Journal of Financial Economics 130 (2018) 484–502

Contents lists available at ScienceDirect

Journal of Financial Economics

journal homepage: www.elsevier.com/locate/jfec

Corporate debt maturity profiles☆

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ARTICLE INFO

Article history:
Received 20 April 2017
Revised 1 August 2017
Accepted 18 August 2017
Available online 25 July 2018

JEL classification:
G13
G31
G32
G33

Keywords:
Capital structure
Debt structure
Debt maturity

ABSTRACT

We study a novel aspect of a firm's capital structure, namely, the profile of its debt maturity dates. In a simple theoretical framework we show that the dispersion of debt maturities constitutes an important dimension of capital structure choice, driven by firm characteristics and debt rollover risk. Guided by these predictions we establish two main empirical results. First, using an exogenous shock to rollover risk, we document a significant increase in maturity dispersion for firms that need to roll over maturing debt. Second, we find strong support that maturities of newly issued debt are influenced by pre-existing maturity profiles.

1. Introduction

Despite the large body of literature on the average maturity of corporate debt, it is not well understood whether or to what extent firms manage the dispersion of their debt maturity profiles. Perhaps surprisingly, the extant literature offers little guidance on this aspect of capital structure. This lack of evidence is at variance with practitioners' assessments that they choose debt maturity profiles to mitigate rollover risk, which is the most commonly mentioned determinant of debt maturity according to, e.g., Servaes and Tufano (2006) survey of chief financial officers (CFOs).[1]

This paper examines the decision to spread out maturity dates across time. To motivate the empirical analysis, we consider a simple framework in which firms trade off costs and benefits of debt maturity dispersion. On the one hand, the fixed cost components involved in issuing debt (Altinkilic and Hansen, 2000) and the secondary market illiquidity of bonds fragmented into many smaller issues (Oehmke and Zawadowski, 2017) should motivate firms to concentrate on a few large debt issues, thereby implementing a concentrated maturity profile. On the other hand, concentrated maturity profiles are risky if capital market conditions are uncertain or if firms can be affected by

☆ We are grateful to Tom Bates, John Graham (the referee), Alex Gorbenko, Mark Flannery, Jeffry Netter, Antoinette Schoar, David Schoenherr, Bin Zhou, and seminar participants at Arizona State University, Boston College, Brattle Group, Catolica Lisbon joint seminar with Nova and ISCTE-IUL, Georgia State University, KAIST, Korea Institute of Finance, and the 2014 Edinburgh Corporate Finance for useful comments and suggestions.

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[1] A few other recent examples are the 2010 CFO Forum and the 2013 Striking Facts reports by J.P. Morgan.

https://doi.org/10.1016/j.jfineco.2018.07.009
0304-405X/

idiosyncratic shocks which lead to rollover risk (Acharya et al., 2011) and limit access to corporate debt markets.[2] In essence, firms may not be able to refinance expiring debt externally and thus need to inefficiently liquidate assets or forgo profitable investment opportunities.

These observations are relevant in corporate practice and suggest an important but heretofore unrecognized dimension of debt structure insofar as a firm's optimal debt maturity profile may vary with these financial and real frictions. The paper develops a simple framework that produces two testable predictions. First, an increase in the probability of market freezes should lead to an increase in debt maturity dispersion. Second, firms should avoid so-called "maturity towers" by issuing new debt with different maturities than the ones in their pre-existing maturity profile.

The basic tradeoff between rollover risk versus issuance costs outlined above is relevant not only for corporate bonds but also for other types of corporate debt.[3] Therefore, we define maturity profiles in the baseline analysis using data from Standard & Poor's Capital IQ for all sources of debt during the 2002–2012 period and merge these data with firm characteristics obtained from Compustat. In addition we provide results based on corporate bond data only, relying on information from Mergent Fixed Income Securities Database (FISD).[4] To measure maturity dispersion, we group each firm's debt maturities into the nearest integer years and compute the fractions of amounts outstanding each year. We build two measures of maturity dispersion. The first measure is the inverse of the maturity profile's Herfindahl index based on these fractions. The second measure is based on the average squared distance between a firm's actual maturity profile and its perfectly dispersed maturity profile with equal fractions maturing each year up to the longest maturity.

Using these empirical measures of maturity dispersions, we analyze whether firms manage their maturity profiles. We do this by investigating two distinct yet related issues. First, we exploit the downgrade of General Motors (GM) and Ford Motor Co. (Ford) in 2005 as a quasi-natural experiment. Consistent with Acharya et al. (2014), the downgrade created an exogenous and unexpected shock to firms' beliefs about rollover risk, especially for firms not in the auto sector. Following Almeida et al. (2011), we consider firms as treated if they had expiring bonds to roll over following the GM-Ford downgrade. Hence these firms could change their maturity structures, either by retiring expiring bonds using internal liquidity or by rolling them over and issuing new bonds. When faced with higher risk of rollover, they should have increased the dispersion of their maturity profiles. In contrast, for the set of firms that did not need to roll over bonds, the shock to rollover risk is less likely to have an immediate effect on maturity dispersion, as this would require them to actively repurchase and replace existing debt. In the empirical analysis, we use otherwise similar (matched) firms from this set as control group. Notably, we establish that treated firms significantly increased maturity dispersion in the aftermath of the downgrade, relative to the set of control firms. In addition, we do not find a similar response of treated firms in terms of higher cash holdings or higher credit lines. Moreover, a placebo test for a period prior to the downgrade episode reveals no significant response in maturity dispersion. These results indicate that higher rollover risk (or beliefs about higher rollover risk) lead firms to increase debt maturity dispersion.

Furthermore, we examine whether firm leverage implies a differential response. We find indeed that, following the GM-Ford downgrade, treated firms with high market leverage or net debt ratios substantially increase debt maturity dispersion, while treated firms with little leverage do not change maturity dispersion much. In addition, the empirical results survive a battery of robustness checks. For example, we remove auto industry firms or employ maturity profiles known one year before the GM-Ford downgrade instead of using profiles known at the time of the downgrades to address a potential concern that firms could have anticipated the GM-Ford downgrades. As another robustness check, we employ a broader sample of firms available in the FISD data and find that treated firms substantially increase bond maturity dispersion after the GM-Ford downgrade.

Second, we study how the maturity choices for new debt issues are affected by maturity dispersion. To address this question, we analyze how pre-existing maturity profiles influence firms' maturity choices when they issue new debt. Specifically, we investigate whether existing amounts in each maturity bucket predict the maturity of newly issued debt. Indeed, we find that, if a firm has a large fraction of debt outstanding in any given maturity bucket, then it is significantly less likely to issue debt in this maturity bucket. For example, the fraction of debt issue amounts in the nine- or ten-year maturity bucket relative to total assets decreases by −20% for a one-percentage-point increase in the fraction of debt outstanding in that maturity bucket. In contrast, debt amounts in other maturity buckets do not tend to affect the fraction of issue amounts in the nine- or ten-year maturity bucket. The results hold across maturity buckets and are also economically significant. These results thus support the view that firms manage maturity dispersion, especially when they issue new debt.

This paper relates to models of debt maturity and rollover risk. Earlier theories of debt maturity are developed, e.g., by Brick and Ravid (1985), Diamond (1991), and Flannery (1986). More recently, Chen et al. (2013) study the link between credit spreads, systematic risk, and lumpy maturity structure. He and Xiong (2012) show that short-term debt exacerbates rollover risk. Diamond and He (2014) find that maturing short-term debt can lead to more debt overhang than non-maturing long-term debt. None of these papers examines the decision of diversifying

[2] The investment management firm BlackRock (Setting New Standards: The Liquidity Challenge II, May 2013) notes that: "By staggering issuance schedules and diversifying across maturities, companies can minimize risks of refinancing and higher rates when credit markets are expensive (or closed, as many discovered during the financial crisis)."

[3] For the relevance of issue fees for syndicated bank loans, see, for example, Berg et al. (2016).

[4] Results for the 1991–2012 period are quite similar to those for Capital IQ and are shown in the Appendix.

rollover risk across debt maturity dates. In our setting, which allows for rollover risk, neither the issuance of a single long-term debt claim nor that of a single short-term debt claim may be optimal, because only a combination of debt with different rollover dates can reduce real inefficiencies triggered by rollover risk.[5]

Our paper also builds on recent empirical and survey research. Based on a global survey, Servaes and Tufano (2006) report that CFOs are concerned about losing access to debt markets and, in particular, that debt maturity choice is driven by the objective of managing rollover risk by avoiding maturity concentrations. Almeida et al. (2011) find that firms with a greater fraction of long-term debt maturing at the onset of the 2007 financial crisis had a more pronounced investment decline than otherwise similar firms. Our results complement and extend theirs in that we establish that firms manage maturity profiles of their debt and that this is especially so for firms with a substantial fraction of debt expiring after the GM-Ford downgrade.

Greenwood et al. (2010) find firms vary their debt maturity to act as macro liquidity providers by absorbing supply shocks due to changes in the maturity of Treasuries. Dass and Massa (2014) argue issuing bonds with different maturities is a way of catering to institutional investors. Using syndicated loan data, Mian and Santos (2018) find that most creditworthy firms extend loan maturities to reduce liquidity risk. Similarly, Xu (2016) documents early refinancing to extend maturities, especially for lower-rated firms. Rauh and Sufi (2010) and Colla et al. (2013) establish that—relative to large, high credit quality firms—small, low-rated firms have dispersed or multi-tiered debt priority structures. Finally, Harford et al. (2014), who document declining debt maturities for U.S. firms, find that firms with greater refinancing risk increase their cash holdings and save more cash from their cash flows. Unlike these studies, we focus on debt maturity dispersion.[6]

The paper proceeds as follows. Section 2 contains a model of maturity dispersion. Section 3 describes the data and variables. Section 4 contains the empirical results and Section 5 concludes. Details on construction of data, variable definitions, and robustness tests are in the Appendices.

2. A simple framework of debt maturity dispersion

In this section, we provide a simple model of debt maturity dispersion. We consider an initially all-equity-financed firm over three periods. The firm has assets in place (or initial net worth), A, and a project that requires a capital outlay, I, at times t_0. The project generates intermediate cash flows c at times t_1 and t_2 and a final cash flow I at time t_3. In addition, the project comes with growth options. By reinvesting a fraction f of an intermediate cash flow, an additional cash flow, H, is generated at time t_3. We assume the risk-free rate is zero, both growth options have a positive net present value, NPV $>$ 0, and, to avoid trivial solutions, $I - A > (1 - f)\,c > (I - A)/2$. The latter assumption implies that an intermediate cash flow is insufficient to exercise the growth option and repay all of the externally funded investment spending, $I - A$, but an intermediate cash flow is sufficient to invest in the growth option and repay half of the externally funded investment spending.

The firm issues one- or two-period debt to raise the required capital of $I - A$. To keep the analysis focused, we do not consider three-period debt or equity, which would require additional considerations, such as asset substitution or informational frictions associated with these forms of funding.[7] Thus, the project is financed by debt at time t_0 that must be rolled over before time t_3. However, at times t_1 and t_2, the debt market may freeze with probability λ (as, e.g., in Acharya et al., 2011).

If the firm is unable to refinance maturing debt due to a market freeze at times t_1 or t_2, it must repay the debtholders out of the project's cash flow. As long as the face value of maturing debt, B, is less than or equal to $(1 - f)\,c$, the firm can repay debt and invest in the growth option. If $B > (1 - f)\,c$ and the debt market is frozen, then the growth option is lost, which reduces the t_3 cash flow by H. Any excess cash not needed to repay the maturing debt is paid out to equityholders.[8]

We consider two initial debt structures, a *concentrated* and a *dispersed* debt maturity profile (see Fig. 1). We refer to the former as firm C and to the latter as firm D. Firm C issues debt at time t_0 with a single maturity, at either time t_1 or time t_2, at which point debt is rolled over to time t_3 whenever possible. Notice that firm C is indifferent between issuing a bond that must be rolled over at time t_1 or one that must be rolled over at time t_2. We therefore only consider the rollover of firm C at time t_2. In contrast, firm D uses multiple issues at time t_0 that mature at t_1 and t_2. We assume that the debt issued initially by firm D has equal face value, so half its debt expires at t_1 and the other half at t_2. Hence firm D has a perfectly dispersed debt maturity profile, while firm C's debt maturity profile is not dispersed at all.

As discussed, a large, single debt issue will have cost advantages over small, multiple debt issues. Altinkilic and Hansen (2000) provide evidence that bond underwriting fees decline monotonically with issue size, which is

[5] Recently, Huang et al. (2017) also build a model to study the dispersion in corporate debt maturities.

[6] Earlier empirical studies by Barclay and Smith (1995), Guedes and Opler (1996), Stohs and Mauer (1996), Johnson (2003), Greenwood et al. (2010), and Saretto and Tookes (2013) exclusively focus on average debt maturity.

[7] In practice, firms rarely use bond maturities greater than 20 years, although some assets, such as buildings, clearly have longer maturities. For the 2002–2012 period, the average (median) bond maturity at issuance is 9.25 (7.0) years with an interquartile range of four to eleven years in the Capital IQ sample. This is likely to reflect informational and contracting frictions associated with very long-maturity debt.

[8] We assume that it is expensive to carry forward excess corporate cash balances from time t_1 to t_2. This is the case if free cash balances can be (partially) expropriated by management or used for empire building purposes. A credit line from a bank cannot solve the refinancing problem either. As in Almeida et al. (2011), the bank cannot commit to *not* revoking the credit line precisely in the state when the firm needs to draw down the credit line.

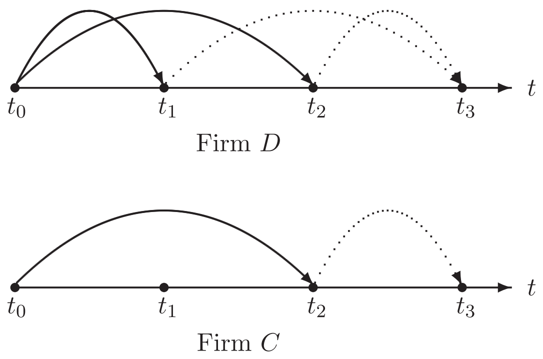


Fig. 1. Evolution of debt rollover. This figure plots the time line of debt rollover for the dispersed maturity structure (or Firm D) with two smaller issues, which expire at times t_1 and t_2, and for the concentrated maturity structure (or Firm C) with one larger issue, which expires at time t_2. An expiring debt issue needs to be rolled over to time t_3 or repaid with internally generated cash to realize the project's cash flow.

consistent with an economies-of-scale interpretation. Furthermore, Berg et al. (2016) show that larger loans have lower spreads, lower facility fees, and lower commitment and letter of credit fees, again consistent with the scale economy interpretation of debt issuance costs.[9] Furthermore, small bond issues will be subject to substantial illiquidity in the secondary market, which will result in higher spreads compared with large issues (Huang and Huang, 2012). Unlike stocks, bonds are traded over-the-counter and investors face higher search costs when they want to trade a particular bond among many other bonds issued by the same firm. Also, small bond issues are not eligible to be included in standard bond indices (e.g., Barclays U.S. Corporate Index), which makes them even more illiquid.[10]

To capture these scale economies of larger issues in a reduced form, we assume that the firm pays a fixed cost per issue, k, at time t_0. As a result, firm C has a transaction-cost advantage, because it incurs issue costs of k, whereas firm D incurs issue costs of $2k$. In addition, k may reflect the fact that a larger debt issue is more liquid than fragmented, smaller issues, similar to Oehmke and Zawadowski (2017). Finally, note that issue costs at each point in time would also favor firm C because it has only two issuances, while firm D has four issuances.

Notice that debt is risk-free and hence the face value of the concentrated firm's debt equals $B^C = I - A$. Therefore, if $B^C > (1-f)\,c$, the concentrated firm faces costly rollover risk. If the debt market freezes at time t_2, the firm must use a large fraction of its cash flow to repay the debt, which leaves less than fc and hence it is insufficient to realize the growth option (i.e., while the outflow of fc at time t_2 is saved, the inflow H at time t_3 is lost too).

On the other hand, the two debt issues of the dispersed firm have a face value of $B_1^D = B_2^D = (I-A)/2$, which is less than $(1-f)\,c$. In case of a market freeze, firm D can reinvest and has enough free cash flow $(1-f)\,c$ at time t_1 and time t_2 to repay $(I-A)/2$. Therefore, the dispersed firm does not face costly rollover risk.[11]

As firm D encounters no inefficiencies, it is easy to verify that firm D's equity value is given by:

$$E^D \;=\; I + 2\,c + 2\,(H - f\,c) - (I - A) - 2\,k\,. \tag{1}$$

With probability $1-\lambda$, firm C has no rollover problem and repays the debt at time t_3. However, if $B^C = (I-A) > (1-f)\,c$, firm C cannot reinvest fc at t_2 with probability λ. Alternatively, if assets in place, A, are sufficiently high such that $B^C \leq (1-f)\,c$, then even the firm with a concentrated maturity structure does not face costly rollover risk. Therefore, firm C's equity value is given by:

$$E^C \;=\; \begin{cases} I + 2\,c + 2\,(H - f\,c) - (I - A) - \lambda\,(H - f\,c) - k \\ \quad \text{if} \;\; B^C > (1-f)\,c\,, \\ I + 2\,c + 2\,(H - f\,c) - (I - A) - k \\ \quad \text{if} \;\; B^C \leq (1-f)\,c\,. \end{cases} \tag{2}$$

The benefits of a dispersed maturity structure are given by the difference in equity values in Eqs. (1) and (2), which provides incentives for creating a dispersed debt maturity structure:

$$\Delta E \;\equiv\; E^D - E^C \;=\; \begin{cases} \lambda\,(H - f\,c) - k & \text{if} \;\; B^C > (1-f)\,c\,, \\ -k & \text{if} \;\; B^C \leq (1-f)\,c\,. \end{cases} \tag{3}$$

The comparison in Eq. (3) says that, for a sufficiently large amount of debt, i.e., $B^C > (1-f)\,c$, a dispersed maturity profile is preferred in the absence of transaction costs because the growth options have a positive NPV, i.e., the firm only wants to invest at times t_1 and t_2 if $H - f\,c > 0$.

The tradeoff faced by firms in choosing their maturity structures is as follows. On the one hand, the potential benefits of a dispersed maturity structure increase with the probability of a market freeze, λ. The model's primary prediction is hence that an increase in the probability of market freezes should lead to an increase in debt maturity dispersion. On the other hand, an increase in the transaction-cost parameter, k, works in favor of a more concentrated maturity structure. There are four additional implications. First, the existence of a tradeoff also implies that a firm with higher flotation and illiquidity costs will have a lower incentive to maintain or move towards a dispersed maturity profile via appropriate bond issues. Second, more levered firms are likely to respond more strongly to the above tradeoff, i.e., ΔE in Eq. (3) is weakly increasing in B^C. Third, more profitable firms with higher intermediate cash flows are less likely to choose

[9] There are likely to be major fixed cost components to making syndicated loans. The fixed costs derive from the need to hire lawyers to write up the contract and to collect information on the borrower, market the issue to potential loan participants, and perform due diligence analyses. In addition, there are likely to be fixed costs in obtaining a credit rating for the loan, which is now common for most syndicated loans. These costs expressed as a percentage decline with loan sizes (see, for example, Table 4 in Berg et al. (2016) for empirical evidence).

[10] Empirically, Lee et al. (1996) and Longstaff et al. (2005) confirm a positive relationship between issue size and secondary market liquidity.

[11] More generally, both types of firms may face rollover risk and hence our framework corresponds to a relative statement in that a concentrated maturity structure will lead to larger inefficiencies than a dispersed one.

dispersed maturity structures, i.e., for a sufficiently large value of c, ΔE in Eq. (3) is negative. Fourth, firms with more valuable growth options have stronger preferences for dispersed maturity structures, i.e., for a sufficiently large value of H, ΔE in Eq. (3) is positive.[12]

In summary, this section formalizes the implications of the fact that firms may be unable to refinance expiring debt externally in some states of the world and therefore need to pass up valuable investment opportunities. Two main predictions follow. First, an increase in the probability of market freezes should lead to an increase in debt maturity dispersion. Second, if a firm in Fig. 1 has a pre-existing t_1 (t_2) debt and would like to be dispersed, then it should issue a t_2 (t_1) debt. Therefore, firms should avoid maturity concentrations by issuing new debt with different maturities than the ones in their pre-existing debt maturity profile. Overall, these results accord with practitioners' concern about maturity towers.

3. Maturity dispersion measures and data

3.1. Measures of debt maturity dispersion

Although practitioners assert that they diversify debt rollover times to avoid "maturity towers," they do not provide specific definitions by which debt maturity dispersion can be quantified. In this section we introduce alternative measures of this important aspect of capital structure. A natural and intuitive candidate for such a measure is based on the Herfindahl index. Specifically, let x_i denote firm j's principal amounts maturing in each maturity bucket i, where the buckets are obtained by grouping debt maturities into the nearest time bucket. The fraction of principal maturing in each maturity bucket is then given by $w_i = x_i/\sum_i x_i$. The concentration index of firm j's debt maturity structure, $HERF_j$, is therefore defined as:

$$HERF_j = \sum_i w_i^2. \tag{4}$$

A corresponding measure of maturity dispersion is then given by $D1 = 1/HERF_j$. Thus, if firm j has n debt issues with equal amounts outstanding in distinct maturities, then $HERF_j = 1/n$ and the dispersion measure $D1 = n$. As the number of debt issues outstanding in separate maturity buckets goes to infinity and the principal amount maturing in each maturity bucket goes to zero, $HERF_j$ converges to zero and $D1$ to infinity.

This measure is directly related to our model. Recall that, in the model, firm C has a single debt issue outstanding, which makes its maturity profile perfectly concentrated, and thus its Herfindahl index at time t_0 is $HERF^C = 1$. Firm D has two debt issues with equal face value outstanding, so that firm D's Herfindahl index at time t_0 is $HERF^D = 0.5 < 1$. Based on this dispersion measure, firm C has a more concentrated (or less dispersed) debt structure than firm D.

While this definition certainly captures important aspects of maturity dispersion, it may not represent all relevant dimensions of the distribution of rollover dates. First, it does not distinguish between debt rollovers that occur in the near future and those that are more distant. Ceteris paribus, more distant rollovers may be less problematic than near ones, as the firm has more time to manage the risks associated with the former by repurchasing debt or extending its maturity. The inverse Herfindahl measure introduced above can be readily adjusted to capture this dimension of maturity dispersion by time-weighting the rollovers. As a robustness check, we therefore apply alternative weighting schemes for the rollover percentages w_i defined above. First, note that the baseline specification in Eq. (4) places equal weight on the fractions of shorter and longer debt maturities. As an alternative measure, we adopt a weighting scheme that places more weight on shorter maturities, namely, $x_i = (\frac{1}{i})/(\sum_{i=1}^{25}\frac{1}{i})$ for maturities up to $i = 25$ years and $x_i = 0$ otherwise. Thus, firms with more rollovers in the near future exhibit ceteris paribus lower dispersion than firms with more distant rollovers. Thus, the weighted Herfindahl measure is given by

$$HERF_j^W = \sum_i (x_i w_i)^2 \tag{5}$$

and the inverse of the weighted Herfindahl index of maturity fractions $D1^W$ by $D1^W = 1/HERF_j^W$.

Second, the inverse Herfindahl measure may be affected by the maximum maturity of bonds that a firm can possibly issue. Thus, it reflects both the firm's maturity decision as well as its dispersion decision. For example, if a firm can only issue bonds with a maximum maturity of five years, its inverse Herfindahl measure will be less than or equal to 0.2. As another robustness check, we therefore introduce an alternative measure that accounts for the firm's maximum debt maturity. A natural measure that achieves this is based on the average squared deviation of a firm's observed maturity profile from the perfectly dispersed maturity profile (i.e., distance from perfect dispersion). A "perfectly dispersed" maturity profile has the same maximum debt maturity as the observed maximum debt maturity, but a constant fraction of principal, $1/t_j^{max}$ maturing in each maturity bucket, where the maximum debt maturity t_j^{max} is the longest maturity of the currently outstanding debt measured at the time of issuance.[13] Thus, the second measure is based on the distance from a perfectly dispersed maturity profile and defined as:

$$DIST_j = \frac{1}{t_j^{max}} \sum_{i=1}^{t_j^{max}} \left(w_{j,i} - \frac{1}{t_j^{max}} \right)^2. \tag{6}$$

To capture dispersion rather than distance from perfect dispersion, we define the $D2$ as the negative value of the log of the squared distance from perfect dispersion, $D2 \equiv -\log(DIST)$.[14]

[12] In this paper, we examine empirically only the model's primary prediction and its second additional prediction.

[13] Using maximum maturity at *issuance* instead of current maximum maturity has the advantage that it prevents mechanical changes in the maturity dispersion measure as time passes.

[14] Note that we add 0.001 to $DIST$ to prevent $D2$ from being negative infinity.

Table 1
Sample descriptive statistics.
The sample is drawn from Standard & Poor's Capital IQ and the annual Compustat files, excluding financial and utility firms, for the period from 2002 to 2012. Panel A reports means, standard deviations, medians, and interquartile ranges of the main variables. *Ndebt* is the number of debt issues outstanding for each firm. *Nmat* is the number of distinct maturities grouped into the nearest integer years for each firm. *D*1 is the inverse of the Herfindahl index of debt maturity fractions. *D*2 is the negative of the log distance from the perfect maturity dispersion. *DebtMat* is the average of firms' debt maturities weighted by amounts. *LoanMat* and *BondMat* are the averages of firms' maturities for loans (revolving credit and term loans in Capital IQ) and for bonds (bonds and notes in Capital IQ), respectively, weighted by amounts. *LoanPct* and *BondPct* are the ratios of firms' total book value of loans and bonds to total book debt in Compustat, respectively. *LoanAmt*/*Asset* and *BondAmt*/*Asset* are *LoanMat* and *BondAmt* divided by total assets, respectively. *Lev* is the market value of leverage and *Size* is the log of total assets. *Age* is the number of years in the Compustat file prior to observations. *Q* is the market-to-book ratio. *Prof* and *Tan* are profitability (operating income divided by assets) and tangibility (property, plant, and equipment divided by assets), respectively. *ProfVol* is the standard deviation of earnings divided by assets using the past five years. *Cash* is cash holdings divided by assets. *LC* is the total amount of credit lines available divided by assets and *EqIssue* is sale of common and preferred stocks divided by assets.

	Mean	Stdev	25%	Median	75%	N
Ndebt	3.98	3.59	1.00	3.00	5.00	24,402
Nmat	2.64	2.21	1.00	2.00	3.00	24,402
*D*1	2.02	1.35	1.00	1.56	2.55	24,402
*D*2	2.91	1.04	1.97	2.76	3.57	24,402
DebtMat	5.15	4.78	2.00	3.93	6.25	24,402
LoanMat	3.43	2.69	1.58	2.92	4.57	24,402
BondMat	6.35	5.94	2.22	4.81	7.97	24,402
LoanPct	0.38	0.42	0.00	0.17	0.88	24,402
BondPct	0.48	0.43	0.00	0.47	0.98	24,402
LoanAmt/*Asset*	0.06	0.13	0.00	0.00	0.06	24,402
BondAmt/*Asset*	0.11	0.14	0.02	0.06	0.14	24,402
Lev	0.19	0.18	0.04	0.13	0.28	21,547
Size	5.32	2.53	3.55	5.52	7.15	24,402
Age	16.75	14.69	6.00	12.00	22.00	24,402
Q	2.69	5.59	1.07	1.46	2.27	21,571
Prof	−0.07	0.68	−0.01	0.09	0.15	24,379
Tan	0.26	0.25	0.07	0.18	0.39	24,389
ProfVol	0.60	3.45	0.03	0.07	0.16	23,577
Cash	0.17	0.21	0.03	0.09	0.23	24,400
LCLimit	0.21	0.19	0.08	0.15	0.27	8,517
EqIssue	0.09	0.27	0.00	0.00	0.02	24,065

Dispersion measure D_2 is also directly related to our theory. In the model, firm *C* has a single debt issue outstanding that is rolled over at time t_2 and its distance measure at time t_0 is therefore given by $DIST^C = (1/2)[(0-1/2)^2 + (1-1/2)^2] = 0.25$. Firm *D* issues two debt issues with equal face value outstanding, maturing at time t_1 and at time t_2. So firm *D*'s distance measure is $DIST^D = (1/2)[((1/2)-(1/2))^2 + ((1/2)-(1/2))^2] = 0 < 0.25$. Hence also based on this dispersion measure, firm *C* has a more concentrated debt structure than firm *D*.

3.2. Data sources

In the empirical analysis, we use data from several sources. Detailed corporate debt structure data are drawn from the Capital IQ database from Standard and Poor's. The Capital IQ database provides data on maturity structures for both public debt and private debt, including corporate bonds, medium term notes, commercial paper, term loans, credit lines, and other private debt as well. The Capital IQ data become comprehensive after 2002 and our data cover until 2012. The historical debt maturities and amounts reported in Capital IQ are based on the detailed information and footnotes provided in various Securities and Exchange Commission (SEC) filings (e.g., the 10-K form) and in many cases report duplicate data items. We provide the detailed process of data clean up and debt maturity construction in Appendix A. We calculate maturity dispersion data from this source.[15]

Accounting data are drawn from the annual Compustat tapes. These data sets enable us to measure debt maturity dispersion and various firm characteristics for the 2002–2012 period. Following standard practice, we exclude financial firms (Standard Industrial Classification (SIC) codes 6000–6999) and utilities (SIC codes 4900–4999), and winsorize the top and bottom 0.5% of variables to minimize the impact of data errors and outliers. Variable definitions are in Appendix B.

3.3. Summary statistics

Table 1 contains the summary statistics for 6139 firms and 24,402 firm-year observations for which we have debt dispersion data available. The number of debt issues and distinct maturities (*Ndebt* and *Nmat*) reported in Table 1 indicate substantial variation in maturity profiles. Firms have on average 3.98 distinct debt contracts

[15] In an earlier version of the paper, we constructed maturity dispersion measures using only corporate bond data available from Mergent Fixed Income Securities Database (FISD). The main empirical results remain qualitatively similar when we use the FISD data only (see the Appendix).

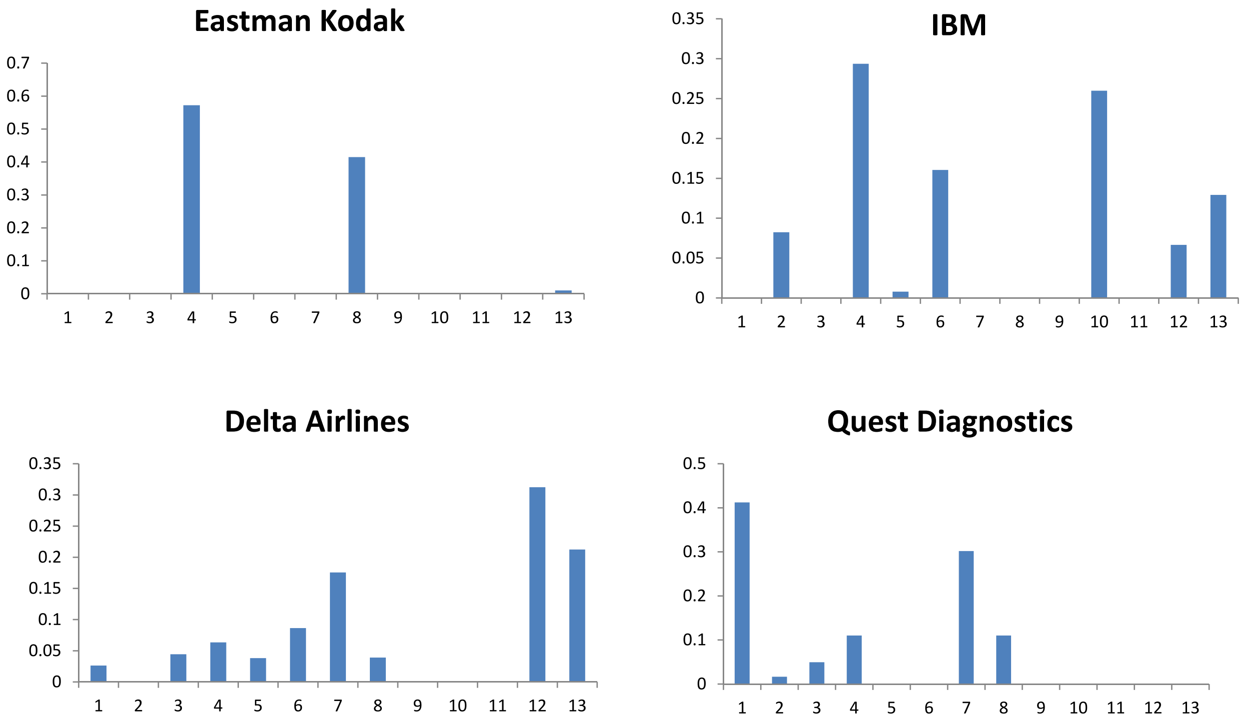


Fig. 2. Corporate debt maturity profiles. This figure shows the ratios of debt amounts maturing for thirteen maturity bins over total debt outstanding (according to Standard & Poor's Capital IQ) for Eastman Kodak and IBM in 2009 and for Delta Airlines and Quest Diagnostics in 2004. We define ten one-year maturity bins for maturities shorter than ten years, two five-year maturity bins for maturities of 11–15 years and 16–20 years, respectively, and a bin for maturities longer than 20 years.

outstanding with a standard deviation of 3.59. Interestingly, firms often concentrate debt issues into close maturity buckets. For example, the average and median of the number of maturities are 2.64 and 2.00, respectively, while those of the number of debt issues are 3.98 and 3.00. These statistics reveal that firms typically have three different debt issues but they tend to bunch two of these, so that the median number of maturity years is two.

In essence, Table 1 suggests clustering instead of spreading of maturities is quite common. Similarly surprisingly, the summary statistics for *D*1 mean that firms not only opt for close or identical maturities but they also have quite unequal amounts outstanding in each maturity. Combined with the median number of maturities (2.00), the median statistic for *D*1 (1.56) indicates that firms typically have 23% and 77% of debt amounts outstanding in two distinct maturities, respectively, i.e., $1/\left(0.23^2+0.77^2\right)=1.56$. Table 1 also shows that, on average, 48% and 38% of debt consists of corporate bonds (see *BondPct*) and bank loans (*LoanPct*), respectively, so that these two types of debt instruments account for the majority of corporate borrowing.

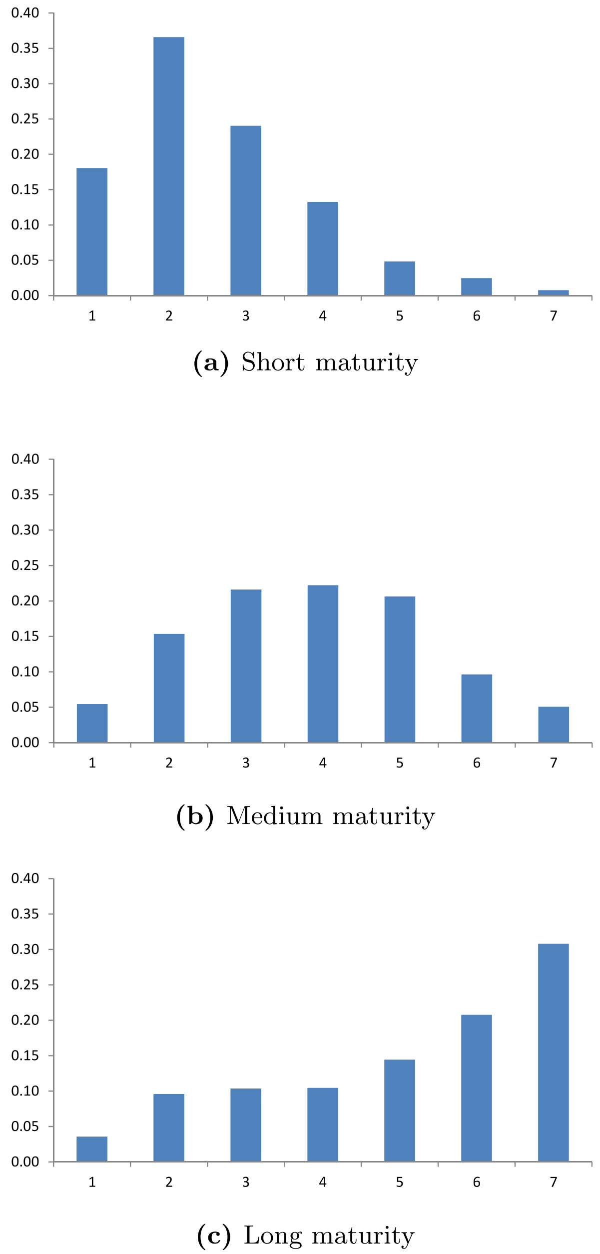
Figs. 2 and 3 depict debt maturity profiles to illustrate heterogeneity in debt maturity dispersion for a few firms in our sample and for differences in average maturity for the full sample. Fig. 2 plots the fractions of debt maturing in each of thirteen maturity bins for Eastman Kodak and IBM in 2009 and for Delta Airlines and Quest Diagnostics in 2004. Fig. 3 shows how average maturity profiles vary when firms are sorted into tercile groups based on debt maturity (*DebtMat*) over seven maturity buckets. In essence, these basic graphs are informative in that they reveal substantial variation in maturity profiles across firms.

4. Empirical analysis

Motivated by the paradigm modeled in Section 2, we analyze whether firms actively manage their maturity structures in the following two distinct yet related issues. First, we analyze an exogenous and unexpected shock to rollover risk (i.e., an increase in λ in the framework of Section 2) and study how firms adjust maturity dispersion in response to this shock. In the second part, we study whether a firm's pre-existing debt maturity profile determines the maturity choice for new debt issues. Thus, this part focuses directly on the maturity choices of firms with pre-existing debt outstanding and whether subsequent maturity choices tend to increase or decrease maturity dispersion.

4.1. Rollover risk and maturity profiles

We examine the model's prediction that firms respond to higher (perceived) rollover risk by increasing debt maturity dispersion. To do so, we employ an exogenous and unexpected shock to rollover risk as a quasi-natural experiment to identify the effect of rollover risk on debt maturity profiles.



(a) Short maturity

(b) Medium maturity

(c) Long maturity

Fig. 3. Average debt maturity profiles. This figure shows average maturity profiles of total debt outstanding for groupings of firms based on short, medium, and long debt maturity (*DebtMat*) over seven maturity buckets. For maturities shorter than ten years ($1 \leq j \leq 5$), there are five two-year buckets, each from $2j-1$ to $2j$ years. For maturities longer than ten years, there are two maturity buckets, one for 11–20 years and the other one for 21 years or longer. The sample period is 2002 through 2012.

4.1.1. The GM-Ford downgrade

In the spring of 2005, GM and Ford were downgraded to speculative status.[16] This event caused a large-scale sell-off of corporate bonds issued by the two auto giants. Many long-term investors including insurance companies, pension and endowment funds, and other investment companies were forced to liquidate their positions in these bonds, because they were not allowed to hold junk bonds due to regulatory or institutional restrictions. Moreover, GM and Ford were the second- and third-largest bond issuers in Lehman's U.S. Investment Grade Credit Index, which implies that investment companies replicating the index also had to liquidate these bonds.

The massive liquidation of GM and Ford bonds in turn had a large, negative impact on corporate bond markets in other sectors, which came as a surprise to firms not in the auto sector, as argued by Acharya et al. (2014) and Acharya et al. (2015). As a consequence of the sell-off, financial intermediaries as market makers of corporate bonds ended up holding large amounts of inventories of the two firms' bonds and thus faced huge inventory risks. This created a spillover effect on bond markets of industries with little relation to the auto sector, because financial intermediaries reduced the provision of market-making services across all the other sectors as well. Furthermore, the spillover effect was a surprise, which primarily changed firms' beliefs about rollover risk, while at the same time the market did not actually freeze so firms were able to access the debt market. Finally, the shock following the downgrade was most likely confined to the corporate debt market, because the U.S. economy was at the time in good health.

4.1.2. Empirical strategy

We use this quasi-natural experiment of the GM-Ford downgrade to identify firms' response to the perception of higher rollover risk in the corporate bond market. To do so, we exploit pre-determined cross-sectional heterogeneity in amounts of expiring bonds in the near future. The treatment group consists of firms that have more than 5% of existing bond amounts expiring during the year following the downgrade. The firms in the treatment group had to pay back the maturing bonds either by using existing liquidity reserves or by rolling them over through new issues. Both cases result in a change in the firms' debt maturity profile. To manage rollover risk with maturity profiles, these firms should choose relatively more broadly dispersed maturity structures after having realized that failure to roll over can be a realistic concern. In contrast, firms with no or few bonds maturing (the control group) do not experience imminent bond rollover risk. Also, for these firms it is more difficult to change their bond maturity structures (i.e., similar to higher k in Section 2), because this would require them to call or buy back existing (but non-expiring) bonds from the secondary markets. Thus, the control group is expected to change maturity dispersion to a lesser extent compared with the treatment group.

An important assumption for our identification strategy is that no unobservable variables can explain the amounts of bonds expiring at the end of May 2005. Debt maturities are choice variables, which might have been affected by the onset of the GM-Ford downgrade. However, given that the median bond maturity is seven years, the bonds expiring in the aftermath of the downgrade are likely to have been determined years prior to the event (i.e., without anticipation of increased rollover risk due to the GM-

[16] On May 5, Standard & Poor's downgraded GM from BBB− to BB and Ford from BBB− to BB+. As a result, both automakers were excluded from Merrill's and Lehman's investment-grade indexes.

Table 2
Summary statistics: Treated, non-treated, and matched control firms.
This table reports summary statistics (mean and median) and the results of difference tests for 2004 across the treated, non-treated, and control firms. The treatment group (*Treated*) is composed of firms that have more than 5% of existing bond amounts expiring in the next year, as measured in May 2005. The non-treated group (*Non-treated*) includes firms in our database that also have corporate bonds outstanding. The control group (*Control*) is a set of firms matched to the firms in the treatment group, using Mahalanobis distance matching. We match two firms for each treated firm with replacement and remove duplicate matches. The variable descriptions are provided in Appendix B. Firms are required to have observations in all three years from 2004 to 2006 (balanced panel). The mean test is a Wilcoxon rank-sum test and the median test is Pearson's chi-squared test.

	Treated	Non-treated	Control	Test of difference			
				Treated vs. Non-treated		Treated vs. Control	
	($N = 52$) Mean [Median]	($N = 316$) Mean [Median]	($N = 81$) Mean [Median]	Mean test (p-Value)	Median test (p-Value)	Mean test (p-Value)	Median test (p-Value)
Q	1.760	1.820	1.850	−0.46	0.02	−0.25	0.01
	[1.620]	[1.540]	[1.530]	(0.64)	(0.88)	(0.80)	(0.91)
Size	8.950	7.480	8.700	−6.37	24.39	−1.52	1.73
	[8.900]	[7.490]	[8.460]	(0.00)	(0.00)	(0.13)	(0.19)
Lev	0.190	0.210	0.170	1.66	1.10	−0.23	0.01
	[0.150]	[0.190]	[0.150]	(0.10)	(0.29)	(0.82)	(0.91)
Tan	0.230	0.290	0.280	1.02	1.10	1.22	0.21
	[0.180]	[0.220]	[0.220]	(0.31)	(0.29)	(0.22)	(0.64)
Prof	0.120	0.110	0.130	−0.720	0.22	0.550	0.67
	[0.120]	[0.110]	[0.130]	(0.47)	(0.64)	(0.58)	(0.41)
BondPct	0.860	0.790	0.800	−1.60	0.20	−0.95	0.92
	[0.920]	[0.900]	[0.870]	(0.11)	(0.65)	(0.34)	(0.34)
D1	4.590	2.690	3.640	−5.04	18.83	−1.62	0.92
	[4.140]	[2.040]	[3.420]	(0.00)	(0.00)	(0.11)	(0.34)
D2	4.440	3.590	4.290	−4.94	18.83	−1.27	0.92
	[4.680]	[3.460]	[4.340]	(0.00)	(0.00)	(0.20)	(0.34)
$\Delta D1$	0.210	−0.010	0.220	−1.53	2.37	−0.05	0.00
	[0.000]	[−0.010]	[0.000]	(0.13)	(0.12)	(0.96)	(1.00)
$\Delta D2$	0.090	0.040	0.100	−1.07	2.45	−0.03	0.00
	[0.000]	[−0.010]	[0.000]	(0.29)	(0.12)	(0.98)	(1.00)
Cash	0.130	0.160	0.110	−0.04	0.56	−1.28	1.73
	[0.100]	[0.080]	[0.070]	(0.97)	(0.45)	(0.20)	(0.19)
LC	0.040	0.060	0.060	0.23	0.04	0.38	0.07
	[0.010]	[0.000]	[0.000]	(0.82)	(0.83)	(0.70)	(0.79)
$\Delta Cash$	0.010	0.000	0.010	−1.23	0.90	0.23	0.00
	[0.010]	[0.000]	[0.010]	(0.22)	(0.34)	(0.82)	(1.00)
ΔLC	0.000	0.010	0.030	0.67	0.03	1.56	0.72
	[0.000]	[0.000]	[0.000]	(0.50)	(0.86)	(0.12)	(0.40)

Ford shock). In this sense, our identification strategy shares the same spirit as that of Almeida et al. (2011), who utilize the effect of maturity choices on firms' investment.

In Table 2, we report the summary statistics for the treatment group, the non-treated group, and the matched control group for 2004 (the pre-downgrade year). To be included in this sample, we require that firms in our database have corporate bonds outstanding and data points available in each three-year period from 2004 through 2006. After this sample requirement, we have 768 firms in our sample, of which 368 firms have Capital IQ data available. The treatment group consists of 52 firms that have more than 5% of total face value of bonds expiring in the subsequent year, as measured in May 2005. The control group comprises all firms from the non-treated group (i.e., 368 − 52 = 316 firms), matched on variables that might affect firms' debt issuance and maturity choices, using Mahalanobis distance matching. Given each of the 52 treated firms is matched (with replacement) to two firms among 316 non-treated firms, we end up with 81 unique matched control firms after removing duplicate matches. As shown in Table 2, we find that the treatment and control groups are quite similar after matching. The mean and median difference tests are not rejected for any of the variables considered. The two groups are similar in terms of standard variables, such as *Q*, *Size*, *Lev*, *Tan*, and *Prof*, as well as bond dependence (*BondPct*). We also check whether the treatment and control groups have the same pre-treatment time trends in maturity dispersion (*D*1 and *D*2) and liquidity variables (*Cash* and *LC*) by comparing their yearly changes and the mean and median tests show that the time trends are statistically indistinguishable between the two groups.

We study control and treatment groups for the three-year period from 2004 through 2006. Specifically, we examine firms' responses in debt maturity dispersion during the post-downgrade period. In the regressions, we use a dummy variable $Event_t$, which is one for the period after May 2005 and zero otherwise. We use a balanced panel, requiring that both control and treatment firms have observations in all three years in the sample. We use the following specification:

$$D_{i,t} = \alpha_0 + \alpha_1 Event_t \cdot Treatment_i + \alpha_2 Event_t + \alpha_3 Treatment_i + \epsilon_{i,t} \quad (7)$$

where $Treatment_i$ is a time-invariant dummy variable for firms that have more than 5% of total bond amounts expiring in the first year after May 2005. If treated firms

Table 3
Effect of increased rollover risk on maturity profiles.
This table reports estimation of the following regression model: $Y_{i,t} = \alpha_0 + \alpha_1 Event_t \cdot Treatment_i + \alpha_2 Event_t + \alpha_3 Treatment_i + \epsilon_{i,t}$ where $Y_{i,\,t}$ is either $D1$, $D2$, $D1^W$, $D1_B$, $D2_B$, $\Delta_A D1_B$, $\Delta_A D2_B$, *Cash*, or *LC*. $D1$ is the inverse of the Herfindahl index of debt maturity fractions. $D2$ is the negative of the log distance from the perfect maturity dispersion. $D1^W$ is the inverse of the weighted Herfindahl index of debt maturity fractions. The dispersion measures with B subscripts represent dispersion measures constructed using only corporate bond maturities. $\Delta_A D_B$ is the active change in bond maturity dispersion. $Event_t$ is a dummy variable, which is one for the period after May 2005 and zero otherwise. $Treatment_i$ is a firm-level, time-invariant variable, which is one if the firm i has more than 5% of its total bond amounts expiring in the next year and zero otherwise, as measured in May 2005. Panel A reports the estimation results for the period from 2004 through 2006. Panel B reports placebo test results for the periods from 2003 through 2005, in which $Event_t$ and $Treatment_i$ are defined using May 2004 information instead of May 2005 information, using the set of firms that have corporate bonds outstanding and Capital IQ data available in each of the three-year period from 2003 through 2005. Panel C uses maturity profiles available one year earlier and sets $Treatment_i$ equal to one for firms that have more than 5% of total bond amounts expiring in the second year after May 2004. Panel D reports estimation results for the subsample excluding the auto industry firms (Fama–French Industry Classification Number 24). We include firm and time fixed effects, which subsume standalone (i.e., uninteracted) dummy variables. The numbers in parentheses are absolute values of t-statistics based on standard errors clustered at the firm level. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Effect of GM-Ford downgrade									
	$D1$	$D2$	$D1^W$	$D1_B$	$D2_B$	$\Delta_A D1_B$	$\Delta_A D2_B$	*Cash*	*LC*
$Event \cdot Treatment$	0.242*	0.098*	0.268**	0.361***	0.134***	0.562***	0.199***	0.011	0.006
	(1.98)	(1.81)	(2.05)	(3.50)	(2.86)	(3.13)	(2.74)	(1.36)	(0.32)
R^2	0.934	0.934	0.890	0.956	0.948	0.310	0.311	0.908	0.711
N	399	399	399	399	399	397	397	398	221
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: Placebo test									
	$D1$	$D2$	$D1^W$	$D1_B$	$D2_B$	$\Delta_A D1_B$	$\Delta_A D2_B$	*Cash*	*LC*
$Event \cdot Treatment$	0.120	0.062	−0.007	0.124	0.053	0.082	0.053	0.008	0.002
	(0.97)	(1.40)	(0.07)	(1.26)	(1.38)	(0.48)	(0.85)	(0.65)	(0.12)
R^2	0.934	0.946	0.884	0.951	0.959	0.307	0.284	0.894	0.621
N	483	483	474	483	483	479	479	483	246
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel C: Using maturity profile one year early									
	$D1$	$D2$	$D1^W$	$D1_B$	$D2_B$	$\Delta_A D1_B$	$\Delta_A D2_B$	*Cash*	*LC*
$Event \cdot Treatment$	0.204*	0.096*	0.224*	0.238**	0.101**	0.317*	0.163**	0.010	0.002
	(1.73)	(1.86)	(1.76)	(2.39)	(2.14)	(1.87)	(2.24)	(1.01)	(0.08)
R^2	0.937	0.940	0.892	0.958	0.954	0.314	0.299	0.901	0.729
N	420	420	420	420	420	418	418	419	219
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel D: Excluding auto industry firms									
	$D1$	$D2$	$D1^W$	$D1_B$	$D2_B$	$\Delta_A D1_B$	$\Delta_A D2_B$	*Cash*	*LC*
$Event \cdot Treatment$	0.224*	0.095*	0.269**	0.360***	0.134***	0.519***	0.185**	0.011	0.006
	(1.81)	(1.73)	(2.01)	(3.43)	(2.79)	(2.86)	(2.50)	(1.33)	(0.33)
R^2	0.935	0.934	0.890	0.956	0.947	0.310	0.311	0.916	0.707
N	390	390	390	390	390	388	388	389	213
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

respond to increased rollover risk by having more dispersed debt structures, then we expect the coefficient on the interaction term $Event_t \cdot Treatment_i$ to be significantly positive, because treated firms need to roll over bonds and can more easily alter debt maturity profiles. We also include both firm and time fixed effects in the regressions, which subsume the standalone *Event* and *Treatment* dummy variables.

4.1.3. Estimation results

Table 3 reports the estimation results for Eq. (7). The first two columns of Panel A ($D1$ and $D2$) show that the firms in the treatment group increase maturity dispersion compared with the control group. Treatment firms with bonds expiring within one year increase $D1$ by 0.242 and $D2$ by 0.098, which correspond to 17.9% and 9.4% of a one-standard deviation increase (estimated from the full sample), respectively. These changes are also statistically significant at the 5% and 10% levels, respectively.[17] Note that in the next column, we find that maturity-weighted dispersion measure $D1^W$ also increases by 0.268 with a t-statistic of 2.05, indicating that these treated firms tend to disperse debt maturities using longer maturity debt instruments.

[17] Given that we do not observe separately supply effects for debt maturity that could exogenously lower maturity dispersion, we only observe a combined (or net) effect. Hence this could lead to an underestimation of α_1 in Eq. (7).

The dispersion measures $D1$ and $D2$ are calculated using all debt instruments, not just bonds. We examine whether increases in maturity dispersion are more pronounced if we focus only on debt maturity dispersion measures constructed using only bonds ($D1_B$ and $D2_B$), because the perceived increase in higher rollover risk should be stronger for the bond markets. We find that the coefficients on the interaction term ($Event_t \cdot Treatment_i$) are more significant for the two bond-based dispersion measures $D1_B$ and $D2_B$ with the t-statistics of 3.50 and 2.86, respectively.

Given that treated firms would want to implement more dispersed maturity structures when rolling over expiring bonds, in the next two columns we examine whether a large part of the dispersion increases documented in the first two columns is driven by firms' active maturity choices. We define an *active* bond dispersion change ($\Delta_A D_B$) as the difference between the actual dispersion in year t and the passive dispersion, $D_{B,t} - PassiveD_{B,t}$. The passive component of bond maturity dispersion, $PassiveD_t$, is defined as the dispersion level that the firm would achieve if it were to replace an expiring bond with a new bond that has exactly the same maturity and face value as the expiring bond had at the time of issue.[18] Thus, an increase in active maturity dispersion implies that firms tend to choose maturities of newly issued bonds so that their maturity profiles are more dispersed than those achieved by a simple rollover strategy. The results in columns $\Delta_A D1_B$ and $\Delta_A D2_B$ show that both active changes in bond dispersion increase for the treatment group during the post-downgrade period (significant at the 1% level). Thus, treated firms actively increase bond maturity dispersion when replacing expiring bonds with newly issued bonds.

Because it is possible that the corporate debt market might not have been functioning normally during the post-downgrade period, firms might resort to liquidity risk management tools other than maturity management. We investigate how firms use these other tools in the last two columns of Panel A. The results show that although firms tend to rely on these means by increasing cash holdings and lines of credit, these changes are not statistically significant. For example, firms with expiring bonds increase cash holdings by 1.1% with a t-statistic of 1.36. Note that these specifications are different from those used by Acharya et al. (2014), who rely on bond dependence (instead of bond expirations) as treatment. That is, our tests compare firms with and without expiring bonds. Therefore, our tests support the view that firms with expiring bonds tend to reach for more dispersed maturity structures, but not necessarily for higher cash holdings or larger credit lines.

Conceivably, firms may always aim at higher maturity dispersion when they roll over bonds. That is, firms with expiring bonds may always increase maturity dispersion, regardless of a market-wide shock to rollover risk. We investigate this possibility via a placebo test as shown in Panel B for a sample period from 2003 to 2005 where $Event_t$ is defined as of May 2004. However, we do not find a reliable increase in maturity dispersion. Intuitively, this result makes sense because many firms in the placebo sample were potentially at the optimal debt maturity dispersion level (according to our tradeoff arguments in Section 2) and hence debt dispersion should not change much. Thus, firms do not reliably increase maturity dispersion in the process of replacing expiring bonds with new ones when there has not been a notable recent rise in rollover risk.[19]

Panels C and D of Table 3 provide a couple of robustness checks to the main results. First, we use maturity profiles one year earlier, i.e., in May 2004, and set $Treatment_i$ equal to one for firms that have more than 5% of total bond amounts expiring two years later. Even if a few firms anticipated the market-wide shock to rollover risk and adjusted their maturity dispersion prior to May 2005, it is even more unlikely that this was the case for firms identified this way in May 2004. For this alternative assignment rule, the results are qualitatively similar to the baseline results shown in Panel A of Table 3. Second, we exclude auto sector firms from the regression analyses. Our results are again qualitatively similar. As another robustness check, we replicate the empirical tests of Eq. (7) using maturity dispersion measures based on bond amounts from Mergent Fixed Income Securities Database (FISD) in Appendix C. For this broader sample of FISD data, we also find that the results are qualitatively similar to the main results in Table 3.

In addition, we test whether there is a differential effect of increased rollover risk, i.e., whether treated firms' response to the event is particularly strong when firms have large debt burdens. All else being equal, rollover risk management through maturity dispersion should not matter much for firms with little or low leverage. We examine this hypothesis by employing a triple interaction with a dummy variable for high leverage firms in the above empirical strategy. Specifically, we define a dummy variable for high leverage (*HighLev*), which takes a value of one if a firm's leverage ratio in 2004 is in the top 50% percentile of the treatment group and zero otherwise. Using this dummy variable, we estimate coefficients on a triple interaction term of *Event*, *Treatment*, and *HighLev* in a regression specification based on Eq. (7). If rollover risk matters particularly for high leverage firms, we should find positive coefficients on the triple interaction, $Event \cdot HighLev \cdot Treatment$. Similar to the estimation of Eq. (7), we include both firm and time fixed effects, which subsume uninteracted dummy variables and the interaction between the *Treatment* and *HighLev* dummies.

Table 4 provides the estimation results. We find that high leverage firms indeed respond more strongly to the GM-Ford shock by increasing maturity dispersion. The coefficients on the triple interaction terms are positive and statistically significant at least at the 10% level throughout the specifications considered. In Columns 1 and 2 based on the triple interactions using market leverage ratios, we find

[18] Note that the passive maturity dispersion level and lagged actual maturity dispersion level need not be the same.

[19] To control for different changes in maturity dispersion of treated and control groups independent of the event, we find estimates of α_1 in Panel A for the event and Panel B for the placebo are significantly different (especially for bond and maturity-weighted dispersion measures).

Table 4
Effect of increased rollover risk on maturity profiles: Impact of high leverage.
This table reports the regression estimation of debt maturity dispersion using the triple interaction of the event (*Event*) and treatment (*Treatment*) dummies with a dummy variable for high leverage (*HighLev*). The high leverage dummy is one if a firm's leverage ratio in 2004 is in the top 50% percentile and zero otherwise. Columns 1 and 2 employ market leverage and Columns 3 and 4 employ net debt ratios (book debt minus cash divided by total assets) to calculate high leverage dummies. The dependent variables are either *D*1 or *D*2. *D*1 is the inverse of the Herfindahl index of debt maturity fractions. *D*2 is the negative of the log distance from the perfect maturity dispersion. The dispersion measures with *B* subscripts represent dispersion measures constructed using only corporate bond maturities. *Event* is a dummy variable, which is one for the period after May 2005 and zero otherwise. *Treatment* is a firm-level, time-invariant variable, which is one if the firm *i* has more than 5% of its total bond amounts expiring in the next year and zero otherwise, as measured in May 2005. The sample period is from 2004 through 2006. We include firm and time fixed effects, which subsume standalone (i.e., uninteracted) dummy variables and the interaction between *Treatment* and *HighLev*. The numbers in parentheses are absolute values of *t*-statistics based on standard errors clustered at the firm level. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

	Market leverage				Net debt ratio			
	$D1$	$D2$	$D1_B$	$D2_B$	$D1$	$D2$	$D1_B$	$D2_B$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Event · HighLev · Treat	0.585**	0.288**	0.625**	0.306**	0.424*	0.184*	0.503**	0.202**
	(2.15)	(2.00)	(2.58)	(2.61)	(1.74)	(1.69)	(2.47)	(2.06)
Event · Treat	−0.162	−0.103	−0.038	−0.083	0.079	0.025	0.172	0.040
	(0.70)	(0.75)	(0.18)	(0.76)	(0.47)	(0.27)	(1.12)	(0.48)
Event · HighLev	0.218	0.126	0.083	0.091	0.191	0.077	−0.022	−0.023
	(1.39)	(1.50)	(0.70)	(1.05)	(1.19)	(1.13)	(0.18)	(0.34)
R^2	0.936	0.937	0.957	0.950	0.935	0.934	0.956	0.947
N	399	399	399	399	399	399	399	399
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

firms increase both the *D*1 and *D*2 measures. We find bigger differential effects for bond-based dispersion measures, as shown by larger coefficient estimates on the triple interaction terms in Columns 3 and 4. We obtain largely similar results in Columns 5–8, using net debt ratios to define high leverage dummy variables. In sum, the results in Tables 3 and 4 establish that firms respond to increased rollover risk by spreading out debt maturity structure.

4.2. Debt issuance and pre-existing maturity profiles

In the model, financial and real frictions determine optimal maturity profiles and hence maturity choices should be affected by pre-existing maturities. Therefore, we examine the prediction that a firm's pre-existing maturity profile explains its debt maturity choice behavior. Specifically, if a firm already has pre-existing debt, it must utilize the new debt issue to move towards its optimal maturity profile, determined by the financial and real frictions. E.g., using the notation of our model in Section 2, if the firm is of type *D* and it has already issued debt with maturity t_1 (t_2), then the subsequent debt issue should be in the maturity bucket t_2 (t_1). In our empirical strategy we thus analyze whether a firm is more (less) likely to choose a particular maturity for a debt issue if it already has a low (high) percentage of its debt expiring at this maturity.

To test this prediction, we explore the multidimensional structure of debt maturity profiles (i.e., amounts outstanding across various maturity dates) via a test of maturity choice, which differs from earlier studies that focus largely on a single dimension of debt maturity profiles, such as average maturity or short-term debt relative to total outstanding debt (e.g., Barclay and Smith, 1995; Guedes and Opler, 1996; Stohs and Mauer, 1996; Johnson, 2003; Greenwood et al., 2010; Saretto and Tookes, 2013). Furthermore, by examining maturities of new debt issues, our analysis uncovers how firms make marginal decisions in terms of maturity management.

4.2.1. Methods

We estimate linear regressions of debt issuance amounts for each maturity bucket *j*. We define seven maturity buckets. For maturities shorter than ten years ($1 \le j \le 5$), there are five two-year buckets, each from $2j-1$ to $2j$ years. For maturities longer than ten years, there are two maturity buckets, one for 11–20 years and the other one for 21 years or longer. For each maturity bucket *j*, we estimate the following issuance model:

$$I_{it}^{j} = a_1 m_{it}^{1} + a_2 m_{it}^{2} + a_3 m_i^{3} + a_4 m_i^{4} + a_5 m_i^{5} + a_6 m_i^{6} + a_7 m_i^{7} + \epsilon_{it}^{j}\ , \tag{8}$$

where I_{it}^{j} is the fraction of newly issued debt amounts relative to total assets in maturity bucket *j*.[20] m_{it}^{1} to m_{it}^{7} are the fractions of debt amounts outstanding in each of the seven maturity buckets relative to the total assets of firm *i*.[21] We include firm and year-month fixed effects in the estimation. Any economy-wide supply-side effects on firms' issuance are absorbed by the year fixed effect. Standard errors are clustered at both the time and firm levels.

[20] We do not count bond exchanges due to Rule 144A securities as new issues. Many firms issue Rule 144A bonds in private placements, which are exchanged later with nearly identical public bonds.

[21] In the previous version of the paper, we defined maturity profiles, m_{it}^{1} to m_{it}^{7}, as deviations from the benchmark maturity profiles based on firm characteristics. We obtain largely similar results from this alternative definition of maturity profiles.

Table 5
Regression of newly issued debt amounts on pre-existing maturity profiles.
This table provides the following linear model estimation results for each maturity bucket ($j = 1, 2, \ldots, 7$):

$I_{it}^{j} = a_1 m_{it}^{1} + a_2 m_{it}^{2} + a_3 m_{i}^{3} + a_4 m_{i}^{4} + a_5 m_{i}^{5} + a_6 m_{i}^{6} + a_7 m_{i}^{7} + \epsilon_{it}^{j}$,

where j is five two-year maturity buckets defined as $2j-1$ to $2j$ years for maturities shorter than ten years ($j \leq 5$), and two maturity buckets (11–20 years and 21 years or longer) for maturities longer than ten years ($j = 6$ or $j = 7$). The variable m_{i}^{j} is the fraction of debt amounts outstanding in maturity bucket j relative to the total assets of firm i. The dependent variable (I_{it}^{j}) is the fraction of newly issued debt amounts relative to total assets in maturity bucket j. We include both firm and year-month fixed effects. Panel A reports the results for all debt instrument issues and Panel B reports only for corporate bond issues. Numbers in parentheses are absolute values of t-statistics for which standard errors are clustered at both the firm and time levels. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. We also report the hypothesis test ($H_0\!: \ a_i - \frac{1}{6}\sum_{n \neq i} a_n = 0$) in the row H_0. The sample includes all issues of debt instruments (i.e., corporate bonds, credit lines, and term loans) in our database from 2002 to 2012.

Panel A: All debt instruments

	1–2 years (1)	3–4 years (2)	5–6 years (3)	7–8 years (4)	9–10 years (5)	11–20 years (6)	21– years (7)
m^1	−0.144***	0.065**	0.001	−0.014***	−0.005***	−0.001	−0.001
	(15.50)	(2.30)	(0.08)	(5.31)	(2.72)	(0.28)	(1.52)
m^2	0.006	−0.210***	−0.020***	−0.004	−0.007**	0.005*	0.001
	(1.33)	(20.68)	(2.91)	(0.75)	(2.21)	(1.96)	(0.37)
m^3	0.003	−0.026***	−0.247***	−0.024***	−0.000	−0.000	−0.001
	(0.74)	(3.29)	(27.57)	(4.30)	(0.10)	(0.09)	(1.06)
m^4	−0.002	−0.028***	−0.037***	−0.221***	−0.017***	−0.003	−0.004***
	(0.55)	(3.67)	(4.55)	(13.37)	(3.51)	(1.04)	(2.63)
m^5	−0.007	−0.032***	−0.015**	−0.057***	−0.202***	−0.019***	−0.004
	(1.44)	(3.71)	(1.99)	(5.71)	(13.20)	(4.24)	(1.42)
m^6	0.002	0.006	−0.008	0.001	−0.012**	−0.281***	−0.004
	(0.38)	(0.81)	(1.25)	(0.21)	(2.16)	(18.05)	(0.83)
m^7	0.003	0.003	0.001	−0.010*	−0.000	−0.010	−0.242***
	(0.73)	(0.42)	(0.11)	(1.88)	(0.07)	(1.47)	(10.33)
R^2	0.351	0.628	0.333	0.297	0.249	0.367	0.378
N	50064	50064	50064	50064	50064	50064	50064
H_0	−0.145	−0.209	−0.236	−0.206	−0.196	−0.277	−0.240
t-stat	14.50***	25.12***	24.66***	13.49***	13.08***	17.86***	10.21***

Panel B: Corporate bonds only

	1–2 years (1)	3–4 years (2)	5–6 years (3)	7–8 years (4)	9–10 years (5)	11–20 years (6)	21– years (7)
m^1	−0.119***	0.050	−0.007	−0.013***	−0.010***	−0.002	−0.002
	(14.49)	(1.34)	(0.74)	(3.21)	(3.95)	(0.39)	(1.53)
m^2	0.009	−0.179***	−0.017*	−0.011	−0.013***	0.004	0.002
	(1.23)	(10.58)	(1.74)	(1.47)	(3.00)	(1.23)	(0.56)
m^3	−0.000	−0.029***	−0.203***	−0.012	0.001	0.001	−0.002
	(0.05)	(3.33)	(19.14)	(1.42)	(0.25)	(0.22)	(0.87)
m^4	0.005	−0.031***	−0.032***	−0.207***	−0.010	0.002	−0.004*
	(0.90)	(2.96)	(2.92)	(9.93)	(1.30)	(0.55)	(1.74)
m^5	0.004	−0.023**	−0.011	−0.041***	−0.233***	−0.019***	−0.003
	(0.90)	(2.49)	(1.27)	(3.45)	(12.40)	(3.02)	(0.97)
m^6	0.004	0.008	−0.001	0.015*	−0.002	−0.292***	0.003
	(0.71)	(0.69)	(0.07)	(1.83)	(0.22)	(16.32)	(0.49)
m^7	0.004	0.013	0.004	0.002	0.002	−0.002	−0.277***
	(0.93)	(1.47)	(0.62)	(0.38)	(0.30)	(0.24)	(10.89)
R^2	0.402	0.360	0.366	0.368	0.316	0.484	0.455
N	27919	27919	27919	27919	27919	27919	27919
H_0	−0.123	−0.177	−0.194	−0.199	−0.228	−0.290	−0.276
t-stat	14.08***	13.82***	18.32***	10.01***	12.40***	16.81***	10.99***

4.2.2. Estimation results

If firms avoid maturity concentrations, the amounts of new debt issues in maturity bucket j should be negatively related to the maturity profile in that bucket, m_{it}^{j}. In particular, this implies the following testable hypotheses. First, the diagonal coefficients, a_j for $j = 1, \ldots 7$, should be significantly negative and, on average, smaller than the off-diagonal coefficients for the other maturity buckets, a_l, where $l \neq j$. Second, if firms, however, do not consider maturity management to be important or if firms prefer selecting maturities of new debt issues at pre-existing maturities (creating maturity towers), to improve secondary

Table 6
Regression of newly issued debt amounts on pre-existing maturity profiles: impact of the GM-Ford downgrade.
This table provides the following linear model estimation results for each maturity bucket ($j = 1, 2, \ldots, 7$):

$$I_{it}^{j} = a_0 Event_t \cdot m_{it}^{j} + a_1 m_{it}^{1} + a_2 m_{it}^{2} + a_3 m_i^3 + a_4 m_i^4 + a_5 m_i^5 + a_6 m_i^6 + a_7 m_i^7 + \epsilon_{it}^{j},$$

where j is five two-year maturity buckets defined as $2j-1$ to $2j$ years for maturities shorter than ten years ($j \le 5$), and two maturity buckets (11–20 years and 21 years or longer) for maturities longer than ten years ($j = 6$ or $j = 7$). The variable m_i^j is the fraction of debt amounts outstanding in maturity bucket j relative to the total assets of firm i. $Event_t$ is a dummy variable, which is one for the period after May 2005 and zero otherwise. The dependent variable (I_{it}^j) is the fraction of newly-issued debt amounts relative to total assets in maturity bucket j. We include both firm and year-month fixed effects. The standalone (i.e., uninteracted) $Event_t$ is subsumed by year-month fixed effects. Numbers in parentheses are absolute values of t-statistics for which standard errors are clustered at both the firm and time levels. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively. The sample includes all corporate bond issues in our database from 2004 to 2006.

	1–2 years (1)	3–4 years (2)	5–6 years (3)	7–8 years (4)	9–10 years (5)	11–20 years (6)	21– years (7)
$Event \cdot m^j$	−0.056**	0.017	−0.003	−0.056	−0.068	0.012	0.005
	(2.26)	(0.23)	(0.05)	(0.83)	(0.78)	(0.26)	(0.13)
m^1	−0.129***	0.036***	−0.001	−0.012*	−0.008	−0.003	0.001
	(8.30)	(3.11)	(0.05)	(1.91)	(1.47)	(0.29)	(1.04)
m^2	0.021	−0.257***	−0.048**	−0.005	−0.009	0.005**	0.001
	(1.66)	(5.76)	(2.62)	(0.46)	(0.81)	(2.16)	(0.50)
m^3	0.008	−0.039***	−0.282***	−0.021	0.010**	0.006**	0.001
	(1.19)	(4.79)	(9.27)	(1.55)	(2.10)	(2.04)	(0.52)
m^4	0.024**	−0.024	−0.074***	−0.247***	−0.011	0.008*	−0.004*
	(2.53)	(1.46)	(4.41)	(7.29)	(0.95)	(1.97)	(1.84)
m^5	0.023***	−0.008	−0.004	−0.051***	−0.316***	−0.016**	−0.003
	(4.59)	(0.60)	(0.28)	(2.76)	(8.96)	(2.43)	(0.91)
m^6	0.012	0.018	−0.011	0.013	−0.016*	−0.382***	0.000
	(1.52)	(1.10)	(0.60)	(1.14)	(2.01)	(10.45)	(0.06)
m^7	0.012*	0.013*	−0.001	0.002	0.007	0.005	−0.384***
	(1.87)	(1.86)	(0.13)	(0.69)	(0.78)	(0.59)	(8.43)
R^2	0.443	0.481	0.461	0.481	0.471	0.565	0.598
N	12503	12503	12503	12503	12503	12503	12503

market liquidity of their bonds (a practice called "reopening" of existing bonds),[22] then the diagonal coefficients should be close to zero or even positive.

The results shown in Table 5 confirm both the hypotheses. Panel A provides the results for the issuances of bonds, term loans, and credit lines.[23] Across all maturity buckets, diagonal coefficients are all negative and also statistically significant at the 1% level, suggesting that firms manage their debt maturity profiles by avoiding maturity towers. Economic magnitudes are remarkably significant too. For example, for the five-to-six-year maturity bucket, firms tend to issue 24.7% of a one percentage point in debt amounts relative to total assets outstanding in that maturity bucket.

In addition, we examine in Table 5 whether the diagonal coefficients are smaller than the average of the other six coefficients in the same binomial choice regression (i.e., column). For this purpose, we test the null hypothesis (of random maturity choice), H_0: $a_i - \frac{1}{6}\sum_{n \neq i} a_n = 0$, as shown in the last rows of Table 5. The results reveal that the diagonal coefficients are always smaller than the average of non-diagonal coefficients. The difference ($a_i - \frac{1}{6}\sum_{n \neq i} a_n$) is negative and statistically significant at the 1% level across all maturity buckets in Panel A.

In Panel B, we provide the results using the fractions of corporate bond issue amounts as dependent variables and obtain largely similar results. Although the sample size shrinks almost in half compared with that of Panel A (i.e., from 50,064 to 27,919), the diagonal coefficient estimates are highly statistically significant across all columns. The non-diagonal coefficient estimates are much smaller in magnitude and also in most cases insignificant statistically. Moreover, the hypothesis H_0: $a_i - \frac{1}{6}\sum_{n \neq i} a_n = 0$ is also rejected across all maturity buckets.

Lastly, we focus on maturity management through bond issuance, using the GM-Ford event as a shock to rollover risk. In particular, we estimate the following issuance model similar to Eq. (8) for the 2004–2006 period but also add an interaction term with $Event$ defined in Section 4.1.2:

$$I_{it}^{j} = a_0 Event_t \cdot m_{it}^{j} + a_1 m_{it}^{1} + a_2 m_{it}^{2} + a_3 m_i^3 + a_4 m_i^4 + a_5 m_i^5 + a_6 m_i^6 + a_7 m_i^7 + \epsilon_{it}^{j}. \quad (9)$$

Intuitively, if firms respond to increased rollover risk due to the GM-Ford downgrade by managing maturity dispersion more actively, then we should find the coefficient estimate of the interaction, $Event_t \cdot m^j$, to be negative especially for short maturity buckets.

[22] Anecdotally, secondary market liquidity or market depth can be important determinants of maturity structures (e.g., Servaes and Tufano (2006)) and firms often "re-open" existing bonds or issue large amounts in pre-existing maturities. The tradeoff faced by firms is also described well in BlackRock's report (Setting New Standards: The Liquidity Challenge II, May 2013):"More frequently re-opening issues could boost liquidity. [...] Over time, large borrowers would develop a single, liquid security at each annual curve point.[...] The downside for issuers: It would concentrate refinancing risk around certain dates such as quarter ends."

[23] For credit line issue amounts, amounts drawn are defined as actual issuances.

The results for Eq. (9) are in Table 6. They support the view that firms manage short-term bond maturities more actively after the GM-Ford downgrade. The coefficient estimate on $Event_t \cdot m^j$ is negative (−0.056) and statistically significant at the 5% level. That is, firms decrease the face value of bonds issued during the event period in the one-to-two year bucket by $12.9\% + 5.6\% = 18.5\%$ for each one percentage point of debt outstanding in that bucket, while before the event the equivalent reduction is only 12.9%. For bond issues in other maturity buckets, shown in Columns 2–7, however, we do not find a significant or reliable relationship between the interaction term and bond issue amounts, showing that the effect of increased rollover risk is concentrated in the shorter maturity horizons. Overall, the findings in this subsection indicate that firms tend to make their maturity profiles more dispersed in that they issue new debt to complement pre-existing maturity profiles.

5. Conclusion

This paper conducts novel analysis of an important dimension of corporate debt structure, namely, maturity profile. Despite evidence that CFOs believe managing debt rollover dates is important, it has been largely ignored in the academic literature. In contrast to extant work, we therefore do not focus on average debt maturity, but instead on the distribution of debt maturity dates across time.

The basic paradigm motivating our analysis is a tradeoff between benefits and costs of debt maturity dispersion, which we study in a framework that guides our empirical strategy. On the one hand, a dispersed debt structure is costly, because several debt issues with different maturities involve higher total issuance costs and lower liquidity in secondary markets compared to a single or a few large debt issues. On the other hand, concentrated debt structures are costly in the presence of rollover risk. Having to refinance a large debt issue when access to the debt market is difficult can lead to substantial investment distortions, such as forgoing profitable investments. The model's primary prediction is that an increase in the probability of market freezes should lead to an increase in debt maturity dispersion. Moreover, more levered firms are likely to respond more strongly to the above tradeoff. The model provides additional empirical predictions that future research can test. First, less profitable firms with smaller intermediate cash flows are more likely to choose dispersed maturity structures. Second, firms with more valuable growth options have stronger preferences for dispersed maturity structures. Third, firms with higher flotation and illiquidity costs will implement less dispersed maturity profiles.

We use two empirical strategies to shed light on how firms manage debt maturity profiles. First, we exploit the downgrade of GM and Ford in May 2005 to analyze the effect of an exogenous and unexpected shock to bond rollover risk. We establish that firms that had to roll over bonds expiring in the months following this shock increase the dispersion of their maturity profile more than a control sample of otherwise very similar firms. Applying the same strategy to a time period without an apparent shock to rollover risk (i.e., a placebo test) does not lead to any significant results. Moreover, we find a differential effect of increased rollover risk. Treated firms' response to the event is stronger if they have higher market leverage or larger net debt ratios. Second, we establish that newly issued debt maturities complement pre-existing maturity profiles. When issuing new debt, firms avoid maturity concentrations by choosing the maturities of new debt such that they fall into buckets for which the firm had less debt expiring and by shunning buckets which already have substantial pre-existing debt expiring. Moreover, we find that firms more actively manage bond maturity profiles in response to the downgrade event by particularly avoiding short-term maturity concentrations.

This paper shows that a firm's debt maturity profile is an important additional dimension of capital structure choice that depends on both capital market conditions and firm characteristics. As such, it only is a first step towards understanding this capital structure phenomenon by formalizing and testing an economically intuitive tradeoff that is considered by practitioners. For instance, while firms should demand more maturity dispersion after a rise in rollover risk, lenders might shorten debt maturities at the same time, which implies a reduction in the supply of maturity dispersion. Given that we cannot discriminate between demand and supply effects of debt maturity dispersion, we observe only a combined effect and hence our results may underestimate the true demand effect. Extending and refining our understanding of the interactions between choices of leverage, average debt maturity, and debt maturity dispersion, especially disentangling supply and demand effects, are very promising avenues for future research.

Appendix A. Capital IQ data

This appendix details the construction of maturity structure data from the Capital IQ database. The database contains information on detailed capital structure including the description of debt issues, debt issue type, principal amounts due, maturity dates (or ranges of maturity), and the types of filing documents used to construct debt issue information. Capital IQ categorizes debt capital structure into the following types: commercial paper, revolving credit, term loans, bonds and notes, capital lease, trust preferred, and other borrowings. The majority of these debt items are revolving credit, term loans, and bonds and notes.

Capital IQ obtains debt structure information from SEC filings including 10-K and 10-Q forms as well as restated filings. In some cases, there are duplicate observations; a debt issue can appear multiple times with different issue identifiers on the same filing date.[24] We clean up the data to deal with duplicate observations. First, we use the latest available filings for a debt issue when there are

[24] These duplicate data items can be found by comparing with Compustat total debt amounts. For example, the total amounts in Capital IQ are sometimes exactly integer multiples of the total amounts in Compustat. In all these cases, Capital IQ reports multiple items of the same debt issues with different debt issue identifiers.

multiple filings for a given filing date. Next, we identify duplicate debt items using principal amounts (*DataItemValue*), data descriptions (*descriptiontext*), maturity (*maturityhigh* and *maturitylow*), interest payment (*interestratehighvalue*), and data item identifiers (*DescriptionID* and *componentid*) and then manually delete redundant items using the detailed description of each debt issue and total debt amounts in Compustat. Also, Capital IQ has both credit limit (total commitment) and drawn amounts for credit lines but does not provide data to distinguish the two. Since we want to measure debt maturity dispersion using existing debt amounts outstanding, we pick observations with the smaller amounts assuming that they are the actual drawn amounts.

After eliminating duplicate observations, we compare the total debt amounts in Capital IQ and Compustat Annual. We first limit our sample to nonfinancial and nonutility firms. Following Colla et al. (2013), we remove observations for which the total debt in Capital IQ is greater than Compustat by more than 10%. There are cases in which debt maturity is missing in Capital IQ. If the total amounts of debt issues with missing maturity are less than 10% of the total amounts for the firm-year observation, we remove observations with missing maturities. Otherwise, we first compare the sums of maturities longer than five years across Capital IQ and Compustat (using total debt amounts minus the sum from *DD*1 through *DD*5 in Compustat, which provide debt amounts maturing in one through five years). If the difference of the two is less than 10% of the sum from Compustat, then Capital IQ has a good representation of debt maturing after five years. In this case, we use *DD*1 to *DD*5 from Compustat for debt maturities less than or equal to five years and Capital IQ data for maturities longer than five years. In addition, if the sum of *DD*1 through *DD*5 equals the total amounts in Compustat, we use *DD*1 through *DD*5 from Compustat as debt maturity structure, since all maturities are within five years. We only include firms with positive total debt in our sample, and also remove firm-year observations with non-positive total assets or book equity. After this data cleansing, we obtain 24,402 firm-year observations for the period from 2002 through 2012.

Appendix B. Variable definitions

This appendix provides the variable construction of all the variables used in the study. All variables in uppercase letters refer to the Compustat items.

*D*1: inverse of Herfindahl index of debt maturity fractions (see Section 3).
*D*2: negative of log distance from the perfect maturity dispersion (see Section 3).
$D1^W$: inverse of weighted Herfindahl index of bond maturity fractions (see Section 3).
Event: dummy variable equal to one for the period after May 2005 and zero otherwise.
Treatment: dummy variable equal to one if firm *i* has more than 5% of its total bond amounts expiring in the year following May 2005 and zero otherwise.
Q: market-to-book ratio, $(AT + PRCC * CSHO - CDQ - TXDB)/AT$.
Size: log of total assets (*AT*).
Age: number of years a firm is in the Compustat file prior to observations.
Lev: market leverage, $(DLTT + DLC)/(AT + PRCC * CSHO - CEQ - TXDB)$.
Prof: operating income before depreciation scaled by total assets, *OIBDP/AT*.
Tan: plant, property, and equipment scaled by total assets, *PPENT/AT*.
DebtMat: average of firms' debt maturities weighted by amounts.
LoanMat: average of firms' loan (revolving credit and term loans in Capital IQ) maturities weighted by amounts.
BondMat: average of firms' bond (bonds and notes in Capital IQ) maturities weighted by amounts.
ProfVol: standard deviation of operating income before depreciation divided by total assets (*OIBDP/AT*) using the past five years.
Ndebt: number of debt issues outstanding for each firm.
LoanPct: ratio of total book value of loans (revolving credit and term loans in Capital IQ) available to total book debt for each firm.
BondPct: ratio of total book value of bonds (bonds and notes in Capital IQ) available to total book debt for each firm.
LoanAmt: revolving credit and term loans in Capital IQ outstanding for each firm.
BondAmt: average amount of bonds (bonds and notes in Capital IQ) outstanding for each firm.
LoanAmt/Asset: *LoanAmt* divided by total assets.
BondAmt/Asset: *BondAmt* divided by total assets.
Cash: cash holdings divided by total assets, *CH/AT*.
LC: credit lines based on Capital IQ divided by total assets *AT*.
EqIssue: sale of common and preferred stocks divided by total assets (*SSTK/AT*).
AssetMat: (book) value-weighted average of the maturities of current assets and net property, plant, and equipment, where the maturity of current assets is current assets divided by the cost of goods sold (*ACT/COGS*), and the maturity of net property, plant, and equipment is that amount divided by annual depreciation expense (*PPENT/DP*).
$PassiveD_{B,t}$: dispersion level that a firm would achieve in *t* if it replaced an expiring bond with a new bond of exactly the same maturity and face value as the expiring bond.
$\Delta_A D_{B,t}$: defined as $D_{B,t} - PassiveD_{B,t}$.
$\Delta_P D_{t+1}$: defined as $PassiveD_{t+1} - D_{t+1}$.

Appendix C. Rollover risk and maturity profiles (FISD sample)

This appendix provides robustness checks using maturity dispersion measures based on bond amounts from Mergent Fixed Income Securities Database (FISD), which is a comprehensive data source for U.S. corporate bond issues. For the 1991–2012 period, we obtain issue dates,

Table C1
Summary statistics: treated and matched firms (FISD sample).
This table reports summary statistics (mean and median) and the results of difference tests for 2004 across the treated, non-treated, and control firms, using the sample constructed by merging the Mergent Fixed Income Securities Database (FISD) with Compustat. The treatment group (*Treated*) is composed of firms that have more than 5% of existing bond amounts expiring in the next year, as measured in May 2005. The non-treated group (*Non-treated*) includes the rest of firms in the FISD sample. The control group (*Control*) is a set of the firms matched to the firms in the treatment group, using Mahalanobis distance matching. We match two firms for each treated firm with replacement and remove duplicate matches. The variable descriptions are provided in Appendix B. Firms are required to have observations in all three years from 2004 to 2006 (balanced panel). The mean test is a Wilcoxon rank-sum test and the median test is Pearson's chi-squared test.

	Treated	Non-treated	Control	Test of difference			
	($N=115$)	($N=653$)	($N=168$)	Treated vs. Non-treated		Treated vs. Control	
	Mean [Median]	Mean [Median]	Mean [Median]	Mean test (p-Value)	Median test (p-Value)	Mean test (p-Value)	Median test (p-Value)
Q	1.780	1.850	1.670	−0.46	0.00	−0.91	0.00
	[1.550]	[1.540]	[1.440]	(0.64)	(1.00)	(0.36)	(1.00)
Size	9.060	7.610	8.710	−9.28	62.22	−1.03	1.52
	[9.070]	[7.560]	[8.410]	(0.00)	(0.00)	(0.30)	(0.22)
MktLev	0.190	0.230	0.190	3.10	8.02	0.97	2.19
	[0.150]	[0.200]	[0.190]	(0.00)	(0.00)	(0.33)	(0.14)
Tan	0.260	0.300	0.280	0.67	0.16	1.31	0.97
	[0.210]	[0.220]	[0.240]	(0.51)	(0.69)	(0.19)	(0.32)
Prof	0.130	0.110	0.120	−1.160	0.83	0.890	0.10
	[0.130]	[0.120]	[0.130]	(0.25)	(0.36)	(0.37)	(0.75)
BondPct	0.760	0.740	0.800	−0.43	0.00	−0.94	0.00
	[0.810]	[0.810]	[0.870]	(0.67)	(1.00)	(0.35)	(1.00)
*D*1	4.810	2.880	4.510	−7.82	39.31	0.76	0.00
	[4.250]	[2.200]	[4.120]	(0.00)	(0.00)	(0.45)	(1.00)
*D*2	4.560	3.680	4.700	−7.82	47.29	0.99	0.00
	[4.740]	[3.580]	[4.740]	(0.00)	(0.00)	(0.32)	(1.00)
Δ*D*1	0.040	0.040	0.250	0.84	0.56	0.44	0.01
	[−0.020]	[0.000]	[0.000]	(0.40)	(0.45)	(0.66)	(0.94)
Δ*D*2	0.060	0.070	0.070	0.15	0.01	−0.04	0.01
	[0.000]	[0.000]	[0.000]	(0.88)	(0.92)	(0.97)	(0.94)
Cash	0.110	0.150	0.090	1.89	2.00	−0.13	0.06
	[0.070]	[0.080]	[0.070]	(0.06)	(0.16)	(0.90)	(0.81)
LC	0.030	0.060	0.050	0.80	0.02	0.71	0.00
	[0.000]	[0.000]	[0.000]	(0.43)	(0.89)	(0.48)	(1.00)
Δ*Cash*	0.010	0.000	0.010	−0.25	0.01	1.50	1.13
	[0.000]	[0.000]	[0.010]	(0.80)	(0.92)	(0.13)	(0.29)
Δ*LC*	0.010	0.010	0.020	−0.07	0.04	−0.06	0.03
	[0.000]	[0.000]	[0.000]	(0.94)	(0.85)	(0.95)	(0.85)

bond maturities, initial and historical amounts outstanding, and other relevant information from FISD, which begins in the 1980s but becomes comprehensive in the early 1990s. We construct the sample by first merging the FISD with Compustat using the first six-digit CUSIP identifiers and also merging bonds issued by subsidiaries using subsidiary information available in the FISD. Following the standard practice, we exclude financial firms (SIC codes 6000–6999) and utilities (SIC codes 4900–4999), and winsorize the top and bottom 0.5% of variables to minimize the impact of data errors and outliers. We reproduce Tables 2 and 3 of the main text in Tables C.1 and C.2, respectively.

Table C2

Effect of increased rollover risk on maturity profiles (FISD sample).

This table reports the estimation of the following regression model: $Y_{i,t} = \alpha_0 + \alpha_1 Event_t \cdot Treatment_i + \alpha_2 Event_t + \alpha_3 Treatment_i + \epsilon_{i,t}$ where $Y_{i,\,t}$ is either $D1_B$, $D2_B$, $\Delta_A D1_B$, $\Delta_A D2_B$, *Cash*, or *LC*. The bond maturity dispersion measures ($D1_B$ and $D2_B$) and active changes in dispersion ($\Delta_A D1_B$ and $\Delta_A D2_B$) are calculated using bond amounts available in the Mergent Fixed Income Securities Database (FISD). $Event_t$ is a dummy variable, which is one for the period after May 2005 and zero otherwise. $Treatment_i$ is a firm-level, time-invariant variable, which is one if the firm *i* has more than 5% of its total bond amounts expiring in the next year and zero otherwise, as measured in May 2005. Panel A reports the estimation results for the period from 2004 through 2006. Panel B reports placebo test results for the periods from 2003 through 2005, in which $Event_t$ and $Treatment_i$ are defined using May 2004 information instead of May 2005 information, using the set of firms that have corporate bonds outstanding and data points available in each of the three-year period from 2003 through 2005. We include firm and time fixed effects, which subsume standalone (i.e., uninteracted) dummy variables. The numbers in parentheses are absolute values of *t*-statistics based on standard errors clustered at the firm level. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Effect of GM-Ford downgrade						
	$D1_B$	$D2_B$	$\Delta_A D1_B$	$\Delta_A D2_B$	*Cash*	*LC*
$Event \cdot Treatment$	0.332***	0.110***	0.305*	0.099**	0.006	0.008
	(3.23)	(3.36)	(1.92)	(2.04)	(1.12)	(0.66)
R^2	0.945	0.959	0.359	0.310	0.913	0.677
N	804	804	804	804	804	354
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: Placebo test						
	$D1_B$	$D2_B$	$\Delta_A D1_B$	$\Delta_A D2_B$	*Cash*	*LC*
$Event \cdot Treatment$	0.126	0.015	0.087	0.009	−0.001	−0.002
	(1.21)	(0.54)	(0.50)	(0.17)	(0.12)	(0.16)
R^2	0.948	0.953	0.337	0.343	0.927	0.600
N	789	789	789	789	789	321
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Panel C: Using maturity profile one year early						
	$D1_B$	$D2_B$	$\Delta_A D1_B$	$\Delta_A D2_B$	*Cash*	*LC*
$Event \cdot Treatment$	0.209**	0.086**	0.267*	0.099**	0.007	0.015
	(2.07)	(2.55)	(1.78)	(2.06)	(1.15)	(1.22)
R^2	0.948	0.956	0.357	0.295	0.897	0.690
N	849	849	849	849	849	371
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Panel D: Excluding auto industry firms						
	$D1_B$	$D2_B$	$\Delta_A D1_B$	$\Delta_A D2_B$	*Cash*	*LC*
$Event \cdot Treatment$	0.317***	0.102***	0.294*	0.086*	0.006	0.009
	(3.04)	(3.15)	(1.82)	(1.74)	(1.18)	(0.64)
R^2	0.945	0.960	0.363	0.316	0.917	0.666
N	780	780	780	780	780	340
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes

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