

The Treasury Market in Spring 2020 and the Response of the Federal Reserve

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April 5, 2021

First version: August 26, 2020

Abstract: This paper studies Treasury market dislocations during the initial phase of the COVID crisis in March 2020. Despite a deteriorating economy, the 10-year yield increased by 64 bps from March 9 to 18. This was not due to higher expected inflation or increased default risk for government debt. In response, the Federal Reserve purchased over \$1T of Treasuries in the first quarter of 2020, more than in either of the QE1, QE2, or QE3 programs. I argue that Fed purchases were causal for driving down yields by documenting the timing of Fed purchases (which were increased sharply on March 19, the same day the yield spike started to reverse) and the timing of yield reversals and Fed purchases in the MBS market, as well as by providing evidence against confounding factors. The Fed's "market-functioning" QE during COVID appears to have worked more via purchase effects than announcement effects, in contrast to earlier QE programs and in contrast to corporate bond purchases during the COVID crisis. I propose that the importance of purchase effects for market-functioning QE is due to the Treasury yield spike being driven by immediate liquidity needs that were unaffected by the initial Treasury purchase announcement on March 15. I document that the main sellers of Treasuries were mutual funds, foreign official agencies, and hedge funds, and argue that urgent liquidity needs were relevant for sellers within these sectors.

¹ I thank Carol Bertaut, Michael Johannes, Jay Kahn, Hyun Shin, and conference and seminar participants at Columbia University, London School of Economics, University of California Berkeley, University of Toronto, Tinbergen Institute, ECB, Board of Governors of the Federal Reserve, Federal Reserve Bank of San Francisco, BIS, Bank of Canada and the Riksbank for helpful comments. All errors are my own.

1. Introduction

In March 2020, as the COVID crisis intensified, unprecedented stressed emerged in the market for Treasury securities. Treasury yields spiked sharply, leading the Federal Reserve to buy large amounts of Treasuries, over \$1T in 2020Q1. This episode is still not well understood. In this paper, I seek to contribute new facts and new analysis to improve our understanding of it.

Figure 1, Panel A documents the fact that motivates this paper. It graphs the S&P500 index level and the 10-year Treasury yield over the first half of 2020. Up until March 9, the series move down together as news about the COVID crisis becomes increasingly negative. This is what one would expect if negative news about the economy leads bond investors to expect lower short rates going forward or to reduce the term premium, fleeing to the safety and liquidity of Treasuries in crisis. The surprising part of the figure is the March 9 to March 18 period during which the 10-year yield spikes sharply (64 basis points) while the stock market keeps falling. The yield spike then reverts quickly over the following week. What caused the Treasury yield spike over the March 9-18 period? Was the intervention by the Federal Reserve central for bringing Treasury yields back down? What lessons does this episode provide for investors and for monetary policy?

I begin my analysis with an asset-pricing decomposition of Treasury yield movements. I document that Treasury yields did not spike because of a loss of confidence in Treasury fundamentals in the sense of higher expected inflation or increased default risk. Based on market measures, inflation expectations fell as yields spiked, implying that real yields increase even more than nominal yields. The 10-year real (and default-adjusted) rate increases by about 100 bps over the March 9 to 18 period. While liquidity in the Treasury market deteriorated, I estimate that this can only account for a few basis points of the yield spike, given the price of liquidity (estimated from the cross-section of Treasury notes and bonds) and the deterioration in liquidity over time.

With default risk, inflation and illiquidity unable to explain the increase in Treasury yields, the natural explanation is a negative demand shock for Treasuries, necessitating a fall in prices for markets to clear. I provide evidence supporting this hypothesis, documenting large sales of Treasury securities by some investor groups: Foreigners, mutual funds, and the household sector (which includes hedge funds). Sales were large in historical terms, at \$287B, \$266B, and \$194B respectively for the three groups in 2020Q1. Notably, neither of these sectors sold many Treasuries at the peak of the financial crisis 2008Q4.

A central part of my analysis is to study the Federal Reserve's intervention in the Treasury market in response to the spike in yields. I document that Treasury yields start falling on March 19 and March 20, lining up well with a large increase in the Federal Reserve's daily Treasury purchases on March 19. This is unlikely to be due to confounding stabilizing factors since corporate yields increase on March 19-20 and the stock market falls. Furthermore, in the MBS market, the spike in yields started reversing a day later than in

the Treasury markets, and the Federal Reserve increased its daily MBS purchases a day later than in the Treasury market, consistent with a causal link from purchases to yields. This reduces the likelihood that confounding factors drove the reversal of Treasury yields since one would expect these to affect MBS markets at the same time.

The Federal Reserve's Treasury purchases during the COVID crisis thus appears to have had large effects on asset prices at the time of purchase, as opposed to have large effects on announcement dates as the prior literature has found (e.g. Krishnamurthy and Vissing-Jorgensen (2011)). I argue that large purchase effects are consistent with some sellers having immediate liquidity needs. If liquidity needs do not change as a result of the Federal Reserve's purchase announcements, then asset prices may not change fully until the announced purchases are implemented, especially in situations where other investors are unwilling or reluctant to buy at announcement in expectation of selling to the Federal Reserve later. I emphasize the "if liquidity needs do not change" part of the argument. In sharp contrast to the importance of large purchases in the Treasury market, corporate markets stabilized in March and April 2020 around Federal Reserve corporate bond purchase announcements. This happened without immediate purchases and purchases made have been delayed and modest. Prior work on the impact of Federal Reserve asset purchases during the COVID crisis by Haddad, Moreira and Muir (2020) study dislocations in corporate bond markets and find large announcement effects on corporate bond yields.² They also show that the announcements affected corporate fundamentals in the sense of reducing credit default spreads. Falato, Goldstein and Hortacsu (2020) argue that Federal Reserve announcements helped reverse outflows from mutual funds holding corporate bonds. Therefore, in the corporate market, announcements did change liquidity needs (of mutual funds in particular) and thus led to large announcement effects, presumably because investors expected that the Fed's intervention would stem the selling. That was not the case in the Treasury market, where an announcement on March 15, 2020, that the Federal Reserve would buy at least \$500B worth of Treasury securities was insufficient to stop the yield increase. Only actual purchases turned the Treasury market around. A simple way of summarizing the differing mechanics of Federal Reserve purchases across markets is that corporate announcements improved perceived corporate fundamentals enough to stop the selling, implying that only small amount of actual purchases were needed. By contrast, in the Treasury markets the spike in yields was not due to problems with Treasury fundamentals (inflation, credit risk) but rather driven by massive selling due to liquidity needs that remained important, Treasury purchase announcement or not. In that sense, providing liquidity requires large purchases (the Treasury market) but

² Gilchrist, Yue, Wei and Zakrajsek (2020) also document announcement effects of Federal Reserve corporate bond interventions though these take several weeks after the announcements to fully emerge in the market for individual corporate bonds, presumably related to infrequent trading of corporate bonds. They exploit a regression discontinuity research design based on maturity restriction on corporate bond eligibility for Fed purchase.

one can stabilize a market with few purchases if the announcement itself moves fundamentals (perceived credit risk) enough to stop investor selling (the corporate market).

Drawing on a series of data sets, I seek to understand drivers of selling by each of the sectors mentioned, in order to argue that urgent liquidity needs was relevant for selling by both mutual funds, foreign official agencies, and hedge funds. I document large outflows from bond mutual funds in 2020Q1 and show that funds with outflows account for the mutual fund sector's overall selling. Consistent with a link between outflows and Treasury selling, I find that in the cross-section of funds in 2020Q1, funds with outflows on average sold more of their Treasury holdings. Furthermore, increased holdings of Treasury securities by mutual funds since the financial crisis, especially for bond mutual funds, explain why funds did not sell Treasuries in 2008Q4, despite the fact that they had similar outflows then measured in quarterly data and scaling flows by the size of fund assets. In terms of why investors pulled money out of bonds (during both crises), I hypothesize that as default risk increases, bond funds cease to satisfy the demand by unsophisticated investors for safe assets. This "safety effect" – investor willingness to pay more for low-risk assets than their default risk and the price of default risk for higher risk assets would imply – was proposed by Krishnamurthy and Vissing-Jorgensen (2012). I interpret bond fund outflows in crisis as a disappearance of the safety attribute and provide asset pricing evidence consistent with this idea.

Turning to foreigners, I find that about 2/3 of Treasury sales by foreigners were from foreign official agencies (including governments and central banks), with the foreign private sector accounting for the rest. Foreign official agencies appear to have sold Treasuries both for immediate cash needs (having net sales of U.S. assets overall), in expectation of future cash needs (increasing holdings of currency and deposits), and for higher expected returns (buying agency debt, corporate bonds, as well as stocks and investment fund shares). Consistent with the first motive, in the cross-section of countries, foreign net purchases of Treasuries are positively related to the change in foreign reserves. Countries that are hedge fund domiciles sell more Treasuries, suggesting that hedge funds may be a driver of foreign private sales. I provide an estimate of Treasury sales by U.S. and foreign domiciled hedge fund that report to the Securities and Exchange Commission of \$183B in 2020Q1, enough to account for a the majority of Treasury sales by foreign private and the U.S. household sector. Prior work link hedge fund Treasury selling to unwinding of the Treasury basis trade, see Barth and Kahn (2020) and Schrimpf, Shin and Sushko (2020).

While I focus my analysis on Federal Reserve purchases and on sectors with large sales, other papers have emphasized the role of broker-dealers and the fact that they did not increase their balance sheets sufficiently in response to selling by other sectors, see He, Nagel and Song (2020) and Duffie (2020).

2. Decomposing Treasury yields

To understand how broad based the Treasury yield curve spike in March was across the maturity spectrum, Figure 1, Panel B graphs Treasury yields for various maturities. The yield spike is stronger for longer maturities but visible even for the 2-year bond. To assess possible drivers of the yield spike, Figure 1, Panel C provides a yield decomposition. The nominal yield can be decomposed as

$$\text{Nominal yield} = \text{Real yield} + \text{expected inflation} + \text{credit risk} \quad (1)$$

I focus on the 10-year maturity. I proxy expected inflation by the rate on inflation swaps and use the credit default swap (CDS) rate to measure credit risk. The inflation swap rate drops by 42 bps over the March 9-18 period, while there is little change in the CDS rate. The March yield spike in Treasury yields is therefore not driven by a deterioration in inflation or credit risk fundamentals but rather by an increase in the real yield. The real yield on 10-year Treasuries implied by the decomposition, the nominal yield minus expected inflation minus credit risk, increases by 103 bps from March 9 to 18. This increase is similar to that for (CDS-adjusted) Treasury inflation-protected securities.

For comparison, Figure 1, Panel D illustrates the same time series for the second half of 2008 during the financial crisis. There is no sudden spike in the Treasury yield as the stock market falls sharply in October 2008. A more slow-moving increase in the two measures of the riskless real yield is visible in the bottom figure. However, this increase reverses in the last quarter of 2008 before any purchases of Treasury securities by the Federal Reserve. Such purchases were announced only on March 18, 2009.

During the COVID crisis, Treasury liquidity deteriorated during around the same time yields spiked, see Fleming and Ruela (2020) and Board of Governors of the Federal Reserve (May 2020). Deteriorating Treasury liquidity could by itself lead to increased Treasury yields as the liquidity benefits of holding one of the normally most liquid asset classes are reduced. To quantify the illiquidity component of yields, I estimate the price of liquidity in the cross-section of Treasury securities and multiply this price by the bid-ask spread for a given security. In the above decomposition, the illiquidity component is part of the real yield component.

To illustrate the link between liquidity and yields, Figure 2, Panel A, graphs the bid yield in percent and the bid-ask spread measured in \$ per \$100 face value across the term structure, as of March 12, 2020 (using data from Bloomberg). I use March 12 because it is the last day before the Federal Reserve starts purchasing Treasuries to stabilize the market but the cross-sectional price of liquidity estimate below is similar if using March 9 or March 18 data. I use the bid-ask spread in dollars to avoid any mechanical correlation between the bid yield and the bid-ask spread that could emerge if scaling the latter by the price. For readability, I graph Treasuries that have remaining maturities between 1 and 10 years and that are still in their original "maturity bucket". Securities between 7 and 10 years in the graph were thus all issued as

10-year bonds and have at least 7 years of remaining life. In the >1 to 10 year range, the Treasury issues securities with initial maturities of 2, 3, 5, 7 and 10.³ The label along the bid yield line indicates the age of the bond in its maturity bucket. The label 1 denotes the most recently issued security in the bucket (the “on-the-run”), 2 is the second most recently issued security in the bucket (the “first off-the-run”), and so on. The graph documents a much lower bid-ask spread and much lower bid yield for on-the-run bonds, and to a lesser extent for the first off-the-run bonds, relative to other bonds that are close in terms of remaining maturities. This makes the yield curve very unsmooth and indicates that investors were willing to pay a substantially higher price for more liquid bonds. This contrasts with Figure 2, Panel B which graphs the same series for January 6, 2020 (first Monday of the year) and shows much lower bid-ask spreads and a much smoother yield curve.

To estimate the cross-sectional price of liquidity, I regress the bid yield on the bid-ask spread along with a cubic in the remaining time to maturity (results are similar using a Nelson-Siegel functional form to relate yields to remaining time to maturity). Since the analysis is for coupon bonds, I also control for the coupon rate (which affects the duration, given the term). Table 1, column 1 estimates this relation for the sample of 76 bonds graphed in Figure 2, Panel A. The cross-sectional price of liquidity is 0.213 meaning that an increase in the dollar bid-ask spread of \$0.1 translates into a bid yield that is 2.13 bps higher. The estimated cross-sectional price is a bit higher at 0.299 when I include all bonds with terms between 1 and 10 years (as opposed to only those still in their original maturity bucket). Columns 3 and 4 show that differences in liquidity appear to fully explain yield differences across on and off-the-run bonds. Column (3) includes dummies for being on-the-run, first off-the-run etc. The coefficient on the on-the-run dummy imply that on-the-run securities have 9 bps lower yields than securities older than the fourth off-the-run. This coefficient goes to approximately zero in column 4 when including the bid-ask spread as a regressor (I return to the remaining dummies in column 3 and 4 related to futures contracts below). Column 5 repeats the regression from column 1 using data from January 6, 2020. The cross-sectional price of liquidity is 0.235, quite similar to that in column (1). This suggests that the much larger yield differences between on- and off-the-run securities in Figure 2, Panel A than Figure 2, Panel B is primarily driven by larger liquidity differences across securities in March than in January, not by a changing cross-sectional price of liquidity.

³ For bonds issued with an initial term of 30 years, bid-ask spreads and yields are also lower for the on-the-run and first few off-the-run bonds than for slightly older issues. I exclude 30-year bonds because they appear to have higher bid-ask spreads than other bonds even controlling for term and coupon, perhaps because many are purchased by long-term buy-and-hold investors. I similarly do not include bonds with less than one year of remaining maturity. The bid-ask spread in dollars (or in pct of the price) is fairly stable across off-the-run 2-year bonds. For terms close to zero, a given difference between bid and ask prices translates to a very large difference between bid and ask yields with very high bid yields and very low ask yields.

The estimates from Table 1 imply that cross-sectional differences in Treasury liquidity in March was sufficiently important to cause major “wiggles” along the yield curve. However, they also imply that deteriorating Treasury liquidity is unlikely to explain a large part of the March 9 to March 18 spike in Treasury yields. Figure 2, Panel C shows the estimated illiquidity component of bid yields on the on-the-run, first off-the-run and fourth off-the-run 10-year bonds over time. I estimate this component as 0.213 (the cross-sectional price of liquidity from Table 1, column 1) times the bid-ask spread (in \$ per \$100 face value). The figure shows that the illiquidity component of the on-the-run bond yield never exceeds more than few basis points. The illiquidity component is larger for the off-the-run bonds (consistent with the visible wiggles in Figure 2, Panel A), but does not exceed 10 bps for the first off-the-run and 20 bps for the fourth off-the-run bond. Furthermore, part of the increase in the illiquidity component for the first and fourth off-the-run bond take place before March 9. Relating back to the 64 bps yield spike in the 10-year yield in Figure 1, Panel A, the rise in the illiquidity component of bond yields can only explain a couple of basis points of this spike. The series in Figure 1, Panel A is from the Federal Reserve’s FRED database and comes from the U.S. Department of the Treasury. This curve is based on bid yields on on-the-run securities and as shown in Figure 1, Panel C, the illiquidity component of on-the-run yields is never large.⁴

With illiquidity effects explaining little of the March yield spike in on-the-run bond yields, I turn to quantity data. A simple explanation for the yield spike would be a negative demand shock for Treasuries, necessitating an increase in yields to clear the market. In order for a demand shock to be reflected in equilibrium quantities, the shock needs to be heterogeneous across groups of investors such that we can infer demand changes from reallocation of ownership. I therefore exploit data on group level holdings and transactions from the U.S. Financial Accounts.

3. Buyers and sellers of Treasuries in 2020Q1

Table 2 documents who owned Treasuries before the COVID crisis hit and how that changed over the first quarter of 2020. As of the end of 2019Q4, about \$19T of Treasuries were outstanding. Column 4, which is based on the “flow” table from the U.S. Financial Accounts, accounts for valuation changes in order to assess the net change in holdings due to purchases and sales.

The Federal Reserve purchased \$1.019T worth of Treasuries in 2020Q1 (\$863B of notes and bonds, \$156B of bills; this detail is not included in the table as it is only available for some sectors). The only other major buyer of Treasuries was money market funds who bought Treasuries worth \$231B, mostly bills (\$36B of notes and bonds, \$195B of bills). Figure 3, Panel A illustrates the unprecedented nature of the Federal Reserve’s Treasury purchases in 2020Q1. The Federal Reserve purchased heavily again in 2020Q2. In 2020Q1 alone, Federal Reserve purchases of Treasuries exceeded purchases under each of the QE1,

⁴ <https://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/yieldmethod.aspx>

QE2, and QE3 programs, which are the visible three sets of positive bars in earlier years in the graph. Summing up quarterly data, purchases were \$301B for QE1 (2009Q1-2009Q4), \$853B for QE2 (2010Q4-2011Q3) and \$811B for QE3 (2012Q4-2014Q3).

Holdings of foreigners (the rest of the world) increased to from \$6.691T at the end of 2019Q4 to \$6.950T by end of 2020Q1, an increase of \$259B. However, these holdings are at market value and the Treasury return over 2020Q1 was positive as yields fell for the quarter as a whole. Accounting for valuation changes, foreigners sold \$287B worth of Treasuries in 2020Q1, making them the sector with the largest sales. Foreign sales of notes and bonds were \$300B, while foreigners purchased \$13B worth of bills. The second largest sellers were U.S. mutual funds, with sales of \$266B (of which notes and bonds \$260B and bills \$6B). The household sector was the third largest seller, selling \$194B worth of Treasuries. This sector includes domestic hedge funds.

To assess the extent to which the sales by foreigners, mutual funds, and the household sector are large relative to typical time series fluctuations, Figure 3, Panel B graphs the time series of quarterly net purchases by these three sectors back to 2000Q1. For foreigners and mutual funds, the 2020Q1 treasury sales exceed sales in any prior quarter by large amounts. For the household sector, net purchases are more volatile over time, likely because this category is calculated as the residual in the U.S. Financial Accounts. Nonetheless, net sales by the household sector are also at their largest value in 2020Q1. Comparing the COVID crisis to the financial crisis, the three sectors with the largest sales in 2020Q1 were net buyers in the second half of 2008, suggesting that something novel was at play during the COVID crisis.

I next argue that the Federal Reserve purchases were essential for reversing the yield spike and then seek to understand what drove the negative demand shocks for Treasuries for foreigners, mutual funds, and the household sector.

4. The role of Federal Reserve purchases in reversing the Treasury yield spike

As the COVID crisis intensified, the Federal Reserve took a series of steps to stabilize the economy and financial markets. Table 3 lists the main policy changes and programs announced during March and April of 2020. The Federal Reserve reduced the Federal funds target, the primary credit rate, and the rate on its dollar swap facilities with five foreign central banks (Bank of Canada, Bank of England, Bank of Japan, ECB and the Swiss National Bank). It also restarted/introduced facilities to stabilize money markets following outflows from prime money market funds. In addition, a series of bond purchases was announced, covering Treasuries, MBS, corporate bonds, municipal bonds, and ABS. On March 15 at 5 p.m. (a Sunday before the open of futures markets), the Federal Reserve announced that it would buy at least \$500B of Treasuries and at least \$200B of mortgage-backed securities. On March 23 at 8 a.m., the Federal Reserve announced that it would “purchase Treasury securities and agency mortgage-backed securities in the amounts needed to support smooth market functioning and effective transmission of monetary policy to broader financial

conditions and the economy”. Furthermore, bond purchases were expanded to include investment grade corporate bonds. On April 9 at 8:30 a.m., it was announced that corporate bond facilities would be expanded in size and extended to fallen angels (bonds that were investment grade as of March 22, but were since downgraded below investment grade) and high yield ETFs with broad corporate bond market exposure. Purchases were also expanded to include municipal bonds.

4.1 Announcements do not line up with the yield spike reversal

Figure 4, Panel A, adds vertical lines to Figure 1, Panel A to indicate the three dates with announcements regarding bond purchases. Since March 15 was a Sunday it is not possible to assess whether this announcement helped lower Treasury yields as markets reopened after the weekend. However, it is clear that the announcement was insufficient to stop the yield spike. The 10-year yield rose by 45 bps on March 17 and 18 combined. Then, on March 19 and 20, it dropped by 26 bps, dropping a further 16 bps on March 23. The majority of the drop on March 23 was not around the 8 a.m. announcement. Treasury markets were closed at the time of the 8 a.m. announcement, but Figure 5, Panel A graphs the cumulative return on the 10-year and 30-year Treasury futures (TY and US) from March 16 to 23. Treasury futures are traded all hours of the day except for 5 to 6 pm on weekdays and weekends until 6 pm Sunday. I graph the cumulative return since the start of the day on March 16 (futures are quoted as a price, not a yield, so no yield is available). A yield spike is thus a futures return trough. The figure shows the reversal of the return trough on March 19 and 20, with only a modest positive return on the 10-year future around the March 23 announcement and only a short-lived positive return spike on the 30-year future around that announcement.

The simple message from Figure 4, Panel A and Figure 5, Panel A is therefore that the reversal of the yield spike on March 19 and 20 does not line up well with Federal Reserve announcements. This stands in sharp contrast to experiences from earlier QE announcements where the literature has documented large yield changes following announcements. In the history of Federal Reserve QE, the most dramatic announcement effect for the Treasury market occurred following the Federal Reserve’s March 18, 2009 announcement which stated that Treasuries would be included in QE1. This episode is illustrated in Figure 5, Panel B which is taken from Krishnamurthy and Vissing-Jorgensen (2011). The 10-year Treasury yield drops over 30 basis points in the minutes after the announcement.

4.2 The yield spiked reversed as Fed purchases were sharply increased

Do these facts mean that the Federal Reserve’s Treasury purchases were not important for reversing the Treasury yield spike in March 2020? No. I will argue that “market functioning” QE (using the Fed’s terminology from above), involving purchases of Treasuries during the COVID crisis worked by affecting yields mainly at the time of purchase, rather than primarily at the time of announcement of purchase. If some investors are selling due immediate liquidity needs, an announcement of purchases by itself (the

March 15, 2020 announcement) may have little effect on yields. An announcement effect on yields would require either that liquidity seeking investors stop selling, or that others start buying, in expectation of later being able to sell the securities at a profit to the Federal Reserve. However, if liquidity needs are immediate and potential buyers are constrained (or see better opportunities elsewhere) a Federal Reserve announcement may by itself have little effect, with the policy instead lowering yields only as announced purchases are implemented. Evidence from the cross-section of Treasury securities is consistent with balance sheet capacity being strained in March. In Table 1, I include dummy variable for securities being cheapest to deliver (CTD) into Treasury futures contracts (a given futures contract allows for delivery of one of a set of securities). On March 12, 2020, CTD securities trade at yields that are 10-20 bps lower than other securities, controlling for maturity.⁵ The CTD security prices were pushed up by high prices of Treasury futures contracts. These contracts allow buyers of long Treasury futures positions exposure to Treasury yields, without a need for balance sheet capacity (aside from margin to be posted). High futures prices – and therefore high CTD Treasury prices – are thus an indicator of tight balances sheets.⁶

An alternative mechanism for yields to move at the time of Federal Reserve purchases is that the purchase turned out larger than expected based on prior announcements, with the purchase thus effectively containing an unspoken announcement element. This may have played a role but probably only modestly so given that the Federal Reserve was far from the initially announced \$500B of Treasury purchases when it increased purchases on March 19. This increase thus did not necessarily signal that purchases would exceed \$500B.

To document how yields fell at the time of purchase, Figure 4, Panel B graphs the 10-year yield along with daily Treasury purchases by the Federal Reserve. I calculate daily Treasury purchases by summing purchases across Treasury auctions held on a given day, using data from the website of the Federal Reserve Bank of New York. The Federal Reserve's daily Treasury purchases were minor until March 13, then around \$40B/day on March 13, 16, 17 and 18, before increasing to around \$70B/day from March 19 to April 1. The increase in daily purchase amount on March 19 lines up perfectly with the yield spike starting to reverse and yields revert to almost their March 9 level by April 1. The large daily purchases from March 19 to April 1 imply that \$723B of the Federal Reserve's total quarterly net purchases of \$1.019T were purchased over a period of just 12 days.

To argue that Federal Reserve Treasury purchases were causal for reversing the yield spike it is important to rule out potential confounding factors. Perhaps other events calmed the market, unrelated to

⁵ I obtain information on which securities are cheapest to deliver from Bloomberg.

⁶ Fleckenstein and Longstaff (2020) argue that one can think of the Treasury futures market as way for balance-sheet constrained investors to effectively rent a Treasury security from the institution taking the short side of the futures trade (and buying the CTD Treasury security to hedge the short position).

the Federal Reserve's purchases. Counter to this possibility, the yield on corporate bonds kept increasing on March 19 and 20. The yield on investment grade corporate bonds went up 53 bps over these two days and the yield on high yield corporate bonds increased 78 bps. The S&P500 index lost 3.9% over these two days. These facts suggest that markets other than the Treasury market kept deteriorating even as Treasury yields started falling. Another central piece of evidence for arguing causality from the Fed's market functioning bond purchases to yields is that in the MBS market, yields start falling and Fed purchases increase one day later than in the Treasury market. This provides one more example linking yield reversal to Fed purchases. Facts about the MBS market are shown in Figure 6. Panel A shows the yield on the Bloomberg Barclays US MBS Index (for fixed-rate agency-backed MBS) and the corresponding option-adjusted spread (OAS), a measure of the risk-premium required by MBS investors. Both peak on March 19, a day later than the peak in the 10-year Treasury yield. Panel B lines up the reversal in MBS OAS (and yield) starting on March 20 to a sharp increase in daily MBS purchases by the Federal Reserve on March 20. The fact that yields fall and Fed purchases increase a day later in the MBS market suggest that confounding factors are not driving the Treasury and MBS yield reversal. Stabilizing factors would be expected to affect both the Treasury and MBS market on the same day.

Liquidity provided by the Fed's dollar swaps lines may have played a complementary role to the Fed's Treasury purchases in stemming market dislocations. The first auctions of dollar liquidity to foreign financial institutions via dollar swap lines with foreign central banks settled on March 19, as illustrated in Appendix Figure 1. A total of \$162B was borrowed, of which \$112B through the ECB. The settlement date of March 19 lines up with the start of the Treasury yield reversal. It is difficult to assess how many foreign Treasury sales may have been averted by foreign financial institutions borrowing dollars rather than having to sell dollar-denominated assets. In terms of where the substantial foreign demand for dollars came from, it may relate to large outflows from prime money market funds in the US, who had net outflows of \$139B in March 2020 (Table 4). Prime funds lend some of their funds to financial institutions by buying financial commercial paper and certificates of deposits, with investments both in the US and abroad.⁷

Perhaps the simplest argument that Federal Reserve purchases led to the reversal of the yield spike is that there is substantial amounts of evidence that Treasury sellers faced immediate liquidity needs. I consider each of the three sectors selling large amount Treasuries. Bond mutual funds faced large outflows leaving them little choice but to liquidate securities and Treasuries were -- despite the Treasury market

⁷ The Federal Reserve were able to reduce its daily purchases on April 2 without yields rebounding. The reduction in daily Fed purchases happened shortly after the Fed introduced a repo facility for foreign central banks to prevent them from having to sell Treasuries to obtain dollars (on 3/31) and after the Fed removed Treasuries and reserves from leverage calculations under the Supplementary Leverage Ratio (on 4/1). These initiatives may thus also have contributed to stabilizing the Treasury market but this is hard to assess as markets had materially improved when these changes were made.

liquidity deterioration -- still among the most liquid securities they held (in a relative sense). Foreign official holders faced immediate liquid needs from FX intervention (leading to reduced dollar reserves) and precautionary liquidation of Treasuries in case of future need for intervention. Foreign private holders include hedge funds who, like the domestic hedge funds included in the U.S. household sector, faced liquidity needs from the unwinding of trades related to the Treasury futures market.⁸

5. Drivers of mutual fund Treasury selling in 2020Q1

This section documents the extent of outflows from mutual funds in the first quarter of 2020, links Treasury selling to these outflows and lays out a possible reason for why investors pulled money out of their mutual funds.

5.1 Fund outflows

The large sales of Treasuries by mutual funds in 2020Q1 coincide with large mutual fund outflows. Table 4 documents mutual fund flows. The table is based on monthly data from the Investment Company Institute, obtained from Bloomberg. This is the same data source as is used for mutual funds by the U.S. Financial Accounts. Bond funds faced outflows in March 2020 of \$257B, corresponding to 5.6% of total net assets (TNA). Outflows were also substantial for hybrid funds (investing in a mix of stocks and bonds), at 3.1% of TNA. Equity funds faced only modest fund outflows relative to their large size, with outflows of 0.4% of TNA. Within bond funds, all subsectors had outflows. Due to its large size, the investment grade sector accounted for the largest dollar outflows at \$89B. In contrast to mutual funds, money market funds saw large inflows of \$688B, with prime funds (which invest in riskier securities) the main exception. Figure 7 graphs the time series of fund flows to assess how abnormal March 2020 was. Panel A shows fund flows as a percent of total net assets, monthly back to 2000M1. The 5.6% outflows in March 2020 were the largest over this sample, but bond funds also faced outflows at the peak of the financial crisis, with outflows of 2.7% of TNA in October 2008. Percentage outflows for hybrid funds in March 2020 were also the largest on record, but these funds had large outflows at the peak of the financial crisis as well, with outflows of 2.4% of TNA in October 2008. Inflows to money market funds in March 2020 were several times the size of any prior percentage inflow. What stood out in the COVID crisis was more the speed than the magnitude of bond fund outflows. Accounting for events moving slower during the financial crisis, Figure 7, Panel B (left) shows that in quarterly data, bond fund outflows were similar as a percent of TNA in 2008Q4 and 2020Q1. Conversely, Figure 7, Panel B (right) shows in weekly data how the bond fund outflows during

⁸ In the interest of space, I do not study the factors underlying the spike in MBS yields in detail. MBS selling was driven by mortgage real estate investment trusts (REITs) who are highly levered investors using repo funding to invest in mortgage-related securities. They faced difficulties during the COVID crisis due to losses on their assets (with increased prepayment risk likely playing a central role), and sold \$124B of agency & GSE backed securities in 2020Q1, reducing their repo funding accordingly. See U.S. Financial Accounts Table FU.129.m and the discussion in Board of Governors of the Federal Reserve (2020).

the COVID crisis were concentrated over just a couple of weeks, with outflows of \$93B in the week ending March 18, 2020 and \$91B in the following week.

5.2 Linking outflows to Treasury sales

The overlapping timing of mutual fund Treasury sales and fund outflows during the COVID crisis does not necessarily imply that the outflows drove the sales. As we have seen (Figure 3), mutual funds did not sell substantial amounts of Treasuries in 2008Q4, despite the fact that this was also a period of large fund outflows. However, three simple arguments (on which I elaborate below) can be made for fund flow to have been a central driver of mutual fund Treasury sales in March 2020. First, in contrast to the financial crisis, funds facing outflows had many more Treasuries to sell. This reconciles the different selling behavior across crises. In order for flows to induce Treasury selling, funds need to have Treasuries to sell. Second, the extent to which funds sold their Treasuries was strongly dependent on whether they had outflows. Third, Treasury sales by fixed income index funds were substantial and are mechanically linked to flows given the indexing.

Providing more detail on each of these arguments, Figure 8 shows the evolution of mutual fund holdings of Treasuries and other bonds over time based on data from the U.S. Financial Accounts. The left graph shows dollar amounts and documents a large increase in mutual fund holdings of corporate bonds, Treasury bonds, and municipal bonds after the financial crisis. Over this period, the supply of corporate bonds and especially of Treasuries grew dramatically, as shown in the middle graph. The right graph illustrates mutual fund holdings as a percentage of the total supply of bonds in a given bond category. There are sharp increases for corporate bonds, Treasury bonds, and municipal bonds, despite the much larger supply of corporates and Treasuries. Falato, Goldstein and Hortacsu (2020) document the increase in total bond fund asset relative to the size of the corporate market. Figure 8 here expands on that fact by showing that increased total bond fund assets led to increased holding not only of corporate bonds but notably also of Treasuries, a central fact for understanding Treasury market dislocations in March 2020. By the end of 2019 funds had lots of Treasuries to sell, with holdings of \$1.311T, more than five times the holdings of just \$173B at the end of 2008Q2 going into the financial crisis. By contrast, when mutual funds had large outflows in 2008Q4 (\$132B across all funds types), they met these outflows by selling agency debt/MBS, municipal bonds, corporate bonds, and equities, with sales of Treasuries of only \$4B (U.S. Financial Accounts, Table FU.122).

Linking mutual fund Treasury sales 2020Q1 to fund outflows, Table 5 studies the relation between Treasury selling, initial Treasury holdings, and fund flows. I use data from the CRSP Survivor-Bias-Free US Mutual Fund Database. I aggregate different share classes for a given fund into one and perform the

analysis at the level of a fund.⁹ I manually code whether a given fund holding is a Treasury security based on security names and include STRIPS securities (but not long positions in Treasury futures since these do not represent ownership of any particular security). I omit exchange-traded funds since the prior analysis reveal large Treasury sales by mutual funds but not ETFs. Panel A documents Treasury holdings and selling in this database. Total Treasury holdings at the end of 2019 were \$1.085T, somewhat lower than the \$1.311T in the U.S. Financial Accounts.¹⁰ Net sales of Treasuries by mutual funds are \$132B in 2020Q1 in the CRSP data are lower than sales of \$266B in the U.S. Financial Accounts. With that qualifier, Panel B decomposes mutual fund Treasury selling in 2020Q1. Consistent with outflows driving Treasury selling, funds with inflows were overall buyers of Treasuries. By contrast, funds with outflows had net sales of \$140B of Treasuries. For funds with outflows, Treasury sales not in excess of outflows amounted to \$103B. As noted, while Treasuries were much less liquid than usual during this time, they were likely still more liquid than most other securities funds held. If funds sold Treasuries first to meet outflows, most Treasury sales may thus have been directly flow-driven.¹¹ For funds with outflows, even sales in excess of the outflows could indirectly be due to outflows in that fund may sell extra to prepare for potential future outflows. Schrimpf, Shim and Shin (2021) document a negative relation between investor flows and funds' change in cash holdings (both as a percent of total net assets) in March 2020 and argue that this is due to managers anticipating possible future outflows. In the context of US funds, my calculations imply that direct flow-driven sales (sales up to outflow) at \$103B were about twice as large as more discretionary sales (sales in excess of outflow) amounting to \$54B, as shown in Table 5, Panel B.

Panel C takes a regression approach to link fund sales of Treasury securities to fund flows. Focusing on funds with positive Treasury holdings at the end of 2019, I estimate the following relation:

$$\begin{aligned}
 & \text{Net purchase of Treasuries}_f^{2020Q1} \\
 &= \beta_0 + \beta_1 * (\text{Treasury holdings}_f^{2019Q4}) * (D[\text{Outflows}_f^{2020Q1}]) \\
 &+ \beta_2 * (\text{Treasury holdings}_f^{2019Q4}) + \beta_3 * (D[\text{Outflows}_f^{2020Q1}]) + \varepsilon_f \quad (2)
 \end{aligned}$$

where $D[\text{Outflows}_f^{2020Q1}]$ is a dummy equal to one for funds with outflows and f denotes a given fund. The coefficient of interest is β_1 which measures whether funds with outflows were more or less likely to sell their Treasuries than funds without outflows. In the baseline regression in column 1, initial Treasury holdings have no explanatory power for flows and neither does the flow dummy itself. However, the

⁹ The CRSP dataset uses the label funds for shareclasses and portfolios for funds. I follow the more standard terminology here.

¹⁰ The Financial Accounts' mutual fund tables are based on data from the Investment Company Institute (ICI). I have unsuccessfully reached out to ICI to reconcile differences across datasets. Total fund outflows are fairly similar across datasets with outflows of \$347B in the CRSP data and \$290B in the ICI data in 2020Q1.

¹¹ See Ma, Xiao and Zeng (2021) for an analysis of funds' liquidation preferences.

interaction term is highly significant. In economic terms, the interpretation of the regression coefficient of -0.180 is that a fund facing outflows sold 18 cents more of Treasury securities per dollar of initial Treasury holdings than a fund with similar Treasury holdings that did not face outflows. Column 1 does not use any weights. In column 2 I show that the coefficient on the interaction term is similar when weighting observations by their initial Treasury holdings (to understand how the typical mutual fund Treasury dollar reacted, as opposed the typical mutual fund). Column 3-5 show that the negative coefficient on the interaction term is present, with similar economic magnitudes, for bond funds (taxable), hybrid funds and equity funds, though not for a smaller set of various other funds in column 6 (these account for only \$27B of initial Treasury holdings). These regressions suggest a link between fund flows and Treasury sales. For bond index funds, this link is even clearer, as funds have little flexibility in what they sell in response to outflows. In the CRSP database, Treasury sales by bond index funds (taxable) in 2020Q1 amount to \$25B.

5.3 Who sold bond funds and why?

As documented in Table 3 and Table 4, Panel A, bond funds faced large outflows and account for the majority of mutual fund Treasury sales.

Who took money out of bond funds? The vast majority of mutual fund redemptions across the overall mutual fund sector were from households. According to the U.S. Financial Accounts (Table FU.122), mutual fund outflows were \$290B in 2020Q1 (a bit smaller than the outflow for March 2020 in Table 3 due to inflows earlier in the quarter). Households including non-profits accounted for almost all of these outflows, withdrawing a total of \$280B from mutual funds in 2020Q1.¹² Separate data by fund type are not available, but based on Investment Company Institute (2020, Table 60), households own over 90% of both equity funds, hybrid funds and bond funds, making it highly likely that the vast majority of bond fund outflows were also from households.

It is unlikely that households sold bond funds mainly because of liquidity needs (even though their fund sales of course led to liquidity needs for the funds). First, the lockdown of the economy was only just starting in March and household increased their investment in money market funds by \$214B over the quarter 2020Q1 in addition to increasing holdings of time and savings deposits by \$346B (U.S. Financial Accounts, Table FU.101). Thus suggests a reallocation towards safer securities as opposed to a liquidity crunch. Second, household sales of mutual funds stopped in 2020Q2 as household mutual fund outflows turned to inflows, despite a sharp deterioration of the economy.

Household sales of mutual funds in 2020Q1 thus appears to be part of a reallocation to safe, short-maturity assets. What is puzzling is that this de-risking involved disproportionate sales of bond funds

¹² The \$280B is comprised of redemptions of \$236B from mutual funds held outside retirement accounts (FU.101) and \$46B from mutual funds held in defined contribution retirement plans (tables FU.118.c, FU.120.c).

compared to stock funds, with March 2020 redemptions from bond funds of 5.6% of total net assets, compared to only 0.4% for equity funds. A possible explanation is what one could refer to as a “disappearing safety effect”. Krishnamurthy and Vissing-Jorgensen (2012) argue that investors are willing to pay extra for very safe and liquid assets. Figure 9, Panel A illustrates the idea. The security price is a decreasing function of default risk but with a higher slope for very low risk, as illustrated by the price lying on the curved segment from A and B, rather than being on the dotted line. Safety effects are described based on default risk (as opposed to duration risk), because the framework addresses yield spreads between similar-maturity bonds with different credit risk. Krishnamurthy and Vissing-Jorgensen (2012) document this effect for Treasuries, showing that yield spreads between Aaa-rated corporate bonds and Treasuries were large, despite Aaa’s having only slightly higher default risk. Furthermore, they showed that changes in Treasury supply is strongly negatively related to the Aaa-Treasury yield spread, thus effectively tracing out a demand curve for the safety/liquidity of Treasuries. They argued that the safety effect was present to some extent also for Aaa corporate bonds, showing that the spread between Baa and Aaa-rate corporate bonds also relates negatively to Treasury supply (a liquidity price premium is less relevant for corporate bonds which all tend to be much less liquid than Treasuries). A possible explanation for large household redemptions from bond funds in 2020Q1 is that these funds initially had safety attributes but lost these as their risk increased. I have indicated this hypothesis with a bond fund sliding down the price-risk curve in Figure 9 Panel A from the top-left green point to the bottom-right green point. In the context of households, a willingness to accept lower yields on investment-grade bonds (beyond what their low credit risk and credit risk pricing for riskier securities would imply) could stem from saved information costs. Investing in an investment-grade mutual fund with low initial risk and daily liquidity does not require a sophisticated understanding of credit risk, but may result in large outflows in response to increased credit risk. The framework applies to the COVID crisis to the extent that the bond funds experiencing withdrawals were funds with low but increasing credit risk. From Table 4 and 5, about half of bond mutual funds (by total net assets) are investment-grade funds and these account for 35% of outflows. Multisector, world and municipal bond funds are harder to classify in terms of credit risk as are government funds which hold Treasuries but also MBS. The literature on safety effects is still relatively new and it is unclear how high default risk needs to be before the safety price premium disappears. Less than 10% of bond mutual funds are high-yield funds that are unlikely to have any safety attributes.

Testing the disappearing safety hypothesis based on flows is difficult. While a disappearing safety attribute may be one reason for mutual fund withdrawals, households may also reallocate funds out of bonds that had lost their safety attribute even before COVID but now became even riskier (high-yield funds). Instead, I provide evidence from asset prices that is consistent with the nonlinearity in the price-credit risk relation from Figure 9, Panel A. In Figure 9, Panel B, I graph corporate bond yield spreads over 5-year

Treasury yields and 5-year credit defaults swap rates for corporate bonds. Investment grade bonds are illustrated in the left graph and high yield bonds in the right graph. The yield spread for investment grade bonds increases much more than one-for-one with the investment-grade CDS rate, consistent with the nonlinearity of the safety demand framework. By contrast, for high yield bonds, the yield spread and CDS rates move by similar amounts, consistent with such bonds not having a safety attribute.¹³ Table 6 presents results from regressing corporate bond yield spreads on CDS rates. For 2020H1, the regression coefficient for investment grade bonds is 2.6, much above one and thus consistent with such bonds sliding down the price-default risk curve describing the safety effect. By contrast, the regression coefficient is close to one for high yield bonds. Results are similar for a longer period going back to 2013 (with the sample length determined by data availability).

6. Drivers of Treasury selling by foreigners in 2020Q1

Turning to sales by the rest of the world, I decompose these into foreign official sales and private sales. I then study drivers of Treasury sales by each of these groups.

6.1 Foreign official and foreign private Treasury sales

Foreigners sold \$287B of Treasuries in 2020Q1 thus exceeding even the large Treasury sales by mutual funds. To start understanding possible drivers of this selling, Table 7 decomposes foreign sales into sales by foreign official agencies (including foreign governments and central banks) and foreign private sales.¹⁴ About 2/3 of Treasury sales were from foreign official agencies and 1/3 from the foreign private sector. The data used in the table is from the Bureau of Economic Analysis (BEA). For a given asset class, the BEA calculates foreign net purchases of US securities from changes in holdings (using Treasury International Capital (TIC) data), combined with assumptions about returns earned on the asset category. The assumed return is based on a combination of market indices, weighted to account for the portfolio composition of foreign holdings (known from reporting in the TIC data, including information about maturity structure). This approach to calculating foreign net purchases from TIC holdings data is preferable to using TIC data on transactions. As described by Bertaut and Judson (2014), the TIC transactions data are recorded according to the country of the first cross-border counterparty, not the country of the ultimate buyer or seller (or issuer) of the security. This leads to a bias toward financial centers in the transactions data. Importantly, the TIC transactions data gives the opposite (and incorrect) conclusion about the relative importance of foreign official and foreign private sales since foreign official agencies accounted for only \$83B of total net foreign sales of \$280B in the transactions data.

¹³ Haddad, Moreira and Muir (2020) also document corporate bonds spreads and CDS rates but do not link these to a disappearing safety effect.

¹⁴ I thank Carol Bertaut from the Board of Governors of the Federal Reserve for help with this table.

6.2 Foreign official agencies' holdings and portfolio changes

Focusing on foreign official agencies, Table 8 Panel A documents how their portfolio of U.S. holdings changed from just before the financial crisis to just before the COVID crisis. Like mutual funds, foreign official agencies increased their reliance on Treasuries. Their total U.S. holdings increased by about \$3T of which \$2.1T was an increase in Treasury holdings. The portfolio weight for Treasuries increased from 45% to 56.3%.¹⁵ Equity and investment fund shares increased by \$0.9T, likely via sovereign wealth fund investments since most central banks do not hold stocks. Table 8, Panel B documents net purchases of U.S. assets overall and by asset class. Foreign official agencies had net sales of \$51B overall, suggesting that their sales of Treasuries was partly motivated by a need for dollars for foreign exchange intervention. Currency and deposits increase by \$60B, likely in expectation of possible future need for cash. Of the total Treasury sales by foreign official agencies of \$182B, the \$111B (\$51B plus \$60B) are thus likely due to liquidity needs. A smaller part was used to reallocate portfolios toward higher yielding assets, with purchases of \$43B of mortgage-related securities and corporate bonds and purchases of \$36B worth of equities and investment fund shares.

As described above, foreigners did not sell Treasuries at the peak of the financial crisis in 2008Q4. In fact, they purchased \$278B worth of Treasuries in that quarter. Table 8, Panel B shows that this was driven mainly by purchases of \$214B of Treasuries by foreign official holders, almost all Treasury bills. This was funded by large sales of long and short-term agency securities for a total of \$174B. The contrast between large foreign official Treasury purchases in 2008Q4 and large foreign Treasury sales in 2020Q1 thus appears to be driven by a combination of factors: (1) a larger cash need in 2020Q1, leading to net sales of U.S. holdings overall, (2) increased reliance on Treasuries in foreign portfolios, resulting in sales of Treasuries rather than mortgage-related securities in the face of liquidity needs, (3) “precautionary” reallocations going into currency and deposits in 2020Q1 rather than Treasury bills in 2008Q4, and (4) Treasury sales for return-seeking purposes in 2020Q1.

6.3 Insights into foreign private sales from the cross-section of countries

To gain insights into the \$105B of foreign private Treasury sales, it is informative to study the cross-section of countries. In Appendix Table 1, I document Treasury holdings and net purchases by country for foreign and private holders combined (country-level data does not distinguish between these two groups). I calculate net purchase of Treasuries in 2020Q1 from the change in holdings from 2019Q4 to 2020Q1 and assumed returns. The table is based on Treasury International Capital (TIC) data, which has some information about maturity composition, dividing Treasury holdings into securities with below one year

¹⁵ As a percent of total Treasuries outstanding, the foreign official agency share decreases since Treasury supply increased by a factor of three over this period.

maturity and securities above one year maturity. I use the return on Bloomberg Barclays Treasury Indices for these two maturity groups for 2020Q1.¹⁶ Appendix Table 1 also tabulates the changes currency reserves using IMF data.

The largest seller is China, selling \$75.9B, partly driven by a \$42.4B reduction in reserves. Brazil and Saudi Arabia also have large sales and large reductions in reserves. However, the Cayman Islands, Ireland and Luxembourg have large Treasury sales, despite changes in reserves close to zero. These three countries are domiciles for a large part of the world's hedge funds. According to U.S. Securities and Exchange Commission (2020), 51.4% of US hedge fund assets were domiciled in the US at the end of 2019, while 34.6% were domiciled Cayman Islands, 4.6% in Ireland, 3.2% in Luxembourg, and just above 1% in each of British Virgin Islands and Bermuda. For European hedge funds, Prequin (2017) states that 56% of European hedge funds are domiciled in Luxembourg and 26% in Ireland. Large sales from countries that are domiciles for large hedge fund assets suggest that hedge fund Treasury selling was a driver of the \$105B of foreign private Treasury sales. Figure 10 shows a cross-country scatter plot of foreign net purchase of Treasuries in 2020Q1 against the change in reserves in 2020Q1. The relation is positive, consistent with FX intervention being one motive for foreign official Treasury sales, but the large sales by the Cayman Island, Ireland and Luxembourg are also visible. The United Kingdom is an outlier with purchases of \$49.7B despite little change in reserves. The UK purchases are driven by purchases in January 2020, prior to the official Brexit data of January 31, 2020 and thus unrelated to the COVID crisis. Table 9 takes a regression approach to assess magnitudes and statistical significance, regressing net purchases on the change in reserves and a dummy for hedge fund domiciles. Both are significant with changes in reserves translating about one-for-one to net purchases of Treasuries and hedge fund domiciles selling about \$17B more each, on average.

7. Hedge fund Treasury sales

Barth and Kahn (2020) and Schrimpf, Shin and Sushko (2020) discuss the unwind of levered hedge fund trades in March 2020. The trade most discussed is the Treasury basis trade. The trade seeks to profit from price difference between Treasury securities (“cash” Treasuries) and Treasury futures. When futures are expensive relative to cash Treasuries, the basis trade consists of a short position in the Treasury future (promising delivery of one of the eligible Treasury securities in return for cash) and a long position in a Treasury security that can be delivered into the futures contract (the cheapest to deliver among those eligible). The long position is typically financed using repo financing. The trade is often highly levered to increase returns. Barth and Kahn (2020) document the increased popularity of this trade especially since

¹⁶ The return is 0.841% for securities with below one year maturity (Bloomberg variable LT12TRUU) and 8.20% for securities with above one year maturity (Bloomberg variable LUATTRUU).

2018 and the unwind of the trade in the COVID crisis (measured based on the evolution of short futures positions by leveraged investors). As the COVID crisis intensified in March, the difference between futures and cash prices widened, with futures becoming even more expensive relative to cash Treasuries than before the COVID crisis. That led to losses on the basis trade and a need for increased margin to be posted. As a result, many hedge funds unwound their basis trades. This would be expected to lead to a sale of Treasury securities to close out the repo borrowing.

The literature does not provide an estimate of how many Treasuries hedge funds may have sold as a result of the unwind of levered trades. In Table 10, I estimate Treasury sales by hedge funds of \$183B in 2020Q1. This number covers hedge funds that report to the Security Exchange Commission (SEC) whether foreign domiciled or domiciled in the U.S. Hedge funds with at least \$150 million in private fund assets under management must report to the SEC on Form PF. Funds domiciled abroad must report if they have U.S. investors. Form PF asks filers for total long and short Treasury exposure, combining exposure from cash Treasuries and derivatives (including futures). The Form PF data are not publicly available but total long Treasury exposure can be extracted from Figure 61 of Office for Financial Research (2020) and is shown in the first row in Table 10. Futures positions are available from the CFTC's Commitment of Traders reports. Subtracting long futures positions for total long exposure, I estimate hedge funds held Treasuries worth \$991B at the end of 2019Q4 and \$889B at the end of 2020Q1. Assuming a return equal to that on the Bloomberg Barclays Treasury Indices for Treasury securities with >1 year remaining maturity (8.2% for 2020Q1), I estimate that hedge fund net purchases of Treasuries were $991 - 1.082 * 889 = -\$183B$ in 2020Q1. Hedge funds sales by domestic and foreign (mainly Cayman Islands) funds reporting to the SEC are thus large enough to account for around 60% of the combined sales by the foreign private sector \$105 and the US household (including US hedge fund) sector of \$194B. Given the fact that only hedge funds selling to US investors report to the SEC, total hedge fund selling is likely larger than the \$183B. The \$183B estimated Treasury sales are larger than the reduction in short Treasury futures positions of \$127B, suggesting that levered trades other than the Treasury basis trade may have been relevant, perhaps related to risk-parity trades (see European Central Bank (2020)).

There is a debate in the literature about whether Treasury selling by hedge funds had substantial pricing implications. Schrimpf, Shin, and Sushko (2020) document the price dislocation of cash Treasuries relative to futures, with cash Treasuries being cheap relative to futures. However, Barth and Kahn (2020) (and my earlier regression evidence in Table 1) show that prices of the securities that were cheapest to deliver (CTD) into futures contracts were abnormally *high* at the peak of the COVID crisis in March, the opposite of what one may expect from large-scale liquidation of these particular securities.

In my view it is likely that hedge fund Treasury sales did materially contribute to the peak in Treasury yields from March 9 to 18, despite the CTDs securities having low yields. While the Treasury market

became less liquid during this period, it is likely that many of traders and dealers were still trying to exploit any relative mispricing along the yield curve. To the extent that the Treasury market remained an integrated market, as opposed each security trading in a segmented market, one would expect hedge fund Treasury selling simply to add to the negative demand shock from mutual funds and foreign official agencies, and thus the yield spike. The lower yields on the CTD Treasury securities reflect the fact that they have the added attribute of being the most advantageous to own/buy for those with short futures positions.

8. Conclusion and policy discussion

The paper has studied the spike in Treasury yields in March 2020, arguing that it was not driven by higher expected inflation or government credit risk but rather a negative demand shock from several groups of investors with urgent liquidity needs: Mutual funds facing outflow, foreign official agencies needing to reduce their currency reserves and reallocate them toward cash in preparation for additional future cash needs, and hedge funds unwinding levered trades. The Federal Reserve's purchases of Treasury securities in just one quarter exceeded its Treasury purchases that in each of its prior QE programs and were concentrated over a short period of just a couple of weeks. These purchases were central for reversing the yield spike, providing liquidity to a market much in need of it. The fact that large Federal Reserve Treasury purchases were needed to reverse the yield spike lines up with my interpretation that the spike was driven by a large negative demand shock from some groups of holdings. A key lesson from this experience is that market-functioning Treasury QE appears to affect asset prices upon purchase more than upon announcement. If announcing purchases does not affect liquidity needs, it takes large actual purchases to stabilize markets. I contrast this with the Fed's corporate bond purchases programs during COVID where announcements stemmed outflows from mutual funds and thus reduced liquidity needs, resulting in few actual purchases being necessary.

With sharply increasing Treasury debt, there is a risk of more frequent Treasury market dislocations. Will the Federal Reserve be able to stabilize the Treasury market even on a very large scale? This requires the banking sector to absorb correspondingly large amounts of reserves, which could affect bank lending, an issue that was less relevant during COVID due to large deposit inflows for banks. Another possible issue is whether the Federal Reserve can commit to intervening in the Treasury market only in response to liquidity shocks, as opposed to in times with yield spikes due to increased expected inflation or credit risk in Treasuries.

Various ideas have been put forward that may reduce the need for Federal Reserve intervention. To improve liquidity supply, Duffie (2020) argues for central clearing to reduce the need for broker-dealer (and Fed) balance sheet space. Liang and Parkinson (2020) propose that reserves be permanently omitted from supplementary leverage ratio calculations to increase banks' ability to absorb assets sold by others in times of market stress. To reduce liquidity demand (Treasury selling) in times of stress, Falato, Goldstein,

and Hortacsu (2020) mention the possible use of swing pricing to reduce run dynamics at mutual funds by penalizing investors for withdrawing when many other investors withdraw. Other possibilities include making the repo facility for foreign central bank introduced in March permanent (in order to reduce Treasury selling during crisis), or addressing high leverage of hedge funds.

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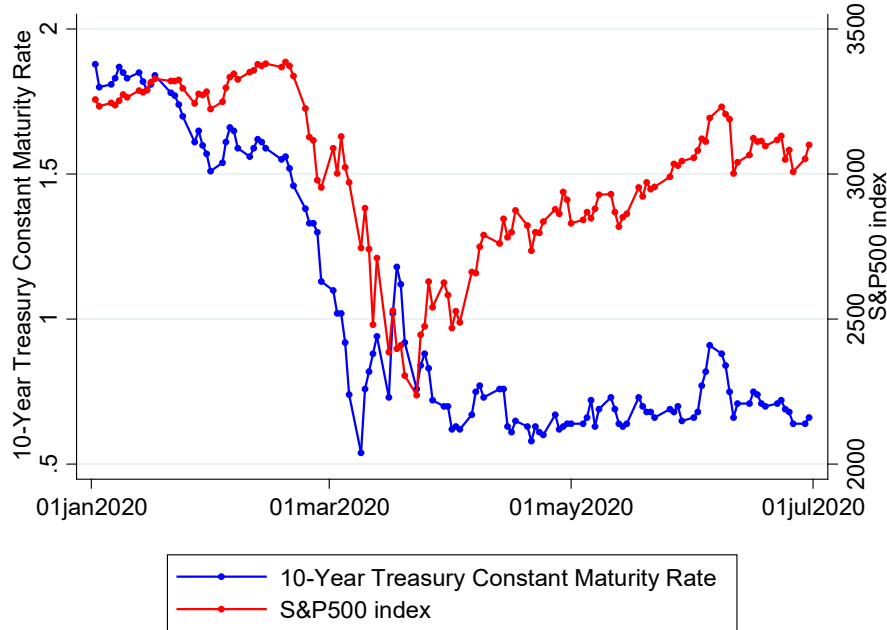
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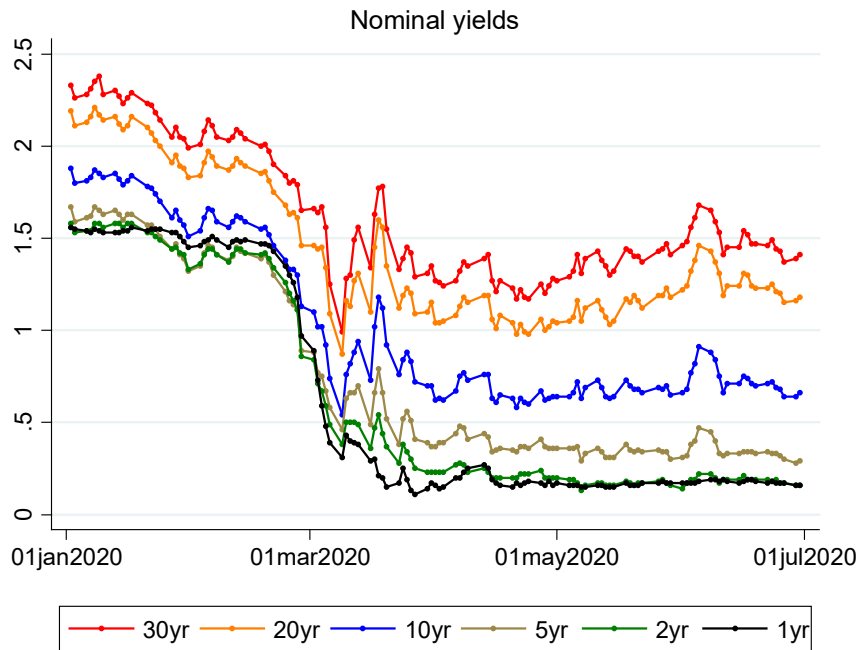
Figure 1. Treasury yields

Treasury yields and the S&P500 index are from the Federal Reserve's FRED database. Inflation swap and credit default swap rates are from Bloomberg.

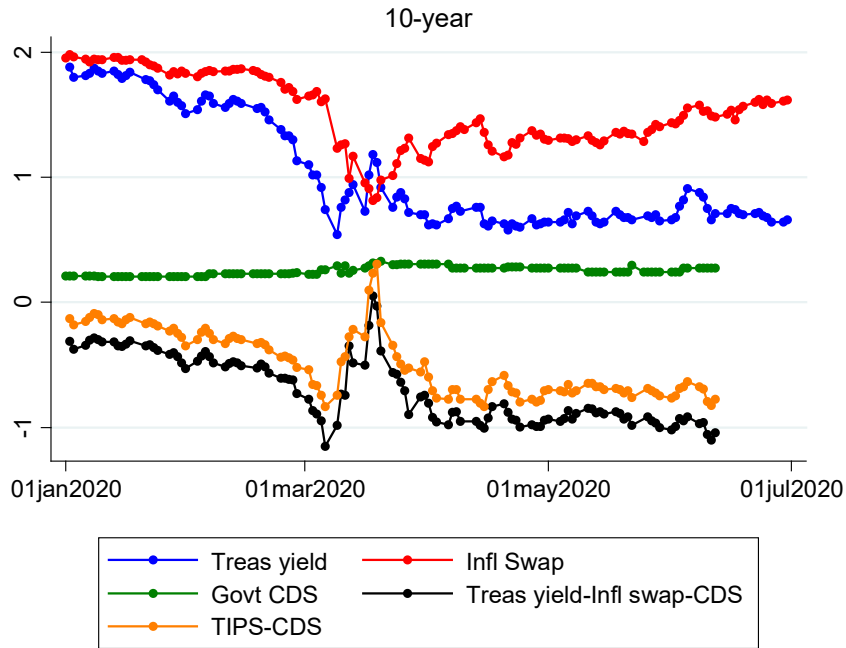
Panel A. Treasury yields spiked in mid-March as the S&P500 index kept falling



Panel B. Treasury dislocations were mostly in longer yields



Panel C. Yield spike driven by higher real yield, not expected inflation or credit risk



Panel D. Comparison to 2008

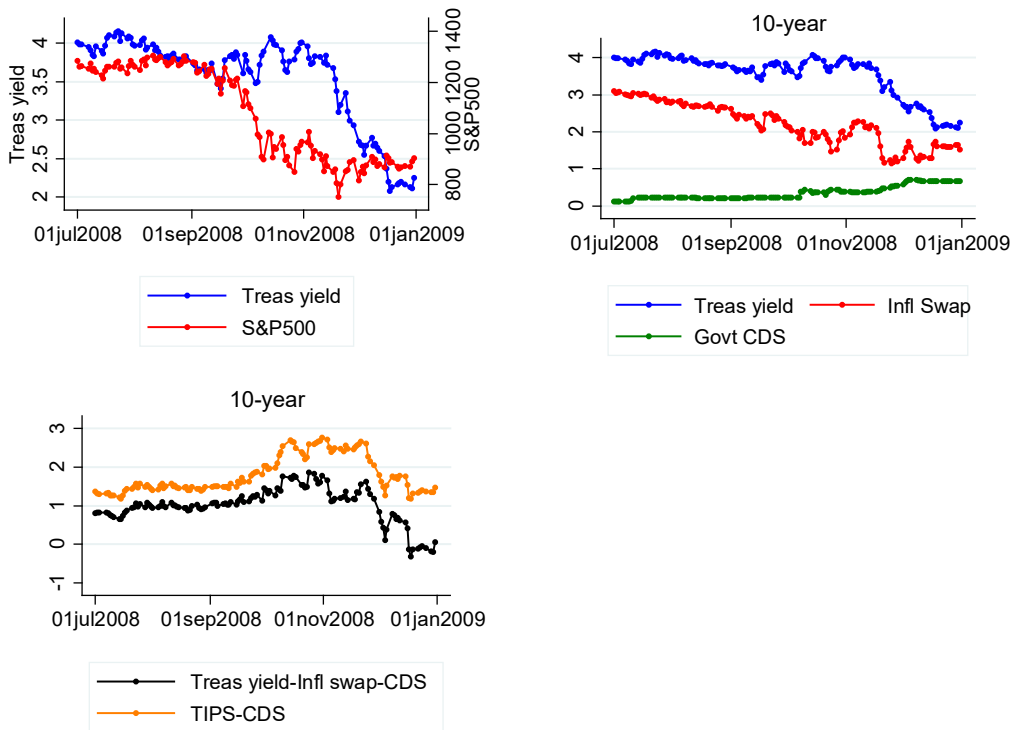
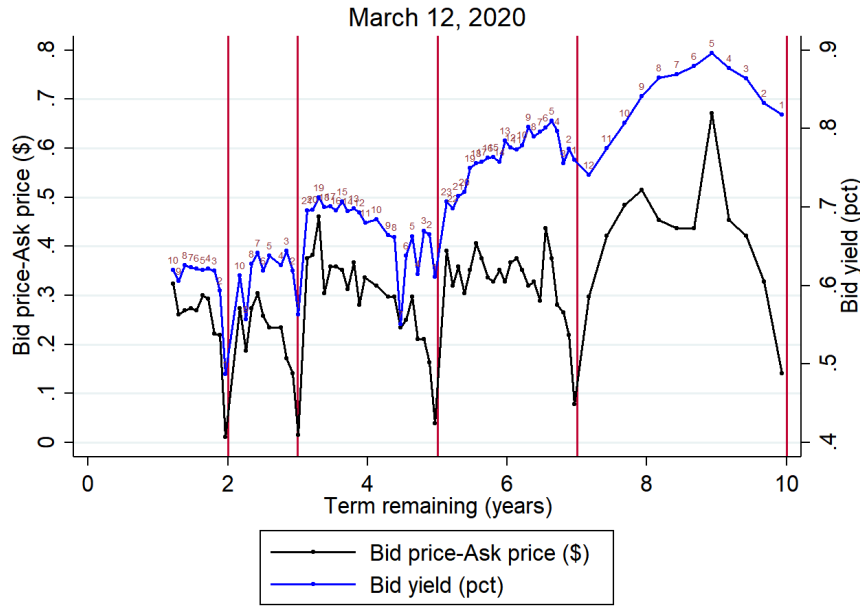


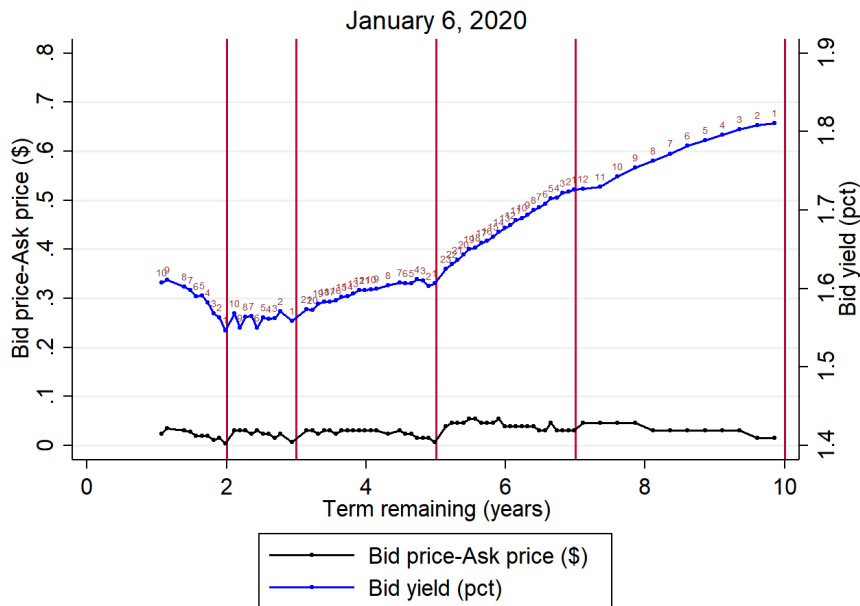
Figure 2. Cross section of Treasury yields and bid-ask spreads

The figure is based on data from Bloomberg. Sample graphed: Bonds with 1 to 10 year maturity that are still in the same maturity bucket they were issued in (e.g., 10-year bonds with remaining term of at least 7 years). Blue line label: Age rank within maturity bucket, 1=on-the-run, 2=first off-the-run etc.

Panel A. March 12, 2020



Panel B. January 6, 2020



Panel C. Illiquidity component of yields implied by cross-sectional price of illiquidity and time series of bid-ask spreads

The illiquidity component of the bid yield is in percent. It is estimated as 0.213 times the bid-ask spread (in \$ per \$100 face value). The factor 0.213 is from Table 1, column 1. The vertical lines indicate March 9 and March 18, 2020.

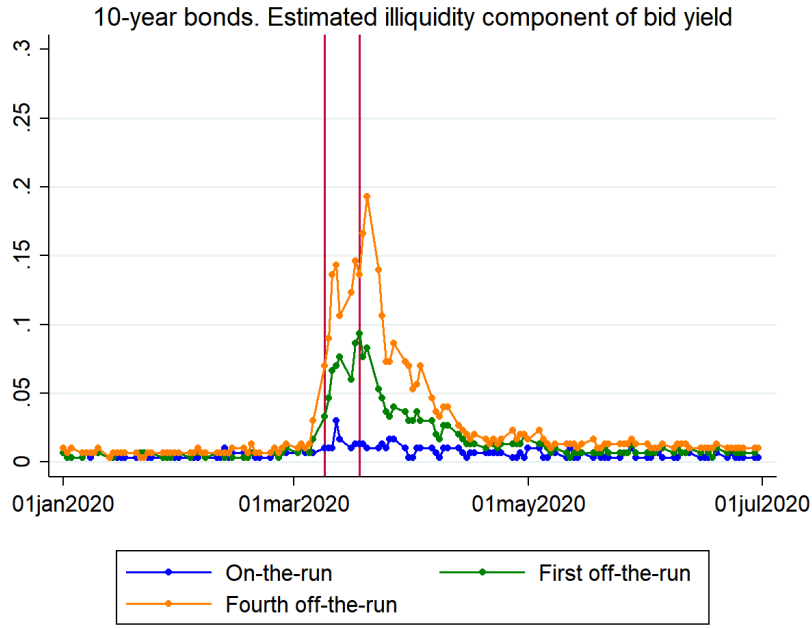
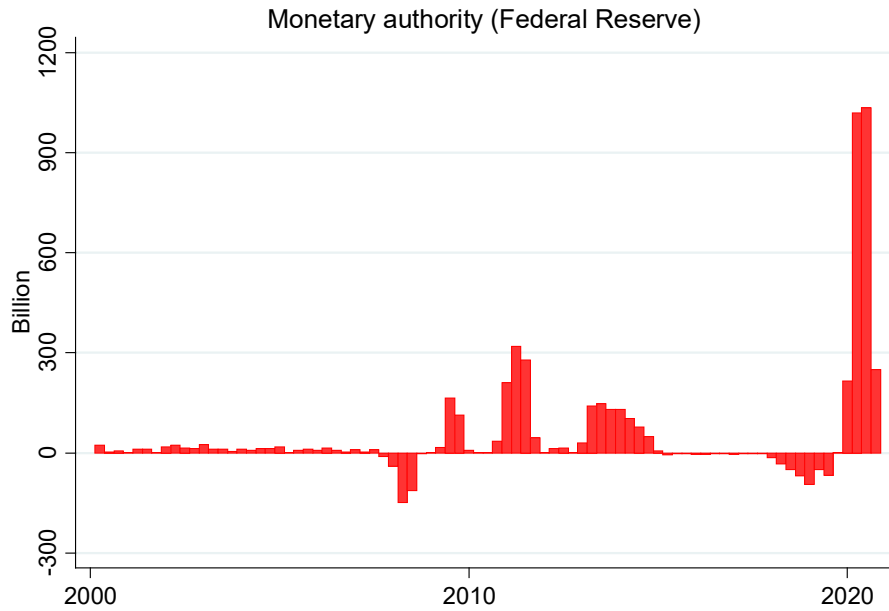


Figure 3. Quarterly net purchases of Treasuries, 2000Q1-2020Q3, U.S. Financial Accounts

Source: U.S. Financial Accounts, Table FU.210 (not seasonally adjusted), December 2020 data release.

Panel A. Net purchases by the Federal Reserve



Panel B. Net purchases by the sectors with the largest sales in 2020Q1

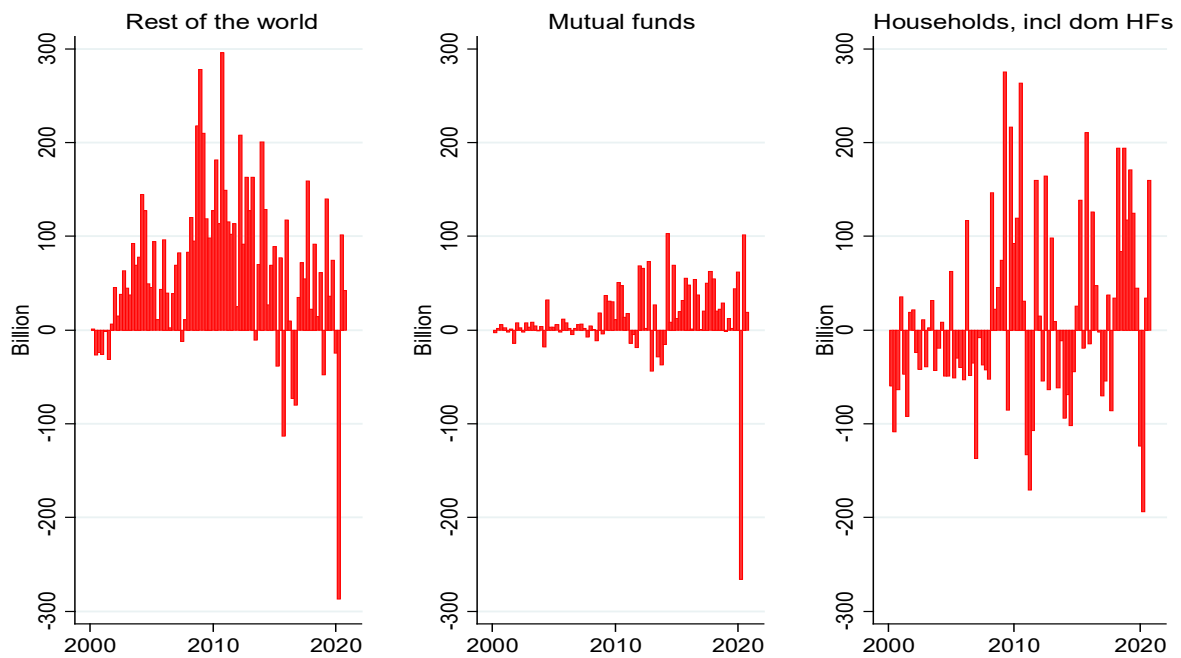
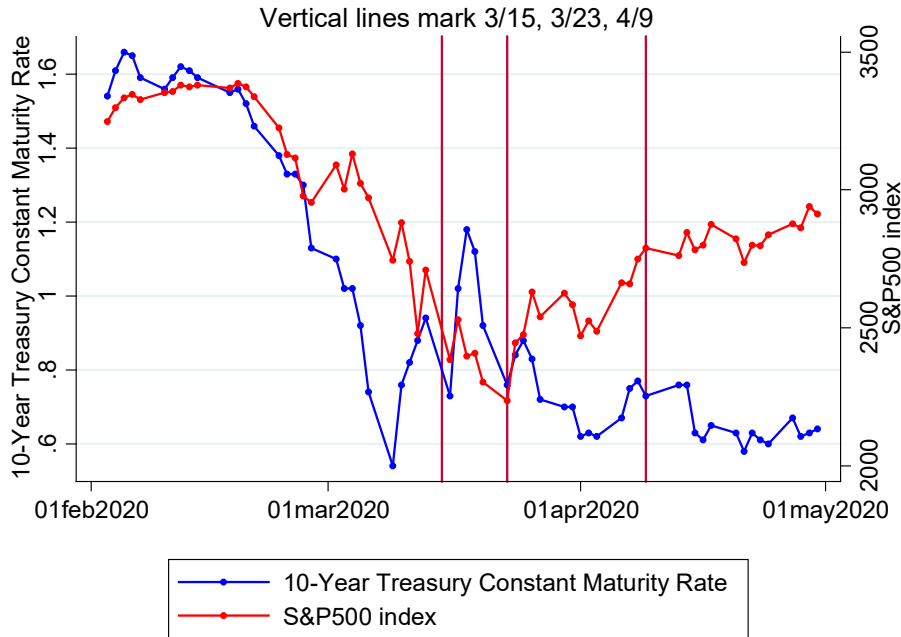


Figure 4. Federal Reserve purchase effects on the Treasury market

Panel A is similar to Figure 1, Panel A, but adds vertical lines to indicate the three Federal Reserve bond purchase announcements during the COVID crisis. Panel B lines up the timing of the Treasury yield reversal to the size of Federal Reserve Treasury purchases, using data from the Federal Reserve Bank of New York.

Panel A. Treasury yields and S&P500



Panel B. Daily Fed Treasury purchases and 10-year Treasury yield

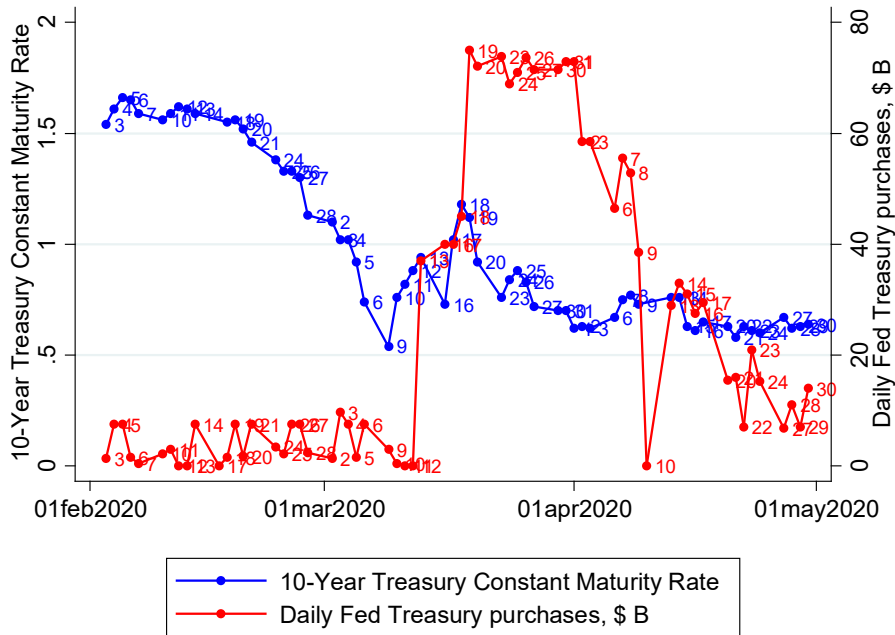
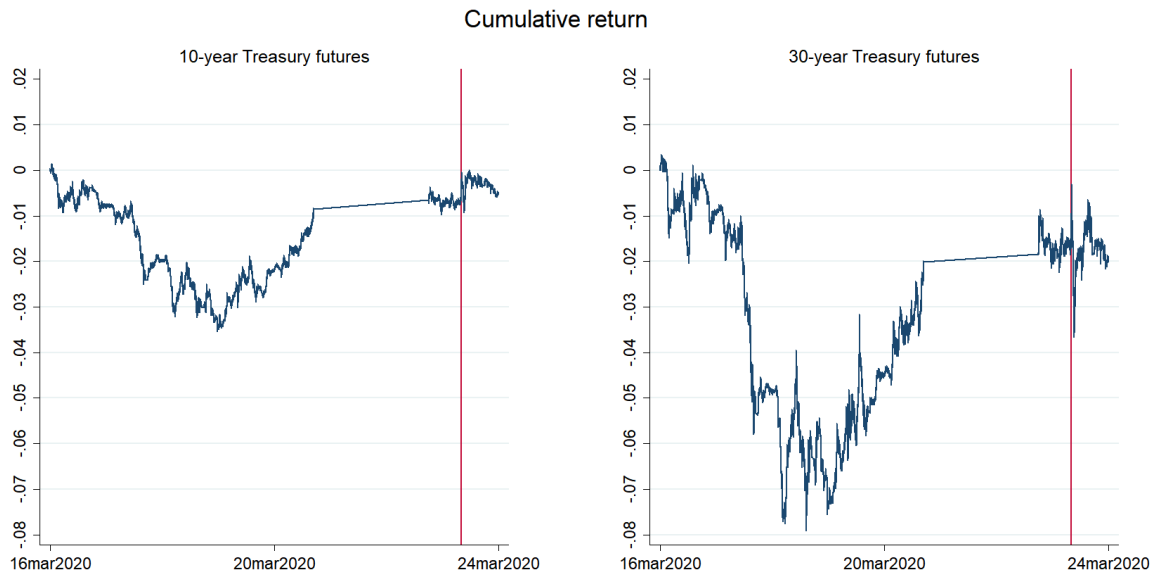


Figure 5. QE announcement effects on yields

Panel A graphs the cumulative return on 10-year and 30-year Treasury futures (with data from kibot.com) from March 16 to 23, measured from the start of the day on March 16. The vertical lines indicate the March 23, 8 a.m. Federal Reserve announcement. Panel B graphs the 10-year Treasury yield around the March 18, 2009 Federal Reserve QE announcement (the figure source is Krishnamurthy and Vissing-Jorgensen (2011)).

Panel A. Treasury futures, minute-level data, March 16 to March 23



Panel B. 10-year Treasury yield around March 18, 2009 QE announcement

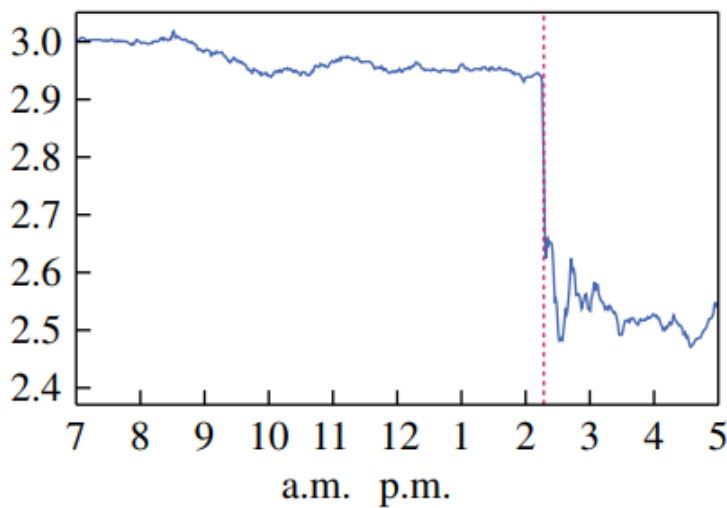
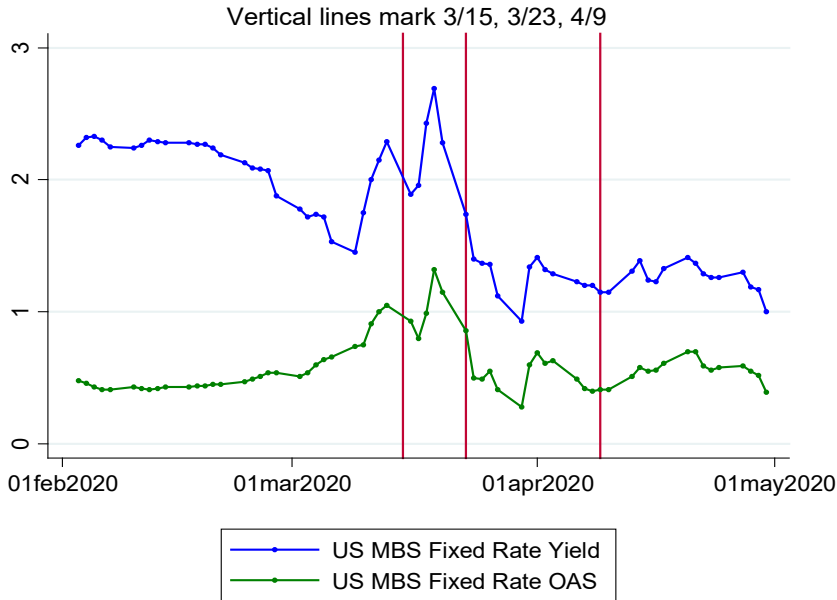


Figure 6. Federal Reserve purchase effects on the MBS market

Panel A graphs the MBS yield and OAS using data from Bloomberg. Panel B lines up the timing of the MBS yield and OAS reversals to the size of Federal Reserve MBS purchases, using data from the Federal Reserve Bank of New York.

Panel A. MBS yield and option-adjusted spread



Panel B. Daily Fed MBS purchases and MBS option-adjusted spread

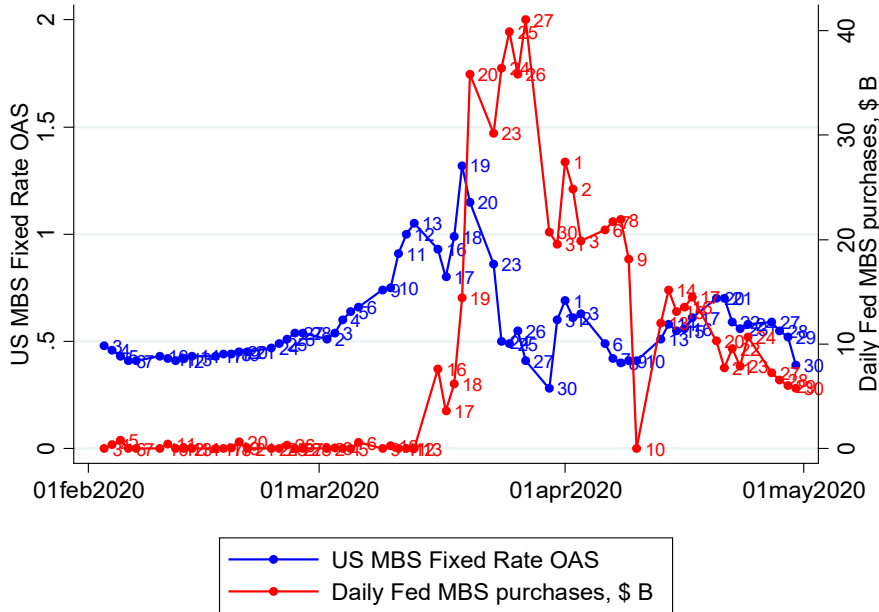
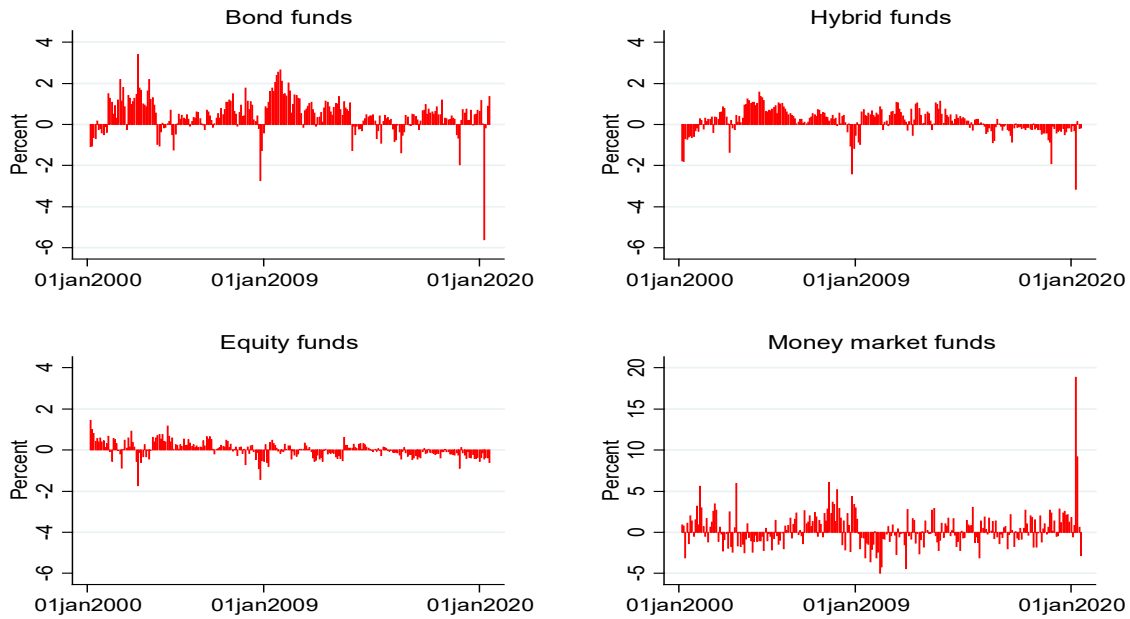


Figure 7. Mutual fund flows

Source: Investment Company Institute data downloaded from Bloomberg. Flow (net new cash flow) is defined as new fund sales less redemptions plus net exchanges.

Panel A. Mutual fund flows as percent of total net assets, monthly, 2000M1-2020M6



Panel B. Measures of bond fund flows

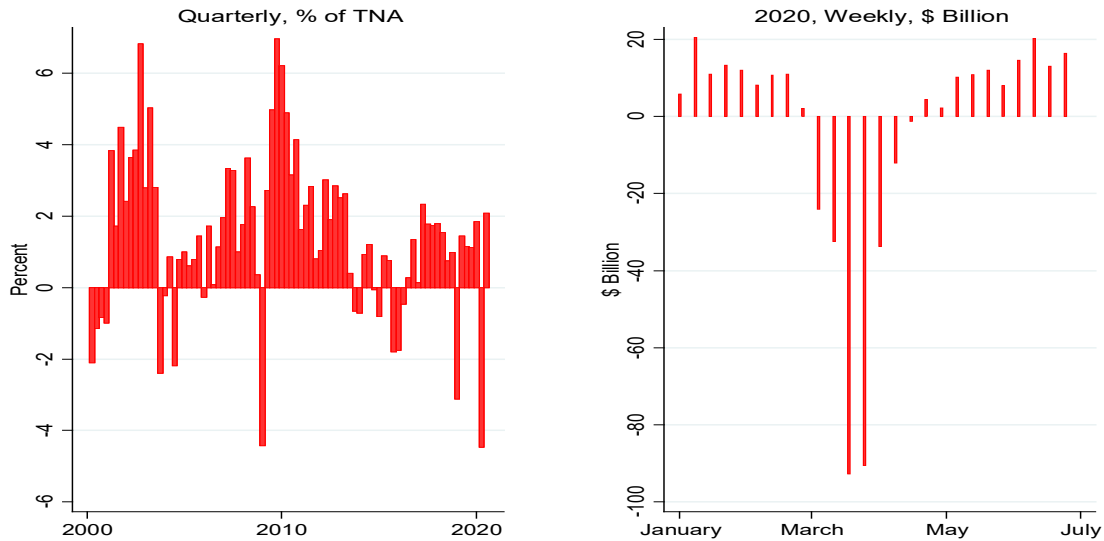


Figure 8. Mutual fund Treasury and other bond holdings

Data are from the U.S. Financial Accounts, Table L.122 and L.208.

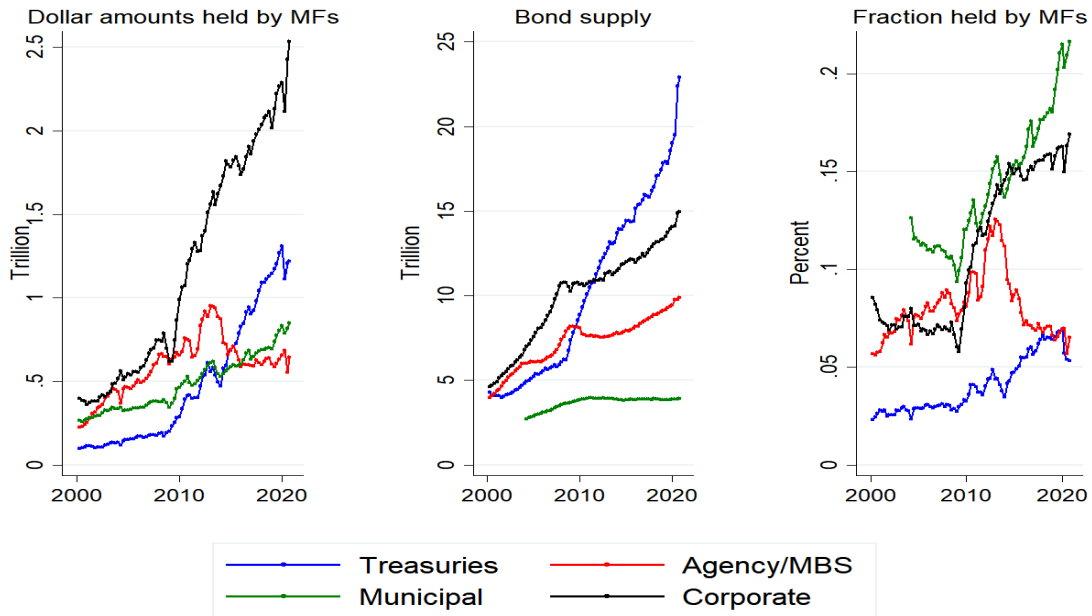
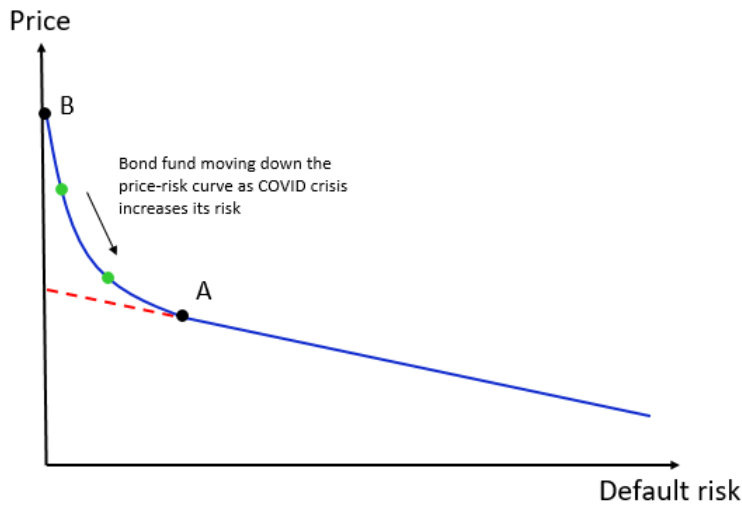


Figure 9. Safety effects

Panel A. The safety effect of Krishnamurthy and Vissing-Jorgensen (2012)



Panel B. Corporate bond yield spreads and CDS rates

The figure shows yield spreads of corporate bond yields over Treasuries to credit default swap (CDS) rates on corporate bonds. Data for the investment grade and high yield corporate bond indices are from the Federal Reserve’s FRED database as are Treasury yields (I use the 5-year Treasury yield to approximately match the duration of the corporate bond indices). CDS rates are from Bloomberg and refer to the 5-year maturity.

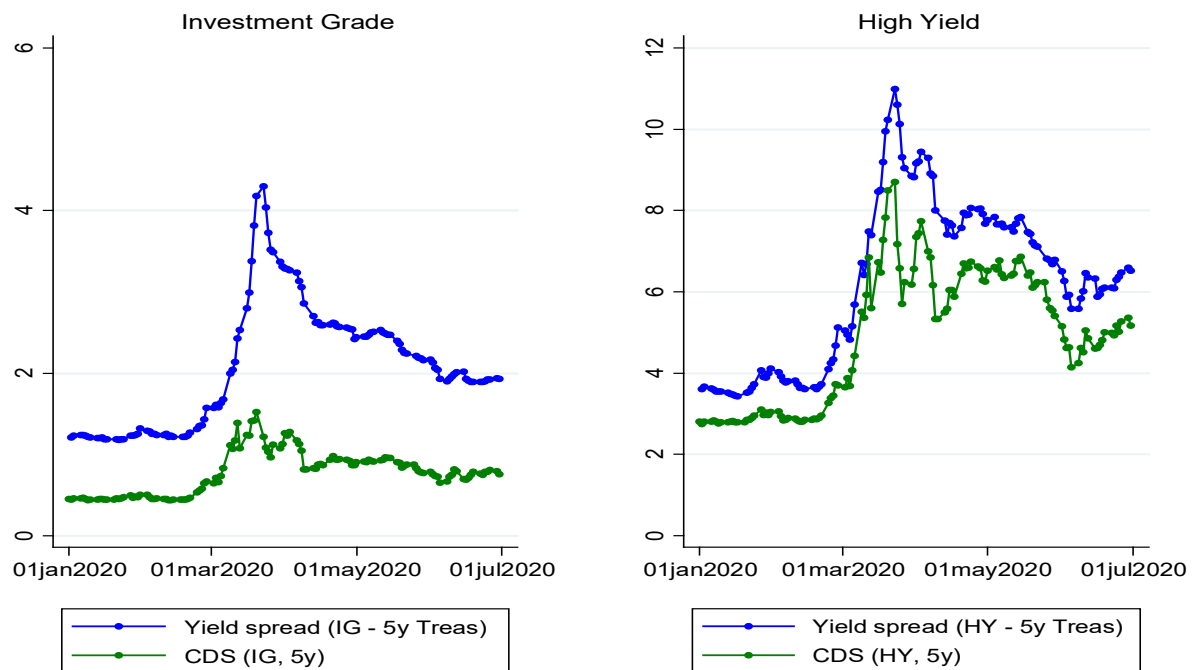


Figure 10. Relating foreign Treasury sales to currency reserves

Net purchases by country are for both official and private holders. Data sources are as for Appendix Table 1. Some country labels are omitted for readability.



Table 1. The cross-section of Treasury yields

This table is based on data from Bloomberg. Sample used: Bonds with 1 to 10 year maturity. CTD stands for cheapest to deliver. t statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01.

	Dept. var.: Bid yield (pct)				January 6, 2020
	March 12, 2020				
	(1)	(2)	(3)	(4)	
Bid-ask spread (\$ per \$100 face value)	0.213*** (4.42)	0.299*** (11.03)		0.269*** (8.98)	0.235* (1.70)
D(On the run)			-0.0919*** (-6.52)	-0.00876 (-0.59)	
D(1st off the run)			-0.0349** (-2.44)	0.00539 (0.43)	
D(2nd off the run)			-0.0266** (-2.05)	0.00369 (0.33)	
D(3rd off the run)			-0.0269** (-2.10)	-0.00669 (-0.62)	
D(4th off the run)			-0.00525 (-0.41)	-0.00762 (-0.72)	
D(CTD in 2yr futures contract)		-0.194*** (-7.07)	-0.167*** (-7.30)		
D(CTD in 5yr futures contract)		-0.142*** (-5.13)	-0.120*** (-5.19)		
D(CTD in 10yr futures contract)		-0.101*** (-3.64)	-0.0811*** (-3.52)		
D(CTD in ultra 10yr futures contract)		-0.0376	-0.0277 (-1.10)	(-0.98)	
Coupon	0.0173** (2.13)	0.00124 (0.28)	0.00686 (1.49)	0.00166 (0.43)	0.0007 (0.28)
Constant, Term, Term ² , Term ³ included	Yes	Yes	Yes	Yes	Yes
N (securities)	76	186	186	186	76
R-squared	0.908	0.855	0.862	0.906	0.989

Table 2. Ownership of US Treasuries, US Financial Accounts

Column 1-3 shows amounts held based on table L.210 in the U.S. Financial Accounts. Column 4 shows ownership changes (flows) and is based on table FU.210. Data is from December 2020 release of the U.S. Financial Accounts.

	(1) Holdings 2019Q4	(2) Holdings 2020Q1	(3) Holdings change 2020Q1-2019Q4	(4) Net purchase 2020Q1
			\$B	
Total liabilities	19,019	19,518	500	500
Total assets	19,429	20,740	1311	500
Discrepancy	410	1,221	811	0
Sectors buying Treasuries in 2020Q1				
Monetary authority (Federal Reserve)	2,541	3,757	1,217	1,019
Money market funds	1,037	1,268	231	231
Exchange traded funds	214	263	49	21
Nonfinancial corporate business	48	69	21	17
Government sponsored enterprises	171	186	14	14
State and local governments	837	902	65	13
Life insurance companies	215	117	-98	11
Private pension funds	421	464	43	8
Property casualty insurance companies	153	169	15	6
Federal government retirement funds	2,150	2,157	6	5
U.S. chartered depository institutions	704	724	20	3
Sectors selling Treasuries in 2020Q1				
Rest of the world	6,691	6,950	259	-287
Mutual funds	1,311	1,114	-197	-266
Household sector, incl. hedge funds	1,971	1,520	-451	-194
State and local government retirement funds	368	352	-16	-50
Brokers and dealers	230	258	29	-19
Foreign banking offices in U.S.	121	116	-5	-15
Holding companies	58	54	-4	-9
Banks in U.S. affiliated areas	17	15	-2	-3
Credit unions	38	39	1	-2
Nonfinancial noncorporate business	79	84	5	-1
ABS issuers	33	32	-1	-1
Closed end funds	3	3	-1	-1

Table 3. Federal Reserve announcements in March and April, 2020

Date	Announcement	Detail
3/3, 10 a.m.	Federal funds target lowered 50 bps to 1-1.25%	
3/15, 5 p.m.	At least: \$500B Treasury purchases, \$200B MBS purchases Federal funds target lowered 100 bps to 0-0.25% Primary credit rate lowered 150 bps to 0.25% Rate on dollar swap lines lowered 25 bps to OIS+0.25%	Discount window borrowing encouraged BoC/BoE/BoJ/ECB/SNB are counterparties
3/17, 10:45 a.m.	Commercial Paper Funding Facility (CPFF) restarted	Buying 3-month A1/P1 commercial paper \$10B credit protection from Treasury
3/17, 6 p.m.	Primary Dealer Credit Facility (PDCF) restarted	Up to 90 day borrowing at primary credit rate
3/18, 11:30 p.m.	Money Market Mutual Fund Liquidity Facility (MMLF)	Lends funds to banks to buy assets from prime money market funds Up to 1-year. \$10B credit protection from Treasury
3/19, 9 a.m.	Temporary dollar liquidity arrangements w/other central banks	
3/20, 10 a.m.	Dollar swap lines goes from weekly to daily operations	
3/20, 11 a.m.	MMLF expanded to municipal bonds	
3/23, 8 a.m.	Unlimited Treasury and MBS purchases \$300B in lending via: 1. Primary market (PMCCF), secondary market (SMCCF) corporate bond facilities 2. Term Asset-Backed Securities Loan Facility (TALF) 3. CPFF, MMLF expanded with more muni debt 4. Main Street Lending Program (MSLP), details to be announced	Agency CMBS now included in MBS purchases \$30B credit protection from Treasury Corporate bond purchases: Investment grade issuers only Fed lending against AAA-rated ABS
3/31, 8:30 a.m.	Repo facility for foreign and international monetary authorities	Objective: To support Treasury (and other) markets
4/1, 4:45 p.m.	Change to Supplementary Leverage Ratio (SLR) for banks	Treasuries and reserves now excluded from SLR
4/6, 2 p.m.	Fed will provide term financing backed by PPP loans	
4/9, 8:30 a.m.	Corporate bond purchases (plus TALF) expanded Main Street Lending Program Municipal Liquidity Facility (MLF)	Up to \$850B, \$85B credit protection. Fallen angels added. Up to \$600B, \$75B credit protection Up to \$500B, \$35B credit protection
4/27, 4/30	Term sheets updated for MLF, MSLP, PPPLF	

Table 4. Mutual fund and money market fund flows, by fund type

The table is based on data from the Investment Company Institute. Flow (net new cash flow) is defined as new fund sales less redemptions plus net exchanges. Monthly data frequency.

Type of fund	Total net assets (TNA), end of Feb 2020, \$B	Net new cash flow, March 2020	
		\$B	% of Feb 2020 TNA
Equity mutual funds	10,381	-46	-0.4
Hybrid mutual funds	1,500	-47	-3.1
Bond mutual funds	4,581	-257	-5.6
Inv. grade (govt, MBS, corp, ABS etc.)	2,258	-89	-3.9
High yield	328	-22	-6.6
Government (incl MBS)	364	-16	-4.5
Multisector	519	-42	-8.1
World	556	-44	-7.9
Municipal	859	-42	-4.9
Money market funds	3,647	688	18.9
Treasury & Repo	794	327	41.2
Treasury & Agency	1,927	507	26.3
Prime	791	-139	-17.6
Tax-Exempt	135	-6	-4.8

Table 5. Mutual fund selling of Treasuries in the CRSP mutual fund data

The table uses data from the CRSP mutual fund database (excluding ETFs). All share classes for a given fund are aggregated into one observation. Panel A and B are based on all 9,234 mutual funds in the database as of the end of 2019. Panel C is based on the 2307 mutual funds with positive Treasury holdings at the end of 2019.

Panel A. Summary statistics on Treasury holdings and selling

Type of fund	End of 2019, \$B		2020Q1, \$B	
	Total net assets (TNA)	Treasury holdings	Net new cash flow	Net purchase of Treasuries
Equity	13,668	64	-111	-9
Hybrid	2,170	105	-56	-22
Bond, taxable	3,815	889	-132	-99
Of which core bond funds	1,558	465	-50	-72
Bond, municipal	807	0	-22	0
Other (MBS, currency funds)	405	27	-26	-4
Sum	20,865	1,085	-347	-132

Panel B. By fund in/outflow status in 2020Q1

Type of fund	End of 2019, \$B		2020Q1, \$B	
	Total net assets (TNA)	Treasury holdings	Net new cash flow	Net purchase of Treasuries
Funds with outflows	14,273	767	-615	-140
Funds selling Treasuries	3663	672	-204	-157
Treasuries sold up to outflow				-103
Treasuries sold in excess of outflow				-54
Funds buying Treasuries	10,609	95	-410	16
Funds with inflows	6,592	318	267	8
	20,865	1,085	-347	-132

Note: Sales are indicated with negative sign and purchases with positive signs.

Panel C. Drivers of Treasury buying/selling by mutual funds

	Dependent variable: Net purchase of Treasuries, 2020Q1, \$B					
	(1)	(2)	(3)	(4)	(5)	(6)
	All funds	All funds	Bond funds, taxable	Hybrid funds	Equity funds	Other funds
Treasury holdings (end of 2019)	-0.180***	-0.208***	-0.212***	-0.273***	-0.285***	0.220*
*D(Outflows in 2020Q1)	(-30.32)	(-64.06)	(-42.51)	(-4.04)	(-11.56)	(1.67)
Treasury holdings (end of 2019)	-0.00335	0.0143***	0.0158***	0.0118	-0.0588**	-0.424***
D(Outflows in 2020Q1)	(-0.78)	(6.69)	(4.80)	(0.17)	(-2.39)	(-3.28)
	-0.0121	0.871***	1.231***	-0.0181	-0.0520*	0.200**
	(-0.57)	(5.78)	(4.95)	(-0.14)	(-1.82)	(1.26)
Constant	0.0114	-0.670***	-0.811***	0.0352	0.0781***	0.0720
	(0.65)	(-5.19)	(-3.86)	(0.29)	(3.05)	(0.52)
Weighted by Treasury holdings (end of 2019)	No	Yes	Yes	Yes	Yes	Yes
N (funds)	2307	2307	1032	364	722	189
R ²	0.470	0.754	0.753	0.904	0.992	0.332

t-statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01.

Table 6. The disappearing safety effect

Daily data frequency. Data sources are as for Figure 9. Yield spreads are relative to the 5-year Treasury yield. Coefficients are estimated by OLS. Standard errors account for AR(1) autocorrelation and are estimated using the bootstrap after bootstrap approach of Krishnamurthy and Vissing-Jorgensen (2015).

	Dependent variable: Yield spread			
	2020H1		2013-2020H1	
	IG	HY	IG	HY
Investment grade CDS index	2.626*** (5.89)		2.325*** (13.78)	
High yield CDS index		1.205*** (13.08)		1.486*** (14.18)
Constant	0.0398 (0.11)	0.281 (0.59)	-0.0101 (-0.08)	-0.851* (-2.11)
N (days)	125	125	1868	1868
R-squared	0.832	0.943	0.770	0.819

Note: Yield spreads are corporate yields minus 5-year Treasury yields.

t statistics in parentheses. * p<0.05, **p<0.01, *** p<0.001.

Table 7. Foreign holdings and net purchases of Treasuries

The table is based on data from the Bureau of Economic Analysis (BEA) International Data, which rely on the same underlying data as the U.S. Financial Accounts. Data for all foreigners are from BEA Table Table 1.2 (U.S. Net International Investment Position at the End of the Period, Expanded Detail) for holdings and Table 7.1 (U.S. International Financial Transactions for Portfolio Investment) for net purchases. Data for foreign official agencies are from BEA Table 3.1 (U.S. International Investment Position for Liabilities to Foreign Official Agencies) for holdings and Table 9.1 (Table 9.1. U.S. International Financial Transactions for Liabilities to Foreign Official Agencies) for net purchases. I calculate data for the foreign private sector as the difference between values for all foreigners and foreign official agencies. The BEA calculates the net purchase based on the change in holdings combined with an assumed return.

	HOLDINGS (\$B)			NET PURCHASES (\$B)
	2019Q4	2020Q1	Pct change	2020Q1
All foreigners				
Treasuries in total	6,691	6,950	3.9	-287
Notes/bonds	5,985	6,220	3.9	-301
Bills	706	730	3.3	13
Foreign official				
Treasuries in total	4,077	4,118	1.0	-182
Notes/bonds	3,808	3,835	0.7	-196
Bills	269	283	5.4	15
Foreign private				
Treasuries in total	2,614	2,832	8.3	-105
Notes/bonds	2,176	2,385	9.6	-104
Bills	438	446	2.0	-1

Table 8. U.S. liabilities to foreign official agencies

The table is based on data from the Bureau of Economic Analysis (BEA) International Data. Panel A is based on Table 3.1 (U.S. International Investment Position for Liabilities to Foreign Official Agencies) and Panel B on Table 9.1 (U.S. International Financial Transactions for Liabilities to Foreign Official Agencies). The category "other" refers to loans, trade credit and advances and special drawing rights allocations. The table underlying Panel A does not separately identify agency debt and corporate bonds within the other long-term securities category.

Panel A. Foreign official agency holdings

	\$B		Percent	
	2008Q2	2019Q4	2008Q2	2019Q4
Total U.S. liabilities to foreign official agencies	3,751	6,763	100.0	100.0
Long term debt securities				
Treasury bonds and notes	1,690	3,808	45.0	56.3
Other long-term securities (agency debt and corporate bonds)	1,073	848	28.6	12.5
Short term debt securities				
Treasury bills and certificates	228	269	6.1	4.0
Other short-term securities	150	32	4.0	0.5
Equity and investment fund shares	363	1,216	9.7	18.0
Currency and deposits	100	391	2.7	5.8
Other	149	200	4.0	2.9

Panel B. Foreign official agency net purchases

	\$B	2008Q4	2020Q1
Net U.S. incurrence of liabilities to foreign official agencies		15	-51
Long term debt securities			
Treasury bonds and notes		20	-196
Federally sponsored agency securities		-107	31
Corporate bonds and notes		2	12
Short term debt securities			
Treasury bills and certificates		194	15
Federally sponsored agency securities		-67	0
Negotiable certificates of deposit		-6	2
Commercial paper and other securities		-6	2
Equity and investment fund shares		11	36
Currency and deposits		12	60
Other		-38	-13

Note: Corporate bonds and notes include a small amount of transactions in state and local government securities and negotiable CDs.

Table 9. The cross-section foreign Treasury sales across countries

Reserve data are from the IMF. Other data is as for Table 8. The table shows country-level regressions of net purchase of Treasuries regressed against the change in reserve, a dummy for being a hedge fund domicile (and a UK dummy to capture UK Treasury purchases prior to Brexit).

	Dept. variable: Net purchase of Treasuries, 2020Q1 (\$B)		
Change in reserves, 2020Q1 (\$B)	0.934*** (5.40)	0.941*** (5.79)	0.970*** (7.30)
D(Hedge fund domicile)		-17.77** (-3.09)	-16.83*** (-3.58)
D(United Kingdom)			58.04*** (5.70)
Constant	-5.506** (-3.40)	-4.157* (-2.62)	-5.094*** (-3.91)
N (countries)	66	66	66
R ²	0.31	0.40	0.61

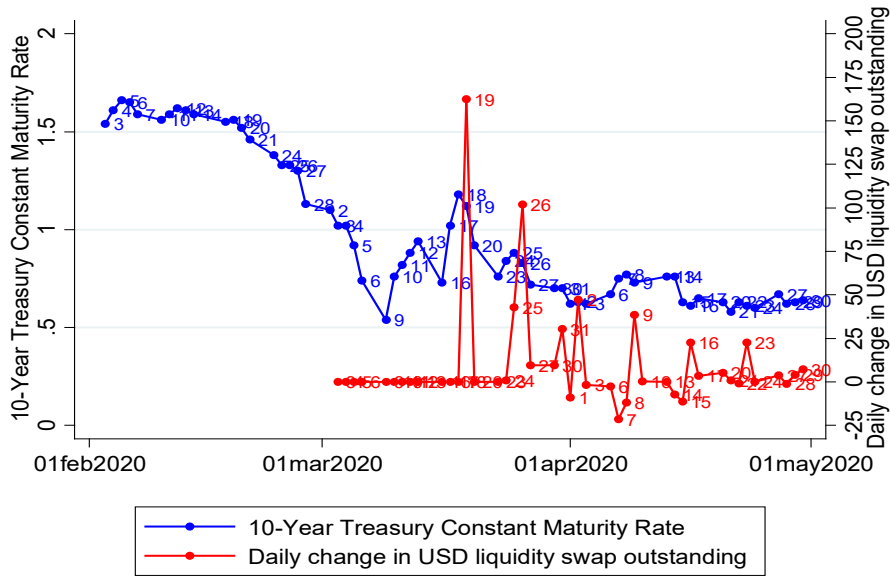
Table 10. Hedge fund selling

Total long Treasury exposure is from hedge fund Form PF reporting to the Securities and Exchange Commission, extracted from Figure 61 in Office of Financial Research (2020). Long and short positions in Treasury note and bond futures are from the CFTC's Commitment of Traders reports. To estimate net Treasury purchases from holdings changes I assume a return equal to that on the Bloomberg Barclays Treasury Indices for Treasury securities with >1 year remaining maturity (8.2% for 2020Q1).

	\$B	2019Q4	2020Q1
Total long Treasury exposure		1297	1164
Long positions in Treasury note/bond futures		306	275
Estimated Treasury holdings		991	889
Estimated net purchase of Treasuries			-183
Short positions in Treasury note/bond futures		746	618
Change in short positions in Treasury note/bond futures			-127

Appendix Figure 1. Dollar swap lines

The figure illustrates the 10-year Treasury yield and the daily change in the amount outstanding on dollar liquidity swap lines with foreign central banks.



Appendix Table 1. Treasury holdings, Treasury net purchases and change in currency reserves, by country

Net purchases by country are for both official and private holders. I calculate them from Treasury International Capital data on holdings combined with assumptions about returns based on Bloomberg Barclays Treasury Indices for securities with >1 and <1 year remaining maturity. Data on currency reserves are from the IMF. I classify the Cayman Islands, British Virgin Island, Bermuda, Ireland, Luxembourg, and Belgium as hedge fund domiciles. See text for detail. I set reserves to zero for Bermuda and British Virgin Islands who both use the US dollar.

Country	Abbreviation	Holdings (\$B)			Net purchase of Treasuries (\$B)	Change in reserves (\$B)	Hedge fund domicile
		2019Q4	2020Q1	Pct change	2020Q1	2020Q1	
China	CHN	1069.9	1081.6	1.1	-75.9	-42.4	
Cayman Islands	CYM	238.2	209.4	-12.1	-41.2	0.0	Yes
Brazil	BRA	281.8	264.4	-6.2	-40.3	-13.7	
Saudi Arabia	SAU	179.8	159.1	-11.5	-32.2	-26.2	
Ireland	IRL	281.9	271.6	-3.6	-29.4	0.1	Yes
Luxembourg	LUX	254.6	246.1	-3.3	-25.6	0.0	Yes
Canada	CAN	143.3	131.5	-8.2	-22.2	0.8	
South Korea	KOR	121.9	110.8	-9.1	-20.8	-8.7	
India	IND	162.0	156.5	-3.4	-18.5	17.9	
Belgium	BEL	207.4	206.1	-0.6	-16.8	0.7	
United Arab Emirates	ARE	40.7	28.0	-31.2	-15.0	-1.1	
Thailand	THA	90.5	81.8	-9.6	-14.9	2.1	
Sweden	SWE	48.7	39.5	-19.0	-13.2	0.0	
Hong Kong	HKG	249.7	256.0	2.5	-13.0	-3.7	
Indonesia	IDN	32.2	23.3	-27.7	-11.4	-8.2	
Bermuda	BMU	71.3	64.2	-9.9	-11.3	0	Yes
Spain	ESP	50.4	43.8	-13.2	-10.6	-0.2	
Switzerland	CHE	237.5	244.6	3.0	-10.0	-4.1	
Singapore	SGP	147.9	151.5	2.4	-7.9	-0.3	
Mexico	MEX	45.3	40.9	-9.8	-7.7	6.8	
Germany	DEU	78.3	77.3	-1.3	-6.8	10.3	
Russia	RUS	10.0	3.9	-61.4	-6.5	9.1	
Kuwait	KWT	43.3	40.1	-7.4	-6.3	-0.4	
Israel	ISR	43.1	41.1	-4.7	-5.2	-0.1	
Colombia	COL	31.4	29.3	-6.6	-4.6	0.2	
Taiwan	TWN	193.1	205.0	6.2	-3.8	2.2	
Italy	ITA	45.3	44.8	-1.0	-3.8	7.2	
Iraq	IRQ	32.9	30.7	-6.7	-3.6	-0.2	
Kazakhstan	KAZ	8.7	5.7	-35.2	-3.2	0.8	
Chile	CHL	30.8	30.1	-2.0	-2.8	-2.7	
Malaysia	MYS	14.3	13.2	-7.9	-2.3	-1.9	
British Virgin Islands	VGB	39.2	40.0	1.8	-2.0	0	Yes
Bahamas	BHS	8.9	7.4	-17.5	-2.0	0.3	
Finland	FIN	6.6	5.6	-14.5	-1.5	-0.3	
Denmark	DNK	16.9	16.8	-0.2	-1.4	-11.7	
Oman	OMN	7.1	6.4	-9.8	-1.3	-0.3	
Netherlands	NLD	65.1	69.1	6.2	-1.2	1.6	
Peru	PER	19.3	19.9	3.2	-0.9	no data	

Guatemala	GTM	6.9	6.5	-5.3	-0.9	0.5
Morocco	MAR	4.7	4.3	-9.1	-0.8	-0.7
Argentina	ARG	6.6	6.0	-9.8	-0.8	-1.4
Portugal	PRT	5.3	5.0	-4.8	-0.7	2.1
Panama	PAN	3.6	3.2	-10.8	-0.5	-0.7
Barbados	BRB	2.1	1.7	-19.0	-0.5	0.0
Costa Rica	CRI	1.9	1.7	-13.2	-0.4	-0.9
Austria	AUT	4.6	4.6	0.0	-0.3	2.3
Trinidad & Tobago	TTO	3.2	3.2	2.2	-0.1	-0.3
Bolivia	BOL	0.3	0.2	-24.4	-0.1	-0.4
Venezuela	VEN	0.3	0.3	-10.7	0.0	no data
Jamaica	JAM	0.7	0.7	3.9	0.0	0.1
Haiti	HTI	0.3	0.2	-2.0	0.0	no data
Algeria	DZA	0.7	0.7	0.0	0.0	-3.8
Liberia	LBR	0.1	0.1	5.2	0.0	0.0
Ecuador	ECU	0.3	0.3	6.6	0.0	-1.4
New Zealand	NZL	7.1	7.6	7.7	0.0	5.7
Cyprus	CYP	0.2	0.3	26.1	0.0	0.1
Bahrain	BHR	1.3	1.5	15.2	0.2	-1.8
Uruguay	URY	9.3	10.1	8.2	0.3	0.8
Turkey	TUR	2.0	2.5	25.9	0.4	-13.5
Norway	NOR	90.1	98.0	8.8	0.5	4.1
Honduras	HND	1.8	2.4	39.4	0.5	0.3
Paraguay	PRY	0.6	1.2	105.0	0.6	0.2
Australia	AUS	41.8	46.3	10.9	1.5	-2.8
South Africa	ZAF	13.8	16.5	19.4	1.6	-2.6
Dominican Republic	DOM	0.4	3.3	771.5	2.9	0.5
Philippines	PHL	34.8	43.1	24.0	5.6	1.0
France	FRA	127.7	156.0	22.2	19.0	9.8
Japan	JPN	1155.2	1272.6	10.2	27.3	42.4
United Kingdom	GBR	392.1	469.7	19.8	49.7	-3.4
