The Cost of Immediacy for Corporate Bonds*

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Abstract

Liquidity provision in the corporate bond market has become significantly more expensive after the 2008 crisis. Using index exclusions as a natural experiment during which uninformed index trackers request immediacy, we find that the cost of immediacy has doubled for short-term investment-grade bonds, and more than tripled for speculative-grade bonds. In addition to this level effect the supply of immediacy has become more elastic with respect to its price. Consistent with higher cost of holding inventory in a more stringent regulatory environment with smaller dealer portfolios, we also find that dealers revert deviations from their target inventory more quickly after the crisis.

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1 Introduction

In dealership, over-the-counter markets dealers are compensated for providing liquidity to market participants. Unlike brokers, who simply match customers, dealers provide immediacy by expanding, or reducing, their inventory (Garman, 1976; Stoll, 1978; Amihud and Mendelson, 1980; Ho and Stoll, 1981). Since the onset of the 2008 credit crisis, aggregate corporate bond inventories have shrunk by 50-60%.[1] During the same period the corporate bond market has been growing steadily: the amount of corporate bonds outstanding has almost doubled; trading volume has increased; and the number of new issuances has increased (see e.g. Figure 1 panel C and D). Shrinking inventories and a growing bond market suggest that providing immediacy to liquidity seekers has become harder. We show that the price of immediacy has more than doubled relative to what it used to be before the 2008 crisis.

Following the credit crisis, dealers have kept their inventories low in anticipation of regulation banning proprietary trading (Volker rule) and imposing tighter capital requirements, (Watson, 2012). For instance, many large banks have shut down their proprietary trading operations long before the application of the Volker rule (Trebbi and Xiao, 2015). While regulation could have the unfortunate side-effect of reducing market liquidity (Duffie, 2012), empirical investigations based on effective bid-ask spreads, or other price impact measures, are unlikely to uncover its adverse effect.[2] A direct application of the well-known Lucas (1976) critique suggests that regulations affecting the cost of immediacy may induce market participants to optimally, albeit

[1]Primary dealer inventories of corporate securities peaked at the beginning of the crisis at $281 bn. In early 2009 the inventories had been cut to $100 bn and in September 2012 the inventories were down to $60 bn (see Figure 1). The specific drop in inventories of corporate bonds is also approximately around 50% from the peak before the crisis.

[2]For instance, Trebbi and Xiao (2015); Adrian, Fleming, Shachar, and Vogt (2015); Bessembinder, Jacobsen, Maxwell, and Venkataraman (2016) all find some evidence that liquidity measures and trading costs have improved after the crisis.

reluctantly, spread their large trades over time, or give up on large trades altogether. In fact, measured trading costs might decrease, leading to erroneous conclusions about recent regulations. To use an analogy, rules increasing the cost of air travel will induce more travelers to use the bus. By discouraging air travel, such regulation might well lower the average cost of transportation (after all, taking the bus is cheaper than a plane ticket), but average utility will surely decline because of the loss of immediacy. Getting from Los Angeles to New York in three days by bus is not the same as completing the trip in five hours by plane.

Liquidity is generally defined as the ability to execute a transaction at a fair price *and* on short notice. Low realized bid-ask spreads thus indicate that transactions are executed near a fair price, but they tell little about the speed of execution, i.e. whether immediacy was supplied by the dealer. Since post-crisis regulation and the change in dealer behavior, e.g. shutting down proprietary trading operations, might have impacted the ability to provide immediacy, we need to look beyond traditional corporate bond liquidity measures.

The main contribution of this study is to quantify the cost of immediacy for corporate bonds in a trading environment that circumvents the Lucas (1976) critique. We identify trading situations in which the motive to obtain immediacy is strong, so that liquidity seekers cannot or will not orchestrate alternative trading arrangements. Furthermore, in our setting, the desire to trade reveals no information about the fundamental value of the assets traded. Specifically, we compute liquidity costs around bond exclusions from the Barclay Capital (formerly Lehman) investment-grade corporate bond index. In this natural experiment, index trackers (the sellers) request immediacy from the dealers (the buyers) in order to minimize their tracking error. Moreover, mechanical index rules, not fundamentals, dictate the decision to trade, so that dealers do not have to worry about information motivating the trades. This last observation ensures that the dealer's pricing reflects the cost of providing immediacy, rather than the adverse selection problem of dealing with unwanted informed traders (Easley and O'hara, 1987).

Our empirical analysis shows that the price elasticity of the supply of immediacy has increased significantly after the crisis. This increase in elasticity is indicative of higher market making cost, which translates into higher average transaction costs,[3] thus providing support for standard theories of market maker inventories (see e.g. Madhavan and Smidt (1993)). For safe bonds, which are quickly turned over again by dealers, the cost of immediacy has approximately doubled, while for more risky bonds, the cost has more than tripled. The adverse increase in transaction costs offsets the impact of previous regulations in the corporate bond market that aimed at lowering the cost of trading through increased transparency (Bessembinder, Maxwell, and Venkataraman, 2006; Edwards, Harris, and Piwowar, 2007; Goldstein and Hotchkiss, 2008).

We also show that the market share of traditional dealers decreases substantially after the crisis. This is consistent with these dealers closing down their proprietary trading operations which reduces their target portfolio. As it becomes more expensive for traditional market makers to supply immediacy other market participants then take over as market makers but at a higher cost (Duffie, 2012).

We infer the cost of immediacy by computing an inter-temporal bid-ask spread, which we define as the percentage difference between the post-exclusion ask price and the pre-exclusion bid price. This measure captures the essence of the dealer's role, who uses her inventory to absorb the selling pressure generated by the index trackers unloading their positions, and then resells the bonds to restore the desired level

[3]On average, the estimated bid-ask spreads in this study are comparable to those of Edwards, Harris, and Piwowar (2007) and Feldhütter (2012).

of inventory. In a competitive dealer market the return from providing immediacy would equal the cost of providing immediacy in expected terms.[4] In order to control for systematic movement in the corporate bond market around the exclusion, we also compute a measure of abnormal bond performance using the methodology proposed by Bessembinder, Kahle, Maxwell, and Xu (2009). Finally, we use a special version of the TRACE database, which we obtained directly from FINRA, to compute dealer specific returns and bond positions around the exclusions. All these measures point to the same conclusion that the cost of providing immediacy has increased in the post-crisis, low-inventory regime.

Before measuring the transaction costs around index exclusions, we verify that these exclusions are indeed events during which index trackers request immediacy. Our analysis reveals that the traded volume of bonds exiting the index peaks during the day of the exclusion, and it is at least four to five times higher than in the weeks surrounding the exclusion. The peak in trading volume is consistent with index trackers attempting to minimize their tracking errors by trading close to the index exclusion date. Blume and Edelen (2004) show that stock index trackers display a similar desire to transact on the exact exclusion date.

Having established the existence of a demand for immediacy, we verify that dealers absorb the selling pressure by increasing their inventories. Dealers slowly increase their inventories a few days before the exclusion, with the increase intensifying at the exclusion day. The speed with which bonds are resold by the dealers in the weeks following the index exclusion depends on the nature of the exclusion: for maturity-related exclusions, the sales take place relatively quickly; for downgrade-related exclusions, the bond sales tend to occur over a longer period.

[4] There could be several alternative specifications of the cost of immediacy, e.g. ask to ask price, bid to bid price, or mid- to mid-price. However, all these measure are highly correlated and we keep a focus on the cost as seen from the dealer's perspective.

Dividing the sample into three sub-periods shows that dealers' behavior has changed after the crisis. Our analysis of the cumulative change in inventories demonstrates that dealers' willingness to hold the bonds in their inventories has declined in the new regulatory, low-inventory regime. While before (and even during) the crisis dealers kept a large share of the downgraded bonds for at least one hundred days, after the crisis the inventories return to near pre-exclusion levels within roughly 20 trading days. More formally, we estimate dealer-specific inventory mean reversion parameters following Madhavan and Smidt (1993), and find that, after the credit crisis, dealers are less willing to tolerate deviations from their desired level of inventories. The estimated inventory half-life significantly decreases from before to during, and from during to after the crisis. These findings indicate a clear shift in the inventory costs of market makers.

For bonds maturing within less than one year, dealers start selling soon after the exclusion date, and inventories are back to normal within two weeks. We note that, during the crisis, the cumulative change in inventories for the short-maturity bonds becomes negative shortly after the exclusion, probably because selling these liquid bonds was an easy way to raise cash. We also note that the dealer behavior for the downgraded bonds were very similar before and during the crisis where a large part of the bonds stayed on the dealers inventory. It is after the crisis, rather than during the crisis, when dealers should have been more financially constrained, that the dealer behavior changes. This change in dealer behavior suggests that it is driven by regulation concerns and the shift to running lower inventories, rather than limited risk bearing capacity in a more traditional sense.

In addition to contributing to the literature on corporate bond liquidity, this paper occupies a natural place in the literature connecting regulations to financial market efficiency. The debate on the repercussions of the Dodd-Frank act on the financial system offers positions that view the regulatory changes as potentially harmful (Duffie, 2012) as well as beneficial (Richardson, 2012). Despite the multitude of opinions on the welfare effects of the regulatory changes that took place after the credit crisis, few empirical investigations exist. In a recent paper, Trebbi and Xiao (2015) argue that the Dodd-Frank act has not had negative welfare consequences, since their breakpoint testing technique cannot detect any "breakpoints in market liquidity for fixed-income asset classes and across multiple liquidity measures, with special attention given to the corporate bond market." However, as already argued these liquidity measures (such as the one shown in Figure 1, Panel B) are the outcome of market participants' optimization problems, and a large-scale policy change alters the optimal behavior of investors and dealers. By focusing on a homogenous, information-free event in which agents do not arrange alternative trading strategies before and after the policy change, our analysis is able to uncover the adverse effect that the new regulatory, low-inventory regime has had on corporate bond liquidity. Using a more recent sample that covers the implementation of the Volker rule, Bao, O'Hara, and Zhou (2016) confirm its adverse impact on liquidity provision. Similarly, Bessembinder, Jacobsen, Maxwell, and Venkataraman (2016) provide some evidence that dealers are less willing to commit capital after the crisis. Our paper differs substantially from these two studies in that we propose an event and a novel measure of immediacy that directly picks up shifts in dealers' cost of providing liquidity and holding inventory over time.

Our paper also contributes to the literature on index revisions, which is quite large when it comes to stocks (Harris and Gurel (1986); Shleifer (1986); Beneish and Whaley (1996); Hegde and McDermott (2003); Denis, McConnell, Ovtchinnikov, and Yu (2003); Chen, Noronha, and Singal (2004); Greenwood (2005)). Bond index revisions have also been studied in Newman and Rierson (2004) and Chen, Lookman, Schürhoff, and Seppi (2014), but both studies have focused on special one-time announcement effects, months before the actual index revision date. Newman and Rierson (2004) look at a large and unique issuance event for European telecom companies. Chen, Lookman, Schürhoff, and Seppi (2014) look at the effect of a unique rating rule change for the Lehman index. Unlike these studies, our paper looks at the trading very close to the actual index revision dates.

Lastly, the finding of our paper have bearing on the literature studying liquidity provision around predictable trades. Bessembinder, Carrion, Tuttle, and Venkataraman (Forthcoming) show that traders engaged in predictable transactions, that do not reveal information about the fundamentals of the traded asset, need not face predatory trading (Brunnermeier and Pedersen, 2005). In fact, disclosing information about the timing and attributes of the transaction mitigates its adverse price impact (Admanti and Pfleiderer, 1991). Our results indicate that the finding of Bessembinder, Carrion, Tuttle, and Venkataraman (Forthcoming) on the periodic portfolio re-balancing by USO (a commodity ETF) are valid in a more general market setting, even when trades are not completely predictable. Lou, Yan, and Zhang (2013) look at anticipated shocks in the treasury market whereas our study focuses on the more illiquid corporate bond market.

2 Corporate bond index tracking

Exclusions from the Barclay Capital (formerly Lehman) corporate bond index provide an ideal natural experiment for studying the cost of immediacy over time. Each month corporate bond index trackers demand immediacy from dealers when they seek to sell bonds exactly when the bonds exit the index.

The rules for bonds entering or exiting the index are both transparent and mechanical which makes the monthly exclusion events information-free and homogeneous over time. Bonds exit the index for three main reasons: time to maturity falls below 1 year; their rating goes from investment-grade to speculative-grade; or when they are called by the issuer. The index is rebalanced once a month on the last trading day of the month at 3:00 PM EST and all bonds that are no longer index eligible are excluded at this point in time. Hence, the actual downgrade date of a bond which may or may not contain information (Ambrose, Cai, and Helwege (2012)) takes place before the bond exclusion from the index (we address this issue in Section 6).

The objective of the index trackers is to minimize tracking error between the return on their portfolio and that of the index. Blume and Edelen (2004) show that index trackers following the S&P 500 index are transacting on the exact day that the index is rebalanced, even though they then sacrifice potential profit by doing so (Beneish and Whaley (1996)). Low tracking error is a signal to investors that the index tracker is in fact committed to tracking the index and thus resolves an agency problem. Figure 2 and Table 1 show that corporate bond index trackers, similar to the S&P 500 index trackers, also seek to transact as close as possible to the exclusion date. Panel A of Figure 2 shows trading volume for all bonds excluded from the index because of low maturity. Day 0, the event day, in the Figure and in the Table is the last trading day of the month in which the bond is excluded. Trading volume is aggregated across all the bonds excluded at a given event date and then averaged across all event dates. Panel B replicates Panel A for bonds excluded because of a recent downgrade to speculative grade. Table 1 shows the same thing as in the Figure as well as the standard error of the mean volume estimate and the trading volume fraction relative to the day 0 volume. In both cases, trading activity spikes on the exclusion date.[5] Table 1 shows that the volume 20 days before and after the event is

[5]A similar trading pattern can be seen around revisions of the S&P 500 (Shleifer (1986); Harris and Gurel (1986); Chen, Noronha, and Singal (2004) and others), the Nikkei 225 (Greenwood, 2005) and the FTSE 100 (Mase, 2007).

only 19% to 25% of that at the event date. The peak in trading activity is thus 4-5 times that of the normal level.

Since corporate bonds trade over-the-counter, index trackers cannot be certain to transact at the desired point in time which is why activity is also high right before and after the exclusion date. Figure 2 and Table 1 clearly confirms that some investors are in fact tracking the index and that they seek to minimize their tracking error as is expected from index trackers.

Bond index trackers are different from stock index trackers in the way they track the target index. Stock index trackers use an exact-replication strategy (Blume and Edelen, 2004), whereas bond index trackers use a sampling strategy (Schwab, 2009; Vanguard, 2009). Exact-replication implies that the investor holds a position in each asset member of the index. For corporate bond index trackers, such a strategy would generate huge transaction costs because the index is large, the market is illiquid, and the index is rebalanced every month. Instead, bond index trackers sample the index by holding only a fraction of the bonds currently in the index. This portfolio is designed to match the index with respect to duration, cash flows, quality and callability. As an example, the Vanguard Total Bond Market Index Fund held 3,731 out of 9,168 bonds in the Barclay Capital US aggregate bond index on December 31, 2008. All the large bond index funds, e.g. BlackRock, Vanguard, Schwab and Fidelity, have similar guidelines for tracking an index by sampling. The typical rule is to have 80% of their assets invested in bonds currently in the index and the remaining 20% invested outside the index. The outside investments are usually in more liquid instruments such as futures, options and interest rate swaps but could also be in non-public bonds or lower rated bonds. The 80% rule followed by index funds is not per se binding but still gives yet another reason why index trackers are selling out close to the exclusion date as we saw in Figure 2 and Table 1. Lehman has also given guidelines on how to track the index using only liquid derivatives (Dynkin, Gould, and Konstantinovsky, 2006) but that is not the way bond index funds are tracking the index.

The criteria for how to invest the last 20% outside the index are rather loose (Schwab, 2009; Vanguard, 2009) so it is not possible to know exactly which assets the funds have on their balance sheets. The lack of transparency makes it even more important for the funds to keep a low tracking error as a way to signal sane investments (Blume and Edelen, 2004). Looking at the Vanguard Total Bond Market Index Fund again, they have had an yearly average absolute return tracking error on their shares compared to the target index of 23.5 bps over 1995-2009. This track record can be compared to that of Barclays Global Investors fund that tracks the S&P 500 index with a tracking error of only 2.7 bps per year (Blume and Edelen, 2004).

Index sampling and the 80-20 rule are examples of a trade off between tracking error and transaction costs. Hence, one could imagine that bond funds would also spread out their selling activity and not trade at day 0 in order to avoid the price pressure induced by other index trackers. This behavior could potentially generate higher returns than those of the index. But first, index trackers do not seek to outperform the index. This is because investors use the index funds to express a view on a certain credit or asset class (see Levine (2016)). The investors thus want to capture a specific set of factors and get pure exposure to these factors. Many investors, for example, short the index funds. Second, conversations with the leading bond funds also support the fact that they are not spreading out their selling of bonds exiting an index. For most bonds they will spread out their selling activity within the exclusion date and for larger bonds or in a more illiquid market they might start selling 1-2 days in advance. This would particularly be the case when for example large countries are excluded from sovereign bond indices where they had a large overall weight in the index. But this is less often the case for corporate bonds.

3 Data

This study uses a unique and complete transaction level dataset for US corporate bonds provided to us by FINRA. The dataset is identical to the Enhanced TRACE dataset available on the Wharton Research Data Services (WRDS), except that we also have anonymized counterparty identifiers for each transaction. This allow us to track the changes in individual dealer inventories around the exclusion events.

3.1 Sample Construction

The bond sample consists of all bonds exiting the Barclay Capital corporate bond index between July, 2002 and November, 2013. The exclusions are fairly equally scattered over time as seen in Figure 3. As of July, 2005, the index contains all US corporate bond issues with an investment-grade rating by at least two of the three major rating agencies (Standard and Poor's, Moody's and Fitch). Furthermore, the issuance size must be at least $250 millions and time to maturity must be above 1 year[6]. Bonds leave the index for the three reasons: if the time to maturity falls below 1 year; if they are called; or if the rating[7] goes from investment-grade to speculative grade. On the other end, bonds enter the index for two main reasons: if they are newly issued and index eligible; or if the rating goes from speculative-grade

[6] There are certain more qualitative rules for being index eligible. See index rules at `https://ecommerce.barcap.com/indices/index.dxml`

[7] Each bond has an index rating defined as the middle rating from Standard and Poor's, Moody's and Fitch. If only two ratings are available, the lower and more conservative rating is used. If only one rating agency provides a rating, then that is the index rating. Before July 1st, 2005 Fitch was not used in the index rating.

to investment-grade.[8] These rules result in an index which covers a large fraction of the market.

Table 2 gives characteristics of the excluded bonds. A large number of bonds have been excluded from the index for "other" reasons. The average issuance size of these bonds is far less than for the rest of the sample. Most of these exclusions have been generated by an increase over time in the lower index limit on issuance size, once in October, 2003 and again in June, 2004. At the end of 2009 the index contained more than 3,400 bonds.

The TRACE data is cleaned up before usage following the guidelines in Dick-Nielsen (2009). We then remove residual price outliers as in Rossi (2014). Finally, we only keep trades equal to, or above $100,000 in nominal value (Bessembinder, Kahle, Maxwell, and Xu, 2009).[9]

3.2 Intertemporal bid-ask spreads

Calculating corporate bond returns is a challenge because most bonds trade infrequently. We calculate dealer-bond specific returns and as a robustness check, we also calculate bond specific returns. Dealer-bond specific returns are calculated by first calculating a dealer specific buying price for each bond. The dealer specific buying price is the average buying-volume weighted price over day -2, -1, and 0 for a given bond. Here day 0 is the index exclusion day, and day -2, and -1 are the two days leading up to the event date. The price thus reflects the individual dealer's average buying price. Second, many dealers may not transact the purchased bonds for many days following the event. To circumvent this problem, we calculate a market-wide

[8] We do not report any results for index inclusions. This is because there is little price pressure at inclusion events. Because index trackers sample the index they can select which bonds to buy. Index trackers thus have a selection of maybe 10-30 bonds and they only need to buy 3-10 of them. This freedom in selection alleviates most of the price pressure.

[9] We keep agency transactions, but results in this study are robust to their exclusion.

average selling price on each day following the event date. The selling price is the volume weighted average selling price over all sell-side transactions across all active dealers in that bond. Since this calculated selling price can be seen as a market-wide price, it is likely the price that the individual dealer would use to mark-to-market her acquired inventory position. The return is then calculated as the logarithmic difference between these two prices (Cai, Helwege, and Warga, 2007; Ambrose, Cai, and Helwege, 2012). If there are no transactions on a given day following the event date the return is calculated using the first available price after that date. In order to limit any information bias caused by the non-trading days, the sample is restricted to bonds where the prices are observed within three days of the non-trading date.[10] The returns are also corrected for any accrued interest. Furthermore, an abnormal return is formed by subtracting the return of a benchmark index (Barber and Lyon, 1997). The benchmark is a portfolio of bonds matched on rating and time to maturity. When matching on time to maturity the bonds in the benchmark bracket the maturity of the excluded bonds.

In order to test the robustness of the dealer-bond specific return, we also calculate a bond specific return. This is done using a procedure similar to the one above. The difference is that instead of a dealer-bond specific buying price, we use a market-wide buying price. The market-wide buying price is the volume weighted average across all buy-side transactions (from all dealers) in that bond.

We define the cost of immediacy as the return on the transaction as seen from the dealer's viewpoint, which is why the bid-ask spread is included in all returns as explained above. Put differently, the cost (or price) of immediacy is the return that dealers must expect to earn in order to provide liquidity promptly and sufficiently.

[10] Both Cai, Helwege, and Warga (2007) and Ambrose, Cai, and Helwege (2012) show that this return calculation method is robust to an even larger window.

We note that these returns are not replicable by other investors in the economy, who would face a possibly large bid-ask spread to implement the strategy of buying at the exclusion and selling afterward. The rest of the study uses the following terminology. When the benchmark return is subtracted from the raw return it is called an abnormal return, and when the benchmark return is not subtracted it is called an inter-temporal bid-ask spread. The latter method is also used as the event return in Goldstein and Hotchkiss (2008), whereas the the former method is used as the event return in Cai, Helwege, and Warga (2007) and Ambrose, Cai, and Helwege (2012).

4 Inventory Dynamics

In an environment where inventories are costly, providing immediacy has implications for both inventory and pricing dynamics (Madhavan and Smidt, 1993). In this section we explore the first implication; we leave the second implication for the next section.

4.1 Dealer inventory around index exclusions

Index trackers demand immediacy when bonds exit the index. Figure 2 and Table 1 showed that trading activity spikes at the exclusion events indicating that index trackers get rid of the bonds. Figure 4 shows the corresponding dealer inventories in the bonds excluded because of low maturity and because of a recent downgrade. The inventories are cumulative, aggregated over all dealers, and with a chosen benchmark of $0 100 trading days before the event. The daily change in inventory is calculated as the total volume in dealer buys minus the sales. Consistent with the story of index trackers demanding liquidity or immediacy at the exclusions, the dealer inventories on average increase in the days leading up to the exclusion and particularly on the event day. Hence, dealers use their inventory actively when providing liquidity. For the low maturity bonds, we see the increase starting around 3 days prior to the exclusion date whereas the buildup for the downgraded bonds starts earlier but also increases in magnitude approximately 3 days prior to the event. The buildup in the downgraded bonds from day -23 up to day -4 is in part caused by a buy up from the dealers on the actual downgrade date. On the downgrade date itself other investors, different from index trackers, demand liquidity because many firms have an investment policy that discourages holding speculative-grade assets. This sell out on the downgrade date happens despite a grace period of up to two month in which the institutional investors are allowed to hold on to these bonds (see e.g. Ellul, Jotikasthira, and Lundblad (2011) and Ambrose, Cai, and Helwege (2012)). However, we will show later that in terms of immediacy, the downgrade date is a smaller event than the exclusion date. At the downgrade date, dealers behave more like brokers, matching buy and sell orders, rather than providing immediacy by taking the bonds on inventory.

After the exclusion event, Figure 4 shows that the dealers sell all or part of their newly acquired inventory. After 2 weeks most of the acquired inventory of the low maturity bonds has been sold off. For the downgraded bonds only around two-thirds of the bonds has been sold after 100 days. The two events thus differ in the way dealers use their inventory. Since dealers on average do not sell one-third of the buildup again within 100 days, the decrease in the general willingness to hold inventory is expected to have affected the transaction cost of the downgraded bond the most.

4.2 Dealer behavior before and after the credit crisis

Figure 5a and 5b show the change in dealer inventories around the event before, during, and after the crisis. Table 3 and 4 show statistics of the corresponding inventory positions. The before period is from 2002Q3 to 2007Q2, the crisis period is from 2007Q3 to 2009Q4, and the after period is from 2010Q1 to 2013Q4. The dealer behavior in the short maturity bonds has changed from before to after the crisis in that the dealers on average provide twice as much immediacy after the crisis than before. But they decrease the inventory to 0 over roughly the same time interval. Hence, the absolute speed with which they sell off again has approximately doubled (we model this more carefully in the next section).

The fact that dealers provide more immediacy after the crisis could be due to index tracking becoming more popular. If index tracking has become more popular over time then the dealer-buying volume (i.e. index trackers selling volume) should have increased over time for the regular maturity exclusions. However, this is not what we see in the data.[11] While index trackers sell slightly more bonds at the exclusion, this cannot alone explain the increase in inventory positions that we observe. Instead, it seems that dealers' reduced matching of buy and sell orders is responsible for the larger inventory buildup.

For the downgraded bonds there is a clear shift in dealer behavior from before and during the crisis to after the crisis. Before and during the crisis the dealers keep a large fraction of the inventory increase on their books. However, after the crisis they only have 16% of the inventor left after 30 days compared to 58% before the crisis and 30% during the crisis. Since the shift in behavior happens after the crisis, and not only during the crisis, it is reasonable to infer that the shift is not driven solely by limited risk-bearing capacity of the dealers. Measures of dealer risk-bearing capacity such as dealer leverage, or the VIX index are all better after the crisis than during the crisis.

This change in behavior occurring after the crisis is consistent with the new reg-

[11]We have not included the results for brevity.

ulatory environment successfully discouraging market makers from keeping a risky inventory portfolio. The risky downgraded bonds are no longer kept on inventory but are instead unloaded rather quickly. This change in behavior has most likely decreased the riskiness of the market makers as was the intention of the post-crisis regulation. Note that much of the regulation is not finally implemented during our sample period. However, the change in behavior happens before the actual implementation date because most of the regulation can be anticipated and because the dealers will not risk ending up with a large inventory position which they then have to unload after the implementation of the various rules. Specifically, starting in 2010 the major investment banks close or sell off their proprietary trading activities. The investment banks motivated this action with reference to regulatory compliance. The reduction of proprietary trading have two effects on the market. First, it reduced the desired portfolio position of the dealers. Second, it potentially reduced demand for the bonds by eliminating a natural counterparty unless the sold off units maintained the same level of activity (which they did not since many of them closed down later). Both of these effects would increase the inventory holding costs thereby increasing the cost of obtaining immediacy (Madhavan and Smidt (1993)).

4.3 Speed of inventory adjustment

In order to provide liquidity, market makers often have to deviate from their desired level of inventory. Provided that inventories are costly and pose risks commensurate to the volatility of the assets traded, dealer inventories will display mean reversion. To estimate the speed of mean reversion for each dealer and each event, we follow Madhavan and Smidt (1993), who derive the following equation relating inventory changes to the dealer desired level of inventory

$$I_t - I_{t-1} = \beta \times (I_{t-1} - I^\star) + \varepsilon_t, \tag{1}$$

where I_t is inventory at time t, $I^\star$ is the desired level of inventory, and ε_t is a mean-zero unanticipated liquidity-driven volume, which is possibly autocorrelated and heteroscedastic. In Madhavan and Smidt (1993), $\beta \in (-1, 0)$, and is more negative when inventory costs or the assets' volatilities are higher.

Madhavan and Smidt (1993) show that failure to account for the time-varying nature of $I^\star$ over long time periods affects the estimation of β. While we consider a relatively short window around the exclusion event, we have conditioned the sample on an event which could potentially change the desired inventory level. Figures 4b and 5b, and Tables 3 and 4 did reveal that on average inventories do not revert to zero within 100 days, suggesting that they might settle at a higher level after the exclusion. For this reason, we propose the following specification for the desired level of inventory

$$I^\star = \alpha_0 - \alpha_1 \mathbf{1}_{[\mathbf{t}>-\mathbf{3}]}, \tag{2}$$

where α_0 and α_1 are constants representing the desired level of inventory before an after the exclusion event. Note that, we activate the indicator variable in Equation (2) at $t-3$ to account for the fact that the increase in inventory happening right before the event is not necessarily a deviation from an old desired level of inventory, but rather a migration toward a new desired level of inventory. We point out that activating the dummy variable at $t = \{-1, -2, 0\}$ makes almost no difference on estimates of β.[12]

Our objective is to investigate whether dealers have sped up their inventory mean reversion in response to the new post-crisis regulatory, low-inventory environment.

[12]Ideally, we would estimate a smooth-transition model, but this is beyond the scope of this paper.

To answer this question, for each event date and for each top-ten dealer, we first estimate Equation (1) with iterated GMM, using a Bartlett kernel with three lags (see Madhavan and Smidt (1993)). To determine top dealers we focus on the dealers that take on the most inventory in $t \in [-2, 0]$ in a given event date. Note that the composition of the top dealers changes over time. Next, we run a pooled regression with period dummies indicating the pre-crisis, crisis, and post-crisis periods. Table 5 shows these regressions for the maturity and downgrade events separately. We consider specifications that also include time-series variables that proxy for dealers' cost of capital. The third and fourth columns present estimates for regressions including dealer fixed effects. In addition to the point estimates, the first three rows of the table convert the coefficients into half-life quantities using the transformation $-\log(2)/(1 + \beta)$. The variables which proxy for dealers' risk bearing capacity are the VIX index as in Lou, Yan, and Zhang (2013) and aggregate leverage growth for broker-dealers from the Federal Reserve Flow of Funds data[13] as in Adrian, Etula, and Muir (2014). The VIX is supposed to proxy for the dealers' funding constraints and the aggregate leverage growth is supposed to capture the dealers' leverage constraints. When aggregate leverage growth is low it has become more costly to obtain leverage and when VIX is high dealers face higher funding constraints. We also include the TED spread to proxy for money market stress.

Table 5 shows a clear pattern. In both types of events, dealers display less tolerance toward deviations from desired inventories. For instance, column two (Panel B) shows that for the typical dealer the half life of her inventory of bonds downgraded to speculative grade falls from seven and half days to almost five and half days, a remarkable two-day difference. Note that this result is not due to a change in the

[13] This data is for primary dealers in the treasury market. Schultz (2001) shows that the major corporate bond dealers overlap significantly with the primary market dealers in the treasury market.

composition of dealers over time, as it continues to hold even in regressions with fixed effects capturing within-dealer variation. The model by Madhavan and Smidt (1993) inventory half life is a function of holding costs and asset volatility. Since bond volatilities have not increased from before to after the crisis, the results strongly suggest that holding costs have increased. This could be due to a combination of higher direct holding costs caused by the new regulation and an effect of the smaller desired dealer inventories.

5 Price Dynamics

Since dealers actively use their inventories to provide liquidity to index trackers, we expect them to earn a positive return on average as compensation for the inventory holding costs. The following section shows that dealers are compensated for providing liquidity. The costs are higher for the downgrade event compared to the low maturity event as would be expected, since the downgraded bonds are both more risky and kept longer on inventory.

5.1 Event study of index exclusions

Table 6 and 7 show the dealer returns for the two exclusion events. Returns are either inter-temporal bid-ask spreads, or abnormal dealer returns. Each of these returns are either equally weighted or value-weighted. The value-weighted returns are weighted by the dealer buying volume (VW1), or by the dealer inventory build-up (VW2), on the event date and over the previous two days. Hence, those bonds purchased by dealers that increased inventory – provided immediacy – are given more weight. The bonds where the inventory build up is negative (because a dealer sold more bonds than she bought) are given a weight of 0.

Looking at Table 6, we see that the abnormal dealer returns for the bonds excluded due to low maturity are uniformly higher after the crisis relative to before the crisis. The equally-weighted column (EW) attributes the same weight to all excluded bonds, even those for which there is very little trading, or inventory build-up. Given the statistical sampling approach to replicating the index, indexers only hold some excluded bonds. For this reason, equally weighted returns may mistakenly give too much weight to bonds for which traders do not seek immediacy. Both value-weighted returns show a much sharper increase (roughly a 100%) in the cost of immediacy for highly rated, short-term bonds over the sample period. Figure 6a, 6c, and 6e illustrate the increase in the cost of immediacy documented in Table 6.

Qualitatively, Table 7 paints the same picture as Table 6. Quantitatively, the returns are much larger, which is to be expected given the low rating of these bonds and the increased inventory risk that they pose. Moreover, the increase in the cost of immediacy since the pre-crisis period is much larger than the maturity exclusion case. As can be seen from the value-weighted abnormal return columns, the increase ranges from 200% at the one-day horizon to almost 700% at the 30-day horizon. Figure 6b, 6d, and 6f illustrate the increase in the cost of immediacy documented in Table 7.

The returns that we use to construct Table 6 and 7 are dealer and bond specific, meaning that we have multiple dealer returns for each bond, depending on the purchase price at which a bond entered a given dealer inventory. While this approach is not typical, it is valuable since it provides a richer picture and will help us control for dealer-specific effects in the multivariate analysis that will follow. Nevertheless, in Table 8 and 9 we replicate the event study using bond returns constructed with a market-wide average buy-side price (across all dealers) and a market-wide average sell-price (across all dealers). The sell-side price is thus the same as before but the buy-side price is no longer dealer specific. As can be seen, the conclusions that we can draw from these tables are very similar to those we have drawn so far. Therefore, going forward, the analysis will use the finer dealer-bond-specific return structure.

In addition to an increasing cost of immediacy, the dealer composition is also expected to change after the crisis. Once the large investment banks sell off their proprietary trading activities and the cost of immediacy increase for these dealers then other new dealers can start competing on the provision of liquidity (Duffie, 2012). We find support for this hypothesis by looking at the market share for the traditional dealers i.e. the most active dealers before the crisis. We define market share as the fraction of the total dealer buying volume on day -2, -1 and date 0 absorbed by each dealer. Table 10 shows the combined average market share for the four largest traditional market makers over time. The traditional market makers are here the four most active dealers before the crisis (conditioned on them being alive and active in the entire sample period from 2002 to 2013 in order to rule out defaulting dealers). On average these dealers have a total market share before the crisis of 21% for the maturity exclusions and 32% for the downgrade exclusions. During the crisis these dealers apparently became very constrained and lost a lot of their market share. After the crisis the dealers have failed to recover their original market share. The loss in market share happens despite other very active dealers defaulting during the crisis and thus leaving a market making void. The most active dealers before the crisis were most likely those with large proprietary trading activities (Duffie, 2012).

5.2 Regression analysis of the cost of immediacy

So far, we have shown a remarkable increase in the price of immediacy (proxied by abnormal dealer returns) taking place since the onset of the credit crisis. Next, we relate the higher returns earned by dealers to the quantity of bonds transacted, and other variables likely to affect the supply and demand of immediacy.

Generally, the price (P) and quantity (Q) of immediacy are jointly determined in the market. Therefore regressing the compensation for immediacy on its quantity subjects the econometrician to simultaneous equation bias. Importantly, we do not usually know if such regression estimates a supply function or a demand function. More formally, the empirical model to consider is given by the system of equations:

$$Q_t^D = \alpha_0 + \alpha_1 P_t + e_t \tag{3}$$

$$Q_t^S = \beta_0 + \beta_1 P_t + u_t \tag{4}$$

$$Q_t^D = Q_t^S = Q_t, \tag{5}$$

where e_t , u_t contain both observable and unobservable supply shifters, and the last equation imposes market clearing. In order to obtain unbiased and consistent estimates of the slopes, a two-stage least squares (2SLS) is normally used. See Choi, Getmansky, Henderson, and Tookes (2010) for a recent application to this methodology to the analysis of issue proceeds and underpricing for convertible bonds.

The premise of this study is that indexers are impatient around bond exclusion events. Our empirical analysis so far suggests that their price demand elasticity around these events is extremely low. Therefore, the exclusion restriction that we impose is to set $\alpha_1 = 0$ in Equation (3). Chacko, Jurek, and Stafford (2008) impose a similar restriction in their theoretical model of the price of immediacy, but in the context of a limit order book.

In summary, setting $\alpha_1 = 0$ identifies the relation between prices and quantities as a supply relation. A non-negative relation between prices and quantities in our setting would provide support for our assumption.

5.2.1 Model specification

The dependent variable in the regressions is the cumulative abnormal bond returns (a proxy for the cost of immediacy, i.e. P(Q)). The independent variable of interest is a measure of liquidity provision (Q). Assuming that dealers see the excluded bonds as reasonable substitutes, we define Q as the aggregate dealer inventory imbalance (measured in $MIO) for each dealer from day -2 to 0 across all excluded bonds at the event (downgrade and maturity separately). We drop all dealers with a net negative inventory imbalance. We interact Q with three dummies indicating whether the observation takes place before, during, or after the credit crisis. As a robustness check, in Section 6 we will consider alternative specifications that adopt different definitions of both P and Q.

We also include other factors likely to influence the cost of immediacy. Specifically, we include the amount outstanding of the bond. Larger bonds are likely more transparent and liquid than smaller bonds and are therefore less risky to have on inventory. We include the variables proxing for dealers' risk baering capacity which we also used in the inventory half life regression. Finally, we include industry (financials Vs non-financials), rating, and period dummies that are interacted with each other. Moreover, we also include dealer fixed effects. To save space, the estimated coefficients on the dummies are not reported in the regression tables.

Table 11 provides descriptive statistics on the variables used in the regression analysis. In addition to pooled statistics (Panel A), the table provides statistics grouped by exclusion event. Given the index inclusion criteria, the average size of the bond index is quite large. Looking at the dealer inventory buildup (Q) in Panel A, it can be seen that the average dealer inventory buildup was about $7.89 MIO before the crisis, $2.85 MIO during the crisis, and then after $6.25 MIO. Looking at

Panel B and C, we see that the recovery in the size of the provision of liquidity is due mostly to maturity exclusions. The average size of Q is higher after the crisis for short-term highly rated bonds (\$6.63 MIO Vs \$4.88 MIO). On the contrary, for downgraded bonds, we go from an average Q of \$11.98 MIO to an average Q of \$5.10 MIO. These differences in average Q suggest a migration away from the risky business of providing liquidity for junk bonds toward the safer business of providing liquidly for basically money-market instruments. In this regard, Dodd-Frank might be seen as a successful regulation.

5.2.2 Cost of immediacy before and after the crisis

Table 12 reports the coefficient estimates of the regressions. As can be seen from the table, the price of providing liquidity is increasing in the amount of liquidity transacted, making the relation reminiscent of a supply curve. Comparing the interaction of Q with the post-crisis dummy to the interaction of Q with the pre-crisis dummy reveals that the supply curve is relatively steeper after the crisis. This result suggests that providing immediacy has become more costly after the crisis, and, consequently, dealers require higher returns for providing additional immediacy.

The results on the effect of Q in Table 12 are also economically significant. Noting that the returns are measured in basis points, a one standard deviation change in Q after the crisis (\$17.73 MIO) is associated to roughly an additional 18 basis points of return over three days, and roughly 37 (17.73×2.17) basis points over a 30 day horizon. Ultimately, the money to compensate dealers for their provision of liquidity comes from the final investors, not the indexer, in the form of lower returns.

The control variables behave as expected although they are not always significant. Larger bonds have a lower cost of immediacy. When dealers are more constrained, i.e. a low leverage growth or a high VIX, the cost of immediacy is higher. Also when the money market undergoes stress, i.e. a high TED spread, the cost of immediacy increases. Money markets are important for market makers since they often fund their market making activity through repo transactions.

6 Robustness checks

6.1 Are downgrades and downgrade exclusions separate events?

The returns for the downgraded bonds could in theory be affected by a slow post-downgrade price and inventory adjustment (Katz, 1974; Grier and Katz, 1976).[14] In order to verify that this is not the case we look at dealer behavior at the actual downgrade date.

Figure 7a and 7b show that the downgrade date itself also sees a lot of trading activity. However, the average turnover is of the same size as that on the exclusion date. Also, the inventory build up on the downgrade date itself is far smaller than that on the exclusion date. Where inventory peaked at the exclusion date and then decreased, here the peak is delayed. This delay is consistent with an inventory build up at the exclusion date instead of at the downgrade date.

Figure 8 shows both the downgrade date and the exclusion date for events with exactly 17 days between the downgrade and exclusion. This is the most common number of days between the two events. The volume figure clearly shows two spikes in trading activity, first on the downgrade date and then on the exclusion date. The inventory graph shows that there is a minor inventory increase at the downgrade date but that the second increase at the exclusion date is larger. Also, after the inventory spike at the exclusion event the inventory immediately starts to decrease.

[14]See Norden and Weber (2004) for a review of other rating change studies.

In summary, the analysis suggests that the downgrade and the exclusion are two separate events. Hence, there should be little or no information on the exclusion date. This is often also the case for the downgrade date itself (Ambrose, Cai, and Helwege (2012)). Also note that the trading activity for the downgrade event is highly concentrated around the downgrade date. The downgrade event is thus fairly short lived. The downgrade date is not well suited for investigating the cost of immediacy because of the potential information contained in the event and simply because dealers provide little immediacy using their inventory compared to the exclusion date.

6.2 Alternative regression model specification

In relating prices to quantity, we have proxied the price/cost of immediacy with dealers' abnormal returns, and the quantity of immediacy with dealers' inventory buildup, measured in millions of dollars. In this section, we explore alternative specifications for both the price and quantity of immediacy.

Table 13 presents coefficient estimates of a regression relating abnormal returns to the natural logarithm of inventory buildup. The coefficients on the variable Q can now be interpreted as elasticities. As can be seen from the table, the coefficient on Q (measured in natural logarithm) is much larger after the crisis.

Table 14 presents coefficient estimates of a regression in which we proxy for the price of immediacy (the dependent variable) with the actual bond price paid by dealers at the exclusion event. Specifically, the dependent variable is the current price (the denominator) used to calculate the inter-temporal bid-ask spreads and abnormal returns. One of the benefits of this specification is that it does not require a final selling price to compute returns, thus leading to a larger sample size. One of the drawbacks of this specification is that prices are a bit more unstable than returns.

To better account for differences in bond price levels, we also include the coupon rate and the time to maturity as additional controls.

As can be seen from Model 2 of Table 14, the coefficient on Q (measured in $MIO) is much more negative after the crisis, and it is the only one that is actually significant. Note that, since the dependent variable is a price, rather than a return, a negative coefficient means that a dealer requires a higher expected return (lower price today) in order to provide additional liquidity.

Taken together, the results of the regression analysis are robust, and all point to the conclusion that after the crisis dealers are more reluctant to provide liquidity. Dealers are willing to provide additional immediacy only if they obtain a higher compensation.

7 Conclusion

The cost of immediacy for corporate bonds has increased significantly after the 2008 credit crisis. We show that the supply of immediacy has become more elastic with respect to its price. Hence, dealers now charge a higher price for supplying a given amount of immediacy. Traditional dealers have lost market share and dealer behavior has changed after the crisis so that risky bonds are no longer kept on inventory for longer periods of time. All these findings are consistent with the predictions in Duffie (2012) on how the post-crisis regulatory regime would impede market making. Furthermore, the findings suggest higher dealer inventory holding costs which are consistent with dealers closing down proprietary trading and running with far lower inventories.

This paper adds to the debate about the consequences of the post-crisis financial regulation. In a study on behalf of SIFMA, Wyman (2012) concluded that the post-crisis regulation would represent a significant risk for market liquidity. Both Johnson (2012) and Richardson (2012) argued against this conclusion. Although, market liquidity in general has not gone down when looking at traditional liquidity measures, the cost of immediacy has increased as predicted by Duffie (2012). Time constrained traders now pay a higher premium for trading than before the decline in dealer inventories.

Whether or not the post-crisis regulation and less risky dealer inventories can be considered a success depends on which segments of the economy will be affected by future shocks. By encouraging traditional market makers to take on less risk than before the crisis, a shock is less likely to originate in the banking sector (Johnson, 2012; Richardson, 2012). However, the lower willingness to use balance sheet for market making might make it harder for dealers to mitigate the selling pressure originating from shocks to other segments of the economy.

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Table 1: Trading activity around the exclusions

This table shows the average transaction volume around the monthly exclusions. The average is across all event dates. Day 0 is the exclusion date. SE is the standard error of the mean transaction volume. Fraction is the transaction volume relative to the volume at the exclusion date.

	Downgrade			Maturity		
Event time	Volume	SE	Fraction	Volume	SE	Fraction
-100	40.2	17.1	0.18	42.9	4.1	0.19
-50	51.5	22.6	0.23	43.5	5.2	0.20
-40	35.5	9.8	0.16	39.2	3.7	0.18
-30	37.5	14.6	0.17	39.6	4.0	0.18
-20	46.3	9.5	0.21	55.4	8.4	0.25
-10	77.9	21.4	0.35	58.2	8.0	0.26
-9	72.3	21.2	0.32	52.2	6.2	0.24
-8	83.0	28.9	0.37	57.5	5.4	0.26
-7	86.4	25.0	0.39	56.0	5.0	0.25
-6	66.3	13.8	0.30	62.8	6.5	0.28
-5	63.8	15.3	0.29	66.0	8.2	0.30
-4	97.4	33.0	0.44	123.2	24.0	0.56
-3	107.2	27.8	0.48	164.1	20.9	0.74
-2	107.8	26.7	0.48	155.7	15.5	0.70
-1	125.7	25.1	0.56	131.7	12.5	0.59
0	222.8	50.2	1.00	221.9	18.1	1.00
1	88.9	27.1	0.40	99.2	8.4	0.45
2	101.3	29.1	0.45	93.5	8.5	0.42
3	95.8	21.8	0.43	85.5	7.6	0.39
4	79.8	16.7	0.36	79.1	7.8	0.36
5	74.0	16.7	0.33	73.2	6.9	0.33
6	69.2	17.5	0.31	72.4	7.6	0.33
7	61.2	14.4	0.27	54.8	5.7	0.25
8	64.0	15.7	0.29	65.1	5.4	0.29
9	49.2	10.7	0.22	65.4	5.6	0.29
10	64.7	18.7	0.29	52.2	4.8	0.24
20	53.5	14.7	0.24	41.1	3.7	0.19
30	47.4	11.6	0.21	43.4	4.4	0.20
40	49.4	15.4	0.22	47.0	5.2	0.21
50	50.3	13.0	0.23	40.8	4.7	0.18
100	56.8	27.7	0.25	34.8	4.7	0.16

Table 2: Barclay Capital corporate bond index exclusion statistics

The statistics are accumulated from July 2002 to November 2013 for the Barclay Corporate Bond Index (formerly Lehman). Market value in $1,000 is the average market value at the time of the index revision. The table shows four reasons for being excluded. The maturity of the bonds can fall below 1 year during the month. The bond can be called. The bond can be downgraded from investment-grade to speculative grade during the month. Finally, there can be various other reasons for being excluded. Most of these exclusions are due to revisions of the general index rules, mainly that the size requirement has been increased twice over the period. In all cases the bonds are excluded at the end of the month (last trading day).

Reason	N	Market Value ($1,000)	OA Duration	Coupon
Maturity<1	3,102	645,374	0.92	5.7
Called	392	461,354	0.52	7.1
Downgrade	1,078	484,269	5.1	6.8
Other	2,119	358,501	6.0	6.5

Table 3: Cumulative dealer inventory positions for low maturity exclusions

This table shows the average cumulative dealer inventory around the monthly exclusions because of low maturity. Cumulative inventory is found by subtracting dealer sells from dealer buys and cumulating the imbalance over time. The dealer inventory is relative to the arbitrarily chosen starting point at event day -100. Inventory (in millions) is aggregated across all the bonds excluded at a given date and then averaged across all the event dates. SE is the standard error of the volume mean estimate. Fraction is the inventory position relative to the position at the exclusion date. The three time periods are 2002Q3-2007Q2, 2007Q3-2009Q4, and 2010Q1-2013Q4.

	Pre - Crisis			Crisis			Post - Crisis		
Event time	Inventory	SE	Fraction	Inventory	SE	Fraction	Inventory	SE	Fraction
-30	-2.1	1.5	-0.02	0.5	1.8	0.01	-0.3	1.9	0.00
-20	8.9	10.3	0.07	2.4	10.5	0.05	21.3	15.3	0.09
-10	-10.1	12.0	-0.08	1.6	12.7	0.03	13.4	14.1	0.06
-5	-18.7	12.8	-0.15	-1.2	10.7	-0.03	19.4	14.5	0.08
-4	23.7	38.2	0.18	7.0	13.0	0.15	65.0	21.5	0.27
-3	25.4	24.1	0.20	36.8	14.0	0.78	117.4	21.5	0.48
-2	48.6	24.2	0.38	37.6	15.2	0.79	140.0	21.6	0.57
-1	65.2	24.6	0.51	33.7	14.4	0.71	153.9	20.6	0.63
0	128.4	26.0	1.00	47.3	17.5	1.00	244.0	26.3	1.00
1	131.1	26.6	1.02	43.7	18.2	0.92	219.6	24.8	0.90
2	126.5	26.2	0.99	32.3	18.4	0.68	201.6	23.9	0.83
3	113.9	26.2	0.89	22.1	17.7	0.47	179.9	23.9	0.74
4	104.9	25.6	0.82	12.5	16.4	0.26	152.1	20.9	0.62
5	99.4	25.6	0.77	5.3	16.9	0.11	134.7	20.5	0.55
10	57.2	26.3	0.45	-14.9	16.2	-0.31	76.5	18.6	0.31
20	28.1	26.3	0.22	-21.2	18.3	-0.45	28.4	18.4	0.12
30	5.8	25.8	0.04	-30.3	18.1	-0.64	-1.9	19.3	-0.01
40	-1.9	29.4	-0.01	-40.4	16.6	-0.85	-31.3	19.9	-0.13
50	-19.4	32.1	-0.15	-52.2	15.8	-1.10	-44.6	21.2	-0.18
100	-46.2	42.3	-0.36	-72.1	15.3	-1.52	-82.9	21.5	-0.34

Table 4: Cumulative dealer inventory positions for downgrade exclusions

This table shows the average cumulative dealer inventory around the monthly exclusions because of a downgrade. Cumulative inventory is found by subtracting dealer sells from dealer buys and cumulating the imbalance over time. The dealer inventory is relative to the arbitrarily chosen starting point at event day -100. Inventory (in millions) is aggregated across all the bonds excluded at a given date and then averaged across all the event dates. SE is the standard error of the volume mean estimate. Fraction is the inventory position relative to the position at the exclusion date. The three time periods are 2002Q3-2007Q2, 2007Q3-2009Q4, and 2010Q1-2013Q4.

	Pre - Crisis			Crisis			Post - Crisis		
Event time	Inventory	SE	Fraction	Inventory	SE	Fraction	Inventory	SE	Fraction
-30	-1.8	1.3	-0.02	-2.8	3.7	-0.02	0.3	1.8	0.00
-20	-8.3	6.9	-0.08	0.8	8.3	0.01	-7.5	7.1	-0.10
-10	0.3	8.6	0.00	40.9	39.0	0.30	6.1	8.8	0.08
-5	2.3	9.8	0.02	52.6	44.9	0.38	17.0	7.6	0.24
-4	45.8	39.4	0.46	57.9	50.3	0.42	18.5	8.9	0.26
-3	36.3	23.5	0.36	59.3	51.1	0.43	21.5	8.8	0.30
-2	39.6	24.9	0.40	73.2	56.1	0.53	26.2	9.9	0.36
-1	56.4	25.5	0.56	87.8	60.7	0.64	38.0	10.0	0.53
0	99.9	35.0	1.00	137.2	83.6	1.00	72.2	16.5	1.00
1	92.5	31.0	0.93	127.1	77.9	0.93	64.4	14.0	0.89
2	89.9	31.0	0.90	119.6	74.9	0.87	55.8	11.9	0.77
3	85.7	30.0	0.86	119.2	75.5	0.87	53.5	11.5	0.74
4	85.5	30.3	0.86	109.6	69.4	0.80	48.8	11.0	0.68
5	84.8	30.1	0.85	103.5	67.2	0.75	49.6	11.0	0.69
10	84.8	29.0	0.85	112.7	77.9	0.82	40.3	10.1	0.56
20	71.6	28.1	0.72	64.9	45.7	0.47	21.7	10.0	0.30
30	57.6	24.1	0.58	52.8	33.5	0.38	11.4	11.1	0.16
40	70.5	31.7	0.71	53.8	35.5	0.39	9.0	9.6	0.12
50	51.1	28.4	0.51	38.0	30.3	0.28	13.1	10.9	0.18
100	53.7	36.6	0.54	29.9	46.1	0.22	-11.2	12.8	-0.15

Table 5: Speed of adjustment

This table reports pooled regression estimates from regressing dealer- and event-specific inventory speed of adjustments over period dummies and other control variables. The speed of adjustments, β, are estimated by fitting the equation $I_t - I_{t-1} = \beta * (I_{t-1} - \alpha_0 - \alpha_1 \mathbf{1}_{[\mathbf{t}>-\mathbf{3}]})$ with iterated general method of moments (IGMM) with a Bartlett kernel (3 lags), for each dealer and event. I_t represents inventory at event-time t, and α_0 and α_1 are two constants representing the desired level of inventory before and after index exclusions. $t = 0$ represents the exclusion date. In addition to the point estimates, the first three rows convert the coefficients into half-life quantities using the formula $-\log(2)/(1+\beta)$.

Model	1	2	3	4
		Panel A: Maturity exclusions		
Pre-crisis	-.0960 / 6.87	-.0869 / 7.62	-.0788 / 8.45	-.0752 / 8.87
	(-18.34)***	(-8.25)***	(-6.18)***	(-4.97)***
Crisis	-.1371 / 4.70	-.1334 / 4.84	-.0929 / 7.11	-.0907 / 7.29
	(-14.98)***	(-6.68)***	(-7.26)***	(-4.40)***
Post-crisis	-.1171 / 5.56	-.1043 / 6.30	-.0993 / 6.63	-.0920 / 7.18
	(-19.69)***	(-7.91)***	(-7.13)***	(-5.09)***
VIX		-.0009		-.0007
		(-1.39)		(-1.45)
TED Spread		0.0002		0.0002
		(1.97)**		(1.63)
Dealer Lev. Growth		-.0100		0.0175
		(-0.38)		(0.92)
Fixed Effects	NO	NO	Dealer	Dealer
Number of Observations	569	569	569	569
R-Square	0.6291	0.6319	0.7331	0.7366
		Panel A: Downgrade exclusions		
Pre-crisis	-.0919 / 7.19	-.0884 / 7.49	-.1042 / 6.30	-.0968 / 6.80
	(-14.08)***	(-7.47)***	(-2.73)***	(-2.51)**
Crisis	-.1205 / 5.40	-.1046 / 6.27	-.1231 / 5.28	-.1092 / 6.00
	(-8.20)***	(-3.58)***	(-3.11)***	(-2.43)**
Post-crisis	-.1250 / 5.19	-.1154 / 5.65	-.1296 / 4.99	-.1186 / 5.49
	(-9.54)***	(-6.01)***	(-3.63)***	(-3.17)***
VIX		-.0002		-.0008
		(-0.23)		(-1.06)
TED Spread		-.0000		0.0001
		(-0.30)		(0.49)
Dealer Lev. Growth		0.0554		0.0192
		(1.82)*		(0.61)
Fixed Effects	NO	NO	Dealer	Dealer
Number of Observations	345	341	345	341
R-Square	0.4969	0.5005	0.7076	0.7000

Table 6: Dealer intertemporal bid-ask spreads: Maturity exclusions

This table shows the dealer-bond specific average returns of bonds excluded from the Barclay Corporate Bond Index because of low maturity. Returns are calculated as log price changes between day 0 (the exclusion date) and day t after the exclusion. The returns are calculated as seen from the dealers perspective. First, the intertemporal bid-ask spread is calculated using the dealer-buy price (dealer-specific average buy price over day -2,-1, and 0) and the average dealer sell price at day t (average across all dealers). Second, the abnormal return is the intertemporal bid-ask spread minus the return on a matched portfolio. The portfolio is matched on rating and time to maturity. EW returns are equally weighted across all excluded bonds. VW1 is weighted by the aggregate buying volume in the specific cusip for all dealers with a positive inventory build-up in the bond. VW2 is weighted by the aggregate inventory build-up for dealers with a net positive inventory change between day -3 to 0. The three time periods are 2002Q3-2007Q2, 2007Q3-2009Q4, and 2010Q1-2013Q4.

Table 6 (continued)

$[0,t]$	N	Intertemporal Bid-Ask EW	Intertemporal Bid-Ask VW1	Intertemporal Bid-Ask VW2	Abnormal Returns EW	Abnormal Returns VW1	Abnormal Returns VW2
Period 1							
1	830	22.87	9.34	9.45	20.22	6.34	6.17
		(14.41)***	(9.08)***	(9.90)***	(12.80)***	(9.23)***	(8.04)***
2	794	25.34	12.61	12.34	20.78	7.31	7.13
		(14.71)***	(10.88)***	(10.25)***	(13.06)***	(10.65)***	(8.12)***
3	780	26.63	14.36	14.45	21.15	7.66	7.94
		(15.55)***	(13.04)***	(12.40)***	(12.92)***	(10.05)***	(9.43)***
4	777	29.42	16.05	15.97	23.03	7.87	8.33
		(16.56)***	(13.87)***	(13.24)***	(12.35)***	(7.92)***	(9.41)***
5	763	30.26	17.09	16.79	22.17	7.59	7.74
		(17.19)***	(14.47)***	(12.36)***	(13.12)***	(8.74)***	(7.60)***
10	727	35.49	24.30	23.55	21.29	8.05	8.20
		(18.22)***	(15.65)***	(15.21)***	(12.20)***	(6.22)***	(7.20)***
20	688	51.52	39.69	37.04	22.76	7.20	7.53
		(19.32)***	(10.40)***	(13.04)***	(9.86)***	(8.40)***	(6.82)***
30	675	64.94	54.87	51.80	23.22	7.92	7.50
		(18.71)***	(12.11)***	(12.40)***	(9.88)***	(7.13)***	(6.46)***
Period 2							
1	269	55.87	58.36	51.22	46.33	50.43	43.02
		(11.89)***	(6.93)***	(7.49)***	(10.26)***	(6.71)***	(6.50)***
2	254	55.15	57.95	50.15	46.57	50.86	42.12
		(13.82)***	(6.88)***	(6.86)***	(8.12)***	(6.25)***	(5.13)***
3	236	59.07	61.12	58.62	49.80	56.52	52.18
		(10.17)***	(8.14)***	(6.52)***	(7.16)***	(5.70)***	(5.00)***
4	235	63.17	62.12	58.59	52.96	56.89	48.79
		(8.30)***	(7.37)***	(6.54)***	(8.38)***	(7.34)***	(6.35)***
5	230	70.03	67.27	62.56	53.18	56.27	47.12
		(9.65)***	(9.73)***	(7.27)***	(6.23)***	(6.35)***	(6.12)***
10	211	82.52	79.42	73.19	63.28	68.71	54.53
		(10.69)***	(7.89)***	(5.14)***	(7.36)***	(7.00)***	(5.09)***
20	211	122.81	94.50	86.86	76.35	72.47	54.52
		(5.59)***	(5.94)***	(7.08)***	(5.58)***	(4.32)***	(3.11)***
30	206	156.75	130.99	119.01	96.55	102.75	80.71
		(5.20)***	(4.25)***	(4.59)***	(4.66)***	(3.90)***	(3.52)***
Period 3							
1	1,085	27.34	14.15	13.67	26.27	13.53	13.30
		(13.81)***	(9.27)***	(8.96)***	(12.76)***	(8.24)***	(8.54)***
2	1,054	29.08	15.21	14.64	27.16	13.79	13.59
		(13.99)***	(11.45)***	(10.76)***	(13.70)***	(9.94)***	(10.12)***
3	1,041	29.04	15.38	14.89	26.47	13.25	13.06
		(12.91)***	(11.90)***	(11.82)***	(12.83)***	(10.15)***	(10.15)***
4	995	32.47	16.57	15.84	29.46	13.99	13.62
		(12.16)***	(9.36)***	(8.98)***	(12.22)***	(8.64)***	(8.73)***
5	990	33.71	17.38	16.85	30.06	14.35	14.08
		(12.06)***	(8.82)***	(8.63)***	(12.29)***	(7.80)***	(7.84)***
10	954	36.16	19.36	18.70	30.19	14.87	14.46
		(12.14)***	(9.01)***	(8.75)***	(13.38)***	(9.24)***	(9.23)***
20	861	44.38	22.90	21.85	34.06	15.93	16.02
		(9.06)***	(6.87)***	(6.78)***	(10.49)***	(9.55)***	(9.23)***
30	814	51.82	27.64	25.31	34.20	15.09	14.37
		(8.71)***	(7.19)***	(7.22)***	(10.39)***	(9.42)***	(8.73)***

Table 7: Dealer intertemporal bid-ask spreads: Downgrade exclusions

This table shows the dealer-bond specific returns of bond excluded from the Barclay Corporate Bond Index because of downgrade from investment-grade to speculative grade. Returns are calculated as log price changes between day 0 (the exclusion date) and day t after the exclusion. The returns are calculated as seen from the dealers perspective. First, the intertemporal bid-ask spread is calculated using the dealer-buy price (dealer-specific average buy price over day -2,-1, and 0) and the average dealer sell price at day t (average across all dealers). Second, the abnormal return is the intertemporal bid-ask spread minus the return on a matched portfolio. The portfolio is matched on rating and time to maturity. EW returns are equally weighted across all excluded bonds. VW1 is weighted by the aggregate buying volume in the specific cusip for all dealers with a positive inventory build-up in the bond. VW2 is weighted by the aggregate inventory build-up for dealers with a net positive inventory change between day -3 to 0. The three time periods are 2002Q3-2007Q2, 2007Q3-2009Q4, and 2010Q1-2013Q4.

Table 7 (continued)

		Intertemporal Bid-Ask			Abnormal Returns		
$[0, t]$	N	EW	VW1	VW2	EW	VW1	VW2
Period 1							
1	243	139.73	162.06	147.54	98.19	96.18	81.19
		(4.62)***	(10.63)***	(7.64)***	(4.39)***	(8.15)***	(5.73)***
2	245	250.70	333.73	307.93	157.89	188.18	166.18
		(3.41)***	(8.14)***	(6.25)***	(3.81)***	(7.21)***	(5.10)***
3	243	282.37	368.52	335.56	160.68	184.35	155.62
		(3.67)***	(9.53)***	(7.27)***	(3.96)***	(7.60)***	(5.12)***
4	234	267.30	328.41	308.38	168.71	195.90	172.19
		(4.95)***	(16.59)***	(13.56)***	(4.96)***	(9.86)***	(7.06)***
5	229	318.45	389.00	367.67	193.42	220.81	196.05
		(5.04)***	(19.10)***	(15.73)***	(5.21)***	(10.94)***	(7.92)***
10	226	389.65	500.46	460.66	251.28	295.58	256.95
		(3.60)***	(10.25)***	(7.51)***	(3.50)***	(8.20)***	(5.29)***
20	215	367.99	399.81	373.50	173.15	154.53	124.79
		(5.06)***	(24.79)***	(19.97)***	(4.70)***	(9.08)***	(6.40)***
30	209	422.03	513.42	470.94	173.25	174.94	142.36
		(3.16)***	(12.15)***	(9.80)***	(2.72)***	(8.46)***	(6.76)***
Period 2							
1	107	48.13	65.43	110.55	58.60	59.14	93.56
		(0.75)	(1.17)	(1.78)*	(1.36)	(1.59)	(1.67)*
2	101	70.68	76.11	135.18	80.74	65.61	112.61
		(0.62)	(0.92)	(1.77)*	(1.08)	(1.26)	(1.88)*
3	102	14.65	87.71	161.95	42.16	74.38	130.23
		(0.09)	(0.79)	(4.96)***	(0.47)	(1.08)	(7.26)***
4	93	30.42	155.40	233.01	50.22	118.90	174.51
		(0.14)	(0.89)	(2.19)**	(0.37)	(0.96)	(2.12)**
5	87	65.02	193.97	334.67	82.48	152.41	260.06
		(0.25)	(0.89)	(2.47)**	(0.53)	(0.98)	(2.46)**
10	91	241.79	296.57	463.31	162.46	193.45	344.43
		(1.01)	(1.69)*	(2.85)***	(0.93)	(1.33)	(2.83)***
20	77	442.86	467.30	576.55	234.47	334.32	492.31
		(1.86)*	(2.97)***	(2.35)**	(1.15)	(1.97)**	(2.84)***
30	71	125.36	412.56	427.40	-139.2	270.88	373.44
		(0.31)	(3.79)***	(4.49)***	(-0.37)	(1.65)*	(3.16)***
Period 3							
1	213	123.91	365.93	372.42	99.91	292.93	294.79
		(1.19)	(2.61)***	(2.85)***	(1.14)	(2.65)***	(2.84)***
2	208	193.05	474.34	494.84	149.92	350.12	366.33
		(1.70)*	(2.69)***	(3.06)***	(1.76)*	(2.79)***	(3.16)***
3	193	240.29	644.88	667.15	185.00	488.51	508.88
		(1.66)*	(2.71)***	(2.93)***	(1.69)*	(2.80)***	(3.04)***
4	185	263.72	757.23	770.70	203.06	577.79	592.19
		(1.55)	(2.69)***	(2.85)***	(1.58)	(2.83)***	(3.07)***
5	188	301.42	844.22	874.81	231.84	651.57	682.85
		(1.59)	(2.87)***	(3.04)***	(1.59)	(2.98)***	(3.21)***
10	177	199.79	413.16	475.31	173.39	381.56	444.73
		(1.74)*	(2.50)**	(2.59)***	(1.71)*	(2.60)***	(2.83)***
20	175	398.41	1061.0	1136.2	314.30	807.29	869.89
		(1.54)	(2.77)***	(3.24)***	(1.62)	(2.87)***	(3.37)***
30	163	538.57	1407.1	1434.4	332.27	937.37	965.48
		(1.70)*	(3.19)***	(3.33)***	(1.45)	(2.99)***	(3.11)***

Table 8: Aggregate intertemporal bid-ask spreads: maturity exclusions

This table replicates Table 6, except that the time zero price is an average (across all dealers) of the transaction prices at time zero.

		Intertemporal Bid-Ask			Abnormal Returns		
$[0,t]$	N	EW	VW1	VW2	EW	VW1	VW2
Period 1							
1	834	7.58 (10.26)***	5.81 (8.65)***	5.96 (8.88)***	5.41 (7.85)***	3.86 (8.41)***	4.02 (8.51)***
2	798	9.25 (9.39)***	8.19 (8.81)***	8.10 (7.99)***	5.87 (8.36)***	5.01 (7.43)***	5.10 (6.66)***
3	782	10.80 (8.78)***	9.50 (10.09)***	9.84 (9.74)***	6.85 (7.16)***	5.56 (7.48)***	6.06 (7.44)***
4	780	13.14 (10.23)***	11.12 (12.34)***	11.46 (13.01)***	8.47 (8.11)***	6.60 (9.94)***	7.23 (12.09)***
5	766	14.81 (11.80)***	12.43 (12.74)***	12.38 (11.77)***	9.08 (8.98)***	6.99 (9.21)***	7.21 (8.76)***
10	731	19.78 (13.14)***	18.81 (15.61)***	18.50 (13.09)***	10.57 (10.36)***	9.25 (10.59)***	9.48 (9.56)***
20	690	31.43 (13.32)***	32.74 (11.95)***	31.28 (13.30)***	15.33 (11.65)***	14.84 (11.41)***	14.40 (11.76)***
30	683	46.04 (14.65)***	45.83 (12.27)***	44.14 (12.20)***	23.48 (13.33)***	21.36 (11.11)***	20.71 (11.02)***
Period 2							
1	274	56.47 (9.10)***	46.28 (8.16)***	44.04 (7.76)***	48.45 (8.47)***	38.19 (8.50)***	37.53 (6.80)***
2	258	64.08 (7.58)***	48.05 (6.33)***	46.30 (6.66)***	54.24 (7.73)***	39.72 (6.10)***	39.06 (5.86)***
3	237	65.85 (8.06)***	54.17 (7.78)***	51.74 (7.62)***	55.56 (7.00)***	46.97 (5.35)***	44.35 (6.26)***
4	239	68.50 (8.32)***	53.68 (6.49)***	56.07 (7.80)***	55.91 (7.50)***	46.90 (6.66)***	49.08 (7.75)***
5	234	73.45 (8.66)***	62.21 (8.32)***	63.55 (7.73)***	58.45 (7.33)***	49.97 (5.33)***	51.16 (6.90)***
10	218	81.24 (8.10)***	70.81 (8.84)***	74.47 (6.18)***	68.48 (8.62)***	65.73 (8.94)***	66.49 (6.89)***
20	216	107.91 (7.45)***	92.59 (5.47)***	88.18 (5.10)***	76.90 (9.09)***	77.35 (6.51)***	72.14 (7.65)***
30	213	143.19 (5.71)***	122.32 (4.21)***	121.24 (4.07)***	99.60 (7.92)***	98.44 (6.69)***	95.83 (7.02)***
Period 3							
1	1,072	13.72 (10.49)***	11.29 (9.68)***	13.18 (8.21)***	12.68 (10.42)***	10.47 (9.57)***	12.49 (8.25)***
2	1,042	14.93 (10.96)***	12.83 (10.65)***	14.29 (8.75)***	13.46 (10.83)***	11.54 (9.70)***	13.14 (8.27)***
3	1,030	15.15 (10.75)***	12.74 (10.99)***	14.88 (6.38)***	13.26 (10.84)***	11.05 (10.29)***	13.26 (6.20)***
4	984	16.72 (9.78)***	13.73 (9.68)***	16.28 (6.86)***	14.63 (9.93)***	11.82 (9.81)***	14.49 (6.73)***
5	981	17.11 (10.30)***	14.74 (8.24)***	17.39 (6.76)***	14.62 (10.57)***	12.53 (7.54)***	15.40 (6.42)***
10	942	19.04 (9.72)***	16.80 (8.15)***	20.13 (5.86)***	15.03 (10.53)***	13.23 (7.79)***	16.95 (5.39)***
20	853	24.08 (7.96)***	20.64 (5.95)***	24.60 (4.54)***	18.17 (9.13)***	15.82 (6.08)***	21.08 (3.86)***
30	804	29.09 (7.67)***	23.49 (6.29)***	34.06 (3.25)***	19.69 (8.06)***	15.21 (6.10)***	27.16 (2.54)**

Table 9: Aggregate intertemporal bid-ask spreads: maturity exclusions

This table replicates Table 7, except that the time zero price is an average (across all dealers) of the transaction prices at time zero.

		Intertemporal Bid-Ask			Abnormal Returns		
$[0, t]$	N	EW	VW1	VW2	EW	VW1	VW2
Period 1							
1	244	100.74	107.76	91.70	78.25	81.91	63.95
		(4.77)***	(4.80)***	(6.37)***	(5.19)***	(3.64)***	(7.23)***
2	246	149.11	207.20	181.77	108.60	153.80	125.45
		(3.03)***	(3.20)***	(3.20)***	(3.37)***	(4.29)***	(3.83)***
3	244	168.44	256.85	215.31	115.43	177.85	137.42
		(3.30)***	(4.18)***	(3.87)***	(3.83)***	(5.62)***	(5.20)***
4	235	177.16	242.64	216.32	127.83	182.74	152.86
		(4.28)***	(5.86)***	(5.49)***	(4.68)***	(7.45)***	(6.90)***
5	229	203.93	278.99	259.63	147.95	200.58	176.04
		(3.99)***	(4.87)***	(5.60)***	(4.61)***	(6.31)***	(7.06)***
10	227	232.72	371.70	295.16	168.31	283.79	205.26
		(2.94)***	(4.51)***	(4.08)***	(3.04)***	(5.39)***	(4.89)***
20	215	255.84	319.06	274.72	156.32	205.81	159.11
		(4.66)***	(4.61)***	(5.62)***	(4.98)***	(6.16)***	(6.24)***
30	210	277.82	322.58	280.44	161.02	187.28	142.17
		(2.62)***	(2.13)**	(2.88)***	(2.46)**	(2.22)**	(2.72)***
Period 2							
1	147	244.81	260.68	251.98	276.21	337.68	338.27
		(2.34)**	(2.90)***	(4.14)***	(2.23)**	(2.68)***	(3.33)***
2	145	248.08	274.92	327.58	278.59	365.23	448.19
		(1.63)	(1.59)	(2.63)***	(1.59)	(1.71)*	(2.38)**
3	138	219.47	219.60	315.24	264.11	307.07	442.94
		(1.39)	(0.93)	(2.43)**	(1.51)	(1.20)	(2.24)**
4	126	61.79	64.76	195.05	228.01	417.62	602.66
		(0.56)	(0.55)	(2.65)***	(1.23)	(2.07)**	(2.60)***
5	119	211.29	259.21	363.23	389.21	603.17	781.29
		(1.35)	(1.88)*	(3.88)***	(1.66)*	(2.55)**	(2.86)***
10	124	-2.59	-72.72	3.35	484.20	857.76	1076.9
		(-0.01)	(-0.29)	(0.01)	(2.04)**	(2.13)**	(2.84)***
20	104	502.34	258.53	231.89	731.14	840.43	910.67
		(1.47)	(0.76)	(0.85)	(2.17)**	(3.44)***	(3.54)***
30	97	482.59	366.42	425.21	653.52	939.52	1129.3
		(1.34)	(2.17)**	(2.99)***	(1.51)	(2.04)**	(2.32)**
Period 3							
1	211	146.26	144.95	133.39	115.29	120.07	104.38
		(2.25)**	(1.88)*	(2.34)**	(2.43)**	(1.99)**	(2.47)**
2	207	230.77	272.94	224.79	182.03	227.37	175.36
		(2.59)***	(2.72)***	(2.94)***	(2.90)***	(3.06)***	(3.36)***
3	191	314.24	357.19	307.21	251.97	296.31	247.27
		(2.29)**	(2.50)**	(2.66)***	(2.45)**	(2.76)***	(2.94)***
4	183	369.22	396.80	352.28	296.71	327.72	286.97
		(2.15)**	(2.25)**	(2.44)**	(2.27)**	(2.52)**	(2.76)***
5	185	414.73	417.02	388.10	336.39	339.23	313.15
		(2.32)**	(2.09)**	(2.47)**	(2.46)**	(2.23)**	(2.75)***
10	179	361.26	278.32	303.73	333.66	264.38	283.66
		(2.35)**	(1.74)*	(2.64)***	(2.28)**	(1.74)*	(2.76)***
20	176	497.84	489.02	497.66	391.35	401.71	407.29
		(2.14)**	(1.97)**	(2.24)**	(2.06)**	(2.02)**	(2.37)**
30	162	690.20	715.33	736.24	494.07	509.90	534.25
		(2.44)**	(2.25)**	(2.51)**	(2.26)**	(2.09)**	(2.44)**

Table 10: Market share for the most active dealers

The table shows the market share for the most active dealers. The market share is calculated as the fraction of total event dealer-buying volume that the most active dealers facilitated. The most active dealers are defined as the 4 dealers that on average facilitated the most event buying volume before the crisis (and which were alive in the entire sample period). The periods are 2002Q3-2007Q2 (pre-crisis), 2007Q3-2009Q4 (crisis), and 2010Q1-2013Q4 (post-crisis). The numbers reported are the average combined market share for the most active dealers.

	Pre-Crisis	Crisis	Post-Crisis
Maturity exclusion	0.212	0.108	0.128
Downgrade exclusion	0.320	0.183	0.235

Table 11: Descriptive statistics of regression variables

This table presents descriptive statistics for the variables used in the regression analysis. The statistics is divided into the whole sample, the downgrade sample, and the low maturity sample. TED spread is the difference between the 3-month LIBOR rate and the 3-month T-bill rate. VIX is the CBOR volatility index derived from the implied volatility on S&P 500 index options. Coupon is the nominal annualized coupon on the corporate bond. Issue size is the offering amount for the bond in millions. Years to maturity is the remaining time to maturity of the bond. Dealer Lev Growth is the aggregate leverage growth for broker-dealers obtained from the Federal Reserve Flow of Funds data. Q is the dealer-specific aggregate imbalance. Rating is an index indicating all rating notches that a bond can take, and takes all integer values from 1 (AAA) to 21 (C). Financials is a dummy indicating whether the bond was issued by a financial institution (according to FISD).

Exclusions	Variable	Obs.	Mean	St. Dev.	p1	p25	p50	p75	p99
All	Bond Mkt Vol - B/L	141	0.11	0.11	0.03	0.05	0.07	0.12	0.69
All	Bond Mkt Vol - B/M	141	0.07	0.07	0.02	0.03	0.04	0.09	0.33
All	Bond Mkt Vol - B/S	141	0.07	0.10	0.01	0.02	0.04	0.08	0.51
All	Bond Mkt Vol - BB/L	141	0.08	0.07	0.02	0.04	0.06	0.09	0.36
All	Bond Mkt Vol - BB/M	141	0.06	0.05	0.01	0.03	0.04	0.06	0.26
All	Bond Mkt Vol - BB/S	141	0.05	0.05	0.01	0.02	0.03	0.06	0.25
All	Bond Mkt Vol - C/L	141	0.24	0.19	0.06	0.13	0.18	0.26	0.97
All	Bond Mkt Vol - C/M	141	0.14	0.15	0.02	0.06	0.09	0.15	0.70
All	Bond Mkt Vol - C/S	141	0.15	0.14	0.05	0.08	0.10	0.15	0.80
All	Bond Mkt Vol - IGS	141	0.01	0.02	0.00	0.00	0.01	0.01	0.07
All	Term Spread	137	1.82	1.11	-0.38	1.14	1.98	2.69	3.38
All	TED Spread	137	0.44	0.60	0.06	0.17	0.23	0.38	3.12
All	VIX	137	20.77	9.04	10.91	14.55	17.83	24.51	55.28
All	Dealer Lev. Growth	137	-0.01	0.20	-0.98	-0.03	0.02	0.04	0.65
All	Coupon	3,016	5.78	1.66	1.38	4.88	5.88	6.89	9.38
All	Issue Size (MIO)	3,016	700.34	589.53	185.00	300.00	500.00	900.00	3000.0
All	Years to Maturity	3,016	2.98	6.07	0.90	0.93	0.95	0.99	28.12
All	Log Quantity (Q)	3,016	16.30	1.30	12.73	15.50	16.33	17.21	18.95
All	A-rated	3,016	0.37	0.48	0.00	0.00	0.00	1.00	1.00
All	BBB-rated	3,016	0.24	0.43	0.00	0.00	0.00	0.00	1.00
All	B-rated	3,016	0.01	0.09	0.00	0.00	0.00	0.00	0.00
All	C-rated	3,016	0.01	0.12	0.00	0.00	0.00	0.00	1.00
All	Log Issue Size	3,016	13.21	0.67	12.13	12.61	13.12	13.71	14.91
Downgrade	Coupon	693	6.61	1.30	3.50	5.75	6.63	7.50	10.00
Downgrade	Issue Size (MIO)	693	685.70	609.53	150.00	300.00	500.00	750.00	3000.0
Downgrade	Years to Maturity	693	9.82	9.99	1.10	3.64	6.50	9.78	34.20
Downgrade	Log Quantity (Q)	693	16.64	1.44	12.45	15.78	16.69	17.69	19.55
Downgrade	B-rated	693	0.03	0.18	0.00	0.00	0.00	0.00	1.00
Downgrade	C-rated	693	0.06	0.24	0.00	0.00	0.00	0.00	1.00
Downgrade	Log Issue Size	693	13.18	0.71	11.92	12.61	13.12	13.53	14.91
Maturity	Coupon	2,323	5.54	1.67	1.25	4.50	5.63	6.70	8.90
Maturity	Issue Size (MIO)	2,323	704.71	583.50	200.00	300.00	500.00	998.75	3000.0
Maturity	Years to Maturity	2,323	0.94	0.02	0.90	0.92	0.95	0.96	1.00
Maturity	Log Quantity (Q)	2,323	16.20	1.24	12.73	15.44	16.25	17.07	18.63
Maturity	A-rated	2,323	0.48	0.50	0.00	0.00	0.00	1.00	1.00
Maturity	BBB-rated	2,323	0.32	0.46	0.00	0.00	0.00	1.00	1.00
Maturity	Log Issue Size	2,323	13.22	0.66	12.21	12.61	13.12	13.81	14.91

Table 12: Liquidity provision before and after the crisis

This table presents regression coefficients for a series of regressions. The dependent variable is the bond- and dealer-specific abnormal return over the period from the exclusion day 0 to day t after the exclusion. Variables are defined in Tabe 11. The regressions include (interacted) period/industry/rating and dealer fixed effects. The periods are 2002Q3-2007Q2 (pre-crisis), 2007Q3-2009Q4 (crisis), and 2010Q1-2013Q4 (post-crisis). We consider two industry categories (financial Vs non-financial) and six rating categories (AAA-AA, A, BBB, BB, B, CCC-C). Robust standard errors are clustered at the bond issuer level.

Event Window: (0,t]	1	2	3	4	5	10	20	30
Q*Postcrisis	0.55	0.72	1.00	1.19	1.41	0.69	1.95	2.17
	(1.77)*	(1.74)*	(2.61)***	(2.46)**	(2.90)***	(2.77)***	(2.47)**	(2.03)**
Q*Crisis	1.04	1.87	2.39	4.51	5.39	4.33	6.12	5.58
	(1.29)	(1.67)*	(2.19)**	(3.01)***	(2.84)***	(2.17)**	(2.54)**	(2.33)**
Q*Precrisis	0.11	0.25	0.19	0.13	0.17	0.11	-0.03	0.19
	(1.74)*	(1.35)	(1.14)	(0.85)	(0.78)	(0.32)	(-0.09)	(0.45)
Log Issue Size	-17.81	-21.55	-22.75	-6.29	-16.81	14.93	2.47	68.36
	(-1.49)	(-1.47)	(-1.39)	(-0.29)	(-0.66)	(0.73)	(0.09)	(1.25)
Dealer Lev. Growth	-92.15	-32.71	-77.85	-10.90	-96.80	-35.89	-189.4	-220.1
	(-1.97)**	(-0.71)	(-1.28)	(-0.11)	(-0.82)	(-0.40)	(-1.33)	(-0.87)
VIX	3.07	2.81	3.83	2.74	2.81	3.01	7.91	5.42
	(2.27)**	(1.89)*	(2.08)**	(1.25)	(1.19)	(1.75)*	(2.38)**	(1.05)
TED Spread	1.26	1.36	1.93	2.37	2.38	1.40	1.83	3.11
	(3.19)***	(3.00)***	(3.35)***	(3.12)***	(2.85)***	(2.08)**	(1.67)*	(1.50)
Number of Observations	15713	15338	14993	14779	14634	14101	13401	12919
Adjusted R-Square	0.3233	0.2935	0.3407	0.3244	0.3480	0.3404	0.4126	0.3287

Table 13: Liquidity provision (Q) measured in natural logs.

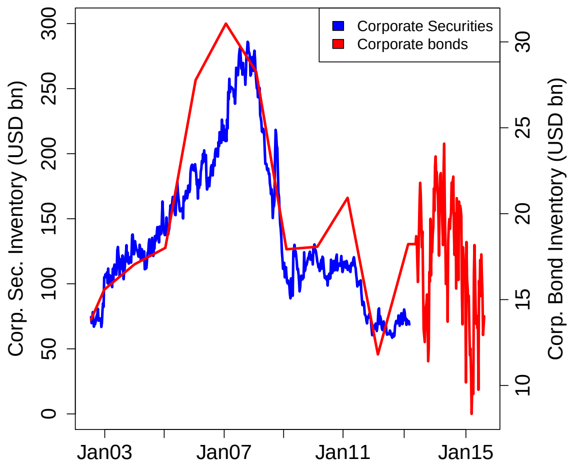
This table replicates Table 12, except that the natural logarithm of dealer inventory is used to proxy for Q.

Event Window: (0,t]	1	2	3	4	5	10	20	30
Q*Postcrisis	11.44	14.50	20.69	23.01	30.39	18.53	40.54	49.46
	(1.73)*	(1.74)*	(2.65)***	(2.22)**	(2.66)***	(2.91)***	(2.36)**	(2.06)**
Q*Crisis	12.83	32.80	53.25	62.72	71.27	49.64	66.80	83.76
	(1.34)	(2.52)**	(3.32)***	(2.96)***	(2.87)***	(2.96)***	(2.25)**	(2.24)**
Q*Precrisis	3.65	12.53	11.86	9.04	14.51	11.46	5.67	14.62
	(0.92)	(1.81)*	(1.55)	(1.47)	(1.75)*	(0.81)	(0.42)	(0.86)
Log Issue Size	-16.74	-20.46	-21.07	-3.41	-13.63	16.32	6.23	73.08
	(-1.41)	(-1.44)	(-1.31)	(-0.16)	(-0.54)	(0.78)	(0.23)	(1.34)
Dealer Lev. Growth	-89.39	-34.90	-88.22	-4.14	-84.93	-18.62	-156.7	-197.0
	(-1.88)*	(-0.74)	(-1.45)	(-0.04)	(-0.69)	(-0.19)	(-1.04)	(-0.76)
VIX	3.19	2.96	4.11	2.97	3.06	3.02	8.21	5.80
	(2.27)**	(1.91)*	(2.17)**	(1.32)	(1.26)	(1.70)*	(2.38)**	(1.10)
TED Spread	1.25	1.35	1.90	2.27	2.28	1.27	1.74	3.10
	(3.19)***	(2.94)***	(3.32)***	(3.03)***	(2.76)***	(1.91)*	(1.59)	(1.51)
Number of Observations	15713	15338	14993	14779	14634	14101	13401	12919
Adjusted R-Square	0.3215	0.2918	0.3427	0.3191	0.3423	0.3347	0.4056	0.3281

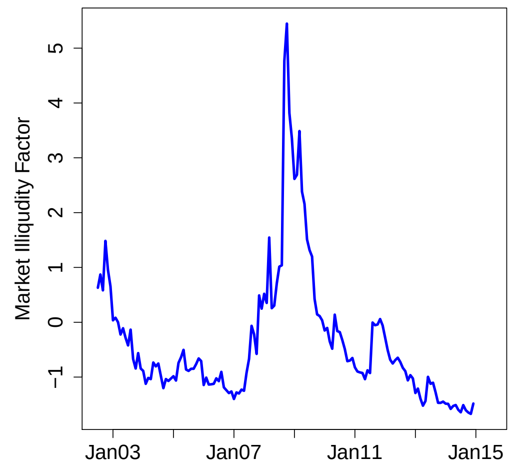
Table 14: Bond purchase price and the provision of immediacy

This table is similar to Table 12, except that the dependent variable is given by bond prices rather than abnormal returns. The specification incudes two additional bond characteristics (coupon and time to maturity) to better control for factors affecting bond prices (but not necessarily returns).

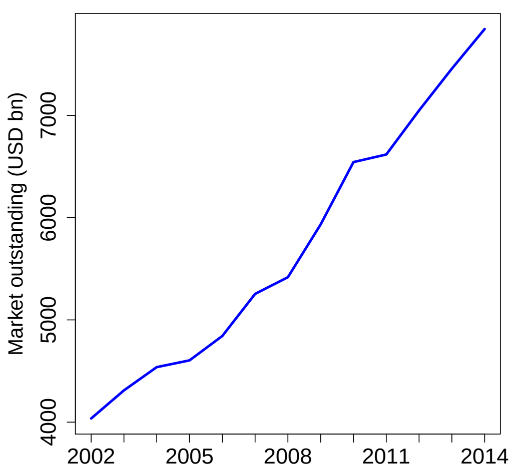
Model	1	2
Q*Postcrisis	-0.07	-0.05
	(-4.04)***	(-4.04)***
Q*Crisis	0.12	0.02
	(2.28)**	(0.41)
Q*Precrisis	-0.01	-0.01
	(-1.35)	(-1.27)
Log Issue Size	2.97	2.63
	(4.70)***	(5.04)***
Coupon	1.52	1.59
	(7.00)***	(7.79)***
Years to Maturity	-0.42	-0.44
	(-3.98)***	(-4.72)***
Dealer Lev. Growth		11.87
		(4.70)***
VIX		-0.28
		(-4.92)***
TED Spread		-0.07
		(-4.61)***
Number of Observations	17415	17415
Adjusted R-Square	0.6381	0.7125



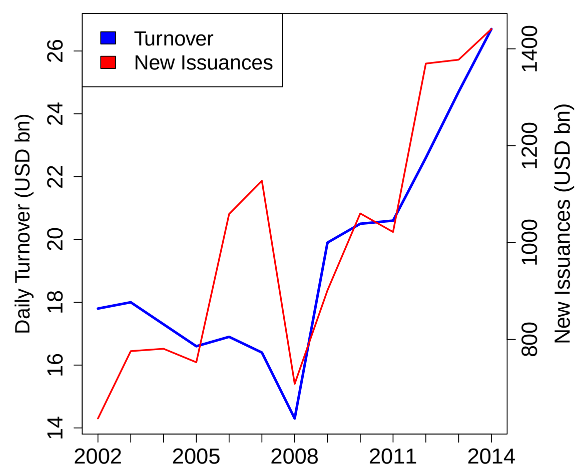
(a) Primary dealer inventory



(b) Market Illiquidity Factor



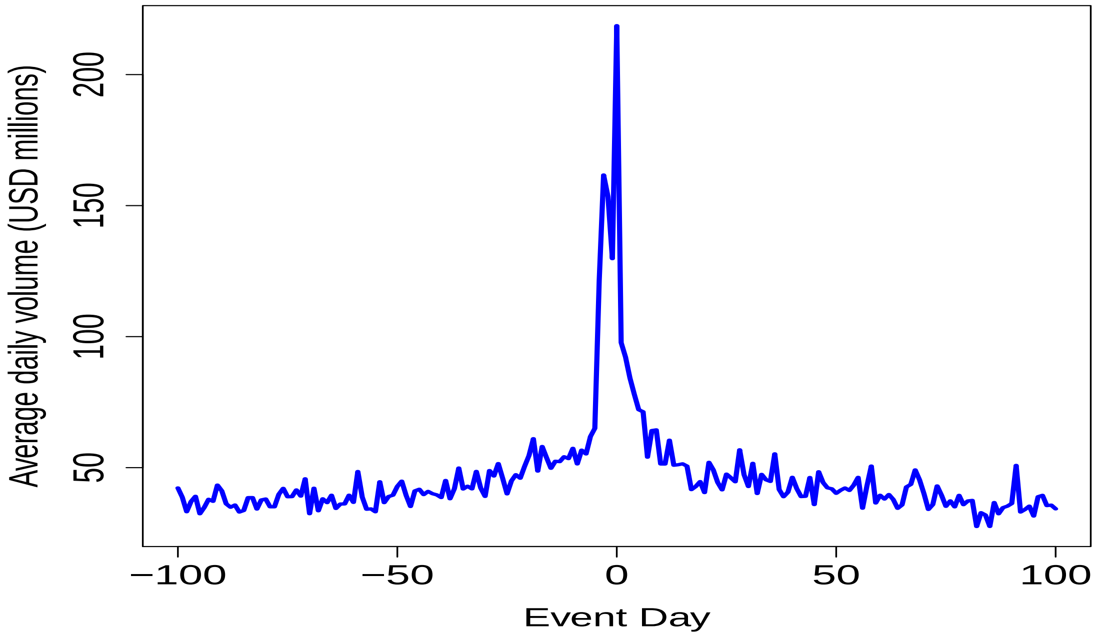
(c) Market Size



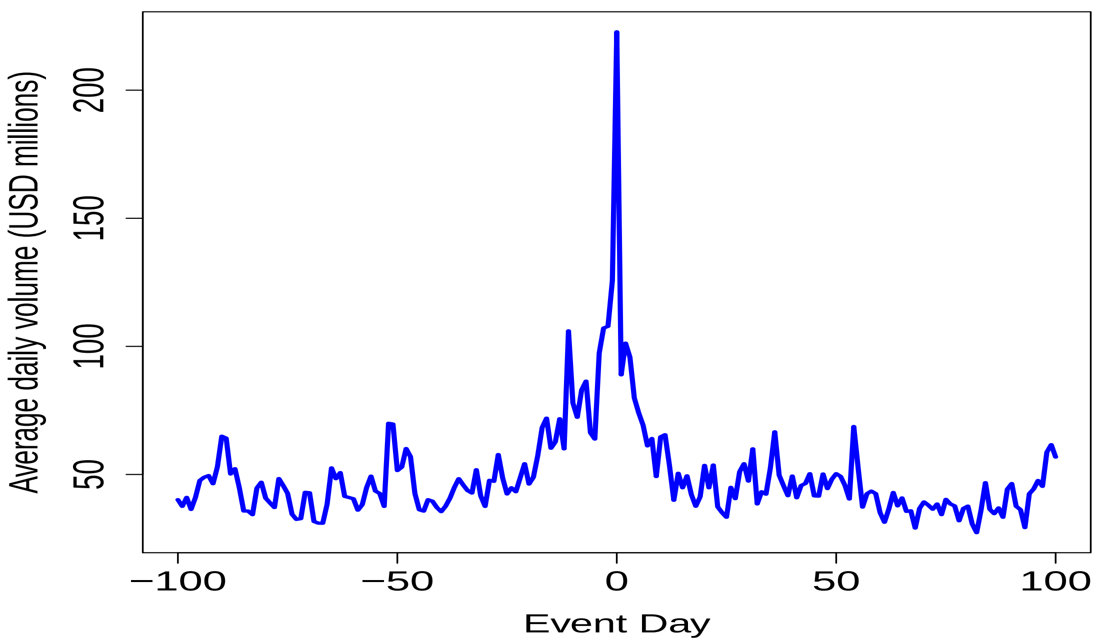
(d) Market Turnover

Figure 1: Corporate bond market statistics

Panel A shows the primary dealer inventories in corporate securities (investment-grade above 1 year in maturity) and in corporate bonds. The first series can be retrieved from the New York Fed statistics on primary dealer holdings. The graph on corporate bonds can be retrieved from the same place after March 2003. The numbers prior to that date have been computed by Goldman Sachs using yearly SEC-filings from the primary dealers. Panel B shows the market liquidity measure from Dick-Nielsen, Feldhütter, and Lando (2012) which can be downloaded from peterfeldhutter.com. Panel C shows total nominal corporate bond market size. Panel D shows total market trading volume and the number of total size of new issuances. Data for panel C and D are retrieved from SIFMA.



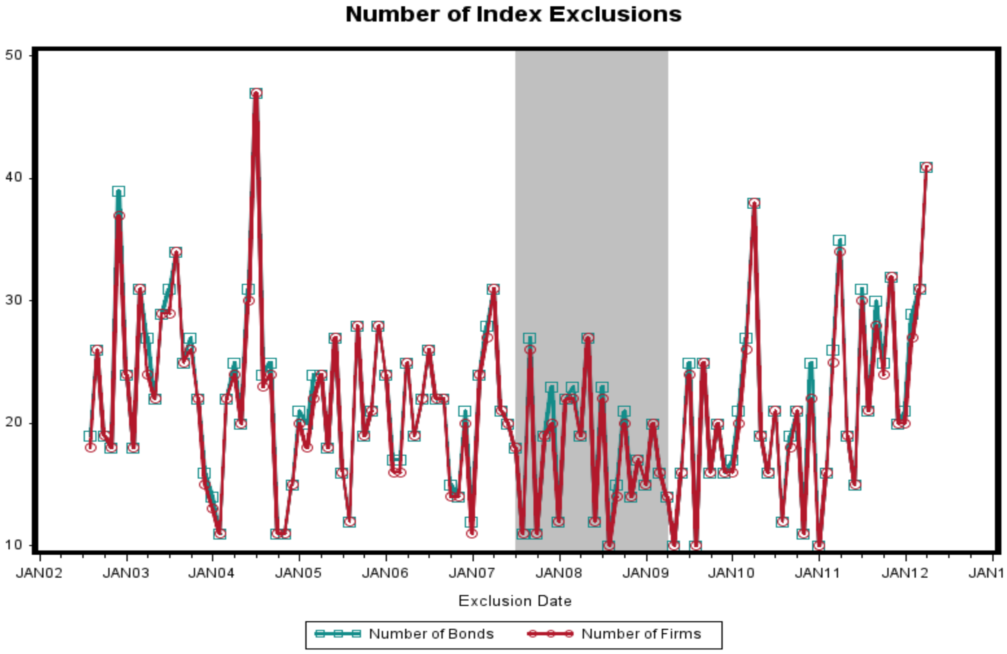
(a) Maturity < 1 Year



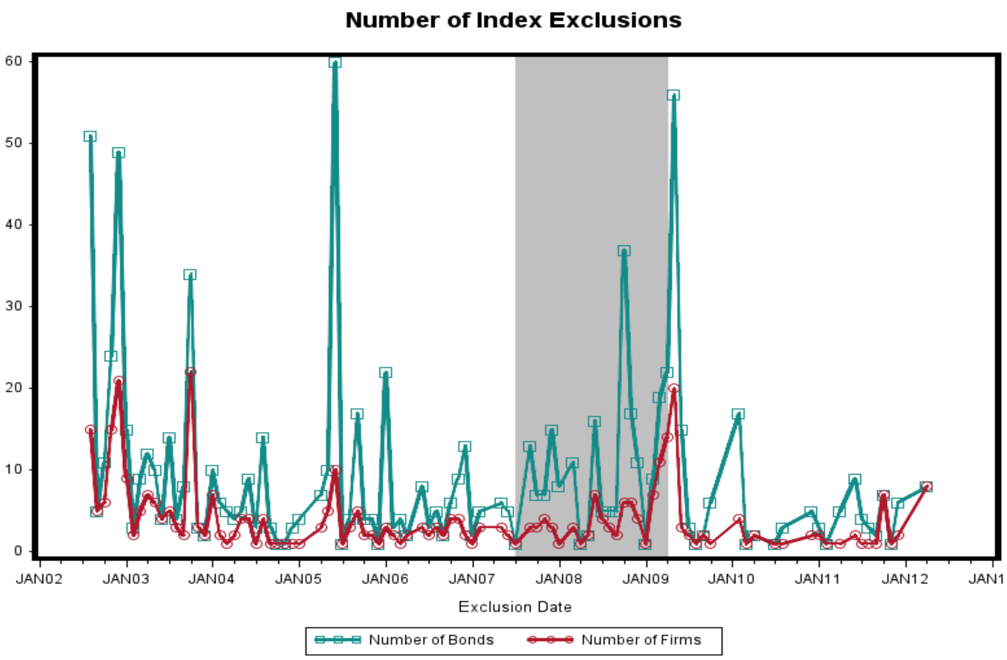
(b) Rating Less Then investment-grade

Figure 2: Trading activity around the event.

This graphs show the average trading volume around the monthly exclusions. Panel A shows the trading volume for the bonds excluded because of low maturity. Panel B is for the bonds excluded because of a downgrade to speculative grade. Trading volume is aggregated across all the bonds excluded at a given event date and then averaged across all event dates.



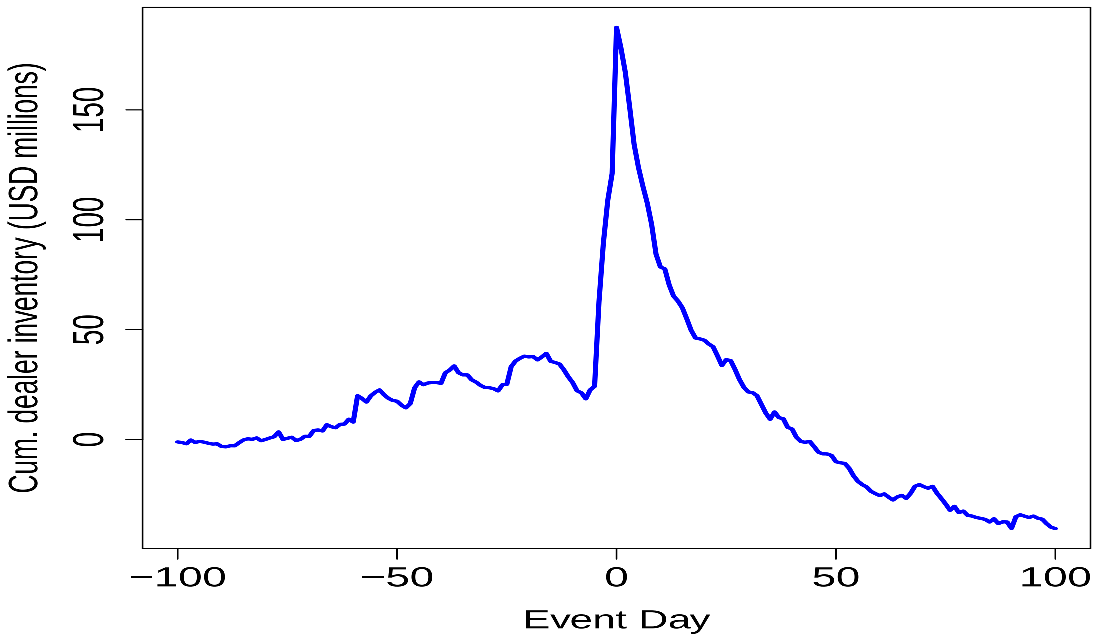
(a) Maturity < 1 Year



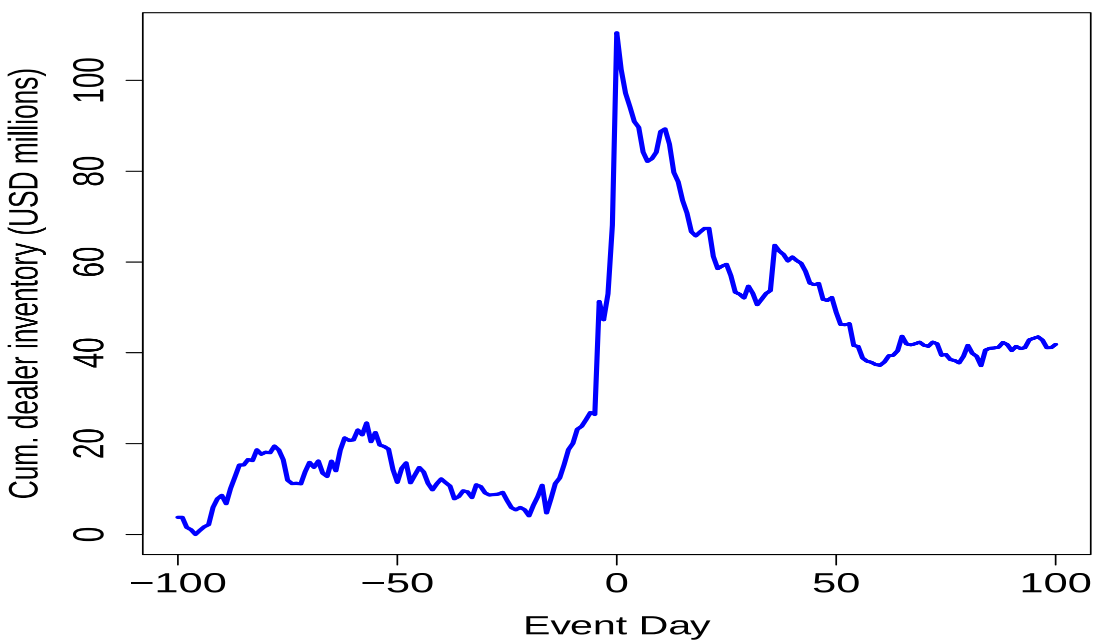
(b) Rating Less Then investment-grade

Figure 3: Index Exclusions Over time

This figure plots the number of bond (square) and firm (circle) exclusions from the Barclay's investment-grade Index. The top panel presents the exclusions due to maturity; the bottom panel presents the exclusions due to rating deterioration. The shaded area represents the sub-prime crisis.



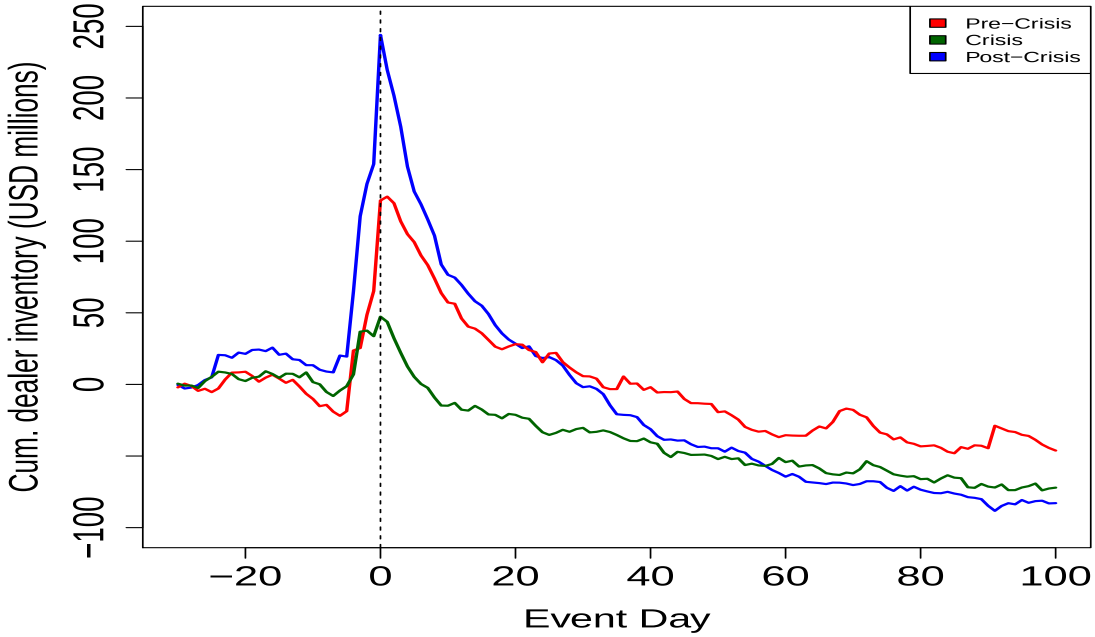
(a) Maturity < 1 Year



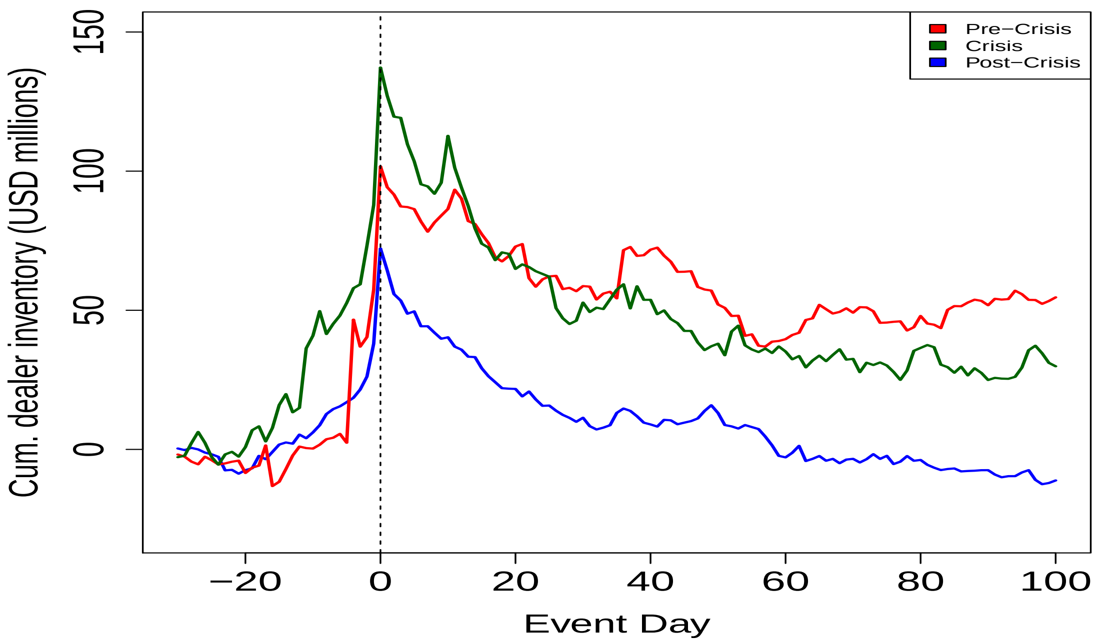
(b) Rating Less Then investment-grade

Figure 4: Cumulative dealer inventory around the event date.

This graphs show the average cumulative dealer inventory around the monthly exclusions. Panel A shows the inventory for the bonds excluded because of low maturity. Panel B is for the bonds excluded because of a downgrade to speculative grade. Cumulative inventory is found by subtracting dealer sells from dealer buys and cumulating the imbalance over time. The dealer inventory is relative to the arbitrarily chosen starting point at event day -100. Inventory is aggregated across all the bonds excluded at a given date and then averaged across all the event dates.

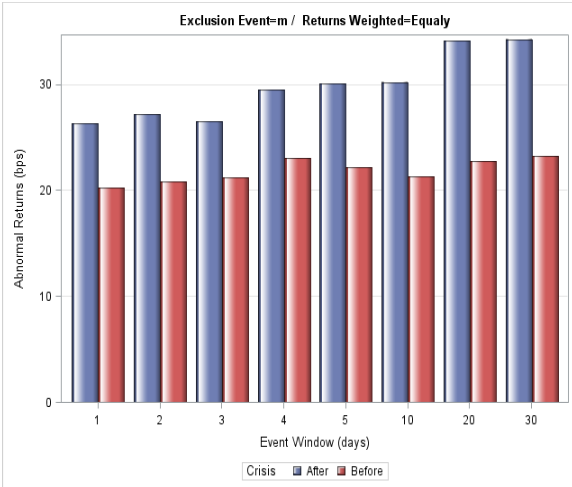


(a) Maturity < 1 Year

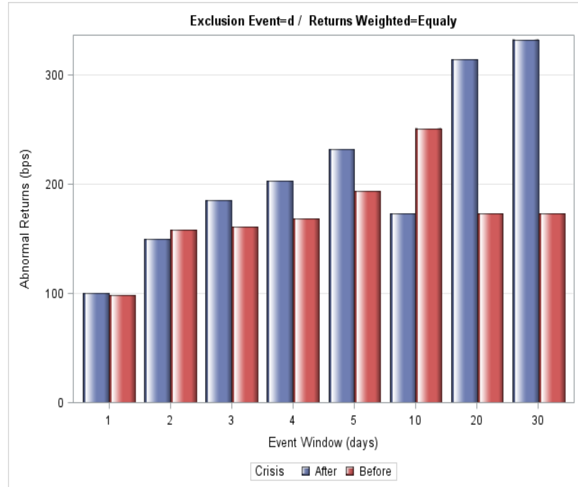


(b) Rating Less Then investment-grade

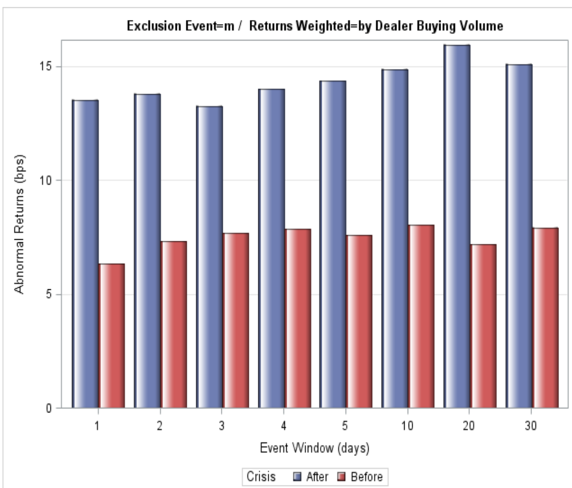
Figure 5: Cumulative dealer inventory around the event date for sub-periods.
This graphs shows the cumulative dealer inventories for three periods. Pre-crisis: 2002Q2 to 2007Q2, Crisis: 2007Q3 to 2009Q4, and Post-crisis: 2010Q1 to 2013Q4. The cumulative inventory and the two panels are calculated as in Figure 4, except that the referencing point is now event day -30.



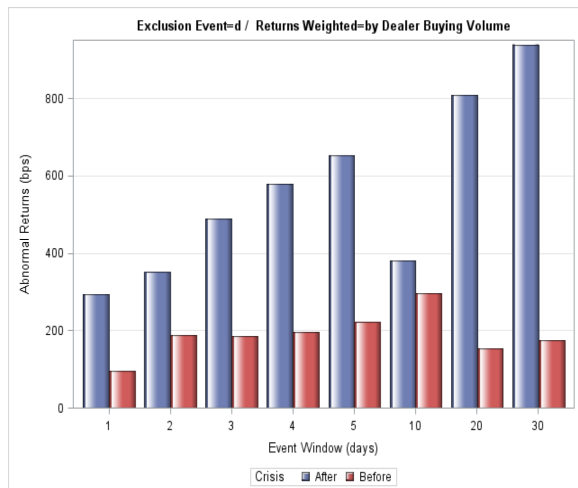
(a) Maturity (EW)



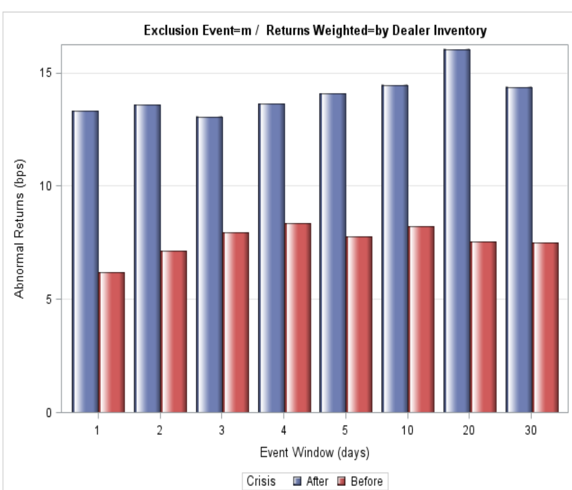
(b) Downgrade (EW)



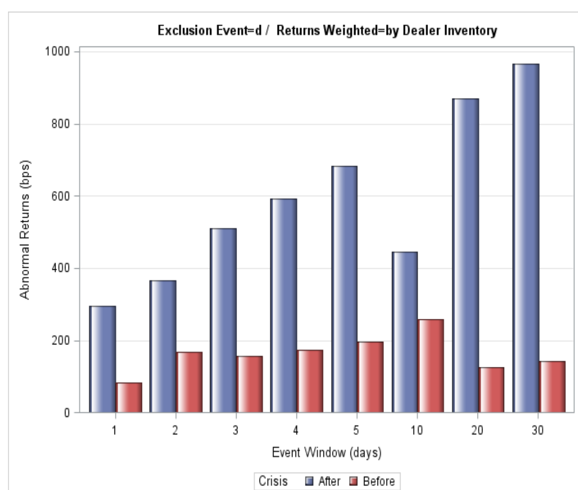
(c) Maturity (VW1)



(d) Downgrade (VW1)

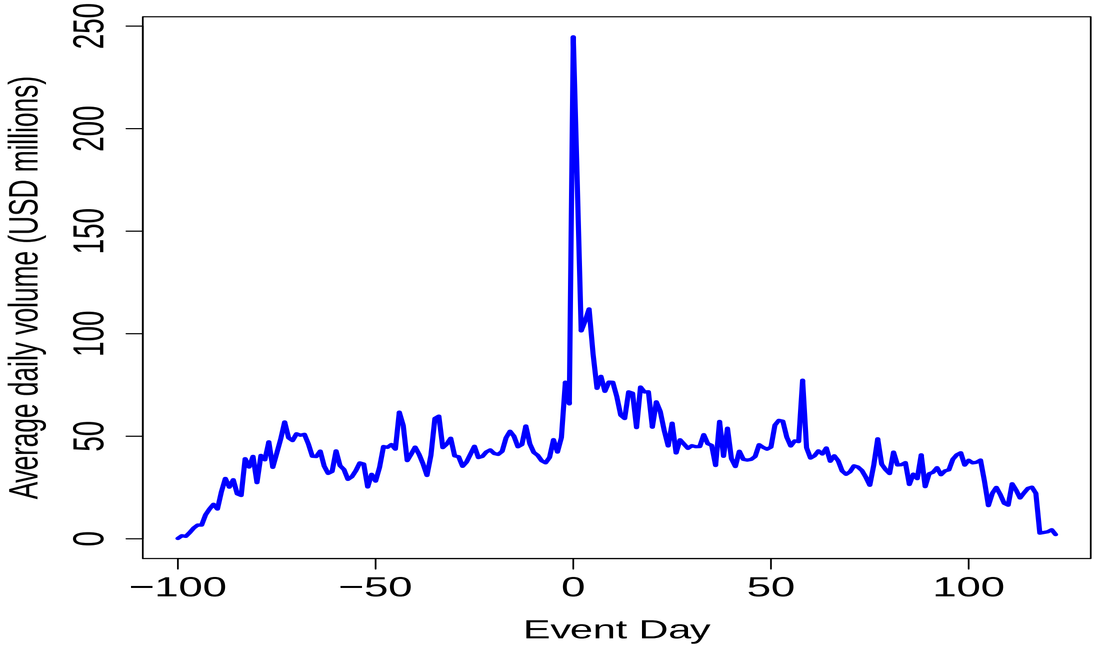


(e) Maturity (VW2)

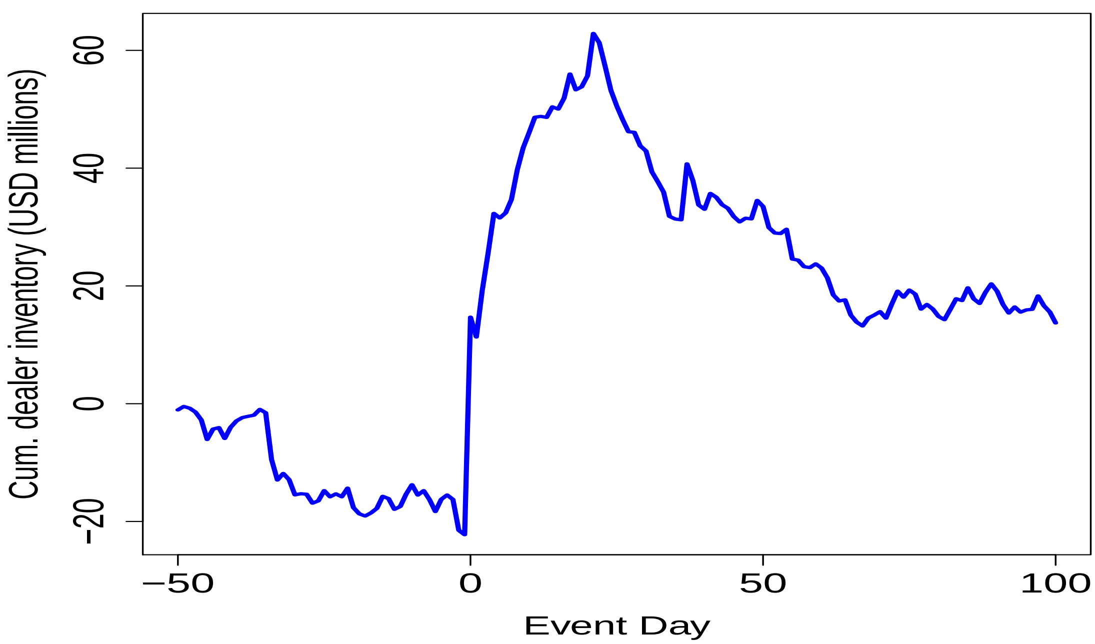


(f) Downgrade (VW2)

Figure 6: Cost of immediacy before and after the credit crisis (dealer level)
The figure provides a graphical representation of the estimates from the last three columns (abnormal returns) in Table 6 (left graphs) and Table 7 (right graphs).



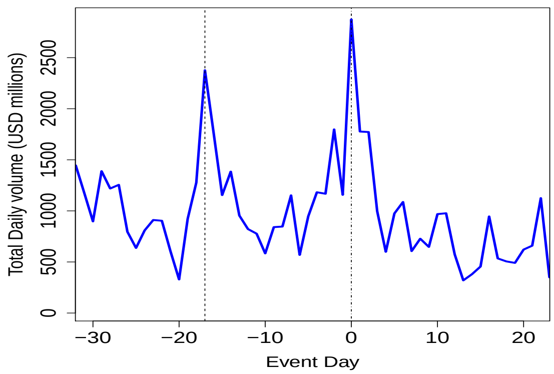
(a) Volume at downgrade date



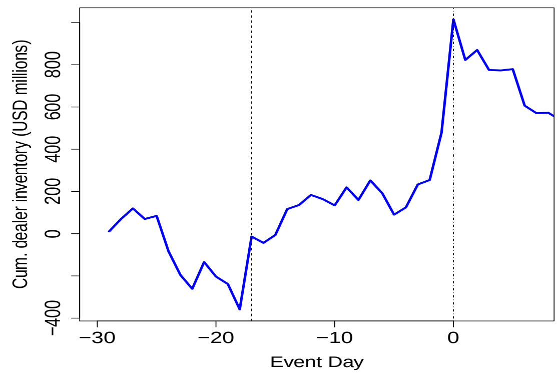
(b) Cumulative inventory at downgrade date

Figure 7: Trading and inventory around the downgrade date.

This graphs show the average trading volume and cumulative dealer inventory around the downgrade date. The downgrade date is the date at which the bond changes index rating from investment-grade to speculative-grade. Trading volume is aggregated across all the downgraded bonds. The cumulative inventory is calculated as in Figure 4, except that the referencing point is now event day -50 and event time is now relative to the downgrade date.



(a) Volume: 17 days lag



(b) Inventory: 17 days lag

Figure 8: Trading and inventory for specific downgrade constellations

The graphs show trading activity (calculated as in Figure 2) and cumulative inventory (calculated as in Figure 4). Event time in these graphs are relative to the index exclusion date (the right vertical line). The left vertical line is the downgrade date. The time lag between downgrade date and index exclusion is kept constant at 17 days which is the most common number of days between the two events. Volume and inventory are not averaged as in the former graphs.