US Treasuries. The work of Duffie (1996) introduced a model that shows how short-selling Treasuries obtained

[2] In financial media, only Izabella Kaminska of FT Alphaville sometimes covered collateral scarcity.

by reverse-repo transactions can create squeezes at delivery dates and so, cause some repos to trade on special. Special repo rates are not studied in this research, however, mechanics of special repos are important because US Treasuries, as a whole asset group, are special on their own. Krishnamurthy and Vissing-Jorgensen (2012) show that yields of US Treasury securities have a non-default component that makes them trade at a significant premiu.

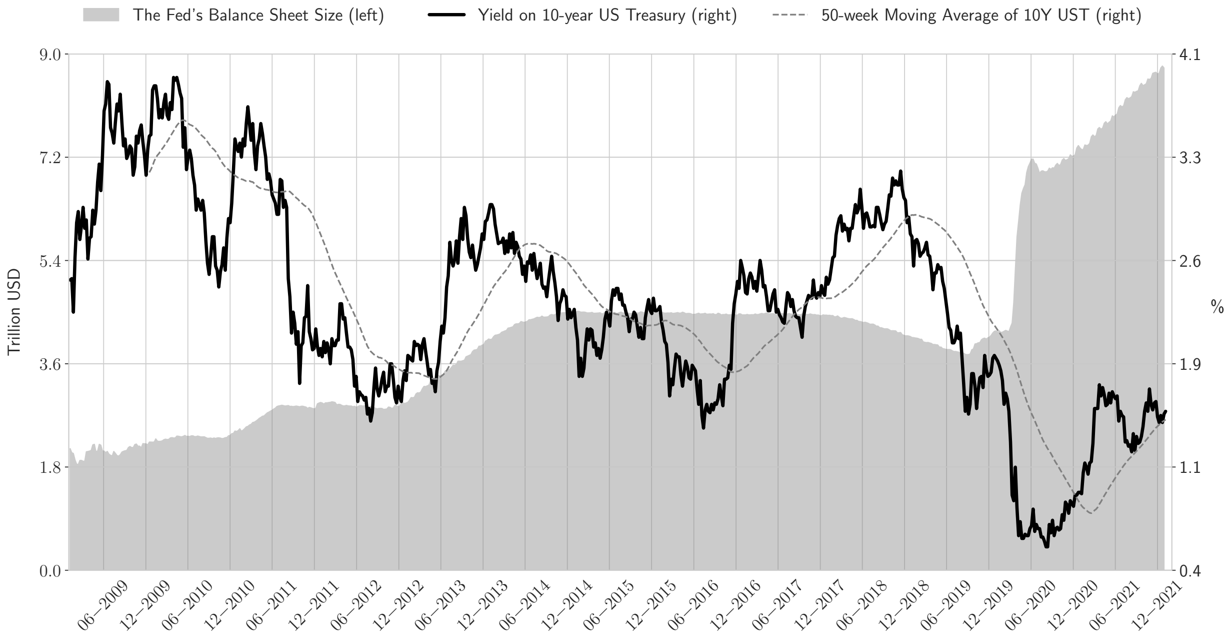
The last branch of literature is concerned with the collateral supply and its intermediation. Singh and Pozsar (2012) shows how collateral agency is embedded into the shadow banking system. Sissoko (2020) show how sufficient collateral supply is crucial to properly functioning money markets and effective monetary policy. Singh and Stella (2012) introduce and explain a phenomenon of "collateral-chains". Singh (2017) calculates the collateral re-use rate that represents endogenous shadow creation of collateral. Jank et al. (2021) finds a positive relationship between ECB bond purchases (PSPP) and the re-use rate of collateral suggesting that the market participants adjust to shocks in collateral scarcity by utilizing more source collateral.

Investigating scarcity effects of unconventional monetary policy is important because it is not certain that government bond purchasing programs of central banks have a net positive effect on the real economy. Benefits of QE or PSPP are not clear. Despite over 10 years of bloated central bank balance sheets, inflation and growth did not follow.[3]. If scarcity effects are large and significant, then a lack of central bank unsterilized actions in response to an external shock may be more beneficial than active bond purchases. Nonetheless, the final assessment must be made by looking at the bigger picture and taking into account other factors like the regulatory environment and demand for reserves. This work studies only scarcity effects. **Last but not least, scarcity effects and connection to .. may shed a light on why some central banks decide to apply controvenial collateral frameworks.**

The remainder of the paper is organized as follows. **Section two. Section three.** The last section concludes.

[3] According to Gern et al. (2015), increase in GDP and inflation are two final effects of the QE/PSPP transmission mechanism.

Figure 1: The long-term rate has been very low in spite of massive QE



Source: FRED

2 Mechanics of collateral

3 Collateral shortage in years 2020-2022

4 Empirical tests

4.1 Data

The main variables that are studied in this research are: Fed's SOMA Treasury holdings, GCF treasury Overnight repo rate and the USD collateral spread.

Repo rate data comes form The Depository Trust & Clearing Corporation (DTCC). The rate is a weighted-average rate of repo contracts that are backed with repo-eligible Treasuries with maturity less than 30 years (CUSIP: 371487AE9). It tracks the average daily interest rate paid for the most-traded GCF Repo contracts for US Treasury securities. DTCC a of clearing house for trading US government securities.

Collateral spread is the difference between an unsecured and secured money market rate. Unsecured financing normally is more expensive that a secured one, since secured lending (e.g. a repo contract) is safer to the leg that lends legal tender money. That is not always the case as showed in figure **??**. Nyborg (2019) explains what drives collateral spread and makes at times to turn negative. Here, the collateral spread, for the US market, is defined as the difference between overnight USD LIBOR rate and the overnight GCF Treasury repo rate. Expressing the repo rate in the form of a collateral spread is important when analysing dynamics of collateral and it's impact on money markets.

Scarcity effects should be most visible in the repo rate because engaging in a reverse repo contract is the cheapest way of obtaining collateral securities. This analysis uses a general collateral repo rate, as opposed to a special repo rate. The reason for such decision is twofold. First, there haven't been done any studies on scarcity effects that investigate a GC repo rate on a macro level. Second, data for the rate is easily accessible online. Using a GC rate is convinient because of the fact, that in regression studies, there is no need to control for specialness and short selling. On the other hand, it is hard to include the market microstructure factors when using a general collateral rate, especially with the weekly data frequency that is applied in this study.

To gauge the volume of Treasury securities on the Federal Reserve balance sheet, I use the System Open Market Account Holdings (SOMA) data. SOMA holding are Fed's assets acquired via open market operations. To make the data relevant for this study, I sum only Treasury bills, notes and bonds and leave out mortgage backed securities and federal agency securities.

Increase in the Fed's SOMA Treasury holdings reduce the supply of government security collateral, however, increase in the outstanding security debt has the opposite effect. I use Debt to Penny daily data of all federal debt outstanding, except debt held by intragovernmental holdings.

This time-series is re-sampled to weekly Wednesday levels to match the frequency of the Fed's Treasury holdings.

The recently popular reverse repo standing facility of the Federal Reserve can alleviate any potential shortage of Treasury collateral, thus I also include these figures as well. For a more detailed analysis of the Fed's RRP sale volumes, please see section 3.

To control for other factors that move the repo rate and collateral spread I include three other variables, namely VIX index, 1-month yield on US Treasury bill and a yield curve defined as 10-year UST yield less 3-month UST yield. All non-dummy variables are defined in table 1.

Lastly, there are four categorical variables used to control for changes in the Fed's monetary policy stance. Two of them show when the Fed rises or lowers the fed funds target rates, and the other two indicate dates when the Fed expands and normalizes its balance sheet. The dates can be seen in table **??**, in the appendix section.

The time range of the whole data set[4] goes from January 2, 2008 to December 29, 2021. All data has weekly frequency, Wednesday levels. Dollar values are in trillion USD, rate values are in basis points (bps). Table 2 shows descriptive statistics of the data used in regression analysis. All of the data, except the LIBOR rate, comes from free online resources. For detail, please see table 1.

4.2 Descriptive Statistics

Figure **??** shows the evolution of the main variables in the last 11 years. The period of the two years that precede the onset of the 2020 pandemic, was the time of balance sheet normalization. Quantitative tightening started at the end of October 2017 and lasted almost two years until the repo rumble on 17th September 2019. Over that period, the Fed allowed Treasury securities and mortgage-backed securities to roll off their balance sheet. The pace of reducing Treasury holdings was $12 billion per month, on average. At the same time the general collateral Treasury repo rate often spiked above the Fed funds upper target and the collateral spread, for almost the whole period, was negative. Interestingly, during times of QE and "taper", when securities weren't systematically bought or sold by the Fed, the collateral spread never stayed negative for so long as it did during the QT.

Table 2 shows basic statistics of the dataset. The average value for the collateral spread, including year 2008, was about 2.9 basis points. If we exclude the whole year 2008 from the sample, the average value changes to -1.5 basis points (median is -0.8). This implies that since

[4] Except primary dealer statistics data that is used in one regression in the appendix.

Table 1: Explanation of variables.
All data was accessed and transformed on 10th March 2022.

Variable	**Definition**	**Source**
TREASURY REPO RATE	GCF (General Collateral Finance) Treasury repo rate weighed index composed of GCF repo-eligible CUSIPs: U. S. Treasury $<$ 30-year maturity, in bps	www.dtcc.com
LIBOR	ICE "Panel Bank" Overnight USD LIBOR rate, in bps	Bloomberg
COLLATERAL SPREAD	USD ON LIBOR rate minus the Treasury repo rate, in bps	
UST 1M	Yield on generic 1-month US Treasury bill, in bps	home.treasury.gov
YIELD CURVE	10-year US Treasury note yield minus 3-month US Treasury bill yield, in bps	home.treasury.gov
SOMA TREASURIES	Fed's Treasury securities at System Open Market Account holdings, tril USD	www.newyorkfed.org
DEBT	Debt held by the public (debt to penny data), in tril USD	fiscaldata.treasury.gov
RRP	Fed's Overnight Reverse Repurchase Agreements – Treasury securities sold by the Federal Reserve in the temporary Open Market Operations, in tril USD	fred.stlouisfed.org
VIX	Chicago Board Options Exchange's CBOE Volatility Index	finance.yahoo.com
PD FAILS	Repo fails to receive and fails to deliver, US Treasury securities, Primary Dealer Statistics, in tril USD	www.newyorkfed.org

2009, the secured rate for interbank liquidity was lower than the secured one. The observation is bizzare, to say the least, since secured lending is much safer than lending that takes place without pledging any collateral.

The average pace of the US debt expansion before the 2020 pandemic was $760 billion per month. From March 2020 to the end of 2021, the total value of the US debt increased by $5.3 trillion, which is 30% of March 2020 level.

The standing reverse-repo facility was opened for the first time in the data sample in September 2013. Since that date, until the end of 2017, the average volume of overnight RRP Treasury sales was about $110 billion. The RRP facility exploded in June 2021 when the Fed added the facility again. Since May 2021, Fed's RRP overnight Treasury sales increased from about $0.25 trillion to over $1.6 trillion at the end of the year.

Figure 2: Development of primary variables.

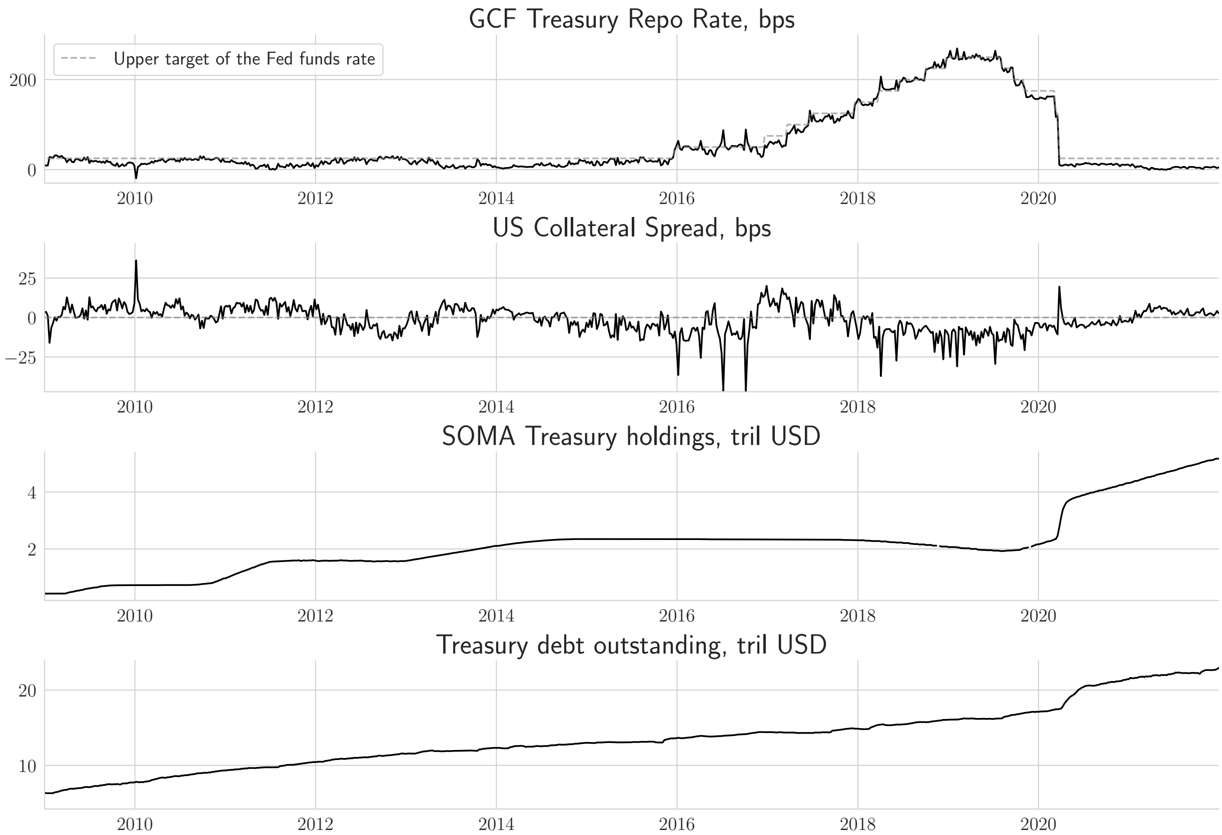


Table 2: Descriptive statistics.

	mean	min	max	std	obs
GCF Treasury O/N repo rate (bps)	64.00	-19.30	418.40	82.63	732
Collateral spread, USD (bps)	2.89	-47.11	495.28	29.63	731
O/N USD LIBOR rate (bps)	66.97	5.46	509.38	87.47	731
1-month UST yield (bps)	51.52	0.00	337.00	77.08	732
10-year less 3-month UST yield (bps)	183.24	-49.00	380.00	96.53	732
Treasury SOMA holdings (tril USD)	2.04	0.43	5.17	1.12	729
Treasury debt outstanding (tril USD)	13.00	5.10	23.03	4.47	732
Fed's RRP standing facility volume (tril USD)	0.09	0.00	1.70	0.25	732
VIX volatility index	20.15	9.19	80.86	9.76	732
Treasury security repo fails (all fails)	0.19	0.06	0.89	0.11	457

Observations from January 2, 2008 to January 5, 2022 (except the last variable which data starts from April 3, 2013). The data above is not transformed, however, regressions in the following section apply first-differencing.

4.3 Base regression specification

The main objective of this paper is to determine whether Fed's Treasury buying programs make Treasury securities more scarce in the market. To see that, I test a casual connection between Treasury security supply factors and the GCF Treasury repo rate with a simple linear regression. All data put into regressions is in first differences in order to remove trends and make time-series stationary.

There are two sets of OLS regressions with two different dependent variables. My basic regression specification involves the general collateral repo rate as the dependent variable and a set of independent variables that reflect supply and demand factors for collateral. The following is the base regression equation

$$\begin{aligned}\Delta \textit{Treasury Repo Rate} = \beta_0 + \beta_1 \Delta \textit{SOMA Treasury}_t + \beta_2 \Delta \textit{Debt}_t \\ + \beta_3 \Delta \textit{RRP}_t + \beta_4 \Delta \textit{UST 1M}_t + \gamma \textit{Controls}_{i,t} + \epsilon_{i,t}\end{aligned} \tag{1}$$

Δ SOMA Treasury and Δ Debt variables are supply factors of the underlying collateral. The former shows to what extend the Fed draws Treasury securities out of the market and the latter variables represents provision of collateral to the market.

Fed's RRP standing facility sales are initiated by agents that seek to lend reserves to the central bank. Therefore, Treasury sales that go through the RRP facility are a demand factor for collateral. RRP volume alone cannot capture all of the demand that exist for liquid Treasury securities. It is so because only eligible parties can access central bank facilities and the price of those reverse-repo contracts is set only by the Fed. In order to account for demand for Treasury securities in the wider market, I use the Δ UST 1M variable, which is a yield on generic one month Treasury bill. **The quality of the underlying collateral affects repo rates as showed by Bartolini et al and Nyborg. Consequently, as the yield of the underlying security rises, the repo rate should also increase**.

To capture the effect of other determinants of the repo rate I incorporate three more macro variables, as well as four categorical variables that control for changes in monetary policy. Those additional macro variables are the VIX stock volatility index and the UST yield curve.

4.4 Problem with the unsecured rate

Repo contracts aren't all about the collateral but also serve as an instrument that provides cash liquidity to the buyer. Sometimes repo rates react more to the "collateral leg", that's when the rates plummet, but usually repo rates respond more to the "cash leg", that is driven by the demand for funds. Thus, it is essential to account for demand for cash liquidity factor, that is not associated with collateral when examining repo rates.

The unsecured rate, which in this case is the US dollar O/N LIBOR rate is an important component that indicates the price of dollar liquidity. However, it would be reckless to include it in the regression as a right-hand side variable because of a potential reverse causality problem.

Since the Global Financial Crisis, activity in the unsecured money market segment have been declining. In 2003, the split of the total lending turnover was roughly equal, but by 2015 the size of the unsecured market was only one-tenth of total De Fiore et al. (2018). Much more bigger and liquid secured markets imply that a demand for funds should be first and foremost captured in repo contracts that are "cash-leg" driven. In short, it should be the secured rate that sets the price of overnight money, which then feeds into the rate of unsecured funds, and not the other way around.

The problem of a possible reverse causality may not be as big as I render it. However, the fact that the USD ICE LIBOR rates use panel bank methodology, which essentially is a daily survey, coupled with a well-known relative illiquidity and tiny size of the fed funds market, suggest that it would be wise to carefully tackle this issue.

$$\begin{aligned} \Delta Collateral\ Spread = \beta_0 + \beta_1 \Delta SOMA\ \ Treasury_t + \beta_2 \Delta Debt_t \\ + \beta_3 \Delta RRP_t + \beta_4 \Delta LIBOR_t + \beta_5 \Delta UST\ \ 1M_t + \gamma Controls_{i,t} + \epsilon_{i,t} \end{aligned} \tag{2}$$

A simple substitution of collateral spread for the repo rate should solve this issue and make the model more robust. The collateral spread, being the difference between the unsecured and secured rate, should remove most of the variability that is caused by the demand for funds as both rates will respond to these occasions in the same direction. For this reason, the second specification sets the collateral spread as the dependent variable and puts the O/N USD LIBOR rate on the right-hand side of the equation to control for any tightness in the unsecured market. Conditions in the unsecured interbank market for liquidity still affects the collateral spread Nyborg (2019), so the unsecured rate is still included as the depended variable, but the reverse causality problem is avoided.

Other known determinants or the collateral spread are liquidity and volatility of the underlying security, haircut and risk-aversion. Regarding attributes of the underlying security in the cash market, it is not clear which security in particular should be analyzed as my repo rate cover a wide variety of Treasuries. For instance, on-the-run Treasury bills are much more liquid than off-the-run Treasury bonds. Thus, I don't use any liquidity metric and for I proxy the overall volatility in the markets as well as risk-aversion with the VIX index. Haircuts are not taken into account as all Treasury securities are deemed to have the same level of safety.

There is also one Treasuries supply factor that should be included in my regressions but isn't due to the unavailability of a high-frequency metric for that factor. It is a variable that represents the rehypothecation of collateral in the monetary system. The more often collateral is re-used collateral in the system, the higher the overall supply of collateral. Some banks put the amount of received collateral that is allowed to be repledged in their quarterly reports. Unfortunately, the size of that data is too small to be meaningful given the time frame of this study.

4.5 Results

The two sets of regressions, which results are showed in the tables below confirm the hypothesis that the Fed's purchases of Treasuries put a downward pressure on the GCF Treasury repo rate, and so a upward pressure on the US collateral spread. A high and statically significant coefficient for the SOMA Treasury holdings variable in each regression specification suggest that the scarcity effects from quantitative easing programs are real.

Table 3 shows how supply factors of US Treasury collateral affect the general collateral Treasury repo rate. The coefficient next to "SOMA TREASURY" variable in the second column of the table (-45.55) implies that a $1 trillion of the Fed's Treasury purchases causes the repo rate to decline, on average, by 45 basis points, with all other determinants held constant. The magnitude of the effect is much smaller than in D'Amico et al. (2014), however, that study is much different as it looks on the special repo rates as opposed to general collateral repo rates.

Four regressions are included in the table 3. The fist column looks only at the level of Treasuries on the Fed's balance sheet and the overall US Treasury debt outstanding. D'Amico et al. (2014) and Arrata et al. (2018) merge two of these values into one variable, that is a ratio of the former to the latter. Here, I put those variables separately to understand a relative magnitude of both. As illustrated in the table, extracting high-quality collateral from the market affects the repo rate more than the US Department of Treasury provision of these securities. The second column adds other important factors that move the repo rate. All of them are statistically significant. Including those factors addresses the omitted variable bias, as both, SOMA and debt, coefficients are much smaller after the model extension. Columns 3, adds the overnight US dollar LIBOR rate. It doesn't change much as the coefficient of the LIBOR rate is small. Moreover, there are possible reverse causality problems when adding this variable, and its statistical explanatory power is very low. The last column adds dummy variables that represent the dates when the Fed clearly took action in regards to the size of their balance sheet. Initiating or expanding quantitative easing contributed to rising repo rate, and doing the opposite plausibly decreased the dependent variable. However, the coefficient of the last variable, which is a dummy for QT dates, is not statistically significant.

Surprisingly, the reverse-repo standing facility had a large impact on the direction of the repo rate. It was expected to have some impact, but the magnitude of its effect is astonishing. Results suggest that freeing up Treasuries from the Fed's balance sheet have more influence of the GC repo rate than the primary issuance of those securities. This is counter-intuitive because on-the-run

Treasuries, which are newly-issued, are more preferred by the market participants

Table 3: Regression — GCF Treasury repo rate and the supply of Treasury securities

	Dependent variable: GCF Treasury repo rate			
	(1)	(2)	(3)	(4)
Intercept	-0.818	-0.265	-0.256	-0.366
	(0.568)	(0.295)	(0.293)	(0.280)
SOMA TREASURY	-91.651**	-45.549***	-41.788**	-40.532**
	(45.276)	(17.261)	(17.358)	(17.597)
DEBT	33.710***	23.180**	23.801**	24.281**
	(12.068)	(10.366)	(10.121)	(10.318)
RRP		30.961**	30.904**	31.183**
		(13.603)	(13.664)	(13.846)
UST 1M		0.630***	0.627***	0.644***
		(0.123)	(0.118)	(0.118)
YIELD CURVE		-0.127**	-0.133**	-0.119*
		(0.063)	(0.059)	(0.065)
C(RATE DOWN)		-36.442***	-35.779***	-36.258***
		(7.825)	(7.706)	(7.825)
C(RATE UP)		19.735***	18.211***	18.103***
		(1.758)	(2.000)	(2.045)
LIBOR			0.065	0.062
			(0.044)	(0.043)
VIX				0.105
				(0.147)
C(FED EASENING)				7.963**
				(3.343)
C(FED TIGHTENING)				-1.934
				(1.362)
Observations	726	726	726	726
Adjusted R^2	0.020	0.504	0.509	0.512
Note:		*p<0.1; **p<0.05; ***p<0.01		

Notes: All variables, except categorical "C" ones, are in first-difference form. Standard errors are heteroscedasticity and autocorrelation robust (HAC) using 5 lags and without small sample correction (in parentheses). All variables are defined in table 1.

Table 4: Regrression — Measuring scarcity effects with collateral spread

	Dependent variable: US Collateral spread		
	(1)	(2)	(3)
Intercept	0.933	0.256	0.366
SOMA TREASURY	25.869	41.788**	40.532**
	(22.988)	(17.358)	(17.597)
DEBT	-46.641**	-23.801**	-24.281**
	(19.162)	(10.121)	(10.318)
	(0.636)	(0.293)	(0.280)
RRP		-30.904**	-31.183**
		(13.664)	(13.846)
UST 1M		-0.627***	-0.644***
		(0.118)	(0.118)
LIBOR		0.935***	0.938***
		(0.044)	(0.043)
YIELD CURVE		0.133**	0.119*
		(0.059)	(0.065)
C(RATE DOWN)		35.779***	36.258***
		(7.706)	(7.825)
C(RATE UP)		-18.211***	-18.103***
		(2.000)	(2.045)
VIX			-0.105
			(0.147)
C(FED EASENING)			-7.963**
			(3.343)
C(FED TIGHTENING)			1.934
			(1.362)
Observations	726	726	726
Adjusted R^2	0.007	0.770	0.772
Note:		*p<0.1; **p<0.05; ***p<0.01	

Notes: Collateral spread is defined as the difference between USD ON LIBOR rate and ON GCF Treasury repo rate. All variables, except categorical "C" ones, are in first-difference form. Standard errors are heteroscedasticity and autocorrelation robust (HAC) using 5 lags and without small sample correction (in parentheses). All variables are defined in table 1.

5 Conclusions

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Appendix

Table 5: Regression – Adding other plausible explanatory variables to the collateral spread specification.

Variable "UST 3M BID-ASK" is the bid-ask spread of a generic 3-month Treasury bill yield. Variable "UST 3M 10W VOL" is the 10-week realized volatility of a generic 3-month Treasury bill yield. The first column regression uses a smaller data sample that starts April 3, 2013. All newly added variables are not statistically significant (p-values exceed as much as 0.3). Condition number of the third column regression is large which indicates strong multicollinearity.

	Dependent variable: US Collateral Spread		
	(1)	(2)	(3)
Intercept	0.411*	0.358	0.253
	(0.237)	(0.284)	(0.294)
SOMA TREASURY	28.773	21.443	41.205**
	(20.417)	(28.856)	(17.177)
DEBT	-21.732***	-19.209**	-23.466**
	(6.063)	(9.457)	(10.184)
RRP	-27.035**	-30.481**	-31.166**
	(13.337)	(13.516)	(13.612)
UST 1M	0.013	-0.581***	-0.626***
	(0.117)	(0.154)	(0.119)
LIBOR	0.109	0.951***	0.937***
	(0.276)	(0.035)	(0.043)
YIELD CURVE	0.178***	0.153***	0.133**
	(0.048)	(0.055)	(0.059)
C(RATE DOWN)	6.631	36.885***	35.694***
	(9.963)	(8.863)	(7.720)
C(RATE UP)	-2.429	-19.216***	-18.174***
	(6.177)	(1.903)	(1.983)
PD FAILS	-0.791		
	(2.826)		
UST3M 10W VOL		0.480	
		(0.490)	
UST3M BIDASK			0.004
			(0.006)
Observations	452	716	726
Adjusted R^2	0.096	0.800	0.770

*p<0.1; **p<0.05; ***p<0.01

Notes: Collateral spread is defined as the difference between USD ON LIBOR rate and ON GCF Treasury repo rate. All variables, except categorical "C" ones, are in first-difference form. Standard errors are heteroscedasticity and autocorrelation robust (HAC) using 5 lags and without small sample correction (in parentheses). All other variables are defined in table 1.

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