Debt Maturity and the Effects of Growth Opportunities and Liquidity Risk on Leverage

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I test the hypothesis that short debt maturity attenuates the negative effect of growth opportunities on leverage. Using simultaneous equations with leverage and maturity endogenous, I find strong support for an economically significant attenuation effect. The negative effect of growth opportunities on leverage for firms with all shorter-term debt is less than one-sixth as large as the effect for firms with all longer-term debt. Short maturity also increases liquidity risk, however, which negatively affects leverage. The results suggest that firms trade off the cost of underinvestment problems against the cost of liquidity risk when choosing short maturity.

Recent capital structure studies go beyond the simple debt-equity choice to focus on various attributes of the debt in firms' capital structures. One particular attribute that has received much attention is debt maturity, which Myers (1977) argues is important in a capital structure context because it can be chosen to reduce underinvestment problems. Firms with risky debt outstanding may reject new profitable projects (i.e., underinvest) if enough of the projects' payoffs would accrue to debt holders. Holding constant the tax shield and other benefits of debt, underinvestment problems created by this risky "debt overhang" reduce optimal leverage if they are left unresolved. Shortening debt maturity so that refinancing occurs before investment options expire reduces underinvestment problems by allowing debt to be repriced so that gains from new projects do not accrue to debt holders. Myers predicts that firms with greater growth opportunities face greater underinvestment problems so they have incentive to use shorter-term debt. Consistent with this prediction, Barclay and Smith (1995), Guedes and Opler (1996), and Barclay, Marx, and Smith (1997) study firms' debt maturity choices and find a negative relation between maturity and growth opportunities.[1]

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[1] Stohs and Mauer (1996) find a positive relation between maturity and firms' growth opportunities. As Barclay, Marx, and Smith (1997) point out, however, the regression coefficients in Stohs and Mauer are potentially biased and inconsistent because the regressions include as independent variables in a debt maturity regression both a leverage measure (an endogenous variable) and an investment opportunities measure. When Stohs and Mauer exclude leverage from the equation, they find a negative relation between maturity and growth opportunities.

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While debt maturity studies support Myers's prediction about firms' maturity preferences, an important question has not been answered: Does short debt maturity attenuate the negative effect of growth opportunities on leverage? The extant evidence from empirical capital structure and debt maturity studies does not imply an affirmative answer to this question. On the contrary, results in Smith and Watts (1992) and Rajan and Zingales (1995) support Myers's prediction that leverage should be negatively related to growth opportunities, a theoretical result dependent on the assumption that debt matures *after* investment options expire, that is, that firms do *not* try to avoid underinvestment problems by choosing short debt maturity. Moreover, Barclay and Smith (1996) and Stohs and Mauer (1996) find that firms with greater growth opportunities have both shorter debt maturity *and* lower leverage. Taken together, results in the capital structure and debt maturity literatures create an apparent contradiction: If firms resolve underinvestment problems by choosing short debt maturity, then why do we still see a negative relation between leverage and growth opportunities?

Ignoring any costs of short debt maturity and assuming a tax advantage or other benefit of debt, firms with growth opportunities should always shorten debt maturity so that growth opportunities should never negatively affect leverage. The empirical evidence of a negative relation between leverage and growth opportunities implies that firms do not or cannot shorten debt maturity sufficiently to avoid underinvestment problems. One possible explanation of this is that choosing short debt maturity has a cost. Diamond (1991, 1993) and Sharpe (1991) develop models in which too much debt maturing in the short term creates a risk of suboptimal liquidation because lenders ignore the full value of control rents. Increasing the risk of suboptimal liquidation can be viewed as increasing expected bankruptcy costs, which capital structure theory predicts will reduce optimal leverage.

Thus while short debt maturity can reduce the cost of underinvestment problems and thereby increase optimal leverage, it can also increase liquidity risk and thereby reduce optimal leverage. Given these two effects, firms would trade off the cost of underinvestment problems against the cost of increased liquidity risk when choosing short debt maturity. A firm for which growth opportunities are more important should choose shorter debt maturity, but may still choose lower leverage because the shorter debt maturity increases liquidity risk. A firm for which liquidity problems are more important should choose longer debt maturity, but may still choose lower leverage because the longer maturity increases the cost of underinvestment problems.

In this article I examine empirically these two effects of short maturity—attenuating the negative effect of growth opportunities and increasing liquidity risk—on leverage. I use a simultaneous equations framework in which leverage and maturity are endogenous and in which the effects of growth opportunities and liquidity risk on leverage depend on maturity.[2] The leverage equation includes growth opportunities and an interaction term between growth opportunities and a measure of short debt maturity. This interaction makes the effect of growth opportunities on leverage conditional on the maturity structure of a firm's debt, and thus allows a test of the hypothesis that short debt maturity attenuates the negative effect of growth opportunities on leverage. If short debt maturity attenuates the negative effect of growth opportunities on leverage, then the interaction between the short maturity measure and the proxy for growth opportunities should have a positive coefficient, while the stand-alone proxy (i.e., the direct effect) for growth opportunities should have the typically observed negative coefficient. I also include the measure of short debt maturity as a direct effect (stand-alone measure) to test the hypothesis that short maturity increases liquidity risk, which negatively affects leverage.

The results strongly support the hypothesis that shorter debt maturity attenuates the negative effect of growth opportunities on leverage. The negative effect of growth opportunities on leverage for firms with all of their debt maturing within three years is less than one-sixth as large as the effect for firms with no debt maturing within that time. The effect of growth opportunities does not vanish for firms with the shortest maturity debt, however, suggesting that firms cannot completely resolve underinvestment problems by choosing short debt maturity. This helps explain the negative relation between leverage and growth opportunities observed in capital structure studies, even when firms can shorten maturity to reduce the cost of underinvestment problems.

The liquidity risk effect of short maturity on leverage is significantly negative, which is consistent with models by Diamond (1991, 1993) and Sharpe (1991) in which too much debt maturing in the short term can lead to suboptimal liquidation risk because lenders ignore future control rents. Liquidity risk effects on leverage should be more important for lower credit quality firms and firms that cannot easily lengthen their debt maturity. On average, firms with unrated debt are likely of lower credit quality than rated firms and also likely find it more difficult to lengthen maturity because they borrow mostly from banks and nonbank private lenders at shorter average maturities than public debt [see Carey et al. (1993)]. Consistent with the prediction that liquidity risk effects should be more important for lower credit-quality firms and firms that cannot lengthen their debt maturity, I find that the effect

[2] Theoretical studies of debt maturity and/or capital structure have not typically modeled the simultaneous choice of leverage and maturity. Lewis (1990) and Wiggins (1990) do explicitly model the choices simultaneously, but assume away the type of interactions between financial and investment decisions that I test here by assuming investment decisions are exogenous. Barclay, Marx, and Smith (1997) model the choices simultaneously and estimate corresponding simultaneous equations. As I discuss later, my results support their results even though we use different specifications. Other empirical studies of debt attributes [Barclay and Smith (1995), Guedes and Opler (1996), and Johnson (1997)] acknowledge that various debt attributes are likely chosen simultaneously, but do not attempt to estimate them simultaneously.

of liquidity risk on leverage is significantly larger in magnitude for unrated firms than for rated firms.

Combining the two effects of short maturity—reduced underinvestment problems and increased liquidity risk—shows that the net effect on leverage depends on whether a firm has rated debt. For unrated firms, the relatively large liquidity risk effect outweighs the attenuation of underinvestment problems effect so that the net effect of shorter maturity on leverage is negative. Thus, unrated firms can try to attenuate the negative effect of growth opportunities by choosing short debt maturity, but in the end this does not increase leverage. On the contrary, the negative direct effect of the increased liquidity risk on leverage more than offsets the positive attenuation effect, producing a net reduction in leverage. This also helps explain why we observe a negative empirical relation between leverage and growth opportunities even when (theoretically) firms can shorten maturity to reduce underinvestment problems. These results are also consistent with Mauer and Ott's (1998) theoretical model in which firms that shorten maturity to reduce underinvestment can also reduce leverage to avoid liquidity risk. For rated firms, the positive effect of reducing underinvestment outweighs the liquidity risk effect so that the net effect on leverage of shortening maturity is positive. Thus rated firms can shorten maturity to reduce underinvestment problems without having to reduce leverage because of liquidity risk.

For the overall sample, there is a net negative relation between leverage and short debt maturity (or equivalently, a positive relation between leverage and longer maturity). These simultaneous equation results are consistent with single-equation findings in Barclay and Smith (1995) and Stohs and Mauer (1996) that firms with longer maturity debt have higher leverage. The relation is also consistent with Barclay, Marx, and Smith's (1997) arguments and findings of strategic complementarities between maturity and leverage, even though we specify our system of simultaneous equations differently. In Riis and Lester (2001), firms also choose the amount and maturity of debt simultaneously, but their model does not rely on underinvestment problems or any other agency cost. Instead, firms dynamically choose the amount, coupon, and maturity of debt by trading off recapitalizing costs and bankruptcy costs against tax benefits. Firms optimally choose finite maturity debt, which has a negative effect on leverage compared to infinite maturity debt; the predicted negative relation between leverage and maturity is consistent with the empirical results in this article.

Parrino and Weisbach (1999), using a simulation approach, estimate the magnitude of underinvestment-related distortions on investment and, consistent with results in this article, find that short maturity reduces the magnitude of such distortions. They conclude, however, that such distortions are too small to explain the negative relation between leverage and growth opportunities documented in previous empirical studies. It is difficult to reconcile their conclusion with my empirical findings that firms attenuate the effects of underinvestment on leverage by choosing short maturity, especially since short maturity appears to be costly for some firms (i.e., it negatively affects leverage).

In addition to attenuating underinvestment problems, short debt maturity may also reduce the severity of asset substitution (risk-shifting) problems, which also reduce optimal leverage. Barnea, Haugen, and Senbet (1980) show theoretically that firms can reduce the severity of asset substitution problems by using short-term debt because it is less sensitive to changes in firm risk. Firms with greater growth opportunities may face potentially more severe asset substitution problems because it is likely easier to increase the risk of new investments than assets in place. To the extent that the severity of asset substitution problems is greater for firms with proportionately more growth opportunities, the evidence in this article suggests that short debt maturity is also effective in reducing the negative effects of this problem on leverage.[3]

Section 1 describes the data and methods. Section 2 contains the results. Section 3 concludes.

1. Data and Methods

The sample includes all nonfinancial firms in Standard & Poor's Compustat PC Plus active and research files from 1986 to 1995 that have nonmissing values for the dependent and independent variables discussed below. One of the independent variables is measured over the four years prior to the year in which leverage and maturity are measured, so a firm must have at least five consecutive years of data for inclusion in the sample. I exclude financial firms because Compustat does not provide debt maturity data for them and because their capital structures are likely influenced by different factors (e.g., capital adequacy regulations) than nonfinancial firms. I begin the sample period in 1986 because this is the first year for which Compustat has complete bond rating data, a potential determinant of debt maturity. I discard observations that have apparently erroneous data for any of the measures (e.g., firms with more than 100% of their debt maturing within a specified period). I also exclude 14 firm-year observations where the bond rating indicates their debt is in default, because acceleration clauses in debt agreements would make maturity measures less meaningful for these firms.[4] The final sample size is 20,565 firm-year observations, representing 4,945 different firms.

As discussed in the previous section, analyzing how debt maturity affects the relation between leverage and growth opportunities means that maturity will be included in some form as a right-hand-side variable in a leverage

[3] Some capital structure studies also use the fixed asset ratio as an inverse proxy for the severity of asset substitution problems. Later I discuss the results of an analysis that allows the effect of the fixed asset ratio to vary with debt maturity.

[4] These 14 firms have significantly lower market-to-book ratios than other firms, but do not differ in leverage or the fraction of short-term debt used. The main results are not sensitive to the exclusion of these firms.

equation. Using ordinary least squares (OLS) regressions could be problematic because firms likely choose a level of debt and the maturity of that debt simultaneously. Barclay, Marx, and Smith (1997) formalize this theoretically and show that leverage and debt maturity are endogenously chosen complements. Given its endogeneity, the coefficients on a maturity variable and any related interaction terms in an OLS leverage regression could be biased and inconsistent.[5]

Thus I specify a system of two simultaneous equations that recognizes that maturity is determined endogenously with leverage. As right-hand-side variables, the leverage equation contains the typical independent variables from previous capital structure studies (including a proxy for growth opportunities), a measure of short debt maturity, and an interaction between the maturity measure and the proxy for growth opportunities. With this specification, the partial derivative of leverage with respect to growth opportunities contains two terms, the coefficient on the growth opportunities measure and the coefficient on the interaction term times the measure of short debt maturity. The first term measures the effect of growth opportunities on leverage assuming that a firm uses zero short-term debt to avoid underinvestment problems. This corresponds to the case in Myers when debt matures after investment options expire, which implies the coefficient on growth opportunities should be negative. The second term measures the reduction or attenuation of the negative effect of growth opportunities on leverage that a firm sees from using short maturity debt and, from Myers, should be positive. The sum of the two terms should be zero for firms that completely eliminate the negative effect of growth opportunities on leverage by choosing short maturity. The maturity equation contains leverage and independent variables drawn from previous debt maturity studies. I estimate this system of equations using two-stage least squares. The specific variables composing each equation are as follows. All measures except volatility and the abnormal earnings measure are from the year before the year in which leverage and maturity are measured.

Barclay and Smith (1995) and Barclay, Marx, and Smith (1997) use the proportion of debt maturing beyond three years as their main measure of debt maturity. The hypotheses I test center around the use of shorter-term debt, so I use the complement of their measure, the proportion of total debt maturing in three years or less, to make interpretation of the results easier. Alternative measures to analyze the robustness of the results include the proportions of total debt maturing within two, four, and five years. Using any of these fractions of debt maturing within a certain period ignores the fact that some debt is callable, and that debt can typically be accelerated in the event of payment or technical default. This means that the measures are potentially understated compared to the "true" use of shorter-term debt. The possibility

[5] Despite the potential problems with an OLS regression, the attenuation effect of short debt maturity on underinvestment problems documented in this article holds if I treat debt maturity as an exogenous variable.

that some firms use short-term debt and others use callable long-term debt to attenuate the negative effects of underinvestment problems [Barnea, Haugen, and Senbet (1980)] creates a bias against finding an attenuation effect.

As the primary measure of leverage, I calculate the ratio of total debt (long-term debt plus debt in current liabilities) to firm value (book value of total assets less book value of common equity plus market value of common equity). As an alternative measure of leverage, I substitute the book value of total assets in the denominator instead of the quasi-market value measure to produce a measure of leverage using only book values. As a second alternative measure of leverage, I use the inverse of the interest coverage ratio from Compustat.

In the leverage equation, I include the following independent variables from previous capital structure studies. Following Myers's (1977) suggestion of a proxy for growth opportunities (or equivalently, the severity of potential underinvestment problems), I use the market-to-book ratio, defined as the market value of assets divided by book value of assets, where market value of assets is calculated by replacing book value of common equity with market value of common equity. Using this measure, Smith and Watts (1992) and Rajan and Zingales (1995) support Myers's prediction that firms with high growth opportunities should use lower leverage to avoid underinvestment problems. Given potential problems with market-to-book [see, e.g., Rajan and Zingales (1995, p. 1456)], I alternatively use the ratio of research and development expenses-to-sales as a proxy for growth opportunities.

The fixed assets ratio, defined as net property, plant, and equipment divided by the book value of assets, is the proxy for the tangibility of assets. Firms with more tangible assets should find asset substitution (risk shifting) more difficult, which lowers debt agency costs and thus raises optimal leverage [Williamson (1988)]. Firms with more tangible assets should also find liquidation values higher, which reduces the cost of inefficient liquidation and increases optimal leverage [Harris and Raviv (1990)].

I include a profitability measure, defined as the ratio of earnings before interest, taxes, depreciation, and amortization (EBITDA) to book value of assets. Myers (1984) argues that firms follow a pecking order in raising capital and prefer using retained earnings first, which implies more profitable firms will have lower leverage. Alternatively, if firms choose higher leverage to force the payout of high free cash flows, then firms with greater earnings should have higher leverage [Jensen (1986)].

I use net sales (in constant 1995 dollars) as a proxy for firm size. Larger firms are likely more diversified, which implies lower expected bankruptcy costs and higher optimal leverage. Conversely, larger firms likely face lower asymmetric information problems, implying they can use more equity [Myers and Majluf (1984)].

I include a volatility measure, defined as the standard deviation of first differences in EBITDA over the four years preceding the sample year, scaled by average assets for that period. Bradley, Jarrell, and Kim (1984) argue that firms with greater earnings volatility should have lower leverage.

As proxies for alternative tax shields that reduce the tax shield value of debt, I define a dummy variable equal to one for firms with net operating loss carryforwards and zero otherwise, and a second dummy variable equal to one for firms with investment tax credits and zero otherwise. DeAngelo and Masulis (1980) argue that firms with alternative tax shields find higher leverage less valuable.

I also include a regulated firm dummy, equal to one for firms with Standard Industrial Classification (SIC) codes between 4900 and 4939, and zero otherwise.[6] Smith (1986) argues that managers of regulated firms have less discretion over investment decisions, which reduces debt agency costs and increases optimal leverage. To test for signaling effects in leverage choices [Ross (1977)], I include the measure of abnormal earnings used in Barclay and Smith (1995) and Barclay, Marx, and Smith (1997), defined as the year-over-year change in the operating earnings per share divided by the previous year's share price.[7]

As independent variables in the maturity equation, I use the following. Market-to-book, defined above, is the proxy for growth opportunities (and thus, underinvestment problems), which Myers (1977) predicts should be positively related to the short maturity measure. Results in Barclay and Smith (1995) and Guedes and Opler (1996) support this prediction. I include the book value-weighted measure of asset maturity, defined by Stohs and Mauer (1996). The maturity of long-term assets is measured as gross property, plant, and equipment (PP&E) divided by depreciation expense, while the maturity of current assets is measured as current assets divided by the cost of goods sold. Total asset maturity is the weighted sum of these measures where (gross PP&E/total assets) is the weight for long-term assets and (current assets/total assets) is the weight for current assets.[8] Myers (1977) argues that firms can match the maturities of their assets and liabilities to reduce underinvestment problems, suggesting a *negative* relation between asset maturity and the *short* debt maturity measure.

Barclay and Smith (1995) argue that regulated firms can borrow longer-term because with less discretion in investment decisions, debt agency problems are less severe. Thus I also include the regulated firm dummy defined above.

Diamond (1991) predicts an increasing, then decreasing relation between debt maturity and credit quality or liquidity risk. As in Barclay, Marx, and

[6] Some other capital structure and debt maturity studies have more groups of firms defined as regulated, but by 1986, the first sample year of the current study, utilities were the only remaining heavily regulated group.

[7] Because the abnormal earnings measure is not predetermined, it could introduce an errors-in-variables problem. The main results of the article are not sensitive to the inclusion or exclusion of this measure.

[8] Guedes and Opler (1996) use only the long-term part of this asset maturity measure, but study a sample of bond issues with maturities of more than one year (i.e., long-term).

Smith (1997), I include firm size (defined above) and its square as proxies for credit quality; Diamond's increasing, then decreasing relation predicts that *short* maturity should be negatively related to size and positively related to size squared. I also include a zero-one dummy for firms with rated debt because unrated firms are more likely of lower credit quality than rated firms and also likely find it more difficult to borrow long-term because (unrated) bank and nonbank private debt have shorter average maturities than public debt [see Carey et al. (1993)]. I include the volatility measure defined above as an additional measure of credit risk. Firms with more volatile cash flows may experience more states where repaying debt is difficult, suggesting a negative relation between short maturity and volatility.

Flannery (1986) and Diamond (1991, 1993) develop models in which firms with private positive information about future prospects prefer short-term debt that can be refinanced after the information is revealed. To test for signaling effects in maturity choices, I include the measure of abnormal earnings defined above.

Brick and Ravid (1985) show theoretically that the tax-shield value of long-term debt is higher when the yield curve is upward sloping; this tax shield value is higher for firms with high marginal tax rates. Thus I include the two tax shield dummies defined above, and a term structure measure, defined as the 30-year U.S. Treasury rate less the six-month U.S. Treasury rate (both from the Federal Reserve Bank of St. Louis's economic database). The tax hypothesis predicts a negative relation between short maturity and term structure and a positive relation between short maturity and the tax shield dummies.

As discussed above, theoretical capital structure studies predict that the fixed asset ratio and the profitability measure are important determinants of leverage. No theoretical debt maturity studies make predictions about fixed asset ratios or profitability measures. Thus I restrict their coefficients to be zero in the maturity equation to help identify the system. Theoretical capital structure studies make no predictions about asset maturity, the rated firm dummy, term structure, or the square of firm size, so I restrict their coefficients to be zero in the leverage equation. Given these restrictions, rank and order conditions imply that the system of two equations is identified, and thus can be estimated by two-stage least squares.

The sample is a cross-sectional time series, so I estimate three types of regressions. One, I estimate a pooled regression that exploits cross-sectional and time-series variation. OLS t-statistics from this regression likely overstate true significance levels, so I make a Fama and MacBeth–type (1973) adjustment in which I first estimate cross-sectional regressions on a year-by-year basis, and then report coefficients as the (weighted) averages of the coefficients from those regressions and t-statistics as the ratios of these averages to their respective standard errors. Two, I estimate a cross-sectional regression that uses firm-specific time-series means, and thus exploits only cross-sectional variation, but avoids serial correlation in the error terms. I omit the term structure measure from the first two types of regressions because it only varies across time. Three, I estimate a fixed effects regression that exploits time-series variation; cross-sectional variation in any omitted effects in this model is captured in firm-specific intercept terms. I omit the regulated firm dummy from this regression because it does not vary over time. White's (1980) tests suggested heteroscedasticity, so reported t-statistics for the cross-sectional and fixed effects regressions use White's heteroscedasticity-consistent standard errors.

Table 1 contains summary statistics for the various measures. Mean (median) leverage is 0.21 (0.18), and varies widely across firms as evidenced by the interquartile range of 0.24. The mean (median) for the fraction of debt maturing within three years is 0.55 (0.54); an interquartile range of 0.61 implies that there is also wide variation in this short debt maturity measure across firms. Market-to-book has a mean (median) of 1.62 (1.29), which implies that the average (median) firm has valuable investment opportunities, and thus potentially faces the type of underinvestment problems described by Myers (1977). The mean ($1,506.91 million) and median ($138.41 million) of firm size suggests the presence of some very large values, so I use the natural log of firm size in the regressions to attenuate the effects of these.

Table 1
Summary statistics

Characteristic	Mean	Median	Standard deviation	Interquartile range
Leverage	0.21	0.18	0.17	0.24
Proportion of debt maturing within three years	0.55	0.54	0.32	0.61
Market-to-book ratio	1.62	1.29	1.01	0.75
Fixed assets ratio	0.34	0.29	0.21	0.29
Profitability	0.11	0.12	0.12	0.11
Firm size ($MM)	1,506.91	138.41	6,455.23	577.57
Volatility	0.07	0.04	0.08	0.07
Asset maturity	6.05	4.23	6.29	4.75
Abnormal earnings	0.02	0.02	0.18	0.09
Proportion of firms with bond ratings	0.20			
Proportion of firms with investment tax credits	0.03			
Proportion of firms with net operating loss carryforwards	0.34			
Proportion of firms that are regulated firms	<0.01			

The summary statistics are for a sample of 20,565 Compustat firm-year observations from 1986 to 1995. Leverage is book value of total debt divided by the book value of assets plus the market value of common equity less the book value of common equity. Market-to-book is the ratio of book value of assets minus the book value of equity plus the market value of equity divided by total assets. The fixed asset ratio is the ratio of net property, plant, and equipment to total assets. Profitability is the ratio of EBITDA to total assets. Firm size is net sales in $MM. Volatility is the standard deviation of first differences in EBITDA divided by total assets. Asset maturity is (gross property, plant, and equipment (PP&E)/total assets) times (gross PP&E/depreciation expense) plus (current assets/total assets) times (current assets/cost of goods sold). Abnormal earnings is the difference between operating income per share in year $t+1$ and year t divided by the share price in year t. Regulated firms have SIC codes between 4900 and 4939.

Table 2
Pearson correlations among measures of leverage, growth opportunities, and debt maturity

	Leverage (market)	Leverage (book)	Inverse interest coverage	Market-to-book	R&D/ sales	Fraction of debt maturing ≤2 years	Fraction of debt maturing ≤3 years	Fraction of debt maturing ≤4 years
Leverage (book)	0.88*							
Inverse interest coverage	0.43*	0.37*						
Market-to-book	−0.41*	−0.20*	−0.17*					
R&D/sales	−0.21*	−0.13*	−0.03*	0.38*				
Fraction of debt maturing ≤2 years	−0.20*	−0.24*	−0.02*	0.12*	0.14*			
Fraction of debt maturing ≤3 years	−0.19*	−0.25*	−0.02*	0.11*	0.13*	0.90*		
Fraction of debt maturing ≤4 years	−0.17*	−0.23*	−0.01	0.08*	0.10*	0.82*	0.94*	
Fraction of debt maturing ≤5 years	−0.15*	−0.21*	−0.01	0.07*	0.08*	0.74*	0.86*	0.94*

The correlations are for a sample of 20,565 Compustat firm-year observations from 1986 to 1995. Leverage (market) is book value of total debt divided by the book value of total assets plus the market value of common equity less the book value of common equity. Leverage (book) is book value of total debt divided by book value of total assets. Market-to-book is the ratio of book value of assets minus the book value of equity plus the market value of equity divided by total assets. R&D/sales is research and development expense divided by sales. The fractions of debt maturing with each period include short-term and long-term debt.

* Indicates correlation is significantly different from zero at the 0.05 level or higher.

Some independent variables that are ratios have extreme values. To minimize the effect of these outliers on the results, ratio variables are Winsorized at the 1st and 99th percentiles (e.g., ratios exceeding the 99th percentile are set equal to the 99th percentile).

Table 2 contains a matrix of Pearson correlation coefficients among the primary and alternative proxies for leverage, debt maturity, and growth opportunities. These correlations reveal some simple relations among the variables before moving to the simultaneous equation regression results. The three leverage measures are negatively correlated with market-to-book and research and development (R&D) expense-to-sales, the two proxies for growth opportunities. These correlations are consistent with Myers's (1977) prediction that potential underinvestment problems negatively affect leverage, and consistent with the findings of previous empirical capital structures. The short debt maturity measures are all positively correlated with market-to-book and R&D expense-to-sales. These correlations are consistent with Myers's prediction that firms facing more severe potential underinvestment problems have an incentive to choose relatively short debt maturity and consistent with most previous debt maturity studies.

Taken together, the correlations raise important questions: If firms shorten debt maturity to try reduce the severity of underinvestment problems, then why do we still find a negative correlation between leverage and growth opportunities? Moreover, if short debt maturity reduces the severity of potential underinvestment problems (which negatively affect leverage), then why do we see negative correlations between leverage and the measures of short debt maturity? The next section seeks to answer these questions with the results of simultaneous equation regressions designed to test whether and to what extent the empirical relations between leverage and proxies for growth opportunities and liquidity risk are affected by firms' choices of debt maturity.

2. Results

The results are presented in five subsections: the first three subsections focus on results in the leverage equation, the fourth contains the results for the maturity equation, and the fifth contains the results of various robustness checks.

2.1 Leverage equation results

Table 3 presents the results of the pooled, cross-sectional, and fixed-effects simultaneous equation regressions for leverage estimated using two-stage least squares. The first-stage regressions used to generate the estimated values of leverage and the debt maturity variable are not reported. I focus discussion on the pooled regression results, and note any differences in the other regressions. In the leverage equation, market-to-book has a significantly negative coefficient of −0.1439 ($t = -21.82$), which is consistent with Myers's (1977) prediction that growth opportunities negatively affect leverage, and consistent with findings in Smith and Watts (1992) and Rajan and Zingales (1995). In contrast, the interaction term between market-to-book and the short debt maturity measure has a significantly positive coefficient of 0.1203 ($t = 16.60$). Thus, consistent with Myers's other prediction, short maturity attenuates the negative effect of growth opportunities on leverage.

Evaluating the partial derivative of leverage with respect to market-to-book at different values for the debt maturity variable shows that the effects are economically significant. For firms with no short-term debt (i.e., no debt maturing within three years), the interaction term drops out so the effect on leverage is −0.1439, the coefficient on the stand-alone market-to-book. For firms that have 100% of their debt maturing within three years, the partial derivative is −0.1439 plus (0.1203 times 100%), or −0.0236. These figures imply that a one standard deviation increase in market-to-book reduces leverage by approximately 69% of its mean for firms with zero debt maturing within three years, but reduces leverage by only approximately 11% of its mean for firms with all of their debt maturing within three years.

In all three regressions, the coefficients on market-to-book are larger in absolute magnitude than the corresponding coefficients on the interaction

Table 3
Second stage regression results for leverage

Regression type	Predicted sign	Pooled	Cross-sectional	Fixed effects
Fraction of short-term debt (predicted)	−	−0.4655 (−22.94)	−0.5129 (−14.42)	−0.2632 (−4.37)
Market-to-book	−	−0.1439 (−21.82)	−0.1644 (−21.47)	−0.0690 (−5.04)
(Market-to-book) ∗ (Fraction of short-term debt (predicted))	+	0.1203 (16.60)	0.1343 (13.41)	0.0679 (3.58)
Control variables:				
Fixed assets ratio	+	0.0364 (2.99)	0.0415 (2.76)	0.1004 (2.73)
Profitability	+/−	−0.0646 (−3.94)	−0.0031 (−0.13)	−0.1616 (−4.82)
Log firm size	+/−	−0.0116 (−7.95)	−0.0125 (−6.23)	0.0144 (2.27)
Volatility	−	−0.0430 (−1.80)	−0.0226 (−0.71)	0.0866 (1.77)
Investment tax credit dummy	−	−0.0500 (−19.36)	−0.0670 (−4.97)	0.0052 (0.15)
Net operating loss carryforward dummy	−	0.0413 (8.79)	0.0467 (7.76)	0.0090 (1.15)
Regulated firm dummy	+	0.0227 (2.01)	0.0108 (0.49)	
Abnormal earnings	+	0.0286 (2.58)	−0.0360 (−1.52)	0.0508 (4.39)
Intercept		0.6305 (24.16)	0.6858 (22.10)	
Adjusted R^2		0.25	0.31	0.10
Sample size		20,565	4,945	17,714

This table presents the results of second-stage simultaneous equation regressions of leverage on explanatory variables estimated using two-stage least squares. First-stage regression results are omitted. The sample contains 20,565 Compustat firm-year observations (4,945 cross-sections) from 1986 to 1995. The variables are as defined in Table 1. Fama and MacBeth-type coefficients and t-statistics (in parentheses) are reported for the pooled regression; heteroscedasticity-consistent t-statistics are reported for the other regressions. The adjusted R^2 does not include firm-specific intercepts for the fixed effects regression. The fixed effects regression excludes firms with less than three years of data.

term, implying that even with 100% short-term debt, the attenuation would be incomplete. Given that most firms have less than 100% of their debt maturing in the short-term, it is clear why capital structure studies typically find a negative relation between leverage and growth opportunities. For example, for a firm using the mean fraction of short-term debt (0.55), a one standard deviation increase in market-to-book would reduce leverage by approximately 37% of its mean.

The coefficient on the stand-alone debt maturity variable is significantly negative and relatively large in magnitude (-0.4655, $t = -22.94$). Diamond (1991, 1993) and Sharpe (1991) develop models in which too much debt maturing in the short term can lead to suboptimal liquidation decisions as lenders ignore future control rents. In these studies, firms lengthen debt maturity to reduce liquidity risk, but it is also reasonable to expect that firms could reduce this risk by reducing leverage. Viewing the negative effect of the stand-alone short maturity measure on leverage as a liquidity risk effect suggests that some firms may borrow short-term and simultaneously reduce leverage to reduce liquidity risk [see Mauer and Ott (1998)]. In the next subsection, I explore this result in more detail.

Combining the large negative direct (i.e., liquidity risk) effect with the positive interaction (i.e., attenuation of underinvestment problems) effect of short maturity from above shows that the *net* effect on leverage is negative. With market-to-book at its mean, a one standard deviation increase in the short maturity measure increases leverage by approximately 30% of its mean through the positive interaction, but reduces leverage by approximately 71% of its mean through the negative direct effect; the net effect is a 41% reduction in leverage.

Thus, while short debt maturity attenuates the negative effect of growth opportunities on leverage, it also increases liquidity risk and thereby negatively affects leverage. These two effects imply that firms trade off the cost of underinvestment problems against the cost of increased liquidity risk when choosing short debt maturity. A firm for which growth opportunities are more important should choose shorter debt maturity, but may still choose lower leverage because the shorter debt maturity increases liquidity risk. This helps explain why we observe a negative empirical relation between leverage and growth opportunities, even though theoretically firms can shorten maturity to avoid underinvestment problems, and also helps explain the findings in Barclay and Smith (1996) and Stohs and Mauer (1996) that firms with greater growth opportunities have both shorter debt maturity *and* lower leverage. Conversely, a firm for which liquidity problems are more important should choose longer debt maturity, but may still choose lower leverage because the longer maturity increases the cost of underinvestment problems.

The coefficients on the other variables in the leverage equation show results generally consistent with previous capital structure studies. The coefficient on the fixed asset ratio is significantly positive in all three regressions and the coefficient on profitability is significantly negative in the pooled and fixed effects regressions. Firm size has significantly negative coefficients in the pooled and cross-sectional regressions, but has a positive coefficient in the fixed effects regression. The investment tax credit dummy is significantly negative and the net operating loss carryforward dummy is significantly positive in the pooled and cross-sectional regressions. Although the sign on the net operating loss carryforward dummy is opposite of that predicted, it is consistent with similar findings in Barclay, Marx, and Smith (1997). A plausible explanation of the positive coefficient is that firms with net operating loss carryforwards have higher leverage because the losses that generated the carryforwards caused equity to fall in value, and thus leverage to rise. Consistent with Smith's (1986) arguments that regulations mitigate debt agency problems, the regulated firm dummy is significantly positive in the pooled regression. Consistent with Ross's (1977) prediction that firms can use debt to signal future cash flows, the abnormal earnings measure has significantly positive coefficients in the pooled and fixed effects regressions; in the cross-sectional regression, which ignores time-series variability, the coefficient is statistically insignificant.

2.2 Differences in the effect of liquidity risk across firms with rated and unrated debt

The negative liquidity risk effect and the effect of positive attenuation of underinvestment problems on leverage discussed in Section 3.1 imply that firms face increased liquidity risk when choosing short debt maturity to reduce underinvestment problems. This is consistent with Mauer and Ott's (1998) theoretical model in which firms that shorten maturity to reduce underinvestment costs can simultaneously reduce leverage to reduce the resulting liquidity risk. Diamond (1991) argues that low credit quality firms that face greater liquidity risk may demand longer-term debt to reduce this risk, but find no lenders willing to supply it at reasonable cost [see also Sharpe (1991) and Diamond (1993)]. In contrast, higher credit quality firms likely face lower liquidity risk, and can also borrow longer term if liquidity risk concerns do arise. Given that the effects of short debt maturity may depend on credit quality and the ability of firms to extend debt maturity to reduce liquidity risk, I reestimate the regressions separately for rated and unrated firms. Rated firms are likely of higher average credit quality and also likely face fewer constraints on extending maturity than firms that rely on bank or nonbank private debt, both of which have shorter average maturities than public debt [see Carey et al. (1993)].

As shown in Table 4, leverage is negatively related to the stand-alone short maturity measure in all regressions for unrated firms. For rated firms, short maturity has a significantly negative coefficient only in the pooled regression; the coefficient is insignificantly negative in the cross-sectional regression and significantly positive in the fixed effects regression. Moreover, in all the regressions the coefficients on short maturity for unrated firms are significantly larger in absolute magnitude (at the 0.01 level) than the corresponding coefficients for rated firms. These results are consistent with arguments that liquidity risk effects are more important for lower credit quality firms and firms that cannot borrow long-term easily.

The differences in liquidity risk effects have implications for how firms use shorter maturity to attenuate the effect of growth opportunities on leverage. Using figures from the pooled regression in Table 4, with market-to-book at its mean, a one standard deviation increase in the fraction of short-term debt increases leverage for rated firms by approximately 52%.[9] These results imply that rated firms can shorten debt maturity to reduce the negative effect

[9] The calculations in this analysis use the respective means and standard deviations for rated and unrated firms.

Table 4
Second-stage regression results for leverage estimated separately for rated and unrated firms

		Rated firms			Unrated firms		
Regression type	Predicted sign	Pooled	Cross-sectional	Fixed effects	Pooled	Cross-sectional	Fixed effects
Fraction of short-term debt (predicted)[a]	−	−0.1895 (−2.26)	−0.5935 (−1.10)	1.0684 (1.96)	−0.6748 (−8.16)	−0.7418 (−3.95)	−0.8872 (−2.68)
Market-to-book	−	−0.3322 (−11.55)	−0.3336 (−1.99)	−0.1691 (−3.61)	−0.1405 (−23.57)	−0.1527 (−15.10)	−0.0741 (−2.30)
(Market-to-book) ∗ (Fraction of short-term debt (predicted))	+	0.5166 (12.37)	0.5029 (1.08)	0.1835 (1.71)	0.1169 (15.50)	0.1242 (9.47)	0.0736 (1.70)
All regressions include control variables defined in Table 3, but coefficients are not reported							
Adjusted R^2		0.39	0.43	0.11	0.22	0.28	0.10
Sample size		4,140	961	3,590	16,425	4,469	13,498

This table presents the results of second-stage simultaneous equation regressions of leverage on explanatory variables estimated using two-stage least squares. First-stage regression results are omitted. The variables are as defined in Table 1. Fama and MacBeth-type coefficients and t-statistics (in parentheses) are reported for the pooled regression; heteroscedasticity-consistent t-statistics are reported for the other regressions. The adjusted R^2 does not include firm-specific intercepts for the fixed effects regression. The fixed effects regression excludes firms with less than three years of data.

[a] The coefficients on the fraction of short-term debt differ significantly at the 0.01 level across rated and unrated firms in the corresponding regressions.

of growth opportunities on leverage without producing a net negative effect on optimal leverage via the liquidity risk effect. For unrated firms, a one standard deviation increase in the fraction of short-term debt reduces leverage by approximately 77%. The net negative effect of short maturity implies that unrated firms can shorten maturity to reduce underinvestment problems, but that this does not ultimately increase optimal leverage. Rather, the negative effect on leverage of the increased liquidity risk from borrowing short-term outweighs the positive effect on leverage from reducing underinvestment problems.

The net effects calculated above are for firms with average market-to-book ratios, and can reverse sign for sufficiently high values of market-to-book. For rated firms with market-to-book ratios less than or equal to 0.37, the net effect of an increase in the fraction of short-term debt is negative. No rated firms in the sample, however, have a market-to-book ratio that low. Unrated firms must have a market-to-book ratio greater than or equal to 5.77 for the net effect to be positive. A relatively small proportion of unrated firms (2.4%) have a market-to-book ratio that high.

2.3 The monotonicity of the attenuation effect of short debt maturity

The results presented in Section 3.1 using the interaction term between market-to-book and the short debt maturity measure in the leverage equation show that increases in market-to-book have less negative effects on leverage for firms that borrow shorter term. Using the interaction term, however, does not allow an analysis of the monotonicity of the attenuation effect. It could be that firms with debt maturing in a particular range are the only ones to experience the attenuation effects of short debt maturity. Thus I analyze results of the leverage regressions estimated in a simultaneous equations framework as before, but with a specification that allows the coefficient on market-to-book to change across sample quintiles based on the predicted fraction of debt maturing within three years. I do this by defining five zero-one dummy variables based on the quintiles and then multiplying each of these times market-to-book. Note that this approach does not produce coefficients that measure *differences* between the slopes, but rather the slopes themselves. I include the predicted proportion of debt maturing within three years (from the first-stage regression) in continuous form, but the results are similar if I suppress the common intercept and substitute the five dummy variables based on the quintiles instead of the continuous measure.

As shown in Table 5, in both the pooled and cross-sectional regressions, the absolute magnitudes of the negative coefficients on market-to-book fall monotonically moving across the quintiles from firms with the longest debt maturity to firms with the shortest debt maturity; in the fixed effects model, there is near monotonicity, with only the second quintile falling out of line. For example, in the pooled regression the coefficients on market-to-book are

Table 5
Second-stage regression results for leverage where underinvestment effects vary across maturity quintiles

Regression type	Predicted sign	Pooled	Cross-sectional	Fixed effects
Fraction of short-term debt (predicted)	–	−0.4842 (−13.10)	−0.4425 (−9.63)	−0.2135 (−9.21)
Market-to-book (bottom short-term debt quintile)	–	-0.1110^{a} (−16.94)	-0.1053^{b} (−14.59)	-0.0403^{c} (−13.59)
Market-to-book (second short-term debt quintile)	–	−0.0711 (−25.26)	−0.0790 (−15.78)	−0.0265 (−13.03)
Market-to-book (third short-term debt quintile)	–	−0.0694 (−31.68)	−0.0697 (−16.81)	−0.0275 (−14.06)
Market-to-book (fourth short-term debt quintile)	–	−0.0586 (−17.44)	−0.06629 (−19.45)	−0.0263 (−14.85)
Market-to-book (top short-term debt quintile)	–	-0.0495^{a} (−22.04)	-0.0552^{b} (−21.18)	-0.0197^{c} (−12.50)
All regressions include control variables defined in Table 3, but coefficients are not reported				
Adjusted R^2		0.24	0.29	0.09
N		20,565	4,945	17,714

This table presents the results of second-stage simultaneous equation regressions of leverage on explanatory variables where underinvestment effects vary across maturity quintiles. First-stage regression results are omitted, as are the second-stage maturity regression results. The dependent variable in each equation, leverage, is book value of total debt divided by the book value of total assets plus the market value of common equity less the book value of common equity. The fraction of short-term debt is the proportion of short- and long-term debt maturing within three years. For each quintile based on the fraction of debt maturing within three years, market-to-book is the ratio of book value of assets minus the book value of equity plus the market value of equity divided by total assets for firms in that quintile, and zero otherwise. This allows the coefficient to differ for each quintile. The other independent variables are as defined in Table 1. Fama and MacBeth–type coefficients and t-statistics (in parentheses) are reported for the pooled regression; heteroscedasticity-consistent t-statistics are reported for the other regressions. Coefficients with superscripted (a) differ significantly from each other at the 0.01 level. The same is true for coefficients superscripted (b) and (c). The adjusted R^2 does not include firm-specific intercepts for the fixed effects model. The fixed effects regression excludes firms with less than three years of data.

−0.1110, −0.0711, −0.0694, −0.0586, and −0.0495 for the bottom through top quintiles, respectively. Moreover, in all three regressions, F-tests imply that the coefficients on the top and bottom quintiles differ significantly from each other at the 0.01 level. Thus the attenuation effect of short debt maturity is not driven by a particular subset of firms with debt in a certain maturity range. Rather, firms that have progressively larger proportions of their debt maturing in the short-term see progressively fewer negative effects of increases in market-to-book on leverage. Notably, however, the negative effect of underinvestment does not vanish for firms with the shortest maturity debt, confirming the earlier calculations based on the interaction terms that suggest that firms cannot completely resolve underinvestment problems by shortening maturity.

2.4 Debt maturity equation results

Table 6 contains the second-stage regression results for maturity that correspond to the second-stage leverage regressions in Table 3. In the regressions that contain the fitted value of leverage, leverage has significantly negative coefficients in the pooled and cross-sectional debt maturity regressions, but is

Table 6
Second-stage regression results for maturity

Regression type	Predicted sign	Pooled		Cross-sectional		Fixed effects	
Leverage (predicted)	−	−1.1674		−1.3284		−0.1543	
		(−12.99)		(−7.83)		(−1.38)	
Market-to-book	+	−0.0740	0.0002	−0.0815	0.0073	−0.0209	−0.0107
		(−10.26)	(0.09)	(−6.76)	(1.84)	(−2.61)	(−3.36)
Asset maturity	−	−0.0056	−0.0095	−0.0042	−0.0089	−0.0034	−0.0036
		(−14.25)	(−28.14)	(−4.62)	(−12.73)	(−4.84)	(−5.25)
Log firm size	−	−0.0657	−0.0822	−0.0468	−0.0711	−0.0131	−0.0153
		(−16.23)	(−26.64)	(−7.91)	(−14.60)	(−1.96)	(−2.34)
Log firm size squared	+	0.0032	0.0055	0.0012	0.0045	0.0024	0.0027
		(8.43)	(21.23)	(1.87)	(9.52)	(3.10)	(3.70)
Volatility	−	0.2143	0.2532	0.1984	0.2685	−0.0036	0.0009
		(10.39)	(12.79)	(3.58)	(5.40)	(−0.10)	(0.03)
Investment tax credit dummy	−	−0.0921	−0.0670	−0.1071	−0.0712	−0.1154	−0.1121
		(−15.01)	(−11.20)	(−4.32)	(−3.20)	(−4.53)	(−4.40)
Net operating loss carryforward dummy	−	0.0679	0.0170	0.0819	0.0152	0.0333	0.0274
		(12.87)	(4.90)	(5.99)	(1.66)	(4.58)	(4.56)
Regulated firm dummy	−	0.0478	−0.0199	0.0514	0.0037		
		(3.32)	(−1.27)	(1.27)	(0.10)		
Rated firm dummy	−	−0.1400	−0.2073	−0.1590	−0.2669	−0.0680	−0.0764
		(−12.87)	(−20.64)	(−7.67)	(−21.90)	(−6.35)	(−8.61)
Abnormal earnings	+	0.0296	−0.0026	−0.0504	−0.0041	0.0245	0.0203
		(3.69)	(−0.30)	(−1.33)	(−0.16)	(2.56)	(2.23)
Term structure	−					0.0026	0.0041
						(1.63)	(3.46)
Intercept		1.1764	0.8757	1.2029	0.8540		
		(44.66)	(70.13)	(24.35)	(44.67)		
Adjusted R^2		0.25	0.24	0.33	0.32	0.01	0.01
Sample size		20,565	20,565	4,945	4,945	17,714	17,714

This table presents the results of second-stage simultaneous equation regressions of maturity on explanatory variables estimated using two-stage least squares. First-stage regression results are omitted. The sample contains 20,565 Compustat firm-year observations (4,945 cross sections) from 1986 to 1995. The variables are as defined in Table 1. Fama and MacBeth-type coefficients and t-statistics (in parentheses) are reported for the pooled regression; heteroscedasticity-consistent t-statistics are reported for the other regressions. The adjusted R^2 does not include firm-specific intercepts for the fixed effects regression. The fixed effects regression excludes firms with less than three years of data.

statistically insignificant in the fixed effects regression. The negative coefficients are consistent with the negative relation between these variables shown in the leverage equation, are consistent with arguments that firms with high leverage try to avoid suboptimal liquidation by choosing longer-term debt [Diamond (1991, 1993) and Sharpe (1991)], and are consistent with arguments that leverage and debt maturity are strategic complements [Barclay, Marx, and Smith (1997)]. The negative relation between leverage and short maturity (or equivalently, a positive relation between leverage and longer maturities) is also consistent with findings in Barclay and Smith (1995) and Stohs and Mauer (1996) that maturity increases with leverage.

In these regressions that include the fitted value of leverage, market-to-book has significantly negative coefficients, which is opposite of that predicted and opposite of the sign of the simple correlations between this ratio and the short debt maturity measures shown in Table 2. Further analysis indicates that the pooled and cross-sectional maturity regressions suffer from severe multicollinearity problems. The highest condition indexes for the pooled and cross-sectional regressions are 43.44 and 37.75, respectively, and the corresponding variance decomposition proportions are greater than 0.9 for both the fitted value of leverage and market-to-book. These figures suggest that multicollinearity problems seriously degrade the regression results [see Belsley, Kuh, and Welsch (1980)]. Similar diagnostics do not suggest that the fixed effects equation suffers from multicollinearity problems.

To understand the source of the multicollinearity problems, recall that in a two-stage least squares estimation of simultaneous equations, the predicted value of an endogenous variable is included instead of its actual value. This value is predicted from a first-stage regression of the endogenous variable on all of the independent variables across both equations. Market-to-book has the most explanatory power in the first-stage regression for leverage. The high correlation ($\rho = -0.81$) between the predicted leverage variable and market-to-book creates a severe multicollinearity problem in the maturity regression, and is at least partly responsible for the negative sign on market-to-book. In a cross-sectional regression that excludes fitted leverage, the coefficient on market-to-book is (weakly) significantly positive ($t = 1.84$). In a pooled regression omitting fitted leverage, the coefficient on market-to-book switches from significantly negative to statistically insignificant; omitting volatility in addition to fitted leverage causes the coefficient on market-to-book to become significantly positive. These positive coefficients on market-to-book are consistent with results from single-equation studies [Barclay and Smith (1995) and Guedes and Opler (1996)], which support Myers's prediction that firms with greater growth opportunities should prefer shorter-term debt. The coefficient of market-to-book in the fixed effects regression is negative, even if it is the only variable in the regression. It is not obvious why the short maturity measure is negatively correlated with the market-to-book ratio in time series as shown in the fixed effects regression, but positively correlated in the cross section.

Barclay, Marx, and Smith (1997) also estimate simultaneous equations for leverage and debt maturity, and find signs opposite of that predicted for leverage in the debt maturity equation, and also opposite of the relation they find in the leverage equation. They also attribute the problem in their analysis to multicollinearity problems created because predicted leverage in the maturity equation is highly correlated with market-to-book, which is also in the maturity equation. Like Barclay, Marx, and Smith, I find that the leverage equation is much more robust, and seems to generate more reliable results.[10] While the multicollinearity problems in the second-stage maturity equation interfere with interpretation of coefficients in that equation, it has no effect on interpretation of the second-stage leverage equation that uses the predicted short debt maturity measure because multicollinearity problems do not bias this predicted measure.

Given the multicollinearity problems evident in the pooled and cross-sectional maturity regressions, the following discussion focuses on results from the fixed effects regression. Asset maturity has a significantly negative coefficient, which is consistent with Myers's (1977) prediction that firms try to match the maturity of their assets and liabilities to reduce underinvestment problems.

Firm size and firm size squared have significantly negative and positive coefficients, respectively. This pattern of coefficients is consistent with Diamond's prediction that low credit quality firms and high credit quality firms borrow short term, while intermediate quality firms borrow longer term. The dummy for firms with bond ratings has a significantly negative coefficient, which is consistent with the view that rated firms find it easier to borrow long term than firms that are limited to bank and nonbank private debt. The coefficient on volatility is insignificantly different from zero.

The investment tax credit dummy variable has a significantly negative coefficient, while the net operating loss carryforward dummy has a significantly positive coefficient. The term structure coefficient is significantly positive. The negative coefficient on the investment tax credit dummy variable and the positive coefficient on the term structure measure do not support Brick and Ravid's (1985) prediction that firms with high marginal tax rates facing an upward sloping yield curve prefer long-term debt to maximize the tax shield value of debt. The positive coefficient on the net operating loss carryforward dummy is consistent with that prediction, but the strong possibility that this dummy variable is also a proxy for financial distress suggests

[10] The results in the second-stage leverage regression are robust to several different specifications of that regression, and several different specifications of the first-stage regression that generates the predicted maturity measure for that regression. The results in the leverage equation also hold outside of a simultaneous equations framework (which implicitly assumes that debt maturity is exogenous). This suggests that the leverage equation results are not driven by a particular simultaneous equations model specification.

this result should be interpreted with caution. Collectively these results for the tax-related variables do not suggest strong support for the tax-related maturity hypothesis. The coefficient on the abnormal earnings variable is significantly positive, which is consistent with signaling explanations of debt maturity [Flannery (1986) and Diamond (1991, 1993)].

2.5 Robustness checks

This section discusses results from several robustness checks of the results. Given the importance of the relation between leverage and growth opportunities in this study, I first examine its robustness. Results in Rajan and Zingales (1995) and Hovakimian, Opler, and Titman (2001) raise questions about whether the negative relation between leverage and market-to-book actually reflects the effects of potential underinvestment problems. It is possible that the negative relation between leverage, which has the market value of the firm in its denominator, and market-to-book, which has the same market value in its numerator, is mechanical, driven by changes in the market value of the firm, holding constant the book values of debt and assets. Another potential problem with using the market-to-book ratio is that managers may try to time equity issues to occur after a firm's market value has risen significantly and/or when its market-to-book is high [Lucas and McDonald (1990) find empirical support for this]. The increased equity value and the equity issues cause leverage to fall for firms with high market-to-book ratios, creating a negative correlation between leverage and market-to-book.

The potential market-timing problem is important in this article because the same asymmetric information conditions that affect a firm's incentive to issue equity may affect its use of short- or long-term debt. Specifically, firms may prefer to borrow short-term and avoid equity issues when they have relatively severe asymmetric information problems to avoid the underpricing problems described in Myers and Majluf (1984) for riskier long-term debt and equity. If well-timed equity issues drive the relation between leverage and market-to-book, then firms that avoid equity issues and borrow short-term will have a weaker negative relation between leverage and market-to-book. The weaker relation would be driven by the weak equity issue-leverage link rather than by the attenuation of underinvestment problems. Conversely, firms that have had a run-up in stock price and face less severe asymmetric problems can borrow longer term and issue equity. The equity issues of these firms would create a stronger negative relation between leverage and market-to-book, which could falsely be attributed to their use of long-term debt exacerbating underinvestment problems.

As a first check on the robustness of the leverage-growth opportunities relation, I reestimate the regressions using measures of growth opportunities and leverage chosen to avoid mechanical relations and equity issue timing-related problems. Results of this analysis are in Table 7. Columns (1)–(3)

Table 7
Second-stage regression results using alternative measures of leverage and growth opportunities

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Regression type	Predicted sign	Pooled	Cross-sectional	Fixed effects	Pooled	Cross-sectional	Fixed effects	Pooled	Cross-sectional	Fixed effects
Leverage measure		Market leverage	Market leverage	Market leverage	Book leverage	Book leverage	Book leverage	Inverse interest coverage	Inverse interest coverage	Inverse interest coverage
Growth opportunities measure		R&D/ sales	R&D/ sales	R&D/ sales	Market-to-book	Market-to-book	Market-to-book	Market-to-book	Market-to-book	Market-to-book
Fraction of short-term debt (predicted)	−	−0.2962 (−10.97)	−0.3022 (−7.51)	−0.1745 (−2.72)	−0.4611 (−17.88)	−0.4990 (−12.71)	−0.2168 (−3.75)	−0.6755 (−5.16)	−0.9550 (−4.54)	−0.3251 (−3.39)
Growth opportunities	−	−0.6195 (−13.70)	−0.5648 (−8.49)	−0.2295 (−1.51)	−0.0809 (−14.33)	−0.0832 (−8.20)	−0.0306 (−2.34)	−0.1834 (−4.66)	−0.2227 (−4.39)	−0.1151 (−4.04)
(Growth opportunities) ∗ (Fraction of short-term debt (predicted))	+	0.3812 (9.66)	0.3515 (4.55)	0.2362 (1.47)	0.0798 (10.46)	0.0739 (5.50)	0.0352 (1.93)	0.1480 (2.31)	0.1914 (2.69)	0.0540 (1.15)
Adjusted R^2		0.16	0.18	0.08	0.13	0.15	0.06	0.09	0.12	0.05
N		12,953	3,163	11,091	20,565	4,945	17,714	16,140	4,094	13,633

This table presents the results of second-stage simultaneous equation regressions using alternative measures of leverage and growth opportunities. Predicted signs are on the left in parentheses. First-stage regression results are omitted, as are the second-stage maturity regression results. The dependent and independent variables are as defined in Table 3. Fama and MacBeth–type coefficients and t-statistics (in parentheses) are reported for the pooled regression; heteroscedasticity-consistent t-statistics are reported for the other regressions. The adjusted R^2 does not include firm-specific intercepts for the fixed effects regression. The fixed effects regression excludes firms with less than three years of data. All regressions include control variables defined in Table 3, but coefficients are not reported.

show results for regressions with the ratio of R&D expense-to-sales substituted for the market-to-book ratio. Compustat has R&D expense data for 12,953 of the 20,565 firm-year observations. The main results continue to hold. In the pooled and cross-sectional regressions, the coefficient on the interaction term between the R&D/sales ratio and the short debt maturity measure is significantly positive, while the coefficient on the stand-alone R&D ratio is significantly negative; in the fixed effects regression, the coefficient signs obtain but the t-statistics are low. The remaining columns of Table 7 contain results of second-stage leverage regressions in which the leverage measures do not contain the market value of the firm. In columns (4)–(6), leverage is measured by the ratio of book value of debt and book value of assets, while in columns (7)–(9) leverage is measured by the inverse of the interest coverage ratio. For both alternative measures, the main results generally hold. In the pooled and cross-sectional regressions, the coefficients on the interaction term between market-to-book and the short debt maturity measure are significantly positive, while the coefficient on the market-to-book is significantly negative; in the fixed effects regressions, the coefficients on the interaction term are positive, but the t-statistics are low in two of the regressions.

The results above using alternative measures of leverage and growth opportunities provide some evidence that well-timed equity issues creating a link between market leverage and market-to-book are not driving the results. I conduct additional analysis to examine more directly the effect of stock price run-ups. If previous stock price run-ups drive the relation between leverage and market-to-book, then the relation should not be robust to controlling for a stock's previous return. Compustat has a five-year stock return (relative to the S&P 500 index return) for 13,645 of the 20,565 firm-year observations. In unreported regressions that contain this return measure, the coefficients on the market-to-book ratio and the interaction maintain their signs and significance levels.

I conduct one additional check based on the proxy for potential underinvestment problems. Myers (1977) predicts that potential underinvestment problems should only be severe, and thus should only negatively affect leverage, for firms with valuable growth opportunities. Thus if the attenuation effect observed actually reflects a reduction in the severity of underinvestment problems, then the effect should hold only among firms with valuable growth opportunities. If the market recognizes the value of firms' growth opportunities, then firms with these opportunities should have market-to-book ratios that exceed one, while other firms should have market-to-book ratios equal to one or less. When I estimate the leverage regressions separately based on whether or not firms' market-to-book ratios exceed one, the results (not reported) show that for firms whose market-to-book ratios exceed one ($n = 16,180$), increases in market-to-book negatively affect leverage, but are attenuated significantly by short debt maturity. In contrast, the results show that for firms with market-to-book ratios equal to one or less ($n = 4{,}385$), market-to-book does not negatively affect leverage (the coefficient is statistically insignificant), and there is no evidence of an attenuation effect. These results are consistent with Myers's model in which only firms with valuable investment options face underinvestment problems, and thus benefit from the attenuation effects of short debt maturity.

Next, I analyze the sensitivity of the results to controlling for industry effects by including dummy variables based on two-digit standard industrial classification (SIC) codes in the first- and second-stage regressions. Bradley, Jarrell, and Kim (1984) find evidence of industry effects in cross-sectional capital structure variation. Unreported results show that the attenuation effects of short debt maturity hold after controlling for industry effects. Unreported results also show that the attenuation effects of short debt maturity also hold among the set of industrial firms (i.e., excluding utilities and other firms).

The summary statistics reported in Table 1 showed that with the three-year maturity demarcation, the average firm has about half of its debt maturing in the "short-term," but there is no way to tell where this demarcation is in relation to the maturity of firms' investment options. Thus I examine the effects of using alternative measures of debt maturity in place of the fraction of debt maturing within three years. Compustat data limit these alternative measures to the fractions of debt maturing within two, four, or five years. Using any of these measures in place of the fraction of debt maturing within three years, the coefficient on the interaction term between the short maturity measure and market-to-book is positive and the coefficient on market-to-book is negative.

Finally, to explore the sensitivity of the results to the simultaneous equations framework and specification, I estimated the leverage equation in a single-equation OLS framework. That is, I used the actual short debt maturity measure instead of the predicted short debt maturity measure. OLS regressions can be relatively robust to specification errors, multicollinearity problems, and errors in variables. Results from this analysis (unreported) show that the main results are robust to using a single-equation OLS estimation for the pooled and cross-sectional regressions, and thus do not appear to be driven by specification or other errors in the simultaneous equations system.

Barnea, Haugen, and Senbet (1980) show that short-term debt may also reduce asset substitution problems. If I treat the fixed asset ratio similar to market-to-book by specifying an interaction term between the short debt maturity measure and the fixed asset ratio in the leverage regressions, I find that the coefficients on the ratio and its interaction term have signs opposite of that predicted. Further analysis reveals that including this interaction term induces a severe multicollinearity problem, as evidenced by sign reversals of the fixed asset ratio coefficient when maturity is omitted from the equation and condition indexes greater than 20.00. This is because the fixed asset ratio has substantial explanatory power in the first-stage regression for maturity, meaning it is highly correlated with the predicted maturity variable that is used in the second-stage regression for leverage. The results discussed earlier for the leverage equation, however, are robust to the inclusion or exclusion of the fixed asset ratio. Perhaps future models that explain more of the variation in debt maturity that is unexplained by the fixed asset ratio can help to solve this problem.

3. Conclusion

This article investigates empirically how debt maturity affects the relation between leverage and growth opportunities and liquidity risk. Using a simultaneous equations framework in which leverage and debt maturity are endogenous, I find strong support for Myers's prediction that using shorter-term debt attenuates the negative effect of growth opportunities on leverage. Short debt maturity also increases liquidity risk, however, which negatively affects leverage. The results suggest that firms trade off the cost of underinvestment problems against the cost of increased liquidity risk when choosing short debt maturity. For firms with unrated debt, the negative effect of increasing liquidity risk outweighs the positive effect on leverage of reducing underinvestment problems; the opposite is true for unrated firms. The results help explain why we observe a negative empirical relation between leverage and growth opportunities even though theoretically firms can choose short debt maturity to avoid underinvestment problems. Given that the results imply choosing short debt maturity can be a costly way to resolve underinvestment problems, an interesting future research question is what other methods firms can use to resolve underinvestment problems (e.g., callable debt), and what factors lead them to choose those methods over shortening maturity.

The framework employed in this article is sufficiently general to allow analysis of how a variety of different debt attributes affect the relation between leverage and proxies for the problems the attributes are designed to mitigate. These debt attributes include such features as maturity, collateral, call and put provisions, conversion features, and sinking funds. The theoretical and empirical models of most debt attributes may be insufficiently developed to allow the specification of an identified system of equations. As theoretical and empirical models of capital structure and debt attributes become richer and more complex, it should be possible to study them using the framework employed in this article.

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