Liquidity Risk and Correlation Risk:

A Clinical Study of the General Motors and Ford Downgrade of May 2005[1]

by

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Abstract

The deterioration in credit quality of General Motors (GM) & Ford to junk status in the spring of 2005 caused a wide-spread sell-off in their corporate bonds. Using a novel dataset, we document that this sell-off appears to have generated significant liquidity risk for market-makers, as evidenced by a significant imbalance in their quotes towards sales. We find that simultaneously there was a substantial increase in the co-movement between innovations in the credit default swap (CDS) spreads of GM and Ford and those of firms in all other industries, the increase being the greatest during the period surrounding the actual downgrade and reversing sharply thereafter. We show that the corporate bond market makers' imbalance towards sales in GM and Ford bonds explains a significant portion of this co-movement. These results linking liquidity risk and correlation risk are consistent with models in which market prices are episodically determined by the limited risk-bearing capacity of financial intermediaries.

Keywords: market liquidity, funding liquidity, excess co-movement, inventory risk, financial crises

JEL Classification: G12, G13, G14, G21, G22

1. Introduction

Theoretical research (starting with Grossman and Miller, 1988, and more recently, Gromb and Vayanos, 2002,He and Krishnamurthy, 2008, Brunnermeier and Pedersen, 2009, and Acharya and Viswanathan, 2011) has argued that due to limited capital available for intermediation activity, liquidity in financial markets is intimately related to the funding liquidity of intermediaries. In practice, financial intermediaries face funding constraints in the form of collateral and margin requirements, value-at-risk constraints and capital requirements. When the risks of intermediation increase, e.g., the price risk of inventory and its funding costs rise, intermediaries may reduce their provision of market-making services and alter prices so that they are being suitably compensated for the risk or both. The resulting reduction in liquidity and the impact on prices may be pervasive, going beyond the asset class which has given rise to liquidity risk initially and affecting especially those assets for which these intermediaries are primary liquidity providers or marginal price-setters. This, in turn, can induce a co-movement in asset prices that is not attributable to correlation in fundamentals affecting these assets. In other words, *liquidity risk* faced by financial intermediaries can induce *correlation risk* for investors in the form of excess co-movement in prices of assets.

The goal of this study is to test this implication – that liquidity risk and correlation risk are inter-twined as a result of limited risk-bearing capacity of financial intermediaries. We conduct a clinical study of the effects on fixed-income markets of the credit deterioration and eventual downgrade of General Motors (GM) and Ford to junk status in the spring of 2005. Our choice of this setting is driven by at least three considerations which lead us to conclude that GM and Ford credit deterioration in 2005 can be considered a "natural experiment" for studying the link between liquidity risk and correlation risk.

First, in analyzing any linkage between liquidity risk and correlation risk, the correlation attributable to co-movement in fundamentals must be controlled for. From an identification standpoint, the GM and Ford episode offers a vantage point since, with the exception of the auto sector, their profit and credit deterioration were largely idiosyncratic to rest of the economy.

Second, the episode allows us to isolate a specific liquidity risk faced by corporate bond market-makers. In particular, GM and Ford constituted a significant proportion of the overall corporate bond market, especially of the investment-grade indices.[2] The profit warnings of GM and Ford in March and April of 2005, and the subsequent downgrade to junk status, caused a large number of bond investors and asset managers, including those that faced portfolio restrictions to invest only in investment-grade bonds and those who tracked investment-grade corporate bond indices, to liquidate their positions.[3] Due to delay in the entry of these bonds into sub-investment grade indices and, more broadly, due to slow movement of arbitrage capital[4], in particular, junk-bond capital, the market-makers faced the risk that they would

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[2] GM and Ford were the No. 2 and No. 3 largest debt issuers in Lehman's U.S. Credit Index, representing 2.02 percent and 1.97 percent of the total index respectively. If moved to the Lehman High Yield Index (post May 5, 2005 downgrade), GM, with a 6 percent share, and Ford, with a 5.9 percent share, would have dwarfed the other members, which constituted 2 percent or less of the index.

[3] Consistent with this fire-sale mechanism, Ellul, Jotikasthira and Lundblad (2010) document downward price pressures and subsequent reversals for corporate bonds downgraded below investment grade during the period 2001-2005. They show that this liquidity effect is linked to forced sales by insurance companies (which as a group hold over one-third of all investment grade bonds), especially by those companies that face stringent capital requirements for holding of speculative-grade bonds.

[4] A part of the literature has argued that capital is "slow-moving" in spite of market distortions (as documented by Mitchell, Pedersen and Pulvino, 2007) due to information- and capital-raising frictions (see, in particular, Duffie, 2010); others have argued that there is often simply a shortage of aggregate capital in equilibrium since idle, available-for-arbitrage capital is costly to set aside for low-probability events that lead to market distortions (see, e.g.,Allen and Gale, 1998, and Acharya, Shin and Yorulmazer, 2008).

struggle to find buyers for these bonds at the same as their rate of liquidation. In particular, these bonds could have taken several weeks (and, in fact, took several months) to liquidate fully, giving them incentives to lower prices in order to induce buyers to enter the market sooner.

Finally, the fixed-income setting helps isolate assets where financial institutions can be reasonably assumed to be the marginal price-setters. We exploit the fact that most financial institutions that make markets in corporate bonds are also the liquidity providers in related segments of the fixed-income markets, such as credit default swaps (CDS). Our starting hypothesis is that since market makers faced substantial inventory risk in GM and Ford bonds, they became reluctant to take on more bonds, and more generally, additional credit risk. Since selling protection via credit default swaps is equivalent to buying bonds in terms of credit exposure, our hypothesis is that market makers would have raised the cost of selling protection via CDS across board and were willing to pay extra for buying protection. As a result, the mid-market spreads at which CDS were quoted in the markets should widen. In particular, CDS spreads should widen not just for the auto sector to which GM and Ford belong (and where the downgrade may have also conveyed fundamental information), but also for other sectors.[5]

Our empirical approach has three key steps. First, using a novel dataset of corporate bond quotes from MarketAxess, a leading corporate bond trading platform, we show that the period around the downgrade of GM and Ford was indeed associated with a substantial increase in inventory risk for corporate bond market-makers. While the data do not provide inventory positions of these intermediaries explicitly, we show that around the downgrade period there was a sudden and marked rise in the imbalance in market makers' quotes of GM and Ford bonds, with substantially more offer quotes and offer volume than bid quotes and volume, compared to the non-downgrade period. Similarly, though we do not have the identity of the intermediaries, we are able to track individual institutions over time and, in doing so, find that there was an increase in the fraction of institutions who were net offerers of GM and Ford bonds compared to the non-downgrade period. In addition, there was also a reduction in the proportion of two-sided quotes.[6] These liquidity effects reversed sharply after the downgrade period.

Second, using the data on 5-year CDS spreads for GM and Ford and firms in eight industries (Auto, Financial, Basic Materials, Consumer Services, Industrials, Oil & Gas, Technology and Utilities), we document that, compared to the non-downgrade period, there was a substantial increase in co-movement between GM and Ford spreads and the average spreads for *each* of these eight industries. Importantly, as with the liquidity effects discussed

[5] We focus on CDS given the availability of CDS data, daily trades in most names, and standardization of contracts to five-year $10mln notional on senior unsecured debt of the underlying entities

[6] Indeed, this is one reason why we do not employ bid-ask spread as a measure of liquidity in our study since it is difficult to compute the bid-ask spread during the downgrade period due to the lack of sufficient two-sided quotes.

above, this excess co-movement is also short-lived, in the sense that it falls substantially following the downgrade period. Of course, it is possible that the increase in the co-movement we identify is simply an increase in co-movement of fundamentals across industries. However, we control for this effect by focussing on CDS *innovations*, calculated as in Acharya and Johnson (2007) as the residuals from regressing CDS changes on (a non-linear no-arbitrage specification of) contemporaneous and lagged equity changes of the underlying firms as well as on interest-rate changes and lagged CDS changes. Controlling for equity changes helps isolate the component of CDS changes that is specific to credit markets and potentially due to liquidity or segmentation effects rather than to fundamental information about credit risk.

The third and the most important step of our analysis is to link the co-movement identified in CDS changes across industries to the liquidity risk faced by corporate bond market-makers in GM and Ford bonds. To this end, we show that a measure of the imbalance in the quotes of GM bonds that we employ to document liquidity risk is in fact significant in explaining the CDS changes, not only for GM and Ford, but for all the other eight industries and even after controlling for similarly computed imbalance measures for corporate bonds of these industries.[7] What is most striking is that our measures of liquidity risk have little explanatory power during the non-downgrade period (R^2 of 5% to 10% for most industries), but two- to three-fold greater explanatory power during the downgrade period (R^2 of 15% to 20% for most industries). The economic magnitude of the effect during the downgrade period is also large: a one standard deviation shock to the liquidity risk measure produces an effect on CDS innovations of the order of 30% to 50% of a standard deviation.

A principal components analysis of the CDS innovations of GM and Ford and the eight industries, conducted separately during the non-downgrade and downgrade periods, reinforces this finding. During the non-downgrade period, the first component explains about 44% of the variation and the measure of imbalance in offer versus bid volume in quotes of GM explains only 13% of this component. In contrast, the first component explains 73% of the variation during the downgrade period and the same imbalance measure explains over 20% of this component.

Next, we provide evidence that a measure of funding constraints faced by intermediaries played a role in the link between liquidity risk and correlation risk. Data on value-at-risk, or the capital and margin requirements faced by intermediaries are difficult to obtain, especially at the level of individual institutions. Instead, we use changes in a measure of the funding cost faced by the financial intermediation sector as a whole, namely the spread

[7] Our results are qualitatively similar but weaker when we use the Ford, rather than GM downgrade imbalance measures. This could be partly explained by the facts that GM had a larger volume of bonds outstanding, GM experienced greater credit deterioration compared to Ford during the downgrade episode and, as we detail later while describing the timeline of the crisis, unlike the GM bonds, Ford bonds left the investment-grade indices during the crisis only for one month.

between financial commercial paper (CP) and the T-bill rate. We show that these changes by themselves are not strongly related to the excess co-movement in CDS innovations of different sectors, but that the effect of quote imbalance in GM bonds on the excess co-movement was stronger in those periods when the financial CP to T-bill spread widened. This provides some evidence that intermediaries' limited risk-bearing capacity and funding constraints were the channels that linked liquidity risk and correlation risk.

The relationship between liquidity risk and correlation risk is robust to controlling for changes in VIX, often perceived to be a measure of the risk appetite of financial intermediaries, which might lead to a change in the provision of market-making services but not for reasons driven by illiquidity in the underlying bonds. Our evidence is also robust to employing lagged liquidity risk measures to avoid the concern of omitted fundamental factors. We also consider alternative measures of liquidity risk, other than the quote imbalance in GM bonds. For instance, the cost of short-selling GM bonds and stocks rose substantially during the episode but these liquidity risk measures do not have significant explanatory power for innovations in CDS rates in the crisis (or before).[8]

The most recent credit crisis of 2007-2009 in markets has provided further evidence that lack of funding liquidity of financial intermediaries can simultaneously affect liquidity and prices in many markets (credit markets, equity markets, foreign exchange markets, etc.).For instance, Aragon and Strahan (2011) examine the price behavior of stocks held by hedge funds that had Lehman Brothers as their prime broker, relative to stocks held by other hedge funds, following the bankruptcy of Lehman Brothers (which led to collateral hold-up and attendant liquidity problems for Lehman's hedge fund clients). They find a strong impact on market liquidity of the first set of stocks, a differential effect not found around the relatively contained collapse of Bear Stearns. While the difficulty of linking market and funding liquidity during the crisis period is formidable, the GM-Ford downgrade shock to credit markets that we analyze in this paper is not contaminated by a substantial deterioration in the underlying economic fundamentals, as has been the case during the recent crisis.

The rest of the paper is organized as follows. In Section 2, we review the related literature. In Section 3, we describe in some detail the events and the aftermath of the GM and Ford downgrade. We provide a description of the data we employ in Section 4. The hypotheses we test and the results we find are documented in Section 5, with additional robustness checks in

[8] It should be noted that our effects are the strongest during the period from profit warning of GM in mid-March 2005 to the actual downgrade in early May 2005, and next in the period immediately after the downgrade. This reassures us that the effects we document are not due to dislocation in the popular credit derivatives trades in that time – the CDS to equity hedge and mezzanine to equity tranche hedge of the CDX index of credit-default swaps. The dislocation in these hedges arose *after* the downgrade in early May, whereas liquidations in GM and Ford bonds arose much earlier, starting in mid-March.

Section 6 and Section 7. In Section 8, we conclude with implications of our results for the management of correlation risk arising in complex derivative and structured products.

2. Additional related literature

Over the past three decades, there have been a large number of occasions where the ability to trade securities and access to capital-market financing has dried up significantly, especially for financial institutions. The most striking of these include the stock market crash of 1987 in the United States, the Russian default in 1998, the Long Term Capital Management episode that followed, the aftermath of GM and Ford downgrade in May 2005, and most recently, the 2007-08 credit crunch following the collapse in the US sub-prime market and eventually the bankruptcy of Lehman Brothers. In parallel, there has been a surge in the recent academic literature on issues concerning expected illiquidity (Amihud and Mendelson, 1986 and Amihud, 2002, being two salient examples) and liquidity risk (Pastor and Stambaugh, 2003, and Acharya and Pedersen, 2005). The recent theoretical literature (cited in the introductory paragraph of the paper) has stressed the role of financial intermediaries in linking liquidity to prices. In particular, this literature has argued that there are limits to the extent of arbitrage and market-making activity that financial intermediaries can undertake and that this limited market-making capacity affects prices. Basak and Croitoru (2000) also study implications of such limited intermediation capacity for prices.

In particular, the lack of perfect mobility of capital across relatively "dislocated" markets has been identified in a number of empirical studies and the findings suggest that this arises either due to investment-style restrictions (regulatory or style-based) or limited capital of intermediaries: large price drops and delayed recovery in connection with downgrades and defaults (Hradsky and Long, 1989) as in our paper; price impact of large issues of credit-risky bonds on other bonds in the issuer's sector (Newman and Rierson, 2003); effect of large capital redemptions from convertible hedge funds on convertible bond prices with a slow rebound in 1998 and 2005 (Mitchell, Pedersen and Pulvino, 2007); slow price adjustments in equity markets to index recomposition events (Shleifer, 1986, Harris and Gurue, 1986, Kaul, Mehrotra, and Morck, 2000, Chen, Noronha and Singhal, 2004, Greenwood, 2005), mutual fund redemptions (Coval and Stafford, 2007), and similar supply shocks (Andrade, Chang and Seasholes, 2008); and the pricing in reinsurance markets in the aftermath of a large loss in one of the markets (Froot and O'Connell, 1997). All these studies point to delays in the adjustments of investors' portfolios.[9]

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[9] As Duffie and Struvolici (2008) note: "The typical pattern suggests that the initial price response is larger than would occur with perfect capital mobility, and reflects the demand curve of the limited pool of investors that are immediately available to absorb the shock. The speed of adjustment after the initial

Given these investor-level frictions, the market-making capacity of intermediaries becomes crucial to limiting the extent of price impacts from events that result in forced sales from one segment of investors but produce entry from another segment only with delay. However, market makers may themselves be capital-constrained in playing such a role due to collateral or margin requirements, and capital and value-at-risk requirements (or some other friction) for trading of securities. As a result, they may withdraw liquidity provision or alter prices so as to induce other agents to take the opposite side in forced sales, and be compensated for the liquidity risk they bear as market makers.

Our main thesis in this study is that an important component of the fluctuations in correlation derives from liquidity risk and not from correlation between the cash flows and discount rates of underlying securities. Given this, our results have implications for the expanding recent literature that has documented evidence of substantial correlation or co-movement risk in asset prices (see Duffie, 2010 for a summary): Driessen, Maenhout and Vilkov (2006) who claim that correlation risk is priced in equity index derivatives; Pollet and Wilson (2007) who show that pair-wise equity correlation risk predicts future equity market returns but also that this risk is high in episodes largely associated with high illiquidity (1970, 1974, 1987, 1998 and 2002); Krishnan, Petkova and Ritchken (2008) who find correlation risk is priced cross-sectionally in the US equity returns; and, Longstaff and Rajan (2007), Bhansali, Gingrich and Longstaff (2008) and Coval, Jurek and Stafford (2008) who find that economy-wide systemic risks seem to affect pricing of CDS and also structured products such as collateralized debt obligations (CDOs) and CDX index tranches. These effects may be liquidity-related rather than a reflection of fundamental correlation risk per se. In this sense, our spirit of enquiry is similar to that of Boyson, Stahel and Stulz (2008) who show that the hedge fund indices for different strategies exhibit significant contagion when the prime brokers lending to hedge funds have experienced significant losses, creating funding problems for hedge funds, and lowering stock market liquidity.

3. The downgrade of GM and Ford and its consequences

Appendix A provides a detailed timeline of events leading up to and during the GM and Ford downgrade episode. On May 5, 2005, Standard and Poor's announced that bonds issued by General Motors Corp and Ford Motor Co, the world's first and third largest automakers respectively, were to be downgraded to junk status for the first time in either company's history. S&P lowered the ratings on bonds of GM and GMAC, GM's finance

price response is a reflection of the time that it takes more investors to realign their portfolios in light of the new market conditions, or for the initially responding investors to gather more capital."

subsidiary, from BBB- to BB, two notches below investment grade (BBB- and above) and Ford and FMCC, Ford's finance arm, from BBB- to BB+, one notch below investment grade. In addition to the downgrade, the agency added that it was maintaining a negative outlook on both companies. S&P cited a number of parallel concerns for the automakers, including falling sales of sport utility vehicles and declining market share in the face of strong competition.[10]

While the May 5, 2005 downgrade by S&P was the most critical event that moved GM and Ford from investment grade into junk status, a number of other credit deterioration events, including downgrades by other rating agencies and profit warnings, took place *before* May 5, 2005. The troubles for the two automakers started as early as Oct 14, 2004, when S&P downgraded GM and GMAC to BBB-. Prior to that, S&P rated GM and GMAC as BBB, and Ford and FMCC as BBB-. In fact, GM and Ford bonds had been trading at or near junk levels since March 16 2005, when GM issued a steep profit warning when it announced that it expected a substantial loss in the first quarter due to loss in the market share of sports utility vehicles to Toyota relative to projections. The news shocked Wall Street and sent GM's stock down nearly 14 percent to a twelve and a half year low. A slew of bad news soon followed in the wake of the profit warning. On the day of the warning, S&P revised its outlook for GM from stable to negative, and Fitch downgraded GM and GMAC one notch to BBB-. On April 5th, Moody's downgraded GM and GMAC one notch to BBB- and BBB respectively and placed Ford and FMCC on review for possible downgrade. A few days later, S&P and Fitch also lowered their outlook for Ford and FMCC from stable to negative and, on April 12th, Ford issued its own profit warning.

In light of GM and Ford's rapid credit-quality deterioration, marked by back-to-back profit warnings and credit reviews, their downgrade to junk status was not entirely unexpected. However, many investors were surprised by S&P's timing – May 5th, 2005 was sooner than many had expected.[11] News of credit deterioration continued after May 5. On May 24, Fitch followed S&P's move, downgrading GM and GMAC to junk status. On July 1, Moody's placed GM, GMAC, Ford, and FMCC on review for possible downgrades. Appendix A provides a detailed timeline of these events. The downgrade announcement of May 5th sent the automakers' bonds tumbling and CDS spreads soaring. Figure 1A plots the 5-year CDS spreads of the two companies. It shows that post downgrade, CDS spreads on GM and Ford rose to 1062 bps and 856 bps respectively from less than 300 bps just few months earlier, but that the

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[10] We thank Ronald Johannes for private communication regarding the details of the downgrade episode.
[11] For example, Edward B. Marrinan, head investment-grade strategist at J. P. Morgan, was quoted by New York Times saying that "the downgrade was no surprise, but the timing of it was and has caught the market on the hop". See the article in The New York Times, "A Big Splash, Ripples to Follow; G.M. and Ford Debt Ratings Downgraded Sooner Than Expected", May 5, 2005.

spreads had been widening since October 2004 and experienced a notable rise for GM in mid-March and for Ford in mid-April.

At the time the events surrounding Ford and GM were seen as a major dislocation in credit markets with an impact on spreads that was by no means limited to the auto sector. That said, it should be noted that the increase in spreads appears very modest compared to those in the crisis, as seen in Figure 1B, which plots CDS spreads on Ford and GM along with those on the CDX high yield and investment grade indices from November 2004 to September 2008.

Because of their size, their prominence in the debt markets, and their importance to the still maturing credit derivative market, the credit deterioration of the two giant automakers constituted a serious test for the functioning of corporate-bond markets, even though for the US economy and the global economy as a whole, the events were largely idiosyncratic and specific to the auto sector. Alone, either GM or Ford would have been the largest corporate debt issuer ever to be cut to junk status by one of the three major debt ratings firms. The amount of debt affected by the downgrade was enormous: GM (including GMAC) bonds outstanding totaled $292 billion (including their Euro-denominated debt), and Ford (including FMCC) bonds totaled $161 billion.

As a result of the deterioration in mid-March which made the downgrade imminent, numerous insurance companies, pension funds, endowments, and other investment funds that owned GM and Ford bonds were forced to liquidate them in order to comply with regulatory and charter restrictions preventing them from investing in junk-rated securities. Moreover, because many investors track bond indices, much of the redistribution of GM and Ford bonds would be forced as the two names dropped from various investment-grade bond indices, such as the corporate bond indices of Lehman Brothers and Merrill Lynch and the credit default swap index iBoxx.[12] Indeed, press reports suggest that much selling of GM and Ford bonds had started taking place in anticipation of the credit downgrading. For example, over the two years up to the end of 2004 the TIAA-CREF pension fund had reduced its holdings in GM bonds by about 50 per cent to $200 million and its holdings fell further in 2005.[13]

Figures 2A and 2B provide some evidence on the reduction in institutional holdings of Ford and GM bonds. Figure 2A shows the quarterly holdings of GM and Ford bonds by insurance companies from January 2003 to December 2007 obtained from the National

[12] All GM, GMAC, Ford, FMCC securities fell out of Lehman Brothers' investment grade (IG) indices into its high yield (HY) indices on May 31, 2005. Due a change in the definition of Lehman Brothers' IG indices (made prior to the downgrade), Ford and FMCC briefly returned to the IG indices on July 1, 2005, before dropping out again on Aug 31, 2005 and Dec 31, 2005 respectively following subsequent downgrades by Moody's and Fitch. Similarly, GM and GMAC fell out of Merrill Lynch's IG indices on May 31, 2005, and Ford and FMCC fell out on Aug 31, 2005 and Dec 31, 2005 respectively.

[13] Source: The New York Times, "Junk Ratings Make a Big Splash, Ripples Are Next", May 6, 2005.

Association of Insurance Commissioners (NAIC) database. The figure shows that insurance company holdings of Ford and GM bonds, already falling in 2003 and early 2004, declined very markedly between mid-2004 and end-2005. The decline is most marked for GM where holdings fell by $9 billion from June 2004 to December 2005, a decline of around two-thirds. Over this same period the number of insurance companies holding any GM bonds fell by around a half.[14]

Figure 2B shows the holdings of Ford and GM bonds (as a percentage of total corporate securities) by the California Public Employees' Retirement System (CALPERS), one of the largest pension funds in the world.[15] At the start of 2004 GM bonds represented over 3% of CALPERS's holdings of corporate securities; by the end of 2005 this had fallen to almost zero. While these data are not comprehensive they suggest strongly that at least some major holders of Ford and GM reduced their holding substantially over the period of the downgrade.

When downgraded to junk, Ford and GM became so-called "fallen angels", the subject of two related studies, also based on the NAIC data, by Ambrose, Cai and Helwege (2008, 2011). Their first (2008) paper finds evidence that insurance companies sell bonds that have become fallen angels, though the scale of selling appears modest. Their second study (2011) asks whether there is evidence of price pressure as a result of these sales and finds that there is not. Although these results may not appear consistent with ours – we find, as just discussed, evidence of significant selling around GM's downgrade to junk and we provide evidence below of a significant liquidity effects in prices – Ambrose, Cai and Helwege study fallen angels in general while our study deliberately focuses on a particular event involving two of the largest issuers of US corporate debt.

As the market began to sell GM and Ford bonds aggressively, the financial institutions that intermediate the debt market – large banks, and, in particular, their high-yield desks - faced the risk that by continuing to provide liquidity they might end up holding a significant fraction of the total supply of GM and Ford bonds. Indeed, we provide some indirect evidence for this in Section 5. This increased inventory risk coupled with unknown increases in hedge-fund counterparty exposure in their prime brokerage businesses had a significant and negative impact on terms on which several large banks could raise funding. Figure 3A shows that, around the downgrade, the 5-year CDS spreads of large banks rose sharply, but fell back in a few weeks to not far above the levels prior to the downgrade[16].

It is important to note that GM and Ford were the second and third largest debt issuers in Lehman's U.S. Credit Index, representing 2.02 percent and 1.97 percent of the total index

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14 Note that, over the period in question, the *total* insurance company holdings of corporate debt increased.

[15] These data are annual and come from the CALPERS website**.**

[16] We plotted the average CDS spreads of the following six banks: Deutsche Bank, Goldman Sachs, JP Morgan, Lehman Brothers, Merrill Lynch, and Morgan Stanley.

respectively. When moved to the Lehman High Yield Index, GM, with a 6 percent share, and Ford, with a 5.9 percent share, would have dwarfed the other members, which constituted 2 percent or less of the index.

The effect of the credit deterioration and subsequent downgrade spilled over to other markets and industries. High yield spreads on many bonds widened on the news of the downgrade. Disorderly dynamics in credit derivatives markets also became a concern. In particular, Figure 3B shows that the average CDS spreads of firms in the Consumer Services industry – which has little relationship to the auto sector – rose considerably around the time of the downgrade. This brief spike in CDS spreads was also seen in other industries. Our main finding in the analysis that follows is that this spill-over effect on other industries and markets can be explained, at least partially, by the liquidity risk faced by financial intermediaries in GM and Ford bonds:

4. Data and sample period division

We obtained daily CDS spreads from Markit Group. Markit provides composite CDS prices, which are calculated from daily quotes provided by leading sell-side contributors and inter-dealer brokers, each of whom provides pricing data from its record of trades and executable bid/offer quotes.[17]. This data then undergoes a rigorous cleaning process where Markit filters for stale quotes, outliers and inconsistent data. Furthermore, if a reference entity does not have quotes from at least three different sources on a certain day for a certain maturity, no data is reported. We focus on the 5-year daily CDS spreads from Markit, the most liquid maturity, though many of our results have also been verified using 1-year maturity CDS spreads, the second most popular contract.

The study also utilises hitherto unexploited quote data on corporate bonds obtained from MarketAxess. MarketAxess operates one of the leading platforms for the electronic trading of corporate bonds, and maintains a comprehensive set of trading information on corporate bonds by combining National Association of Securities Dealers (NASD) TRACE data and its own trading data. From MarketAxess, we obtained daily bond quotes from Sept 11, 2003 to May 19, 2006. Appendix B provides a snapshot of our MarketAxess data. The data consists of all bid and offer quotes from all the dealer-brokers trading on the MarketAxess

[17] Over 60 contributing dealers provide data to Markit, including ABN-Amro, Banks of America, Barclays, Bear Stearns, BNP Paribas, Commerzbank, Credit Suisse First Boston, CIBC, Citigroup, Deutsche Bank, Dresdner Bank, Goldman Sachs, HSBC, JPMorgan, Lehman Brothers, Morgan Stanley, Merrill Lynch, National, Nomura, RBC Financial Group, The Royal Bank of Scotland Bank, Financial Group, UBS, Westpac.

platform.[18] For each dealer quote, we have information on the identity of the bond, the quantity bid/offered (number of bonds), and the yield/price of the bid/offer. Using these daily bond quotes, we construct a number of quote imbalance measures to proxy for the inventory risk of GM and Ford bond positions faced by financial intermediaries. It should be noted that the MarketAxess "inventory" data consists of quotes put by market-makers to solicit trades, rather than their responses to "Request for Quotes" (RFQs) from other participants. In other words, if we see market-makers putting out more quotes to sell bonds, it reflects *their* propensity to sell credit risk, rather than that of other participants.

The selection of our sample is mainly driven by the Markit's coverage of the CDS market and classification of industries as well as the need to match firms with equity returns from CRSP. This resulted in a sample of 524 firms belonging to eight different industries: Auto, Financial, Basic Materials, Consumer Services, Industrials, Oil & Gas, Technology and Utilities. Table I Panel A reports the number of firms that belongs to each industry.

Panels B-D of Table I provide summary statistics for the firms in our sample during the period Sept 11, 2003 to May 19, 2006. Panels B and C report summary statistics for GM and Ford and Panel D for all firms in our sample. The median market capitalization of GM **a**nd Ford is 21.2 and 21.7 billion dollars respectively during the sample period. At this time the credit risk metrics for GM and Ford were very similar, with a median 5-year CDS spread of 289 bps and 282 bps respectively. When their credit ratings deteriorated, their spreads reached highs of 1062 bps (GM) and 856 bps (Ford). In comparison with GM and Ford, the average firm in our sample is both smaller and less risky with a median CDS spread is 53 bps, a median firm size of 5.4 billion dollars and a median credit rating is BBB. Finally, Panel E of Table I provides summary statistics on VIX, the financial commercial paper (CP) rate, and the 90-day T-bill rate, variables that we employ later in our analysis.

5. Empirical tests and results

5.1 Liquidity risk in corporate bond trading around the downgrade

We first show evidence consistent with the claim that the GM and Ford credit deterioration was indeed associated with heightened inventory risk in corporate bonds for intermediaries.

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[18] There were 27 dealer-brokers that traded on the MarketAxess platform: ABN AMRO, Banc of America Securities, Barclays Capital, Bear Stearns, BNP Paribas, CIBC World Markets, Calyon, Citigroup Global Markets, Credit Suisse, Deutsche Bank, Dresdner Kleinwort, DZ BANK, FTN Financial, Goldman, Sachs & Co., HSBC, ING Direct, Jefferies & Company, JPMorgan, Lehman Brothers, Merrill Lynch, Morgan Stanley, Santander Investment Securities Inc., SG Corporate & Investment Banking, RBC Capital Markets, The Royal Bank of Scotland, UBS , Wachovia Securities.

Daily bond quotes provided by MarketAxess allow us to construct a number of quote imbalance measures to proxy for the inventory risk faced by financial intermediaries. We employ three such measures: *Imb%, Offer Ratio,* and *Offerer*. For a given bond on a given day, *Imb%* measures the quote imbalance as the difference in the *volume* of offers and bids as a *proportion* of the total volume:

$$\text{Imb\%} = \frac{(\text{Total vol. of offers- Total vol. of bids})}{(\text{Total vol. of bids } + \text{ Total vol. of offers})}. \qquad (0)$$

Offer Ratio measures the total *number* of offer quotes as a proportion of the total number of bids and offers, and is calculated for each bond on each day as:

$$\text{Offer Ratio} = \frac{(\text{Total \# of offers})}{(\text{Total \# of bids } + \text{ Total \# of offers})}. \qquad (0)$$

Finally, to calculate *Offerer,* we classify a quote provider as net neutral, net bidder, or net offerer based on the net quantity it quotes for a particular bond on a given day.[19] *Offerer* is then defined, for that bond on that day, as:

$$\text{Offerer} = \frac{(\text{ \# of net offerers})}{(\text{\# of quote providers})}. \qquad (0)$$

To reduce the noise associated with daily imbalances, we employ for most parts of the paper weekly imbalances computed by averaging the corresponding daily measures.

Bid-ask spread, the more commonly used liquidity measure, is not used in this study. This is because more than 90% of MarketAxess' quotes are one-sided quotes, with either a bid or an offer component, but not both, and this prevents a direct calculation of the bid-ask spreads.

Table II reports the mean and standard deviation of the calculated weekly imbalance measures for GM (Panel A) and Ford (Panel B) for six sub-periods of our sample defined by the dates of key events. These are: S&P's downgrade of GM to one notch above junk status (14 October 2004); GM's profit warning (16 March 2005); S&P's downgrade of GM to junk status (5 May 2005) and Ford's return to the Lehman investment grade index along with Moody's decision to place GM on review for possible downgrade (1 July 2005).

All three of our main imbalance measures – *Imb%, Offer Ratio, and Offerer* – are positive throughout the sample period, indicating that there were always more offers for GM and Ford bonds than there were bids. In the one and half months immediately prior to the May 5 downgrade, *Imb%, Offerer,* and *Offer Ratio* for both GM and Ford increased significantly, reaching their highest levels in the entire sample period. The fact that quote imbalance was the most severe immediately prior to the downgrade is consistent with our earlier suggestion

[19] On a given day, a quote provider is classified as a net bidder (offerer) of a bond if the total volume of its bid quotes exceeds (is below) the total volume of its offer quotes on that bond.

(Section 3) that the market had anticipated a downgrade and so investors had started to sell off significant volumes of GM and Ford bonds before the actual downgrade occurred in May.

Notice also that the definition of *Imb%* measure means that a modest increase may represent a substantial change in the relation between the volume of offers and bids. For example, between the second and third sub-period the increase in the average value of *Imb%* from 0.65 to 0.83 translates into a ratio of offers to bids that more than doubles (from 4.7 to 10.8).

Each of the imbalance measures declined after the downgrade, but continued to stay relatively high for the next month. For example, GM *Imb%* which, as just noted, averaged 0.83 in the period from March 16, 2005 to May 4, 2005, declined to 0.74 in the month post the downgrade (May 5, 2005 to May 31, 2005*).*

Importantly, the table shows that while the levels of imbalance rose during the crisis sub-periods, their variability measured by standard deviation within the sub-period fell. That is, during the crisis sub-periods, illiquidity was consistently high. As further evidence of the increased market imbalance, Table II reports the percentage of two-sided quotes for GM and Ford bonds in different periods. For both GM and Ford bonds we observe that the proportion of two-sided quotes dropped considerably around the downgrade; for GM, it went from 10% (October 14, 2004 to March 15, 2005) to less than 2% (March 16, 2005 to July 1, 2005), before bouncing back to 10% . Finally, Table II also presents the aggregate volume and the number of bid and offer quotes for GM and Ford bonds.

A curiosity of these data is that the mean value of *Imb%*, which would be zero if the volume of bids and offers were the same, is consistently positive, not only for Ford and GM during the crisis period but for all our data, all of the time. These data are shown in Table III, panel A. For example, in the pre-crisis period from September 2003 to October 2004, the average value of *Imb%* ranges from 0.35 for utilities to 0.8 for the financial sector. This is in fact a general feature of corporate bond and credit derivatives data. MarketAxess' explanation is that many dealers are banks and have direct exposure (e.g., loans) to credit risk of same firms they are making markets in bonds of, or have correlated exposure due to loans made to other firms in sectors of such firms. These dealers are using the MarketAxess platform to reduce risk by taking issues off their balance sheet. While they are acting as liquidity providers and will take the bid side of a trade if need be, it is far more likely to be in their interest to offer issues through the system rather than act as a buyer. Similarly, surveys by British Bankers' Association and Bank for International Settlements show that banks are "net buyers" of credit risk protection – sellers of credit risk – to rest of the financial sector.

However, one feature of these data that is quite different from that for Ford and GM is that the *Imb%* measure for other industries is, on average, no lower in the crisis period than in the non-crisis period. In contrast, for both Ford and GM, as Table II shows, in the period between March 16, 2005 and May 4, 2005 the *Imb%* measure rises significantly. In this period, the number of bids for both Ford and GM falls to less than 10% of the number of offers (compared to around 20% in the pre-crisis period). Another way of seeing this contrast is in Table III, panel B, which shows that the correlation between GM *Imb%* and *Imb%* of firms in other sectors is quite high in the non-crisis period, consistent with trading in corporate bonds being highly correlated across different sectors in this period; however, during the crisis period, this correlation falls substantially, confirming that the GM and Ford credit deterioration was an idiosyncratic shock that led to significant sell-off in their bonds.

5.2 Increase in co-movement of corporate credit around the downgrade

In this section we provide evidence that correlation across different names in the corporate CDS market increased significantly around the downgrade. The main reason why we focus on the CDS market is that the evidence suggests that the CDS market is both more liquid and informationally more efficient than the bond market (see, for example, Altman, Gande and Saunders, 2003 and Blanco, Brennan and Marsh, 2005). CDS are traded over the counter, and major CDS market makers are the same large banks that also intermediate the bond market.[20] In fact, within banks and financial institutions that make markets in both corporate CDS and corporate bonds, the two activities are by and large organisationally integrated. Given this, and given the close to arbitrage relation that exists between bond spreads and CDS spreads, if bond intermediaries factor their funding constraints into bond prices, these are highly likely to be detectable in CDS spreads. Put simply, if market-makers are less willing to buy bonds or take on credit risk and, as a result, lower bond prices and raise bond spreads, they would also be willing to pay more to buy CDS protection (shedding credit risk) and charge more to sell CDS protection (increasing credit risk), thus also raising the mid-market CDS spreads.

It is also important to note that large banks that intermediate the CDS market are often exposed to background credit risk on their loan books. They either have direct exposure (i.e. loans) to same firms on which they are making markets in CDS, or have correlated exposure due to loans made to firms operating in the same sectors as these firms. Therefore, while they provide liquidity by taking orders on both sides, they also have a natural desire to hedge in the CDS market. This is another reason why banks are unlikely to keep mid-market CDS premia unchanged when they face liquidity risk and are in fact more likely to raise the premium when selling CDS. If intermediaries indeed *systematically* increased CDS spreads around the GM and Ford downgrade, then CDS returns, and more precisely, the component of CDS returns that is unrelated to changes in the fundamentals, would be expected to become more correlated across different entities.

[20] This can be seen by the fact that many of the dealers (large banks) that provide CDS quotes to Markit Partners (our CDS data provider) also provide bond quotes to MarketAxess (our bond data provider). See footnotes 11 and 12.

To isolate the component of CDS returns that is unrelated to changes in the fundamentals, we exploit the key idea that if the widening of the CDS spreads were due purely to an increase in default risk or a change in the risk premium, then under the assumption of no-arbitrage between CDS and equity markets, the widening should have been accompanied by a corresponding deterioration in the equity value of the underlying CDS name. Thus, equity returns around the downgrade can be employed to isolate the component of the CDS returns ("CDS innovations") that cannot be attributed purely to default risk changes. To isolate CDS innovations we employ an econometric methodology similar to that used by Acharya and Johnson (2007) in their study of insider trading in credit derivatives. Their construction of CDS innovations allows for a non-linear relationship between contemporaneous returns in CDS and equity markets of a given entity, the non-linearity being implied by any structural model of credit risk such as Merton (1973). Denoting the daily change in CDS premium for firm *i* at date *t* as $(CDS\ return)_{i,t}$, and the contemporaneous changes in 90-day US treasury-bill rate and 10-yr US treasury rate as $\Delta TBill_t$ and ΔTSY_t respectively, the CDs innovation $u_{i,t}$ is obtained as the residual from the following specification:

$$(CDS_{i,t} - CDS_{i,t-1}) = \alpha_i + \sum\nolimits_{k=0}^{5} [\beta_{i,t-k} + \gamma_{i,t} / CDS_{\ i,t}](Stock\ return)_{i,t-k} \\ + \sum\nolimits_{t=1}^{5} \delta_{i,t-k} (CDS_{i,t} - CDS_{i,t-k}) + \theta_i \Delta TBill_t + \lambda_i \Delta TSY_t + u_{i,t} \qquad (0)$$

$$CDS\ innv_{i,t}\,(\text{standardized arithmetic}) = u_{i,t} / CDS\ level_i$$

Our method of measuring the CDS return as the arithmetic difference in CDS spreads ($CDS_t - CDS_{t-1}$) has a certain intuitive appeal because it is approximately proportional to the return from holding a leveraged position in a bond of the entity on which the CDS is written.[21]

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[21] To see this, consider a portfolio that combines a long position in T-year floating rate par bond issued by firm *j* and a short position in a T–year floating rate riskless bond (a "Treasury"). To a close approximation this position has cash-flows that are the same as those on a short position in a T-year CDS contract on firm *j* with a nominal value of par (i.e., selling protection). The initial value of the both the CDS contract and the long-short bond position is zero and the *change* in the value of the CDS between from time *t* to *t+1* is therefore equal to the change in value of the long-short bond position.

$$\Delta V_{CDS} = \Delta P_{def} - \Delta P_{Treas}$$

where ΔV_{CDS} is the change in the *value* of the CDS contract, ΔP_{def} is the change in the value of the credit risky bond (*j*)and ΔP_{Treas} is the change in value of the Treasury. This position may be thought of as a 100% leveraged position in the credit risky bond or, a position in the credit risky bond that is (approximately) duration hedged.

The change in the value of the CDS contract is equal to the change in the CDS rate, □*he*, multiplied by the value of a defaultable T-year annuity, *A(T,λ)*, where *λ* is the default intensity and therefore:

$$\Delta CDS = \left(\frac{1}{A(T,\lambda}\right)\left(\frac{\Delta P_{def}}{100} - \frac{\Delta P_{Treas}}{100}\right),$$

This specification is estimated firm by firm to obtain daily CDS innovations for all firms in the study. To reduce the noise associated with daily measures, we aggregate these daily innovations into weekly innovations. Finally, we average innovations across all firms in each industry to construct industry-level innovations for the eight industries in our sample.

As preliminary evidence of the correlation increase around the downgrade, Figure 4 presents a scatter plot of CDS innovations of GM and the Consumer Services industry. In the plot, innovations in the crisis period (Oct 2004 to July 2005) are plotted with stars and innovations in the non-crisis period (all periods excluding Oct 2004 to July 2005) are plotted with dots. We observe that the slope of the regression line that fits through the crisis innovations is steeper than those of the regression line that fits through non-crisis innovations. The same correlation pattern is observed for CDS innovations of GM (Ford) and each of the eight industries in our sample (not shown), providing support for our hypothesis that correlation in the CDS market increased around the Ford and GM downgrade.

We next provide a formal test of whether the increase in correlation around the downgrade is statistically significant. We calculate the crisis and non-crisis correlations between CDS innovations in GM and in of each of the following eight industries: other Autos (excluding GM and Ford), Financial, Basic Materials, Consumer Services, Industrials, Oil & Gas, Technology and Utilities. Fisher's transformation is used to convert correlations into z-scores, allowing us to perform a simple z-test. Table IV, panel A reports the test results. Consistent with our hypothesis, all nine correlations increased around the downgrade and all nine increases are statistically significant. For example, the correlation between GM and the Consumer Services industry is only 0.07 in the non-crisis period but rose to 0.46 in the crisis period. The increase of 0.39 is statistically significant.[22]

Testing for a difference in correlation across different sample periods may not be entirely reliable because estimation of correlation coefficients may be subject to bias from changes in volatility across these periods (Forbes and Rigobon, 2001 and 2002). As a robustness check for the correlation results, we re-test the above hypothesis by examining the betas, i.e. regression coefficients, between pairs of CDS innovations since beta estimates are not affected

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In other words, the arithmetic change in the CDS rate is equal to the return on a 100% leveraged position in the underlying bond divided by the value of a defaultable annuity. Regressions of ΔCDS on the return on firm *j*'s equity and the change in the riskless rate are therefore, apart from the annuity value, $A(T,\lambda)$, quite similar to those run by Schaefer and Strebulaev (2005).

[22] From this point on, for sake of brevity, we report and discuss the results for GM only for brevity. All tests were also performed on Ford, but, in general, Ford's results are weaker than those of GM. This is to some extent expected because Ford's profit warning came out in mid-April, almost a month after that of GM, and Ford suffered less than GM from the May 4th 2005 downgrade. Firstly, it was rated one notch higher than GM. Secondly, while GM and GMAC fell out of Merrill Lynch's IG indices on May 31, 2005, Ford and FMCC fell out on Aug 31, 2005 and Dec 31, 2005 respectively. Finally, Ford briefly returned to Lehman Brother's IG indices in July and August of 2005 after dropping out in June 2005, whereas GM never returned on Lehman's IG indices after dropping out in June 2005.

by such changes in volatility (also, see Forbes and Rigobon, 2001 and 2002). For example, instead of calculating the correlation between innovations of GM and Consumer Services (CS) industry, we regress CS innovations on GM innovations as in the following model:

$$CDSinv_{CS,t} = \alpha_1 + \alpha_2 * Crisis_t + \beta_1 * CDSinv_{GM,t} + \beta_2 * (Crisis_t * CDSinv_{GM,t}) + e_t \quad (0)$$

$Crisis_t$ is a dummy variable that equals 1 for observations in the 10-month period between October 2004 and July 2005 and 0 for observations in other periods. $Crisis_t * CDSinv_{GM,t}$ is an interaction variable, allowing the slope coefficient to differ across crisis and non-crisis periods. Equation (0) is re-estimated using innovations in GM and Ford, as well as GM and the seven remaining industries. All regressions in our study are performed using the Generalized Method of Moments (GMM) and the resulting standard errors are adjusted for heteroscedasticity and auto-correlation. To investigate whether the sensitivity of CS innovations to GM innovations increased in crisis, we test β_2 >0. Table IV, panel B shows that our earlier finding on correlation coefficients continues to hold: β_2 in all nine specifications is statistically greater than zero, providing strong evidence that dependence between CDS innovations increased around the GM and Ford downgrade.

5.3 Linking liquidity risk to correlation risk

Having established first that there was illiquidity in GM and Ford bonds due to the downgrade and next that co-movement in CDS innovations rose significantly around the downgrade, we now proceed to establish a link between the two. We relate fluctuations in correlation to liquidity by observing that, if (i) CDS innovations in *both* GM and, for example, CS are related to the degree of imbalance in GM; and (ii) the sensitivity of the CDS innovations to GM imbalance is higher in the crisis period for both GM and CS, then this may provide one explanation of the increase in dependence between the CDS innovations of GM and CS. More specifically, if

$$\begin{aligned} CDSinv_{GM,t} &= \alpha_{GM} + \beta_{GM} * GMImb_t + e_{GM,t} \\ CDSinv_{CS,t} &= \alpha_{CS} + \beta_{CS} * GMImb_t + e_{CS,t} \end{aligned} \quad (0)$$

end $e_{GM,t}$ and $e_{CS,t}$ are uncorrelated, then:

$$Cov(CDSinv_{GM,t}, CDSinv_{CS,t}) = \beta_{GM} * \beta_{CS} * Var(GMImb_t) \quad (0)$$

β_{GM} in the above specification captures the sensitivity of GM CDS innovations ($CDSinv_{GM,t}$) to imbalance in GM bonds ($GMImb_t$). Likewise, β_{CS} captures the sensitivity of Consumer Services sector's innovations ($CDSinv_{CS,t}$) to imbalance in GM bonds. Finding $\beta_{CS} > 0$ and $\beta_{GM} > 0$ (and significant) means that CDS innovation increases with GM imbalance. Moreover, if both betas are significantly positive, the covariance expression shown above indicates that covariance in CDS innovations are positively correlated with variance in GM bond imbalance. This relationship, if found, is a re-statement of our thesis – correlation risk (covariance in CDS innovations) and liquidity risk (variance in GM bond imbalance) are intimately linked.

We proceed to test $\beta_{CS} > 0$ and $\beta_{GM} > 0$. In estimating the regressions, we modify the specification (0) in two ways. First, as a RHS variable, we add the industry bond imbalance to control for any effect that the general liquidity in the market for bonds of a particular industry may have on CDS innovations of that same industry. Bond imbalance for an industry is calculated by averaging the imbalances of all bonds in that industry Second, our hypotheses imply that the relationship between CDS innovations and GM imbalance is stronger (or only exists) in the period around the downgrade (crisis period) than at other non-crisis times. Hence, we estimate the relationship between imbalance and CDS innovations for crisis and non-crisis periods separately by interacting the GM imbalance measure as well as the industry imbalance measures with a crisis-period dummy. The regressions that we estimate – again using the consumer service sector as an example – are as follows:

$$CDSinv_{GM,t} = \alpha_{GM,1} + \alpha_{GM,2} * Crisis_t + \beta_{GM} * GMImb_t + \beta_{GM,Crisis}(Crisis_t * GMImb_t) + e_{GM,t}$$

$$\begin{aligned} CDSinv_{CS,t} = {} & \alpha_{CS,1} + \alpha_{CS,2} * Crisis_t + \beta_{CS1} * GMImb_t + \beta_{CS1,Crisis} * (Crisis_t * GMImb_t) \\ & + \beta_{CS2} * IndustryImb_{CS,t} + \beta_{CS2,Crisis} * (Crisis_t * IndustryImb_{CS,t}) + e_{CS,t} \end{aligned}$$

(0)

In addition to consumer services, the model is estimated for industry-level CDS innovations for other Autos and the Financial, Basic Materials, Industrials, Oil & Gas, Technology and Utilities sectors. As before, since imbalance measures at daily level are noisy, these regressions are performed with weekly measures for innovations and imbalance. If the hypothesis that inventory imbalance has a significant impact on CDS prices around the downgrade holds, then loadings on the interaction term $Crisis_t * GMImb_t$ should be significantly positive.

Panel A of Table V reports the estimation results for equation (0).[23] We observe that the coefficient estimates on our key variable of interest $Crisis_t$*$GMImb_t$ are statistically significantly positive in regressions with CDS innovations for GM and six of the eight industries. This is consistent with our hypothesis. The direct loadings on $GMImb_t$ are positive for all industries and statistically signify cant for seven of the eight industries. Loadings on $Crisis_t$*$GMImb_t$ are, on average, about the same magnitude as those on $GMImb_t$ implying that the sensitivity to $GMImb_t$ is around twice as high in the crisis as in the non-crisis period. $IndustryImb_t$ is insignificant for each sector and $Crisis_t$*$IndustryImb_t$, is significantly positive for only two out of eight industry sectors.[24] [25]

It is also interesting to gauge the significance of $GMImb_t$ by looking at how much of the variation in CDS innovations can be explained by the variation in $GMImb_t$ in the crisis period versus in the non-crisis period. This is best done by estimating (0) separately for the crisis and non-crisis periods and comparing the corresponding R^2 values. These are reported in the second last two columns in Panel A of Table V where we observe that the R^2 was much higher in the crisis period for GM CDS innovations as well as for all eight industries. For example, $GMImb_t$ explains as much as 18.4% of the variation in CDS innovations of the Consumer Services industry in the crisis, but only 8.7% in the non-crisis period. When *Offer Ratio* and *Offerer* are used as the imbalance measure, the results in terms of the coefficient on $Crisis_t$*$GMImb_t$ and the R^2 are very similar, but slightly weaker.[26]

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[23] All three main GM imbalance measures – *Imb%, Offer Ratio,* and *Offerer* – were used separately as measures of $GMImb_t$ but for brevity the results are reported only for *Imb%*. Given the high correlation of the three measures, the results are qualitatively almost identical.

[24] The residuals in the regressions in Panel A may, of course, be correlated across the various sectors and so the coefficient estimates may themselves be correlated.

[25] It may seem counter-intuitive that the sign of $Crisis_t$, the crisis period dummy, is negative for all industries (although significant for only four of the eight sectors). To resolve this, we rewrite the model in terms of the deviation of the GM imbalance from its mean in the crisis period, $GMImb_{Avg\ Crisis}$.

$$\begin{aligned} CDSinv_{CS,t} &= -\ \alpha_{CS,2} \times Crisis_t + \ \beta_{CS1,Crisis} \times Crisis_t \times GMImb_t \\ &= Crisis_t \times \left[\left(\alpha_{CS,2} \ + \beta_{CS1,Crisis} \times GMImb_{Avg.\ Crisis} \right) + \ \beta_{CS1,Crisis} \times (GMImb_t - \ GMImb_{Avg.\ Crisis}) \right] \\ &= Crisis_t \times \left[K + \ \beta_{CS1,Crisis} \times (GMImb_t - \ GMImb_{Avg.\ Crisis}) \right] \end{aligned}$$

where $K = \alpha_{CS,2} \ + \beta_{CS1,Crisis} \times GM\,\mathrm{Im}\,b_{Avg.\ Crisis}$.

In the last line, K is the coefficient on the crisis dummy and, although not zero averages only -0.03 over the eight industrial sectors (compared with - 0.09 for the raw intercept in Panel A). In other words, even though the switch to downgrade period by itself has little net effect on *average* CDS innovations, $GMImb_t$ helps to explain the *within-crisis* variation in CDS innovations. In particular, the positive impact on CDS innovations only exists when $GMImb_t$ is above its average during the crisis period.

[26] It would be possible for the difference between the crisis and non-crisis R^2's to be the result of increased explanatory power of industry imbalances (rather than GM imbalances) in the crisis. To investigate this, we repeat the estimation by excluding industry imbalances and their crisis interaction terms. We find that this hardly diminishes the crisis R^2's relative to those in Table V. The minimum

So far, we have established that the GM bond imbalance is *statistically* significant in explaining the variation in CDS innovations of firms across a wide range of industries around the GM and Ford downgrade. However, it remains to be seen whether the impact of variation in the quote imbalance is *economically* significant. Table V Panel B answers this question in the affirmative. To measure the economic significance of GM imbalance in the crisis period, we first sum the coefficient estimates on $GMImb_t$ and $Crisis_t*GMImb_t$ (reported in Table V) for each industry, then multiply this sum by the standard deviation of the GM *Imb%* in the crisis period. The results, reported under column A, measure how much each industry's CDS innovations increase for a one standard deviation increase in GM *Imb%.* Focusing on Consumer Services again, we find that, around the downgrade, the CDS innovations of the Consumer Services sector increased by 1.7% for a one standard deviation increase in GM *Imb%* (0.0928). This 1.7% increase represents 39.8% of the standard deviation of the Consumer Sector's CDS innovations in the crisis period (column B). This ratio is also economically significant for of each of the other seven industries ranging from 27.3% for Financials to 43.7% for Industrials. The results from using *Offer Ratio* and *Offerer* (not reported) are similar.

We also note that GM imbalance affects CDS innovations for an industry, even *after* controlling for illiquidity in the bonds of that industry. This suggests that the observed effect is not local to the CDS and bonds of each entity, but is pervasive, arising from a common factor, namely the liquidity or inventory risk perceived by market makers in GM (and Ford) bonds.

6. Additional tests

6.1 Principal components analysis

Collin-Dufresne, Goldstein, and Martin (2001) [CDGM] investigate the determinants of credit spread changes and find that those variables suggested by the structural models – primarily equity returns and changes in the interest rate – have rather limited explanatory power. In addition, the residuals from the regression, averaged by credit rating and maturity, are highly correlated cross-sectionally, with the first principal components explaining 75% of the variation. They considered several macroeconomic and financial variables as candidate proxies, but failed to explain this common systematic component. Given this (negative) finding by Collin-Dufresne, Goldstein, and Martin (2001), it is interesting to ask how much of the common variation in CDS innovations – analogous, in many respects, to CDGM's regression residuals – can be explained by the GM bond imbalance. To capture the common variation, we estimate the principal components of CDS innovations in GM, Ford, and the eight industries, computed

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difference across crisis and non-crisis R^2's in this case is 8% (Financial) and the average difference is 14%.

As shown in Table VI, the first three factors explain, respectively, 73%, 13%, and 4% of variations in the crisis period, and 44%, 20%, and 8% in the non-crisis period. Note that in both the crisis and non-crisis periods the first component is approximately equally-weighted across innovations in GM, Ford and the different industries. It is also interesting to note the much higher fraction of the variance explained by the first principal component in the crisis period (71% vs. 47%).

6.2 Effect of VIX, the "risk appetite" of financial intermediaries

It is possible that our liquidity risk measures are simply a proxy for heightened risk aversion in the financial markets. One measure of such risk aversion, VIX, is a variable that might affect *both* CDS innovations and equity returns.

There are two reasons to examine the role of the VIX option volatility index. First, to a significant extent VIX reflects the actual volatility of stock markets. Thus, controlling for VIX in the first-stage computation of CDS innovations helps control for the possible omission of a market-wide volatility effect. Second, and perhaps more important, the role of VIX as a measure of the global risk appetite of financial institutions has found some support as a common factor driving co-movement of sovereign CDS (Pan and Singleton, 2008, and Longstaff et al. 2011).

Therefore, we add the weekly percentage changes in VIX to our base model (0) as a new regressor (denoted as ΔVIX_t), also allowing it to interact with $Crisis_t$. Table VII Panel A shows that changes in VIX do have a significant impact on CDS innovations, especially during the crisis period. However, the explanatory power of the GM quote imbalance in the crisis survives and the coefficients on $Crisis_t*GMImb_t$ neither lose their significance nor diminish in magnitude. This finding suggests that changes in VIX and our crisis-liquidity variable $Crisis_t*GMImb_t$ are almost orthogonal.

6.3 Effect of funding cost measured as financial commercial paper to T-bill spread

We have argued that intermediaries of bond and CDS markets priced their liquidity risk exposure to GM and Ford bonds into securities they intermediated, and that it was through this channel that CDS of different entities became more correlated around the GM and Ford downgrade. The higher the funding cost faced by intermediaries to buffer against the liquidity risk, the greater should be the effect of liquidity risk on prices. Since it is not easy to obtain data on institution-level funding constraints, we use the spread between financial commercial paper and T-bill rates as a common proxy for the funding cost faced by financial intermediaries. In particular, we employ the weekly changes in the spread between 90-day AA financial CP rate and the 90-day T-bill rate. We then included the weekly change in this spread (denoted as

ΔCP_t), its interactions with $Crisis_t$, $GMImb_t$ and $IndustryImb_t$ in the regression of CDS innovations on $GMImb_t$:

The first set of columns of Table VII Panel A reports the results of a regression that includes only ΔCP_t and ΔCP_t*Crisis. We find that both by itself and interacted with the crisis dummy, the CP to T-bill spread changes are insignificant for most of the sectors, suggesting that funding cost by itself does not have explanatory power for CDS innovations. In contrast, when we estimate the full specification, the rightmost seven columns set of columns of Table VII Panel B, the loadings on *GMImb* are significant for all but one industry and either *Crisis*GMImb or Crisis*GMImb*ΔCP* is significant for all but one industry. The fact that changes in the CP to T-bill spread, when interacted with GM imbalance, is positively correlated with CDS innovations *only* during crisis indicates that large CDS innovations coincided with heightened funding constraints *and* forced liquidations of GM and Ford bonds around the downgrade.

6.4 Robustness checks

We have performed several additional tests to investigate whether that the relationship between liquidity risk and correlation risk is robust to alternative model and variable specifications. In particular, we (i) use lagged imbalance measures instead of contemporaneous ones, (ii) estimate CDS innovations separately for the downgrade and the non-downgrade period, (iii) replace GM imbalance with imbalance of the Consumer Services industry and confirm that only GM imbalance explains market-wide CDS innovations, (iv) use the combined imbalance of GM and Ford bonds, and (v) investigate whether the CDS spillover was different for investment grade and sub-investment grade entities and show that the effect seemed across board rather than being stronger for one of the two rating groups. These results are available from authors upon request.

7. Alternative liquidity risk measures and explanations

7.1 Bond short-selling costs

In this and the next sub-section we consider measures of liquidity risk other than the imbalance in GM bonds, specifically the costs of short-selling GM and Ford securities.

We obtained lending data on GM and Ford bonds from Data Explorers Limited, a firm which collects this information from a significant number of the largest custodians in the securities lending industry.[27] The short-selling data comprise weekly security-level information

[27] The custodians include some of the largest ones but cannot be named due to a confidentiality agreement with Data Explorer Ltd. We thank Pedro Saffi for sharing the short-selling data with us.

on actual lending transactions. Each lending transaction comes with information on the borrowing fee, and we average these borrowing fees across all transactions in each week to obtain weekly short-selling fees for GM and Ford bonds.[28] Figure 5 plots the short-selling fees for GM and Ford bonds. We observe that the fees for GM and Ford bonds rose sharply in the three and half months immediately around the downgrade – the short-selling fee for GM bonds rose from around 25 bps p.a. in February 2005 to around 55 bps after GM's March 16th profit warning and stayed there for three-and-half months. This increase in short-selling fee indicates that GM and Ford bonds became more costly to short. Increased short-sale constraints are often accompanied by decreased liquidity in the underlying security (Diamond and Verrecchia, 1987, Charoenrook and Daouk, 2005). This relationship between short-sale constraints and liquidity makes short-selling fees a candidate proxy for liquidity risk.

The first three columns of Table VIII Panel A report the results of regressing CDS innovations against the bond short selling fee (*BSSF)* and *BSSF* interacted with the crisis dummy. By itself *BSSF* is insignificant for each industry (and for GM) but when interacted with the crisis dummy is significant for five of the eight industries.

Note, however, that the R^2 in these regressions is far lower compared to those in Table V where we employed GM imbalance as the proxy for liquidity risk. Hence, we examine the incremental explanatory power of GM bonds' short-selling fee by regressing CDS innovations on both *BSSF* and *GMImb* imbalance (and their interactions with $Crisis_t$). We observe from the last five columns of Table VIII Panel A that the GM bond short-selling fee loses the horse race against GM imbalance: *BSSF* remains insignificant for all industries but *BSSF* interacted with $Crisis_t$ loses significance for all industries while *GMImb* retains significance for all but one (utilities).

7.2 Stock short-selling costs and other trade dislocations

From Data Explorers Limited, we also obtained the short-selling fees on GM stocks (*SSSF*) and these also increased markedly in the three months around the May 5th downgrade. In fact the magnitude of this increase was even more dramatic than that for GM's bonds: *SSSF* jumped from 20 bps p.a. in the first half of March 2005 to more than 300 bps p.a. in the end of May 2005.

Interestingly, despite this major change over the period of the downgrade, when we replaced the short-selling fee of GM bonds with that of GM stocks in the regressions described in Panel A, the short-selling fee for stocks has no greater explanatory power. Excluding *GMImb*

[28] Fees can be divided into two parts depending on the type of collateral used. If borrowers use cash as collateral - the dominant form in the US - then the borrowing fee is defined as the difference between the risk-free interest rate and the rate paid for the collateral. If instead the collateral is non-cash (that is, some securities) then the fee is negotiated between the borrower and the lender and defined directly in basis points per year.

(the three left-hand columns of Panel B) the coefficients on both *SSSF* and *SSSF*Crisis* are insignificant for each industry. When *GMImb* is included – the five rightmost columns in Panel B – the coefficient on the crisis interaction term (*SSSF*Crisis*) becomes significant for GM and two industries.

The absence of any strong relationship between the GM stock short-selling fee and excess co-movement of CDS innovations also helps rule out the alternative hypothesis that our results on CDS co-movements are due to the dislocation in one popular trade of that period: selling protection on GM (buying GM bonds, effectively) and shorting equity. This trade experienced a dislocation due to the increase in the cost of short-selling GM stocks, which in turn generated a hedging demand in the form of a switch to buying protection on GM and caused GM CDS fees to widen. While this dislocation may have been operative, it certainly did not have a pervasive effect on CDS fees of other industries.

Yet another dislocation, frequently mentioned in the press and by practitioners around the downgrade episode, was that between the (model-based) hedged positions in mezzanine and equity tranches of CDX index for North American Investment Grade (CDX.NA.IG), where CDX is simply an index or portfolio of CDS on 125 underlying names. These "correlation" trades were structured to hedge the shifts in underlying correlation, which would move the tranches in opposite directions, but the credit deterioration of GM and Ford created an increase in idiosyncratic default risk of GM and Ford, which were both parts of the CDX, causing the trade to experience severe dislocation in terms of its exposure to credit risk. The dislocation supposedly triggered a substantial demand for CDS protection on GM and Ford. Once again, it is unclear why this would affect CDS fees for all industries. But, more importantly, our communication with practitioners and reading of their accounts suggests that the correlation trade dislocated *after* the downgrade, in fact, upon the announcement of Kerkorian's bid for GM. In contrast, our strongest effect of CDS co-movement being linked to GM bond imbalance is observed during the preceding period from March 16th till May 4th.

Another plausible view is that the CDS co-movement seen around the downgrade was induced by an increase in counter-party risk. Large banks were adversely affected by the GM and Ford downgrade as a result of their increased inventory risk and unknown losses from their primary brokerage business (exposure to hedge funds that lost money as a result of the correlation-trade dislocation described above). This is evidenced by the fact that CDS spreads of large banks increased sharply around the downgrade (see Figure 3A). One could perhaps, thus, hypothesize that CDS spreads increased uniformly across the market because the counter-party risk, i.e. the risk that counterparties of CDS contracts may default, rose around the downgrade. To test this hypothesis, we control for counter-party risk in our estimation of (0) by adding two new terms: the median CDS spread of large banks and its interaction with the *Crisis* dummy. The median CDS level of large banks and its interaction with the *Crisis* dummy should effectively control for the impact of counter-party risk in both crisis and non-crisis periods. The results (not reported) show that, compared to imbalance in GM bonds, bank's CDS has little explanatory power over CDS innovations. The coefficients on $Crisis_t*GMImb_t$ remain significant for all but one industries.

8. Concluding remarks

Our paper makes the important observation that liquidity risk and correlation risk in markets are inter-twined as a result of the limited risk-bearing capacity of financial intermediaries. We provided supporting evidence by studying the effects on fixed-income markets of the credit deterioration and eventual downgrade of General Motors (GM) and Ford to junk status in the spring of 2005. Since the credit deterioration events were specific to GM and Ford, rather than being part of an episode of market-wide bad news, one can regard our investigation as exploiting a "natural experiment" to study the link between liquidity risk (caused by credit market dislocation following the GM and Ford downgrades) and correlation risk (induced by liquidity risk, but not caused directly by the news leading to GM and Ford downgrades).

The paper makes at least three other significant contributions. First, it provides direct evidence as to whether a significant component of fluctuations in credit market prices is, at least some of the time, unrelated to equity values and whether institutional frictions and liquidity effects are responsible for such segmentation. Our evidence suggests that the answer to these questions is in the affirmative.

Second, our results suggest that "crowded-out" trades, where exogenous shocks leave the intermediaries on one side of the market, may be especially vulnerable to liquidity-risk effects. Regulatory capital requirements on intermediaries, investment restrictions on investors, herding by mutual fund and hedge-fund managers on specific trading strategies, etc., are all outcomes of some deeper incentive problems, but these contribute to inducing pervasive liquidity effects in response to shocks that are local to specific trades, securities and markets.

Third, if liquidity risk and correlation risk are inter-twined, there are important implications for risk managers of financial institutions and the hedging strategies they employ. For example, liquidity effects of the kind examined in this paper can cause temporal fluctuations in correlations measured from statistical data and implied from standard valuation models for CDOs, CLOs, and their tranches. Neither traditional covariance calculations nor derivative-pricing models allow for such liquidity effects, and, hence, cannot differentiate between correlation risk due to fundamentals and that due to liquidity risk. Recognizing and understanding the true source of fluctuation in the implied correlations can be important for hedging of correlation products.

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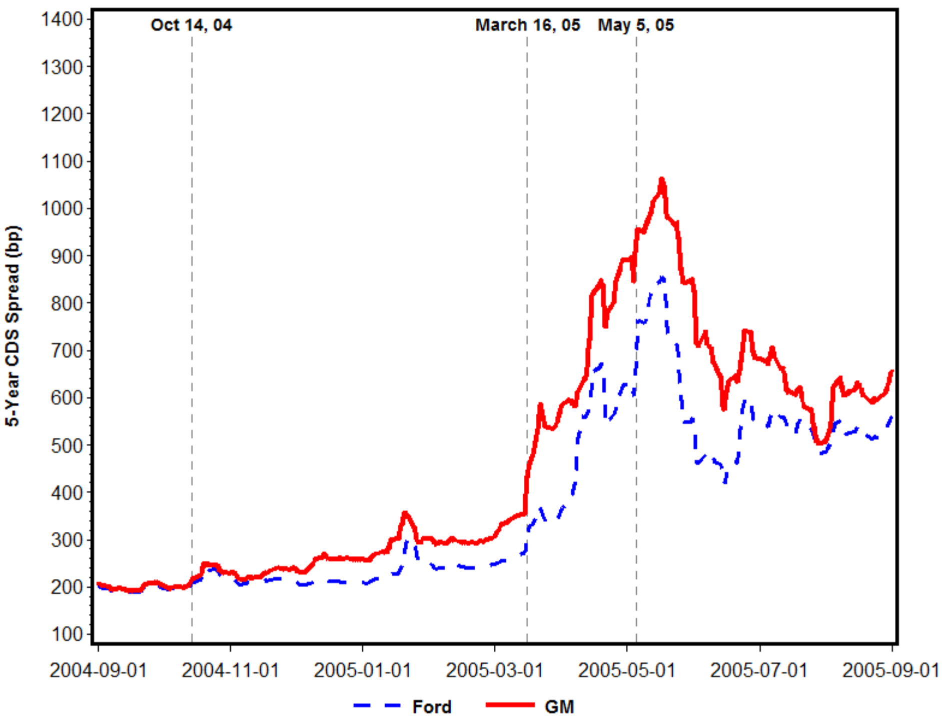
Figure 1

A. Daily 5-year CDS spreads of GM and Ford (09/2004 to 09/2005)



A.

B. Daily 5-year CDS spreads of GM and Ford, CDX (IG) & CDX (HY)

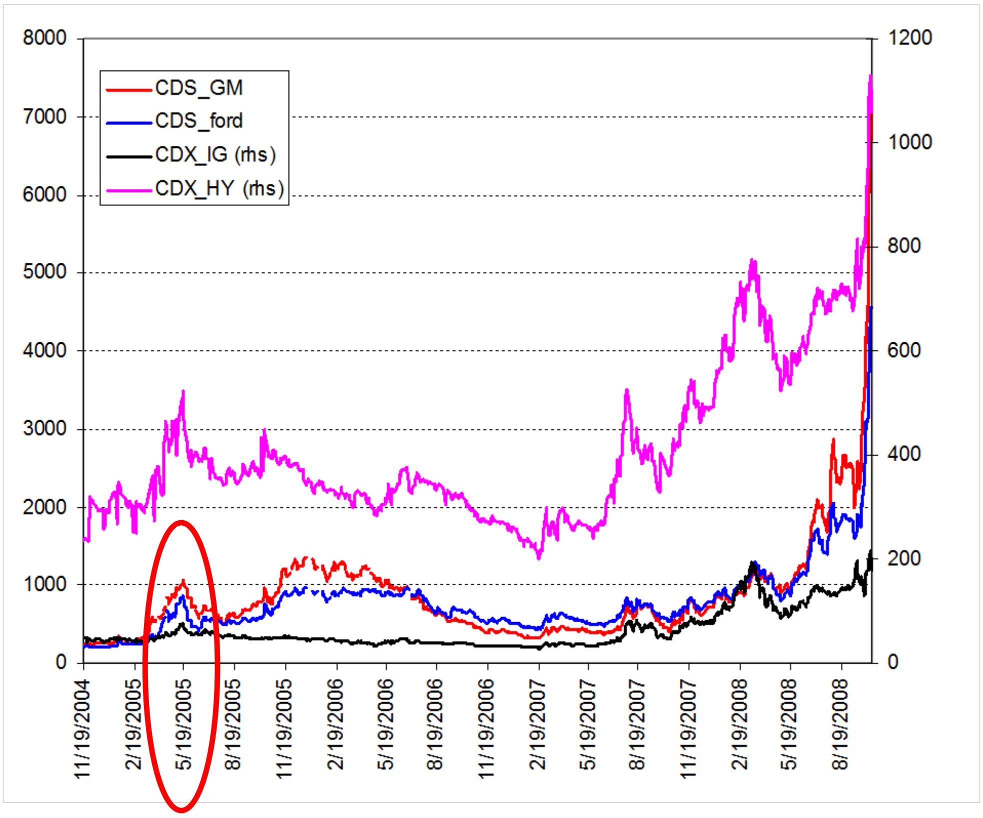
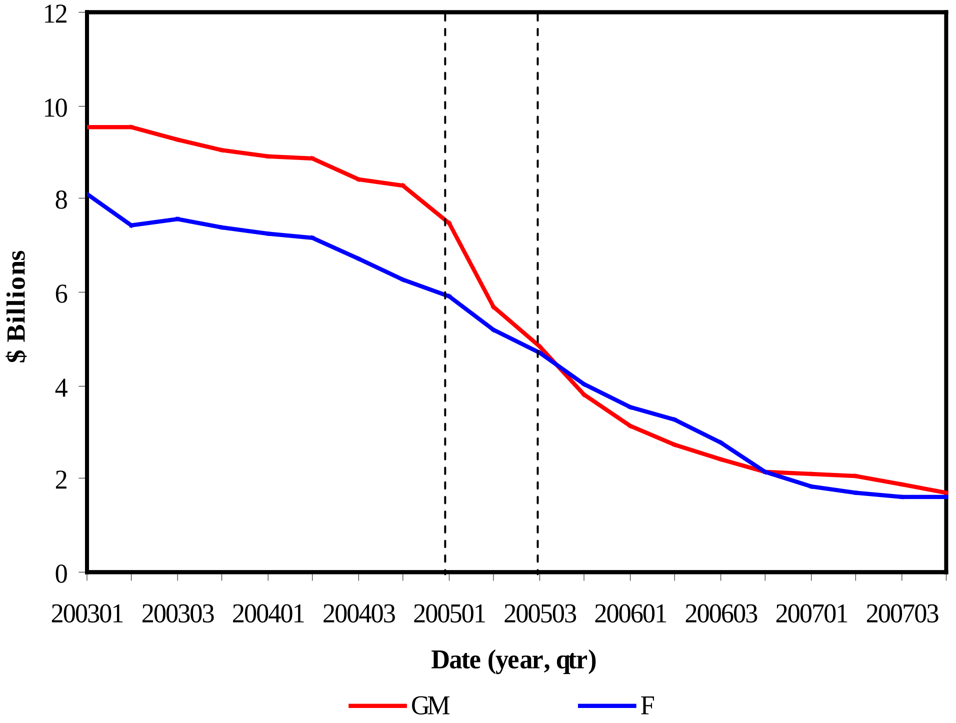


Figure 2

A. Holding of GM and Ford Bonds by Insurance Companies



B. Calper's GM & Ford Holdings (% of Total Corporate Securities)

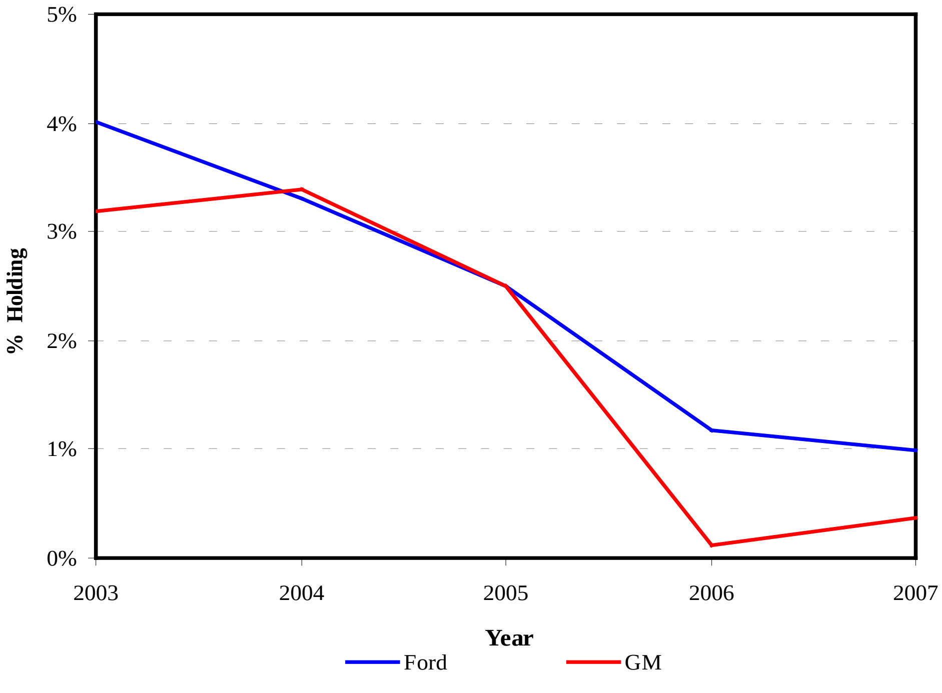


Figure 3A. Average CDS Spreads of Large Banks around the Downgrade

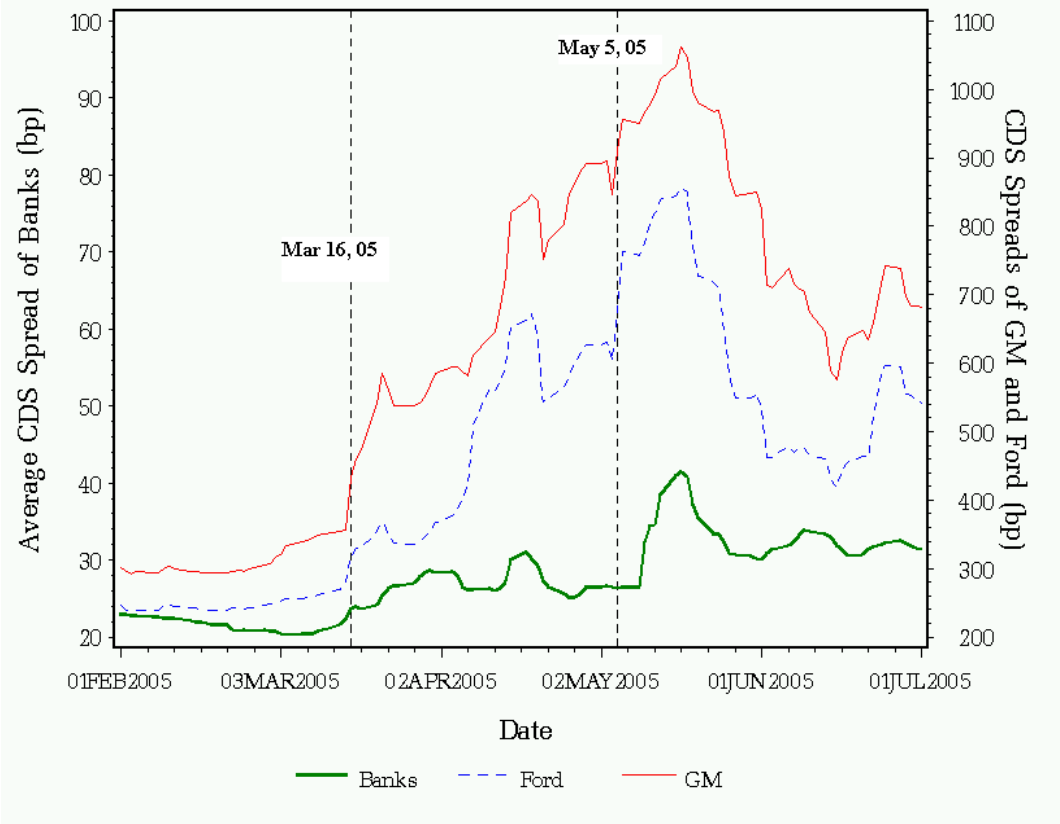


Figure 3B. Average CDS Spreads of the Consumer Services Sector around the Downgrade.

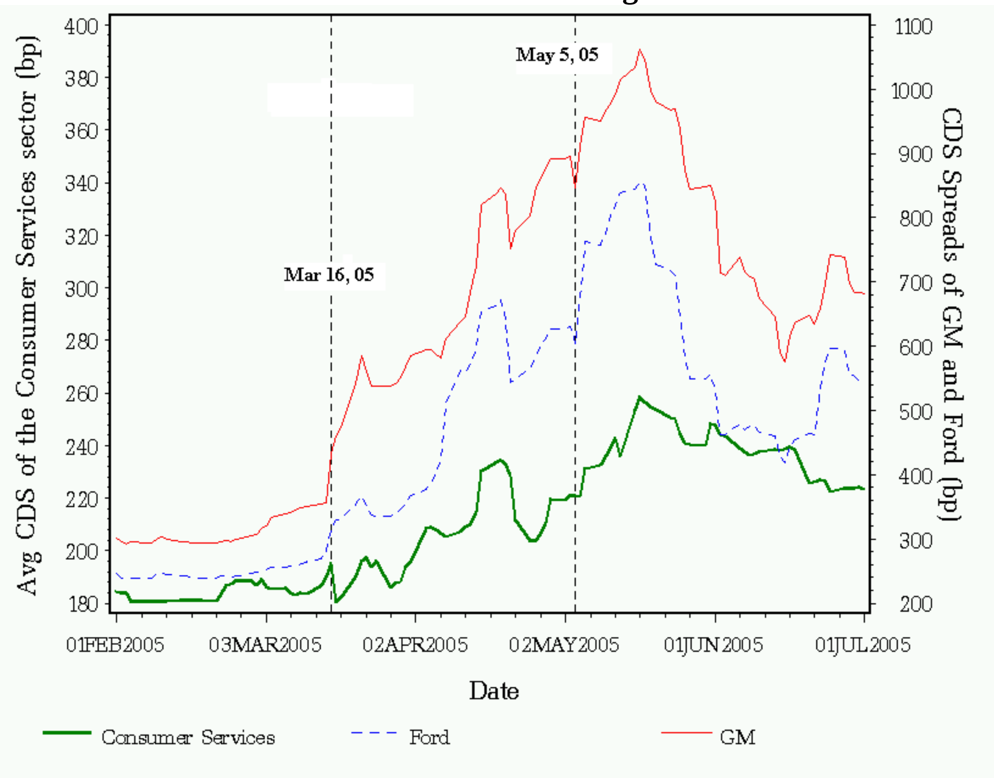


Figure 4. X-Y scatter plot and regression lines for GM CDS innovations and CDS innovations of the Consumer Services sector.

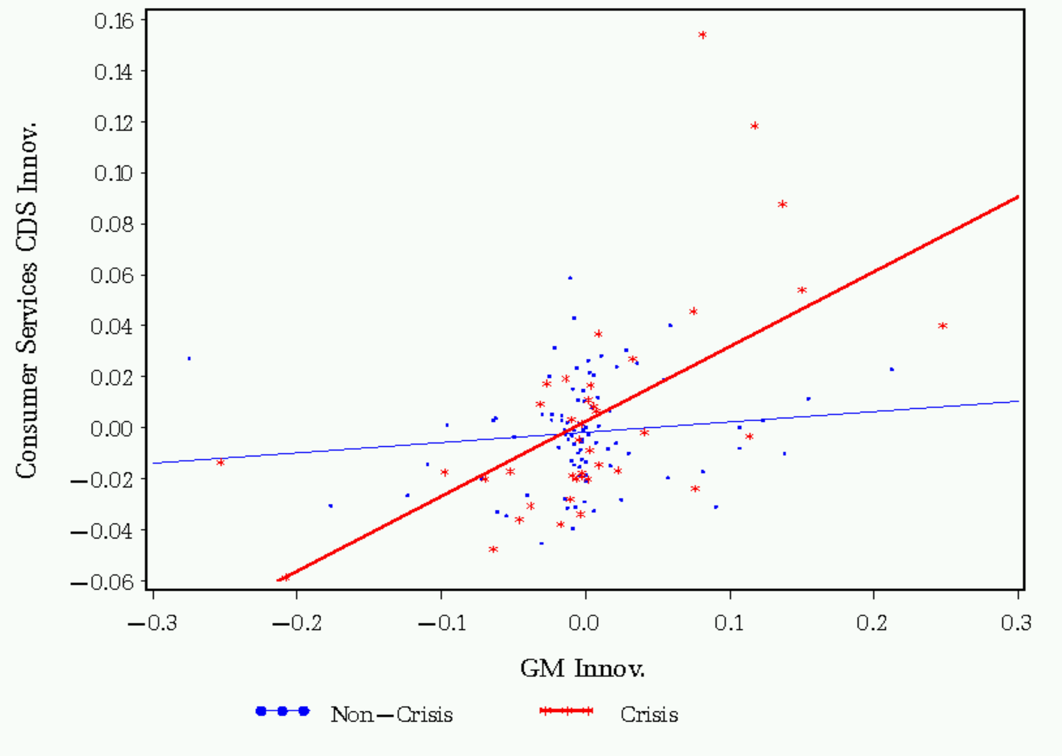


Figure 5. Average short-selling fees for GM and Ford bonds.

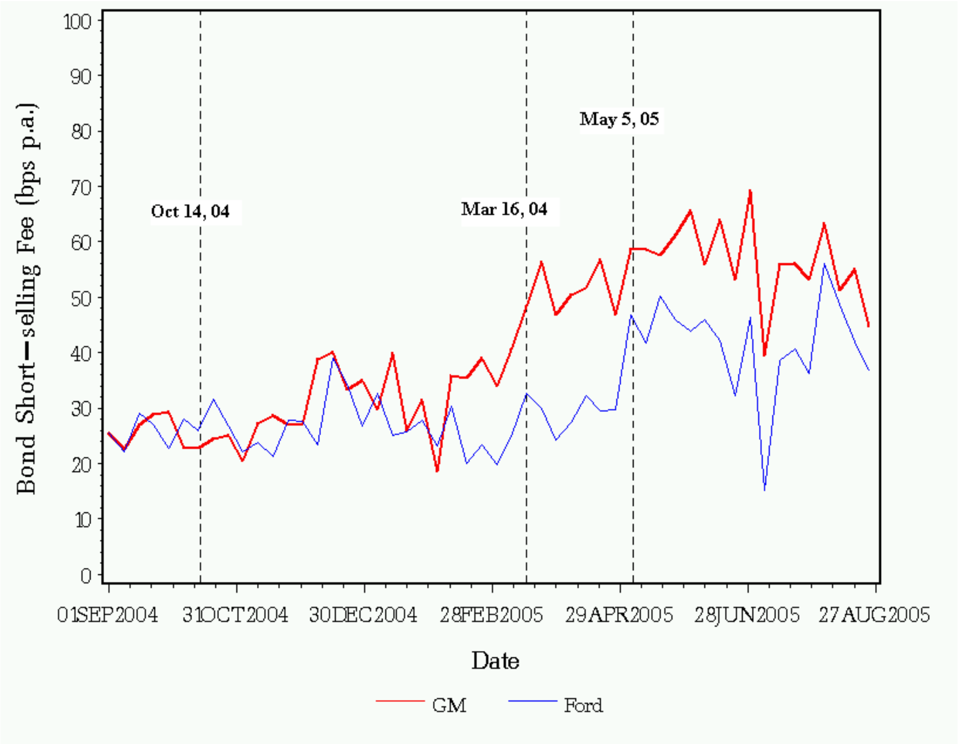


Table I
Summary Statistics

This table contains basic summary statistics for firms in our sample. Panel A reports the number of CDS observations per day for each of the eight industries in our sample. Industry group classification is based on Markit's industry classifications. Panels B to D contain the summary statistics on the CDS spread, firm size, and credit rating for GM, Ford, and other firms in our sample. (See Section 4 for details on sample selection criteria). Panel E contains summary statistics of VIX, 90-day financial commercial paper rate, and 90-day T-bill rate during the sample period. The sample period is from Sept 11, 2003 to May 19, 2006.

Panel A: # of Observations per Day for each Industry

Industry	*Min*	*Median*	*Max*
Auto	11	15	18
Basic Materials	40	50	58
Consumer Services	70	86	93
Financial	56	86	98
Industrials	72	84	93
Oil & Gas	33	45	53
Technology	26	33	38
Utilities	38	46	52

Panel B: GM

	Min	*Median*	*Max*
5-yr CDS sprd (bp)	134	288	1376
Firm Size (equity mkt val, $mm)	10,524	21,213	30,841
Credit Rating	BBB	BBB-	B

Panel C: Ford

	Min	*Median*	*Max*
5-yr CDS sprd (bp)	166	282	991
Firm Size (equity mkt val, $mm)	12,185	21,700	30,099
Credit Rating	BBB	BBB-	B+

Panel D: All Firms

	Min	*Median*	*Max*
Avg. 5-yr CDS sprd (bp)	8.4	52.7	3523
Avg. Firm Size (equity mkt val, $mm)	5	5,439	35,4711
Avg. Credit Rating	AAA	BBB	CCC-
Observations /day	354	444	488

Panel E: VIX, Financial CP, and T-bill

	Min	*Median*	*Max*
VIX	10.2	13.9	22.7
AA 90-day Financial CP Rate (%)	1.0	2.6	5.1
90-day T-bill Rate (%)	0.9	2.3	4.8

Table II

Quotation Imbalance and Volume Measures Across Six Sub-periods

Panels A and B of this table report the mean and standard deviation (in parentheses) of quotation imbalance measures and trading volume for GM (Panel A) and Ford (Panel B) across the six sub-periods of our sample. The statistics for *Imb%, Offer Ratio, Offerer, and Two quotes %* are computed from weekly averages of the corresponding daily values. The statistics *for Total Bid, Total Offer, Bid #, and Offer #* are computed directly from daily measures. All measures are derived from daily quotes provided by MarketAxess.

Imb%	(total volume of offers-total volume of bids)/(total volume of bids + total volume of offers)
Offer Ratio	total # of offers / (total # of bids + total # of offers)
Offerer	(# net offerers) / (# quote providers)
Two quotes %	% of quotes with both bid and ask components
Total Bid	daily total bid volume (in millions of bonds).
Total Offer	daily total offer volume (in millions of bonds).
Bid #	daily total number of bid quotes.
Offer #	daily total number of offer quotes.

Period	*Imb%*	*Offer Ratio*	*Offerer*	*Two Quotes %*	*Total Bid*	*Total Offer*	*Bid #*	*Offer #*
Panel A: GM								
Sept 11, 03 - Oct 13, 04	0.71	0.87	0.86	0.03	7.6	38.5	21	106
	-0.1	(0.05)	(0.06)	(0.03)	(4)	(11.9)	(10)	(30)
Oct 14, 04 - Mar 15, 05	0.65	0.82	0.8	0.10	13.5	50.7	36	139
	(0.09)	(0.04)	(0.05)	(0.04)	(5.6)	(11.8)	(12)	(30)
Mar 16, 05 – May 4, 05	0.83	0.92	0.92	0.02	3.4	33.2	9	97
	(0.09)	(0.04)	(0.04)	(0.02)	(1.6)	(7.5)	(4)	(20)
May 5, 05 – May 31, 05	0.74	0.88	0.88	0.00	3.8	18.5	10	57
	(0.07)	(0.03)	(0.03)	(0.00)	(1.4)	(5)	(3)	(12)
Jun 1, 05 – Jul 1, 05	0.71	0.86	0.87	0.02	3.3	17.8	9	57
	-0.1	(0.04)	(0.05)	(0.02)	(1.7)	(3.3)	(4)	(8)
Jul 2, 05 – May 19, 06	0.7	0.84	0.84	0.08	4.7	20.9	18	73
	(0.13)	(0.07)	(0.08)	(0.07)	(2.4)	(5.3)	(11)	(16)
Panel B: Ford								
Period	*Imb%*	*Offer Ratio*	*Offerer*	*Two Quotes %*	*Total Bid*	*Total Offer*	*Bid #*	*Offer #*
Sept 11, 03 - Oct 13, 04	0.68	0.85	0.85	0.02	7.3	34.7	20	94
	(0.1)	(0.05)	(0.05)	(0.03)	(3.1)	(9.7)	(8)	(25)
Oct 14, 04 - Mar 15, 05	0.65	0.83	0.81	0.07	12.2	44.8	29	122
	(0.08)	(0.03)	(0.05)	(0.03)	(4.3)	(9.5)	(10)	(24)
Mar 16, 05 – May 3, 05	0.84	0.92	0.92	0.01	3.5	35.2	9	103
	(0.04)	(0.02)	(0.02)	(0.01)	(1.6)	(6.9)	(4)	(18)
May 4, 05 – May 31, 05	0.71	0.87	0.87	0.01	3.6	21.5	9	70
	(0.11)	(0.05)	(0.05)	(0.01)	(1)	(4.8)	(3)	(13)
Jun 1, 05 – Jul 1, 05	0.78	0.88	0.89	0.01	2.3	21.9	8	67
	(0.09)	(0.04)	(0.04)	(0.02)	(1.2)	(4.6)	(3)	(12)
Jul 2, 05 – May 19, 06	0.62	0.81	0.78	0.08	4.3	18.4	17	67
	(0.15)	(0.08)	(0.12)	(0.07)	(1.8)	(5.4)	(9)	(14)

Table III

Panel A: Industry Imb% Across Different Periods

Period	*Other Autos*	*Basic Materials*	*Consumer Services*	*Financial*	*Industrials*	*Oil & Gas*	*Technology*	*Utilities*
Sept 11, 03 - Oct 13, 04	0.66	0.64	0.60	0.80	0.67	0.69	0.60	0.35
	(0.13)	(0.06)	(0.05)	(0.04)	(0.05)	(0.09)	(0.10)	(0.14)
Oct 14, 04 - Mar 15, 05	0.62	0.40	0.49	0.73	0.54	0.55	0.60	0.18
	(0.14)	(0.09)	(0.05)	(0.06)	(0.04)	(0.07)	(0.08)	(0.08)
Mar 16, 05 – May 4, 05	0.65	0.44	0.57	0.79	0.59	0.66	0.57	0.46
	(0.11)	(0.07)	(0.05)	(0.03)	(0.03)	(0.03)	(0.05)	(0.21)
May 5, 05 – May 31, 05	0.77	0.51	0.56	0.82	0.58	0.69	0.57	0.74
	(0.04)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)
Jun 1, 05 – Jul 1, 05	0.69	0.48	0.48	0.80	0.56	0.67	0.38	0.63
	(0.11)	(0.04)	(0.05)	(0.06)	(0.05)	(0.02)	(0.04)	(0.06)
Jul 2, 05 – May 19, 06	0.49	0.38	0.33	0.61	0.40	0.46	0.34	0.40
	(0.14)	(0.11)	(0.08)	(0.09)	(0.08)	(0.06)	(0.10)	(0.04)

Panel B: Correlation between GM Imb % and Imb% for other sectors during the Crisis and Non-crisis periods.

Variables (Imb%)	**Crisis**	**Non-crisis**	**Diff.**
X=GM, Y=Ford	0.80	0.61	0.19
X=GM, Y=Other Autos	0.01	0.34	-0.33
X=GM, Y=Basic Materials	0.22	0.39	-0.17
X=GM, Y=Consumer Services	0.04	0.56	-0.52
X=GM, Y=Financial	0.32	0.57	-0.25
X=GM, Y=Industrials	0.24	0.52	-0.28
X=GM, Y=Oil & Gas	0.46	0.53	-0.07
X=GM, Y=Technology	-0.14	0.32	-0.46
X=GM, Y=Utilities	0.45	0.35	-0.10

Table IV
Tests of Increase in Correlations and Betas of CDS innovations During the Crisis Period

Panel A reports the correlation coefficients between pairs of CDS innovations during crisis and non-crisis periods and the difference between the crisis and non-crisis correlations. The significance of the difference is tested by converting correlations into z-scores using Fisher's transformation and computing the corresponding *t*-stats. The tests of correlation differences are one-sided, i.e. i.e., we test Corr(Crisis)>Corr(Non-crisis). The crisis period is defined as Oct 1 2004 to July 1 2005 and the non-crisis period from Sept 11 2003 to May 19 2006 excluding the crisis period. The number of observations in each regression is 127.

Panel B reports the estimation results of the following regression (with Consumer Services industry as an example):

$$CDSinv_{CS,t} = \alpha_1 + \alpha_2 * Crisis + \beta_1 * CDSinv_{GM,t} + \beta_2 * (Crisis * CDSinv_{GM,t}) + e_t$$

The dependent variable is the CDS innovation of Consumer Services industry. The independent variables are a dummy variable (*Crisis*) that equals to one in the crisis period (Oct 2004 to July 2005) and zero otherwise, CDS innovations of GM ($CDSinv_{GM,,t}$), and their interaction (*Crisis** $CDSinv_{GM,,t}$). The dependent variable of each regression is shown in the first column.

The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation. The asterisks for the estimates of α_1, α_2, and β_1 indicate their level of significance (two-sided tests). The asterisks for the estimates of β_2 indicate the significance of the test $\beta_2>0$ (one-sided). Rejection of the null at the 10%, 5%, or 1% level is indicated by *, **, or ***, respectively

	Panel A : Correlation Coefficients		
Variables	*Corr (Crisis)*	*Corr (Non-crisis)*	***Diff.***
X=GM, Y=Ford	0.77	0.67	**0.10***
X=GM, Y=Other Autos	0.79	0.49	**0.30*****
X=GM, Y=Financials	0.70	0.17	**0.53*****
X=GM, Y=Basic Materials	0.59	0.12	**0.47****
X=GM, Y=Consumer Services	0.46	0.07	**0.39*****
X=GM, Y=Industrials	0.59	0.06	**0.54*****
X=GM, Y=Oil & Gas	0.62	0.10	**0.52*****
X=GM, Y=Technology	0.53	0.11	**0.42****
X=GM, Y=Utilities	0.61	0.06	**0.55*****

	Panel B : Betas (Regression Coefficients)				
Variables (CDS innov.)	α_1	α_2	β_1	$\boldsymbol{\beta_2}$	R^2
X=GM, Y=Ford	0.0013	-0.0058	0.533***	**0.237****	*53%*
X=GM, Y=Other Autos	-0.0012	0.0008	0.253***	**0.267*****	47%
X=GM, Y=Basic Materials	-0.0016	0.0031	0.051	**0.301*****	35%
X=GM, Y=Consumer Services	-0.0019	0.0044	0.040	**0.253*****	25%
X=GM, Y=Financials	-0.0014	0.0024	0.019	**0.163*****	14%
X=GM, Y=Industrials	-0.0018	0.0036	0.019	**0.199*****	18%
X=GM, Y=Oil & Gas	-0.0006	0.0001	0.042	**0.291*****	23%
X=GM, Y=Technology	-0.0008	0.0020	0.043	**0.175*****	15%
X=GM, Y=Utilities	-0.0007	0.0011	0.027	**0.196*****	15%

Table V
Regression of Weekly CDS Innovations on GM *Imb%*

Panel A reports regressions of weekly CDS innovations on weekly GM *Imb%* as in the following example for the Consumer Services industry:

$$CDSinv_{CS,t} = \alpha_1 + \alpha_2 * Crisis_t + \beta_{CS1} * GMImb_t + \beta_{CS1,Crisis} * (Crisis_t * GMImb_t)$$
$$+ \beta_{CS2} * IndustryImb_{CS,t} + \beta_{CS2,Crisis} * (Crisis_t * IndustryImb_{CS,t}) + e_t$$

The dependent variable is the CDS innovation of Consumer Services industry ($CDSinv_{CS,t}$). The independent variables are a dummy variable (*Crisis*) that equals to one in the crisis period (Oct 2004 to July 2005) and zero otherwise, GM quote imbalance ($GMImb_t$), the Consumer Services industry quote imbalance ($IndustryImb_{CS,t}$), and the two *Crisis* interaction terms ($Crisis^* \ GMImb_t$ and $Crisis^* \ IndustryImb_{CS,t}$). The dependent variable (and the corresponding industry imbalance) is shown in the first column. All estimations are performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.

The asterisks on estimates of the loadings of (*Crisis* GMImb*) and (*Crisis*IndustryImb*) indicate the significance of one-sided tests. The asterisks for all other coefficient estimates indicate the level of significance in two-sided tests. The sample period is from Sept 11, 2003 to May 19, 2006.

The last two columns report the R^2 of the following estimation, performed separately for observations in crisis and non-crisis periods:

$$CDSinv_{CS,t} = \alpha + \beta_{CS1} * GMImb_t + \beta_{CS2} * IndustryImb_t + e_t$$

Panel B reports the economic significance of the relationship between GM imbalance and CDS innovations in the crisis period, based on the coefficients reported in Panel A. Column A estimates the size of a one standard deviation shock in the GM imbalance in the crisis period The results, reported under column A. Column B reports the standard deviation of industry CDS innovations in the crisis period and the final column reports the ratio.

Panel A: Regression of Weekly CDS Innovations on GM Imb%

Dependent Variable	*α*	*Crisis*	*GM Imb*	***Crisis* GM Imb***	*Industry Imb*	*Crisis* Industry Imb*	R^2	***Crisis*** R^2	***Non-crisis*** R^2
GM	-0.029	-0.264**	0.038	**0.387*** **			10.2%	**21.4%**	**0.3%**
Other Autos	-0.073***	-0.099	0.11***	**0.134** **	-0.011	0.017	13.5%	**16.4%**	**9.3%**
Basic Materials	-0.028	-0.086**	0.048**	**0.097** **	-0.016	0.053	10.4%	**10.7%**	**7.7%**
Consumer Servic	-0.047**	-0.096**	0.064*	**0.118** **	-0.001	0.04	15.9%	**18.4%**	**8.7%**
Financial	-0.027	-0.108**	0.049**	**0.051**	-0.013	0.102*	10.6%	**12.7%**	**6.4%**
Industrials	-0.044**	-0.057*	0.079***	**0.069** **	-0.026	0.026	17.0%	**19.2%**	**13.6%**
Oil & Gas	-0.025	-0.126**	0.049	**0.126** **	-0.018	0.068	11.2%	**16.4%**	**3.6%**
Technologies	-0.025	-0.097***	0.049*	**0.093** **	-0.023	0.068**	10.4%	**14.9%**	**5.7%**
Utilities	-0.071***	-0.019	0.114***	**0.008**	-0.029	0.046	18.2%	**19.2%**	**17.4%**

Panel B: Economic Significance of the Relationship Between GM Imb %

Dependent Var. (CDS innov.)	*CDS innv. change for 1 std. dev. change In Imb%*		*Period Std. Dev.*	
		(A)	*(B)*	*(A)/(B)*
GM	0.0928*(0.038+0.387)=	3.9%	8.5%	46.2%
Other Autos	0.0928*(0.110+0.134)=	2.3%	5.6%	40.5%
Basic Materials	0.0928*(0.048+0.097)=	1.3%	4.3%	31.3%
Consumer Services	0.0928*(0.064+0.118)=	1.7%	4.2%	39.8%
Financial	0.0928*(0.049+0.051)=	0.9%	3.4%	27.3%
Industrials	0.0928*(0.079+0.069)=	1.4%	3.1%	43.7%
Oil & Gas	0.0928*(0.049+0.126)=	1.6%	4.6%	35.1%
Technology	0.0928*(0.049+0.093)=	1.3%	3.5%	37.6%
Utilities	0.0928*(0.114+0.008)=	1.1%	3.1%	36.5%

Table VI

Principal Components Analysis of CDS Innovations

This table reports the principal components for weekly CDS innovations of GM, Ford, and eight industries. The principal components are taken separately for the crisis period (Oct 2004 to July 2005) and the non-crisis period (all other periods between Sept 2003 and May 2006), reported in Panel A and Panel B respectively. The first part of each panel reports the eigenvalue, the proportion explained, and the cumulative proportion explained by the first five principal components. The second part reports the loading each of the variables has on the first, second, and third principal components.

Crisis Period				**Non-Crisis Period**			
PC	*Eigen-value*	*Proportion*	*Cum. Prop.*	*PC*	*Eigen-value*	*Proportion*	*Cum. Prop.*
1	7.31	73.1%	73.1%	1	4.38	43.8%	43.8%
2	1.30	13.0%	86.1%	2	1.97	19.7%	63.5%
3	0.43	4.3%	90.4%	3	0.75	7.5%	71.0%
4	0.30	3.0%	93.4%	4	0.59	5.9%	76.9%
5	0.18	1.8%	95.2%	5	0.50	5.0%	81.9%

Variables	*PC1*	*PC2*	*PC3*	*Variables*	*PC1*	*PC2*	*PC3*
GM	0.28	0.49	-0.15	GM	0.13	0.58	0.37
Ford	0.18	0.74	0.19	Ford	0.15	0.57	0.23
Other Autos	0.34	0.20	-0.07	Other Autos	0.19	0.48	-0.43
Basic Mat.	0.35	-0.05	-0.12	Basic Mat.	0.33	0.07	-0.50
Consumer Svc.	0.34	-0.13	0.29	Consumer Svc.	0.37	-0.04	-0.22
Financial	0.30	-0.18	0.82	Financial	0.37	-0.15	-0.09
Industrials	0.34	-0.20	-0.15	Industrials	0.39	-0.13	0.02
Oil & Gas	0.34	-0.17	-0.29	Oil & Gas	0.37	-0.13	0.18
Technology	0.32	-0.20	-0.17	Technology	0.34	-0.18	0.54
Utilities	0.34	-0.10	-0.18	Utilities	0.37	-0.14	0.07

Table VII
Robustness Checks with VIX and Changes in Financial CP Spread

Panel A contains the estimation results of the regression of CDS innovations on GM *Imb%* and the change in the VIX index (ΔVIX) as in the following example for the Consumer Services industry:

$$CDSinv_{CS,t} = \alpha_1 + \alpha_2 * Crisis + \beta_{CS1} * GMImb_t + \beta_{CS1,Crisis} * (Crisis * GMImb_t) + \beta_{CS2} * IndustryImb_t$$
$$+ \beta_{DS2,Crisis} * (Crisis * IndustryImb_t) + \beta_{VIX} * \Delta VIX_t + \beta_{VIX,Crisis} Crisis * \Delta VIX_t + e_t$$

The dependent variable is the CDS innovations of Consumer Services industry ($CDSinv_{CS,,t}$). The independent variables are as defined in Table II with the addition of the percentage change in VIX (ΔVIX_t).

Panel B gives the estimation results for an identical regression where the change in VIX (ΔVIX_t) is replaced by the change in the financial CP spread (ΔCP_t). Other details are as in previous tables.

Panel A

Dependent Var. (CDS innov.)	α	*Crisis*	*GMImb*	***Crisis* GMImb***	*Industry Imb*	*Crisis* Industry Imb*	***Δ VIX***	***Crisis * Δ VIX***	R^2
GM	-0.04	-0.25**	0.06	**0.37*** **			**0.11***	**0.03**	12.9%
Other Autos	-0.07***	-0.10	0.11***	**0.15*** **	-0.01	0.01	**0.000**	**0.28******	26.3%
Basic Materials	-0.03*	-0.09**	0.05**	**0.10****	-0.01	0.07*	**0.02**	**0.17****	22.9%
Consumer Services	-0.05***	-0.09**	0.07***	**0.12****	0.000	0.04	**0.05****	**0.14****	30.8%
Financial	-0.03	-0.12***	0.05**	**0.05**	-0.01	0.11*	**0.01**	**0.09****	15.7%
Industrials	-0.05***	-0.06*	0.08***	**0.07***	-0.02	0.03	**0.02**	**0.10****	24.1%
Oil & Gas	-0.03	-0.13**	0.06*	**0.12****	-0.01	0.08	**0.06****	**0.19****	29.4%
Technology	-0.04	-0.08**	0.06**	**0.09****	-0.02	0.05*	**0.07******	**0.11***	25.5%
Utilities	-0.08***	-0.01	0.12***	**-0.01**	-0.03	0.06*	**0.06****	**0.08***	28.8%

Panel B

Dependent Var. (CDS innov.)	*Δ CP*	*Crisis * Δ CP*	R^2	*GMImb*	*Δ CP*	*Crisis* GMImb*	*Crisis * Δ CP*	*Δ CP* GMImb*	***Crisis * Δ CP *GMImb***	R^2
GM	0.014	-0.004	0.7%	0.04	0.06	0.34**	-0.15	-0.06	**0.26**	13.0%
Other Autos	0.018	-0.017*	0.8%	0.11***	0.05	0.13*	-0.05	0.11	**-0.08**	15.7%
Basic Materials	-0.006	0.004	0.8%	0.05**	0.06	0.05	-0.15*	-0.13	**0.25****	14.0%
Consumer Services	-0.014**	0.015	1.6%	0.06**	-0.05	0.06	-0.12	0.03	**0.09***	24.8%
Financial	-0.01*	0.006	1.6%	0.04**	0.01	0.03	-0.12	-0.08	**0.13**	12.2%
Industrials	0.003	-0.005	1.0%	0.08***	0.05	0.03	0.01	-0.07	**0.16***	19.2%
Oil & Gas	0.018*	-0.021**	1.3%	0.04	0.05	0.11*	-0.19*	0.04	**-0.05**	13.6%
Technologies	-0.001	-0.002	0.4%	0.05*	0.03	0.04	-0.05	-0.09	**0.21****	13.4%
Utilities	-0.007	0.007	0.4%	0.12***	0.06	-0.02	-0.10	-0.02	**0.10**	21.4%

Table VIII

Robustness Checks with Short Selling Fees on GM's Bonds and Stock

Panel A of this table reports the results of regressions that included the short-selling fee for GM bonds. As before, using the Consumer Services sector as an example, the regression is:

$$CDSinv_{CS,t} = \alpha_1 + \alpha_2 * Crisis_t + \beta_{CS1} * SSFee_t + \beta_{CS1,Crisis} * (Crisis_t * SSFee_t) + \beta_{CS1} * GMImb_t + \beta_{CS1,Crisis} * (Crisis_t * GMImb_t) + e_t$$

The dependent variable is the CDS innovations of Consumer Services industry (*$CDSinv_{CS,,t}$*). The independent variables are as defined in Table II with the addition of the short selling fee of GM securities (*$SSFee_t$*, in % p.a., i.e. 100 bps p.a.). Other details are as in previous tables. Panel B reports the corresponding results for the short-selling fee on GM stocks. The sample period is from Sept 11, 2003 to May 19, 2006 and the number of observations is 105.

Panel A: Bond short-selling fee

Dep. Var. (CDS innov.)	*SSFee*	*SSFee *Crisis*	R^2	*SSFee*	*Crisis* SSFee*	*GMImb*	*Crisis* GMImb*	R^2
GM	-0.0038	-0.007	0.5%	-0.002	-0.040*	0.010	0.100***	12.6%
Other Autos	-0.0043	0.006	0.9%	-0.001	-0.016	0.022***	0.043**	16.7%
Basic Mat.	-0.0013	0.012*	3.7%	0.0001	0.001	0.009*	0.026**	16.4%
Cons. Svc.	-0.0028	0.015*	4.8%	-0.001	0.002	0.011*	0.028***	17.3%
Financial	-0.0003	0.010*	4.4%	0.0003	0.004	0.004	0.016**	10.0%
Industrials	0.0002	0.014*	8.8%	0.002	0.004	0.012***	0.015**	22.7%
Oil & Gas	0.0010	0.011	4.0%	0.001	-0.003	0.003	0.041***	21.8%
Technologies	-0.0012	0.009	2.1%	-0.0002	-0.001	0.007	0.025**	13.2%
Utilities	-0.00001	0.010*	4.4%	0.002	-0.001	0.017***	0.013	25.2%

Panel B: Stock short-selling fee

Dep. Var. (CDS innov.)	*SSFee*	*SSFee *Crisis*	R^2	*SSFee*	*Crisis* SSFee*	*GMImb*	*Crisis* GMImb*	R^2
GM	-0.0001	-0.0016	0.6%	0.0002	-0.005**	0.013	0.099***	13.4%
Other Autos	-0.0003	0.0004	0.1%	0.0003	-0.002*	0.020***	0.041**	17.0%
Basic Mat.	0.00001	0.0009	1.9%	0.0003	-0.001	0.010*	0.027**	16.7%
Cons. Svc.	-0.0003	0.0009	1.7%	0.00001	-0.001	0.012**	0.033***	18.1%
Financial	0.0002	0.0003	1.4%	0.0003	-0.001	0.005*	0.020**	10.0%
Industrials	0.0002	0.0010	5.7%	0.0005	-0.001	0.011***	0.018**	22.1%
Oil & Gas	0.0004	0.0003	1.7%	0.0005	-0.001*	0.004	0.046***	23.4%
Technologies	-0.0001	0.0003	0.2%	0.0001	-0.0010	0.008	0.029***	15.1%
Utilities	0.0003	0.0006	2.7%	0.0007	-0.001	0.017***	0.015*	25.9%

Appendix A: Timeline of events surrounding the downgrade of GM and Ford.

		GM's Credit Rating			**Ford's Credit Rating**		
Date	***Event***	***Moody's***	***S&P***	***Fitch***	***Moody's***	***S&P***	***Fitch***
	Rating prior to October 2004	Baa1 (BBB+)	BBB	BBB	Baa1 (BBB)	BBB-	BBB+
14th October, 2004	**S&P downgrade GM and GMAC 1 notch to BBB-**		BBB-				
14th November, 2004	**Moody's downgrade GM and GMAC 1 notch to Baa2 and Baa1 respectively**	Baa2 (BBB)					
14th Jan, 2005	S&P affirm GM rating and outlook but it will review them "within the next 6 months"						
14th Feb, 2005	GM reaches agreement with Fiat						
17th February, 2005 (Source: Riskmetrics Creditgrades Report)	"Moody's cut the North American automaker's credit outlook, citing the $2 billion it paid to terminate Italian conglomerate Fiat Group's option to sell Fiat Auto to GM for a fair market price."						
16th March, 2005	**GM issues profit warning**						
16th March, 2005	**Fitch downgrade GM and GMAC 1 notch to BBB-with a negative outlook**			BBB-			
16th March, 2005	**S&P changes GM and GMAC outlook to negative from stable**						
5th April, 2005	Moody's places Ford and FMCC on review for possible downgrade						
5th April, 2005	**Moody's downgrade GM and GMAC 1 notch** to Baa3 (BBB-) and Baa2 (BBB) respectively, outlook negative	Baa3 (BBB-)					
8th April, 2005	S&P change Ford and FMCC outlook to negative from stable						
11th April, 2005	Fitch change Ford and FMCC outlook to negative from stable						
12th April, 2005	**Ford issues profit warning**						
19th April, 2005	GM releases Q1 results						
20th April, 2005	Ford releases Q1 results						
4th May, 2005	GMAC completes the transfer of its mortgage business to a new holding company, Residential Capital Corporation, which will be seeking a stand-alone credit rating						
4th May, 2005	Kirk Kerkorian announces his intention to purchase a further 4.8% stake in GM, adding to the 4% already purchased						
4th May, 2005 (Source: FT)	Kirk Kerkorian announces plans to purchase 9% of GM shares, pushing the stock price up 18%.						

5th May, 2005	**S&P downgrade GM and GMAC 2 notches to BB with a negative outlook**		BB				
5th May, 2005	**S&P downgrade Ford and FMCC 1 notch to BB+ with a negative outlook**					BB+	
12th May, 2005	**Moody's downgrade Ford and FMCC 2 notches to Baa3 (BBB-) and Baa2 (BBB) respectively, outlook negative**				Baa3 (BBB-)		
19th May, 2005	**Fitch downgrade Ford and FMCC 1 notch to BBB with a negative outlook**						BBB
21th May, 2005 (Source: FT)	"Ford bonds rose after Fitch Ratings downgraded the carmaker one notch to BBB-, but said it was 'unlikely that Ford would be downgraded to non-investment grade in 2005.'--- The spread on GMs 2014 Euro bond tightened nearly 100 basis points" [since May 17]						
24th May, 2005	**Fitch downgrades GM and GMAC 1 notch to BB+, outlook negative**			BB+			
25th May, 2005	Ford reaches agreement with Visteon						
31st May, 2005	**Lehman's and Merrill's investment-grade indices reclassified, GM and GMAC drop out of both, Ford and FMC fall out of Lehman's but will return to it at end-June**						
1st June, 2005	GM and Ford sales fell around 5% yoy in May (sales day adjusted)						
1st June, 2005	Q3 production: GM cut 9% and Ford 2.3%						
7th June, 2005	Kirk Kerkorian purchases a further 2.4% stake in GM, taking his total holding to 7.2%						
21st June, 2005	**Ford issues profit warning**						
22nd June, 2005	Moody's places Ford and FMCC on review for possible downgrade						
1st July, 2005	Ford and FMC return to Lehman's investment-grade index						
1st July, 2005	GM sales rose 41% yoy in June (sales day adjusted) following heavy discounting, Ford's rose 0.7% yoy. Q3 production schedules were unchanged						
1st July, 2005	Moody's places GM and GMAC on review for downgrade						
1th July, 2005	Rating	Baa3 (BBB-)	BB	BB+	Baa3 (BBB-)	BB+	BBB
	* GMAC rating the same as GM's, except with Moody's who always rate GMAC one notch higher than GM.						
	** FMCC rating the same as Ford's, except with Moody's who always rate FMCC one notch higher than Ford.						

Appendix B: A snapshot of daily bond quotes obtained from MarketAxess.

ISSUEID	CUSIP	ISIN	TICKER	COUPON	MATURITY	BID_LEVEL	BID_SIZE	OFFER_LEVEL	OFFER_SIZE	SPREAD_AGAINST	DEALERID
10106478	013817AF8	013817AF	AA	6	01/15/2012	72	1000	null	null	M	4
10106478	013817AF8	013817AF	AA	6	01/15/2012	72	183	null	null	M	114
10106478	013817AF8	013817AF	AA	6	01/15/2012	78	1150	58	2000	M	7
10106478	013817AF8	013817AF	AA	6	01/15/2012	null	null	60	625	M	6
10106478	013817AF8	013817AF	AA	6	01/15/2012	null	null	62	170	M	2
10097728	013817AH4	013817AH	AA	5.375	01/15/2013	null	null	70	311	M	77