The New Rules of the Rating Game: Market Perception of Corporate Ratings

Rainer Jankowitsch* Giorgio Ottonello† Marti G. Subrahmanyam ‡

November 16, 2015

Abstract

In this paper, we analyze the impact of credit rating changes on the pricing and liquidity of US corporate bonds. In particular, we address the question of whether the informativeness of rating events varies in different economic environments, particularly after the introduction of the Dodd-Frank Act. During the financial crisis, rating agencies and rating-contingent regulation were blamed for causing inflated (overly optimistic and often stale) ratings, triggering, to some extent, the near collapse of the financial system, and leading to important regulatory reforms. It is essential, therefore, to understand the impact of downgrades/upgrades on prices and trading activity, particularly in the aftermath of these reforms. We find that the informativeness of rating changes is low before the crisis, particularly for financial bonds. However, after the passage of the Dodd-Frank Act, rating changes lead to significantly stronger market reactions for non-financial bonds, whereas the reactions are weaker for financial bonds, indicating that the new regulatory framework has ambiguous effects on the impact of such changes. We link this finding to the difference in complexity of the securities by testing various hypotheses based on existing models of rating agency behavior in different regulatory and economic environments.

JEL-Classification: G01, G12, G24
Keywords: ratings, Dodd-Frank Act, corporate bonds, liquidity

*WU (Vienna University of Economics and Business), Welthandelsplatz 1, Building D4, 4th floor, 1020 Vienna, Austria; email: rainer.jankowitsch@wu.ac.at

†VGSF (Vienna Graduate School of Finance), Welthandelsplatz 1, Building D4, 4th floor, 1020 Vienna, Austria; email: giorgio.ottonello@vgsf.ac.at

‡New York University, Stern School of Business, Department of Finance, 44 West Fourth Street, Room 9-68, New York, NY 10012; email: msubrahm@stern.nyu.edu

1 Introduction

Credit rating agencies (CRAs) represent an important source of information for market participants' determination of the creditworthiness of corporations. CRAs assess the ability of a firm to respect its obligations, reflecting this in a rating grade representing the probability of default and additionally, in some cases, the expected recovery rate. The informativeness of ratings is accentuated by rating-contingent regulation, which makes it necessary for certain investors (e.g., banks and insurance companies) to take ratings into account in their lending, investment and asset allocation strategies.

However, the recent financial crisis, accompanied by massive and sudden downgrades of investment-grade securities in 2008 and 2009, has severely undermined the reputation of CRAs, bringing their business model into question. Since CRAs are paid by the issuers who request credit ratings, this mechanism can lead to a conflict of interests, incentivizing CRAs to provide overly optimistic (inflated) ratings and also to react too slowly when negative information arrives. Such incentives, along with the regulatory advantage for better-rated securities, favor the diffusion of potentially unreasonably high and sticky ratings, i.e., ratings with poor informativeness. This is one of the elements that is widely considered to have been a causal factor of the financial crisis, with resultant massive downgrades and defaults of highly rated securities in the period after the Lehman bankruptcy.[1]

The principal regulatory response to the financial crisis is the Dodd-Frank Wall Street Reform and Consumer Protection Act [2010] (known popularly as Dodd-Frank), enacted on July 21, 2010. Dodd-Frank aims at a fundamental reform of many areas of the US financial system. In particular, in "Title IX- Investor Protections and Improvements to the Regulation of Securities" the "Subtitle C- Improvements to the Regulation of Credit Rating Agencies" includes provisions concerning the credit rating industry and its interaction with the market. An aim of the regulators is to improve rating informativeness by making rating agencies legally liable when they provide misleading information to the market. In particular, with Dodd-Frank, the Securities and Exchange Commission (SEC) can more easily sanction rating agencies, and also courts are more likely to entertain private actions against CRAs.[2] Moreover, under the new rules,

[1] See, e.g., Opp et al. [2013] and Krugman [2010].

[2] According to section 933, the statements of CRAs should be considered as "statements made by a registered public accounting firm or a securities analyst under the securities laws" and not "forward-looking statements". Additionally, in private actions, it is sufficient to prove that the agency "knowingly or recklessly failed to conduct a reasonable investigation of the rated security" or "to obtain reasonable verification" of the information provided with the rating.

rating-contingent regulation has to be gradually dismantled, in order to eliminate the regulatory advantage held by highly rated securities, as previously mentioned a relevant factor among the causes of the financial crisis.

One of the markets most heavily affected by this new regulation is the US corporate bond market, in which credit ratings play a major role. In this market, trades take place over-the-counter (OTC), and not all relevant credit information is easily accessible to investors. In particular, bonds of certain issuers, e.g., those issued by financial firms, are more complex to rate as the risk of such issuers' assets is difficult to evaluate based on public information alone. Thus, credit ratings are important in assessing credit risk. However, in contrast to most other OTC markets, detailed transaction data are available on prices and volumes. Such a dataset is provided by the Financial Industry Regulatory Agency (FINRA), and is known as the Trade Reporting and Compliance Engine (TRACE). This database aggregates virtually all transactions in this market, contributing to greater transparency. Thus, the US corporate bond market provides an ideal environment in which to study the effect of rating changes.

In this paper, we analyze how different economic environments and, in particular, the introduction of Dodd-Frank, have altered the impact of rating agency decisions on prices and liquidity in the US corporate bond market. We test various hypotheses based on existing theoretical models, drawing mainly on the predictions of the models in Skreta and Veldkamp [2009] and Opp et al. [2013], and integrating them with the findings of He and Milbradt [2014], who consider the liquidity effect of changes in credit risk. First, we test whether the incentive to provide inflated ratings is indeed high in good economic times, i.e., before the crisis, particularly for more complex securities, as suggested, e.g., by Skreta and Veldkamp [2009], and as has been argued in the aftermath of the crisis. In addition, we analyze the market reactions around regulatory rating thresholds, e.g., between investment-grade and speculative-grade bonds. Second, we test the prediction that the informativeness of rating changes is high in crisis periods. In such periods, the credit quality of corporate bonds is low; i.e., firms are exposed to greater credit risk, and their outside options, such as financing using equity or loans, are less attractive. According to the model of Opp et al. [2013], the benefits to CRAs from inflating ratings are lower in such times, leading to more information acquisition by them and thus resulting in more informative ratings. Furthermore, there is additional interaction between credit and liquidity risk in crisis periods, potentially increasing their price and liquidity impacts.[3] Third, we analyze whether

[3]See Friewald et al. [2012] for a documentation of this interaction effect during periods of financial crisis.

eliminating rating-contingent regulation and increasing the cost of biased ratings, following the introduction of Dodd-Frank, leads to an improvement in the informativeness of credit ratings. Interestingly, in the model of Opp et al. [2013], the opposite effect may be observed for more complex securities, because, following the elimination of the incentives that rating-contingent regulation sets for rating these securities, rating agencies may simply stop acquiring information about them, due to the costs being too high.

Our sample covers corporate bond ratings from 2003 to 2014 including 6,594 rating events with 4,332 downgrades and 2,162 upgrades. We analyze three sample periods: rating changes before the crisis, during the crisis and recession, and after the passage of Dodd-Frank. Moreover, we split the sample between bonds of non-financial firms (hereafter non-financial bonds) and bonds of financial firms (hereafter financial bonds), considering the latter to be more complex to rate given their exposure to multiple risk factors. We set up a time window of 181 working days around the rating event (the event day, the 90 days before, and the 90 days after the event), covering all transactions in this window.

In our empirical analysis, we find that rating informativeness is indeed low before the crisis, financial bonds being less informative overall, with an average price variation of -0.59% as opposed to -0.71% for non-financial bonds, in the case of downgrades. In addition, we confirm that downgrades are more important for market participants than upgrades: the price reaction for downgrades is almost double that for upgrades. Both financial and non-financial bonds show the highest price reactions during the crisis. This arises against a backdrop of a significant increase in illiquidity, which is particularly high for non-financial bonds. After Dodd-Frank, downgrades of non-financial bonds are significantly more informative than before the crisis: in the latter period the price decrease amounts to -1.12%. On the other hand, downgrades of financial bonds produce less information for the market, triggering an effect of only -0.31%, thus indicating a much weaker reaction for more complex bonds. A regression analysis confirms these results, while providing a better understanding of the determinants of price variations surrounding downgrades and upgrades. In addition, we show that price reactions are stronger when the changes in trading activity and liquidity are higher. Interestingly, before the crisis, there is a stronger effect when a bond is downgraded from investment to speculative grade. Nevertheless, this effect almost disappears after Dodd-Frank, which might be a direct consequence of the trend towards eliminating rating-contingent regulation. Finally, through the estimation of market-implied ratings, we analyze whether rating changes are anticipated by market participants, and whether

this expectation is different across the three periods. We find that downgrades are anticipated before the crisis, but not after Dodd-Frank. Thus, it appears that the staleness of ratings before downgrades almost disappeared after the introduction of the new regulation. Interestingly, upgrades are instead more expected after Dodd-Frank than before the crisis, indicating that CRAs are more reluctant to upgrade bonds, as a consequence of the potentially asymmetric litigation risk: the penalty from optimistic ratings increased dramatically relative to the benefits of such issuer-friendly ratings.

Overall, our paper provides a detailed analysis of how the market reaction to corporate rating changes has varied through the financial crisis, and following the new regulation introduced by Dodd-Frank. Our findings go beyond what is currently available in the literature on corporate ratings. We provide detailed evidence analyzing the whole corporate bond market and add new results on trading activity and liquidity, which represent an important second dimension regarding how the market reacts to credit rating changes. While the price effects of rating changes are important, the liquidity consequences are equally so, since they influence portfolio choices and may even feed back to prices. Moreover, we provide interesting evidence on price effects by separating financial bonds from non-financial bonds, and by discussing the different effects observed during and after the financial crisis. Additionally, we estimate implied ratings, which help to complete the general picture by providing evidence on how the market is able to anticipate rating movements in different economic and regulatory environments. Finally, we link our empirical evidence with recent theoretical studies concerning the strategic behavior of CRAs and the interaction between corporate bonds' default risk and market liquidity.

The remainder of the paper is organized as follows: Section 2 reviews the literature, Section 3 discusses the hypotheses, Section 4 describes the data, Section 5 presents the methodology, and Section 6 the results.

2 Literature Review

This paper is related to three strands of the literature. The first set of papers includes studies of the announcement effect of bond credit ratings and credit outlook changes on bond and stock returns. The second strand focuses on theoretical and empirical research regarding the strategic behavior of rating agencies. The third group consists of papers that analyze the liquidity of the corporate bond market, in general.

Previous empirical papers analyze the price reaction of credit rating changes and seem to generally support the hypothesis that these changes significantly affect returns.[4] Most of these papers report significantly stronger price reactions for credit downgrades compared to upgrades; however, they focus mainly on *stock returns*. There is not as much agreement in the literature about whether there is bond market anticipation of these rating changes, nor about whether the ratings' outlook affects bond prices. Overall, the different magnitudes and varying statistical significance of price effects in the literature on bond ratings can be attributed to the great variety of sample periods, methodologies, and datasets used by researchers. The last is especially crucial when it comes to corporate bonds, as the studies mentioned above typically rely on data reflecting a small sub-set of the market and, moreover, mainly on monthly bond data, which significantly decreases the power of the tests of these effects in comparison with daily data.[5]

It has been possible to overcome these limitations to a large extent since the creation of the TRACE dataset by FINRA, which collects price and volume data for all the transactions in the US corporate bond market. Using this dataset, May [2010] studies the impact of bond rating changes on corporate bond prices using a sample period up to 2009. Significant abnormal returns are found both around downgrades and upgrades, while the cross-sectional analysis shows that these effects are stronger for unexpected rating changes, firms with a lower rating, and upgrades from speculative to investment grade. Ellul et al. [2011] concentrate on downgrades from investment to speculative grade of bonds held by insurance companies. Fire sales of downgraded bonds caused by regulatory constraints are documented, with those effects being more likely for firms with more severe regulatory constraints, especially when the overall insurance industry is in distress.

The paper that is most closely related to ours is that of Dimitrov et al. [2015], which is the first to examine the impact of Dodd-Frank on credit ratings by analyzing non-financial bonds in the US corporate bond market. The motivation for their analysis is the possibility of stricter regulatory penalties if ratings are inflated. Their empirical evidence suggests that, since the passage of the Dodd-Frank Act in July 2010, CRAs have issued lower ratings and downgrades have been less informative for the market, with similar effects observed for upgrades. Given that Dodd-Frank

[4]The first papers to analyze credit rating effects on bond prices were Weinstein [1977], Wakeman [1978], and Wansley and Clauretie [1985]. They found no effect, whereas Katz [1974], Grier and Katz [1976], and Ingram et al. [1983] did. More recently, significant effects in the stock price are found only for downgrades in Holthausen and Leftwich [1986], Hand et al. [1992], Griffin and Sanvicente [1982], Goh and Ederington [1993], Nayar and Rozeff [1994], Norden and Weber [2004], and Li et al. [2006]. However, Hsueh and Liu [1992], Dichev and Piotroski [2001], Jorion et al. [2005], and Kim and Nabar [2007] find significant stock price effects in upgrades and downgrades, while Hand et al. [1992] and Hite and Warga [1997] find the same for bonds.

[5]See, e.g., Bessembinder et al. [2009].

penalizes inflated ratings, the authors conclude that CRAs have become protective of their reputations and lowered their ratings, regardless of the underlying information. This paper presents the first important insights regarding the impact of Dodd-Frank on credit ratings, and provides a good starting point for our analysis. Our paper offers significant new insights, given that we add liquidity as a second important dimension after that of prices, analyze the *whole* market including financial and non-financial bonds, and carefully consider effects during and after the financial crisis in our results.

A recent and growing literature tackles the strategic behavior of rating agencies, and the changes in rating standards, both theoretically and empirically. Skreta and Veldkamp [2009] show, in a model, how more complex assets incentivize rating shopping, and consequently rating inflation. An important theoretical contribution is made by Opp et al. [2013], who develop a theoretical model explaining the variation in credit rating standards over time, and across asset classes. This model suggests that the introduction of rating-contingent regulation, which favors highly rated securities, increases the volume of highly rated securities, independently of the effect it has on information. The impact on informativeness depends on an endogenous threshold level of the regulatory advantage, beyond which the rating agency is better off terminating information acquisition and inflating its credit rating. The threshold depends on the complexity of the security, the credit quality of the issuer, and the issuer's outside options. Given rating-contingent regulation, the model predicts lower rating informativeness during booms, in general. More importantly, the model predicts that the elimination of ratings-based regulation leads to higher informativeness. However, such an effect might be reversed if the security is too complex (i.e., costly) to be rated. Additionally, Cohn et al. [2015] model the interaction between the CRAs' monitoring and the issuer's manipulation of the information provided to them. They find that greater monitoring can have a distortive effect on the ratings' informativeness, given that it might increase the issuer's incentive to manipulate. Specifically, they predict that a regulation that increases the CRAs' monitoring incentives, e.g. by imposing higher sanctions on CRAs as under Dodd-Frank, can have ambiguous effects on rating informativeness. Furthermore, Becker and Milbourn [2011], Bolton et al. [2012], and Bongaerts et al. [2012] analyze how increased competition affects the credit rating market, finding that such competition lowers the quality of ratings, reduces efficiency through rating shopping, and makes additional rating changes more likely for regulatory purposes.

Alp [2013] examines the time-series variation of corporate rating standards, finding a structural

shift towards stricter ratings in 2002, which cannot be explained completely by market conditions. Baghai et al. [2014] analyze the consequences of the shift to more conservative ratings for firms' capital structures. They find that firms affected by such conservatism issue less debt, and that the market does not perceive the increase in conservatism to be fully warranted. In a more recent model, Sangiorgi and Spatt [2015] show how imposing regulatory disclosure to the market of all the ratings an issuer has obtained can improve rating informativeness and, therefore, investment decisions based on them.

The effects of rating changes on corporate bond prices are closely related to market liquidity, given the low level of trading activity in the corporate bond market, in general. Since the creation of TRACE, this has motivated many researchers to focus on the analysis of corporate bond market liquidity. These papers quantify various aspects of trading costs and activity for different market segments, time periods, and particular events, e.g., defaults.[6] In addition, theoretical models, e.g. in He and Milbradt [2014], study the interaction between default and liquidity in the corporate bond market, which arises endogenously in a loop via the roll-over channel: lower-rated bonds are linked to lower liquidity. Such feedback effects are particularly important when analyzing the market reaction to credit events and, therefore, allow us to formulate hypotheses related to liquidity.

3 Hypotheses

The main research question that we address in this paper is whether the financial crisis and the subsequent introduction of Dodd-Frank have fundamentally changed the informativeness of ratings. In this context, rating informativeness is measured by the price and liquidity impact of rating changes. If secondary market prices and liquidity (i.e., trading volume and transaction costs) are not affected by rating changes, it obviously implies that market participants consider the information transmitted by the rating changes weak.[7] This is either because the rating changes do not reflect the signaling value of the new information or because this information is already incorporated in prices. When comparing rating changes before and after Dodd-Frank, it is important to consider the effects of the financial crisis carefully, since credit rating effects could

[6] Hotchkiss and Jostova [2007] analyze the determinants of the trading volume and liquidity of corporate bonds. Bao et al. [2011] document the illiquidity to be significantly higher than is explicable by the bid-ask spread. Dick-Nielsen et al. [2012] and Friewald et al. [2012] document a dramatic increase in the contribution of illiquidity to corporate bond spreads during the financial crisis. Jankowitsch et al. [2014] study the effect of corporate bond defaults on the trading microstructure.

[7] Note that we focus on rating events and not on changes in rating outlook, as only actual rating changes are directly relevant to rating-contingent regulation.

be fundamentally different during such economic downturns. In light of these considerations, we provide hypotheses based on three different periods (*before the crisis*, *during the crisis* and *after Dodd-Frank*), and are particularly interested in comparing the first and last periods.

The hypotheses we present in this section are directly based on the recent theoretical and empirical literature, discussed in Section 2. The main references on which we draw are Opp et al. [2013] and He and Milbradt [2014]. Opp et al. [2013] develop a theoretical model of credit rating standards over time and across asset classes. Furthermore, their model allows us to base our predictions on the complexity of the rated securities. In the context of the US corporate bond market, this is particularly interesting, as certain issuers are more difficult to evaluate. In particular, Morgan [2002] provides evidence that bonds of financial issuers are much more complex to rate. The main point is that the risk of the assets is difficult to evaluate and, in addition, their exposure to risk factors can be changed quickly using derivatives. Considering liquidity, He and Milbradt [2014] provide evidence that price and liquidity impacts of rating changes might be stronger in a crisis period, adding to the arguments in Opp et al. [2013]. Due to the liquidity risk associated with rolling corporate debt over in a crisis, there are clear feedback effects of illiquidity interacting with credit risk in their model. These conditions lead to

Hypothesis 1. The informativeness of credit ratings for corporate bonds was low before the crisis, particularly for complex bonds, with the strongest price variations occurring around regulatory rating thresholds.

The low informativeness comes directly from the findings of Opp et al. [2013]: before the crisis, rating-contingent regulation was in place, and the economy was in an expansionary phase. Thus, the endogenous threshold level of the regulatory advantage was lower, beyond which the rating agency would have been better off terminating information acquisition and inflating the rating. A stronger market reaction around the regulatory threshold is also intuitively appealing, as well as being empirically supported by many papers in the literature.[8] In addition, under the assumption of financial bonds being more complex instruments, acquiring information is more costly when it comes to bonds issued by financial firms. Hence, the threshold level of regulatory advantage is lower and rating inflation more pronounced. This is in line with the model of Skreta and Veldkamp [2009], which links asset complexity to rating inflation via rating shopping.

[8] See, e.g., Kisgen and Strahan [2011], Bongaerts et al. [2012], and Ashcraft et al. [2011], who provide evidence of price effects through regulatory channels.

Hypothesis 2. The informativeness of credit rating changes for corporate bonds was high in the crisis period, and associated with high illiquidity.

In a crisis period, the credit quality of corporate bonds is low; i.e., firms are exposed to greater credit risk, and their outside options, e.g., financing using equity or loans, are less attractive. Following the theoretical literature, the benefits to CRAs from inflating ratings are lower, and there is more information acquisition and, thus, more informative ratings. Furthermore, there is additional interaction between credit and liquidity risk, as discussed in He and Milbradt [2014], potentially increasing the price and liquidity impacts. In line with this theory, the empirical evidence in the US suggests that the corporate bond market experienced an extremely high level of illiquidity during the global financial crisis, as shown by Friewald et al. [2012]. Thus, we would expect to find particularly large price and liquidity effects during a financial crisis.

Hypothesis 3. The regulations in the Dodd-Frank Act caused an improvement in the informativeness of credit ratings, but the effect may have been the opposite for complex bonds.

Removing the regulatory advantage for highly rated securities (through the increased liability of CRAs and the elimination of rating-contingent regulation) increases rating informativeness for both upgrades and downgrades. However, Opp et al. [2013] show that if a security is *too complex* to be rated, the effect could be reversed, due to information acquisition being too costly.[9] Interestingly, Dodd-Frank not only eliminated the regulatory advantage of credit ratings, but also introduced an asymmetry with regard to litigation risk, allowing for additional announcement effects. As argued by Dimitrov et al. [2015] on the basis of Goel and Thakor [2011], it is much more likely for CRAs to be sued due to optimistically biased ratings than pessimistic ones. This leads to asymmetric penalties between biased downgrades and upgrades. Consequently, CRAs will be much more reluctant to upgrade a bond, given the increased litigation risk. Thus, in the case of less information acquisition by the rating agency, differences between downgrades and upgrades might emerge.

4 Data

Our dataset represents credit downgrades and upgrades of US corporate bonds between January 2003 and May 2014, obtained from the Mergent Fixed Income Securities Database (FISD). We

[9] Ambiguous effects on rating informativeness from the introduction of a regulation that incentivizes higher issuer monitoring by the CRAs have also been demonstrated in Cohn et al. [2015].

consider the ratings of the three main rating agencies for our analysis: Standard & Poor's, Moody's, and Fitch. We exclude default or close-to-default events (i.e., downgrades to CCC-, Caa3 or lower and upgrades from CCC-, Caa3 or lower), which might be strongly influenced by asymmetric information and strategic behavior related to the default event.[10] Furthermore, we consider only straight, callable or puttable bonds, excluding all others with complex structures as the price reactions of these bonds might be driven mainly by embedded options.[11] We also only consider bonds with an amount issued greater than or equal to $10 million.

We set up a time window of 181 working days around the rating event (the event day, the 90 days before, and the 90 days after the event). Inside that window, we collect the transaction data for the downgraded/upgraded bonds from TRACE. Since July 2002, following an initiative of FINRA with the aim of bringing more transparency to the market, all transactions in US corporate bonds have had to be registered in the TRACE system by broker-dealers within 15 minutes of their execution; the relevant information provided includes the bond price as a percentage of the face value and the volume traded, among other details.[12] We cleanse the transaction data of errors using the algorithm described in Dick-Nielsen [2009]. In particular, we delete duplicates, trade corrections and trade cancellations on the same day. Moreover, we remove reversals, which are errors detected on a later day than that of the initial trade. Additionally, we implement the price filters used in Edwards et al. [2007] and Friewald et al. [2012]. Specifically, we adopt a reversal filter, that should eliminate extreme price movements, and a median filter, which identifies outliers in prices reported in TRACE within a given time period.

Given the high illiquidity of the corporate bond market, we only include bonds that have one or more trades in at least 15 out of the 90 days before and also 15 out of the 90 days after the event, similarly to Jankowitsch et al. [2014]. Moreover, we only consider bonds that, over the event day and the 5 days after it, either have an average cumulative daily volume of at least $1 million or an average volume per trade of $100,000. This allows us to exclude downgrades and upgrades of bonds whose price and liquidity impacts are mainly driven by retail investors.[13]

Our final sample contains 6,594 events, of which 4,332 are downgrades and 2,162 are upgrades. Table 1 contains a detailed description of the distribution of downgrades and upgrades over the rating grades and periods. We observe 3,178 downgrades of financial bonds and 1,254 of

[10] Default events in the US corporate bond market have been covered extensively in Jankowitsch et al. [2014].

[11] Convertibles, asset backed, exchangeable, foreign currency, perpetual and bonds with other complex optionalities are thus excluded from the final sample.

[12] Note that the volume data in TRACE are capped at $5 million for investment-grade bonds and at $1 million for high-yield bonds.

[13] Note that our main results hold if those bonds are included in the sample.

non-financial bonds: this considerable difference is mainly driven by the crisis period, when an extremely large number of downgrades occurred in the financial sector. In contrast, upgrades are less divergent between the two sectors: 1,338 are for financial and 826 for non-financial bonds. We match the sample with bond characteristics taken from the Mergent dataset and firm characteristics obtained from Compustat. In particular, in our analysis we use coupon, maturity, amount issued, inflation-corrected total assets and intangible assets. Table 2 presents summary statistics of the bond and firm characteristics.

5 Methodology

This section presents the methodology applied to measure the effect of rating changes on prices and liquidity. We present, here, our definitions of the three analyzed time periods, bond price and liquidity impacts, and various types of rating-related variables. We also present the regression setup that we use in our analysis.

5.1 Time Periods of Interest

We define three time periods, which include the financial crisis and the subsequent regulatory reforms. The first period represents rating events *before the crisis*, between January 2003 and November 2007. The second period represents rating changes *during the crisis*, starting in December 2007, which we identify as the beginning of the financial crisis in accordance with National Bureau of Economic Research [2010], and ending on July 21, 2010. The third period covers all events after the signing of the Dodd-Frank Act into federal law (*after Dodd-Frank*), and up until May 2014. Note that, with the introduction of Dodd-Frank, certain provisions came into force immediately, whereas others were to be implemented over time. More specifically, the CRAs' increased liability and the relaxation of pleading standards in private actions against rating agencies were valid immediately.[14] On the other hand, the elimination of rating-contingent regulation has instead had a gradual implementation, depending on the individual federal agencies, which have the responsibility for introducing new measures of creditworthiness that do not rely on ratings. The SEC produced a final rule effective from September 2011, and the Federal Reserve (FED) from June 2012, whereas the Office of the Controller of the Currency (OCC) made the new rules effective starting from January 2013.[15] On the other hand, the National Association

[14] Such rules are part of provision 933 of the Dodd-Frank Act.

[15] For more details, see e.g. SEC Final Rule on Security Ratings [2011] and FED Market Risk Capital Rule [2012].

of Insurance Commissioners (NAIC) has eliminated reference to credit ratings only for residential and commercial mortgage-backed securities but "still continues to rely on rating agencies for other asset classes", as documented in NAIC [2015].[16] Note that our results are robust to variations in the definitions of the three time periods.

In this respect, in the appendix we additionally provide tests for structural breaks, following Andrews [1993]. Overall, these results confirm our choice of time periods. As expected, we find a structural break at the time of the financial crisis around the Lehman default, confirming that the financial crisis led to significantly different market reactions. In addition, we find for both financial and non-financial bonds that a structural break occurs in mid-2010. Thus, the introduction of Dodd-Frank can be linked to this second structural break. Further details on the methodology and the results of these tests are presented in the appendix.

5.2 Price and Liquidity Impacts

For each rating event in our sample, we consider a time window of 181 days (the event day, the 90 days before and the 90 days after the event) and observe all transactions related to the affected bond. In a first step we calculate daily measures of price and liquidity, and in a second step we estimate the impact of the rating event on these measures.

Volume-Weighted Average Daily Price

We use a volume-weighted measure for the price, also applied by Bessembinder et al. [2009], for example. This measure places more weight on prices arising from transactions with higher volumes, reducing the noise introduced by smaller, potentially unrepresentative trades. The volume-weighted daily average price P_{it} of bond i on day t is given by

$$P_{it} = \frac{\sum_{j=1}^{n_{it}} p_{itj} v_{itj}}{\sum_{j=1}^{n_{it}} v_{itj}}$$

where p is the price observed for transaction j, with a volume of v, and n is the number of transactions on day t.

[16] As different market participants were affected at different points in time, an additional area of research would be to investigate potentially diverse trading behavior among these groups, before and after the new regulation became effective for each of them. However, given the small time intervals between the different implementations, this analysis would only be possible with data on the bond holdings of individual institutional investors.

Trading Activity

The trading activity can be identified both by the frequency and by the volume of trading. Thus, our first measure is the daily trading frequency, which is the number of transactions n_{it} in bond i on day t. The second measure of trading activity we adopt is the cumulative daily volume V_{it}, which is the sum of the volumes of the transactions in bond i on day t, given by

$$V_{it} = \sum_{j=1}^{n_{it}} v_{itj}$$

where v is the volume of transaction j.

Transaction Costs

The metric we use to capture liquidity is the price dispersion measure, introduced in Jankowitsch et al. [2011]. This is a direct estimate of transaction costs, based on the dispersion of the individual traded prices around the fundamental value of the bond, which is given by the average price, in this case. We calculate a daily measure of price dispersion D_{it} for bond i on day t

$$D_{it} = \sqrt{\frac{1}{\sum_{j=1}^{n_{it}} v_{itj}} \sum_{j=1}^{n_{it}} \left[\left(\frac{p_{itj}}{\frac{1}{n_{it}} \sum_{j=1}^{n_{it}} p_{itj}} - 1 \right)^2 v_{itj} \right]}$$

where p is the price, v the volume of transaction j, and n the number of transactions on day t. At least two transactions of bond i on day t are needed to calculate the measure. Many other liquidity measures are available for quantifying transaction cost, e.g., the Amihud or Roll measures (see Friewald et al. [2012] for a discussion). However, the price dispersion measure is ideal in the setting of corporate bond markets, as it does not require a long time series for its estimation, and is robust to effects from retail trading.[17]

Price and Liquidity Effects

Based on the daily price and liquidity measures, we consider a time window from 5 days before to 5 days after the rating change. The price and liquidity impacts are defined by the difference between the average of the daily measure across the 5 days before the event, and the average across the event day and the 5 days after it.[18] Note that the observed price changes could arise

[17] Note that our basic results also hold when we use other liquidity measures, and are available upon request.

[18] In addition, we use longer time windows such as 10, 15, 20, 25 and 30 days on either side of the event date as a robustness check, and find basically identical results.

due to market-wide movements of other factors, such as the risk-free interest rate. Thus, as an alternative definition of price impact, we consider the effect of the risk-free rate by estimating the price change of a duration-matched risk-free zero-coupon bond in the same time window, and adjust the observed price change (i.e., by subtracting the risk-free price change).[19]

5.2.1 Rating-Related Variables

In our analysis, we use different variables that are related to the credit rating or its change during the event. In a first step, we assign integer values to the different rating grades, starting from 1 for the highest to 21 for the lowest (see Table 1). This *rating number* allows us to construct various related variables.

We define the *number of notches* as the difference between the rating number before and that after the event, indicating the amount by which the downgrade/upgrade moved the bond rating. Intuitively, the more levels by which the rating is changed, the stronger we would expect the price reaction to be. Furthermore, we use a variable related to the *rating threshold* implied by the rating-contingent regulation in place before Dodd-Frank, when, especially for financial institutions, investment-grade bonds had preferred treatment. In order to analyze whether this effect was present in our sample, and whether it changed after Dodd-Frank, we include a dummy variable for rating changes that cross the investment-speculative rating threshold.

Note that every event in our sample is related to a rating change made by one of the three main rating agencies (Standard & Poor's, Moody's and Fitch). Based on the information from these rating agencies, we include the *number of agencies*, indicating how many CRAs rated the bond at the time of the rating change. In addition, we calculate the *rating dispersion*, representing the average absolute difference in the ratings of the three different agencies on the day the rating change occurred. This variable allows us to analyze whether greater disagreement among rating agencies leads to stronger price effects.

Implied Ratings

We also derive market-implied ratings to analyze whether rating changes are anticipated by the market. If the price information of bonds indicated an anticipation of future rating events, we could conclude that the additional information provided by the actual event was low. We measure market anticipation by estimating a *market-implied rating* based on the observed bond

[19] The risk-free rate used in the calculation of the yield spread is obtained from the term structure of swap rates, which come from Bloomberg.

yields in the whole US corporate bond market. For every rating event, we specify a time window from 90 days to 30 days before the event.[20] We calculate the mean of the yield spread for each rating grade of the agency involved in the particular event across all days and bonds traded in the market.[21] Thereby, we derive, for each rating grade, an average market yield spread related to each rating event. In the next step, we fit the following nonlinear model across rating grades:

$$y_i = exp(a + bi) + \epsilon_i$$

where y is the market yield spread calculated as above and i is the rating number. Based on the estimates for a and b, the implied rating of a bond between 90 and 30 days before its downgrade/upgrade is given by

$$\textit{market-implied rating} = \frac{log(y) - a}{b}$$

where y is the average yield spread across the 90 to 30 days before the rating change of the bond that is to be downgraded/upgraded. For each rating event, we compute the difference between the numerical rating of the bond preceding the rating change and the implied rating of the same bond, as a measure of the gap between the rating and the market. If the difference is negative, the implied rating is worse than the actual rating of the bond, which can be seen as an anticipation of the forthcoming downgrade from the market, i.e., that the rating implied by the bond yield has already incorporated the upcoming deterioration of the rating after the future downgrade.

5.3 Regression Analysis

We use a pooled regression model to investigate the determinants of changes in bond prices, where the dependent variable is given by the price change adjusted by the change in the risk-free rate, calculated as described in Section 5.2. The regression equation that explains the price variation related to the rating change of bond i of firm s, on day t, by rating agency u, is given

[20] We perform the same analysis with different time windows (90-60, 60-30, 30-1) and find that the results are similar.

[21] The risk-free rate used in the calculation of the yield spread is obtained from the term structure of swap rates from Bloomberg. The risk-free rates are then matched with the bond durations.

by

$$
\begin{aligned}
y_{i,t,s,u} = \alpha &+ \beta(\textit{Time Period Dummies})_t + \gamma(\textit{Rating-Related Variables})_{i,t,s,u} \\
&+ \delta(\textit{Changes in Liquidity and Trading Activity})_{i,t,s} \\
&+ \zeta(\textit{Bond Characteristics})_i + \eta(\textit{Firm Characteristics})_{t-1,s} + \epsilon_{i,t,s,u}
\end{aligned}
$$

Thus, this specification combines the entire time series and the cross-section of price changes. In the construction of our regression sample, whenever there are bonds of the same firm that are downgraded/upgraded on the same day, by the same rating agency, to and from the same rating grade, we take the average of our regression variables and consider it as one observation. In this manner, we avoid the concern that a single event might show up in the regression with multiple observations and potentially bias the results. We run the regressions with standard errors corrected for heteroscedasticity and clustered at the firm level.[22] In addition, we present regressions that are run for each time period separately, allowing us to analyze changes in the model parameters over time.

6 Results

This section provides the empirical analysis of market reactions to rating changes. For all rating events, we examine the time interval from 90 days before to 90 days after the rating events. We focus on the price changes but, in addition, cover metrics of changes in trading activity and liquidity for the three defined periods. First, we provide graphical representations of these time series and, in the main analysis, test the statistical significance of the observed changes directly around the event dates, i.e., from 5 days before to 5 days after the events. Second, we employ regression models to analyze the determinants of the price variations. Third, we explore whether market-implied ratings predict rating changes, and whether this relation changes over time.

6.1 Price, Trading Activity and Liquidity Changes

In this section, we analyze the changes in the prices, volumes, numbers of trades and transaction costs around rating changes. Figures 1 to 4 show the time series of average prices and traded

[22] As a robustness check, we ran regressions considering rating events on the same day, by the same rating agency, to and from the same rating grade, as separate events. In addition, we selected a set in which only rating events that did not overlap with any other event were considered. Moreover, we also clustered standard errors by firm-event combinations (using different definitions of the clusters). We basically obtained similar results in these robustness checks (which are not presented in detail in the paper, but are available upon request).

volumes in the time window from 90 days before to 90 days after the events, for downgrades and upgrades, and for bonds issued by non-financial and financial firms (non-financial and financial bonds), respectively. Starting with downgrades (see Figure 1 for non-financial and Figure 2 for financial bonds), we find statistically significant price reductions in all three periods around rating events. The strongest effect occurs in the crisis period for both non-financial and financial bonds; i.e., prices drop by around 6% of face value in the 91 days running up to and including the event, with a significant proportion of the reduction taking place in a short interval around the event. The period before the crisis shows the lowest effect, with a price move in the 90 days before the event of around 2%, and only a small reaction around the event day itself. The post-Dodd-Frank period lies in between, with the exception that, for financial bonds, the price reactions are more similar to those in the period before the crisis. Considering trading volume, we find that it often spikes significantly in a short period around the event day, increasing by up to four times the average volume. This can be observed for all three periods in the case of non-financial bonds. However, for financial bonds, we observe a volume spike only before the crisis. In general, the trading volumes before and after the events are in line with average trading volumes in the US corporate bond market (see, e.g., Friewald et al. [2012]).

Analyzing upgrades (see Figure 3 for non-financial and Figure 4 for financial bonds), we find much smaller reactions of bond prices to the rating change announcements. In addition, we do not observe particular price increases directly around the event days, but rather upward-sloping price trends over the whole period. The only exception, for financial bonds, is during the crisis period, when, in the first 90 days, prices increase by 6%, although again without any strong reaction on the event day. The trading volume shows a similar picture, in that we observe some increase in the trading volume around the event day for some periods, but the reaction is not as clear as for downgrades. Overall, we find, as May [2010] has documented previously, that credit downgrades seem to elicit a stronger reaction than upgrades from market participants.

To analyze the hypotheses presented in Section 3, we provide a formal test of the price reactions. Table 3 reports price changes as a percentage of the face value of the bond, adjusted for changes in the risk-free rate, and the results of the t-test and signed-rank test for downgrades and upgrades of financial and non-financial bonds, focusing on the price reaction directly around the event date (i.e., from 5 days before to 5 days after the event date).[23] Analyzing the effects of

[23]Note that we discuss price changes adjusted for changes in the risk-free rate in this section. We also test for relative price changes. Additionally, we test only for events that do not overlap the 5-day window. All methods provide basically identical results (which are available upon request).

downgrades, we find that price changes before the crisis are relatively low: downgrades of non-financial bonds have a decrease of -0.71%, whereas downgrades of financial bonds experience a drop of -0.59%. Moving to the crisis period, in comparison, price variations become much stronger for all credit rating downgrades: -1.35% and -1.51% for non-financial and financial bonds, respectively. In both cases, the differences between the two periods (i.e., -0.64% for non-financial and -0.92% for financial bonds) are statistically significant. These results are consistent with Hypotheses 1 and 2, predicting a low market reaction (due to rating inflation) in good times, especially for complex securities (e.g., financial bonds), and a much stronger reaction due to an increase in informativeness in the crisis period. We find that the effect doubles for non-financial bonds and triples for financial bonds. After Dodd-Frank, downgrades of non-financial bonds have a relatively high price effect of -1.12%, which is comparable to the crisis period and much higher than before the crisis. The difference between the periods *after Dodd-Frank* and *before the crisis*, which amounts to -0.41%, is again statistically significant. This result is in line with Hypothesis 3, according to which rating changes since the Dodd-Frank Act was passed should be more informative for the market, as rating-contingent regulation favoring high ratings was eliminated. Interestingly, for financial bonds, downgrades have a much lower price impact than before the crisis, decreasing by only -0.31% of face value, which amounts to a statistically significant difference between the two periods of 0.28%. Thus, as predicted in Hypothesis 3, the increase in informativeness cannot be observed for all bonds, and is reversed in the case of financial bonds, representing more complex securities.

As for upgrades, we find statistically significant price increases, as well, albeit on a much lower scale. Basically, the price reaction of an upgrade is only roughly 50% of the reaction of a downgrade in all periods. For non-financial bonds, we find price increases of 0.31%, 0.55% and 0.34%, respectively, in the three periods, providing similar insights to those for the downgrades.[24] For financial bonds, the results are 0.04%, 0.51% and 0.85%, respectively.[25] The main difference compared to the downgrades of financial bonds is that upgrades in the post-Dodd-Frank period lead to rather strong price increases. A possible explanation for this price impact is the asymmetry of responses with regard to litigation risk that has been created by Dodd-Frank. Following the argument presented in Section 3, it is much more likely for CRAs to be sued for optimistically biased ratings than for pessimistic ones, which leads to asymmetric penalties between biased downgrades and upgrades. CRAs are, therefore, much more reluctant to upgrade

[24] In the case of upgrades of non-financial bonds, the differences across periods are only marginally significant.
[25] For upgrades of financial bonds, the differences between the periods are statistically significant.

a bond for which they have acquired less information (i.e., for a complex security such as the bond of a financial firm). Consequently, to upgrade a bond, they must have received a clear signal indicating an improvement in its credit quality. The market anticipates this possibility and, considering that CRAs have access to some level of private information, reacts strongly whenever an upgrade occurs.

We analyze the reaction of bond market liquidity to credit rating changes, and in Table 4 we present the changes in trading volume, trading frequency and price dispersion, and the results of the corresponding t-test and signed-rank test for both downgrades and upgrades of non-financial and financial bonds. For downgrades, we find the strongest volume increase (around \$2 million) before the crisis for both non-financial and financial bonds (see Panels A and B). Considering the low price impact of these events, this result suggests that at least some of the trading is driven by the shifting of clientele due to the breaches of rating-contingent thresholds, rather than in reaction to new information. During the crisis, volumes increase by \$1.39 million and \$0.43 million for non-financial and financial bonds, respectively. Thus, the high price reactions occur with rather moderate increases in volumes, especially for financial bonds, indicating lower market activity, potentially because of higher sell-side pressure (see discussion of transaction costs below). After Dodd-Frank, volume increases are high for non-financial bonds, at \$1.59 million, and only moderate for financial bonds, in line with the price reactions presented above. For upgrades, we find only moderate volume increases before the crisis, i.e., \$0.45 million and \$0.66 million for non-financial and financial bonds, respectively, in line with the low price reactions. The strongest volume increase of around \$1 million can be observed during the crisis, indicating that an upgrade might reduce the effects of sell-side pressure. After the Dodd-Frank Act, we find a rather large increase in volume (\$2.02 million) for financial bonds, again in line with the price reactions. The change in the number of trades (presented in Panels C and D) shows a similar picture to that of the trading volume, in that we see a larger increase in the number of trades when the volume also increases.

Panels E and F of Table 4 show that all bond downgrades during the crisis are accompanied by a statistically and economically significant increase in transaction costs and, therefore, a lower level of liquidity, indicating sell-side pressure.[26] Downgrades during the crisis trigger increases in transaction costs of 26.44 bp and 5.06 bp for non-financial and financial bonds, respectively. Moreover, downgrades of non-financial bonds lead to a 9 bp increase in transaction costs after

[26] We consider a variation in price dispersion of at least 5 bp to be economically relevant.

Dodd-Frank, which is consistent with the higher price and volume impact observed for such bonds in that period. Note that, in our data, the average level of price dispersion in the 5 days before a downgrade is 72 bp.

Overall, we find that, for non-financial bonds, the price reactions increased after Dodd-Frank compared to before the crisis, whereas for financial bonds downgrades became less informative after Dodd-Frank. Trading activity and liquidity provide additional insights concerning the reaction of market participants, showing different levels of price reactions across the three periods.

6.2 Regression Analysis

In this section, we present the results of different regression models analyzing the price changes presented earlier. The first set of regressions uses time-period dummies, which allow us to confirm the tests of the previous section; in the second set, we run individual regressions for each period to analyze whether the impact of explanatory variables changes over time (see Section 5). In all these regressions, the dependent variable represents the price changes following downgrades, as these events turned out to be more important, based on the earlier analysis.[27]

Tables 5 and 6 show the results of the regression models using time-period dummies for non-financial and financial bonds, respectively. In Model 1, rating variables, liquidity and trading activity are included. Model 2 instead has bond and firm characteristics. Model 3 includes all the variables taken together: this is our main benchmark for explaining the determinants of the bond price changes. Analyzing Model 3 for non-financial bonds, we find that during the crisis and after Dodd-Frank the informativeness of downgrades is higher than in the pre-crisis regime. Specifically, prices decrease 0.27% and 0.58% more in the crisis period and after Dodd-Frank, respectively. However, only the *After Dodd-Frank* dummy is statistically significant. The effect observed during the financial crisis is captured mainly by liquidity (this effect will be discussed in more detail in reference to the single-period regressions presented in Table 7). In addition, the analysis of the rating-related variables shows that downgrades have weaker price impacts when bonds are rated by a larger number of agencies. Interestingly, we find a significant effect for the rating threshold between the investment and speculative grades: the price change following such a downgrade has a 1.01% larger decline. Considering liquidity and trading activity, an increase in the transaction cost and trading frequency is related to a stronger price impact of downgrades (i.e., a one-standard-deviation change leads to price changes for these three variables of -0.50%

[27] The results for credit upgrades are not reported here in the interest of conserving space, but are qualitatively similar.

and -0.34%, respectively). Additionally, we find a slightly weaker reaction for bonds with a longer time to maturity. Finally, non-financial bonds with higher coupons experience stronger price decreases when they are downgraded, possibly because they represent bonds with greater credit and liquidity risk.

In the case of the results from the regression models for downgrades of financial bonds, we find, based on the time-period dummies in the full model, that the crisis period is associated with a decrease in prices that is 0.68% larger, following a downgrade, consistent with our Hypothesis 2 and the results of the price tests. Although positive, the post-Dodd-Frank dummy is not statistically significant. Thus, the finding that Dodd-Frank improves informativeness only for non-financial bonds is confirmed: the informativeness of financial bonds is, at best, as low as in the period before the crisis. Analyzing the rating-related variables, we find a stronger reaction following downgrades by Moody's, which might be driven by the fact that Moody's is the only agency that takes into account recovery after default in its ratings methodology, something that could be more relevant for financial bonds. Downgrades from investment to speculative grade do lead to a stronger reaction; however, these effects are only marginally significant. Trading activity and liquidity variables provide similar effects to those for non-financial bonds. Analyzing firm and bond characteristics, we find a size effect: the greater the amount issued of a bond, the lower is the price reaction following a downgrade.

Two important issues are not covered in this set of results. First, it would be interesting to know whether the effect of credit downgrades/upgrades on the regulatory threshold changed after the introduction of Dodd-Frank, when this threshold was no longer legally binding.[28] Second, Hypothesis 2 stresses the importance of liquidity in relation to price changes during the financial crisis. From this perspective, knowing whether or not the liquidity effect was constant across time periods would provide a useful insight regarding the relation between corporate bond prices and liquidity when rating changes occur. We tackle both issues in the second set of regressions that provide individual estimations for the three periods.

Table 7 shows the results of these regressions. Focusing first on the rating threshold, we find that, in the case of non-financial bonds, the negative coefficient obtained in the first set of regressions is driven solely by the years before the crisis. Since Dodd-Frank, being downgraded from investment to speculative grade has not led to greater price reactions, as Dodd-Frank has

[28]Following Dodd-Frank, regulatory thresholds stopped being legally binding, although this happened at different times for different kinds of investors, as pointed out in Section 5.1. Analyzing the different effects of such changes across investor categories (pension funds, insurance companies, etc.) might a be a fruitful direction for future research.

progressively weakened rating-contingent regulation. Considering financial bonds, consistent with the results of Tables 5 and 6, we find that downgrades from investment to speculative grade do not play as important a role for financial bonds as for non-financial bonds. Moving to the analysis of liquidity, we find that, in the case of non-financial bonds, the liquidity effect comes mostly from the crisis period, i.e., that the transaction cost variable is statistically significant. This supports the idea that liquidity captures the stronger price reactions for non-financial bonds over the crisis period, consistent with the discussion of the results of Table 5. In addition, trading volume has a significant effect after Dodd-Frank, consistent with the plots in Figure 1. A strong liquidity effect during the crisis is also present for financial bonds, which is, again, in line with the tests on liquidity previously discussed. In the case of financial bonds, liquidity and trading activity also have statistically significant impacts on prices in the other periods. However, overall, the effect is smaller than during the crisis period. All other variables provide similar results to those in the first set of regressions.

6.3 Implied Ratings Analysis

In this section, we analyze whether rating changes are anticipated by market participants, and whether such expectations are different across the three periods. We estimate a market-implied rating before the rating event by comparing the yield of the particular bond to the observed yields in the various rating classes, based on all bonds in the market (see Section 5). This market-implied rating is compared to the actual rating of the bond before the event. If a credit rating change occurred unexpectedly, this difference is zero; otherwise, there is a negative difference when credit downgrades were anticipated, and a positive one for anticipated upgrades.

Table 8 shows the average differences for downgrades and upgrades, separately for non-financial and financial bonds. Starting with downgrades, we find that, before the crisis, rating changes were anticipated in the market; i.e., on average, the differences are -0.85 and -1.30 notches for non-financial and financial bonds, respectively. Thus, for financial bonds the anticipation is significantly stronger. During the crisis, we basically observe no anticipation. After Dodd-Frank, there is no economically signficant anticipation either; i.e., the average differences are -0.21 and -0.14 notches, for non-financial and financial bonds, respectively. Based on the previous finding, we assume there are different reasons for this observation: for non-financial bonds, it could be a result of the higher informativeness of the ratings (as market prices react to the change), and for financial bonds it could be a simple consequence of bonds being downgraded immediately,

in line with publicly available information, without any increase in the informativeness of rating changes (as market prices do not react), as legal claims in a tort case could be based on such rating differences.

The results for upgrades are interesting, as well. Comparing the time periods before the crisis and after Dodd-Frank, we find that after Dodd-Frank the expectation of upgrades is higher, i.e., on average 0.21 vs 1.09 for non-financial bonds, and 1.08 vs 1.98 for financial bonds, respectively. Thus, before the crisis, ratings were adjusted rather quickly in response to good news, whereas since Dodd-Frank rating agencies have become more reluctant to upgrade, especially in the case of financial bonds. Again, this result could be a direct consequence of the asymmetric litigation risk brought about by Dodd-Frank.

Overall, we find that the anticipation of rating changes is different in the three time periods. In particular, we find that credit downgrades were anticipated before the crisis, but are not since Dodd-Frank. Thus, the staleness of ratings before credit downgrades has disappeared since the introduction of the new regulation. However, CRAs are now more reluctant to upgrade bonds, as a consequence of the potential litigation risk in the event of a lawsuit for damages. In general, these results are in line with the observed price changes and the hypotheses discussed.

7 Conclusion

The financial crisis in 2008-2009 and the subsequent regulatory changes introduced by Dodd-Frank are two recent events that have heavily affected the credit rating industry, first, by bringing into question the informativeness of credit ratings, and second, by eliminating rating-contingent regulation and increasing litigation risk. One of the markets most heavily affected by these events is the US corporate bond market. In this market, CRAs play an important role in assessing the credit risk, as private credit information is not easily available to investors. In addition, this market represents an ideal laboratory as virtually all transaction data are available.

In this paper, we analyze the impact of rating changes on the prices and liquidity of US corporate bonds from 2003 to 2014. Our dataset covers three important periods: before the crisis, during the financial crisis and recession, and after Dodd-Frank. Moreover, we analyze financial bonds and non-financial bonds separately. We find that the informativeness of rating changes was generally low before the crisis, and that rating changes for financial bonds were less informative than those of non-financial bonds. Furthermore, the informativeness increased during the

crisis, in combination with a high level of illiquidity in relation to all downgrades. Since Dodd-Frank, credit rating changes have led to a significantly stronger market reaction for non-financial bonds, whereas we find a weaker reaction for financial bonds, indicating that the new regulatory framework has ambiguous effects depending on the complexity of the securities. These results are consistent with the predictions of the existing theoretical models, such as Skreta and Veldkamp [2009] and Opp et al. [2013]. A regression analysis additionally shows the importance of rating-contingent thresholds before the introduction of Dodd-Frank. Finally, we analyze ratings implied by market yields, finding that downgrades are less anticipated after Dodd-Frank than before the crisis, whereas the opposite holds for upgrades. This suggests that Dodd-Frank might have eliminated stale, overly optimistic ratings that were released before the crisis. However, the asymmetric penalties imposed by Dodd-Frank could make CRAs reluctant to upgrade bonds promptly.

Overall, our paper contributes to the understanding of how the effect of credit ratings changes on US corporate bonds has varied in different economic environments, particularly since the introduction of Dodd-Frank. We provide new evidence by analyzing trading activity and liquidity surrounding downgrades/upgrades, covering the whole market, and going well beyond the existing literature. Our results may be of interest to policy makers, in relation to evaluating the efficiency of existing regulations, and to market participants, in relation to adapting their investment and risk management strategies to the new regulatory framework.

Appendix: Structural Break Test

In this section, we provide tests for identifying structural breaks in the price variations of US corporate bonds surrounding rating changes, in our time period from January 2003 to May 2014. Such tests allow us to evaluate the choice of the three time periods (see Section 5.1).

The most basic test for structural breaks is the Chow test, introduced by Chow [1960]. It is designed for time series, and it allows one to identify a single break at a known time point t^*. Consider the regression models $y_t = x'\beta + \epsilon_t$ and $y_t = x'\beta_t + \delta_t x'\gamma + \epsilon_t$, where δ_t is a dummy that equals 1 if $t < t^*$. Under the null of no structural break at t^*, which is equivalent to $\gamma = 0$, the test statistic is given by

$$F_{t^*} = \frac{(RSS_1 - RSS_2)(T - 2k)}{RSS_2 \cdot k}$$

where RSS_1 and RSS_2 are the residual sums of squares of the first and second regression models presented above, respectively. T is the point of the last observation in the time series and k is the number of regressors. The test statistic has a χ^2 distribution with k and $T - 2k$ degrees of freedom and it rejects the null hypothesis when it is too large. A limitation of the Chow test is imposed by the fact that the break date needs to be specified. The structural break F-test described in Andrews [1993] overcomes this problem and allows one to test for a structural break at an unknown point in time. The basic idea here is to extend the Chow test by calculating the Chow test statistic for *all* the potential breakpoints in a given interval $[\underline{t}, \bar{t}]$. $\underline{t}$ is observation n in the time series, where $n > k$, and conversely $\bar{t}$ is observation $T - n$, where T is the last observation. The test statistic is given by

$$supF = \sup_{\underline{t} \leq t \geq \bar{t}} F_t$$

which has a non-standard pivotal distribution that depends on the number of parameters and dates tested. We apply this test based on our regression model presented in Section 5.3. Given that the test is designed for time series, we create a monthly time series of our model by taking the average of the price changes and all the regressors in each month of our sample period.

In the presentation of the results, we focus on price changes of downgrades for financial and non-financial bonds. However, the tests concerning upgrades provide a similar picture. Figure 5

summarizes our results and presents the time series of the F-statistics, covering the full period in the two upper plots and the sub-periods in the two lower plots, separately for financial and non-financial bonds. Starting with the full time series of the F-statistics for financial bonds, we find a sharp increase during the crisis period, particularly around the Lehman default, in line with our result of more significant price changes in this period. Interestingly, the F-statistic drops below the pre-crisis level after the introduction of Dodd-Frank. Considering non-financial bonds, we again find an increase around the Lehman default; however, there is a second sharp increase after the introduction of Dodd-Frank. Thus, we find important differences between financial and non-financial bonds, as in our analysis of price and liquidity changes.

Applying the test to these F-statistics based on the whole time series, we basically find a structural break in the financial crisis around the Lehman default, confirming that the financial crisis led to a significant difference in the market reaction. However, as the test can only identify one structural break and we are particularly interested in whether an additional structural break occurred after the introduction of Dodd-Frank, we separately analyze a sub-period spanning only the crisis and the post-Dodd-Frank period. These results are presented in the two lower plots. We find, for both financial and non-financial bonds, that a structural break occurs in mid-2010 (in July for financial and April for non-financial bonds). The F-statistics are significantly lower for financial and higher for non-financial bonds after the break. Thus, these results support our choice of time periods, confirming that a structural break occurred directly around the introduction of Dodd-Frank.

References

A. Alp. Structural shifts in credit rating standards. *The Journal of Finance*, 68(6):2435–2470, December 2013.

D. W. K. Andrews. Tests for parameter instability and structural change with unknown change point. *Econometrica*, 61(4):821–856, July 1993.

A. Ashcraft, P. Goldsmith-Pinkham, P. Hull, and J. Vickery. Credit ratings and security prices in the subprime MBS market. *American Economic Review*, 101(3):115–119, May 2011.

R. P. Baghai, H. Servaes, and A. Tamayo. Have rating agencies become more conservative? Implications for capital structure and debt pricing. *The Journal of Finance*, 69(5):1961–2005, October 2014.

J. Bao, J. Pan, and J. Wang. The illiquidity of corporate bonds. *The Journal of Finance*, 66(3): 911–946, June 2011.

B. Becker and T. Milbourn. How did increased competition affect credit ratings? *Journal of Financial Economics*, 101(3):493–514, September 2011.

H. Bessembinder, K. M. Kahle, W. F. Maxwell, and D. Xu. Measuring abnormal bond performance. *The Review of Financial Studies*, 22(10):4219–4258, 2009.

P. Bolton, X. Freixas, and J. Shapiro. The credit ratings game. *The Journal of Finance*, 67(1): 85–111, February 2012.

D. Bongaerts, K. J. M. Cremers, and W. N. Goetzmann. Tie breaker: Certification and multiple credit ratings. *The Journal of Finance*, 67(1):113–152, February 2012.

G. C. Chow. Tests of equality between sets of coefficients in two linear regressions. *Econometrica*, 28(3):591–605, July 1960.

J. Cohn, U. Rajan, and G. Strobl. Credit ratings: Strategic issuer disclosure and optimal screening. *Working Paper*, November 2015.

I. D. Dichev and J. D. Piotroski. The long-run stock returns following bond ratings changes. *The Journal of Finance*, 56(1):173–203, February 2001.

J. Dick-Nielsen. Liquidity biases in TRACE. *The Journal of Fixed Income*, 19(2):43–55, Fall 2009.

J. Dick-Nielsen, P. Feldhutter, and D. Lando. Corporate bond liquidity before and after the onset of the subprime crisis. *Journal of Financial Economics*, 103(3):471–492, March 2012.

V. Dimitrov, D. Palia, and L. Tang. Impact of the Dodd-Frank act on credit ratings. *Journal of Financial Economics*, 115(3):505–520, March 2015.

Dodd-Frank Wall Street Reform and Consumer Protection Act. July 2010. URL `https://www.sec.gov/about/laws/wallstreetreform-cpa.pdf`.

A. K. Edwards, L. E. Harris, and M. S. Piwowar. Corporate bond market transaction costs and transparency. *The Journal of Finance*, 62(3):1421–1451, June 2007.

A. Ellul, C. Jotikasthira, and C. T. Lundblad. Regulatory pressure and fire sales in the corporate bond market. *Journal of Financial Economics*, 101(3):596–620, September 2011.

FED Market Risk Capital Rule. June 2012. URL `http://www.gpo.gov/fdsys/pkg/FR-2012-08-30/pdf/2012-16759.pdf`.

N. Friewald, R. Jankowitsch, and M. G. Subrahmanyam. Illiquidity or credit deterioration: A study of liquidity in the US corporate bond market during financial crises. *Journal of Financial Economics*, 105(1):18–36, July 2012.

A. M. Goel and A. V. Thakor. Credit ratings and litigation risk. *Working Paper*, March 2011. URL `http://dx.doi.org/10.2139/ssrn.1787206`.

J. C. Goh and L. H. Ederington. Is a bond rating downgrade bad news, good news, or no news for stockholders? *The Journal of Finance*, 48(5):2001–2008, December 1993.

P. Grier and S. Katz. The differential effects of bond rating changes on industrial and public utility bonds by maturity. *The Journal of Business*, 49(2):226–239, April 1976.

P. A. Griffin and A. Z. Sanvicente. Common stock returns and rating changes: A methodological comparison. *The Journal of Finance*, 37(1):103–119, March 1982.

J. R. M. Hand, R. W. Holtausen, and R. W. Leftwich. The effect of bond rating agency announcements on bond and stock prices. *The Journal of Finance*, 47(2):733–752, June 1992.

Z. He and K. Milbradt. Endogenous liquidity and defaultable bonds. *Econometrica*, 82(4): 1443–1508, July 2014.

G. Hite and A. Warga. The effect of bond rating changes on bond price performance. *Financial Analysts Journal*, 53(3):35–51, May-June 1997.

R. W. Holthausen and R. W. Leftwich. The effect of bond rating changes on common stock prices. *Journal of Financial Economics*, 17(1):57–89, September 1986.

E. S. Hotchkiss and G. Jostova. The determinants of corporate bond trading: A comprehensive analysis. July 2007.

L. Hsueh and Y. Liu. Market anticipation and the effect of bond rating changes on common stock prices. *Journal of Business Research*, 24(3):225–239, May 1992.

R. W. Ingram, L. D. Brooks, and R. M. Copeland. The information content of municipal bond rating changes: A note. *The Journal of Finance*, 38(3):997–1003, June 1983.

R. Jankowitsch, A. Nashikkar, and M. G. Subrahmanyam. Price dispersion in OTC markets: A new measure of liquidity. *Journal of Banking and Finance*, 35(2):343–357, February 2011.

R. Jankowitsch, F. Nagler, and M. G. Subrahmanyam. The determinants of recovery rates in the US corporate bond market. *Journal of Financial Economics*, 114(1):155–177, October 2014.

P. Jorion, A. Z. Liu, and C. Shi. Informational effects of regulation FD: Evidence from rating agencies. *Journal of Financial Economics*, 76(2):309–330, May 2005.

S. Katz. The price adjustment process of bonds to rating reclassifications. *The Journal of Finance*, 29(2):551–559, May 1974.

Y. Kim and S. Nabar. Bankruptcy probability changes and the differential informativeness of bond upgrades and downgrades. *Journal of Banking and Finance*, 31(12):3843–3861, December 2007.

D. J. Kisgen and P. E. Strahan. Do regulations based on credit ratings affect a firm's cost of capital? *The Review of Financial Studies*, 23(12):4324–4347, March 2011.

P. Krugman. The effect of bond rating changes on common stock prices. *New York Times*, April 2010. URL `http://www.nytimes.com/2010/04/26/opinion/26krugman.html?_r=0`.

J. Li, Y. Shin, and W. Moore. Reactions of Japanese markets to changes in credit ratings by global and local agencies. *Journal of Banking and Finance*, 30(3):1007–1021, March 2006.

A. D. May. The impact of bond rating changes on corporate bond prices: New evidence from the over-the-counter market. *Journal of Banking and Finance*, 34(11):2822–2836, November 2010.

D. P. Morgan. Rating banks: Risk and uncertainty in an opaque industry. *American Economic Review*, 92(4):874–888, September 2002.

NAIC. NAIC report on rating agencies. 2015. URL `http://www.naic.org/cipr_topics/topic_rating_agencies.htm`.

National Bureau of Economic Research. September 2010. URL `http://www.nber.org/cycles/sept2010.pdf`.

N. Nayar and M. S. Rozeff. Ratings, commercial paper and equity returns. *The Journal of Finance*, 49(4):1431–1449, September 1994.

L. Norden and M. Weber. Informational efficiency of credit default swap and stock markets: The impact of credit rating announcements. *Journal of Banking and Finance*, 28(11):2813–2843, November 2004.

C. C. Opp, M. M. Opp, and M. Harris. Rating agencies in the face of regulation. *Journal of Financial Economics*, 108(1):46–61, April 2013.

F. Sangiorgi and C. Spatt. Opacity, credit rating shopping and bias. *Working Paper*, November 2015.

SEC Final Rule on Security Ratings. September 2011. URL `http://www.sec.gov/rules/final/2011/33-9245.pdf`.

V. Skreta and L. Veldkamp. Ratings shopping and asset complexity: A theory of ratings inflation. *The Journal of Monetary Economics*, 56(5):678–695, July 2009.

L. Wakeman. Bond rating agencies and the capital markets. *Working Paper, University of Rochester NY*, 1978.

J. W. Wansley and T. M. Clauretie. The impact of credit watch placement on equity returns and bond prices. *Journal of Financial Research*, 8(1):31–42, 1985.

M. I. Weinstein. The effect of a rating change announcement on bond price. *Journal of Financial Economics*, 5(3):329–350, December 1977.

Figure 1: **Time Series for Downgrades of Non-Financial Bonds.**
This figure presents, for each of the three sample periods, the time series of the daily average price and daily average cumulative trading volume. Each is calculated across all events within the time interval from 90 days before to 90 days after the event. The lefthand column shows the results for the price and the righthand one those for the trading volume. Our data refer to downgrades and upgrades that occurred in the US corporate bond market between January 2003 and May 2014. We obtain the ratings from Mergent FISD and the daily bond transactions from TRACE. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014).

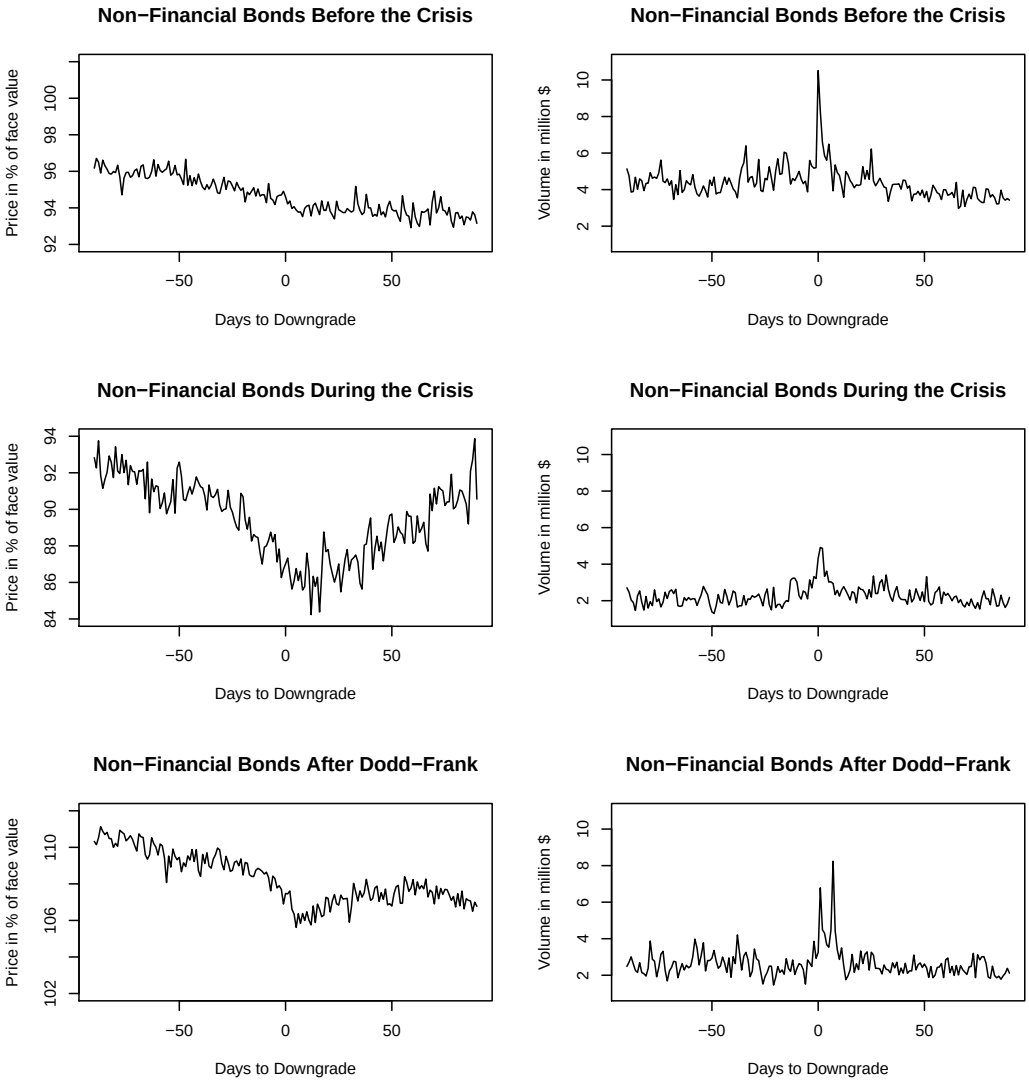

Figure 2: **Time Series for Downgrades of Financial Bonds.**
This figure presents, for each of the three sample periods, the time series of the daily average price and daily average cumulative trading volume. Each is calculated across all events within the time interval from 90 days before to 90 days after the event. The lefthand column shows the results for the price and the righthand one those for the trading volume. Our data refer to downgrades and upgrades that occurred in the US corporate bond market between January 2003 and May 2014. We obtain the ratings from Mergent FISD and the daily bond transactions from TRACE. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014).

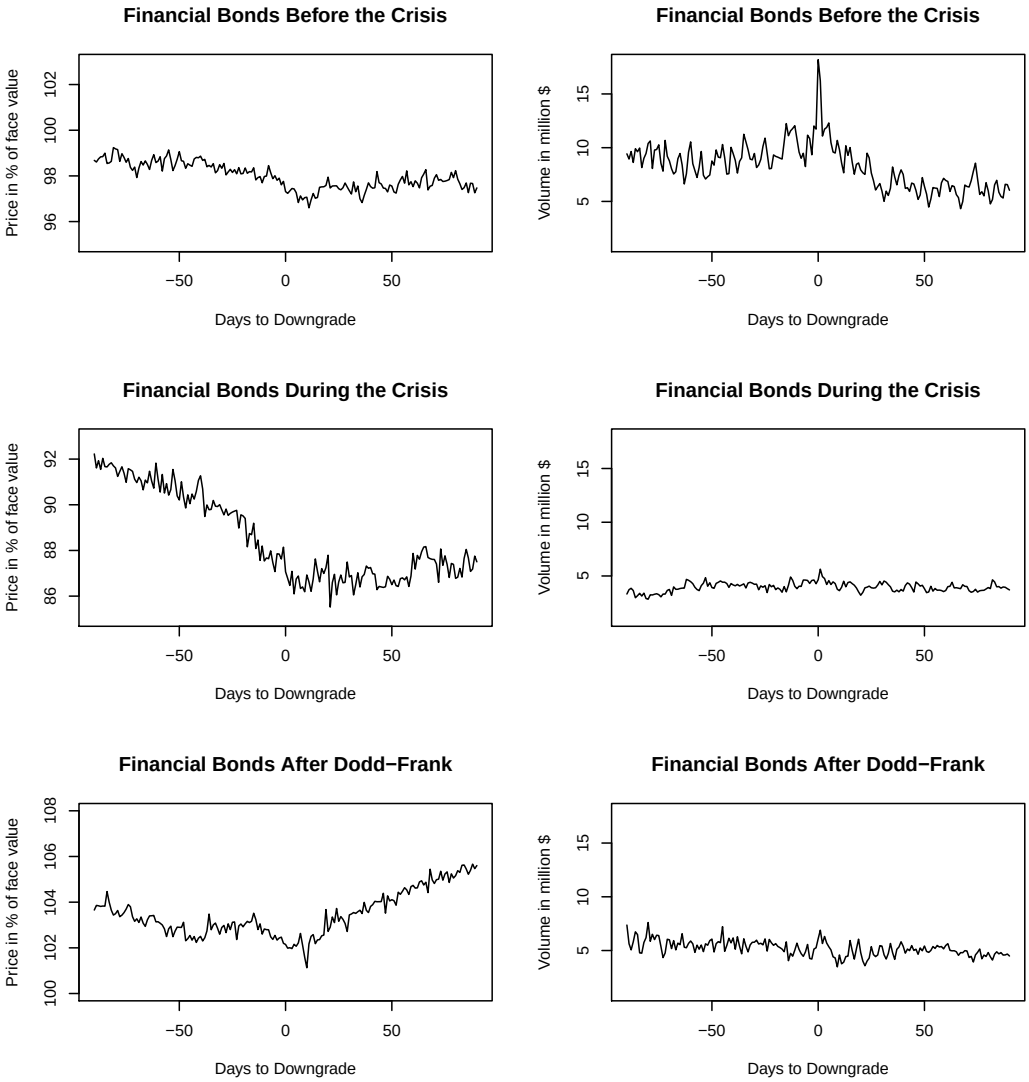

Figure 3: **Time Series for Upgrades of Non-Financial Bonds.**
This figure presents, for each of the three sample periods, the time series of the daily average price and daily average cumulative trading volume. Each is calculated across all events within the time interval from 90 days before to 90 days after the event. The lefthand column shows the results for the price and the righthand one those for the trading volume. Our data refer to downgrades and upgrades that occurred in the US corporate bond market between January 2003 and May 2014. We obtain the ratings from Mergent FISD and the daily bond transactions from TRACE. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014).

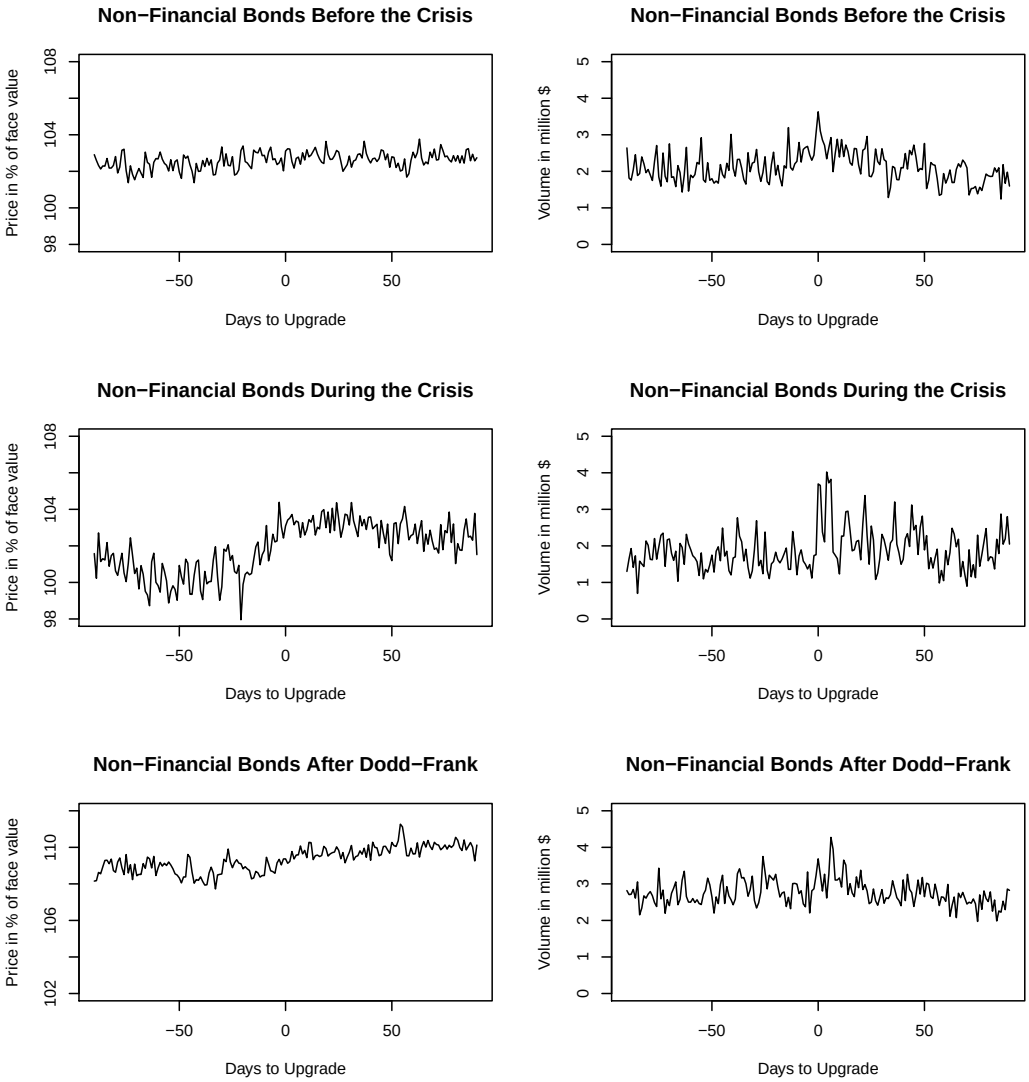

Figure 4: **Time Series for Upgrades of Financial Bonds.**
This figure presents, for each of the three sample periods, the time series of the daily average price and daily average cumulative trading volume. Each is calculated across all events within the time interval from 90 days before to 90 days after the event. The lefthand column shows the results for the price and the righthand one those for the trading volume. Our data refer to downgrades and upgrades that occurred in the US corporate bond market between January 2003 and May 2014. We obtain the ratings from Mergent FISD and the daily bond transactions from TRACE. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014).

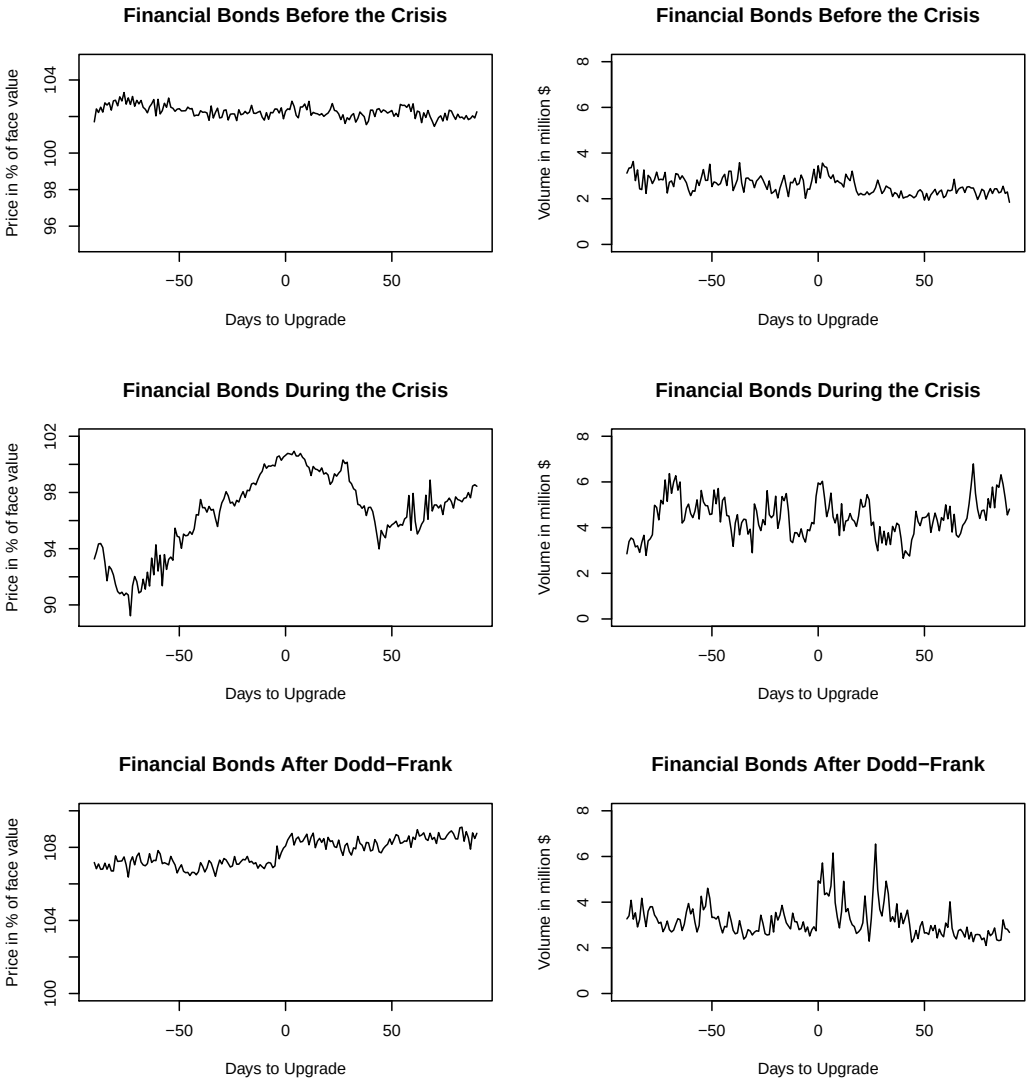

Figure 5: **Structural Break Tests: Downgrades of Financial and Non-Financial Bonds**
This figure shows the results of the Andrews [1993] test for a structural break in the price variations surrounding rating changes in the US corporate bond market. The results for financial and non-financial bonds are presented in the lefthand and righthand columns, respectively. The two upper plots show the results for the full sample period, whereas the two lower plots concentrate on the sub-periods *during the crisis* and *after Dodd-Frank*. The reference model for the test explains the price variation related to a rating change, as presented in Section 5.3, excluding the time dummies. The test is performed on a monthly time series of the model, obtained by taking the average of the price changes and all the regressors in each month of the sample period. The horizontal line marks the 1% level of significance derived from the test, where the test statistic is given by SupF, under the null hypothesis of no structural break.

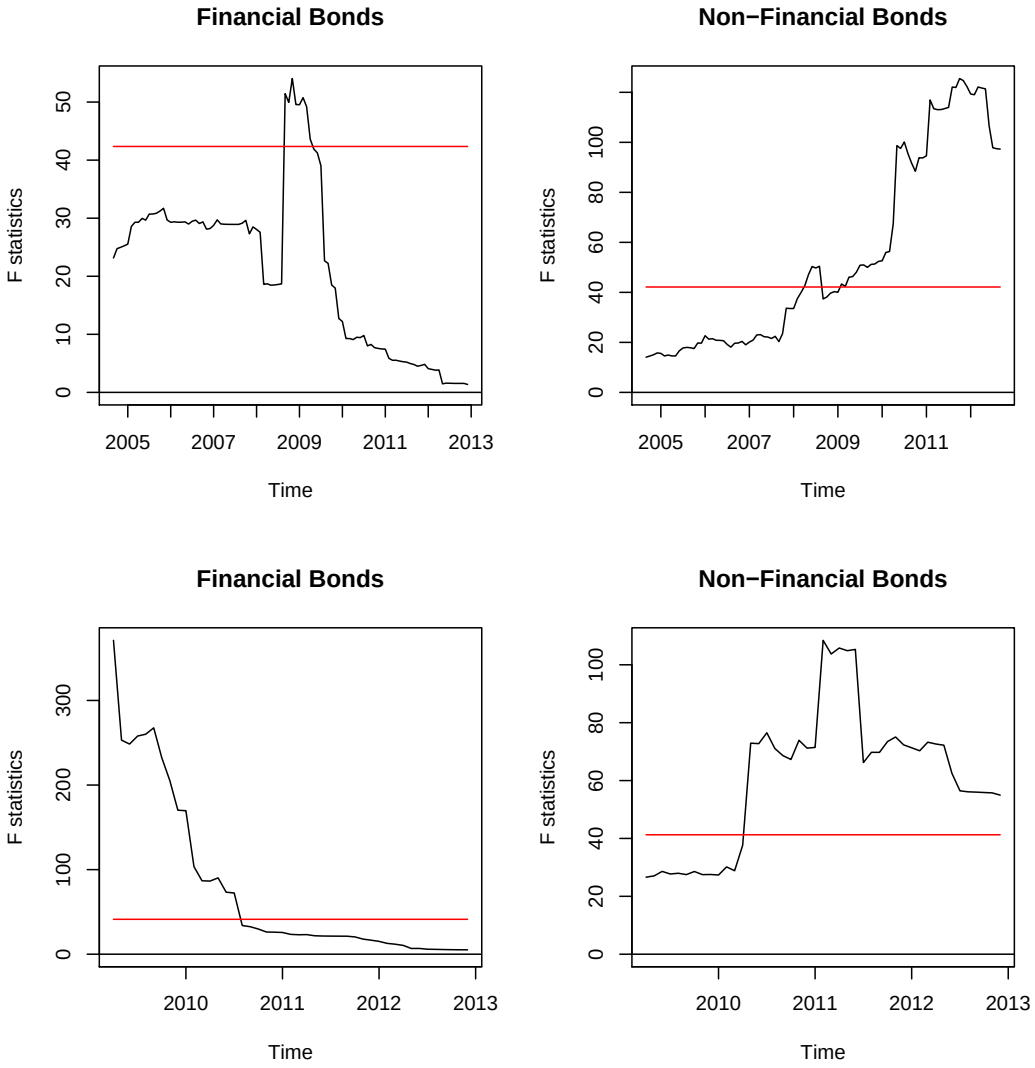

Table 1: **Summary Statistics of Downgrades and Upgrades.**
This table shows how the rating events are distributed in our sample. The table reports the ratings of the bonds after the downgrade/upgrade. Rating is a variable that assigns integer values to the different rating grades, starting from 1 for the highest and extending down to 21 for the lowest rating grade. The table is divided by rating grade, type of event (downgrade/upgrade), bond issuer (financial/non-financial) and time period (before the crisis, during the crisis and after Dodd-Frank). We obtain the ratings from Mergent FISD and the daily bond transactions from TRACE. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014).

	Downgrades									Upgrades									ALL EVENTS
Rating	Financial Bonds				Non-Financial Bonds				All Bonds	Financial Bonds				Non-Financial Bonds				All Bonds	All Bonds
	Before	During	After	All Periods	Before	During	After	All Periods	All Periods	Before	During	After	All Periods	Before	During	After	All Periods	All Periods	All Periods
AAA/Aaa/1	0	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	0	10	10
AA+/Aa1/2	5	45	7	57	0	1	1	2	59	57	2	0	59	0	0	0	0	59	118
AA/Aa2/3	7	71	12	90	1	13	0	14	104	132	20	1	153	1	3	22	26	179	283
AA-/Aa3/4	19	104	55	178	4	9	6	19	197	202	37	19	258	2	0	49	51	309	506
A+/A1/5	89	220	154	463	34	11	0	45	508	150	31	31	212	28	11	34	73	285	793
A/A2/6	33	254	151	438	90	30	10	130	568	78	18	9	105	39	24	57	120	225	793
A-/A3/7	41	181	178	400	53	35	93	181	581	35	6	23	64	29	16	52	97	161	742
BBB+/Baa1/8	71	101	135	307	52	45	57	154	461	22	1	66	89	48	29	51	128	217	678
BBB/Baa2/9	79	125	122	326	63	45	37	145	471	16	1	18	35	42	13	18	73	108	579
BBB-/Baa3/10	58	67	32	157	64	47	24	135	292	3	1	59	63	35	3	32	70	133	425
BB+/Ba1/11	119	33	46	198	49	31	21	101	299	42	0	41	83	27	2	10	39	122	421
BB/Ba2/12	109	28	16	153	44	9	7	60	213	0	0	29	29	24	5	27	56	85	298
BB-/Ba3/13	63	18	16	97	36	6	15	57	154	1	27	16	44	11	5	26	42	86	240
B+/B1/14	34	70	4	108	34	17	8	59	167	0	25	39	64	3	2	12	17	81	248
B/B2/15	16	66	0	82	37	2	6	45	127	0	13	3	16	10	0	7	17	33	160
B-/B3/16	1	61	12	74	39	6	5	50	124	0	37	10	47	6	1	8	15	62	186
CCC+/Caa1/17	2	26	6	34	31	8	5	44	78	0	0	5	5	2	0	0	2	7	85
CCC/Caa2/18	0	0	16	16	4	6	3	13	29	0	0	0	0	0	0	0	0	0	29
CCC-/Caa3/19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CC/Ca/20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C/C/21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All Ratings	746	1470	962	3178	635	321	298	1254	4432	748	219	369	1336	307	114	405	826	2162	6594

Table 2: **Summary Statistics of Bond and Firm Characteristics.**
This table shows summary statistics of the main characteristics of the bonds and related firms. The table shows the statistics for each of the three sample periods, separately and all together. Moreover, the sample is divided into downgrades, upgrades, financial bonds and non-financial bonds. Maturity and coupon are measured in years and percentage of face value, respectively. Amount issued, total assets and intangible assets are given in millions of dollars. Rating is a variable that assigns integer values to the different rating grades, starting from 1 for the highest and extending down to 21 for the lowest rating grade. We obtain the ratings from Mergent FISD and the daily bond transactions from TRACE. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014).

	Before			**During**			**After**			**Total**		
	Mean	**SD**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**
Panel A: Downgrades of Financial Bonds												
Time to Maturity	4.94	5.68	3.37	5.69	6.58	3.60	6.29	6.94	4.02	5.70	6.51	3.66
Coupon	6.16	1.43	6.22	5.65	1.53	5.63	4.99	1.61	5.25	5.57	1.59	5.63
Amount Issued	1.19	1.11	1.00	1.04	0.94	0.75	1.36	0.90	1.25	1.17	0.98	1.00
Rating	9.51	3.03	10.00	7.85	3.83	7.00	7.52	2.83	7.00	8.14	3.46	7.00
Total Assets	318.20	269.40	287.44	751.93	803.37	348.36	1121.23	848.52	807.70	758.00	784.96	358.99
Intangible Assets	4.90	5.86	5.80	23.85	34.77	6.29	28.08	30.95	11.41	20.61	30.60	6.82
Panel B: Downgrades of Non-Financial Bonds												
Time to Maturity	10.83	9.59	7.25	6.17	7.37	3.58	10.52	12.50	5.30	9.56	10.07	5.43
Coupon	6.66	1.51	6.75	5.93	1.15	5.63	5.62	1.90	5.60	6.23	1.60	6.18
Amount Issued	0.49	0.37	0.40	0.52	0.29	0.50	0.82	0.60	0.60	0.57	0.44	0.50
Rating	10.26	3.64	10.00	9.12	3.31	9.00	9.05	2.81	8.00	9.68	3.42	9.00
Total Assets	124.90	171.33	23.23	44.85	111.28	39.04	106.36	111.93	36.59	100.04	149.29	28.34
Intangible Assets	7.93	11.63	3.11	5.37	15.29	0.09	45.90	56.42	2.60	15.68	33.07	2.51
Panel C: Upgrades of Financial Bonds												
Time to Maturity	5.23	5.43	3.63	4.54	4.86	3.60	6.07	6.06	4.20	5.35	5.54	3.82
Coupon	5.53	1.78	5.73	6.71	1.83	6.55	6.01	2.16	6.00	5.86	1.95	5.88
Amount Issued	0.63	0.55	0.50	1.28	0.85	1.10	0.99	0.68	1.00	0.83	0.69	0.68
Rating	4.83	2.23	4.00	9.28	5.13	7.00	9.68	3.17	10.00	6.90	3.91	5.00
Total Assets	679.83	539.56	503.55	441.88	441.46	150.13	294.60	545.20	105.74	533.08	551.36	320.52
Intangible Assets	25.65	27.67	14.59	10.90	20.44	0.83	4.40	12.39	0.13	17.22	25.04	4.57
Panel D: Upgrades of Non-Financial Bonds												
Time to Maturity	12.23	12.03	7.47	10.61	9.12	7.94	10.30	9.70	6.61	11.06	10.58	7.16
Coupon	6.56	1.45	6.88	6.36	1.26	6.27	5.60	2.15	5.63	6.06	1.87	6.13
Amount Issued	0.48	0.41	0.33	0.54	0.43	0.43	0.69	0.55	0.50	0.59	0.49	0.43
Rating	8.96	2.82	9.00	7.81	2.43	8.00	7.90	3.35	7.00	8.28	3.08	8.00
Total Assets	25.74	19.29	21.50	41.95	53.07	20.70	40.20	41.53	24.12	34.89	37.43	23.07
Intangible Assets	4.56	10.87	0.78	11.40	21.99	2.63	11.42	21.21	1.97	8.78	18.36	1.15

Table 3: **Results of Statistical Tests on Price Variations.**
This table shows the variations in prices surrounding US corporate bond rating changes that occurred between January 2003 and May 2014. The sample period is divided into three: before the crisis (January 2003 - November 2007), during the crisis (December 2007 - July 21, 2010) and after Dodd-Frank (July 22, 2010 - May 2014). The price variations are obtained by calculating the risk-free-adjusted difference between the average of the mean volume-weighted daily price across the 5 days before the event and the average across the event day and the 5 subsequent days. Variations are tested to see whether their mean and median are statistically significantly different from zero. The tests are performed separately for downgrades and upgrades, and financial and non-financial bonds, in each of the periods. Moreover, the differences between *during the crisis - before the crisis*, *after Dodd-Frank - before the crisis* and *after Dodd-Frank - during the crisis* are tested. The table reports the mean of the variations, the value of the two-sided t-test and the pseudo-median derived from the Wilcoxon signed-rank test. The significance is indicated as follows: * < 0.1 , ** < 0.05, *** < 0.01.

	Downgrades			**Upgrades**		
Period	**Mean**	**t-Test**	**Wilcoxon**	**Mean**	**t-Test**	**Wilcoxon**
Panel A: Price Difference within 5 Days of Non-Financial Bonds						
Before the Crisis	−0.71	−8.50***	−0.48***	0.31	4.37***	0.12***
During the Crisis	−1.35	−5.47***	−0.79***	0.55	2.24**	0.57***
After Dodd-Frank	−1.12	−8.42***	−0.72***	0.34	5.01***	0.18***
During-Before	−0.64	−2.45**	−0.06	0.24	0.95	0.31**
After-Before	−0.41	−2.59***	−0.20**	0.03	0.29	0.05
After-During	0.23	0.82	−0.17	0.21	−0.85	−0.29**
Panel B: Price Difference within 5 Days of Financial Bonds						
Before the Crisis	−0.59	−8.76***	−0.47***	0.04	1.49	0.01
During the Crisis	−1.51	−8.88***	−0.59***	0.51	4.22***	0.49***
After Dodd-Frank	−0.31	−5.26***	−0.05**	0.85	12.00***	0.64***
During-Before	−0.92	5.02***	0.04	0.47	−3.80***	0.43***
After-Before	0.28	−3.08***	0.38***	0.81	−10.70***	0.51***
After-During	1.20	6.65***	0.30***	0.34	−2.46**	0.14*

Table 4: **Results of the Statistical Tests on Volume, Trading Frequency and Liquidity Variations.**
This table shows variations in cumulative daily trading volume, daily trading frequency and daily price dispersion surrounding US corporate bond rating changes that occurred between January 2003 and May 2014. The sample period is divided into three: before the crisis (January 2003 - November 2007), during the crisis (December 2007 - July 21, 2010) and after Dodd-Frank (July 22, 2010 - May 2014). The volume variations are obtained by calculating the difference between the average cumulative daily volume (daily trading frequency, daily price dispersion) across the 5 days before the event and the average across the event day and the 5 subsequent days. Variations are tested to see whether their mean and median are statistically significantly different from zero. The tests are performed separately for downgrades, upgrades, financial and non-financial bonds in each of the periods. The table reports the mean of the variations (in millions of $ for the volume in Panels A and B, in number of trades for the trading frequency in Panels C and D, and in basis points for the price dispersion in Panels E and F), the value of the two-sided t-test and the pseudo-median derived from the Wilcoxon signed-rank test. The significance is indicated as follows: * < 0.1 , ** < 0.05, *** < 0.01.

	Downgrades			**Upgrades**		
Period	**Mean**	**t-Test**	**Wilcoxon**	**Mean**	**t-Test**	**Wilcoxon**
Panel A: Volume Difference within 5 Days of Non-Financial Bonds						
Before the Crisis	2.23	5.33***	0.98***	0.45	1.81*	0.58***
During the Crisis	1.39	4.35***	1.27***	1.65	4.26***	1.07***
After Dodd-Frank	1.59	4.31***	0.78***	0.33	1.58*	0.23**
Panel B: Volume Difference within 5 Days of Financial Bonds						
Before the Crisis	2.30	3.90***	0.87***	0.66	4.14***	0.52***
During the Crisis	0.43	2.78***	0.50***	1.17	3.39***	1.20***
After Dodd-Frank	1.15	6.58***	0.79***	2.02	7.50***	1.19***
Panel C: Trading Frequency Difference within 5 Days of Non-Financial Bonds						
Before the Crisis	3.67	5.46***	1.18***	0.10	0.49	0.17
During the Crisis	2.86	2.04**	0.83***	1.25	2.89***	0.67**
After Dodd-Frank	1.92	3.67***	1.57***	0.44	1.66*	0.08
Panel D Trading Frequency Difference within 5 Days of Financial Bonds						
Before the Crisis	4.92	4.92***	2.82***	0.38	2.85***	0.17**
During the Crisis	−1.72	−2.01**	0.00	4.40	3.07***	2.92***
After Dodd-Frank	2.25	6.14***	1.19***	1.61	3.31***	1.28***
Panel E: Price Dispersion Change within 5 Days of Non-Financial Bonds						
Before the Crisis	−3.86	−2.12**	−3.79***	−1.57	−0.52	0.11
During the Crisis	26.44	4.23***	19.94***	−3.19	−0.50	1.83
After Dodd-Frank	9.00	4.14***	6.28***	0.28	0.17	0.24
Panel F: Price Dispersion Change within 5 Days of Financial Bonds						
Before the Crisis	1.38	0.92	0.73	−3.14	−2.82***	−1.45**
During the Crisis	5.06	2.24**	4.00***	−6.75	−1.70*	−3.66*
After Dodd-Frank	−0.12	−0.11	−0.17	3.15	1.92*	1.76*

Table 5: **Determinants of Price Changes: Downgrades of Non-Financial Bonds.**
This table shows the results of different regression models, where the dependent variable is the risk-free-adjusted difference between the average of the mean volume-weighted daily price across the 5 days before the event and the average across the event day and the 5 days after it. The explanatory variables are given by time-period dummies (during financial crisis, after Dodd-Frank), rating-related variables (rating number, rating dispersion, number of agencies, notches, regulatory threshold dummy, Moody's dummy, Standard and Poor's dummy), changes in liquidity and trading activity (change in price dispersion, change in volume, change in trading frequency), and bond and firm characteristics (time to maturity, coupon, amount issued, log(total assets), intangible assets/total assets). The regression sample includes downgrades of non-financial US corporate bonds that occurred between January 2003 and May 2014. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014). The table reports the results for three different regression specifications. Test statistics, derived from standard errors corrected for heteroscedasticity and clustered at the firm level, are given in parenthesis. The significance is indicated as follows: * < 0.1, ** < 0.05, *** < 0.01.

Model	(1)	(2)	(3)
After Dodd-Frank	-0.473^{**}	-0.542^{**}	-0.581^{**}
	(-1.978)	(-2.261)	(-2.281)
Financial Crisis	-0.262	-0.366	-0.237
	(-0.834)	(-1.095)	(-0.739)
Rating Number	-0.046		-0.016
	(-1.338)		(-0.461)
Rating Dispersion	-0.054		-0.060
	(-0.686)		(-0.735)
Number of Agencies	0.564^{*}		0.533^{*}
	(1.744)		(1.649)
Notches	-0.172		-0.191
	(-1.378)		(-1.468)
Invest/Specul. Threshold	-0.967^{**}		-1.007^{***}
	(-2.509)		(-2.620)
Moody's	0.141		0.104
	(0.715)		(0.534)
Standard & Poor's	-0.337		-0.343
	(-1.588)		(-1.619)
Price Dispersion	-0.008^{***}		-0.009^{***}
	(-3.039)		(-3.171)
Trading Volume	0.005		-0.0001
	(0.179)		(-0.003)
Trading Frequency	-0.021^{***}		-0.018^{***}
	(-4.455)		(-3.745)
Time to Maturity		0.026	0.025^{*}
		(1.033)	(1.659)
log(Total Assets)		0.117	0.040
		(1.074)	(0.486)
Intangible Assets / Total Assets		-0.006	0.206
		(-0.005)	(0.334)
Coupon		-0.196^{***}	-0.193^{**}
		(-2.762)	(-2.128)
Amount Issued		0.0002	0.0002
		(0.824)	(0.740)
Intercept	-1.119	-0.754	-0.799
	(1.070)	(-0.509)	(-0.637)
Observations	454	454	454
R^2	0.150	0.032	0.163
Adjusted R^2	0.126	0.016	0.130
Residual Std. Error	2.065 (df = 441)	2.192 (df = 446)	2.061 (df = 436)
F Statistic	6.464^{***} (df = 12; 441)	2.081^{**} (df = 7; 446)	4.998^{***} (df = 17; 436)

Table 6: **Determinants of Price Changes: Downgrades of Financial Bonds.**
This table shows the results of different regression models, where the dependent variable is the risk-free-adjusted difference between the average of the mean volume-weighted daily price across the 5 days before the event and the average across the event day and the 5 days after it. The explanatory variables are given by time-period dummies (during financial crisis, after Dodd-Frank), rating-related variables (rating number, rating dispersion, number of agencies, notches, regulatory threshold dummy, Moody's dummy, Standard and Poor's dummy), changes in liquidity and trading activity (change in price dispersion, change in volume, change in trading frequency), and bond and firm characteristics (time to maturity, coupon, amount issued, log(total assets), intangible assets/total assets). The regression sample includes downgrades of financial US corporate bonds that occurred between January 2003 and May 2014. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014). The table reports the results for three different regression specifications. Test statistics, derived from standard errors corrected for heteroscedasticity and clustered at the firm level, are given in parenthesis. The significance is indicated as follows: * $<$ 0.1, ** $<$ 0.05, *** $<$ 0.01.

Model	(1)	(2)	(3)
After Dodd-Frank	0.545	0.227	0.393
	(1.598)	(0.948)	(1.327)
Financial Crisis	−0.666*	−0.839**	−0.680**
	(−1.776)	(−2.513)	(−2.067)
Rating Number	−0.055		−0.023
	(−1.329)		(−0.338)
Rating Dispersion	0.071		0.051
	(0.603)		(0.414)
Number of Agencies	−0.160		−0.219
	(−0.333)		(−0.442)
Notches	−0.491		−0.489
	(−1.419)		(−1.412)
Invest/Specul. Threshold	−0.775		−0.737
	(−1.247)		(−1.209)
Moody's	−0.616*		−0.653*
	(−1.751)		(−1.823)
Standard & Poor's	−0.281		−0.297
	(−0.769)		(−0.782)
Price Dispersion	−0.017***		−0.016***
	(−3.724)		(−3.697)
Trading Volume	−0.098**		−0.108**
	(−1.993)		(−2.363)
Trading Frequency	−0.003		−0.001
	(−0.353)		(−0.092)
Time to Maturity		−0.018	−0.019
		(−0.700)	(−0.707)
log(Total Assets)		0.152	0.139
		(1.401)	(1.073)
Intangible Assets / Total Assets		1.402	−0.768
		(1.252)	(−0.542)
Coupon		0.021	0.051
		(0.296)	(0.627)
Amount Issued		0.001***	0.0005**
		(2.954)	(2.329)
Intercept	1.134	−3.282**	−1.225
	(0.768)	(−2.217)	(−0.661)
Observations	733	733	733
R^2	0.130	0.038	0.142
Adjusted R^2	0.115	0.029	0.122
Residual Std. Error	3.719 (df = 720)	3.896 (df = 725)	3.705 (df = 715)
F Statistic	8.929*** (df = 12; 720)	4.091*** (df = 7; 725)	6.960*** (df = 17; 715)

Table 7: **Determinants of Price Changes: Single-Period Regressions for Downgrades.** This table shows the results of different regression models, where the dependent variable is the risk-free-adjusted difference between the average of the mean volume-weighted daily price across the 5 days before the event and the average across the event day and the 5 days after it. The explanatory variables are given by time-period dummies (during financial crisis, after Dodd-Frank), rating-related variables (rating number, rating dispersion, number of agencies, notches, regulatory threshold dummy, Moody's dummy, Standard and Poor's dummy), changes in liquidity and trading activity (change in price dispersion, change in volume, change in trading frequency), and bond and firm characteristics (time to maturity, coupon, amount issued, log(total assets), intangible assets/total assets). The regression sample includes downgrades of non-financial and financial US corporate bonds that occurred between January 2003 and May 2014. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014). The table reports the results for non-financial and financial bonds in each single period separately. Test statistics, derived from standard errors corrected for heteroscedasticity and clustered at the firm level, are given in parenthesis. The significance is indicated as follows: * < 0.1, ** < 0.05, *** < 0.01.

	Non-Financial			Financial		
Model	**Before the Crisis**	**Financial Crisis**	**After Dodd-Frank**	**Before the Crisis**	**Financial Crisis**	**After Dodd-Frank**
Rating Number	−0.071**	0.098	0.167	0.024	−0.032	−0.041
	(−2.219)	(1.049)	(0.996)	(0.407)	(−0.260)	(−1.281)
Rating Dispersion	0.003	−0.208	−0.319	0.159	0.190	−0.164
	(0.045)	(−0.821)	(−1.206)	(0.975)	(0.755)	(−1.425)
Number of Agencies	0.386	0.011	4.107	−0.379	−0.358	−0.089
	(1.231)	(0.008)	(1.146)	(−0.982)	(−0.324)	(−0.392)
Notches	−0.143	−0.024	−0.092	0.563**	−0.839	−0.017
	(−1.013)	(−0.063)	(−0.317)	(2.317)	(−1.401)	(−0.150)
Invest/Specul. Threshold	−0.981**	−1.423	0.384	−0.896	−0.617	−0.826*
	(−2.502)	(−0.906)	(0.478)	(−1.353)	(−0.275)	(−1.792)
Moody's	0.038	0.415	−0.241	−0.484	−1.087*	−0.258
	(0.172)	(0.932)	(−0.631)	(−1.318)	(−1.786)	(−0.913)
Standard & Poor's	0.182	−1.847**	0.024	0.547**	−0.676	−0.264
	(0.818)	(−2.350)	(0.059)	(2.210)	(−1.054)	(−0.744)
Price Dispersion	−0.005	−0.014***	−0.0001	−0.019***	−0.017***	−0.012**
	(−1.038)	(−3.530)	(−0.017)	(−3.966)	(−3.222)	(−2.115)
Trading Volume	0.009	−0.168	−0.264***	0.008	−0.226**	−0.063
	(0.515)	(−0.969)	(−3.310)	(0.398)	(−2.018)	(−1.321)
Trading Frequency	−0.019	−0.009	−0.018	−0.030	0.023	−0.036***
	(−1.545)	(−0.912)	(−0.353)	(−1.583)	(1.597)	(−2.957)
Time to Maturity	0.030**	0.045	0.025	−0.067***	−0.005	−0.030
	(2.220)	(0.825)	(0.675)	(−5.101)	(−0.128)	(−1.419)
log(Total Assets)	0.013	0.295	−0.054	−0.080	0.221	0.052
	(0.161)	(1.205)	(−0.220)	(−0.587)	(1.016)	(0.686)
Intangible Assets / Total Assets	−0.016	−0.337	1.490	−0.519	−0.016	−0.667
	−0.026	−0.183	1.205	−0.320	−0.002	−0.694
Coupon	−0.160	−0.536*	−0.155	−0.071	0.113	0.002
	(−1.496)	(−1.742)	(−0.738)	(−0.814)	(0.628)	(0.031)
Amount Issued	0.0001	0.0001	0.001*	0.0004**	0.0004	0.0004***
	(0.245)	(0.082)	(1.804)	(2.423)	(0.990)	(2.601)
Intercept	−0.015	−0.490	−14.101	0.891	−2.123	−0.009
	(−0.012)	(−0.089)	(−1.201)	(0.460)	(−0.594)	(−0.008)
Observations	267	109	78	104	391	238
R^2	0.189	0.309	0.339	0.497	0.133	0.319
Adjusted R^2	0.141	0.198	0.179	0.411	0.099	0.273
Residual Std. Error	1.514 (df = 251)	3.065 (df = 93)	1.516 (df = 62)	1.407 (df = 88)	4.860 (df = 375)	1.387 (df = 222)
F Statistic	3.908*** (df = 15; 251)	2.777*** (df = 15; 93)	2.118** (df = 15; 62)	5.792*** (df = 15; 88)	3.847*** (df = 15; 375)	6.926*** (df = 15; 222)

Table 8: **Implied Rating Analysis.**
This table shows the average difference between the rating of the bonds before the downgrade/upgrade and the market-implied rating. The market-implied rating is calculated from bond market yields over the time interval from 90 days before to 30 days before the rating change. Rating is a variable that assigns integer values to the different rating grades, starting from 1 for the highest and extending down to 21 for the lowest rating grade. The sample includes downgrades and upgrades of financial and non-financial US corporate bonds that occurred between January 2003 and May 2014. The sample period is divided into *before the crisis* (January 2003 - November 2007), *during the crisis* (December 2007 - July 21, 2010) and *after Dodd-Frank* (July 22, 2010 - May 2014). The table reports the results for upgrades, downgrades, non-financial and financial bonds in each single period separately.

	Downgrades			**Upgrades**		
	Before the Crisis	**During the Crisis**	**After Dodd-Frank**	**Before the Crisis**	**During the Crisis**	**After Dodd-Frank**
Non-Financial	-0.85	0.42	-0.21	0.21	2.65	1.09
Financial	-1.30	-0.14	-0.14	1.08	0.57	1.98