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WHEN SELLING BECOMES VIRAL:
DISRUPTIONS IN DEBT MARKETS IN THE COVID-19 CRISIS AND THE FED'S RESPONSE

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ABSTRACT

We study disruptions in debt markets during the COVID-19 crisis. The safer end of the credit spectrum experienced significant losses that are hard to fully reconcile with standard default or risk premium channels. Corporate bonds traded at a large discount to their corresponding CDS, and this basis widened most for safer bonds. Liquid bond ETFs traded at a large discount to their NAV, more so for Treasuries, municipal bonds, and investment-grade corporate than high-yield corporate. These facts suggest investors tried to sell safer, more liquid securities to raise cash. These disruptions disappeared nearly as fast as they appeared. We trace this recovery back to the unprecedented actions the Fed took to purchase corporate bonds rather than its interventions in extending credit. The March 23rd announcement to buy investment-grade debt boosted prices and lowered bond spreads (particularly at shorter maturities and the safer end of investment-grade) while having virtually no effect on high-yield debt. April 9th, in contrast, had a large effect on both investment-grade and high-yield, even for the riskier end of high yield which would only indirectly benefit from the policy. These facts highlight the importance of financial frictions early on in the crisis, but also challenge existing theories of these frictions.

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1. Introduction

Bond markets were distressed in March 2020 as the COVID-19 crisis affected financial markets. This paper attempts to quantify this distress and studies the effect of interventions by the Federal Reserve in debt markets.

As motivation, Figure 1 plots the evolution of the yield spread of a 6-year bond issued by Google – one of the largest companies in the world with a AA credit rating and nearly $120 billion in cash as of the end of 2019 (exceeding total liabilities by around $45 billion). We also plot the 5-year credit default swap (CDS) for Google along with the spread. Both the CDS and bond spread are around 25 basis points through early February.

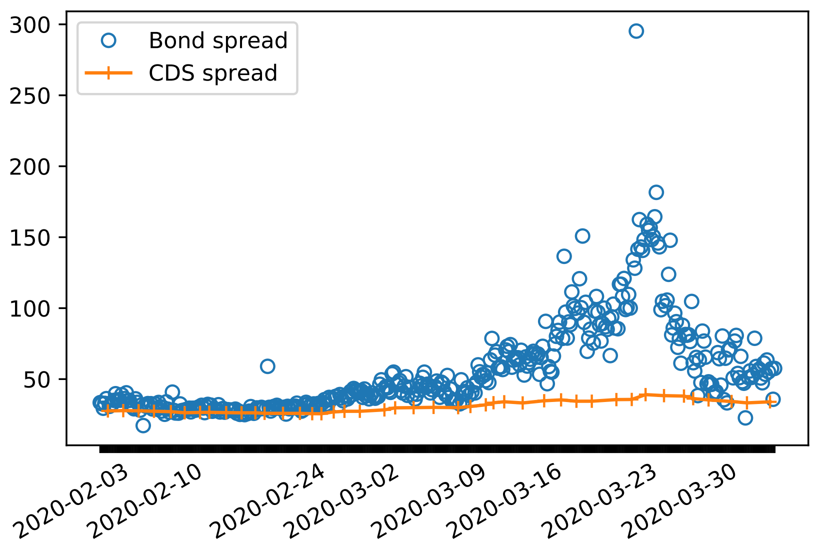


Figure 1: Google: Bond Spread and CDS Spread.

Google's bond spread spikes dramatically in March, increasing around 150 basis points. Meanwhile the CDS spread barely budged. This picture highlights that bond prices – even for extremely safe firms – plummeted substantially more that what one would reasonably attribute to default based either on the CDS or on Google's financial position.

The case of Google is not special; rather, it illustrates a much broader pattern in the first half of March of 2020. During that period the cumulative return on investment grade corporate debt was -20%, about as much as the overall stock market over the same period. This is unusual in part because debt (particularly investment-grade) typically has a beta far below 1.[1] In keeping with the picture above, much of this fall in investment grade coincided with "disruptions" in debt markets. For example, we find that the CDS-bond basis (the difference in spread implied by the CDS and the bond prices) for a basket of investment-grade companies widened substantially to around 300 bps as corporate bond prices fell. Similarly, other disruptions appeared as well. The prices of bond ETFs experienced large departures from their net asset values, including for ETFs with a matched mutual fund. Thus, the same portfolio of bonds had different prices for mutual fund and ETF investors, and these spreads were substantial, averaging around 5% across several categories of debt.

These broad disruptions are important – the investment-grade corporate bond market totals around $7 trillion and is one of the most important sources of funding for US corporations. More generally, disruptions in debt markets and spikes in credit spreads would likely have negative real effects if they persist as credit spreads are strongly associated with declines in future economic activity (Gilchrist and Zakrajek, 2012).[2]

We find these disruptions were most salient in investment-grade bonds in general (corporate, but also municipal bonds and Treasuries), with somewhat less of an effect in high-yield debt. For example, CDS and bond spreads moved more in tandem for high-yield debt, while many large investment-grade bond have an experience similar to Google. Similarly, investment-grade corporate and municipal bond ETFs traded at a large discount to their NAV as asset prices were dropping. High-yield ETFs, while they experienced a similar price decline, did not see such dislocation. A potential explanation for this

[1] Haddad and Muir (2019) present theory and evidence that this type of behavior is typical of episodes of poor health of the financial.

[2] See also López-Salido et al. (2017) and Krishnamurthy and Muir (2018)

pattern is that as bond investors got into trouble and tried to convert their assets in cash, they sold the most liquid bonds first (as well as liquid ETFs), putting large downward pressure on prices and driving up yields. This is consistent with the CDS basis evidence: rather than sell these bonds at low prices (high yields), why wouldn't investors instead simply buy relatively cheap protection in the CDS market? While this may approximate a risk-free bond, it does not help raising cash and freeing up balance sheet space. This can also help explain NAV discounts because ETFs tend to be more liquid and more easily converted to cash than the underlying bonds. These facts thus help us to distinguish channels for the drop in prices.

We then turn to large-scale interventions in debt markets by the Federal Reserve during this period using high frequency event studies and show how Fed interventions affected debt markets. In particular, the March 23 announcement to purchase investment grade bonds raised investment grade bond prices by 7% on announcement with virtually no effects on other asset prices. The typical investment-grade bond in our index has a duration of just over 9 years, so this price change represents an implied decline in yields of around 75 bps. We see larger effects on shorter maturity bonds that were directly targeted in the program (below 5 years in maturity) with an implied decline in yields of over 200 bps. We also find larger effects on the safer end of the investment grade spectrum in terms of credit rating. Thus, the effects were most concentrated at lower maturities and lower credit risk. This decrease came in part through a default risk channel (lowering of CDS spreads) but also largely through improving liquidity (a shrinkage of the CDS-bond basis). In contrast, the April 9th announcement, which increased bond purchases and extended the scope to include "fallen angels," raised the price of both investment-grade and high-yield bonds and appeared to have broader effects on other asset prices as well.

We also compare these disruptions to those experienced in 2008 (Krishnamurthy, 2010) to gauge magnitudes. While the magnitude of disruptions in debt markets during the recent episodes were large and comparable to 2008, the experience of 2020 differs along two major dimensions (so far). First, not only did the disruptions appear extremely quickly — in a matter of days rather than months — but also disappeared quickly following a fast and unprecedented response by the Fed. Of course, we do not observe the counterfactual evolution of the disruptions absent Fed intervention. Second, the deterioration of prices was particularly severe for investment-grade debt, while during the 2008 crisis disruptions were more pronounced in more illiquid asset classes.

Our results speak to theories and channels of asset price movements in March 2020, particularly for corporate bonds. First, asset prices can be depressed either through cash flow or risk premium channels. The relative behavior of investment grade and high yield, and the behavior of bond spreads compared to CDS or ETFs compared to NAV speak against these as full explanations for the drop in investment grade bonds. A default and risk premium channel should have equal effects on the CDS and the yield spread. Further, a risk premium channel would typically have a larger effect on high yield compared to investment grade bonds. This is because high yield has a higher probability of default and so is more sensitive to an increase in the premium per unit of default risk. A cash flow (default risk) channel may well play a role in overall bond prices. A sensible story is that the COVID-19 crisis raised the probability of a disaster, and this would have an effect on corporate debt. However, this also does not explain why this doesn't show up in CDS, and this story would require more assumptions to explain differential patterns in investment grade and high yield (e.g., if one assumes the disaster will trigger default for all firms across the ratings spectrum it can explain why investment grade falls as much as high yield). Instead, our results are consistent with selling pressure to convert more liquid bonds into cash, and are also consistent with theories of a safety demand channel (Krishnamurthy and Vissing-Jorgensen, 2012; Moreira and Savov, 2016).

Section 2 describes the aggregate behavior of debt markets. Section 3 zooms in on particular disruptions and how they relate to overall movements. Section discusses the impact of Fed interventions. Finally, Section 5 discusses implications of our results and remaining questions.

Related Literature

Several papers have specifically focused on liquidity in bond markets in the COVID-19 crisis as well, including Kargar et al. (2020), Fleming et al. (2020) and Schrimpf et al. (2020). This relates to a broader literature on asset pricing and intermediation in various asset classes (He and Krishnamurthy, forthcoming; Haddad and Muir, 2019; Haddad and Sraer, 2020). Bahaj and Reis (2020) show CIP deviations in the current crisis and point to strain in dollar funding markets. Finally, Gormsen and Koijen (2020) study the impact of COVID-19 on future growth expectations by studying dividend futures. **?** discusses the case for corporate bond purchases in the current crisis.

A broader literature studies how these disruptions arise more generally. First, there may be large changes in asset market liquidity. Investment grade bonds may be liquid in normal times, but become far less liquid in periods of severe stress (Moreira and Savov, 2016).[3] This fits more generally into a literature on safety demand (Longstaff, 2004; Greenwood and Vissing-Jorgensen, 2018; Krishnamurthy and Vissing-Jorgensen, 2012; Greenwood and Vayanos, 2014). Second, the ability to obtain funding can have a significant impact on bonds. That is, disruptions in repo markets, increases in haircuts, and so on can lead to difficulties in funding in debt markets that then feedback into prices (Brunnermeier and Pedersen, 2009; Duffie, 2010; Lewis et al., 2017). Bai and Collin-Dufresne (2019) and Fontana et al. (2010) study the CDS bond basis with a focus on 2008, while Longstaff et al. (2005) examine CDS and bond spreads over a longer sample. For overviews of disruptions in the 2008 crisis see also Duffie (2010) and Mitchell and Pulvino (2012).[4] Further, He and Milbradt (2014) show how bond liquidity can feedback into default.

Another literature focuses on the effects of bond purchases by the Federal Reserve on

[3]See also Longstaff (2009)

[4]See also Hu et al. (2013), Du et al. (2017), Siriwardane (2016), Fleckenstein et al. (2014) for specific examples.

asset prices. The leading example is Krishnamurthy and Vissing-Jorgensen (2011) who use an event study to assess the effects of quantitative easing in 2008-2009.[5] Greenwood et al. (2018) discuss this event study methodology when asset markets may be partially segmented.

2. Aggregate Changes in Debt Prices

Before getting at disruptions within each market, we consider overall movements in prices for various types of debt during the COVID-19 crisis. Figure 2 reports cumulative returns for a variety of debt markets between February 1 and April 23 2020. As a benchmark, we report the cumulative returns on the S&P500 index. Of the asset classes we report, stocks experience the largest decline: a cumulative return around -35% from peak to through, with the minimum reached in the third week of March. They subsequently rebound but the cumulative return is still as low as about -15% in late April. Next in terms of poor performance is corporate debt. We report the returns on two large corporate bond ETFs of the iShares family, LQD and HYG. These funds aim at capturing the universe of investment-grade and high-yield corporate bonds, respectively. We provide more details on the ETFs in Section 3.2. For now, we just take them as representative of returns in these asset classes. Both indices exhibit a similar pattern as stocks. While their decline started almost two weeks after stocks, its magnitude is substantial: the two indices drop by about 20% from peak to through. Notably, the drop for the three weeks from March 1st to 20th is about the same for investment grade, high yield, and the overall stock market, with investment grade actually suffering slightly larger losses. After that, the two corporate bond indices recover. By the end of our sample, investment-grade bonds are virtually back to their early 2020 level and the loss in high-yield debt is of -10%. Similarly, we measure the returns of municipal bonds using MUB, which tracks

[5] See also Hanson and Stein (2015) and Greenwood et al. (2016)

Standard & Poor's National AMT-Free Municipal Bond Index. The performance of this fund has an extremely similar trajectory to investment-grade debt, albeit of somewhat smaller magnitude. For example, the dip in returns is only of about -12%. Finally, we use TLT to track long-term Treasuries. Consistent with an environment of decreasing interest rate, cumulative returns on Treasuries are positive. However, they also experience a large drop between March 9 and March 19, which reverts quickly after that.

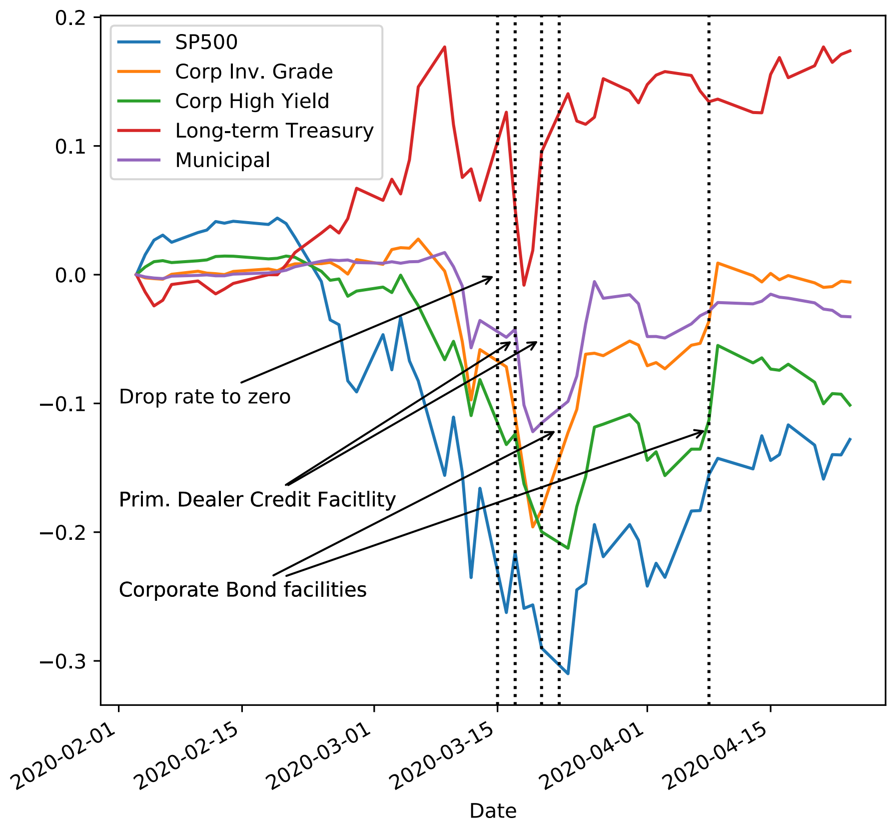


Figure 2: Returns during the COVID-19 crisis across asset classes.
This figure reports the cumulative log returns for the stock market (S&P500), an Investment-Grade corporate bond ETF (LQD) , a High-Yield corporate bond ETF (HYD), a long-term Treasury ETF (TLT), and a Municipal Bond ETF (MUB) through the COVID-19 crisis (February 2020 through early April).

Figure 3 compares this behavior to the Great Financial Crisis of 2008-2009. This comparison highlights that the magnitude of the decline in prices is comparable to the worst historical episodes. In the 2008 episode, high-yield bonds closely track the stock market, while investment grade declines by much less. Another salient aspect is the speed that asset pricing movements took place in the recent episode. While one can think of the start of the GFC going back to the summer of 2007 when it became clear that the subprime segment of the mortgage market had issues, it was not until October 2008 that the stock market had a decline as large as experienced in the first two weeks of March. The speed of the policy response can to some extent also be gauged from the behavior of long-term treasuries. During the recent period Treasuries rallied by 20% as the market went down.[6]

We place these asset price movements in context by scaling all returns to have a beta of 1 with the stock market on Figure 4. In particular, we use the last two years of daily data up to January of 2020 to estimate the beta of each fund with respect to the stock market. We then use this estimate to leverage each fund to have a beta of 1. This calculation provides a simple way to illustrate how unusual the price movements in investment-grade credit are during the recent period. By this beta-adjusted metric, corporate investment-grade bonds dropped by more than twice the stock market, while high yield bonds also dropped by more than the market but not as much. This observation suggests that the investment-grade market in particular, which is the core funding market for US companies and totals over $7 trillion, was dysfunctional. We investigate this possibility in Section 3. In Appendix Figure 17, we show this graph instead as cumulative abnormal returns where each series is regressed on the stock market, daily changes in the VIX, and daily changes in 10 year Treasury yields. We find similar patterns – investment grade appeared especially to drop by much more than would be implied by just the fall in the stock market, increase in volatility, or changes in longer term yields. Naturally, one would expect the beta of debt to increase during times of distress, and somehow mitigate this

[6] A unique aspect of the recent episode (which we discuss in Section 3) is that the long-term Treasury market seems to have malfunctioned in the second week of March while in 2008 they only started rallying in mid November (by 30%) and peaked in the end of the year.

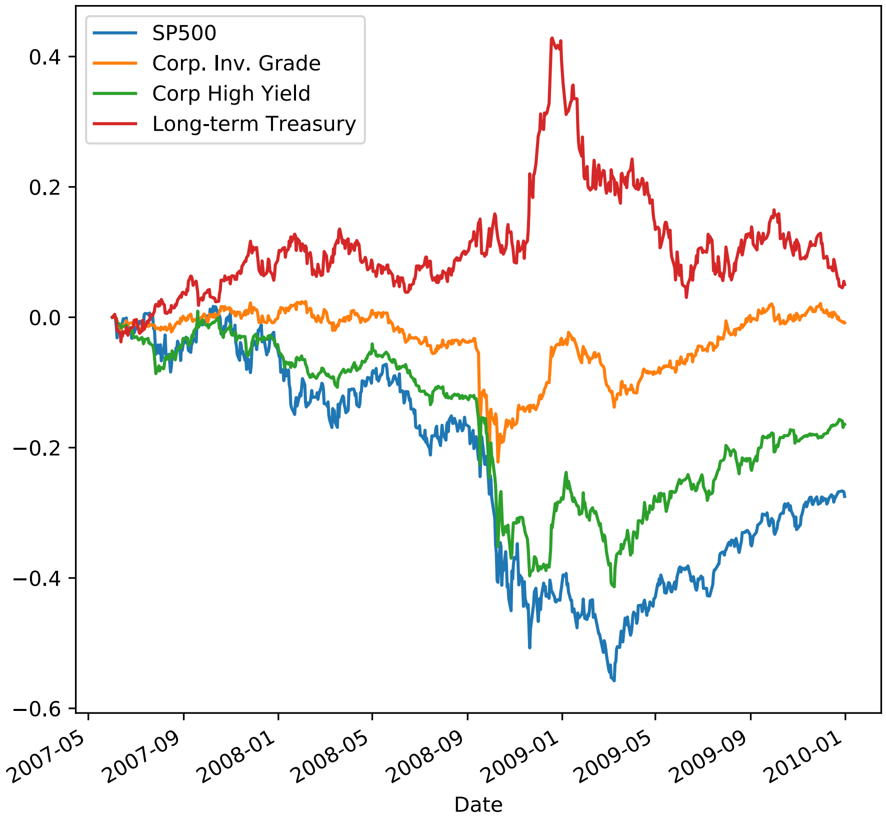


Figure 3: Returns during the 2008-2009 crisis across asset classes.
This figure reports the cumulative log returns for the stock market (S&P500), an Investment-Grade corporate bond ETF (LQD) , a High-Yield corporate bond ETF (HYD), a long-term Treasury ETF, and a Municipal Bond ETF through the 2008 financial crisis (Late 2007 through late 2009)

observation. However, the quantitative challenge remains: rarely does the beta of debt increases to values close to 1 in standard approaches to reconcile debt and equity prices such as the Merton model.

This "disconnect" between the stock market and credit markets is suggestive that market segmentation played an important role, i.e., that investment-grade debt was hit especially hard relative to what one would expect from other asset prices. Intermediary-based models imply powerful amplification that could potentially make sense of this disconnect. However, in contrast with the GFC where the weak balance sheets of banks were

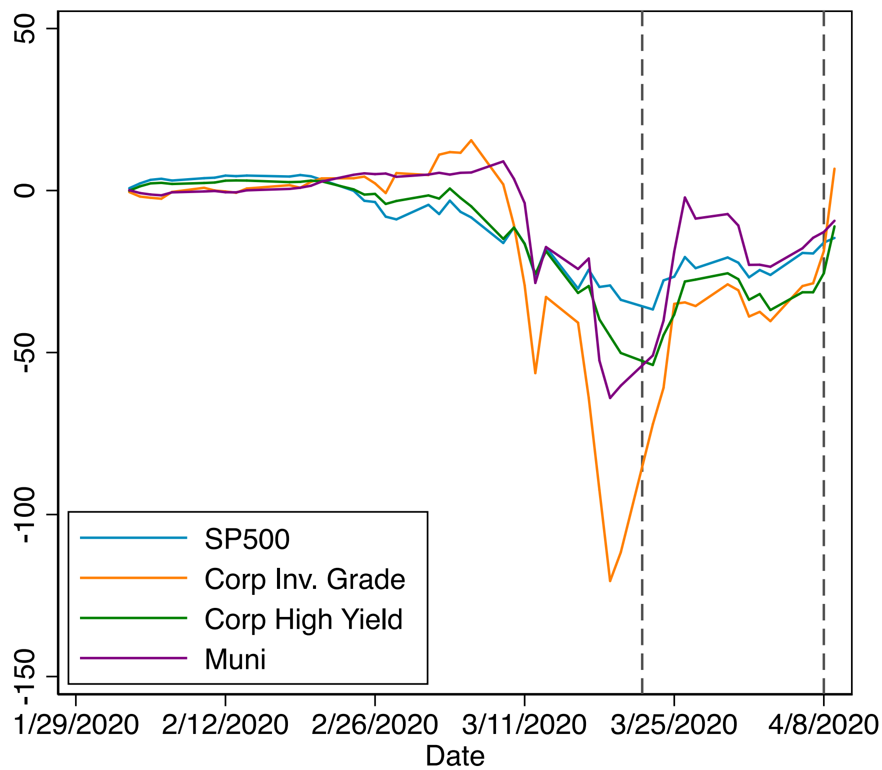


Figure 4: Returns during the COVID-19 crisis across asset classes, normalized by beta. This figure reports the cumulative log returns for the stock market (S&P500), an investment-grade corporate bond ETF (LQD) and a high-yield corporate bond ETF (HYD) through the COVID-19 crisis (January 2020 through early April). Returns are scaled to all have a beta of 1.

front and center to understand the severity of the crisis, in the recent period banks appear to much better capitalized. For example, while in 2007 US banks had 6% of their assets in tier 1 capital, in the end of 2019 they had 15%. Meanwhile, primary dealers also became much less relevant in the corporate bonds market. In 2007 dealer net positions were about 15% of the total universe of US issued investment grade corporate bonds. Now they consistently hold less than 0.5% of the market. Therefore primary dealers are unlikely to be a source of shock amplification, but their absence could potentially explain why movements in investment grade were so brisk. For example, early in the fall of 2008 even with impaired balance sheets, primary dealers increased their position in corporate bonds by about 4% of the total investment-grade universe outstanding and only reversed to their previous position by the end of 2008. This would be as if they had purchased 240 billion dollars of corporate bonds during the recent period, a net supply of liquidity in line with what the Federal Reserve did in the recent March 23. In contrast, through mid-March of 2020, if anything dealers decreased positions which were already small to start with.

Starting March 15th the Fed unveiled interventions in a brisk place. We summarize announcement dates and the respective policy interventions in Table 1. Most of the early announcements were targeted at short-term funding markets in line with what was done in 2008: swap lines with core central banks (March 15), the introduction of the Commercial Paper Lending Facility and Primary Dealer Lending Facilities (March 17), Money Market Lending Facility (March 18 and March 20), swap lines with periphery central banks (March 20), certification of large foreign institutions to repo treasuries with the Fed (March 31), and exclusion of treasuries and deposits from the leverage calculation for bank holding companies (April 1). These interventions targeted what are broadly described as money markets and to a large extent were classic liquidity operations. But on March 23, the FED went beyond the playbook used in 2008 by unveiling facilities that explicitly take on credit risk by directly buying investment grade corporate debt, asset backed securities, and short-term municipal securities. The Treasury provided an equity backstop to these facilities. On April 9, the Fed further expanded these programs. In Section 4, we show that these two interventions in particular had powerful effects on the corporate bond market. The March 23rd announcement primarily impacts investment-grade credit but has little impact on other markets (including high-yield). In fact the effects appear most concentrated at the safer end of the investment-grade spectrum. April 9th appears to be broader, affecting both investment grade and high yield (and stocks to some extent), and particularly affecting the higher risk end of high yield which would not directly benefit from the intervention. In contrast, most of the other interventions did not appear to have major effects.

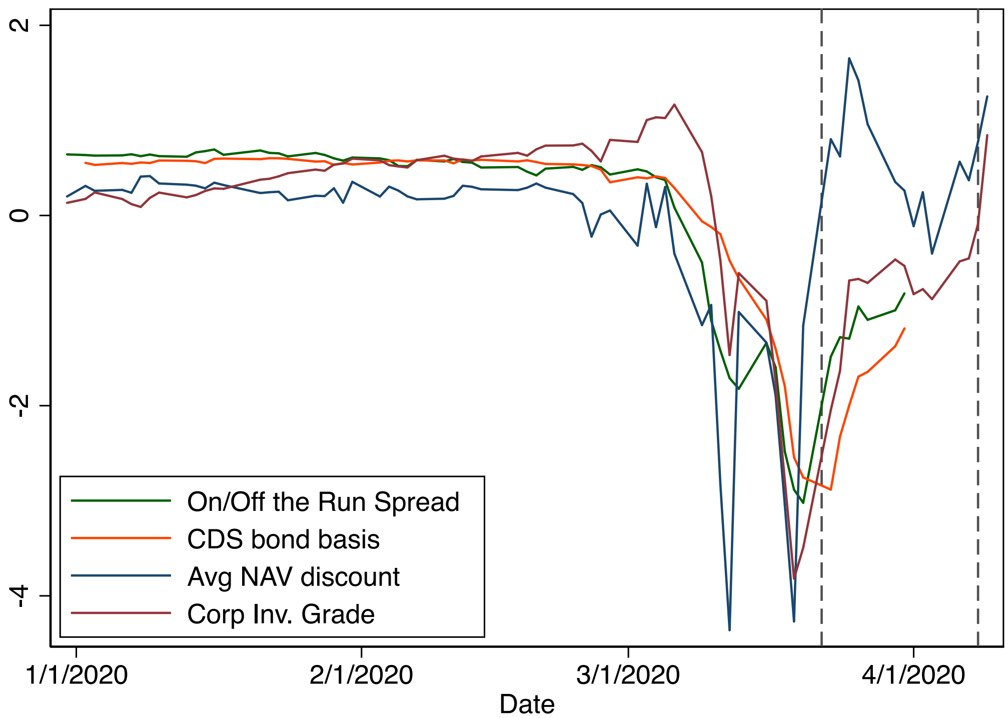
3. Disruptions in the Pricing of Debt

Under the view that distress within the financial sector drives in part these price movements, a natural consequence is the appearance of pricing disruptions: breakdowns in how prices are connected across markets. These disruptions give the appearance of arbitrage opportunities emerging. For example, Duffie (2018), Mitchell and Pulvino (2012), and Krishnamurthy (2010) give an overview of some of these disruptions in previous episodes. Bai and Collin-Dufresne (2019) and Fontana et al. (2010) study the CDS bond basis in 2008, Fleckenstein et al. (2014) and Hu et al. (2013) focus on disruptions in Treasuries, and Du et al. (2017) document covered interest parity violations. Of course, issues with the functioning of markets could also occur even if the large price movements are not due to this disruption. In this section we document a number of these disruptions and how they are related to the unusual fluctuations in bond prices. Several other papers document liquidity effects in bonds in the COVID-19 episode (Kargar et al., 2020; Fleming et al., 2020; Schrimpf et al., 2020).

3.1 Synchronization of Disruptions

Figure 5 plots disruptions across different bond categories where each disruption is normalized to have unit standard deviation so that they are on the same scale in the figure. We return to absolute magnitudes of each and the details of the construction of each series shortly. We plot the CDS-bond basis for investment grade bonds (difference between CDS and bond yield spread), along with the on-the-run off-the-run spread, which compares yields for a newly issued 30-year Treasury and an "old" 30-year Treasury bond with remaining maturity 29.5 years. We also add the average deviation between bond ETF net

Figure 5: Disruptions. We plot the CDS bond basis investment grade bonds, the on the run off the run spread, and the average NAV discount for investment grade corporate bonds, municipal bonds, mortgage backed securities, and a long term Treasuries. All series standardized to be on the same scale.



asset values (NAV) and the ETF price average across corporate bonds, municipal bonds, MBS, and a long term Treasuries. A negative value indicates the ETF price was below NAV. Again, we discuss this construction in more detail shortly.

The most salient feature of Figure 5 is that these disruptions are fairly synchronized despite being across different asset categories in the fixed income space, and all occur in line with the height of the crash in investment grade debt in March. This points to widespread issues in liquidity, funding, or arbitrage capital across many assets. We now zoom in on each of these disruptions individually.

3.2 ETF-NAV Basis

Fixed income ETFs have grown substantially over the past decade, passing $1 trillion in assets as of last June.[7] We compute deviations of ETF prices from net asset value (NAV) in several ways for several categories of funds (see Pan and Zeng (2019) for a longer history of NAV deviations). First, we compare share prices for Vanguard ETFs and matched Vanguard mutual funds – both give a claim to the same underlying portfolio of securities but ETF prices were trading at a large discount in mid March. This means mutual fund investors could have sold their mutual fund shares, purchased the ETF, and captured this difference in prices while having the exact same portfolio of underlying assets. The discounts are very large – up to 10%, with an average peak of around 5%. The average annual return across the four fixed income funds we study (muni, corp, Treasury, MBS) is around 4% – around the same size as the average peak discount. We also choose these particular funds because the ETFs are large and very liquid. We plot the behavior of the difference between the ETF and the mutual fund shares in Panel A of Figure 6.

We plot iShares NAV discounts in Panel B of Figure 6 of ETFs tracking similar indices. These have advantage that they correspond directly to the portfolios we consider in our main analysis on investment grade bonds, high yield bonds, municipal bonds, and Treasuries and we use these exact funds in our high frequency event studies. A downside is they don't have a matched mutual fund, so NAV discounts require a different process to try to arbitrage.

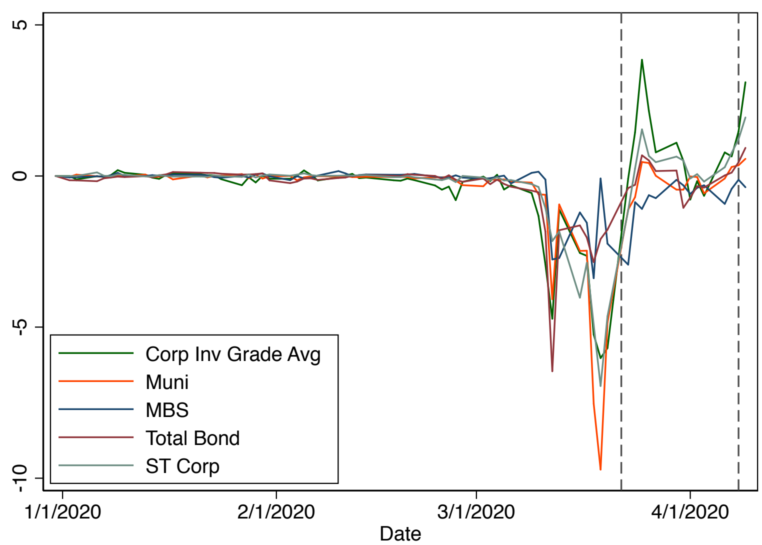
If an investor does not already own the mutual fund, how does the arbitrage process work to try to capture this spread when the ETF trades at a discount? The arbitrage process can only be done by authorized participants (APs) who are allowed to redeem or create shares, which for bond ETFs consist mainly of primary dealers (Pan and Zeng, 2019).[8] The AP would buy the ETF, redeem the shares, and receive the underlying basket

[7] https://www.wsj.com/articles/bond-exchange-traded-funds-pass-1-trillion-in-assets-11561986396

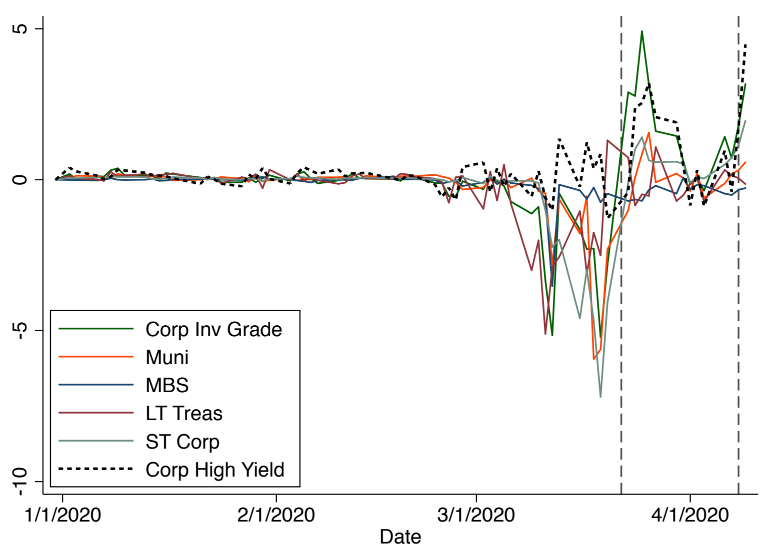
[8] BlackRock lists among the most common APs: Bank of America Merrill Lynch, Cit-

Figure 6: ETF Discounts. Panel A plots discounts between matched Vanguard ETF and mutual fund shares trading the same portfolio for municipal bonds, corporate bonds, mortgage backed securities, and a total bond index (70% Treasuries, 30% Investment grade bonds). Discounts are given in percent. Panel B plots iShares discounts from NAV for an Investment Grade corporate bond ETF (LQD), a Treasury ETF (TLT), a High Yield Corporate Bond ETF (HYG), muni ETF (MUB), MBS ETF (MBB), and ETFs that track both short and long term investment grade corporate bonds (IGSB and IGLB).

Panel A: ETF NAV discounts Vanguard



Panel B: ETF NAV discounts iShares



of securities which they would then sell. This highlights a few issues: when bond markets are illiquid it may be either that it will take time to sell the bonds during which prices may change or the AP can't sell the bonds at NAV (e.g., NAV could be based on stale bond prices due to some bonds not trading frequently). Further, the more illiquid the market for bonds the more the arbitrage requires balance sheet space that may be expensive at this point in time, and we later show primary dealer bond inventory shrunk substantially for many years after the 2008 crisis implying they may not have been in a position to execute this trade easily. Furthermore, providing liquidity to investors expose AP's to adverse selection and volatility risk as shown in Drechsler et al. (2018). Appendix Figure 15 shows that AP's did in fact redeem shares in large amounts (30 billion USD) exactly when these discrepancies arose, suggesting they did view this as a mispricing.

Pan and Zeng (2019) find empirical evidence for two of these channels. Note, however, that whichever of these frictions may be present, the very large magnitude of the discounts means that these frictions (liquidity and/or balance sheet space) must be quite large to justify discounts of this magnitude. The size of the NAV discount would imply very little depth and liquidity in bond markets or very constrained balance sheets or both. Of course, a non-authorized participant could also take advantage of the NAV discount by simply buying the apparently underpriced ETF, though this is unhedged and involves risk. For example, the NAV discount may remain open for a while and the NAV gap could close but the ETF price could still continue to fall.

An important aspect of Figure 6 Panel B that helps with the liquidity story is the behavior of the high yield NAV discount (black dashed line). Notably, similar to what we will show in stocks, there was no discount in high yield in mid March when there was a large discount for the other categories. That is, for high yield NAV kept in line

igroup, Credit Suisse, Deutsche Bank, Goldman Sachs, JP Morgan, Morgan Stanley, UBS, Jefferies (https://www.blackrock.com/corporate/literature/whitepaper/viewpoint-etf-primary-trading-role-of-authorized-participants-march-2017.pdf).

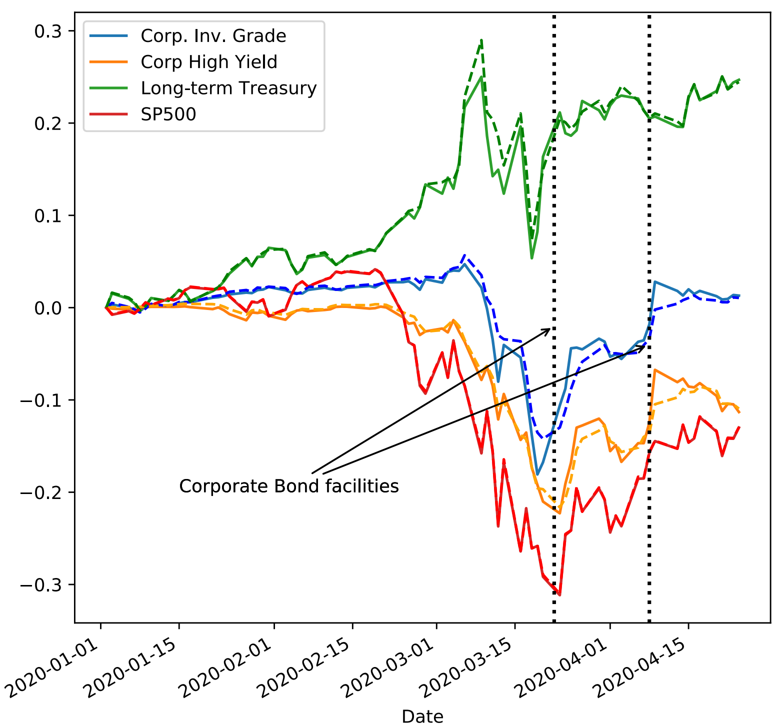
with the ETF. This is evidence against a pure price staleness story – that NAV in the mid March period only reflects stale bond prices which may lag their "true" prices reflected in the ETF. If anything, high yield bonds tend to be less liquid and likely more prone to price staleness than investment grade, MBS, and so on. This is another sense in which dislocations appeared larger in investment grade bonds, and we find the same effects when studying the CDS bond basis.

These disruptions in NAV were unique to the safest parts of bond markets, and particularly investment grade. We already discussed that high yield did not face a large NAV discount. Figure 7 shows the same picture for the stock market, and shows no substantial deviations. Interesting, large discounts emerge in Treasury and Municipal bond ETFs. First, this shows that these deviations were showing up exactly in assets typically perceived as safer. Second, this highlights less liquidity issues in stocks at the time and less market disfunction. Notably, stock volatility in this period is extremely elevated, so one needs more than high volatility to explain the behavior of bond ETF discounts. Third, we see that the deviations are as large as the price movements of the ETF, so these were economically meaningful deviations.

Another key point about Figure 7 is that for treasuries the NAV moved more than the ETF price. This suggests that the gap that opened up between ETF prices and bond prices in their basket was not about slow updating of the NAV, but rather about the more liquid asset, the ETF in this case, trading at lower prices than the less liquid asset, the basket of individual bonds.

The appendix looks at several of these NAV departures in more detail, plotting the evolution of ETF prices along with the implied discounts. Figure 18 shows corp bonds and MBS, Figure 19 shows a total bond index and municipal index.

Figure 7: ETF prices and NAV. We show ETF prices along their contemporaneous Net Asset Value for an Investment Grade corporate bond ETF (LQD), a Treasury ETF (TLT) , and High Yield Corporate Bond ETF (HYG), and a S&P 500 ETF (IVV).



3.3 CDS-Bond Basis

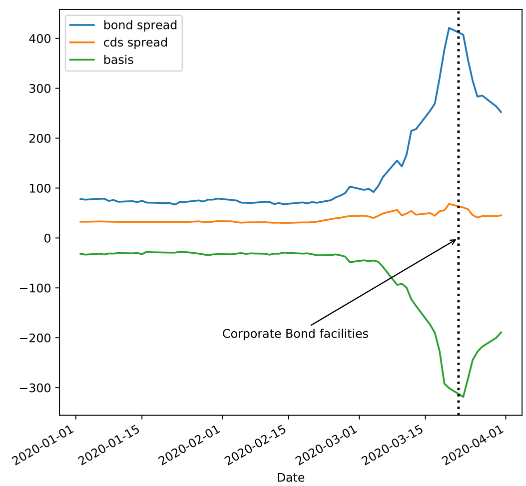
To get a better understanding of the source of these disruptions we zoom in on corporate bonds. The TRACE database allows us to observe all trades up to 03/31/2020. We complement this data with daily CDS data from ICE through Capital IQ. To make sure that these CDS prices are representative of market conditions we focus only on names that belong to the on-the-run CDX indexes. CDX IG for investment grade and CDX HY for high yield as the components of indexes tend to be the most liquid names in the CDS market. We also only use the 5 year maturity which is also known to be the most liquid point of the credit curve. To further focus on the most relevant bonds of the Investment Grade universe we use the bonds held by the LQD iShares ETF (as of 3/2/2020). We then match these bonds from the LQD portfolio with trades on TRACE and CDS prices for each name. To compute the basis we focus on bonds with durations ranging from four to six years. We duration match each bond with the treasury bond rate to compute the bond spread and compute the cds-bond basis by subtracting the bond spread from the CDS spread, so that when the basis is negative the bond is cheap relative to a portfolio that replicates the bond cash-flow with treasuries and the CDS.

In Figure 8 we see that bond spreads increased sharply starting on the week of March 2nd for both Investment Grade and High Yield, but CDS for Investment Grade bonds barely changed. At the peak three fourths of the bond spread was due to the basis that reached 300 basis point on March 20th. In the High Yield market instead we see a large increase in the CDS spreads. While the basis also increases, it increases by much less (proportionally). This contrasts with what happen in the Fall of 2008 where riskier bonds experienced much larger basis than safer bonds. Some bonds like the ones issued by Berkshire Hathaway famously experienced positive basis back then. This contrasts sharply with what happen in March 2020.

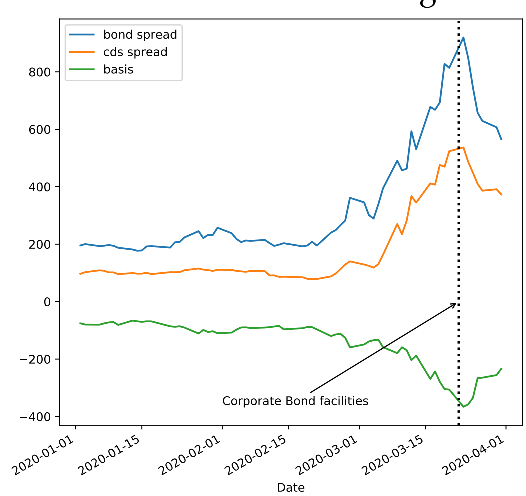
Figure 9 show that this pattern of distortions being larger on safer bonds also hold

Figure 8: CDS-Bond Basis. The figure plots the median CDS-bond basis across investment grade bonds in the LQD portfolio with CDS contracts present in the CDX IG basket (Panel A) and High Yield bonds in the HYG portfolio with CDS contracts present in the CDX HY basket (Panel B). Panel C shows the median basis for both High Yield and Investment grade bonds See text for details.

Panel A: CDS Bond Basis: Investment Grade



Panel B: CDS Bond Basis: High Yield



Panel C: CDS Bond Basis: High Yield and Investment Grade

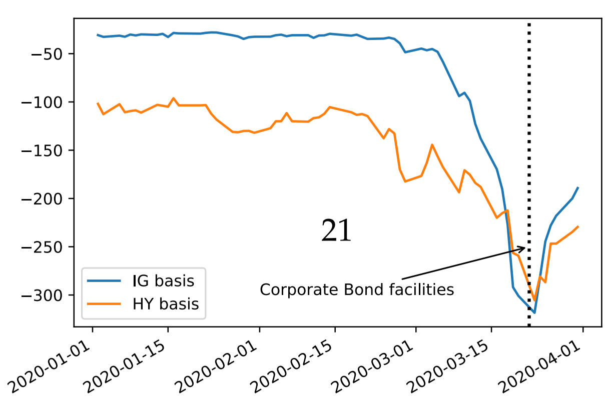
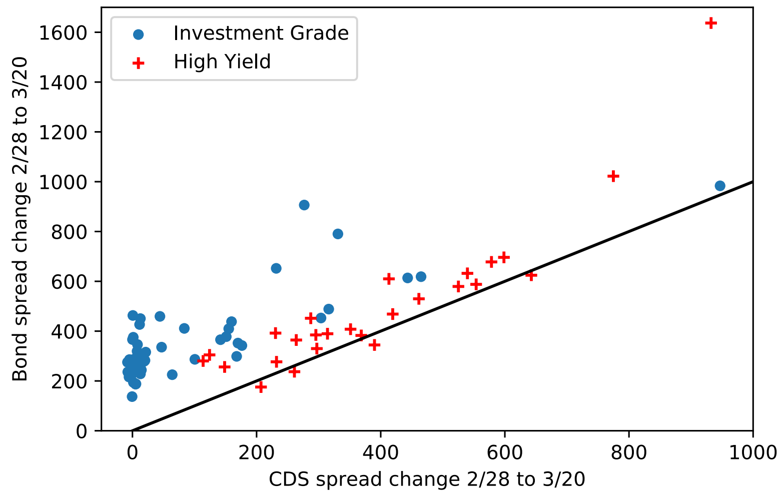


Figure 9: CDS Bond Basis at the Bond Level.



within Investment Grade. The Figure shows in the x-axis the CDS spread change from February 28th (roughly the start of event in financial markets) to March 20th, one business day before the first Federal reserve intervention directly targeting the corporate bond market, and the y-axis we have the bond spread change during the same period. Each dot is a firm, so the bonds spreads and the basis are averaged within firm. This figure shows a striking pattern. We see that within High Yield, CDS and spread changes go roughly one-to-one with the changes of the pricing of bonds and CDS moving very consistently with each other (i.e. the high yield bonds are all around the forty-five degree line). In Investment Grade on the other hand we have a cloud of firms with very small changes in CDS spreads and huge increases in bond spreads. Strikingly every single IG firm is above the fort-five degree line, i.e., for all these firms the basis went up and for some almost the entire spread change is due to the basis. We highlight a few examples of specific firms shortly. A natural interpretation here is that for these very safe firms bond prices got disconnected from fundamentals and were instead shaped exclusively by some investors need to sell these bonds quickly.

It is important to point out that the fact that we can cleanly identify large pricing disruptions in the Investment Grade segment of the corporate bonds market does not mean that these disruptions were contained there. The examples in the introduction and the cross-sectional evidence here presented shows that the disruptions are particularly large in the very safest names of investment grade. The way to think about this fact is not that these disruptions only impacted safe firms, but because these firms have very solid balance sheets breaking the feedback from bad funding conditions into default risk He and Xiong (2012); He and Milbradt (2014) which gives us the ability to cleanly identify the pricing disruptions in these markets. It is certainly plausible that the disturbances that impacted the price of very safe debt were even stronger in high yield debt and beyond, but because the feedback from liquidity conditions into the ability of the firm to operate, these distortions impact the firm default risk and it's CDS prices. Thus according to theory the safe firms are the ideal laboratory to measure these distorton

3.4 Corporate Bond Liquidity

Is the drop in corporate bond prices just the manifestation of a trading freeze, with uninformative prices? Certainly liquidity in bond markets played an important role as shown in Kargar et al. (2020).

However, we find substantial discounts in liquid bonds that traded frequently. Figure 10 tracks the behavior of three bonds for Google, Amazon, and Goodyear, respectively, as well as their respective CDS. The duration of each are roughly around 5 years at 5.86, 5.25, and 5, respectively. First, Amazon and Google are investment grade with strong credit ratings and balance sheets, and each has a bond spread and respective CDS around 30 bps in January. The dots in the graph highlight intraday movements in yield. As spreads widen going into March, prices also become more volatile with large intraday movements. One can also see these bonds trade frequently through this period. Yet the high frequency price volatility is dwarfed by both the overall price movement and the difference in yield and CDS for these companies – CDS do not reflect substantially more risk and hardly move. The third panel plots Goodyear, which is in the high yield index. Notably, spreads start out much higher, reflecting the lower credit rating, but also the CDS tracks spreads fairly closely as the crisis unfolds with both rising to nearly 700 bps. These examples are consistent with the earlier results on the CDS-Bond basis and are representative of what happen more broadly in bond markets.

To highlight that these prices moved with plenty of trading, Figure 11 plots trading volume by week from February to April. Volume in investment grade didn't decline substantially, and if anything appears to fall more for high yield toward the end of March. We don't take this to imply that there weren't trading frictions or that these weren't important to understand these events (see Kargar et al. (2020)). Rather, our point is that there does not appear to be a complete collapse in trade such that microstructure issues likely drive all the aggregate moves in prices.

Figure 12 plots primary dealer positions in corporate bonds. Most importantly, it shows that dealer positions were a small fraction of what they were in 2008, making up just 0.1% of the total investment grade market cap, compared to 10% in 2008. If anything, dealer positions shrink through the first half of March, while they increased their holdings from roughly 7% of the IG market to about 11% through the acute phase of the 2008 crisis, highlighting that dealers are much less active in bond markets and did not play a role in absorbing the shocks in 2020.

3.5 Treasury markets

TBD

Figure 10: Select bond spreads. We plot the yield spread and CDS for three bonds: See text for details.

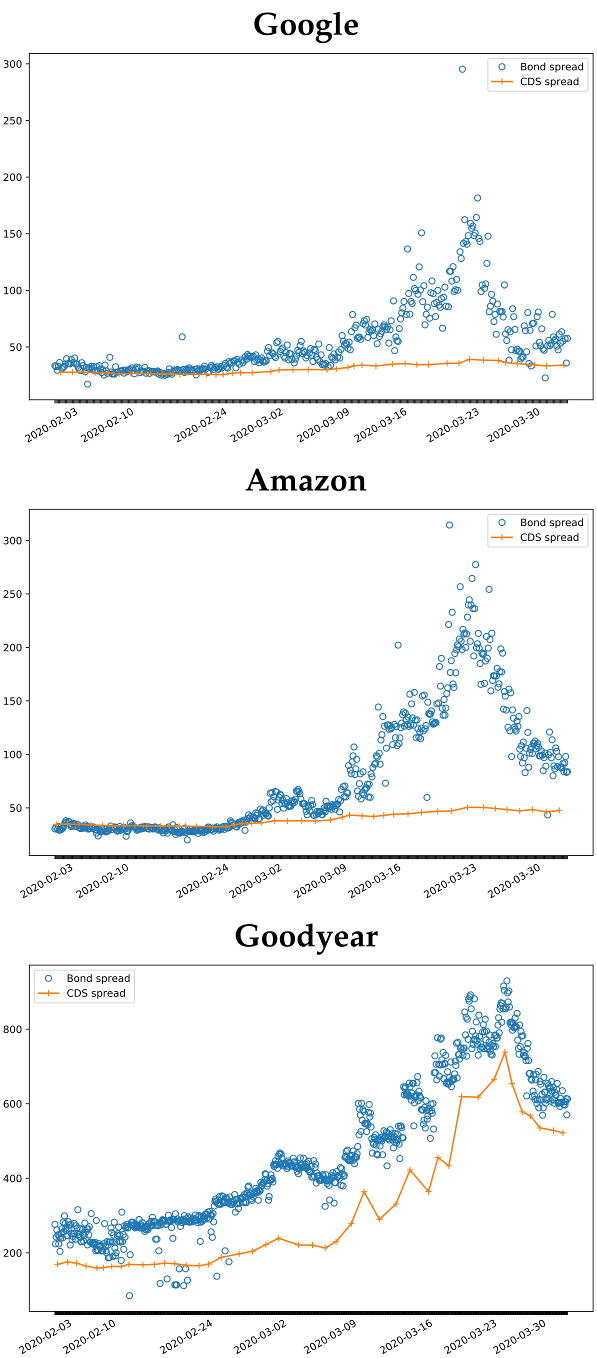
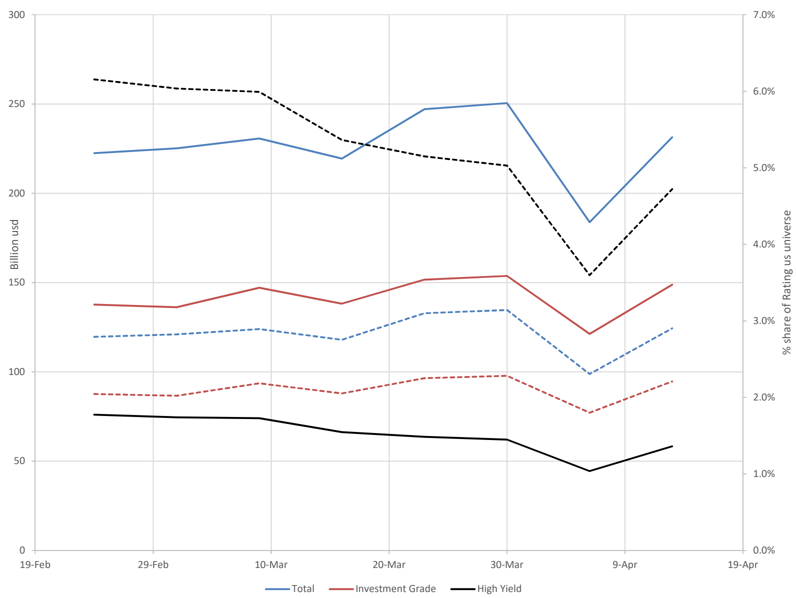


Figure 11: Weekly Trading Volume . Continuous lines depict weekly trading volume in each rating universe in billions of usd (left axis). The dashed line on the right reports trading volume divided by the total market cap of each bond universe (right axis).

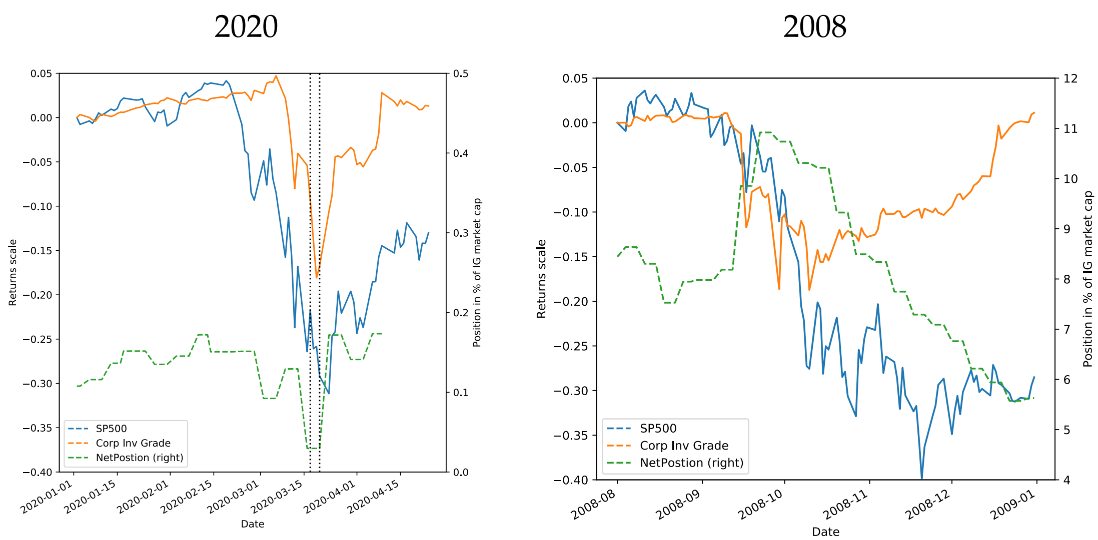


4. The Effect of Fed Interventions

4.1 An Overview of the Federal Reserve's Interventions in Debt Markets

Starting March 15th the fed unveiled interventions in a brisk place. We summarize announcement dates and the respective policy interventions in Figure 1. Most of the early announcements were targeted at short-term funding markets in line with what was done in 2008: Swap lines with core central banks (March 15), Commercial paper lending facility and Primary Dealer lending facilities (March 17), Money market lending facility (March 18 and March 20), Swap lines with periphery central banks (March 20), certification of large foreign institutions to repo treasuries with the FED (March 31), and exclusion of treasuries and deposits from the leverage calculation for holding companies

Figure 12: Primary Dealer positions in corporate bonds in the recent period and during the Fall of 2008. See text for detail.



(April 1). These interventions targeted what are broadly described as money markets and to a large extent were classic liquidity operations. But on March 23 the FED went beyond the playbook used in 2008 by unveiling facilities (with an equity backstop provided by the treasury) that explicitly take on credit risk by directly buying investment grade corporate debt, asset backed securities, and short-term municipal securities. On April 9, the FED further expanded these programs. In Section 4, we show that these two interventions in particular had powerful effects on the corporate bond market. The March 23rd announcement primarily impacts investment grade credit but has little impact on other markets (including high yield). In fact the effects appear most concentrated at the safer end of the investment grade spectrum. April 9th appears to be broader, affecting both investment grade and high yield (and stocks to some extent), and particularly affecting the higher risk end of high yield which would not directly benefit from the intervention.

In contrast, most of the other interventions did not appear to have major effects.

Table 1: Fed Intervention timeline. See text for detail.

Date	Time	Description
15-Mar	5:00 PM	Lower policy rate to zero
		Swap lines with Core Central Banks
		Purchase $500bn of Treasurys and $200bn of agency-MBS
17-Mar	10:45 AM	Commercial Paper Funding Facility
		Purchase high quality Commercial Paper with a $10bn equity tranche from the Treasury
		First time 13(3) is invoked
17-Mar	6:00 PM	Primary Dealer Credit Facility
		Allow primary dealers to pledge a wide range of assets as collateral
18-Mar	11:30 PM	Money Market Funding Facility
		Provide funding for primary dealers to purchase MMF assets
19-Mar	9:00 AM	Swap lines with periphery central banks
20-Mar	11:00 AM	Extend MMF facility to municipal assets, PDCF goes online
23-Mar	**8:00 AM**	PMCCF and SMCCF: purchase of investment-grade bonds on primary and secondary markets
		Term ABS loan facility: provide loan against high-quality ABS
		Extend range of municipal securities that qualify for MMFF and CPPF
		$300bn total capacity among the Corporate, ABS, CP and MMF facilities
		Agency-CMBS can be purchased with the $200bn allotment from 3/15
31-Mar	8:30 AM	Allow certain foreign counterparties to directly repo Treasurys with the FED
1-Apr	4:45 PM	Exclude Treasurys and deposits of leverage calculations for bank holding companies
9-Apr	**8:30 AM**	Establish $500bn Municipal lending facility (primary market) for maturities of up to 24 months
		Extend PMCCF and SMCCF to $850bn (from less than $300bn)
		Extend SMCCF to purchase high-yield bonds if they were investment-grade as of March 22
		$600bn Main Street lending facility to lend to medium-sized companies through banks

4.2 Event Study Around Fed Announcements

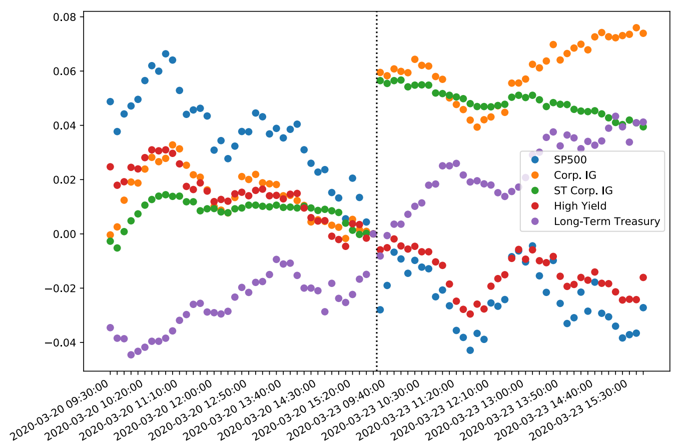
We start with a high frequency study of key Fed announcements on asset prices, highlighting a few interventions from Table 1. We use ETFs for this purpose because this allows us to get high frequency intraday data to see the immediate impact of announcements – this is important for identification as there is a lot of intraday price movement in this period. After assessing this we move to daily data on yields on a number of bonds.

Results are given in Figure 13 where the x-axis denotes 10 minute intervals. We take the log of all series and normalize them to 0 just before the event, hence the y-axis denotes the return relative to the value immediately before the event. For example, for investment grade corporate on March 23rd, we see a 6% return on the announcement.

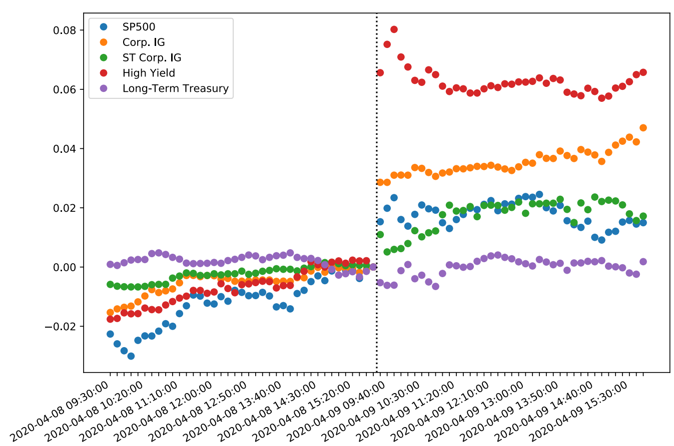
Because both the March 23 and April 9 announcements were held outside of stock-

Figure 13: Fed Intervention Event Study. ETF evidence

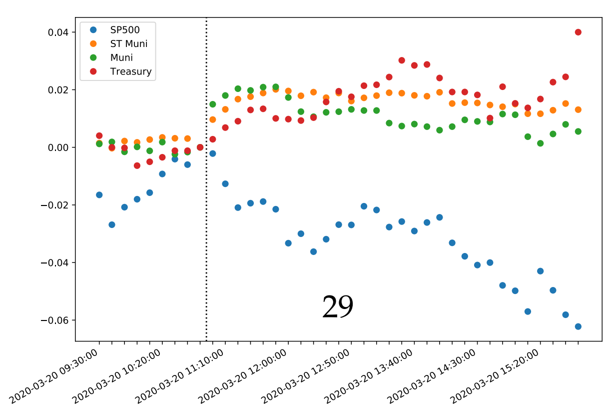
Panel A: 3/23 Purchase Investment Grade Corp



Panel B: 4/9 Increase Purchases, Extend to High Yield



Panel C: 3/20 11am Extend MMLF to Municipal

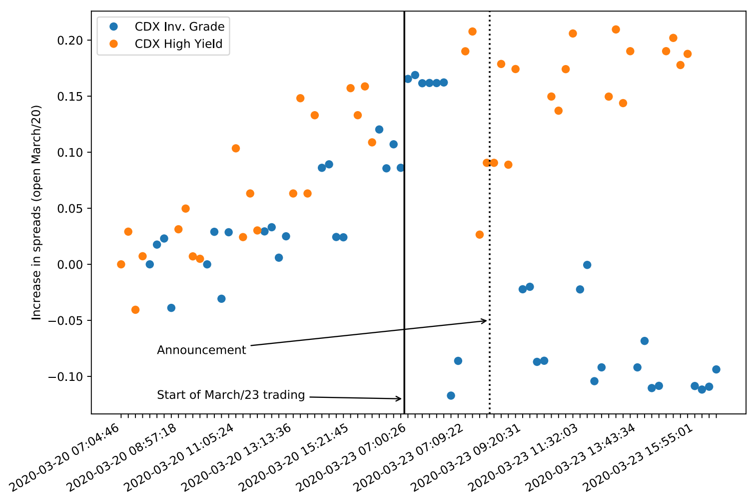


market trading hours, the identification on the effect of FED policy relies on comparing the closing price of the last business day with the opening price after the announcement. A concern is that other news came out between the close and open that raised IG or HY bond prices that confounds our inference, and we alleviate this in two ways. First, the the stock market response doesn't suggest good macroeconomic news arrived on these dates (the market was down slightly in the first even and close to flat in the second). Second, and more importantly, we use the fact that the Credit Default Swap market *is* open during these announcements, so we don't have to rely on close to open reactions. In Figure 14 below we use tick-by-tick transaction on data on the Investment Grade and High-Yield CDX indexes to show that the market responded exactly at the time of the FED announcement. For example, we see that on March 23rd both High Yield and Investment Grade debt had spreads increasing by 15% (i.e if spreads were 200bps, they increased to 230bps). We see that around the announcement IG spreads go down sharply while High Yield spreads remain elevated – and this occurs within a 5 minute window of the announcement. On April 9th we see both reacting strongly. Both are directionally in line with the evidence from ETFs.

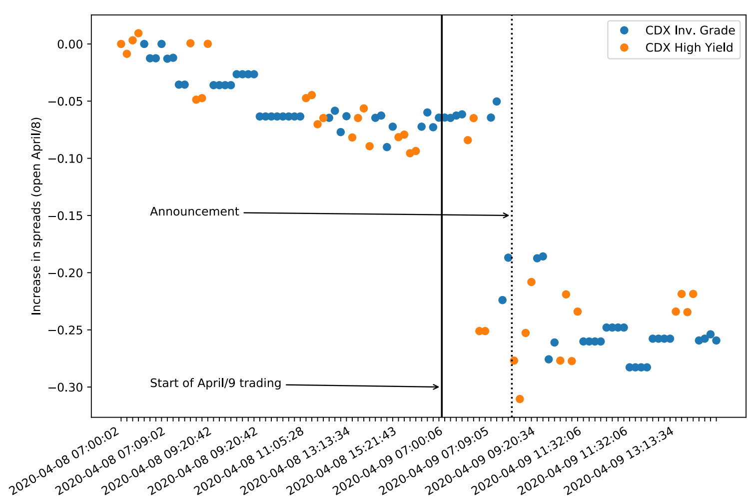
The purchase of investment grade bonds on March 23 increases prices for the investment grade ETF by 7%. Note that there is no effect in either stocks or high yield, and the effect for investment grade is very discrete, occurring within a tight window. While this plot is in price space, it is useful to consider the implied effect on yields for investment grade corporate bonds. The average duration in LQD ETF is around 9.5 years, hence we can approximate the change in yield space as being around -70bps. Notably, the price of the short term corporate bond ETF – which focuses on maturities below 5 years, also increases by about the same amount, around 6%. While this represents the same change in price, it implies a much larger change in yields because of shorter duration. The short term corporate bond ETF has a duration of about 2.65 years, hence the implied drop in yield is over 200 bps. This makes sense because the program is targeted at investment

Figure 14: Fed Intervention Event Study. CDS Evidence. Here we report tick-by-tick transaction data on the CDX IG and CDX HY. We report the implied increases in CDS spreads from the market opening one day before the announcement.

Panel A: 3/23 Purchase Investment Grade Corp



Panel B: 4/9 Increase Purchases, Extend to High Yield



grade corporate bonds with a maturity below 5 years, hence this is where we see the largest decline in yields.

The purchase of investment grade as well as high yield bonds which were previously investment grade ("fallen angels") on April 9 increases prices for the investment grade ETF by about 3% using just the immediate reaction and about 4.7% using the reaction through the end of day. For investment grade, this translates roughly to an implied decline in yields of about 30-50bps. For high yield, the effective duration is shorter at about 4 years, so a 6% increase in the ETF translates roughly to a decline in yields around 150bps. These roughly accord with what we see in OAS changes in Panel B of Table 2 which regresses OAS changes on event dummies. Following Krishnamurthy and Vissing-Jorgensen (2011) we use 2 day changes (1 day after relative to 1 day before) rather than the high frequency approach to allow for illiquidity effects in corporate bonds. The implied yield changes from the ETF prices are a bit larger in magnitude, but in the same ballpark, as the effect on yields in Panel B. Panel B also shows a useful pattern across the rating spectrum: March 23rd appears to have a larger effect on the safest bonds, even within the investment grade category. We have already shown that within investment grade there was a larger effect on shorter maturities, hence the March 23rd announcement in total has the largest effect on safer short maturity bonds where we have documented the larger price distortions. The maturity effect is consistent with the bonds that are directly targeted in the program. April 9th, in contrast, has a larger effect on the risky end of investment grade and the whole spectrum of high yield, even those that are far from investment grade. Thus April 9th represented a broader effect on credit markets than what was directly targeted.

Table 2: Fed Response.

Panel A: Return Responses

	(1) Investment Grade	(2) High Yield	(3) Stock Market
March 23	7.20***	-1.53	-2.82
	(1.59)	(1.71)	(3.58)
April 9	4.67***	6.43***	1.59
	(1.59)	(1.71)	(3.58)
Observations	70	70	70
R-squared	0.37	0.23	0.09

Panel B: Yield Changes

	(1) Aaa	(2) Aa	(3) A	(4) Bbb	(5) Bb	(6) B	(7) C	(8) Stocks
March 23	-53.39***	-27.96	-18.39	3.42	28.31	38.61	55.04	-2.78
	(16.14)	(18.44)	(20.37)	(26.21)	(47.07)	(58.50)	(69.08)	(3.65)
April 9	-18.39	-23.96	-33.39	-53.58**	-112.69**	-134.39**	-150.96**	1.63
	(16.14)	(18.44)	(20.37)	(26.21)	(47.07)	(58.50)	(69.08)	(3.65)
Observations	73	73	73	73	73	73	73	70
R-squared	0.15	0.05	0.05	0.06	0.08	0.08	0.07	0.01

4.3 How Narrow are the Effects of the Fed Interventions?

The March 23 announcement targeted investment grade companies in particular and we saw that bonds of High Yield firms do not respond at all to this announcement. Thus, it is natural to ask how narrow are the effects of the Fed intervention. To start addressing this question we exploit the fact that the policy targeted bonds with maturities shorter than five years in particular. In Panel A of Figure 13 we show announcement effects for an ETF that holds the shorter end of the maturity spectrum (1 to 5 years), and one that holds intermediate maturities (5 to 10). We see that while the effect is substantially stronger in the ETF that holds directly targeted bonds, it is also sizable on the intermediate maturity ETF and does tell us that the Fed policy does have some positive spillovers for assets that were not directly targeted.

We use bond-level data from TRACE to get more precisely at this distinction, focusing on bonds that are in either of the two ETFs LQD and HYD. Because individual bonds trade less frequently and with larger spreads, we compare the average spread on the trading day after the announcement to the average spread on the trading day before the announcement. Table 3 compare response across bonds with different ratings. We report the change in log spread, that is the proportional change in spread, the raw change in spread in basis points, and the change in spread relative to the increase in spread from the start of 2020 until March 20. Panel A compares investment-grade and high-yield bonds. We observe a slightly larger recovery in absolute magnitude for investment grade (85 bps vs 67 bps), but proportionally a much smaller change for high-yield debt: of about 6% relative to 26%, and a much smaller decrease in spreads for high yield relative to the increases experienced before the interventions. Panel B confirms this result across the entire rating scale. Ratings decrease are of almost the same magnitude across ratings, if anything bigger for safer bonds. Proportionally they are much larger for safer bonds. For example AA+ spreads, at the top of investment-grade, recover by about 50% while BBB-, at the bottom, recover only by 13%. Further, there is a discrete drop off in spread recovery once one hits the high yield spectrum. The discrete shift implies that even firms with similar default risk, but one which happened to just fall into the high yield category, experienced very different effects on the March 23rd announcement.

Table 4 repeats this comparison across maturity. The change in spreads decreases roughly monotonically as we go from shorter to longer maturity. For maturities between 2 and 3 years, bond spreads decrease by about 120bps for both high- and low-rated bonds. In contrast, bonds with maturities between 9 and 10 years, only experience decreases of about 60 to 75 bps. Again, these differences are magnified when comparing them to the overall level of spreads (by focusing on the change in logs) or relative to the increase in spread before the Fed interventions. Further, there again seems to be a larger decrease around the 5 year maturity mark, consistent with these bonds benefitting most from the

Table 3: Response to the March 23rd Fed Announcement Across Ratings

Panel A: Investment-grade vs. High-Yield

	$\Delta ln(spread)$	$\Delta spread$	Share of Increase
Inv Grade	-0.26	-84.74	-0.31
High Yield	-0.06	-66.68	-0.06

Panel B: By Rating

	$\Delta ln(spread)$	$\Delta spread$	Share of Increase
AAA	-0.47	-79.53	-0.53
AA+	-0.48	-96.25	-0.52
AA	-0.41	-84.70	-0.42
AA-	-0.36	-90.93	-0.36
A+	-0.38	-88.65	-0.41
A	-0.31	-91.28	-0.35
A-	-0.30	-94.69	-0.35
BBB+	-0.25	-90.36	-0.31
BBB	-0.22	-90.79	-0.29
BBB-	-0.13	-75.39	-0.18
BB+	-0.03	20.95	-0.05
	-0.05	-48.46	-0.04
BB	-0.10	-68.10	-0.11
BB-	-0.06	-49.73	-0.06
B+	-0.06	-86.46	-0.08
B	-0.05	-62.00	-0.05
B-	-0.04	-175.99	-0.04
CCC+	-0.07	-152.89	-0.08
CCC	-0.04	0.33	-0.05
CCC-	-0.05	-397.96	-0.07
C+	0.05	81.78	0.09

program.

The comparisons we have drawn so far considered broad spillovers of the Fed interventions throughout debt markets. Next, we identify a more specific type of spillover *within* firms. To the extent that the bond purchase help short-maturity debt financing, they should bring stability to firms borrowing this way. So if we compare the debt spread among firms with long-maturity debt, we can hypothesize than the firms who also issued short-maturity debt should experience a stronger recovery. Table 5 implements this comparison. Panel A shows that firms that have short-term debt (which we define as ma-

Table 4: Response to the March 23rd Fed Announcement Across Maturities

Panel A: High-Rating Firms

	$\Delta ln(spread)$	$\Delta spread$	Share of Increase
Maturity			
(2, 3]	-0.41	-106.96	-0.38
(3, 4]	-0.48	-122.57	-0.42
(4, 5]	-0.38	-96.31	-0.35
(5, 6]	-0.36	-86.86	-0.36
(6, 7]	-0.32	-75.68	-0.33
(7, 8]	-0.28	-63.76	-0.31
(8, 9]	-0.37	-90.13	-0.39
(9, 10]	-0.28	-73.96	-0.33

Panel B: Low-Rating Firms

	$\Delta ln(spread)$	$\Delta spread$	Share of Increase
Maturity			
(2, 3]	-0.28	-133.03	-0.28
(3, 4]	-0.28	-133.50	-0.27
(4, 5]	-0.25	-103.26	-0.25
(5, 6]	-0.19	-69.40	-0.20
(6, 7]	-0.20	-69.17	-0.23
(7, 8]	-0.17	-66.30	-0.20
(8, 9]	-0.18	-58.11	-0.24
(9, 10]	-0.16	-59.84	-0.21

turity less than 5 years) experience a spread decrease of 90bps following the announcement, whereas firms with no short-term debt only recover by 50bps. Panel B confirms that this difference is not driven by different maturity of the long-term debt, by implementing this comparison within maturity buckets. For all maturity groups, we observe a stronger recovery of spreads for firms that also issue short-term debt.

5. Implications

Together, these results inform our understanding of why bond markets suffered so much during March 2020. We review in turn several potential explanations for this phenomenon and point out their strength and limitations. We emphasize that we only draw relative conclusions for bond markets – we do not claim, for example, some of these explanations

Table 5: Response to the March 23rd Fed Announcement: Firms with and without Short-Term Debt. We compare firms that have existing short term debt (remaining maturity less than 5 years) to those that do not. Specifically, we look at the change in bond spreads of longer maturity debt for those that do and don't have short maturity debt outstanding.

Panel A: Overall

	$\Delta ln(spread)$	$\Delta spread$	Share of Increase
Short			
Y	-0.24	-89.17	-0.28
N	-0.14	-49.69	-0.19

Panel B: By Maturity

		$\Delta ln(spread)$	$\Delta spread$	Share of Increase
Maturity	Short			
(5, 10]	Y	-0.22	-73.76	-0.24
	N	-0.14	-46.86	-0.16
(10, 20]	Y	-0.30	-93.04	-0.39
	N	-0.14	-52.78	-0.21
(20, 100]	Y	-0.26	-79.39	-0.40
	N	-0.16	-53.26	-0.25

aren't responsible for the behavior of the stock market over the same period.

Fundamental distress. A first explanation for the drop in price experienced across market is that expected payoffs of the assets have dramatically decreased. After all, the COVID-19 crisis and the public policy response to it have led the way to a sharp drop in GDP, unemployment is hitting extreme heights, and many firms are on the brink of bankruptcy. This uncontroversial negative effect on the economy suggests poor performance of firms' stocks and bonds ahead. However, several of our findings challenge this view.

First, safe debt and high-yield debt experienced comparable losses. Both have lost less than the stock market but overall losses were of a similar order of magnitude. As we have already pointed out, it is difficult to explain these relative magnitudes in standard models. When economic conditions deteriorate, equity holders lose first, and it is likely that the most fragile high-yield firms default before investment-grade firms. This simple mechanism implies a clear ranking of losses that does not show up in the data.

Second, zooming in on extremely safe firms reinforces this point. The accounting information of many of these firms (Google, Amazon, Microsoft ...) suggest they do not face much risk of bankruptcy in the near future. These firms often hold large amounts of cash in excess of their near-term liabilities. Financial markets also convey a similar message. CDS contracts, which insure against the default of these firms, experience very little movement in this episode. The departure of CDS and bond spread from each other is suggestive of financial frictions at play, but more importantly highlights that large swarth of the markets are not pricing fundamental distress for those firms.

One potential resolution of these tensions is to rely on expectations of a total economic collapse, where all firms default simultaneously. A high probability of such an event (and no possibility of milder intermediate recession) would affect all debt contracts and stocks similarly. Such a view is actually not very plausible for multiple reasons. Not only would it need to have an extremely high probability (over 10% over the next 5 years to explain the price of safe bonds), but also would still not explain spreads on CDS contracts and the response to the Fed interventions. Specifically, the March 23rd intervention had very large effects on investment grade bonds without impacting High Yield debt at all. This suggests that the original driver of these price movements is unlikely to be this ”end of the world” event.

Risk compensations. If bond prices did not drop due to a fall in cash-flow expectations, it has to be that bonds had high expected returns looking forward. A prominent set of theories of expected returns is based on the idea that they constitute compensation for aggregate risks affecting everybody in the economy. Under this view, risk premia can vary due to changes in the risk of the economy (as in Bansal and Yaron (2004)) or variations in willingness to bear risk (as in Campbell and Cochrane (1999)).

These theories face similar challenges to explanations based on cash-flow. Increases in economic risk naturally have a larger impact on more risky firms. And, a lower willingness to bear risk should move more the price of more risky assets. Here again, the concentration of large price drops, as well as pricing disruptions, in the safer firms runs against the grain of these models. This observation contrasts with previous episodes where the risk explanation and explanations based on financial frictions lined up more closely. For example, during the financial crisis of 2008, non-agency mortgage-backed securities suffered large losses. It is difficult to assess how much of this was because of unusual default prospects, or financial distress among investors in these securities.

Financial frictions. The consistent pattern of disruptions we document is suggestive of explanations rooted in distress in the financial sector. Specifically, the early phases of the COVID-19 crisis not only saw extreme declines in asset prices, but also large pricing disruptions. Large bond ETFs traded at discounts relative to their NAV, bonds traded at a discount relative to the corresponding CDS. These disruptions are not the usual small mismatches associated with market microstructure distortions such as bid-ask spread, but rather of the same order of magnitude as the overall price drops. The emergence of these disruptions indicates two things: typical arbitrageurs were unable to equate prices across markets, and some participants in these markets became unwilling to buy some assets relative to others. For example, investors in bonds were willing to trade at a much lower price than in CDS.

The fact that arbitrageurs in bond markets had a limited ability to absorb the sudden large flows is not surprising: since 2008, the corporate bond holdings of primary dealers have steadily decreased, and are now tiny relative to size of the market. However, several observations about dealers during March and April 2020 does not suggest that they are distressed, nor that they are the root cause of price drops. Dealers do not appear to attempt to reduce drastically their holdings of bonds. While intermediation spreads and trading volume both increase, suggesting a period of larger than usual flows to intermediaries, there is no clear sense that dealers are particularly in trouble. For example it is not the case that every market is disrupted in the same way as would be expected if the shock originated in the dealer sector. Or there is no evidence that most of the price disruptions are intermediation spreads collected by the dealers.

These observations leave us with the question of what pushed prices to diverge so much. One interpretation which lines up well with our evidence is some investors were particularly desperate for cash, possibly due to mounting losses, and liquidated many positions to obtain cash on short notice. These investors focused on the initially more liquid and safe securities: Treasury ETFs, investment-grade corporate bond ETFS, and the most liquid securities within each universe. Such importance for cash or equivalently freeing balance sheet space would explain why the response in CDS of investment-grade companies was so muted compared to the movements in bond prices. It also explains why investment-grade bonds, usually the most liquid, saw the largest *change* in prices, converging to discounts similar to the already illiquid high-yield bonds. Under this interpretation, an enterprise for future research will be to identify who are these investors, and why balance sheet space suddenly became so expensive for them.[9] Doing so is particularly important given the overall size of corporate debt market, and the impact these disruptions would have on firm's ability to fund themselves if they lasted. The flip side of this question is why deep pocket investors did not step in to prove liquidity in corporate bonds markets. This is particularly surprising given that the most acute disruptions happened in treasury and Investment Grade corporate bond markets where deep pocketed long-term investors such as pension funds, insurance companies, foreign central banks, and sovereign wealth funds are active participants.

Another important observation is that the disruptions did not last. We find that un-

[9] One such candidate are insurance companies. Insurers hold about a third of the corporate bond market and experienced substantially larger deterioration in stock price than the market during this episode. Chodorow-Reich et al. (2020) discuss how insurers can weather illiquidity in bond markets when in good health, but might also amplify distress if they are sufficiently affected.

precedented actions the Federal Reserve played a major role in shrinking these disruptions quickly. Disruptions in investment-grade corporate debt shrunk right when the Fed first announced it would buy corporate bonds, and when it extended its programs to "fallen angels", i.e. firms that would become "high yield" after the COVID-19 shock. Both increased sharply in value precisely at the time of these interventions. Exactly because these interventions were so unprecedented, announcement effects provide us with a particularly clean estimation of the effects of these actions on financial markets. We find that the effects of the interventions were large and of the same order of magnitude of the interventions themselves (several hundreds of billions of dollars). That said, it remains unclear the ultimate goals of the Fed intervention, and whether it should have intervened. Specifically, the rational for the 2008 interventions– limited risk-bearing capital in the financial sector and widespread bank runs– didn't seem present in 2020.

Echoing our previous comments, the Fed might have wanted to stop a financial crisis in the making if some of the major actors of corporate lending would have gotten in more trouble. Or, it might have tried to just directly subsidize credit for industrial firms with the intention to accelerate the recovery process once the pandemic is controlled. In both of these views, the response to the initial intervention on March 23 is only a half-success. As we show in Section 4 (see also Figure 20 in the appendix) the intervention doesn't seem to effect markets more broadly. While the recovery of corporate bond is important in itself, the lack of response of other asset classes is inconsistent with the Fed interventions being effective in eliminating the potential of a deeper recession. The more widespread effects on April 9 suggests more success in this view, but maybe at the cost of promising an unlimited quantity of interventions. Dissecting exactly which mechanisms played a role in creating large and heterogeneous responses to the Fed interventions will be key to evaluate the overall value of these interventions, and will require being able to take a more precise stand on how the situations would have evolved absent these interventions. Here again, this task will require a better understanding of the root causes of the disruptions. We plan to continue pursuing this objective as our paper evolves.

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Appendix

A. Appendix Tables and Figures

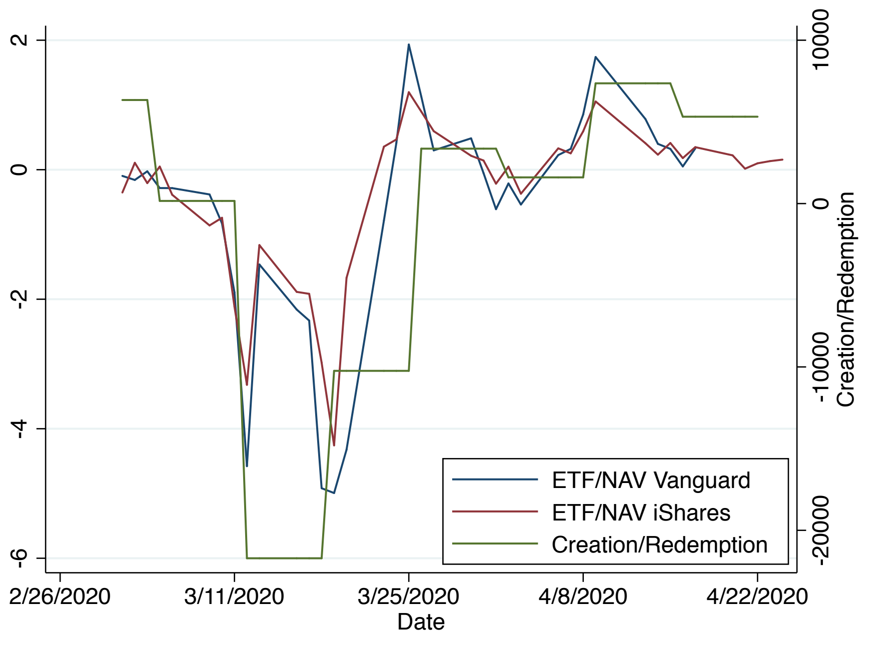
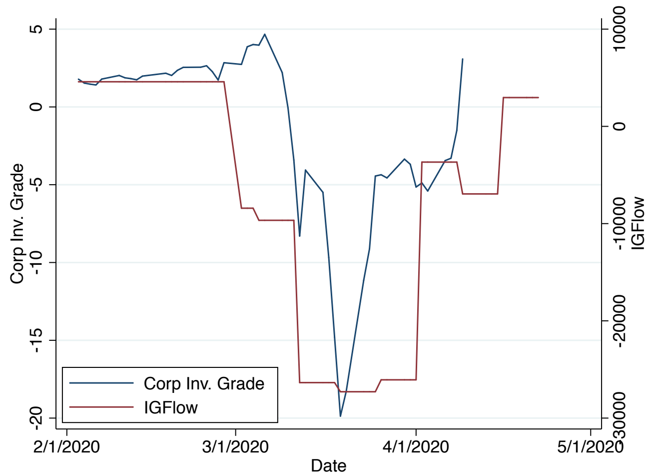


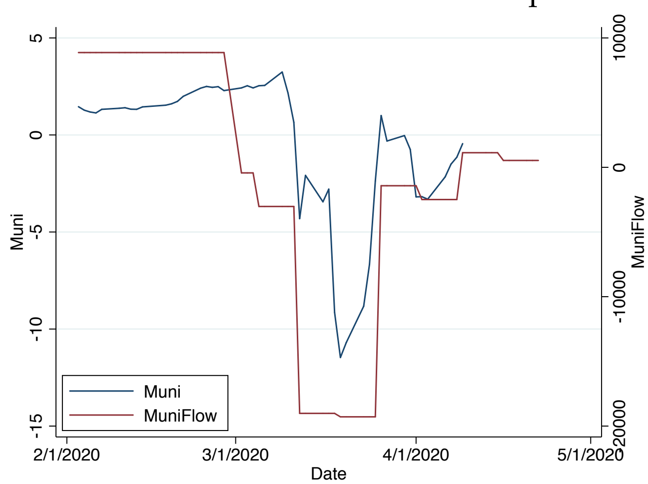
Figure 15: ETF NAV Discounts and Redemption / Creation of ETF Shares.
This figure plots average NAV discounts for Vanguard and iShares against creation or redemption of ETF shares (plotted on the right scaled in millions of dollars, with negative numbers indicating redemptions). When the ETF trades below NAV, authorized participants (typically primary dealers) can redeem ETF shares and sell the bonds to capture the spread.

Figure 16: Mutual Fund Flows. Panel A plots investment grade mutual fund flows (billions of USD, right axis) against the cumulative return to investment grade bonds. Panel B does the same for municipal bonds. Panel C shows high yield corporate.

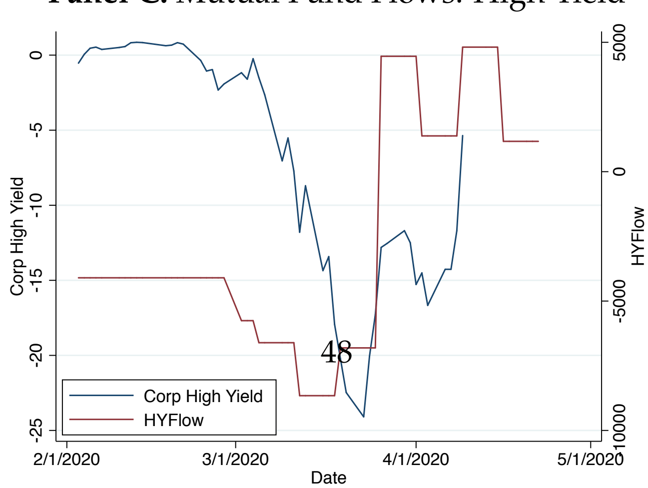
Panel A: Mutual Fund Flows: Investment Grade



Panel B: Mutual Fund Flows: Municipal Bonds



Panel C: Mutual Fund Flows: High Yield



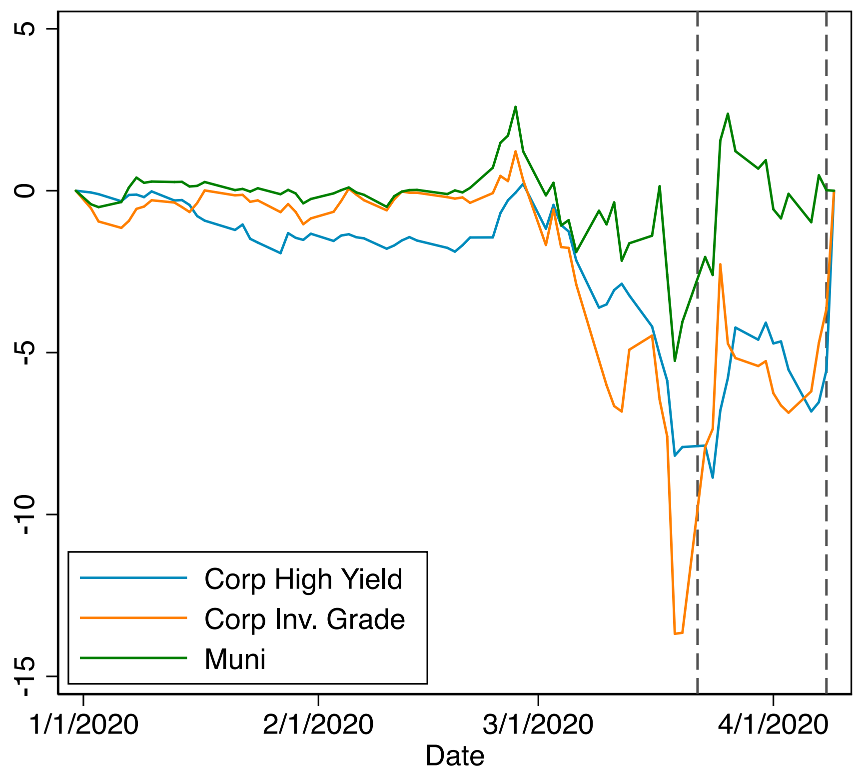
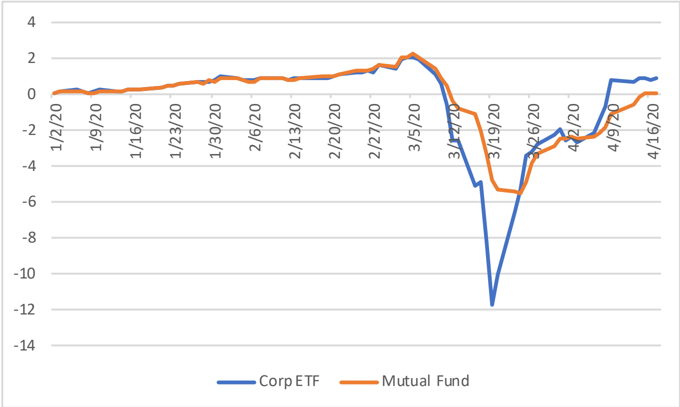


Figure 17: Cumulative abnormal returns during the Covid Crisis.
This figure reports the cumulative abnormal log returns for an investment-grade corporate bond ETF (LQD), a high-yield corporate bond ETF (HYD), and municipal bond ETF (MUB) through the Covid-19 crisis (January 2020 through early April). Daily returns are regressed on the stock market returns, changes in the VIX, and changes in 10 year Treasury yields and we plot the cumulative sum of residuals. This highlights whether the movements in each series are well explained by changes in the market, volatility, or long term rates.

Figure 18: Corporate Bond and MBS ETFs vs Mutual Fund. This figure plots cumulative log index based on Vanguard ETFs vs Mutual Funds. Panel A looks at corporate bonds where both the fund and ETF track the Bloomberg Barclays U.S 1-5 Year Corporate Bond Index (tickers are VCSH and VSCSX). Panel B looks at Mortgage-Backed Securities meant to track the Bloomberg Barclays U.S. MBS Float Adjusted Index (tickers are VMBS and VMBSX). Source: Yahoo Finance.

Panel A: Vanguard Mutual Fund vs ETF Short Term Corporate Index



Panel B: Vanguard Mutual Fund vs ETF MBS Index

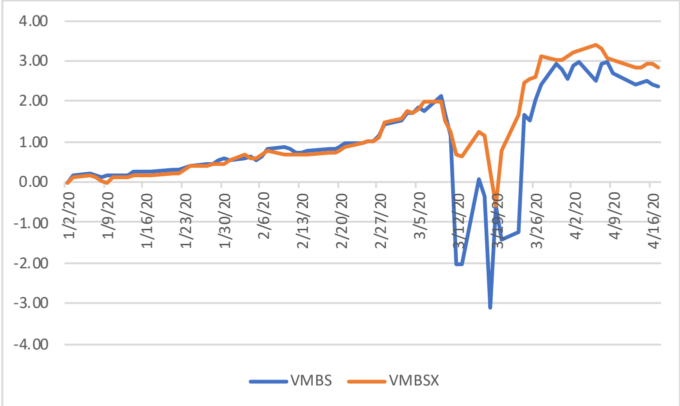
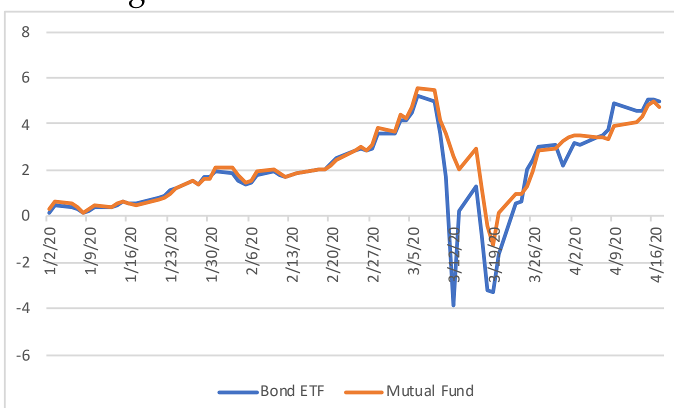


Figure 19: Bond and Muni ETFs vs Mutual Fund. Panel A plots cumulative log index based on Vanguard ETF vs Mutual Fund. Vanguard Total Bond Market Index Fund ETF Shares (BND) and Vanguard Total Bond Market Index Fund Admiral Shares (VBTLX). Both are meant to track the Bloomberg Barclays U.S. Aggregate Float Adjusted Index. Panel B plots cumulative log index based on Vanguard Tax-Exempt Bond Index Fund ETF Shares (VTEB) and Vanguard Tax-Exempt Bond Fund Admiral Shares (VTEAX). Both track the Standard & Poor's National AMT-Free Municipal Bond Index. Source: Yahoo Finance.

Panel A: Vanguard Mutual Fund vs ETF Total Bond Index



Panel B: Vanguard Mutual Fund vs ETF Municipal Index

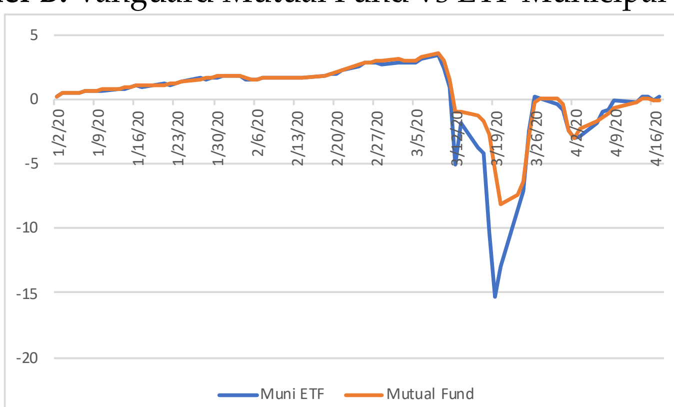
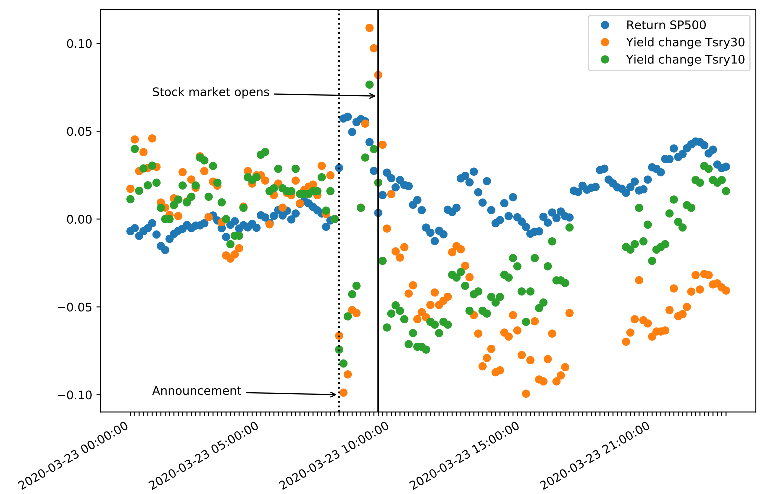


Figure 20: Fed Intervention Event Study. Here we look at indirect effects of the policy intervention. We look at SP500 futures and the yields of 10 and 30 year treasury bonds.

Panel A: 3/23 Purchase Investment Grade Corp



Panel B: 4/9 Increase Purchases, Extend to High Yield