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The effects of corporate bond granularity [☆]

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ABSTRACT

We investigate whether and how firms manage their rollover risk by having a dispersed bond maturity structure (granularity). Granularity can be achieved or maintained by frequently issuing sets of bonds with different maturities. We find that firms with higher granularity have higher availability of financing, lower cost of financing, lower financial constraints and lower stock return volatility. The effects are stronger for firms that face higher rollover risk. The evidence suggests that spreading out bond maturities is an effective corporate policy to manage rollover risk.

1. Introduction

Managing rollover risk is essential for the success of a firm. Rollover risk arises when a firm cannot meet its financing needs – either being unable to rollover its debt at maturity or being unable to finance new investment opportunities (e.g., Diamond, 1991). When a firm faces severe rollover risk, it may be forced to search for expensive alternative financing sources, undertake a costly debt restructuring process, or even liquidate its assets, possibly at fire-sale prices (e.g., Brunnermeier and Yogo, 2009). Survey evidence suggests that, when deciding on debt issues, one of the primary concerns for CFOs is to avoid the clustering of debt maturity dates (e.g., Graham and Harvey, 2001; Servaes and Tufano, 2006). Ideally, firms with a well-spread maturity structure of outstanding debt expect to straddle the rollover risk as they have to refinance only a small fraction of their total debt at any point of time. Despite its popularity in practice, research on corporate debt maturity granularity is scarce.

In this paper we examine which firms create and maintain a dispersed bond maturity structure through new bonds issues and what the impact of granularity is on key aspects of corporate finance. Our analysis complements and extends the study of Choi et al. (2014) and studies on the interplay of rollover risk and credit risk, especially for financially constrained firms and during the financial crisis (e.g., Gopalan et al., 2014; Almeida et al., 2012; Duchin et al., 2010).

We focus on publicly listed firms from the United States to study whether and how the bond maturity structure is used to manage rollover risk. We consider firms' financing with public debt for several reasons. First, different from the equity financing which has infinite maturity debt financing has fixed maturity. This gives repeatedly rise to rollover risk, making debt finance a logical choice to study firms' maturity management. Second, in contrast to the private debt market the public debt market is characterized by a large number of bond investors. This makes public debt renegotiation extremely costly if not impossible when firms face large rollover risk, as it requires unanimous bondholder consent under the "Trust Indenture Act" (Smith and Warner, 1979; Buchheit and

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Gulati, 2002). As the costs of rollover risk of bond financing are higher, firms have an additional incentive to actively manage the bonds maturity structure to prevent the higher costs associated with rollover risk. Third, previous research shows that due to the market frictions, firms that have access to public debt market are the ones that are subject to less informational asymmetries (e.g., Myers, 1984; Diamond, 1991; Denis and Mihov, 2003). Public bond offerings are sold to public at a fixed "take-it-or-leave-it basis" (Kwan and Carleton, 2010). Therefore firms that borrow in the bond market have a stronger position vis-à-vis their investors, and there is little input from public investors especially with respect to the design of bond contract features. This implies that those firms would have more flexibility in building up a desired maturity structure using bond financing.

We base our analysis on data on corporate bond taken from the Mergent FISD database. We merge the bond data with a wide set of firm characteristics collected from Compustat. In practice, firms build up and maintain their bond maturity structure at a certain level through managing new bonds issues. The example illustrated in Fig. 1 shows that the granularity and the frequency of firms' bonds issues are two important dimensions of firm's incremental bond maturity choice when it issue bonds. Following the studies of Guedes and Opler (1996), Denis and Mihov (2003), we focus on firms' incremental maturity decisions when they issue new bonds. This approach has several advantages and can be seen as complementary to the analysis of the maturity structure of outstanding bonds shown in Choi et al. (2014). The latter is a cumulative result of a sequence of incremental decisions made by firms at the time of bond issuances in the past. The incremental analysis makes it possible for us to link a firm's maturity choices at issuance with firm characteristics measured before the issue. Moreover, this approach is well-suited to capture changes in a firm's incremental maturity choice due to the time-variation in firm characteristics. We look at firms' bond issue activities and investigate the types of firms that maintain a dispersed maturity structure over time by frequently issuing a set of bonds with heterogeneous maturities. We find that firms with larger total assets, higher leverage, and a well-spread maturity structure of already outstanding bonds at issuance issue more frequently, and are more likely to issue multiple bonds with different maturities. A combination of these two financing policies leads to a highly granular maturity structure of outstanding bonds. The results complement and extend the study of Choi et al. (2014) that focuses on the granularity of outstanding corporate debt.

We then investigate potential effects of bond granularity. Our results indicate that having a granular maturity structure improves the availability of finance, lowers the cost of finance, lowers financial constraints and lowers the stock return volatility. Firms that have a dispersed bond maturity structure are more likely to meet their (re-)financing needs arising from bonds expiries or new investment opportunities, and face lower cost of financing when they issue new bonds. Those firms ultimately become less financially constrained and also reduce their stock market risk. Interestingly, we find that the effect is strongest for firms with high rollover risk, i.e., firms that are bank-dependent or that have a large proportion of bonds maturing in the short term.

Our study contributes to the literature on the link between rollover concerns and firms' choice of debt maturity structure. Diamond (1991) points out that managing rollover risk is an important consideration when firms decide about debt maturity. He defined liquidity risk as the risk of a borrower being forced into inefficient liquidation because refinancing is not available. Morris and Shin (2009) argue that liquidity risk could also be seen as the probability of a default due to a run by short-term creditors when the firm would otherwise have been solvent. Theory and empirical evidence suggests that the use of short-term debt exposes firms with rollover risks and higher chance of inefficient liquidation (Diamond, 1991; Guedes and Opler, 1996; Brunnermeier, 2009; Cheng and Milbradt, 2012; He and Xiong, 2012a). Carvalho and Santikian (2012) argue that firms within an industry manage rollover risk in an interdependent way and their debt maturity decisions also reflect the situation in the industry. Gopalan et al. (2014) show that the rollover risk associated with having long-term debt maturing within one year reduces firms' current credit quality. Our study contributes to this strand of literature by showing that firms can actively manage rollover risk by spreading out the maturity of their bond finance.

Moreover, our paper provides evidence on recent theoretical work about the costs and benefits of maturity granularity (Choi et al., 2014; He and Xiong, 2012b; Acharya et al., 2011). Empirical evidence on the granularity of bond maturity structure is scarce. The survey of Graham and Harvey (2001) indicates that many firms aim at dispersing their bond maturity structure to "limit the magnitude of refinancing in any given year". The latter has also been emphasized by Servaes and Tufano (2006) as the primary concern for CFOs when making decisions on the bond maturity. The recent studies by Gopalan et al. (2014) and Almeida et al. (2012) show an adverse impact on credit quality and investment for firms that have a large proportion of debt maturing within one year. For comparison, our paper considers the granularity of firms' entire bond maturity structure. The theoretical model of Choi et al. (2014) describes the firm's choice between a concentrated or "granular" bond maturity structure as a trade-off between flexibility benefits and transaction costs. Our findings are in line with their model: We show that firms that consistently maintain a well-spread maturity structure over time are the ones that face higher rollover risk and they can afford the transaction costs of maintaining the dispersed maturity structure. The two main differences to Choi et al. (2014) are that we focus on the incremental maturity choice of new bond issues conditional on the maturity structure prior to the issue, and that we investigate the impact of granularity on the availability and cost of finance.

The rest of the paper proceeds as follows. In Section 2 we describe the data and the measurement of granularity. In Section 3 we present the empirical analysis. In Section 4 we summarize the findings of additional checks. Section 5 concludes.

2. Data and measurement

2.1. Data

Our data comprise information on firm characteristics, bond characteristics, and stock returns. We collect yearly data on firms' accounting variables and S&P long-term debt ratings from Compustat. We start with all publicly listed firms from the US and exclude utility and financial companies (SIC 4000-4999 or 6000-6999). We collect data on bond issues and maturity structure from the Mergent FISD database and merge it with the Compustat data using firms' CUSIPs. We then use the permno-gvkey concordance key provided by WRDS to merge the sample with firms' yearly stock return volatility constructed using daily and monthly stock return during each year from CRSP database. As the FISD database has only sufficient coverage from the early 1990s, we limit the sample period of our analysis from January 1, 1991 to December 31, 2011. The final sample comprises 16,857 firm-year observations from 2388 firms.

We winsorize all accounting variables from Compustat at 1% and 99% level to limit the impact of potential outliers. Table 1 displays definitions, data source and summary statistics on the main variables.

Firms in our sample exhibit a mean leverage ratio is 32.8%. Corporate bonds are the key source of debt finance as the median bond-to-total debt ratio is 72%. We also identify the year when the firm issued its first bond and the year when the firm was first assigned a credit rating by Standard and Poor's. It turns out that more than 50% of firms in our sample issued their first bond and/or received a credit rating in the mid-1990s. This observation indicates that the majority of firms have access to the corporate bond market during our sample period.

2.2. Granularity and frequency of new bonds issues

How can we identify bond issues that lead to a dispersed rather than a concentrated maturity structure? In this study, we focus on the granularity of new bonds issues and the frequency of new bonds issues as two important indicators that distinguish the granularity-increasing activity from the granularity-decreasing activity. Let us consider an example to illustrate how the two indicators reflect firm's incremental maturity choice. Suppose there are two firms A and B, and both firms have the same amount of public debt capacity D, meaning that they could only issue bonds up to the maximum amount of D. Firms A and B follow different strategies with regard to their maturity structure. The two situations are illustrated in Fig. 1.

The horizontal axis indicates the time in years. For simplicity we consider the period from year t to year $t+4$. The vertical axis shows that the total public debt capacity D is the same and assumed constant over time for both firms. Firm A does not follow a maturity granularity policy. In year t, the firm issues only one bond with a maturity of two years that corresponds to 100% of the debt capacity. In $t+2$, when the bond matures, firm A rolls over the bond through issuing a new bond of the same amount D and the same maturity of two years. Firm B follows maturity granularity policy and builds up a dispersed maturity structure by issuing two bonds with different maturities. At year t, firm B divides the total amount of public debt capacity D into two and issues two

Table 1
Definitions of variables and summary statistics.

Variable	Definition	Mean	Median	S.D.
Firm characteristics (Source: Compustat and FISD)				
Firm size	Total assets (in million $)	4656.18	865.09	20457.61
Log_firm_size	Logarithm of total assets	6.768	6.763	1.824
Cash flow volatility	Standard deviation of the cash flow (income before extraordinary items – dividends total)/total asset from the past three year starting in year $t-2$ to year t	0.068	0.028	0.124
Leverage	(Long-term debt + short-term debt)/total assets	0.328	0.289	0.258
ROA	Income before extraordinary items/total assets	0.108	0.124	0.139
Cash holdings	Cash and marketable securities/total assets	0.136	0.061	0.182
Tobin's Q	Firm market value/total assets	1.964	1.463	1.722
Bank dependence	One for bank-dependent firms (non-investment grade rated or non-rated firms), and zero for other firms (rated as investment-grade)	0.710	1.000	0.454
Bond_Start_yr	Year in which firm issues bonds for the first time	1996	1998	9.6
Maturity granularity of outstanding bonds and bond issues (Source: FISD)				
Granularity	Granularity of volume of outstanding bonds. $Dispersion_{i,t,p} = \frac{1}{\sum_{p=1}^{n} w_{i,t,p}^2}$ (where $w_{i,t,p}$ is the fraction of the total volume of outstanding bonds that mature in the same year p)	2.016	1.000	1.808
Granularity_maturity_weighted	Maturity weighted granularity of volume of bond outstanding $Dispersion\_maturity\_weighted_{i,t,p} = \frac{1}{\sum_{p=1}^{n} w_{i,t,p}^2 \cdot \frac{1}{\lvert m_{i,t,p} - \bar{m}_{i,t} \rvert + 1}}$ (where $w_{i,t,p}$ is the fraction of total volume of outstanding bonds that mature in the same year p; $m_{i,t,p}$ is the maturity (in years) of firm i's outstanding bonds that mature in year p, measured at the end of year t; and $\bar{m}_{i,t}$ is the average maturity of outstanding bonds in year t)	8.804	2.500	15.662
Granularity_issue	Granularity of volume of issued bonds. $Granularity\_issue_{i,t,p} \frac{1}{\sum_{p=1}^{n} w_{i,t,p}^{*2}}$ (where $w_{i,t,p}$ is the fraction of total volume of newly issued bonds that mature in the same year p)	1.309	1.000	0.672
Issue_time_gap	Time in years between the current bond issue year and the previous bond issue year	2.747	2.000	2.968
Short_maturity	One if the firm's outstanding bonds maturity is shorter than 7.6 years (the median remaining years to maturity of outstanding bonds in our sample), and 0 otherwise	0.500	0.000	0.500
Access to financing (Source: Compustat and FISD)				
Funding_success_dummy_mat	One if at least one of the firm i's bonds expires and the firm is able to issue at least one bond in the same year t, and zero if no bond is issued in a bond expiry year t	0.377	0.000	0.485
Funding_success_dummy_inv	One if the firm i's investments grow by 40% in year t and the firm issues at least one bond in the same year t, and zero if no bond is issued in year t in which the firm i's investments grow by 40%	0.209	0.000	0.406
Costs of financing (Source: FISD)				
Yield spread	The average difference between the yield to maturity of the firm's bond issues and the yield to maturity of US government bonds with the same maturity as the bonds issued in year t, measured in basis points	246.099	180.000	214.62
Financial constraints (Source: Compustat)				
KZ index	The Kaplan–Zingales Index is constructed following Lamont et al. (2001) KZ index = $-1.001909[(ib + dp)/\text{lagged } ppent] + 0.2826389[(at + prcc\_f \times csho - ceq - txdb)/at] + 3.139193[(dltt + dlc)/(dltt + dlc + seq)] - 39.3678[(dvc + dvp)/\text{lagged } ppent] - 1.314759[che/\text{lagged } ppent]$, where all variables in italics are Compustat data items	−4.230	−0.300	14.168
Stock market risk (Source: CRSP)				
Volatility of daily stock returns	The standard deviation of firm's daily stock returns measured during each calendar year	0.033	0.028	0.023
Volatility of monthly stock returns	The standard deviation of firm's monthly stock returns measured during each calendar year	0.067	0.055	0.087

This table reports definitions and summary statistics of the main variables. The sample is based on data from the Mergent FISD, Compustat and CRSP database and comprises 2236 firms. We exclude utility and financial firms with SIC code of 4000–4999 and of 6000–6999. The sample period starts on January 1, 1991 and ends on December 31, 2011. We report the definitions, mean, median and standard deviation (S.D.) of the variables.

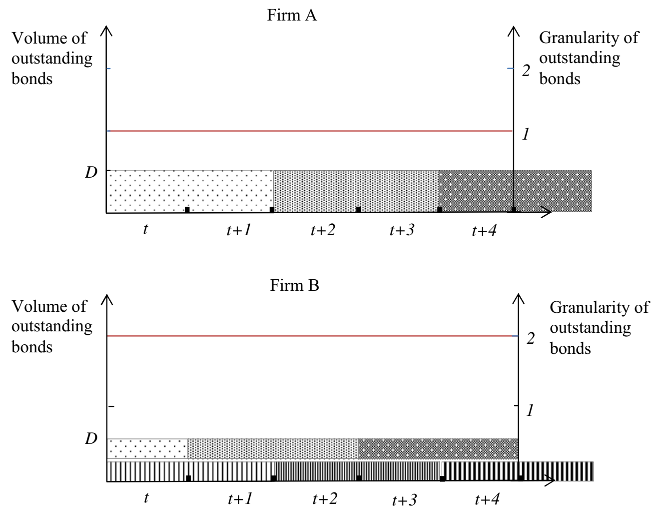

Fig. 1. Issue frequency and corporate bond granularity. This figure shows firms' bond issuance activity and the overall granularity of bonds outstanding. The left axis shows the total public debt capacity D, and the right axis shows the granularity of outstanding bonds. Firm A issues one bond with amount of D and maturity of 2 years and then rolls over with a bond with 2 years maturity whenever the bond matures. Firm B issues two bonds with amount of $\frac{D}{2}$ and maturity of 1 and 2 years and rolls over with bond with 2 years maturity whenever a bond matures. The horizontal axis indicates the time in years.

bonds each to the amount of $\frac{D}{2}$ but with different maturities of one year and two years, respectively. Then, in year $t+1$ and $t+2$, when the two bonds mature, firm B issues new bonds to the amount of $\frac{D}{2}$ with maturity of 2 years to replace the maturing bonds. Firm B has to repeat this policy again until year $t+3$ and $t+4$ and so forth.

Comparing the patterns of the bond issue activities of the two firms shown in Fig. 1 we observe two key characteristics of firm B's incremental granularity activity at issues. First, the maturity structure of new bonds issued is more dispersed. Second, the issue frequency is higher. We use variable *Granularity_issue* to measure the maturity granularity of bond issues. It is similar to the *Granularity* used by Choi et al. (2014) to measure the maturity granularity of outstanding bonds, except that we look exclusively at new bond issues rather than at all outstanding bonds. For each firm *i* at the end of each year *t*, we first consider all bonds that are issued during the year and assign bonds to their expiry year *p*. Then, for each of the expiry years *p*, we calculate the fraction of the total amount of issued bonds that mature in an expiry year ($w^*_{i,t,p}$). We then take the inverse of the sum of the squared terms of the fractions and that gives $Granularity\_issue_{i,t,p}$ (see Eq. (1)).

$$Granularity\_issue_{i,t,p} = \frac{1}{\sum_{p=1}^{n} w^{*2}_{i,t,p}} \quad (1)$$

Intuitively, the higher the value of this variable, the more dispersed is the maturity of the bond issues. The measure has a minimum of one (i.e., there is only one bond issued or bonds with different terms are issued but they have the same maturity), which means no maturity granularity is observed at issuance. The value of *Granularity_issue* for firm A equals one according Eq. (1) when it first issues bond in year *t*, and it means that Firm A issue bonds with a concentrated maturity structure. The higher value of *Granularity_issue* for firm B $\left(\frac{1}{0.5^2+0.5^2} = 2\right)$ when it issues two bonds indicates a more granular maturity structure and means that firm B faces less rollover risk than firm A in bond expiry years. Next, we measure the frequency of firms' bond issues using *Issue_time_gap*. For each issue year, we measure the time in years that elapsed between the previous year of bond issue and the current year of bond issue and call this variable *Issue_time_gap*. The more frequently a firm issues, the shorter the time gap is.

3. Empirical analysis

3.1. Firm characteristics and the incremental bond maturity choices at issuance

We use *Granularity_issue* and *Issue_time_gap* as two main dependent variables to measure firm's incremental bond maturity choice at issue and link them to key firm characteristics before bond issues. We use firm size, cash flow volatility, leverage ratio, profitability, cash holdings, Tobin's Q and bank dependence as the main explanatory variables. We expect that bigger and non-bank dependent firms face less information asymmetry in the public debt market and thus enjoy more flexibility in establishing granular maturity structure of bonds. We use cash flow volatility, leverage ratio and Tobin's Q to capture firms' needs to hedge rollover risks. Firms with higher cash flow volatility and higher leverage are more likely to face a funding illiquidity problem and therefore have stronger incentives to construct a granular bond maturity structure. Profitability and cash holdings enable firms to better deal with rollover risks. We therefore hypothesize that firms that are less profitable and that hold less cash have stronger incentives to construct a granular maturity structure.

We estimate OLS regression models with industry and year fixed effects and lags of all explanatory variables including the granularity of outstanding bonds. We also use robust standard errors clustered at the firm level. Table 2 reports the results.

We find that firm size positively relates to the granularity of new bonds issues and negatively relates to the frequency of bonds issues. This result suggests that bigger firms have a more sophisticated policy to spread out their maturity structure over time since they are the ones that could afford the transactions costs associated with repeated access to the public debt market. Over time, these firms are able to achieve the most dispersed maturity structure of outstanding bonds. We also find that firms with higher leverage are more likely to maintain a dispersed maturity structure through issuing bonds with granular maturities and issuing frequently. For example, a one standard deviation increase in the leverage ratio is associated with a 0.283 years decrease in the time gaps between two issues, and this is equivalent to a 10.32 percent decrease compared to the mean *Issue_time_gap*. One explanation is that firms with a relatively high leverage are more exposed to rollover risk than others and therefore strive for a dispersed bond maturity structure to mitigate this risk.

A similar but slightly weaker result is found for firms' cash holdings and growth opportunities. Firms' growth opportunities negatively correlate with the time gap between issues. They positively correlate with maturity granularity at issue although the impact is not significant. The result are in line with the literature suggesting that firms with higher growth opportunities primarily issue short-term bonds, and thus need to issue frequently. It is also interesting to see that, contrary to expectations, firms holding more cash and that are more profitable are more likely issue bonds with dispersed maturities. This potentially indicates that firms hold more cash as a complementary strategy to buffer against rollover risks. In addition, we find that firms with higher cash flow volatility issue bonds with more dispersed maturity structure but they do not issue more frequently. The latter suggests that the costs of following a maturity granularity policy to manage rollover risk might be lower than the costs of frequently issuing corporate bonds.

Table 2
Granularity of new bond issues and time gap between issues.

Dep. Var.	(1) Granularity_issue			(2) Issue_time_gap		
	Coeff.	*t*-Stat.	Sig.	Coeff.	*t*-Stat.	Sig.
Granularity_{t-1}	0.040	3.92	***	−0.271	−6.05	***
Firm characteristics						
$\text{Log\_firm\_size}_{t-1}$	0.173	10.68	***	−0.329	−5.69	***
Cash flow volatility $_{t-1}$	0.239	2.51	**	0.119	0.31	
Leverage $_{t-1}$	0.116	1.88	*	−1.098	−4.26	***
ROA_{t-1}	0.232	1.99	**	0.132	0.33	
Cash holdings_{t-1}	0.198	2.21	**	−0.351	−1.09	
Tobin's Q_{t-1}	0.016	1.38		−0.100	−3.04	***
Bank dependence_{t-1}	−0.099	−3.12	***	−0.419	−3.87	***
Bond_start_yr	−0.001	−0.6		−0.060	−9.41	***
Adj. R^2	0.225			0.183		
Number of obs.	3341			3337		
Number of firms	1120			1118		

This table reports the results of OLS regression models that estimate firms' incremental maturity choice at issuance. The dependent variables are (1) the maturity granularity firms' bond issues (Granularity_issue) and (2) the time gap between current new issues and the last issues (Issue_time_gap). Explanatory variables are the lagged maturity granularity of outstanding bonds (Granularity) and firm characteristics. See Table 1 for variable definitions. We control for year and industry fixed effects and robust standard errors are employed and clustered at firm level. The sample period is from January 1, 1991 to December 31, 2011. *, **, *** indicate coefficients that are significantly different from zero at the 10%, 5%, and 1% level.

We further find that the time gap between bond issues negatively correlates with bank dependence and the year when firms first issued bonds, but negatively correlates with the maturity granularity at issuance. This indicates that these firms are frequent issuers but not spreading out maturity. Previous research shows that bank-dependent firms exhibit higher informational asymmetries, which limits their abilities to issue bonds, especially long-term bonds (e.g., Myers, 1984; Diamond, 1991; Rajan, 1992; Denis and Mihov, 2003). They do not have the flexibility to issue bonds with both short and long maturity, but are rather constrained to issue short-term bonds (e.g., Diamond, 1991). Patterns in the data confirm this explanation: the average maturity of new bonds issued by bank dependent firms is 9.5 years, which is shorter than the average maturity of 13.6 years for non-bank dependent firms. As a result, bank-dependent firms are often constrained to issue only short-term bonds and it is harder for them to realize a policy that aims at establishing a dispersed bond maturity structure. Similarly, the maturity of new issues for firms that have later access to bond market is 10 years versus 12.3 years for the ones that had earlier access. Taking the evidence together enables us to conclude that the issue activity of bank-dependent firms and firms that have late access to the public debt market is largely limited to bonds with concentrated and short maturity.

Another interesting finding is that the maturity granularity of existing bonds has an important impact on the issue activity. A one point increase in the maturity granularity of outstanding bonds is associated with a 4% point increase of maturity granularity of new issues and a 27.1% point decrease of the time gaps between two issues. This finding suggests that firms with a more dispersed maturity structure continue to follow granularity policy when issuing new bonds.

Overall, the results on firms' *incremental* maturity choice are largely in line with the findings of Choi et al. (2014) who focus on the determinants of the *overall* maturity granularity structure of bonds outstanding. We conclude that firms that are larger, more leveraged, and that have a more dispersed maturity structure of outstanding bonds are the ones that are more likely to issue more frequently and simultaneously issue new bonds with different maturities.

3.2. The impact of granularity on the availability of finance

We now examine the effects of granularity on the availability of finance by considering the probability of a firm being able to meet its financing needs arising from (i) expiring bonds and (ii) new investment opportunities. We define years when firm's refinancing needs arise due to bonds' expiry if at least one bond expires in that year. We define years when firm's financing needs arise due to new investment if firms' total investments (measured by the sum of firm's capital expenditure, R&D expense, and advertising expense) grow by at least 40% in that year (this happens less than 25% of all firm-year observations in our sample).

Specifically, we create two dummy variables that indicate the success of firms in meeting the two types of financing needs. The dummy variables equal one if at least one new bond is placed by the firm during the year when firm's financing needs arise in either of the two situations, and equal to zero when no bond is issued during the year when financing needs arise. Importantly, in this analysis we do not consider firms' financing activities in years in which no financing need arises. Summary statistics show that on average, successful refinancing of expiring bonds through new issues occurs more frequently (38.6%) than successful financing of new investments (20.4%).

We use Probit models to estimate the probability of successfully (re-)financing. Specifically, we regress the dummy variables of a firm's funding success in year t on its lagged maturity structure and controlling for firm characteristics at the end of year $t-1$. Since a well-dispersed maturity structure implies that the firm faces lower rollover risk, we expect that this lower risk increases the firm's availability of financing in year t, controlling for the other factors. Table 3 reports the results.

The findings from both regression models point to the same direction. We observe that, ceteris paribus, having a dispersed maturity structure has a significantly positive impact on firm's financing success. The unconditional probability of refinancing maturing bonds is 37.7%. The marginal effect of 0.019 shows that a one point increase in *Granularity* increases the probability of successful refinancing by 5% (1.9/37.7). Similarly, having a granular maturity structure increases the likelihood of firms' financing

Table 3
The impact of granularity on the availability of finance.

Dep. Var.	(1) Funding_success_dummy_mat					(2) Funding_success_dummy_inv				
	Coeff.	*t*-Stat.	Sig.	Marginal effects	Sig.	Coeff.	*t*-Stat.	Sig.	Marginal effects	Sig.
Granularity$_{t-1}$	0.054	3.31	***	0.019	***	0.138	4.22	***	0.043	***
Firm characteristics										
Log_firm_size$_{t-1}$	0.157	4.4	***	0.053	***	0.175	5.31	***	0.054	***
Cash flow volatility$_{t-1}$	−0.610	−1.14		−0.214		−0.251	−0.79		−0.078	
Leverage$_{t-1}$	0.801	3.7	***	0.275	***	0.421	2.6	***	0.130	***
ROA$_{t-1}$	0.282	0.6		0.073		−0.530	−1.56		−0.164	
Cash holdings$_{t-1}$	−1.051	−2.61	***	−0.353	***	−0.517	−2.29	**	−0.160	**
Tobin's Q$_{t-1}$	0.110	2.37	**	0.037	**	0.070	2.78	***	0.022	***
Bank dependence$_{t-1}$	−0.140	−1.21		−0.039		0.064	0.7		0.020	
Bond_start_yr$_{t-1}$	0.003	0.79		0.001		0.014	2.98	***	0.004	***
McFadden's Adj. R^2	0.092					0.054				
Number of obs.	1573					2242				
Number of firms	724					1148				

This table reports the results of probit regression models that estimate the likelihood of successfully refinancing (1) expiring bonds (Funding_success_dummy_mat) and (2) new investments (Funding_success_dummy_inv). Explanatory variables are the lagged maturity granularity of outstanding bonds (Granularity) and firm characteristics. See Table 1 for variable definitions. We control for year fixed effects and robust standard errors are employed and clustered at firm level. The sample period is from January 1, 1991 to December 31, 2011. *, **, *** indicate coefficients that are significantly different from zero at the 10%, 5%, and 1% level.

new investment – a one point increase in *Granularity* increases the probability of a successful financing by 20.6% (4.3/20.85). Moreover, the impact of firm characteristics is consistent across the two models. Larger firms and firms with a higher leverage ratio, lower cash holdings, and higher growth opportunity are more likely to be able to refinance maturing bonds and/or new investments.

3.3. The impact of granularity on the cost of finance

We also analyze the impact of having a dispersed maturity structure on corporate cost of financing associated with bond finance. According to He and Xiong (2012a), firm's rollover risk leads to an increase in the liquidity premium of corporate bonds and also higher firms' credit risk. The evidence provided by Gopalan et al. (2014) shows that the credit quality deteriorates when the firm faces higher rollover risk caused by a large proportion of short-term debt. We measure firms' costs of bond financing with the average yield spread per year in basis points. This variable captures the average firm-specific costs of bond financing and reflects credit risk and rollover risk in a year. For every new bond issue, we calculate the differences between the yield to maturity of the new bond and the yield on treasury bonds (r_f) with similar maturity. We then calculate the average spread of all bonds that a firm has issued during each year to obtain the average yield spread of the firm's new issues per year. The average *yield spread* in our sample is 246 basis points.

We use a panel data regression to analyze whether firms with a more dispersed maturity structure benefit from a lower cost of financing when they issue new bonds, controlling for firm characteristics. We lag the explanatory variables by one period to avoid potential endogeneity issues. The results are shown in Table 4.

We find that the maturity granularity of outstanding bonds negatively relates to the firm's cost of financing as measured by the yield spread. A one standard deviation increase of the granularity structure of outstanding bonds reduces the yield spread by 6.42 basis points. This suggests that spreading out the bond maturities effectively improves a firm's costs of financing. In addition, coefficients on firm characteristics indicate that company fundamentals have significant impact on the costs of firms' new bonds issues. Larger firm size and earlier access to the bond market lower a firm's cost of financing because of lower information asymmetry and stronger fundamentals.

Table 4
The impact of granularity on the cost of finance.

Dep. Var.	Yield spread		
	Coeff.	*t*-Stat.	Sig.
Granularity $_{t-1}$	−3.552	−1.9	*
Firm characteristics			
Log_firm_size$_{t-1}$	−20.966	−4.98	***
Cash flow volatility$_{t-1}$	344.390	3.33	***
Leverage$_{t-1}$	108.112	3.79	***
ROA$_{t-1}$	−270.662	−5.03	***
Cash holdings$_{t-1}$	−37.478	−0.7	
Tobin's Q$_{t-1}$	−25.650	−5.03	***
Bank dependence$_{t-1}$	102.793	10.9	***
Bond_start_yr$_{t-1}$	1.012	2.92	***
Adj. R^2	0.533		
Number of obs.	2091		
Number of firms	737		

This table reports the results of an OLS regression model using the cost of financing associated with new bond issues (Yield spread) as dependent variable. We measure the yield spread as the average spread between the yield on firm's new issues and the yield of US government bonds with the same maturity in year *t*. Explanatory variables are the lagged maturity granularity of outstanding bonds (Granularity) and firm characteristics. See Table 1 for variable definitions. We control for year and industry fixed effects and robust standard errors are employed and clustered at firm level. The sample period is from January 1, 1991 to December 31, 2011. *, **, *** indicate coefficients that are significantly different from zero at the 10%, 5%, and 1% level.

3.4. The impact of granularity on corporate financial constraints

Next, we examine whether higher granularity lowers corporate financial constraints. In the previous sections we showed that having a more dispersed maturity structure allows firms to have easier and less expensive access to the bond market when they need to raise finance. This reasoning implies that there is an improvement in firms' external financing if the maturity structure becomes more dispersed. We therefore test the impact of bond maturity granularity on corporate financial constraints. We employ the widely used Kaplan–Zingales Index (KZ index; Kaplan and Zingales, 1997; Lamont et al., 2001) as firm-specific and time-varying measure of financial constraints. A higher KZ index indicates that the firm is more financially constrained. The median KZ index in our sample is −0.3077. We hypothesize a negative relationship between firms' bond maturity granularity and the KZ index. We use the same model specification as in the previous analyses to investigate whether firms with a more dispersed maturity structure become less financially constrained. The results are reported in Table 5.

Most importantly, we find that *Granularity* has a negative impact on the KZ index, meaning that a firm is less financially constrained if its maturity structure of corporate bonds is more dispersed. We further find that the estimated coefficients of the firm controls are consistent with the previous literature. For example, we find that highly levered and bank dependent firms are more financially constrained. The impact of bond maturity granularity on corporate financial constraints is also economically meaningful. A one point increase in *Granularity* decreases the KZ index by 0.19 points, which is relatively large effect compared to the median of the KZ index in our sample. Overall, these results are consistent with the previous results on the availability and cost of finance and highlight the benefits firms could obtain by having a dispersed bond maturity structure.

3.5. The impact of granularity on stock return volatility

Our results show that higher granularity allows firms to achieve a smooth debt redemption schedule over time, resulting in higher availability of finance and lower costs of finance. Spreading out the maturity of bonds decreases firms' exposure to rollover risk and should therefore reduce firms' overall risk. We use the volatility of firms' stock returns as a market-based measure of firm risk.

We collect data on the firms' stock prices from CRSP for our sample period from 1990 to 2010 and calculated the buy-and-hold return for a daily and monthly frequency. For each year, we calculate the volatility of firms' stock returns measured as the standard deviation of daily and monthly stock return over this year. We regress firms' yearly stock return volatility on *Granularity* and other variables controlling for firms' characteristics from the previous year. Table 6 reports the results.

We find that *Granularity* has a significant negative impact on firm's stock return volatility, regardless whether we use daily or monthly stock returns to calculate volatility. One standard deviation increase in *Granularity* is accompanies with 0.2% point decrease in the volatility of monthly stock returns, and this is equivalent to a 1.4% decrease in the volatility of monthly stock returns compared to the mean. These results indicate that investors in stock markets recognize the decrease in firms' rollover risk due to a higher bond granularity.

Table 5
The impact of granularity on financial constraints.

Dep. Var.	KZ index		
	Coeff.	*t*-Stat.	Sig.
Granularity $_{t-1}$	−0.193	−2.34	**
Firm characteristics			
Log_firm_size$_{t-1}$	1.240	3.01	***
Cash flow volatility$_{t-1}$	−2.768	−0.9	
Leverage$_{t-1}$	4.847	3.61	***
ROA$_{t-1}$	−3.513	−1.45	
Cash holdings$_{t-1}$	−14.628	−3.85	***
Tobin's Q$_{t-1}$	−0.905	−3.93	***
Bank dependence$_{t-1}$	2.037	4.99	***
Adjusted R^2	0.133		
Number of obs.	11881		
Number of firms	1793		

This table reports the results of an OLS regression with financial constraints, measured by the KZ index, as dependent variable. Explanatory variables are the lagged maturity granularity of outstanding bonds (Granularity) and firm characteristics. See Table 1 for variable definitions. We control for year and firm fixed effects and robust standard errors are employed and clustered at firm level. The sample period is from January 1, 1991 to December 31, 2011. *, **, *** indicate coefficients that are significantly different from zero at the 10%, 5%, and 1% level.

Table 6
The impact of granularity on stock return volatility.

Dep. Var.	Volatility of monthly stock returns			Volatility of daily stock returns		
	Coeff.	*t*-Stat.	Sig.	Coeff.	*t*-Stat.	Sig.
Granularity $_{t-1}$	−0.001	−1.65	*	−0.0002	−1.95	**
Firm characteristics						
Log_firm_size$_{t-1}$	−0.005	−2.24	**	−0.001	−2.39	**
Cash flow volatility$_{t-1}$	0.020	1.56		0.008	2.15	**
Leverage$_{t-1}$	0.044	6.05	***	0.013	5.22	***
ROA$_{t-1}$	−0.103	−8.68	***	−0.029	−8.39	***
Cash holdings$_{t-1}$	−0.022	−2.42	**	−0.009	−3.58	***
Tobin's Q$_{t-1}$	0.002	2.19	**	0.001	4.53	***
Bank dependence$_{t-1}$	0.009	3.23	***	0.002	3.17	***
Adj. R^2	0.273			0.176		
Number of obs.	11,637			11,752		
Number of firms	1739			1752		

This table reports the results of an OLS regression model using the firms' stock return volatility within year t as dependent variable. Stock volatility is measured as the standard deviation of monthly and daily stock returns, respectively. Explanatory variables are the lagged granularity of outstanding bonds (Granularity) and firm characteristics. See Table 1 for variable definitions. We control for year and firm fixed effects and robust standard errors are employed and clustered at firm level. The sample period is from January 1, 1991 to December 31, 2011. *, **, *** indicate coefficients that are significantly different from zero at the 10%, 5%, and 1% level.

4. Additional checks

4.1. The impact of granularity for firms with higher or lower rollover risk

Our findings indicate that certain types of firms manage to achieve a dispersed maturity structure over time (granularity) and that such policy mitigates firms' financial constraint and improves firms' availability and cost of finance. We now investigate whether these benefits depend on the level of rollover difficulties faced by firms. For this purpose, we use bank dependence and the average remaining years to maturity of outstanding bonds (short versus long term) to differentiate between firms with higher and lower level of difficulties of rollover bonds.

First, bank-dependent firms are more likely financially constrained and have difficulties in issuing bonds because of the higher information asymmetry compared to non-bank dependent firms. Thus, there is additional room for improvement in the availability of financing for bank dependent firms. Based on this reasoning, we expect that bank-dependent firms should exhibit the highest marginal benefits if they succeed in building up a well-spread bond maturity structure.

Second, as the average years to maturity of outstanding bonds become shorter, rolling over debt in the near future becomes more difficult. The maturity of outstanding bonds thus partially reflects the level of firms' rollover risk (Gopalan et al., 2014). The related literature documents that having outstanding bonds with a shorter maturity creates large rollover risk and the potential for inefficient liquidation (Froot et al., 1993; Brunnermeier and Yogo, 2009; Cheng and Milbradt, 2012). In this case, as the median maturity of outstanding bonds for all firms is 7.6 years, we create the dummy variable *Short_maturity* that equals one if the firm's average maturity of outstanding bonds is shorter than 7.6 years and zero otherwise. We re-estimate the models of availability of finance from Table 3 and include the lagged interaction term of *Granularity* and *Bank dependence*, and alternatively, the lagged interaction term of Granularity and *Short_maturity*. Panel A of Table 7 reports the results for bank-dependence and Panel B of Table 7 the results for the maturity focus.

Since we use a nonlinear estimation model, it is advised not to interpret the coefficients of the interaction terms the same way as they are interpreted in a linear model (Ai and Norton, 2003;

Table 7
The impact of granularity by bank dependence and short-term maturity focus.

Dep. Var.	(1) Funding_success_ dummy_mat					(2) Funding_success_ dummy_inv				
	Coeff.	*t*-Stat.	Sig.	Marginal effects	Sig.	Coeff.	*t*-Stat.	Sig.	Marginal effects	Sig.
Panel A. Bank dependence										
Granularity$_{t-1}$	0.046	2.85	***	0.015	***	0.110	3.1	***	0.034	***
Bank dependence$_{t-1}$ * granularity$_{t-1}$	0.102	2.36	**	0.034	**	0.097	1.77	*	0.030	*
Firm characteristics										
Log_firm_size$_{t-1}$	0.125	3.28	***	0.041	***	0.162	4.91	***	0.050	***
Cash flow volatility$_{t-1}$	−0.582	−1.06		−0.192		−0.251	−0.79		−0.077	
Leverage$_{t-1}$	0.751	3.43	***	0.248	***	0.394	2.44	**	0.121	**
ROA$_{t-1}$	0.348	0.73		0.115		−0.523	−1.54		−0.161	
Cash holdings$_{t-1}$	−1.006	−2.47	**	−0.332	**	−0.510	−2.25	**	−0.157	**
Tobin's Q$_{t-1}$	0.111	2.38	**	0.037	**	0.070	2.8	***	0.022	***
Bank dependence$_{t-1}$	−0.492	−2.9	***	−0.163	***	−0.131	−0.96		−0.040	
Bond_start_yr$_{t-1}$	0.003	0.76		0.001		0.015	3.1	***	0.005	***
McFadden's Adj. R^2	0.124					0.054				
Number of obs.	1573					2242				
Number of firms	724					1148				
Panel B. Short-term maturity focus										
Granularity$_{t-1}$	0.166	5.23	***	0.054	***	0.202	4.28	***	0.062	***
Short_maturity$_{t-1}$ * Granularity$_{t-1}$	0.140	4.20	***	0.046	***	0.091	1.78	*	0.028	*
Firm characteristics										
Log_firm_size$_{t-1}$	0.130	3.59	***	0.043	***	0.166	5.1	***	0.051	***
Cash flow volatility$_{t-1}$	−0.540	−0.98		−0.177		−0.237	−0.74		−0.073	
Leverage$_{t-1}$	0.658	2.98	***	0.216	***	0.404	2.5	**	0.125	**
ROA$_{t-1}$	0.334	0.69		0.110		−0.575	−1.69	*	−0.177	*
Cash holdings$_{t-1}$	−0.974	−2.4	**	−0.319	**	−0.502	−2.23	**	−0.155	**
Tobin's Q$_{t-1}$	0.108	2.28	**	0.036	**	0.073	2.92	***	0.022	***
Bank dependence$_{t-1}$	−0.116	−1		−0.038		0.059	0.65		0.018	
Bond_start_yr$_{t-1}$	0.003	0.84		0.001		0.014	2.94	***	0.004	***
Short_maturity$_{t-1}$	−0.490	−3.17	***	−0.161	***	−0.256	−2.39	**	−0.028	**
McFadden's Adj. R^2	0.130					0.077				
Number of obs.	1573					2242				
Number of firms	724					1148				

This table reports the results of probit regression models that estimate the likelihood of successfully refinancing (1) expiring bonds (Funding_success_dummy_mat) and (2) new investments (Funding_success_dummy_inv). Explanatory variables are the lagged maturity granularity of outstanding bonds (Granularity) and firm characteristics. See Table 1 for variable definitions. Panel A shows the impact of bank dependence. Panel B shows the impact of firms' maturity focus, which we measure with the dummy variable Short_maturity (one if the average remaining years to maturity of the outstanding bonds is below the median, otherwise zero). We control for year fixed effects and robust standard errors are employed and clustered at firm level. The sample period is from January 1, 1991 to December 31, 2011. *, **, *** indicate coefficients that are significantly different from zero at the 10%, 5%, and 1% level.

Greene, 2010). Using graphical analysis as recommended by Greene (2010), we find that bank-dependent and short-maturity focused firms exhibit the highest benefits of having a dispersed bond maturity structure. The analysis confirms our expectation that spreading out bond maturity improves the availability of financing for firms that face more rollover risk. We also tried alternative methods by splitting the sample into two groups either according to the bank dependence or maturity focus. We run separate regressions on the groups of bank dependent versus non-bank dependent firms as well on the groups of firms with higher versus lower maturity risk. We then test the differences between the coefficients of *Granularity* using the approach of Williams (2009). Results shows that the differences in the coefficients on *Granularity* between the two groups split by bank dependence and maturity are all statistically significant.

We also test the influence on firms' cost of financing by including the lagged interaction term of *Granularity* and *Bank dependence*, and alternatively, the lagged interaction term of Granularity and *Short_maturity* to the models in Table 4 (not reported here). We do not find significant interaction effects. This result implies that having a dispersed maturity structure lowers the cost of financing for weaker and stronger firms in a more equivalent matter.

In sum, our finding suggests that having a well-spread bond maturity structure benefits all firms but that the incremental improvement in the availability of bond financing is larger for firms that face higher rollover risk.

4.2. Maturity-weighted granularity and the heterogeneity in maturity structure

When we investigate firms' maturity structure it matters how far the maturities of different bonds are away from each other. For example, the maturity structure for firms with two bonds of equal amounts that mature in year $t + 5$ and $t + 6$ is different from firms with two bonds of equal amounts that mature in year $t + 1$ and $t + 10$. The key difference between the two situations is how stretched out the years to maturity are, or how heterogeneous are they are. We consider use a modified version of the variable *Granularity* to capture the heterogeneity in bond maturity. We calculate the difference between the maturity (in years) of firm i's outstanding bonds that mature in year p, measured at the end of year t and the average years to maturity of all bonds outstanding in year t. We add this maturity deviation $|m_{i,t,p} - \bar{m}_{i,t}|$ as a weight to the formula to calculate the variable *Granularity* and get an alternative variable for bonds granularity, which we label *Granularity_maturity_weighted* (see Eq. (2)). We avoid zero or negative weights by taking the absolute value of the difference between an individual maturity and the average maturity and add one to the value.

$$Granularity\_maturity\_weighted_{i,t,p} = \frac{1}{\sum_{p=1}^{n} W_{i,t,p}^2 \cdot \frac{1}{|m_{i,t,p} - \bar{m}_{i,t}| + 1}} \quad (2)$$

The variable has a mean of 8.803 and a median of 2.5. Intuitively, the more heterogeneous the maturity of outstanding bonds is, the higher the score is. We compare this variable with our original granularity measure and conduct the same set of analyses using the maturity weighted granularity variable. Results for the weighted variable to measure the incremental granularity at bonds issues largely resemble our findings in Table 2 using the *Granularity_issue*.

We further use the maturity weighted granularity variable to test the impact on firms' availability of financing and cost of financing. We find that this variable highly correlates with *Granularity* as Pearson's correlation coefficient equals to 0.826. Results show that the maturity weighted granularity measure decreases firm's cost of financing and stock market volatility to a similar degree as the *Granularity* does. We observe a significant positive impact on firm's new investment funding activities but no significant impact on funding expiring bonds and firms' financial constraints. We further show that the impacts are much stronger for bank dependent firms and firms with outstanding bonds of short maturities, which is consistent with the findings from Table 7. We conclude that the results using the maturity weighted granularity variable yields similar results as the variable *Granularity*.

4.3. The fraction of funding needs met via bond financing

In addition to the probability of whether financing needs are met it is useful to examine to which extent firm's financing needs are met. Instead of using dummy variables, as we did in Section 3.2, we now calculate the ratio of "financing raised over financing needed". The fraction of financing needs met is measured as the dollar amount of new bonds issues divided by the dollar amount of bonds maturing/increase in investment in the same year. The variable is zero if there are financing needs but zero dollar-amount of bonds is issued in the year. We find that when new bonds are issued to replace existing bonds' expiry, the median refinancing ratio is 5.7, meaning that the new bonds issued on average are more than enough to cover the amount of bonds maturing. The refinancing ratio is 4.4 for cases when there is an increase in the investment. Thus, the two types of financing needs are more than sufficient when firms issue bonds during the year. We also use model specifications similar to Table 3 but now use the fraction of financing needs met.

We find that the granularity of outstanding bonds has a significant and positive impact on the fraction of financing needs that is met when a firm has new investment opportunities. A one point increase in the maturity granularity relates to a 13.7% point increase in the fraction of financing needs that are met when firms have new investment opportunities. Overall, the results point to the same direction as our findings with the dummy variables. Having a granular maturity structure not only matters for the probability of a refinancing but also matters for the extent to which funding needs are met.

4.4. Reliance on bond financing

One concern might be that bond maturity granularity is less or not relevant for firms that do not heavily rely on bond financing. To investigate this issue, we compare the incremental bond maturity choice of firm's overall maturity structure for firms that rely more and less on bond financing and also check the difference in their bond issues activity. We measure to what degree firms rely on bond financing using firms' bond to total debt ratio and create two subsamples of firms according to the median bond ratio (72% in our sample). We rerun the tests similar to the ones in Table 2 on the two subsamples of firms with higher and lower bond ratio separately.

The results are consistent with the findings using the full sample. We find that the relationship between the granularity, the frequency of firm's bond issues and various firm characteristics stays largely unchanged across the two sub-samples of firms with different bonds to debt ratios. Analysis on firms' new bonds issuance also exhibits comparable patterns across the two sub-samples. Overall, we find that firms that rely less on bond finance also manage the bonds maturity granularity overtime through their bond issuance activities.

5. Conclusion

In this paper we investigate which types of firms have a granular bond maturity structure (granularity) through new bonds issues and what is the impact of granularity on key aspects of corporate finance. We focus on firms' incremental maturity granularity decision by examining the granularity and the frequency of bonds issues by US firms over time during the period 1991–2011 and the impact of having a granular maturity structure on firm's financing and riskiness.

Consistent with prior literature looking at firm's granularity structure of outstanding bonds, we find that larger, more leveraged firms and firms with a more granular maturity structure of existing bonds are the most likely to issue bonds with a more granular maturity structure and with a higher frequency. Most importantly, we find that firms having a more granular maturity structure have higher availability of finance, lower cost of finance, lower financial constraints, and lower stock return volatility. Interestingly, the effects are stronger for firms with high rollover risk. The result is consistent with the survey evidence from the literature, and suggests that certain firms effectively follow a maturity granularity policy. Our paper complements and extends the literature on rollover risk management by documenting that firms could successfully mitigate such risk through building up and maintaining a granular bond maturity structure over time.

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