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# LIQUIDITY RISK AND CORRELATION RISK: A CLINICAL STUDY OF THE GENERAL MOTORS AND FORD DOWNGRADE OF MAY 2005

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## ABSTRACT

# Liquidity Risk and Correlation Risk: A Clinical Study of the General Motors and Ford Downgrade of May 2005*

The GM and Ford downgrade to junk status during May 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 in the significant imbalance in their quotes towards sales. We also document that simultaneously, there was excess co-movement in the fixed-income securities of all industries, not just in those of auto firms. In particular, using credit-default swaps (CDS) data, we find a substantial increase in the co-movement between innovations in the CDS spreads of GM and Ford and those of firms in all other industries, the increase being greatest during the period surrounding the actual downgrade and reversing sharply thereafter. We show that a measure of liquidity risk faced by corporate bond market-makers – specifically, the imbalance towards sales in the volume and frequency of quotes on GM and Ford bonds – explains a significant portion of this excess co-movement. Additional robustness checks suggest that this relationship between the liquidity risk faced by market-makers and the correlation risk for other securities in which they make markets was likely causal. Overall, the evidence is supportive of theoretical models which imply that funding liquidity risk faced by financial intermediaries is a determinant of market prices during stress times.

JEL Classification: G12, G13, G14, G21 and G22
Keywords: excess co-movement, financial crises, funding liquidity, inventory risk and market liquidity

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Submitted 17 December 2007

## 1. Introduction

Recent theoretical research (see, for example, Gromb and Vayanos, 2002 and Brunnermeier and Pedersen, 2005) has argued that market liquidity and funding liquidity in financial markets are intimately related. Since financial intermediaries face funding constraints (e.g., collateral and margin requirements), when faced with liquidity risk – the risk of being forced to hold onto large chunks of inventory of an asset – they may reduce the provision of their market-making services. In particular, the resulting reduction in liquidity may be pervasive and go beyond the asset which has originally given rise to the funding constraint to affect other assets too, especially those for which these intermediaries are primary liquidity providers or marginal price-setters. This, in turn, can induce a co-movement in prices of assets that is not attributable to the underlying statistical 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 due to constraints faced by financial intermediaries. In order to do so, we conduct a clinical study of the effects on some of the fixed-income markets arising from the downgrade of General Motors (GM) and Ford to junk status in May 2005.

Our choice of this setting is driven by two considerations. First, this 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] Their downgrade to junk status caused a large number of bond investors and asset managers, those who faced portfolio restrictions to invest only in investment-grade bonds, to liquidate their positions. Due to delay in the entry of these bonds into sub-investment grade indices and, more broadly, due to slow movement of capital (Mitchell, Pedersen and Pulvino, 2007), the market-makers were left with significant inventories of these bonds that could have taken several weeks (or even a few months) to liquidate fully.

[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. When 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, will dwarf the other members, which are 2 percent or less of the index.

Second, 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 of the financial institutions that make markets in corporate bonds are also the liquidity providers in other related segments of the fixed-income markets, specifically in credit markets such as credit default swaps (CDS) and collateralized loan and debt obligations (CLO's and CDO's). If our starting hypothesis is correct, then the inventory risk from GM and Ford bonds faced by market-makers should also increase the spreads at which these other credit-risk instruments were quoted in the markets. In particular, these spreads should widen not just for the auto sector where GM and Ford belong (and where the downgrade may have also conveyed fundamental information), but also for other sectors. Given availability of data, we focus on CDS markets

Our empirical approach rests on three key steps. First, using a novel dataset of corporate bond quotes from MarketAxess, a leading corporate bond trading platform, we document 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 we do not have the exact inventory positions of these intermediaries, we show that around the downgrade period, there was a sudden rise in the imbalance in quotes of GM and Ford bonds, with substantially more offer quotes and offer volume than bid quotes and volumes, 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.[3] Finally, we also check the illiquidity in GM and Ford bonds indirectly by showing that the basis between CDS and bond spreads of GM and Ford widened substantially during the downgrade period, consistent with the no-arbitrage relationship between CDS and bonds that takes account of the difficulty of selling the bonds. All these liquidity effects reversed sharply after the downgrade period.

Second, we employ the data on 5-year CDS spreads from Markit Group for GM and Ford and firms in eight industries (Auto, Financial, Basic Materials,

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

Consumer Services, Industrials, Oil & Gas, Technology and Utilities) to 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, like the liquidity effects discussed above, this excess co-movement is also short-lived, in the sense that it falls substantially following the downgrade months. Of course, it is possible that the increase in co-movement we identify is simply an increase in co-movement of fundamentals across industries. However, by focussing on the downgrade of GM and Ford, a shock specific to corporate bond market rather than to the whole economy, and finding that the co-movement is extends across all industries, alleviate this concern to some extent. But what really gives us the confidence to call the identified increase in co-movement as "excess co-movement" is the fact that the CDS changes we employ are in fact CDS *innovations*, calculated as the residuals from regressing CDS changes on (a non-linear no-arbitrage specification of) contemporaneous 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 (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 the various imbalance measures in trading of GM and Ford bonds that we employ to document liquidity risk are in fact significant in explaining the CDS changes, not only for GM and Ford, but for all other eight industries and even after controlling for similarly computed imbalance measures for corporate bonds of these industries. What is most striking is that our measures of liquidity risk have little explanatory power during the non-downgrade period ($R^2$ of the order of 1% to 3% for most industries), but substantial explanatory power during the downgrade period ($R^2$ of the order of 15% to 20% for most industries). The economic magnitude of the effect during the downgrade period is large too: A one standard deviation shock to the liquidity risk measure produces an effect of the order of 30% to 50% of the standard deviation of CDS innovations.

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 47% of the variation and the measure of imbalance in offer versus bid volume in quotes of GM explains only 5% of this component. In contrast, the first component explains 71% of the variation during the downgrade period and the imbalance measure explains over 22% of this component.

A series of robustness checks lead us to believe that the relationship between liquidity risk and correlation risk is in fact causal. Specifically, the evidence for the relationship is robust to (i) estimating CDS innovations separately for the downgrade and the non-downgrade period, (ii) employing lagged liquidity risk measures to avoid the concern of omitted fundamental factors, and (iii) controlling for changes in VIX, often perceived to be a measure of the risk appetite of financial intermediaries (which might lead to liquidity risk but not for reasons driven by illiquidity in the underlying bonds). Additionally, we use changes in the spread between financial commercial paper (CP) and T-bill rates, a proxy for the funding constraints of financial intermediaries, to show that the level of intermediaries' funding constraints was directly correlated with the degree of excess co-movement in CDS during the downgrade. This provides direct evidence that intermediaries' funding constraints was the channel (or at least one of the channels) that linked liquidity risk and correlation risk. Finally, we show that the effect of bond imbalance on CDS was stronger for firms in the eight industries with a sub-investment grade compared to investment-grade firms (though the effect is statistically weak), consistent with the hypothesis that intermediaries withdrew liquidity more sharply from bonds with greater inventory risk.

While all clinical studies must be taken with a pinch of salt, we believe that our investigation also sheds light on some outstanding puzzles in the credit-risk area. Collin-Dufresne, Goldstein and Martin (2001) and Schaefer and Strebulaev (2005) have documented convincingly that there is a significant portion of "credit" spreads on corporate bonds that does not seem related to credit risk. Collin-Dufresne, Goldstein and Martin (2001) document the presence of a significant principal component that is equally-weighted across bonds of different ratings and maturities, suggesting a factor specific to fixed-income markets and perhaps arising from segmentation between these and equity markets. Our identification of a liquidity risk factor that appears to have driven the principal component of CDS innovations (relative to equity markets) during a crisis episode that was specific to credit markets is direct evidence that provides a possible explanation for the Collin-Dufresne, Goldstein and Martin (2001) finding. Indeed, the principal component we identify across the CDS innovations of GM and Ford and eight other industries is also (roughly) equally weighted across the underlying series. Further research examining other crisis events, such as the most recent (2007) credit turmoil in markets, seems promising in shedding further light on these issues.

The rest of the paper is organized as follows. In Section 2, we review the related literature and present the conceptual framework that underlines our view of the connection between liquidity risk and correlation risk. In Section 3, we describe in some detail the foreground and the aftermath of the GM and Ford downgrade. We provide a description of 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 Section 6. In Section 7, we conclude with implications of our results for the management of correlation risk arising in complex derivative and structured products.

## 2. Related literature and conceptual framework for our study

Over the last decade or two, there have been a large number of events where the ability to trade securities and access capital-market financing dried up considerably 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 credit crunch following the collapse in the US sub-prime market.

To investors, liquidity generally refers to transaction costs arising from the bid-ask spread, price impact and (limited) market depth for trading in securities. By token, liquidity *risk* for investors generally refers to unpredictable variations in transaction costs. This notion of liquidity and liquidity risk pertains to "market liquidity." In contrast, and oftentimes in addition, risk managers at banks and financial institutions are concerned about liquidity on the funding side. This pertains to the ease with which cash shortfalls of the enterprise can be funded through various sources of financing – internal or external – to which the enterprise has access. This aspect of liquidity is known as "funding liquidity" and its unpredictable fluctuations over time as funding liquidity risk.

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, most notably Gromb and Vayanos (2002) and Brunnermeier and Pedersen (2005), has argued that collateral requirements for trading of securities and hair-cuts on collateral value of securities imply that there is an important inter-linkage between "market liquidity" and "funding liquidity".[4] In particular, they suggest that when a market liquidity shock is severe enough, an inability to raise capital against the full value of assets in inventory (or more broadly, entire future trading profits) can produce further illiquidity by preventing intermediaries from providing liquidity through market making.

Two implications of this effect are central to our study. First, that prices in capital markets (effectively) exhibit two *regimes*. In the *normal* regime, intermediaries are well-capitalized and liquidity effects are minimal: prices of assets reflect fundamentals and there is no (or little) liquidity effect. In the *illiquidity* regime, intermediaries are close to their capital or collateral constraints and prices now reflect the shadow cost of capital to these intermediaries, i.e., the cost they incur from issuing an additional unit of funding capital to undertake a transaction. In particular, there is "cash-in-the-market" pricing (as in Shleifer and Vishny, 1992 and Allen and Gale, 1998) and the total capital of participants in a particular security market affects the price of that security.

Second, that this view of prices as consisting of two liquidity-differentiated regimes can potentially help in understanding the characteristics of a seemingly unrelated phenomenon, namely correlation risk, i.e., the risk that the correlation of returns across different markets (within a country and potentially also across countries) fluctuates over time. The documented characteristics of correlation risk bear a striking relationship to liquidity risk in that the correlation of returns on primitive securities (such as stocks and bonds) appear to rise in bear markets relative to bull markets (Longin and Solnik, 1995, 2001 and Ang and Chen, 2002), and aggregate volatility also rises in bad times (Bekaert and Wu, 2000).[5]

[4] Ultimately, of course, funding liquidity risk may arise because agency problems facing financial institutions become severe following certain shocks and in certain states of the world such as crisis events (Acharya and Viswanathan, 2007).

[5] A now expanding body of work in international finance has sought to establish excess co-movement across country-level stock returns and sovereign credit spreads, often around sovereign rating

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. To see this, note that while in the *normal* regime, correlations across asset prices are primarily driven by correlation in fundamentals of the underlying entities or risks, in the *illiquidity* regime, prices are also affected by the shadow cost of constraints faced by intermediaries. Since this liquidity effect (the illiquidity discount) is related to intermediaries' capital rather than to fundamentals of the security, it affects prices of securities traded by these intermediaries across the board, inducing a correlation in securities' market prices that is over and above the one induced by fundamentals.

Since there is substantial commonality in liquidity across different assets (Chordia, Roll and Subrahmanyam, 2000), it is not straightforward to structure a test of the hypothesis that a liquidity shock to one asset affects liquidity in other assets through the funding risk faced by intermediaries. Hence, we focus on a specific event – the GM and Ford downgrade in May 2005 – and its effects on credit markets. The downgrades of GM and Ford were considered largely idiosyncratic events in terms of underlying credit risk in the economy. The downgrades combined with (regulatory or style) restrictions imposed on many asset managers for investing in investment-grade assets ensured that market-makers in corporate bonds were left with significant inventories from GM and Ford bond liquidations. Since these bonds constituted a substantial portion of the daily trading volume of corporate bonds, the setting gives the researcher statistical power to detect the impact of an idiosyncratic liquidity shock in one asset (GM and Ford bonds) on other assets (credit default swaps of all industries). The choice of credit default swaps for firms of all industries as "other assets" is driven by the observation that trading in these markets is primarily due to

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downgrades. Hence, this work is directly related to our analysis in this paper. On the empirical front, Rigobon (2002) studies the effects on correlations of country-level stock returns of an upgrade on Mexican debt from non-investment grade to investment grade. Kaminsky and Schmukler (2002) examine a similar issue encompassing a bigger set of countries. Pan and Singleton (2007) use sovereign credit default swap spreads and show that there is perhaps a spillover of the U.S. macroeconomic conditions and of credit risk appetite of financial institutions, which introduce excess co-movement into these spreads. For theoretical work on such co-movement across countries, see Pavlova and Rigobon (2007) and references therein. In particular, they argue that one of the sources of excess co-movement could be the portfolio constraints faced by internationally investing institutions (for example, limits on concentration of exposure to a country and to non-investment grade set of countries). Finally, there is also a working paper by Gande and Parsley (2007), who show that mutual funds withdraw funds from countries in response to a sovereign rating downgrade.

over-the-counter institutional trading, whereby shocks to the balance-sheet of financial institutions are potentially likely to play an important role in affecting prices in these markets.

## 3. The downgrade of GM and Ford and its consequences

On May 5, 2005, S&P 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 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, which had warned in recent weeks that both companies could be downgraded, cited a number of parallel concerns for the automakers, including falling sales of sport utility vehicles and declining market shares in the face of strong global competition.

While many investors had anticipated the downgrade, they were surprised by its timing; the move came sooner than many had expected.[6] The announcement sent the automakers' bonds tumbling and CDS spreads soaring; it also knocked down GM and Ford's shares by nearly 6 percent and 5 percent respectively. Figure 1 plots the 5-year CDS spreads of the two companies. It shows that post downgrade, GM and Ford's CDS rose to more than 1000 bp and 800 bp respectively from less than 300 bp just few months earlier.

The downgrade of the two giant automakers constituted a serious test for the functioning of the financial markets, because of the enormous size of the companies, their prominence in the debt markets, and their consequent importance to the still maturing credit derivative market. Furthermore, the prevailing low level of the

[6] 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.

overall credit spreads at the time, increased the vulnerability of credit markets to a sudden unwind in "search for yield" and a jump in investor risk aversion.[7]

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 about $292 billion, and Ford (including FMCC) bonds totaled about $161 billion. As a result of the downgrade, 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 that prevented them from investing in junk-rated securities. Moreover, because many investors track bond indices, much of the redistribution of GM and Ford bonds will be forced as the two are dropped from various investment-grade bond indices. These included investment grade indices of Lehman Brothers, Merrill Lynch and iBoxx.[8] It is important to note that 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. When moved to the Lehman High Yield Index, GM, with a 6 percent share, and Ford, with a 5.9 percent share, will dwarf the other members, which are 2 percent or less of the index.[9] It was estimated by Bank of America that at the time of the downgrade, "*the total amount of debt likely to need to clear the market in moving high grade holders to high yield and distressed holders…based on average Trace volumes in April, the market could <u>clear that amount of debt in just under four months</u> of trading for both GM and Ford.*" [10]

As the market began to sell GM and Ford bonds aggressively, financial institutions that intermediate the debt market – large banks, and, in particular, their high-yield desks - ended up holding a significant fraction of the total supply of GM

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7 We thank Ronald Johannes for private communication regarding the details of the downgrade episode.

8 In one instance of the havoc caused by the timing of the downgrade, all GM, GMAC, Ford, FMCC securities would be removed from Lehman Brothers' investment grade indices on May 31, but with a twist. In a decision made well ahead of the downgrade, Lehman Brothers changed the definition of its investment grade bond index, effective July 1. This definition change could allow both GM and Ford to return to the investment-grade indices on July 1 if neither Moody's nor Fitch downgrades them before. If the downgrade came after July 1, the companies would remain on the index, so a lot of investors are surprised by the timing of S&P. See the article in TheStreet.com, "S&P Junks GM and Ford", May 5, 2005.

9 See the article in The New York Times, "Big Splash and More Ripples to Follow", May 6, 2005.

10 The quote is from Notes for discussion at the Moody's Academic Credit Risk Conference, London May 25, 2005, Compiled by Darrell Duffie, with help from Chris Mahoney.

and Ford bonds. Indeed, we provide evidence for this in section 5. As a result of their large inventories of the junk-rated GM and Ford bonds, these intermediaries faced significantly increased risk from further drops in the prices of these bonds. This increased inventory risk coupled with unknown losses from their prime brokerage business had a significant negative impact on several large banks. Figure 2 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.

The effect of the 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 because GM and Ford's importance in credit derivative trading. Around the same time, tranches in the Dow Jones CDX North America index also saw sharp rises and equally sharp reversals. In later sections, we show that this spill-over effect on other markets and industries can be explained, at least partially, by the market illiquidity in GM and Ford bonds. The illiquidity adversely affected the inventory positions of intermediaries that make the bond markets, forcing them to price their heightened inventory risk into prices of all securities that they intermediate, most notably being CDS.

## 4. Data and sample period division

### 4.1 Data

Daily CDS spreads are obtained from Markit Group, a London-based distributor of credit pricing data. Markit provides composite CDS prices, which are calculated from daily quotes provided by leading sell-side contributors and inter-dealer brokers.[11] Each bank provides pricing data from its book of records and executable bid/offer records. This data then undergoes a rigorous cleaning process where Markit filters for stale, 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 are reported. We focus on the 5-year daily CDS

[11] 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, Deutche 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.

spreads from Markit, the most liquid maturity. Additional matching bond data for calculating CDS-bond basis are obtained from Datastream.

The study also relies on hitherto unexploited inventory data on corporate bonds obtained from MarketAxess. MarketAxess operates one of the leading platforms for the electronic trading of corporate bonds, and it 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 the bid and offer quotes from all the dealer-brokers trading on the MarketAxess platform.[12] For each dealer's quote, we have information on the identity of the bond, the quantity bid /offered, and the yield/price of the bid/offer. Using these daily bond quotes, we construct a number of quote imbalance measures which we use as proxies for the inventory risk of GM and Ford bond positions faced by financial intermediaries.

Our sample consists of 524 CDS entities, 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 belong to each industry. 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 CDS quotes with equity returns from CRSP. This resulted in a sample of 524 firms.[13] The sample period of Sept 11, 2003 to May 19, 2006 is determined by the availability window of MarketAxess' bond data.

Tables I Panel B-D provide summary statistics for the credits in our sample during the sample period of Sept 11, 2003 to May 19, 2006. Panels B and C report the summary statistics for GM and Ford. Panel D reports the same statistics for all firms in our sample. The median market capitalization of GM and Ford are 21.2 and 21.7 billion dollars respectively during the sample period. GM and Ford are very similar in

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[12] There are 27 dealer-brokers that trade 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.

[13] Some CDS names that matched with CRSP were excluded because few firms in the same industry are covered by Markit.

credit risk, with median 5-year CDS spread 289 basis points (bps) and 282 bps respectively. When their credit rating deteriorated, their spreads reached highs of 1377 bps (GM) and 991 bps (Ford). In comparison with GM and Ford, the average firm in our sample is both smaller and less risky. The median CDS spread is 53 bps, the median firm size is 5.4 billion dollars, and the median credit rating is BBB. Finally, Tables I Panel E provides summary statistics of VIX, financial commercial paper (CP) rate, and 90-day T-bill rate in our sample period.

**4.2 Division of the sample period**

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, various other credit deterioration events, such as downgrades by other rating agencies and profit warnings, also took place around 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-. The automakers were particular hard hit on March 16, 2005 when, on the same day GM issued profit warning, Fitch downgraded GM and GMAC to BBB-, and S&P changed its outlook for GM and GMAC from stable to negative. 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.

In the sections to follow, we perform various empirical tests which require us to divide the sample period (Sept 11, 2003 to May 19, 2006) into separate crisis and non-crisis periods. Taking the aforementioned credit deterioration dates into account, the crisis period is defined to be the 10-month period between October 2004 and July 2005; all other periods, including both the pre-crisis (September 2003 to September 2004) and post-crisis (August 2005 to May 2006) periods, are classified as the non-crisis period.

In addition to the division of into crisis and non-crisis periods, we further divide our sample into six interesting sub-periods with the five credit deterioration dates discussed above.

| | From | To |
|---|---|---|
| *Period 1* | 11 September 2003 | 13 October 2004 |
| *Period 2* | 14 October 2004 | 15 March 2005 |
| *Period 3* | 16 March 2005 | 04 May 2005 |
| *Period 4* | 05 May 2005 | 31 May 2005 |
| *Period 5* | 01 June 2005 | 01 July 2005 |
| *Period 6* | 02 July 2005 | 19 May 2006 |

We use this division of the sample period in part of our analysis of bond imbalances and CDS correlations. Periods 3, 4 and 5 cover the three-and-half months immediately around the May $5^{th}$ downgrade, so we expect to see the most market reaction in these periods.

## 5. Empirical tests and results

### 5.1 Liquidity risk in corporate bond trading around the downgrade

The main hypothesis of our paper is that the GM and Ford downgrade increased the inventory risk of financial intermediaries, forcing them to discount prices of securities across the board. To address this hypothesis, we first show that the GM and Ford downgrade indeed heightened intermediaries' inventory risk.

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. Three such measures used throughout this paper are: *Imbalance % (Imb%), Offer Ratio, and Offerer*. *Imb%* measures the relative *proportion* of the total volume of bids and offers for a given bond on a given day. It is calculated as:

$$\text{Imb\%} = \frac{(\text{Total vol. of offers - Total vol. of bids})}{(\text{Total vol. of bids} + \text{Total vol. of offers})} \qquad (1)$$

*Offer Ratio* captures the difference in the total number of bid and offer quotes, and is calculated for each bond on each day as:

$$\text{Offer Ratio} = \frac{(\text{Total \# of offers})}{(\text{Total \# of bids} + \text{Total \# of offers})} \qquad (2)$$

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. The imbalance measure, *Offerer*, is then defined, for that bond on that day, as:

$$\text{Offerer} = \frac{(\text{\# of net offerers})}{(\text{\# of quote providers})} \qquad (3)$$

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; bid-ask spreads cannot be calculated from these one-sided quotes.

Table II reports the mean and standard deviation of the calculated imbalance measures for GM and Ford in the six sub-periods described in the last section. Figures 3A and 3B plot the mean levels of *Imb%* and *Offer Ratio*. Note that 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.[14] We observe that 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. These imbalance measures declined after the downgrade, but continued to stay relatively high for the next two months. For example, GM *Imb%* rose from an average of 0.64 (Oct 14, 2004 to Mar 15, 2005), to an average of 0.84 (May 16, 2005 to May 4, 2005); it then declined to 0.73 in the month post the downgrade (*May 5, 2005 to May 31, 2005).* As further evidence of the increased market imbalance, Table 2 reports the percentage of two-sided quotes for GM and Ford bonds in different periods. We observe that the proportion of two-sided quotes for both GM and Ford bonds dropped considerably around the downgrade; For GM, it went from 10% (Oct 14, 2004 to Mar

[14] This is a general feature of the MarketAxess data. We find that, for almost all bonds, the aggregate offer volume in a day is higher than the aggregate bid volume. 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 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.

15, 2005) to less than 2% (May 16, 2005 to July 1, 2005), before bouncing back to 10% .

The movements in the imbalance measures indicate that the market for GM and Ford bonds became increasingly imbalanced around the downgrade, with offering quotes far out-numbering bid quotes. The fact that quote imbalance was the most severe immediately prior to the downgrade is consistent with our earlier discussion that the market had expected a downgrade, so investors had already started a large sell-off of GM and Ford bonds before the actual downgrade.[15] However, the large sell-off of GM and Ford bonds continued at least one month after May 5, indicating that the announcement itself still had considerable market impact.

The market imbalance for GM and Ford bonds suggests that the liquidity for these bonds dried up considerably around the downgrade. This conclusion is reinforced by the behaviour of the CDS-bond basis of GM and Ford around this time. A "close-to-arbitrage" relationship dictates that for any given firm, the CDS spread should be approximately equal to the credit spread of a bond of the same maturity.[16] Deviations from this relationship, measured by the CDS-bond basis, are most frequently caused by an underlying illiquidity in the bond market (Nashikkar and Pedersen, 2007). Figure 4 plots the CDS-bond basis around the downgrade.[17] Not surprisingly, we observe that the basis for both GM and Ford jumped considerably around the downgrade, suggesting that GM and Ford bonds indeed became very illiquid in this period.

In this section we have documented evidence which suggest that the downgrade of GM and Ford bonds induced a large sell-off of these bonds, leading to a

[15] Press reports suggest that much selling of G.M. and Ford had been done in anticipation of the credit downgrading. For example, one institutional investor that had already begun selling G.M. was the TIAA-CREF pension fund. At the end of 2004, its G.M. holdings had dropped about 50 percent in two years to $200 million and have fallen further 2005. See the article in The New York Times, "Junk Ratings Make a Big Splash, Ripples Are Next", May 6, 2005.

[16] The relationship would be exact for a floating rate defaultable bond paying a continuous coupon and a CDS contract with the same maturity as the bond and a premium that is also paid continuously.

[17] To calculate the 5-year CDS-bond basis, we need the credit spread of an underlying bond with a maturity of five years. Since a bond that matures in exactly five years is not available for every point in time, we approximate it by linearly interpolating the spreads of two bonds whose maturities are closest to five years (one with maturity just under five years, and the other just over five years). We perform the interpolation on each day, choosing the two bonds from a pool of available GM/Ford bonds. Note that only senior, straight bonds are used for the credit spreads. Also note that short-term GM bonds are not available for the calculation of the 5-year CDS-bond basis, so 10-year CDS-bond basis is calculated for GM. 5-year CDS-bond basis is calculated for Ford.

high level of market imbalance and causing these bonds to become highly illiquid. In the following section, we will show that correlation in the CDS market also increased significantly in the downgrade period, and next, we will establish the relationship between these liquidity and correlation risks.

### 5.2 Increase in co-movement of fixed-income securities around the downgrade

The main thesis of this study is that the large sell-off of GM and Ford bonds adversely affected the inventory positions of intermediaries that make the bond market, forcing them to price their heightened inventory risk into prices of all other securities that they intermediate. Consistent with the hypothesis, we now demonstrate that CDS prices across all industries showed excess co-movement around the downgrade**.**

Why do we focus on the CDS market? There are at least three reasons. First, CDS are traded over the counter, and major intermediaries of CDS are the same large banks that also intermediate the bond market.[18] Therefore, if bond intermediaries were pricing their funding constraints into securities, they very likely adjusted CDS prices. Second, the spill-over effect of the GM and Ford downgrade was the largest in the fixed-income market. CDS market, being a very important part of the fixed-income market, provides a very good test ground for detecting the spill-over effect. Finally, we chose CDS over bonds because pricing data of CDS is superior to that of bonds and that the CDS market is more liquid and informationally efficient than the bond market (see, for example, Altman, Gande and Saunders, 2003 and Blanco, Brennan and Marsh, 2005).

It is important to note that large banks that intermediate the CDS market are often exposed to credit risk on their loan books. They either have direct exposure (i.e. loans) to same firms they are making markets in CDS for, or have correlated exposure due to loans made to firms in sectors of such firms. Therefore, while they provide liquidity by taking orders on both sides, they also have a natural desire to hedge in the CDS market. That is, on net flows, banks are buying CDS (paying CDS fee) but in many transactions, they also end up selling CDS (receiving CDS fee). The latter transaction raises their credit risk. Hence, when faced with heightened inventory risk,

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

banks are unlikely keep mid-market fee the same and simply widen their bid and ask quotes. They are more likely to raise the fee when selling CDS because buyers of CDS will have to pay higher fees to banks to compensate for the incremental credit risk that the transaction incurs. Thus, when intermediaries are constrained, even if they widen the bid-ask spread on a CDS name, they will mostly likely increase the mid-market fee for the CDS concurrently.

If intermediaries indeed systematically increased CDS spreads around the GM and Ford downgrade, CDS returns, and more precisely, the component of CDS returns that is unrelated to changes in the fundamentals, is expected to have become more correlated across different entities. 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.

Specifically, we employ the econometric methodology employed by Acharya and Johnson (2007) in their study of insider trading in credit derivatives to isolate CDS innovations. 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 percentage change in CDS level as $(CDS\ return)_{i,t}$ for firm i at date t, and the contemporaneous change in 90-day T-bill rate and 10-yr TSY rate as $TBill_t$ and $TSY_t$, the CDs innovation $u_{i,t}$ is obtained as residuals from the following specification:

$$\begin{aligned}(CDS\ return)_{i,t} = \alpha_i + \sum\nolimits_{k=0}^{5}[\beta_{i,t-k} + \gamma_{i,t}/(CDS\,level)_{i,t}](Stock\,return)_{i,t-k} \\ + \sum\nolimits_{t=1}^{5}\delta_{i,t-k}(CDS\ return)_{i,t-k} + TBill_t + TSY_t + u_{i,t}\end{aligned} \quad (1)$$

This specification is estimated firm by firm to obtain CDS innovations for all firms in the study. Innovations are then aggregated to into industry-level innovations by averaging innovations across all firms in the industry for each date. Remember that CDS innovations capture the component of CDS returns that is unrelated to changes in fundamentals (or default risk).

As preliminary evidence of the correlation increase around the downgrade, Figures 5 present X-Y scatter plots of CDS innovations for GM and the Consumer Services industry. In the plot, innovations in May 2005 are plotted with stars, innovations between Oct 2004 and July 2005, excluding May 2005, is plotted with circles, and innovations in rest of the period are plotted with dots. We observe that the slopes of the regression lines that fit through the innovations of May 2005 and innovations of Oct 2004 to July 2005, excluding May 2005, are steeper than those of the regression lines that fit through the innovations of the rest of the periods. This correlation pattern is observed for CDS innovations GM and each of all eight industries in our sample (not shown), providing clear evidence that correlation in the CDS market increased around the Ford and GM downgrade.

We proceed to test formally whether the increase in correlation around the downgrade is statistically significant.

$$H_o: Corr(Crisis)=Corr(Non\text{-}crisis)$$
$$H_a: Corr\ (Crisis)>Corr\ (Non\text{-}crisis)$$

We calculate the crisis and non-crisis correlations between the CDS innovations of GM and Ford, and CDS innovations between GM and 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 3A reports our test results. Consistent with our hypothesis, all nine pair's correlation increased significantly around the downgrade. The results for Ford (not reported) are weaker.

Testing difference in correlations across different sample periods may not be entirely reliable because estimation of correlation coefficients may be subject to bias (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. 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:

$$CDSinv_{CS,t} = \alpha_1 + \alpha_2 * Crisis_t + \beta_1 * CDSinv_{GM,t} + \beta_2 * (Crisis_t * CDSinv_{GM,t}) + e_t \quad (2)$$

*$Crisis_t$* 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. Estimation of (2) is repeated for innovations of GM and Ford, as well as GM and seven other industries. The estimation of (2) and all subsequent regressions in this study is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.

To test whether the sensitivity of CS innovations to GM innovations increased in crisis, we test $\beta_2$ >0. Table III Panel B shows that our earlier finding with correlation coefficients continues to hold for betas: $\beta_2$ in all nine specifications are statistically greater than zero, providing strong evidence that correlation increased around the GM and Ford downgrade. The results for Ford (not reported) are weaker.

Table IV provides further insight into the time series patterns in CDS co-movement in our sample period. It reports the betas in each in each of the six sub-periods for GM and Ford, as well as GM and each of the eight industries. Let's focus on betas between GM and the Consumer Services industry (plotted in Figure 6). We observe that in period 1 (*Sept 11, 2003 to Oct 13, 2004*), the beta between GM and CS innovations was 0.1. It increased slightly in the next few months, before jumping to 0.25 in period 4 (*May 5, 2005 to May 31, 2005).* This rise was quickly reversed in the two next periods, when beta fell to 0.04. The same pattern – beta rising to a maximum in the month after the downgrade and quickly dropping back to its pre-downgrade level - is observed between GM and each of the all eight industries. The pattern in betas suggests that co-movement in CDS rose sharply immediately post the downgrade and then quickly disappeared after a couple of months. This indicates that the excess CDS co-movement was relatively short-term, i.e., temporary in nature, consistent with our hypothesis in which the excess co-movements is driven by short-term liquidity effect rather than changes in the fundamentals.

In this section, we have shown that correlations across the CDS market increased significantly around the downgrade. In addition, we observed that the correlation increase was short-term in nature. These observations are supportive of our story that financial intermediaries, faced with large imbalances in their inventories, adjusted CDS prices across the board to compensate for their increased cost of intermediation around the time of 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 second that correlation 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 making the following observation: *If*

$$\begin{aligned} CDSinv_{GM,t} &= \alpha + \beta_{GM} * \text{GM Imb}_t + e_t, \quad \textit{and} \\ CDSinv_{CS,t} &= \alpha + \beta_{CS} * \text{GM Imb}_t + e_t, \quad \textit{then} \end{aligned} \tag{3}$$

$$Cov(CDSinv_{GM,t}, CDSinv_{CS,t}) = \beta_{GM} * \beta_{CS} * Var(\text{GM Imb}_t).$$

$\beta_{GM}$ in the above specification captures the sensitivity of GM CDS innovations ($CDSinv_{GM,t}$) to imbalance in GM bonds ($\text{GM Imb}_t$). Likewise, $\beta_{CS}$ 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 carrying out the actual regressions estimated, we modify specification (3) in two ways. First, as a LHS variable, we add industry bond imbalance to control for any effect that general liquidity in bonds of an industry may have on CDS innovations of that same industry[19]. Second, we believe that the relationship between CDS innovations and GM imbalance is stronger (or only exists) in the period around the downgrade (crisis period) than in other times (non-crisis period). The betas should be higher around the downgrade because the concurrent market illiquidity during that period significantly increases an intermediary's cost and risk of holding an imbalanced inventory, which makes intermediaries more likely to increase CDS spreads. To test our theory, we estimate the relationship between imbalance and CDS innovations for crisis and non-crisis periods separately by interacting imbalance with a crisis-period dummy. The regressions that we estimate are as follows:

$$CDSinv_{GM,t} = \alpha_1 + \alpha_2 * Crisis_t + \beta_{GM} * \text{GM Imb}_t + \beta_{GM,Crisis}(Crisis_t * \text{GM Imb}_t) + e_t$$

$$\begin{aligned} CDSinv_{CS,t} = {} & \alpha_1 + \alpha_2 * Crisis_t + \beta_{CS1} * \text{GM Imb}_t + \beta_{CS1,Crisis} * (Crisis_t * \text{GM Imb}_t) \\ & + \beta_{CS2} * \text{Industry Imb}_{CS,t} + \beta_{CS2,Crisis} * (Crisis_t * \text{Industry Imb}_{CS,t}) + e_t \end{aligned} \quad (4)$$

The model is also estimated for industry-level CDS innovations of other Autos, Financial, Basic Materials, Industrials, Oil & Gas, Technology and Utilities. The analysis is also repeated with Ford imbalance measures. Because imbalance measures at daily level are excessively noisy, these regressions are performed with weekly measures.

If the hypothesis that inventory imbalance has a significant impact on CDS prices around the downgrade holds, then loadings on the interaction term $Crisis_t * \text{GM Imb}_t$ should be significantly positive. Table V reports the estimation results for equation (4). All three main GM imbalance measures – *Imb%, Offer Ratio,* and *Offerer* – are used separately as measures of $\text{GM Imb}_t$. Their results are reported in Panels A, B, and C respectively. Focusing on the results for *Imb%* for the moment, we observe that $Crisis_t * \text{GM Imb}_t$ is statistically significantly positive in regressions with CDS innovations of GM and all eight industries. This is consistent with our hypothesis. The loading on $\text{GM Imb}_t$ are positive for all industries, but is not

[19] Bond imbalance for each industry is calculated by averaging the imbalances of all bonds in that industry.

statistically significant for most of the industries. In comparison, loadings on $Crisis_t * \text{GM Imb}_t$ are many times larger than loadings on $\text{GM Imb}_t$. Take the Consumer Services industry as an example, the loading on $Crisis_t * \text{GM Imb}_t$ is 0.16 (significantly positive at 1%) and the loading on $\text{GM Imb}_t$ is 0.02 (insignificant). Industry $\text{Imb}_t$ is largely insignificant. $Crisis_t$*Industry $\text{Imb}_t$, on the other hand, is significantly positive for five out of eight industries. It is counter intuitive that the sign of $Crisis_t$, the crisis period dummy, is negative (significant) for all industries. There is an interesting way of looking at Table V Panel A's results which makes this negative sign natural. Again, take the Consumer Services industry as an example, the net effects on CDS innovations in the crisis period is as follows:

$$-0.12 * Crisis_t + 0.16 * Crisis_t * \text{GM Imb}_t$$
$$= Crisis_t * (-0.12 * + 0.16 * \text{GM Imb}_{\text{Avg. Crisis}} + 0.16 * (\text{GM Imb}_t - \text{GM Imb}_{\text{Avg. Crisis}})$$
$$= Crisis_t * (-0.12 + 0.16 * 0.7 + 0.16 * (\text{GM Imb}_t - \text{GM Imb}_{\text{Avg. Crisis}}) )$$
$$= Crisis_t * (\text{approx. } 0* + 0.16 * (\text{GM Imb}_t - \text{GM Imb}_{\text{Avg. Crisis}}))$$

$\text{GM Imb}_{\text{Avg. Crisis}}$ is the average $\text{GM Imb}_t$ during the crisis period, which is equal to 0.7 for *Imb%*. Rewriting the model as deviation of $\text{GM Imb}_t$ from its average during the crisis illustrates that the downgrade period has little net effect on CDS innovations; the positive impact on CDS innovations only exists when $\text{GM Imb}_t$ is above its average during the crisis period.

It is also interesting to gauge the significance of $\text{GM Imb}_t$ by looking at how much of the variation in CDS innovations can be explained by the variation in $\text{GM Imb}_t$ in the crisis period versus in the non-crisis period. This is best done by estimating (4) separately for crisis and non-crisis periods and comparing the corresponding $R^2$'s. The last two columns of Table V report these $R^2$ values. We observe that the $R^2$ was much higher in the crisis period for GM CDS innovations as well as all eight industries. For example, $\text{GM Imb}_t$ explains as much as 19.5% of the variation in CDS innovations of the Consumer Services industry in crisis, but only 3.4% in non-crisis. When *Offer Ratio* and *Offerer* are used as the imbalance measure, the results in terms of the coefficient on $Crisis * \text{GM Imb}_t$ and the $R^2$ are very similar, but slightly weaker. The corresponding results for Ford innovations and imbalance measures (not reported) are very similar to those for GM.

So far, we have established that the GM and Ford bond imbalance is *statistically* significant in explaining the variations in CDS innovations of firms across a wide range of industries around the GM and Ford downgrade. However, it remains to be seen the impact of variation in the quote imbalance is *economically* significant.

Table VI 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 $\text{GM Imb}_t$ and $Crisis_t * \text{GM Imb}_t$ (reported in Table V) for each industry, then multiply this sum by the standard deviation of the imbalance in the crisis period. Panel A reports these economic-significance measures of *Imb%,* and Panel B and C report the same measures for *Offer Ratio* and *Offerer.* Focusing on Consumer Services again, we find that, around the downgrade, the CDS innovations of the Consumer Services sector increased by 1.7% for every one standard deviation increase in GM *Imb%* (0.093). This 1.7% increase is equivalent to an increase of 40.2% when measured in terms of the standard deviation of Consumer Sectors' CDS innovations in the crisis period. The relationship between GM imbalance and CDS innovations of each of the other seven industries' are also economically significant. CDS innovations for these industries show increases ranging from 1.12% (Utilities) to 2.14% (Auto) for a one standard deviation increase in *Imb%,* equivalent to a 32% and a 48% standard deviation increase in CDS innovations respectively. Once again, the results from using *Offer Ratio* and *Offerer* are very similar.

In this section, we have shown that imbalance in quotations in GM and Ford bonds is both statistically and economically significant in explaining the increase in the co-movement of CDS innovations that occurred during the GM and Ford downgrade. This finding provides strong support for our main thesis that the downgrade of GM and Ford increased the cost of intermediation for large banks, forcing banks to discount prices of securities across the board (including CDS spreads).

## 6. Extensions and robustness checks

### 6.1 Principal components analysis

Another way to investigate whether liquidity risk is indeed the driver of co-movement across industries is to estimate the principal components of CDS returns across industries and link these to liquidity risk factors.

Collin-Dufresne, Goldstein, and Martin (2001) investigate the determinants of credit spread changes and find that variables that should in theory determine credit spread changes 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 fail 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 can be explained by the GM and Ford bond imbalances. To capture the common variation, we estimate the principal components for CDS innovations in GM, Ford, and the eight industries. The principal components are computed separately for the crisis and non-crisis periods.

The results, reported in table VII, reveal that the first three factors explain 71%, 14%, and 4% of variations in the crisis period, and 47%, 18%, and 7% in the non-crisis period. Note that the first component in both the crisis and non-crisis periods 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%).

Next, each of the first three principal components is regressed on the GM imbalance measures as follows:

$$\begin{aligned} PC_{1,t} &= \alpha + \beta_1 * \text{Imb\%}_t + e_t \\ PC_{1,t} &= \alpha + \beta_1 * \text{Imb\%}_t + \beta_2 * OfferRatio_t + \beta_3 * Offerer_t + e_t \end{aligned} \qquad (5)$$

In the first specification, $PC_{1,t}$ is regressed only on *Imb%.* In the second specification, it is regressed on *Imb%, Offer Ratio, and Offerer*. Table VIII reveals that *Imb%* explains 22%, 4%, and 0.2% of the first, second, and third principal components in crisis, respectively, and 5%, 0.3%, and 0.01% in non-crisis. The three imbalance measures combined explain 22%, 29%, and 10% of the first, second, and third principal components in crisis and 16%, 1%, and 0.1% in non-crisis. These results strongly support our contention that, during the crisis period, the common variation in CDS innovations is strongly linked to variation in market liquidity. Outside the crisis period this relationship is much weaker.

### 6.2 Separately estimating crisis and non-crisis CDS innovations

In our previous analysis, CDS innovations are estimated for the entire period. To allow for a structural shift in the underlying dynamics linking CDS and equity returns, we re-estimate innovations for the crisis and non-crisis periods separately. One reason for a possible structural shift may be a change in the nature of information linkage between stock and CDS markets. Acharya and Johnson (2007) show, for example, that the leading of CDS markets by stock markets becomes weaker immediately prior to credit deterioration events. Another reason for a structural shift is that there may be a change in the volatility between the crisis and the non-crisis periods which would imply a change in the coefficients of regressing CDS returns on stock returns. The separate computation of CDS innovations in the two periods addresses the possibility that CDS innovations are more correlated in crisis period simply due to some common model error in our earlier computation of CDS innovations.

To this end, CDS innovations are re-estimated separately for the crisis and non-crisis periods and equation (5) is then re-estimated. Table IXA shows our earlier findings remain: $Crisis_t * \text{GM Imb}_t$ continues to be statistically significant for all but two industry, and $R^2$ is much higher in the crisis period than the non-crisis period.

### 6.3 Lagged daily imbalance measures

In our analysis so far, we have regressed weekly CDS innovations on contemporaneous weekly imbalance measures. Endogeneity may be a concern here because it is also plausible that changes in CDS innovations may also affect GM and Ford quote imbalances at the same time. Therefore, to conclude that it is indeed the imbalance that has caused CDS correlation to increase, and not the other way around, we regress CDS innovations on the lagged imbalance measures. Lagging weekly imbalances, however, can be problematic because the illiquidity effect they capture is very short-term in nature and may disappear in a day or two. Lagged daily imbalance measures, while quite noisy, are much better because they capture this short-term liquidity effect.

Replacing weekly CDS innovations with daily CDS innovations, and contemporaneous weekly imbalances with lagged daily imbalances, we again re-estimate equation (5) and report the results in Table IXB. Compared to the weekly regressions, the $R^2$ for these daily regressions are much smaller, reflecting the fact that the daily measures are noisier. However, our earlier findings continue to hold, namely that the $R^2$ in the crisis period is much higher than in the non-crisis period and $Crisis*$ $\text{GM Imb}_t$ is statistically significant (for all, but three industries).

**6.4 Contemporaneous plus lagged weekly imbalance**

As an extension of the base model with only contemporaneous GM imbalance, we include both the contemporaneous (t) and the lagged (t-1) imbalances to gauge their combined effect on CDS innovations (t). Specifically, we perform the following regression with weekly measures:

$$\begin{aligned} CDSinv_{CS,t} = {} & \alpha_1 + \alpha_2 * Crisis_t + \beta_{CS1,t} * \text{GM Imb}_t + \beta_{CS1,Crisis,t} * (Crisis_t * \text{GM Imb}_t) \\ & + \beta_{CS2,t} * \text{Industry Imb}_{CS,t} + \beta_{CS2,Crisis,t} * (Crisis_t * \text{Industry Imb}_{CS,t}) \\ & + \beta_{CS1,t-1} * \text{GM Imb}_{t-1} + \beta_{CS1,Crisis,t-1} * (Crisis_t * \text{GM Imb}_{t-1}) \\ & + \beta_{CS2,t-1} * \text{Industry Imb}_{CS,t-1} + \beta_{CS2,Crisis,t-1} * (Crisis_t * \text{Industry Imb}_{CS,t-1}) + e_t \end{aligned} \quad (6)$$

The imbalance measures are highly persistent, with auto-correlations raging between 0.75 and 0.95. It was, therefore, not surprising that, the coefficients on $Crisis_t * \text{GM Imb}_t$ and $Crisis_t * \text{GM Imb}_{t-1}$ are both positive but insignificant for almost all of the industries. However, since we are interested in gauging the combined effect of the contemporaneous and lagged imbalances, we sum the coefficients on $Crisis_t * \text{GM Imb}_t$ and $Crisis_t * \text{GM Imb}_{t-1}$ to test whether the sum is greater than zero; the same is done for the industry imbalances. Table IVC reports the estimation and test results. We observe that the summed coefficient on $Crisis_t * \text{GM Imb}_t$ and $Crisis_t * \text{GM Imb}_{t-1}$ is significantly greater than zero for GM innovations and innovations of all eight industries. Compared to the coefficient on $Crisis * \text{GM Imb}_t$ in the base model (See Table V), the magnitude or significance of the summed coefficient on $Crisis_t * \text{GM Imb}_t$ and $Crisis_t * \text{GM Imb}_{t-1}$ is not significantly higher, suggesting that including $\text{GM Imb}_{t-1}$ did not significantly improve the explanatory power of the imbalance measure on CDS innovations.

### 6.5 Financial commercial paper to T-bill spread

We have argued that intermediaries of bond and CDS markets priced their funding constraints into securities that they intermediate, and that it was through this channel which CDS of different entities became more correlated around the GM and Ford downgrade. It is, however, conceivable that the observed correlation increase in CDS operated through other channels. One plausible argument is that the liquidity effect was caused by heightened demand for CDS: bonds became highly illiquid and difficult to short, so investors sought to purchase CDS and this is what drove CDS prices up.

There are at two observations that lend more support to our story than to the increased demand story. First, GM imbalance affected not only GM CDS, but also the CDS in all other industries. For the demand channel story to be valid, one needs to believe that illiquidity in GM and Ford bonds spilled over to other bonds, so all bonds became difficult to trade and short during the downgrade, driving up the demand and prices of all CDS. Second, GM illiquidity affected CDS innovations of an industry, even after controlling for illiquidity of bonds of that industry. This suggests that the observed effect is not local to CDS and bonds of each entity, but is perhaps coming from a common factor affected by illiquidity in GM bonds. Our hypothesis is that this common factor is the intermediaries being left with and inventory imbalances and raising spreads of CDS that they intermediate.

To more explicitly show that it was funding constraints of financial intermediaries that increased CDS correlation across the board, we analyse a proxy for these funding constraints – the spread between financial commercial paper (CP) and T-bill rates. We calculated the weekly percentage changes in the spread between 90-day AA financial CP rate and the 90-day T-bill rate. We then included weekly change in this CP - T-bill (denoted as $CP_t$), its interactions with $Crisis_t$, GM $Imb_t$ and Industry $Imb_t$ in the regression of CDS innovations on GM $Imb_t$ as follows:

$$\begin{aligned} CDS\ inv_{CS,t} = {} & \alpha_1 + \alpha_2 * Crisis_t + \beta_{CS1} * GM \text{ Imb}_t + \beta_{CS1,Crisis} * (Crisis_t * GM \text{ Imb}_t) \\ & + \beta_{CS2} * Industry_{CS} \text{ Imb}_t + \beta_{CS2,Crisis} * (Crisis_t * Industry_{CS} \text{ Imb}_t) \\ & + \beta_{CP1} * CP_t + \beta_{CP1,Crisis} * Crisis_t * CP_t + \beta_{CP2} * CP_t * GM \text{ Imb}_t \\ & + \beta_{CP3} * CP_t * Industry_{CS} \text{ Imb}_t + \beta_{CP2,Crisis} * Crisis_t * CP_t * GM \text{ Imb}_t \\ & + \beta_{CP3,Crisis} * Crisis_t * CP_t * Industry_{CS} \text{ Imb}_t + e_t \end{aligned} \tag{7}$$

Table IVD reports the results of the estimation. Loadings on $CP_t$, $CP_t$*Industry $Imb_t$, $CP_t$*GM $Imb_t$ and $Crisis_t$*$CP_t$*Industry $Imb_t$ are insignificant. However, we observe that loadings on $Crisis_t$*$CP_t$*GM $Imb_t$ are positive for all but one industry (significantly positive for CDS innovations of GM and five industries). The fact that changes in the CP - T-bill spread, when interacted with GM imbalance, is positively correlated with CDS innovations during crisis indicates that large CDS innovations was associated with heightened funding constraints when GM and Ford bonds became illiquid around the downgrade. This finding lends support to our story that CDS became more correlated around the downgrade because CDS spreads incorporated intermediaries' increased funding constraints.

### 6.6 Controlling for the "risk appetite" of financial intermediaries

Is it possible that our liquidity risk measures are simply a proxy for heightened aversion to risk in general 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 at least two reasons to examine the role of CBOE U.S. VIX option volatility index. First, there is at least some component of VIX which is tied to the underlying volatility of stock markets (as captured in implied volatility of options). Though we already demonstrated the robustness of our results to estimating CDS innovations separately in crisis and non-crisis periods for each underlying firm, controlling for VIX while relating CDS innovations of different firms helps control for a possible omission of a market-wide volatility effect in the computation of our innovations. Second, and perhaps more important, the role of VIX as a measure of global risk appetite of financial institutions has found some support as a common factor driving co-movement of sovereign CDS (Pan and Singleton, 2007, for example)[20].

Therefore, we add the weekly percentage changes in VIX to our base model (5) as a new regressor (denoted as $VIX_t$), also allowing it to interact with $Crisis_t$. Table IXE shows that changes in VIX do indeed have a significant impact on CDS innovations, especially during the crisis period. Once again, however, the explanatory power of the quote imbalance in the crisis still remains and the coefficients on $Crisis_t * \text{GM Imb}_t$ neither loses its significance nor diminishes in magnitude. For most of the industries, the magnitude of loadings $Crisis_t * VIX_t$ and $Crisis_t * \text{GM Imb}_t$ are very similar. Take Consumer Services as an example again, the loadings on $VIX_t$ and $Crisis_t * VIX_t$ are 0.05 (significant at 10%) and 0.14 (significantly greater than zero at 5%) respectively. The loadings on $\text{GM Imb}_t$ and $Crisis * \text{GM Imb}_t$ are 0.03 and 0.17 (significantly greater than zero at 1%) respectively. Comparing these results to those without including changes in VIX (reported earlier in Table V), we see that the coefficients on $Crisis_t * \text{GM Imb}_t$ are almost unchanged, suggesting that changes VIX and our crisis-liquidity variable $Crisis_t * \text{GM Imb}_t$ are almost orthogonal.

### 6.7 Effect on investment grade versus sub-investment grade spreads

It is commonly held that, during crisis, liquidity generally dries up more severely for sub-investment-grade than for investment-grade securities. In this case the relationship between inventory imbalance and CDS innovations may be different for investment-grade and sub-investment-grade firms.

To test this hypothesis, we create dummy variables $Crisis_t$ and $NonCrisis_t$ for observations around the downgrade and observations in other periods, and dummy variables *Inv* and *Subinv* for sub-investment-grade and investment-grade firms. The

[20] Pan and Singleton (2007) extract risk premia embedded in the CDS fees for Mexico, Turkey and Korea, three seemingly unrelated countries, and show that these risk premia are significantly correlated to the U.S. VIX, the 10-year BB corporate to 6-month treasury bill spread in the U.S. and own-country's currency option volatility: "[D]uring some subperiods, a substantial portion of the co-movement among the term structures of sovereign spreads across countries was induced by changes in investors' appetites for credit exposure at a global level, rather than to reassessments of the fundamental strengths of these specific sovereign economies."

four dummies and their interactions with lagged GM inventory imbalance are then used as dependent variables in the following regression:

$$\begin{aligned} CDS\ inv_{GM,t} &= \alpha_1 * Inv * Crisis_t + \alpha_2 * Inv * NonCrisis_t \\ &+ \alpha_3 * Subinv * Crisis_t + \alpha_4 * Subinv * NonCrisis_t \\ &+ \beta_{Inv,NonCr}(Inv * NonCrisis_t * \text{GM Imb}_t) + \beta_{Inv,Cr}(Inv * Crisis_t * \text{GM Imb}_t) \\ &+ \beta_{Sub,NonCr}(Subinv * NonCrisis_t * \text{GM Imb}_t) + \beta_{Sub,Cr}(Subinv * Crisis_t * \text{GM Imb}_t) + e_t \end{aligned} \tag{8}$$

Similar regressions are estimated for CDS innovations for all eight industries. Using the estimated regression coefficients from specification (VII), we test whether:

$$(\beta_{Sub,Cr} - \beta_{Sub,NonCr}) - (\beta_{Inv,Cr} - \beta_{Inv,NonCr}) > 0$$

This relation should hold if the impact of GM and Ford inventory imbalances on CDS spreads during the crisis was larger for sub-investment-grade firms than for investment-grade firms.

Table IXF gives the estimation results for (8). We observe that $(\beta_{Sub,Cr} - \beta_{Sub,NonCr}) - (\beta_{Inv,Cr} - \beta_{Inv,NonCr}) > 0$ for all but one industry, but it is significantly different greater than zero for only Auto and Technology.

## 7. Concluding remarks

Besides being the first academic study to our knowledge which studies in detail the effects of GM and Ford downgrade, our paper has at least two other significant implications. First, it provides direct evidence as to whether fluctuations in prices in credit markets are unrelated to changes in equity markets, at least some of the times, and whether institutional frictions and liquidity effects are responsible for such segmentation. Our evidence suggests that the answer to this questions may be in the affirmative and this has the potential to shed light on the long-standing puzzle of why credit spreads are much wider than predicted by structural models of credit risk and exhibit a common unexplained factor across corporate bonds of different ratings and maturities (Collin-Dufresne, Goldstein and Martin, 2001 and Schaefer and Strebulaev, 2005).

Second, if market liquidity risk, funding liquidity risk, and correlation risk are all inter-twined, then 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 fluctuations in correlations measured using statistical data and implied from extant models employed to value products such as CDOs, CLOs, and their tranches: Traditional covariance calculations or derivative-pricing models do not allow for such liquidity effects, and, hence, cannot isolate correlation risk due to fundamentals and that due to liquidity risk. The problem is akin to the one raised by Grossman (1988) and Grossman and Zhou (1996) in that just as option-pricing models based on frictionless market assumptions end up catching all effects of market frictions in the implied volatility parameter, current correlation models end up absorbing all liquidity effects in the implied correlation parameters. Recognizing and understanding the true source of fluctuation in the implied correlations can be important for hedging of correlation products. Specifically, in times of no stress to market and funding liquidity, hedging of correlation risk by model-implied hedging strategies is likely to be successful, whereas during times of liquidity crises, model-implied delta-hedging based on underlying risks or securities is unlikely to be effective. The model-based hedging actually undertaken in markets by holders of CLO and CDO tranches may have partly contributed to the "dislocation" in correlation trading witnessed around the GM and Ford downgrade. The message from our study is that hedging of such liquidity risk and correlation risk requires being prepared to enter stress times with liquid buffers, good collateral and access to funding sources (perhaps even the Central Bank in times of severe stress).

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**Figure 1. Daily 5-year CDS spreads for GM and Ford**

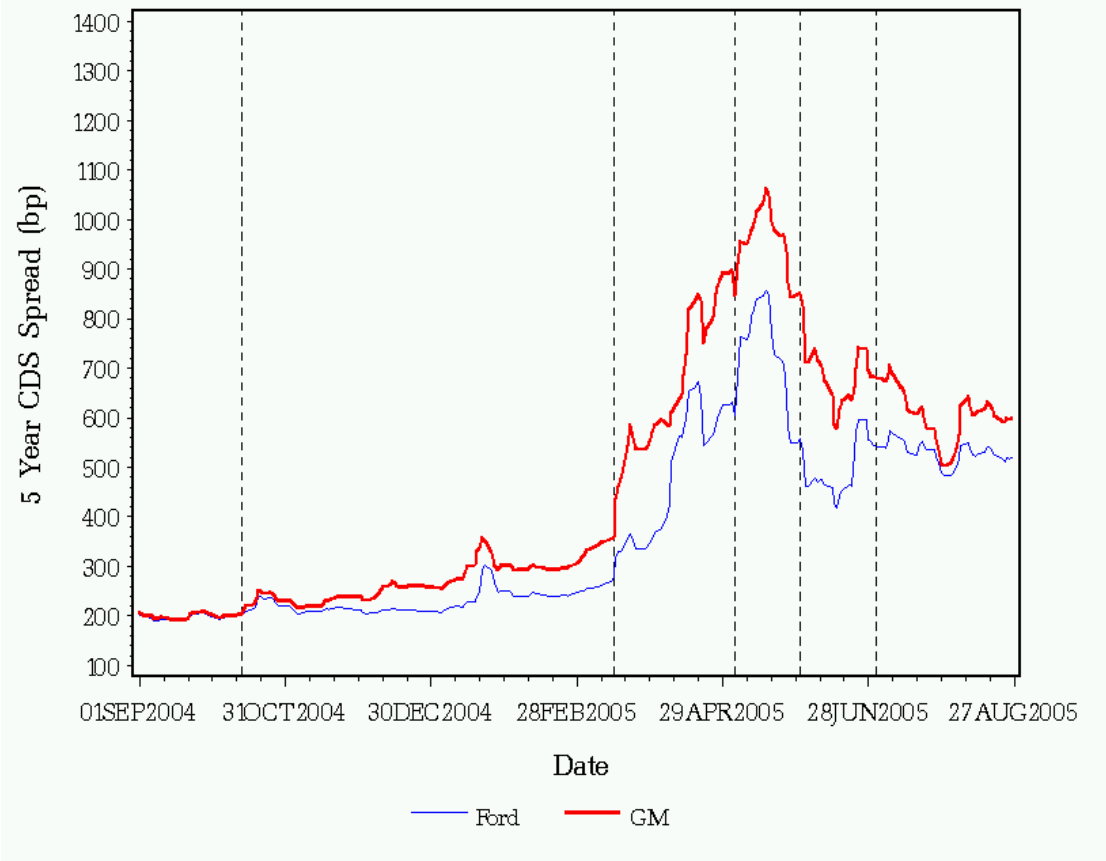


**Figure 2. Daily 5-year CDS spreads for six large banks.**

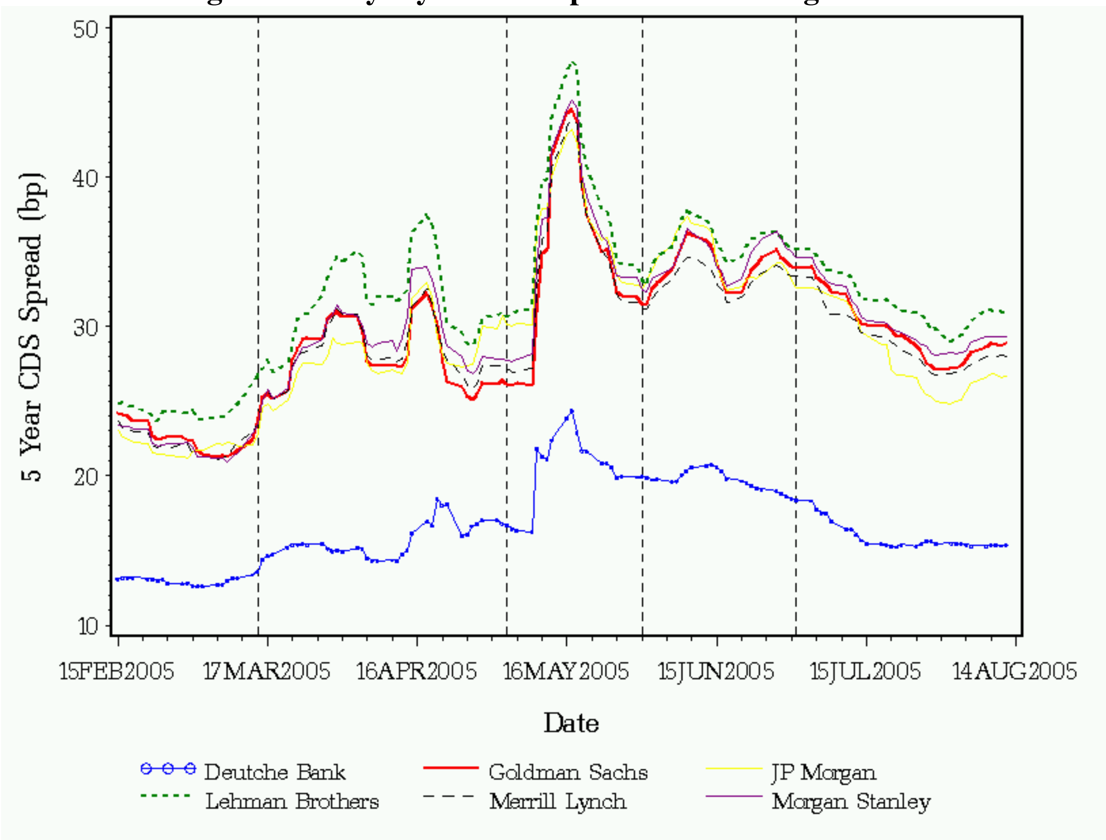

**Figure 3A. GM and Ford *Imbalance %* in six sub-periods.**

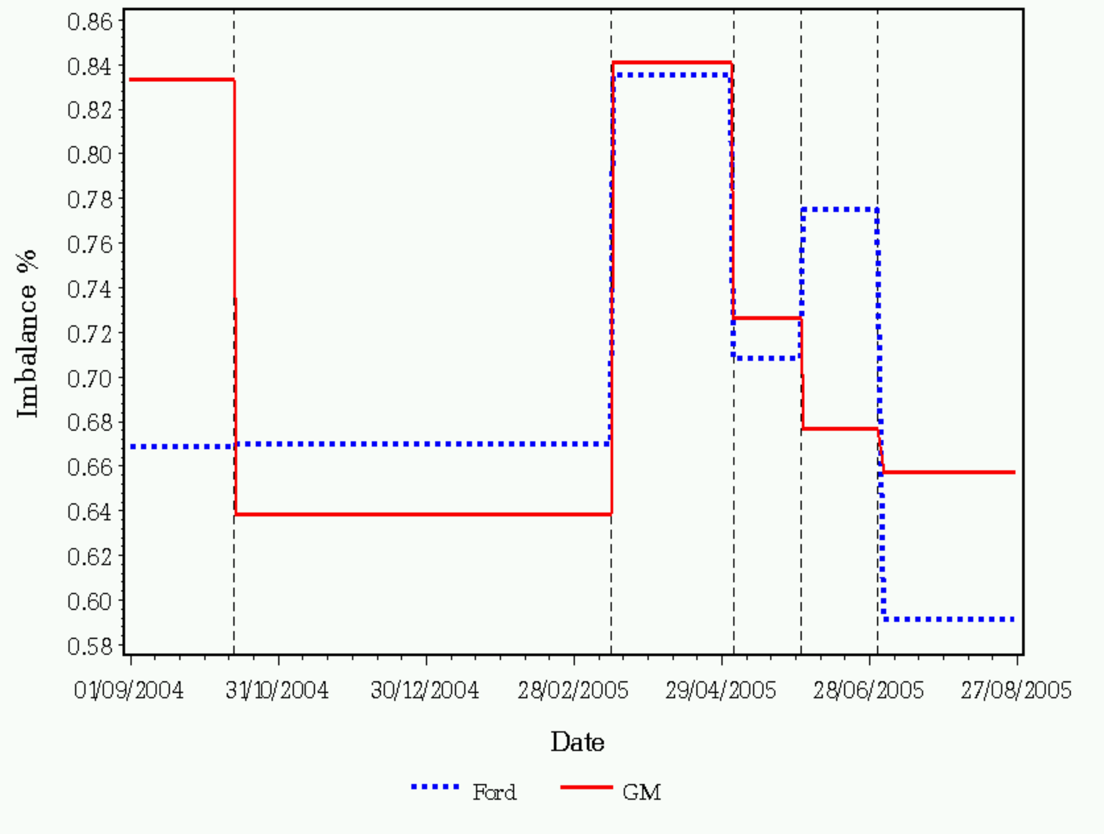


**Figure 3B. GM and Ford *Offer Ratio* in six sub-periods.**

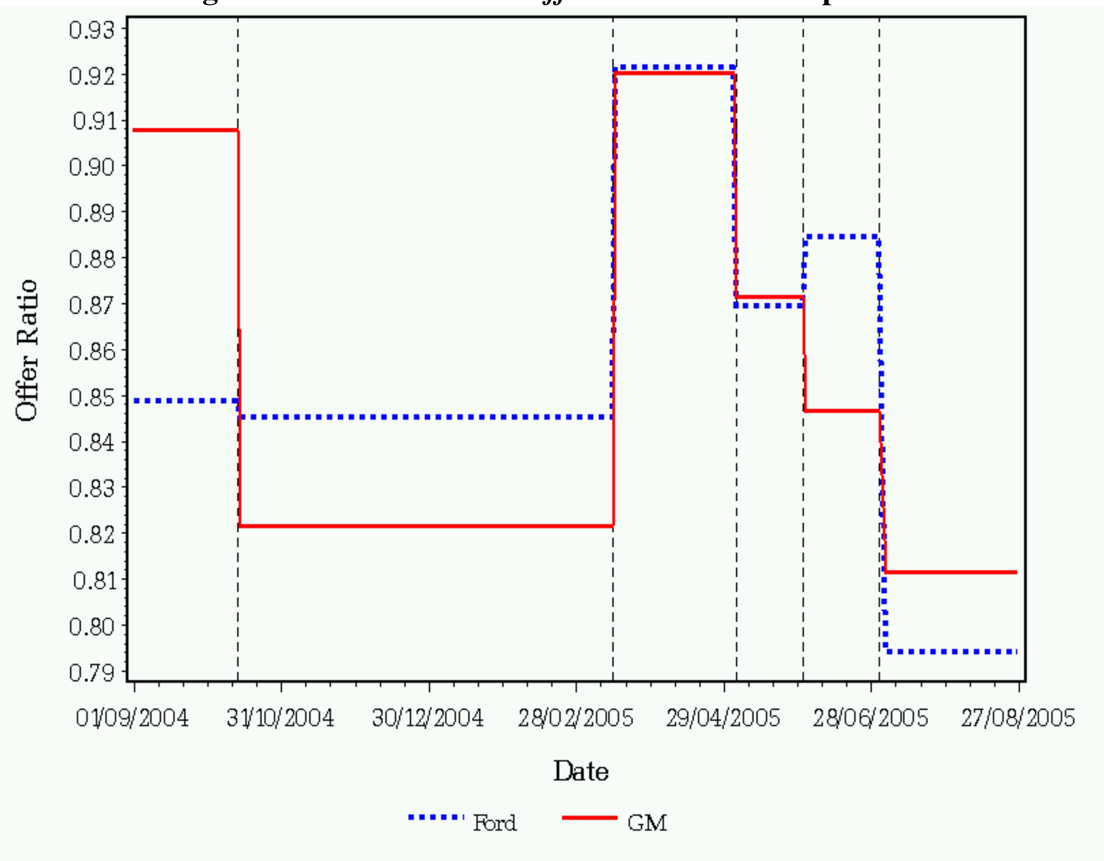

**Figure 4. Daily CDS-bond basis for GM and Ford.**


**Figure 5. X-Y scatter plot and regression lines for GM CDS innovations and CDS innovations of the Consumer Services sector.**

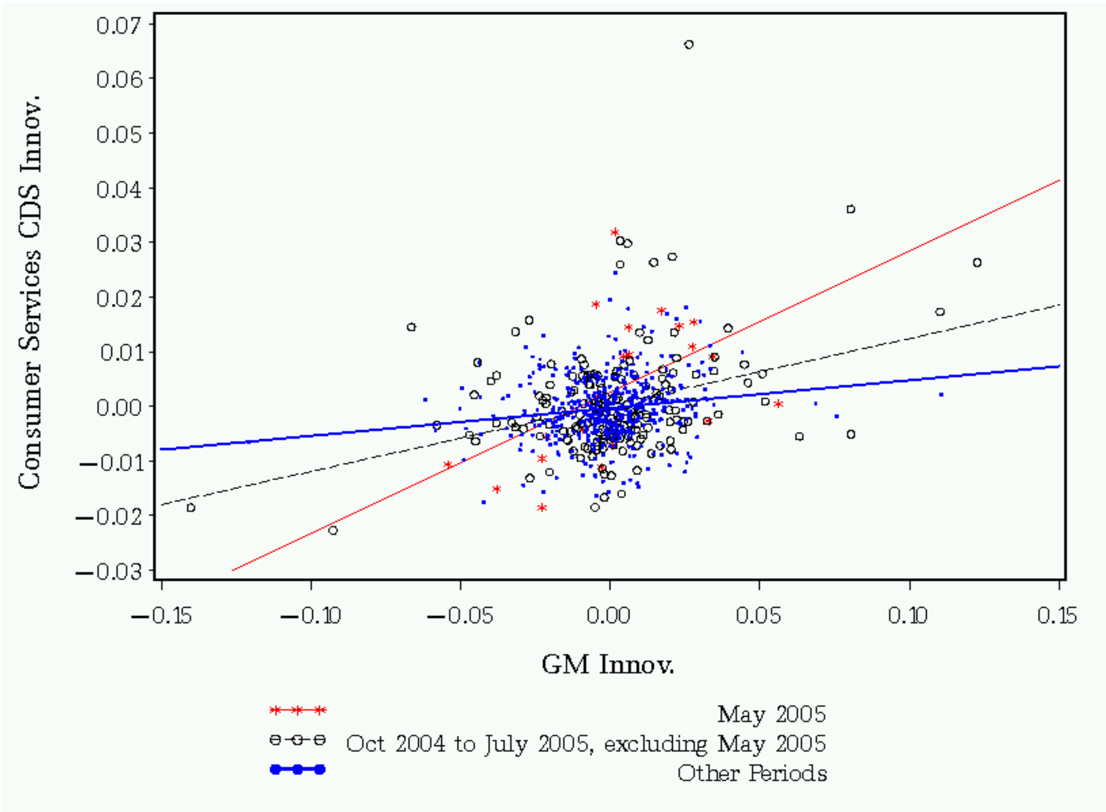

**Figure 6: Betas between CDS innovations of GM and the Consumer Services sector in six sub-periods.**

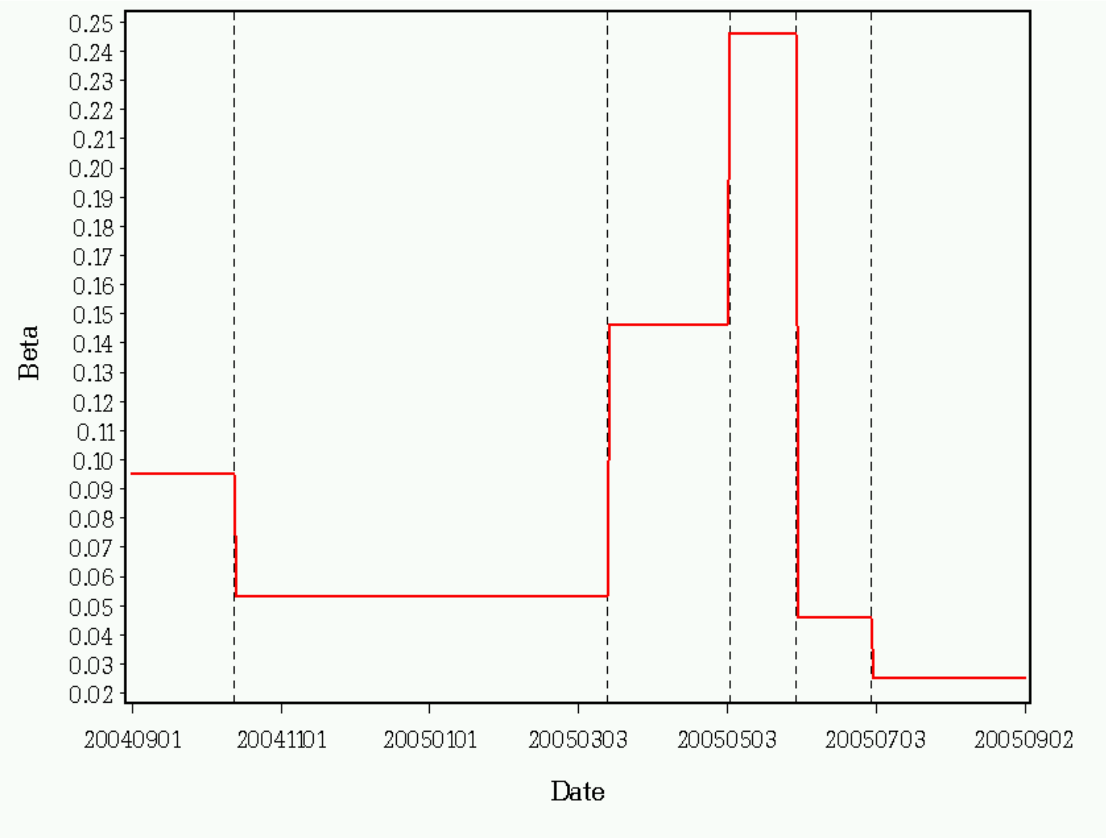

**Table I**

Summary Statistics

This table contains basic summary statistics for firms in our sample. Panel A reports the number of 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 for GM, Ford, and all firms in our sample. See the Data section (section 4) of the paper for details on the criteria for inclusion in the sample. 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 | *Low* | *Median* | *High* |
|---|---|---|---|
| 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**

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

**Panel C: Ford**

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

**Panel D: All Firms**

| | *Low* | *Median* | *High* |
|---|---|---|---|
| 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 Risk | AAA | BBB | CCC- |
| Observations /day | 354 | 444 | 488 |

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

| | *Low* | *Median* | *High* |
|---|---|---|---|
| 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**

Various Imbalance Measures Across Different Periods

This table reports the mean and standard deviations (in brackets) of various weekly imbalance measures for GM and Ford across six sub-periods of our sample.
*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.

**Panel A: GM**

| *Period* | *Imb %* | *Offer Ratio* | *Offerer* | *Two Quotes %* |
|---|---|---|---|---|
| Sept 11, 03 - Oct 13, 04 | 0.83<br>(0.12) | 0.91<br>(0.06) | 0.90<br>(0.07) | 0.03<br>(0.03) |
| Oct 14, 04 - Mar 15, 05 | 0.64<br>(0.08) | 0.82<br>(0.04) | 0.79<br>(0.05) | 0.10<br>(0.03) |
| Mar 16, 05 – May 4, 05 | 0.84<br>(0.05) | 0.92<br>(0.03) | 0.92<br>(0.03) | 0.02<br>(0.02) |
| May 5, 05 – May 31, 05 | 0.73<br>(0.06) | 0.87<br>(0.02) | 0.87<br>(0.02) | 0.00<br>(0.00) |
| Jun 1, 05 – Jul 1, 05 | 0.68<br>(0.07) | 0.85<br>(0.02) | 0.85<br>(0.03) | 0.02<br>(0.01) |
| Jul 2, 05 – May 19, 06 | 0.66<br>(0.13) | 0.81<br>(0.08) | 0.82<br>(0.10) | 0.10<br>(0.09) |

**Panel B: Ford**

| *Period* | *Imb %* | *Offer Ratio* | *Offerer* | *Two Quotes %* |
|---|---|---|---|---|
| Sept 11, 03 - Oct 13, 04 | 0.67<br>(0.06) | 0.85<br>(0.03) | 0.84<br>(0.04) | 0.02<br>(0.02) |
| Oct 14, 04 - Mar 15, 05 | 0.67<br>(0.08) | 0.85<br>(0.04) | 0.82<br>(0.05) | 0.08<br>(0.03) |
| Mar 16, 05 – May 3, 05 | 0.84<br>(0.02) | 0.92<br>(0.01) | 0.92<br>(0.01) | 0.01<br>(0.01) |
| May 4, 05 – May 31, 05 | 0.71<br>(0.06) | 0.87<br>(0.03) | 0.87<br>(0.03) | 0.01<br>(0.01) |
| Jun 1, 05 – Jul 1, 05 | 0.78<br>(0.08) | 0.88<br>(0.03) | 0.89<br>(0.03) | 0.01<br>(0.01) |
| Jul 2, 05 – May 19, 06 | 0.59<br>(0.14) | 0.79<br>(0.08) | 0.76<br>(0.12) | 0.09<br>(0.08) |

## Table III

### Tests of Increase in CDS Correlations and Betas During the Crisis Period

This table tests the significance of the increase in correlations and betas of daily CDS innovations during the crisis period. Panel A uses correlation coefficients as the correlation measure. Testing the significance of the difference between two correlations involves converting correlations into z-scores using Fisher's transformation and computing the appropriate t-stats. All tests performed on the correlation differences are one-sided, since a correlation increase in the crisis period is predicted. Panel B uses regression coefficients (betas) as the correlation measure. It is based on the estimation of

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

The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The *s for $\alpha_1$, $\alpha_2$, and $\beta_1$ indicate its level of significance (two-sided tests).
The *s for $\beta_2$ 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.
The number of observations for all specifications is 634.

**Panel A : Correlation Coefficients**

| *Variables* | *Corr (Non-Crisis)* | *Corr (crisis)* | ***Diff.*** |
|---|---|---|---|
| X=GM, Y=Ford | 0.681 | 0.781 | **0.010*** ** |
| X=GM, Y=Other Autos | 0.360 | 0.589 | **0.229*** ** |
| X=GM, Y=Basic Materials | 0.114 | 0.273 | **0.159** ** |
| X=GM, Y=Consumer Services | 0.158 | 0.353 | **0.196*** ** |
| X=GM, Y=Financials | 0.180 | 0.326 | **0.146** ** |
| X=GM, Y=Industrials | 0.128 | 0.281 | **0.154** ** |
| X=GM, Y=Oil & Gas | 0.131 | 0.332 | **0.201*** ** |
| X=GM, Y=Technology | 0.154 | 0.290 | **0.136** ** |
| X=GM, Y=Utilities | 0.098 | 0.259 | **0.161** ** |

**Panel B : Betas (Regression Coefficients)**

| *Variables* | $\alpha_1$ | $\alpha_2$ | $\beta_1$ | $\boldsymbol{\beta_2}$ | $R^2$ |
|---|---|---|---|---|---|
| X=GM, Y=Ford | 0.0002 | -0.001 | 0.723*** | **0.195** ** | 54.4% |
| X=GM, Y=Other Autos | -0.0003 | <0.001 | 0.223*** | **0.094* ** | 22.3% |
| X=GM, Y=Basic Materials | -0.0003 | 0.001 | 0.041** | **0.075** ** | 5.1% |
| X=GM, Y=Consumer Services | -0.0003 | 0.001 | 0.050*** | **0.084** ** | 8.7% |
| X=GM, Y=Financials | -0.0003 | 0.001 | 0.051*** | **0.058** ** | 7.8% |
| X=GM, Y=Industrials | -0.0002 | <0.001 | 0.040*** | **0.052** ** | 5.0% |
| X=GM, Y=Oil & Gas | -0.0001 | <0.001 | 0.049*** | **0.105*** ** | 7.4% |
| X=GM, Y=Technology | -0.0001 | <0.001 | 0.076*** | **0.053* ** | 5.2% |
| X=GM, Y=Utilities | <0.0001 | <0.001 | 0.038** | **0.055** ** | 3.6% |

**Table IV**

# Betas (and Increments in Betas) Between Daily CDS Innovations Across Six Sub-periods

This table provides the betas between various pairs of daily CDS innovations (in the left-most column) in six sub-periods:

*Period 1: Sept 11, 2003 to Oct 13, 2004;*
*Period 2: Oct 14, 2004 to March 15, 2005;*
*Period 3: March 16, 2005 to May 4, 2005;*
*Period 4: May 5, 2005 to May 31, 2005;*
*Period 5: June 1, 2005 to July 1, 2005;*
*Period 6: July 2, 2005 to May 19, 2006;*

$\beta_1$ is the beta in period 1. $\beta_2$ to $\beta_6$ are the increments in betas (over $\beta_1$) in periods 2 to 6. For example, beta in period 2 is ($\beta_1+\beta_2$).
The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The *s for $\beta_1$ indicate its level of significance (two-sided tests).
The *s for $\beta_2$ to $\beta_6$ indicate the significance of the test $\beta_i>0$ (one-sided).
Rejection of the null at the 10%, 5%, or 1% level is indicated by * , * * , or * * * , respectively.
The number of observations for all specifications is 634.

| *Variables* | $\beta_1$ | $\beta_2$ | $\beta_3$ | $\beta_4$ | $\beta_5$ | $\beta_6$ | $R^2$ |
|---|---|---|---|---|---|---|---|
| X=GM, Y=Ford | 1.033*** | -0.051 | -0.12* | 0.287* | -0.194* | -0.516*** | 58.2% |
| X=GM, Y=Other Autos | 0.156*** | 0.033 | 0.146** | 0.313** | 0.135*** | 0.115* | 25.8% |
| X=GM, Y=Basic Materials | 0.089*** | 0.012 | -0.048 | 0.322** | -0.029 | -0.072** | 14.6% |
| X=GM, Y=Consumer Services | 0.095*** | -0.042 | 0.051 | 0.151* | -0.049 | -0.07*** | 18.7% |
| X=GM, Y=Financials | 0.083*** | -0.003 | 0.054 | 0.148* | -0.077** | -0.052** | 15.3% |
| X=GM, Y=Industrials | 0.073*** | -0.058 | -0.002 | 0.171* | -0.007 | -0.057*** | 16.3% |
| X=GM, Y=Oil & Gas | 0.081** | -0.044 | 0.092** | 0.178* | 0.016 | -0.053* | 12.9% |
| X=GM, Y=Technology | 0.134*** | -0.117* | 0.006 | 0.084 | -0.075 | -0.09** | 9.0% |
| X=GM, Y=Utilities | 0.085** | -0.039 | -0.028 | 0.248* | -0.066* | -0.069** | 10.3% |

# Table V

## Regression of Weekly CDS Innovations on GM Imbalance Measures

This table contains the regression results of weekly CDS innovations on weekly GM imbalance measures as in the following model:

$$CDSinv_{CS,t} = \alpha_1 + \alpha_2 * Crisis_t + \beta_{CS1} * \text{GMImb}_t + \beta_{CS1,Crisis} * (Crisis_t * \text{GMImb}_t) + \beta_{CS2} * \text{Industry Imb}_{CS,t} + \beta_{CS2,Crisis} * (Crisis_t * \text{Industry Imb}_{CS,t}) + e_t$$

*Crisis* is a dummy that is equal to one in the period between Oct 2004 and July 2005.
The last two columns display the $R^2$ of the following estimation for Crisis and Non-crisis periods:

$$CDS\ inv_{CS,t} = \alpha + \beta_{CS1} * GM\ IMB_t + \beta_{CS2} * Industry_{CS}\ IMB_t + e_t$$

The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
Panel A shows the results using *Imbalance %* as the imbalance measure. Panel B shows the results using *Offer Ratio* as the imbalance measure. Panel C shows the results using *Offerer* as the imbalance measure.
The *s loadings on (*Crisis* GM Imb*) and (*Crisis*Industry Imb*) indicate the significance of the one-sided tests.
The *s for all other coefficient estimates indicate their level of significance (two-sided tests).
Rejection of the null at the 10%, 5%, or 1% level is indicated by *, **, or ***, respectively.
The number of observations for all specifications is 127.

**Panel A: Imbalance %**

| *Industry* | α | *Crisis* | *GM Imb* | ***Crisis* GM Imb*** | *Industry Imb* | *Crisis* Industry Imb* | $R^2$ | ***Crisis*** $R^2$ | ***Non-crisis*** $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| GM | -0.01 | -0.20** | 0.003 | **0.30**** | | | 11.1% | **20.9%** | **<0.1%** |
| Other Autos | -0.02 | -0.13*** | 0.02 | **0.21***** | 0.01 | -0.02 | 13.4% | **21.8%** | **1.7%** |
| Basic Materials | -0.01 | -0.12*** | 0.02 | **0.14***** | -0.02 | 0.06* | 10.3% | **12.0%** | **3.9%** |
| Consumer Services | -0.02 | -0.12*** | 0.02 | **0.16***** | 0.01 | 0.04 | 15.4% | **19.5%** | **3.4%** |
| Financial | -0.01 | -0.13*** | 0.02 | **0.07*** | -0.02 | 0.11** | 10.7% | **14.0%** | **3.0%** |
| Industrials | -0.02 | -0.11*** | 0.06*** | **0.07*** | -0.05* | 0.14** | 19.5% | **24.0%** | **11.8%** |
| Oil & Gas | -0.01 | -0.13*** | 0.04* | **0.14**** | -0.04 | 0.07 | 11.5% | **15.5%** | **3.8%** |
| Technology | -0.02 | -0.10*** | 0.03 | **0.11**** | -0.02 | 0.06* | 9.2% | **12.9%** | **3.7%** |
| Utilities | -0.02 | -0.07** | 0.04** | **0.08*** | -0.06 | 0.05* | 14.4% | **19.9%** | **7.4%** |

**Panel B: Offer Ratio**

| *Industry* | *α* | *Crisis* | *GM Imb* | ***Crisis* GM Imb*** | *Industry Imb* | *Crisis* Industry Imb* | $R^2$ | ***Crisis*** $R^2$ | ***Non-crisis*** $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| GM | -0.03 | -0.40*** | 0.03 | **0.49**** | | | 7.9% | **13.9%** | **0.2%** |
| Other Autos | -0.06* | -0.28** | 0.04 | **0.39***** | 0.02 | -0.06 | 12.7% | **19.7%** | **2.7%** |
| Basic Materials | -0.01 | -0.30*** | 0.05 | **0.29***** | -0.05 | 0.09 | 10.8% | **12.0%** | **5.8%** |
| Consumer Services | -0.05 | -0.30*** | 0.05 | **0.31***** | -0.01 | 0.06 | 14.4% | **17.6%** | **4.7%** |
| Financial | -0.02 | -0.28*** | 0.06 | **0.12** | -0.04 | 0.20* | 10.4% | **12.6%** | **4.9%** |
| Industrials | -0.04 | -0.29*** | 0.12*** | **0.14*** | -0.10* | 0.2* | 20.2% | **22.8%** | **15.5%** |
| Oil & Gas | -0.02 | -0.32*** | 0.08 | **0.34**** | -0.07 | 0.05 | 11.8% | **15.8%** | **4.1%** |
| Technology | -0.04 | -0.27** | 0.07* | **0.17*** | -0.04 | 0.16** | 9.0% | **11.4%** | **5.2%** |
| Utilities | -0.05 | -0.22*** | 0.11* | **0.17*** | -0.08 | 0.11* | 15.8% | **19.8%** | **10.8%** |

**Panel C: Offerer**

| *Industry* | *α* | *Crisis* | *GM Imb* | ***Crisis* GM Imb*** | *Industry Imb* | *Crisis* Industry Imb* | $R^2$ | ***Crisis*** $R^2$ | ***Non-crisis*** $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| GM | -0.03 | -0.25** | 0.03 | **0.31**** | | | 5.8% | **9.6%** | **0.3%** |
| Other Autos | -0.06*** | -0.17* | 0.04 | **0.28**** | 0.03 | -0.07 | 10.7% | **15.6%** | **3.5%** |
| Basic Materials | -0.01 | -0.28*** | 0.05** | **0.21***** | -0.04 | 0.14* | 11.1% | **12.2%** | **6.5%** |
| Consumer Services | -0.05* | -0.27*** | 0.08*** | **0.22**** | -0.02 | 0.13* | 17.1% | **19.5%** | **9.2%** |
| Financial | -0.02 | -0.27*** | 0.06** | **0.09** | -0.04 | 0.23** | 12.0% | **14.5%** | **6.0%** |
| Industrials | -0.03 | -0.27*** | 0.09*** | **0.12**** | -0.07 | 0.23*** | 20.2% | **25.2%** | **11.7%** |
| Oil & Gas | -0.01 | -0.28*** | 0.07* | **0.21**** | -0.06 | 0.14 | 11.6% | **15.5%** | **4.0%** |
| Technology | -0.05 | -0.23** | 0.09** | **0.12*** | -0.04 | 0.18** | 11.5% | **13.2%** | **8.0%** |
| Utilities | -0.05 | -0.15** | 0.09** | **0.11** | -0.05 | 0.09* | 14.3% | **18.3%** | **9.4%** |

## Table VI

### Economic Significance of the Relationship Between GM Imbalance Measures and CDS Innovations In the Crisis Period

This table reports the economic relationship between GM Imbalance measures and CDS innovations in the crisis period, based on the coefficients on *Crisis*GM Imb* and *GM Imb* estimated for Table VI.

**Panel A: Imb % (1 Std. Dev. of GM Imb%=0.093)**

| | *CDS innv. change for 1 std. dev. change In imb%* | | *Period Std. Dev.* | |
|---|---|---|---|---|
| | | *(A)* | *(B)* | *(A)/(B)* |
| GM | 0.093*(0.003+0.3)= | 2.9% | 6.2% | 46.1% |
| Other Autos | 0.093*(0.02+0.21)= | 2.1% | 4.5% | 48.1% |
| Basic Materials | 0.093*(0.02+0.14)= | 1.5% | 4.5% | 33.4% |
| Consumer Services | 0.093*(0.02+0.16)= | 1.7% | 4.6% | 40.2% |
| Financial | 0.093*(0.02+0.07)= | 0.8% | 3.5% | 25.8% |
| Industrials | 0.093*(0.06+0.07)= | 1.2% | 3.3% | 36.4% |
| Oil & Gas | 0.093*(0.04+0.14)= | 1.7% | 4.6% | 36.4% |
| Technology | 0.093*(0.03+0.11)= | 1.3% | 3.8% | 34.4% |
| Utilities | 0.093*(0.04+0.08)= | 1.1% | 3.5% | 31.8% |

**Panel B: Offer Ratio (1 Std. Dev. of GM Offer Ratio=0.045)**

| | *CDS innv. change for 1 std. dev. change in Offer Ratio* | | *Period Std. Dev.* | |
|---|---|---|---|---|
| | | *(A)* | *(B)* | *(A)/(B)* |
| GM | 0.045*(0.03+0.49)= | 2.3% | 6.2% | 37.9% |
| Other Autos | 0.045*(0.04+0.39)= | 2.0% | 4.5% | 44.5% |
| Basic Materials | 0.045*(0.05+0.29)= | 2.3% | 4.5% | 52.5% |
| Consumer Services | 0.045*(0.05+0.31)= | 2.0% | 4.2% | 47.6% |
| Financial | 0.045*(0.06+0.12)= | 1.0% | 3.3% | 31.9% |
| Industrials | 0.045*(0.12+0.14)= | 1.0% | 3.3% | 31.1% |
| Oil & Gas | 0.045*(0.08+0.34)= | 2.3% | 4.6% | 50.8% |
| Technology | 0.045*(0.07+0.17)= | 2.0% | 3.8% | 52.3% |
| Utilities | 0.045*(0.11+0.17)= | 1.0% | 3.5% | 29.5% |

**Panel C: Offerer (1 Std. Dev. of GM Offerer=0.058)**

| | *CDS innv. change for 1 std. dev. change in Offerer* | | *Period Std. Dev.* | |
|---|---|---|---|---|
| | | *(A)* | *(B)* | *(A)/(B)* |
| GM | 0.058*(0.03+0.31)= | 2.0% | 6.2% | 32.0% |
| Other Autos | 0.058*(0.04+0.28)= | 1.9% | 4.5% | 41.7% |
| Basic Materials | 0.058*(0.05+0.21)= | 1.5% | 4.5% | 33.8% |
| Consumer Services | 0.058*(0.08+0.22)= | 1.7% | 4.2% | 41.8% |
| Financial | 0.058*(0.06+0.09)= | 0.9% | 3.3% | 26.8% |
| Industrials | 0.058*(0.09+0.12)= | 1.2% | 3.3% | 36.6% |
| Oil & Gas | 0.058*(0.07+0.21)= | 1.6% | 4.6% | 35.3% |
| Technology | 0.058*(0.09+0.12)= | 1.2% | 3.8% | 32.2% |
| Utilities | 0.058*(0.09+0.11)= | 1.2% | 3.5% | 33.1% |

## Table VII

### Principal Components Analysis

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 and the non-crisis period, 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.

**Panel A: Crisis Period**

| *PC* | *Eigenvalue* | *Proportion* | *Cumulative* |
|---|---|---|---|
| **1** | 7.10 | 71.0% | 71.0% |
| **2** | 1.38 | 13.8% | 84.8% |
| **3** | 0.41 | 4.1% | 88.9% |
| **4** | 0.31 | 3.1% | 91.9% |
| **5** | 0.23 | 2.3% | 94.2% |

| *Variable* | *Prin1* | *Prin2* | *Prin3* |
|---|---|---|---|
| **GM** | 0.27 | 0.51 | -0.06 |
| **Ford** | 0.17 | 0.72 | 0.07 |
| **Other Autos** | 0.33 | 0.25 | 0.03 |
| **Basic Materials** | 0.35 | -0.11 | -0.25 |
| **Consumer Services** | 0.34 | -0.11 | 0.25 |
| **Financial** | 0.33 | -0.09 | 0.27 |
| **Industrials** | 0.35 | -0.20 | -0.08 |
| **Oil & Gas** | 0.35 | -0.17 | -0.16 |
| **Technology** | 0.31 | -0.20 | 0.62 |
| **Utilities** | 0.33 | -0.12 | -0.61 |

**Panel B: Non-Crisis Period**

| *PC* | *Eigenvalue* | *Proportion* | *Cumulative* |
|---|---|---|---|
| **1** | 4.66 | 46.6% | 46.6% |
| **2** | 1.84 | 18.4% | 65.0% |
| **3** | 0.69 | 6.9% | 71.9% |
| **4** | 0.56 | 5.7% | 77.5% |
| **5** | 0.50 | 5.0% | 82.5% |

| *Variable* | *Prin1* | *Prin2* | *Prin3* |
|---|---|---|---|
| **GM** | 0.17 | 0.58 | 0.28 |
| **Ford** | 0.20 | 0.58 | 0.13 |
| **Other Autos** | 0.26 | 0.41 | -0.14 |
| **Basic Materials** | 0.32 | 0.02 | -0.61 |
| **Consumer Services** | 0.37 | -0.07 | -0.21 |
| **Financial** | 0.36 | -0.15 | -0.05 |
| **Industrials** | 0.38 | -0.15 | -0.09 |
| **Oil & Gas** | 0.36 | -0.13 | 0.22 |
| **Technology** | 0.29 | -0.26 | 0.63 |
| **Utilities** | 0.37 | -0.17 | 0.07 |

## Table VIII

### Regression of First Three Principal Components on Various Imbalance Measures

This table reports the results for regressing each of the first principal components on the weekly GM *imb%* as follows:

$PC_{1,t} = \alpha + \beta_1 * IMB\ \%_t + e_t$ $PC_{1,t} = \alpha + \beta_1 * IMB\ \%_t + \beta_2 * OfferRatio_t + \beta_3 * Offerer_t + e_t$

Panel A reports the results using principal components estimated for the crisis period, and Panel B reports the results using principal components estimated for the non-crisis periods.
The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The *s for all coefficient estimates indicate their level of significance (two-sided tests).
Rejection of the null at the 10%, 5%, or 1% level is indicated by * , * * , or * * * , respectively.
The number of observations for the specifications in Panel A (the crisis period) is 40.
The number of observations for the specifications in Panel B (the non-crisis period) is 87.

**Panel A: Crisis Period**

| ***Imb % Only*** | | | | ***All three Imbalance Measures*** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Dep. Var.* | α | *Imb %* | ***R²*** | *Dep. Var.* | α | *Imb %* | *Offer ratio* | *Offerer* | ***R²*** |
| PC1 | -9.35*** | 13.39*** | 21.8% | PC1 | -5.38 | 17.98 | -3.47 | -5.03 | 22.0% |
| PC2 | -1.85 | 2.65 | 4.4% | PC2 | 22.20** | 28.34*** | -29.50 | -20.24** | 28.6% |
| PC3 | 0.19 | -0.27 | 0.2% | PC3 | 10.00** | 8.70 | -18.08** | -0.89 | 10.4% |

**Panel B: Non-Crisis Period**

| ***Imb % Only*** | | | | ***All three Imbalance Measures*** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Dep. Var.* | α | *Imb %* | ***R²*** | *Dep. Var.* | α | *Imb %* | *Offer ratio* | *Offerer* | ***R²*** |
| PC1 | -2.78* | 3.55 | 5.0% | PC1 | -22.79*** | -19.54** | 29.68** | 13.59** | 15.7% |
| PC2 | 0.44 | -0.56 | 0.3% | PC2 | -3.62 | -5.19 | 8.05 | 0.67 | 1.3% |
| PC3 | -0.05 | 0.07 | <0.1% | PC3 | -0.78 | -0.77 | 1.24 | 0.33 | 0.1% |

# Table IXA

## Regression of Separately Estimated (Crisis and Non-crisis) CDS Innovations on GM Imb%

This table contains the regression results of weekly CDS innovations, separately estimated for the crisis and non-crisis period, on weekly GM Imb% as in the following model:

$$CDSinv_{CS,t} = \alpha_1 + \alpha_2 * Crisis_t + \beta_{CS1} * \text{GMImb}_t + \beta_{CS1,Crisis} * (Crisis_t * \text{GMImb}_t) + \beta_{CS2} * \text{Industry Imb}_{CS,t} + \beta_{CS2,Crisis} * (Crisis_t * \text{Industry Imb}_{CS,t}) + e_t$$

*Crisis* is a dummy that is equal to one in the period between Oct 2004 and July 2005;
The last two columns display the $R^2$ of the following estimation for Crisis and Non-crisis periods:

$$CDS\ inv_{CS,t} = \alpha + \beta_{CS1} * GM\ IMB_t + \beta_{CS2} * Industry_{CS}\ IMB_t + e_t$$

The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The *s on loadings of (*Crisis* GM Imb*) and (*Crisis*Industry Imb*) indicate the significance of the one-sided tests.
The *s for all other coefficient estimates indicate their level of significance (two-sided tests).
Rejection of the null at the 10%, 5%, or 1% level is indicated by *, **, or ***, respectively.
The number of observations for all specifications is 127.

| *Dependent Variable* | α | *Crisis* | *GM Imb* | ***Crisis* GM Imb*** | *Industry Imb* | *Crisis* Industry Imb* | $R^2$ | ***Crisis*** $R^2$ | ***Non-crisis*** $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| GM | <0.01 | -0.16*** | <0.01 | **0.24*** ** | | | 6.8% | **17.7%** | **<0.1%** |
| Other Autos | -0.02 | -0.08** | 0.01 | **0.15*** ** | 0.02 | -0.04 | 10.2% | **23.3%** | **2.1%** |
| Basic Materials | -0.01 | -0.10*** | 0.02 | **0.11*** ** | -0.02 | 0.04 | 10.0% | **13.0%** | **4.5%** |
| Consumer Services | -0.02 | -0.09*** | 0.02 | **0.12*** ** | 0.01 | 0.02 | 12.3% | **18.6%** | **3.5%** |
| Financial | -0.01 | -0.11*** | 0.03 | **0.05** | -0.02 | 0.11** | 9.6% | **14.4%** | **3.3%** |
| Industrials | -0.02* | -0.09*** | 0.06*** | **0.05** | -0.05* | 0.12*** | 18.0% | **24.3%** | **11.8%** |
| Oil & Gas | -0.01 | -0.11*** | 0.05** | **0.11** ** | -0.04 | 0.07 | 11.5% | **17.6%** | **4.8%** |
| Technology | -0.02 | -0.07* | 0.03 | **0.07* ** | -0.02 | 0.04 | 6.2% | **9.4%** | **3.6%** |
| Utilities | -0.03* | -0.06** | 0.05** | **0.07* ** | -0.03 | 0.05* | 12.8% | **20.0%** | **7.5%** |

**Table IXB**

Regression of Daily CDS Innovations on Lagged Daily GM Imb %

This table contains the regression results of daily CDS innovations on lagged daily GM imbalance % as in the following model:

$$CDS\ inv_{CS,t} = \alpha_1 + \alpha_2 * Crisis + \beta_{CS1} * GM\ IMB_{t-1} + \beta_{CS1,Crisis} * (Crisis * GM\ IMB_{t-1}) + \beta_{CS2} * Industry_{CS}\ IMB_{t-1} + \beta_{CS2,Crisis} * (Crisis * Industry_{CS}\ IMB_{t-1}) + e_t$$

*Crisis* is a dummy that is equal to one in the period between Oct 2004 and July 2005;
The last two columns display the $R^2$ of the following estimation for Crisis and Non-crisis periods:

$$CDS\ inv_{CS,t} = \alpha + \beta_{CS} * GM\ IMB_{t-1} + \beta_{CS2} * Industry_{CS}\ IMB_{t-1} + e_t$$

The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The *s loadings on (*Crisis* GM Imb*) and (*Crisis*Industry Imb*) indicate the significance of the one-sided tests.
The *s for all other coefficient estimates indicate their level of significance (two-sided tests).
Rejection of the null at the 10%, 5%, or 1% level is indicated by * , ** , or *** , respectively.
The number of observations for all specifications is 633.

| *Dependent Variable* | α | *Crisis* | *GM Imb* | ***Crisis* GM Imb*** | *Industry Imb* | *Crisis* Industry Imb* | $R^2$ | ***Crisis $R^2$*** | ***Non-crisis $R^2$*** |
|---|---|---|---|---|---|---|---|---|---|
| GM | 0.001 | -0.027** | -0.002 | **0.042*** ** | | | 1.4% | **2.5%** | **<0.1%** |
| Other Autos | -0.002 | -0.022** | 0.001 | **0.038*** ** | 0.002 | -0.006 | 3.6% | **8.0%** | **0.2%** |
| Basic Materials | -0.001 | -0.020*** | 0.004 | **0.024*** ** | -0.004 | 0.010 | 4.9% | **7.3%** | **1.1%** |
| Consumer Services | -0.003 | -0.020*** | 0.002 | **0.025*** ** | 0.001 | 0.007 | 6.4% | **9.8%** | **0.7%** |
| Financial | -0.001 | -0.017** | 0.003 | **0.010* ** | -0.001 | 0.014** | 2.8% | **4.1%** | **0.4%** |
| Industrials | -0.005*** | -0.015*** | 0.010*** | **0.007** | -0.006** | 0.024** | 8.0% | **10.5%** | **5.0%** |
| Oil & Gas | -0.003 | -0.017** | 0.005* | **0.022** ** | -0.003 | 0.006 | 3.7% | **5.6%** | **0.9%** |
| Technology | -0.003 | -0.011* | 0.005* | **0.011** | -0.004 | 0.009* | 1.7% | **2.2%** | **1.0%** |
| Utilities | -0.004* | -0.009* | 0.007** | **0.008** | -0.004* | 0.011* | 5.0% | **7.9%** | **2.5%** |

## Table IXC

# Regression of Weekly CDS Innovations on Weekly Contemporaneous and Lagged GM Imb %

This table contains the regression results of weekly CDS innovations on weekly contemporaneous and lagged GM imb% as in the following model:

$$CDS\,inv_{CS,t} = \alpha_1 + \alpha_2 * Crisis + \beta_{CS1,t} * \text{GM Imb}_t + \beta_{CS1,Crisis,t} * (Crisis * \text{GM Imb}_t) + \beta_{CS2,t} * \text{Industry Imb}_{CS,t} + \beta_{CS2,Crisis,t} * (Crisis * \text{Industry Imb}_{CS,t})$$
$$+ \beta_{CS1,t-1} * \text{GM Imb}_{t-1} + \beta_{CS1,Crisis,t-1} * (Crisis * \text{GM Imb}_{t-1}) + \beta_{CS2,t-1} * \text{Industry Imb}_{CS,t-1} + \beta_{CS2,Crisis,t-1} * (Crisis * \text{Industry Imb}_{CS,t-1}) + e_t$$

*Crisis* is a dummy that is equal to one in the period between Oct 2004 and July 2005.
We report the summed coefficients on pairs of matching contemporaneous and lagged variables (e.g. $Crisis_t * \text{GM Imb}_t$ and $Crisis_t * \text{GM Imb}_{t-1}$).
The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The *s loadings on the crisis interactions indicate the significance of the one-sided tests.
The *s for all other coefficient estimates indicate their level of significance (two-sided tests).
Rejection of the null at the 10%, 5%, or 1% level is indicated by *, **, or ***, respectively.
The number of observations for all specifications is 127.

| *Dependent Variable* | α | *Crisis* | *GM Imb$_t$ + GM Imb$_{t-1}$* | *Industry Imb$_t$ + Industry Imb$_{t-1}$* | ***Crisis* (GM Imb$_t$ + GM Imb$_{t-1}$)** | *Crisis* (Industry Imb$_t$+Industry Imb$_{t-1}$)* | $R^2$ |
|---|---|---|---|---|---|---|---|
| GM | <0.01 | -0.21** | -0.01 | | **0.31*** ** | | 12.0% |
| Other Autos | -0.02 | -0.13*** | 0.01 | 0.01 | **0.22*** ** | -0.03 | 15.1% |
| Financial | -0.01 | -0.08* | 0.03 | -0.01 | **0.06* ** | 0.06 | 14.7% |
| Basic Materials | -0.01 | -0.12** | 0.03 | -0.02* | **0.16*** ** | 0.04 | 15.6% |
| Consumer Services | -0.02 | -0.09** | 0.03 | 0.00 | **0.19*** ** | -0.07** | 25.4% |
| Industrials | -0.02 | -0.12*** | 0.06*** | -0.05* | **0.09** ** | 0.11 | 24.3% |
| Oil & Gas | -0.01 | -0.12** | 0.04 | -0.04* | **0.16** ** | 0.04 | 13.4% |
| Technologies | -0.02 | -0.08* | 0.04** | -0.03 | **0.09** ** | 0.05 | 14.2% |
| Utilities | -0.02 | -0.1** | 0.05* | -0.03 | **0.12** ** | 0.05 | 16.1% |

## Table IXD

# Regression of Weekly CDS Innovations on GM Imb % and Changes in the Spread between Financial CP and T-bill Rates

This table contains the regression of weekly CDS innovations on weekly Changes in Financial CP Spread on T-bill and GM Imb %as in the following model:

$$CDS\ inv_{CS,t} = \alpha_1 + \alpha_2 * Crisis + \beta_{CS1} * GM\ IMB_t + \beta_{CS1,Crisis} * (Crisis * GM\ IMB_t) + \beta_{CS2} * Industry_{CS}\ IMB_t + \beta_{CS2,Crisis} * (Crisis * Industry_{CS}\ IMB_t)$$

$$+ \beta_{CP1} * CP_t + \beta_{CP1,Crisis} Crisis * CP_t + \beta_{CP2} * CP_t * GM\ IMB_t + \beta_{CP2,Crisis} Crisis * CP_t * GM\ IMB_t + \beta_{CP3} CP_t * Industry_{CS}\ IMB_t + \beta_{CP3,Crisis} Crisis * CP_t * Industry_{CS}\ IMB_t + e_t$$

*Crisis* is a dummy that is equal to one in the period between Oct 2004 and July 2005.
The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The *s loadings on the crisis interactions indicate the significance of the one-sided tests.
The *s for all other coefficient estimates indicate their level of significance (two-sided tests).
Rejection of the null at the 10%, 5%, or 1% level is indicated by * , * * , or * * * , respectively.
The number of observations for all specifications is 127.

| *Dependent Variable* | α | *Crisis* | *GM Imb* | *Ind Imb* | *CP* | *GM Imb *CP* | *Ind Imb *CP* | *GM Imb *Crisis* | *Ind Imb *Crisis* | *CP* Crisis* | ***Imb GM* CP*Crisis*** | *Imb Ind * CP*Crisis* | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GM | -0.01 | -0.19** | <0.01 | | 0.11 | -0.14 | | 0.28*** | | -0.15* | **0.23**** | | 13.2% |
| Other Autos | -0.02 | -0.13*** | 0.02 | <0.01 | 0.09 | -0.01 | -0.12 | 0.20*** | -0.01** | -0.03 | **-0.02** | 0.07 | 15.4% |
| Financial | -0.01 | -0.12*** | 0.03** | -0.01 | -0.03 | -0.02 | 0.05 | 0.04 | 0.12** | -0.07 | **0.07** | 0.03 | 13.6% |
| Basic Materials | -0.01 | -0.08* | 0.03 | -0.02 | -0.02 | -0.02 | 0.04 | 0.08* | 0.06* | -0.07 | **0.15**** | -0.02 | 14.0% |
| Consumer Services | -0.02* | -0.08* | 0.03 | 0.00 | 0.01 | -0.07 | 0.07 | 0.08* | 0.05 | -0.19* | **0.20**** | 0.17 | 26.3% |
| Industrials | -0.02* | -0.08** | 0.06*** | -0.05* | 0.01 | -0.03 | 0.02 | 0.02 | 0.13*** | -0.06 | **0.14**** | -0.05 | 22.6% |
| Oil & Gas | -0.02 | -0.11** | 0.04* | -0.03 | 0.10 | -0.07 | -0.06 | 0.12* | 0.06 | -0.15** | **0.11** | 0.12 | 13.3% |
| Technologies | -0.02 | -0.06 | 0.03 | -0.02 | 0.06 | -0.11 | 0.07 | 0.05 | 0.06* | -0.06 | **0.25***** | -0.20 | 14.3% |
| Utilities | -0.03* | -0.05 | 0.05** | -0.02 | 0.11 | -0.12 | -0.05 | 0.05 | 0.05* | -0.17** | **0.24**** | 0.03 | 18.2% |

## Table IXE

## Regression of Weekly CDS Innovations on changes in VIX and GM Imbalance Measures

This table contains the regression of weekly CDS innovations on weekly GM imbalance % and weekly changes in VIX as in the following model:

$$CDS\ inv_{CS,t} = \alpha_1 + \alpha_2 * Crisis + \beta_{CS1} * GM\ IMB_t + \beta_{CS1,Crisis} * (Crisis * GM\ IMB_t) + \beta_{CS2} * Industry_{Fin}\ IMB_t + \beta_{DS2,Crisis} * (Crisis * Industry_{CS}\ IMB_t) + \beta_{VIX} * VIX_t + \beta_{VIX,Crisis} Crisis * VIX_t + e_t$$

*Crisis* is a dummy that is equal to one in the period between Oct 2004 and July 2005.
The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The *s loadings on (*Crisis* GM Imb*) and (*Crisis*Industry Imb*) indicate the significance of the one-sided tests.
The *s for all other coefficient estimates indicate their level of significance (two-sided tests).
Rejection of the null at the 10%, 5%, or 1% level is indicated by * , * * , or * * * , respectively.
The number of observations for all specifications is 127.

| *Dependent Variable* | α | *Crisis* | *GM Imb* | ***Crisis* GM Imb*** | *Industry Imb* | *Crisis* Industry Imb* | ***VIX*** | ***Crisis*VIX*** | $R^2$ |
|---|---|---|---|---|---|---|---|---|---|
| GM | -0.01 | -0.20** | 0.01 | **0.30*** ** | | | **0.07** ** | **0.01** | 13.2% |
| Other Autos | -0.02 | -0.13** | 0.02 | **0.22*** ** | 0.01 | -0.03 | **0.00** | **0.18*** ** | 21.6% |
| Basic Materials | -0.01 | -0.13*** | 0.02 | **0.14*** ** | -0.02 | 0.08* | **0.02** | **0.18* ** | 23.5% |
| Consumer Services | -0.02* | -0.12*** | 0.03 | **0.17*** ** | <-0.00 | 0.04 | **0.05* ** | **0.14** ** | 30.3% |
| Financial | -0.01 | -0.14*** | 0.02 | **0.08* ** | -0.01 | 0.12** | **0.01** | **0.10* ** | 17.1% |
| Industrials | -0.02* | -0.11*** | 0.06*** | **0.06* ** | -0.05* | 0.16** | **0.01** | **0.13*** ** | 29.7% |
| Oil & Gas | -0.01 | -0.14*** | 0.04* | **0.13** ** | -0.04 | 0.11** | **0.05** ** | **0.21* ** | 31.6% |
| Technology | -0.02 | -0.09** | 0.03 | **0.12** ** | -0.01 | 0.04 | **0.06*** ** | **0.12* ** | 23.4% |
| Utilities | -0.03* | -0.07* | 0.05** | **0.07* ** | -0.03 | 0.07* | **0.05** ** | **0.12* ** | 27.5% |

**Table IXF**

## Regression of Weekly CDS Innovations on GM Imb %: Investment- vs. Sub-investment Grade Firms

This table reports the estimation of weekly CDS innovations on GM *Imb%* for investment-grade and non-investment-grade firms as in the following regression:

$$CDSinv_{GM,t} = \alpha_1 * Inv * Crisis_t + \alpha_2 * Inv * NonCrisis_t + \alpha_3 * Subinv * Crisis_t + \alpha_4 * Subinv * NonCrisis_t$$
$$+ \beta_{Inv,NonCr}(Inv * NonCrisis_t * \text{GM Imb}_t) + \beta_{Inv,Cr}(Inv * Crisis_t * \text{GM Imb}_t) + \beta_{Sub,NonCr}(Subinv * NonCrisis_t * \text{GM Imb}_t) + \beta_{Sub,Cr}(Subinv * Crisis_t * \text{GM Imb}_t) + e_t$$

Dummy variables *Crisis* and *Non Crisis* for observations around the downgrade and observations in other periods, and dummy variables *Inv* and *Subinv* for sub-investment-grade and investment-grade firms.
The estimation is performed with GMM, producing standard errors that are adjusted for heteroscedasticity and auto-correlation.
The bolded column tests $(\beta_{Sub,Cr} - \beta_{Sub,NonCr}) - (\beta_{Inv,Cr} - \beta_{Inv,NonCr}) > 0$
Rejection of the null at the 10%, 5%, or 1% level is indicated by *, **, or ***, respectively.
The number of observations for all specifications is 127.

| | Inv. | | | Sub-inv. | | | Diff. in Diff. | |
|---|---|---|---|---|---|---|---|---|
| *Industry* | $\beta_{NonCrisis}$ | $\beta_{Crisis}$ | $\beta_{Cr} - \beta_{NonCr}$ | $\beta_{NonCrisis}$ | $\beta_{Crisis}$ | $\beta_{Cr} - \beta_{NonCr}$ | $(\beta_{Sub,Crisis} - \beta_{Sub,NonCrisis})$ - $(\beta_{Inv,Crisis} - \beta_{Inv,NonCrisis})$ | $R^2$ |
| Auto | 0.03 | 0.13* | 0.10** | 0.02 | 0.30*** | 0.28*** | **0.19**** | 11.4% |
| Basic Materials | 0.02 | 0.16*** | 0.14*** | 0.01 | 0.17*** | 0.17*** | **0.02** | 7.5% |
| Consumer Services | 0.02 | 0.21*** | 0.18*** | 0.02 | 0.14*** | 0.14*** | **-0.04** | 12.1% |
| Financial | 0.02 | 0.10*** | 0.09** | 0.02 | 0.17*** | 0.15*** | **0.06** | 6.2% |
| Industrials | 0.03 | 0.14*** | 0.11*** | 0.04 | 0.21*** | 0.17*** | **0.06** | 11.4% |
| Oil & Gas | 0.02 | 0.17*** | 0.15*** | 0.01 | 0.25*** | 0.24*** | **0.09** | 9.5% |
| Technology | 0.04 | 0.10* | 0.06* | 0.00 | 0.19*** | 0.18*** | **0.12*** | 6.2% |
| Utilities | 0.04 | 0.13*** | 0.09** | 0.04 | 0.27*** | 0.23*** | **0.13** | 9.6% |

## Appendix A

This appendix contains the events sounding 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 intensioin 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% oya 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 | | | | | | |
| 7th July, 2005 | Current 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. | | | | | | |
| | | | | | | | |
| | **Important dates going forward** | | | | | | |
| 19th July, 2005 | **Q2 Earnings data released by Ford** | | | | | | |
| 20th July, 2005 | **Q2 Earnings data released by GM** | | | | | | |

## Appendix B

This appendix contains 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 |