Evidence for a debt financing channel in corporate investment

Robin Greenwood*
Harvard Business School
rgreenwood@hbs.edu

First draft: November 2002
This draft: June 12, 2003

Abstract

In the simplest frictionless theory, an increase in real interest rates causes a symmetric decline in investment for all firms because they discount new projects at a higher cost of capital. I develop and test a specific debt-market financing channel in which differences in the maturity structure of debt result in varied responses of investment to changes in the cost of debt capital. Firms with high levels of short-term debt suffer a decline in cash flows, relative to firms financed with long-term debt, when nominal interest rates increase. In U.S. firm-level data between 1953 and 2001, Holding leverage fixed, I find that the investment of firms with a high current portion of debt is more sensitive to changes in real and nominal interest rates when compared with firms that have only long-term debt.

---

* I thank Heitor Almeida, Malcolm Baker, Murillo Campello, Ben Esty, Ken Froot, Lubov Getmansky, Tom Knox, David Laibson, N. Gregory Mankiw, Jorge Rodriguez, Richard Ruback, David Scharfstein, Andrei Shleifer, Nathan Sosner, Eric Stafford, Jeremy Stein, Peter Tufano, Josh White, Jeffrey Wurgler, and seminar participants at Harvard, Emory, the University of Southern California, Dartmouth, the University of Illinois Urbana-Champaign, and the London Business School for their comments. Financial support from the Division of Research of the Harvard Graduate School of Business Administration is gratefully acknowledged.

I. Introduction

The relationship between interest rates and business investment is a topic of interest in macroeconomics and corporate finance alike. In frictionless capital markets, an increase in real interest rates leads to a decline in investment because firms discount new projects at a higher cost of capital. Controlling for opportunities, changes in real interest rates affect firms symmetrically.

A major shortcoming of the frictionless view is that it pays no attention to how firms actually raise capital, or have raised capital in the past. Firms with high levels of short-term debt, or with maturing long-term debt, for example, must refinance at market interest rates, while the debt service payments of firms with long-term debt are determined by interest rates at the time of issuance.

In a perfectly efficient capital market without financing constraints, Modigliani and Miller (1958) and Stiglitz (1974) prove that the source of financing is irrelevant, and changes in the cost of capital affect all firms symmetrically. They show that investment is independent of how financing is raised: it simply equates the marginal product of capital with the risk adjusted market rate of interest. However, recent research finds support for the existence of external finance constraints, even though there is some debate as to how best to identify them (see Fazzari, Hubbard and Petersen (1988), Hoshi, Kashyap and Scharfstein (1991), Whited (1992), and Kaplan and Zingales (1997, 2000)). These papers find that an important determinant of firm investment is the relative cost of different forms of financing. Related research shows that these costs have large effects on the composition of new finance (see Baker and Wurgler (2000) for evidence on equity versus debt issues, and Baker, Greenwood, and Wurgler (2002) for evidence on the maturity structure of debt issues).

This paper advances a simple theory by which changes in the cost of debt capital affect firm inventory and fixed investment, and tests the theory using annual investment data from U.S. manufacturing firms between 1953 and 2001. Holding leverage and the maturity structure of debt fixed, the theory compares financing cash flows between firms with short- and long-term debt. When interest rates increase, firms with short-term debt or long-term debt about to retire refinance at higher interest rates, while firms financed with long-term debt continue to pay interest at the old rate. Those firms financed with short-term debt suffer a decline in net worth because the present value of their debt liabilities is unchanged while the present value of growth opportunities has declined. Thus, these firms see their balance sheet deteriorate, in contrast to firms financed with long-term debt or equity, which experience equal declines in the present value of assets and liabilities. If firms' ability to borrow hinges on net worth, then firms with high levels of short-term debt reduce investment relative to the frictionless benchmark. I call the the interaction between maturity structure of debt and interest rates the debt market financing channel.

I test the theory by studying capital expenditure and inventory investment in a large panel of U.S. manufacturing firms between 1953 and 2001. Controlling for firm- and industry-level investment determinants, I find that firms with debt retiring after increases in nominal interest rates tend to have lower investment than firms without short-term liabilities. Second, I find that within groups of firms with similar leverage, those with more short-term debt relative to long-term debt decrease investment more.

The empirical results are subject to two general sets of explanations. Either financial structure causes the sensitivity of investment to interest rates, or financial structure and the response of investment to interest rates are jointly determined by another factor. In the latter explanation, unanticipated cash flows arising from past financing decisions have no influence on future investment. This implies that the high investment-interest rate sensitivity I detect among firms with short-term debt— that I attribute to financing constraints— must be due to mismeasurement of what investment *would have been* if these firms had been financed in a different way in the past. It is possible, for example, that the maturity structure of debt is *chosen* by firms to be optimal in the face of changing business conditions. In other words, firms choose short-term debt because they anticipate reducing desired investment when interest rates go up.[1]

In my paper, concerns about endogeneity are mitigated by a number of factors. First, I study the effect of unanticipated changes in nominal interest rates on investment. This means that differentials in cash flows arising from past maturity structure decisions are unanticipated. Second, the basic results hold when I focus on the much narrower maturity measure which excludes short-term debt and studies only the fraction of long-term debt due to retire. Thus ignoring short-term debt entirely, I find that firms with relatively large current portions of long-term debt reduce investment more after increases in nominal interest rates. Third, I attempt to control for the endogeneity of maturity structure by doing two-stage regressions, in which I first estimate the determinants of corporate debt maturity (following Barclay and Smith (1995)), and then estimate the sensitivity of investment to changes in nominal interest rates, sorting firms based on deviations from optimal debt maturity. Finally, in robustness checks, I control for industry-year-level determinants of investment and maturity structure. Since most theories of maturity structure predict similar maturity schedules for firms in the same industry, these controls capture a large amount of endogenous variation in the financing variables.

The results in this paper are consistent with the well-established balance sheet channel of monetary policy (Bernanke and Blinder (1995), Bernanke, Gertler and Gilchrist (1996)). Broadly defined, this theory asserts that changes in credit market conditions arising from monetary policy may be accelerated by changes in the financial position of firms, which in turn affect firms' investment and spending decisions. The balance sheet channel has been used to explain several features of economic activity not captured by rational business cycle models, such as differences in the performance of large and small firms during recessions. I depart from their framework because I do not attempt to identify the source of variation in interest rates and

[1] For similar arguments on the endogeneous relationship between firm performance and capital structure, see Kovenock and Phillips (1997), Zingales (1998) and Campello (2003)).

instead focus narrowly on the differential in financing cash flows between firms with different debt maturity schedules. Nevertheless, the results in this paper have implications for monetary policy and business cycle analysis.

My results also complement recent research in corporate finance that finds that fixed investment may depend on the cost of equity finance through a financing channel (Bosworth (1975), Morck, Shleifer and Vishny (1990), Blanchard, Rhee and Summers (1993) and in particular Stein (1996)). Baker, Stein and Wurgler (2002) find that the investment of firms that rely on equity finance is more sensitive to Tobin's *Q* than firms without financial constraints.

The paper proceeds as follows. The next section describes a model of investment when a portion of debt is due for refinancing. Section III describes the data. Section IV analyzes firm investment and debt maturity structure during the 1982 recession, an episode during which both nominal and real interest rates were abnormally high. Section V presents the empirical results on a large panel of firms between 1953 and 2001. Section VI examines alternative hypotheses. Section VII concludes.

II. A model of a debt financing channel

This section lays out a simple model in which the retirement of debt exacerbates increases in interest rates by reducing the present value of a firm's liabilities relative to the present value of its assets. This reduction serves as a change in the value of collateral available to lenders. While the mechanism relies on a reduction in the value of collateral, many models in which external finance is costly will deliver the same predictions (see Stein (2002) for a synthesis). The model has the feature that new lenders, who are junior to existing debt-holders, are unwilling to extend new funds after reductions in net worth, because the firm is unable to guarantee repayment in the next period. This is the classic debt overhang problem, first described in Myers (1977). Thus reductions in cash flows due to the interaction of interest rates and past financing decisions, influence investment through their effects on borrower net worth.

The basic model is also suitable for understanding the effects of changes in expected inflation (ie, changes in the nominal interest rate, holding the real interest rate fixed) on firms with short- or long- term debt.

a. A model of investment and refinancing

The basic result can be illustrated by a simple example, which loosely follows Bernanke, Gertler and Gilchrist's (1996) treatment of Kiyotaki and Moore (1995). There are two periods, 0 and 1. An entrepreneur in period 0 has access to a technology f that takes a variable input x. Output in period 1 is given by $f(x)$, where $f(\bullet)$ is increasing and concave.

Assume that the entrepreneur begins period 0 with no cash but a positive debt burden, the result of past debt obligations.[2] To consider the effect of shifting debt from short- to long-term, I assume that existing debt has a face value $b_0 \geq 0$, of which a fraction γ ($0 \leq \gamma \leq 1$) matures in period 0 with value $\gamma r_0 b_0$, and a fraction $(1-\gamma)$ matures in period 1 with period 1 value $(1-\gamma) r_0^2 b_0$, where r_0 denotes the gross interest rate at time of borrowing. It is a critical assumption that from period 0, the maturity structure of debt obligations is exogenous, even though it may have been optimal ex-ante.[3]

Since the entrepreneur has no cash and must refinance her maturing debt, investment x is linked to new borrowing b_1 by

$$x = b_1 - \gamma r_0 b_0 \qquad (1)$$

[2] In principle, the firm could hold cash in period 0, in which case the period 0 debt burden would be reduced by current cash holdings. This has no qualitative effect on the results.

[3] A multitude of theories derive the optimal maturity structure of debt. Guedes and Opler (1996) group these hypotheses according to liquidity risk (Sharpe(1991), Diamond (1991), and Titman (1992)), agency costs of debt (Myers (1977)), tax benefits (Brick and Ravid (1985)), and asymmetric information (Diamond (1993)). In addition, Baker, Greenwood and Wurgler (2002) suggest that past market timing may be an additional determinant of the cumulative maturity structure outcome.

Contracting works as follows. Following Hart and Moore (1994), it is costly for the lender to seize all of the entrepreneur's output in case of default, but it is not costly to enforce a contract that transfers a fraction θ $(0 \le \theta \le 1)$ of output *f(x)* to the borrower.

Lenders in period 0 will provide new funds up to the discounted value of the pledged portion of investment income, net of promised payments to date 0 investors:

$$0 \le b_1 \le \frac{\theta f(x) - (1-\gamma) b_0 r_0^2}{r_1} \tag{2}$$

Substituting (1) into (2) gives:

$$x - \frac{\theta f(x)}{r_1} \le \frac{-(1-\gamma) b_0 r_0^2}{r_1} - \gamma r_0 b_0 \tag{3}$$

The entrepreneur chooses x in period 0 to maximize output in period 1 net of repayment of the old and new debt, subject to the borrowing constraint given by (3).

There are two solutions. In the first, if θ is very high relative to the debt burden, then the borrowing constraint is not binding and investment is at the first best level given by $f'(x) = r_1$. In the second, the constraint is binding, and so (3) holds with equality. When (3) holds

$$\frac{\partial x}{\partial r_1} = \frac{(1-\gamma) b_0 r_0^2 - \theta f(x)}{r_1 (r_1 - \theta f'(x))} \ge 0 \text{ since } \theta f'(x) < r_1 \text{ if (3) is binding and } (1-\gamma) b_0 r_0^2 - \theta f(x) \ge 0$$

$$\frac{\partial^2 x}{\partial r_1 \partial \gamma} = \frac{-b_0 r_0^2}{r_1 (r_1 - \theta f'(x))} < 0$$

$$\frac{\partial^3 x}{\partial r_1 \partial \gamma \partial b_0} = \frac{-r_0^2}{r_1 (r_1 - \theta f'(x))} < 0$$

The first equation says that investment is increasing in r_1: increases in interest rates relax the borrowing constraint by reducing the present value of long-term debt. The second equation says that increases in r_1 lead to less investment for firms with high γ. This is the basic result of the model. Further, holding γ fixed, increases in leverage reduce the collateral of the firm, thus reducing investment. To summarize, holding leverage fixed, firms with a greater short-term component of debt should reduce investment more when interest rates rise. Second, the differential between firms with short- and long-term debt should grow as leverage increases.

So far, I have used a simple model of debt overhang to understand the effects of changes in *real* interest rates on firms with different debt maturity schedules. However, debt contracts are rarely denominated in real terms. Fortunately, the above results also apply to changes in nominal interest rates when the nominal quantity of debt is fixed. Holding the real interest rate and nominal total leverage fixed, firms with high nominal long-term debt burdens experience increases in wealth when inflation is unexpectedly high. If the borrowing constraint is binding in period 0, increases in expected inflation may increase investment. Similar to the previous case, the differential impact of inflation increases as we increase leverage.

b. Empirical implementation

The model predicts that interest rate conditions are more important for firms with high leverage, and even more so for firms with large amounts of short-term debt or long-term debt due for refinancing. This mechanism applies to all forms of investment, but may be especially important for components of investment with low adjustment costs.[4] In the remainder of the paper, I study inventory investment and capital expenditure separately, and I show that the main results hold with both measures.

The basic strategy is to see whether firms with high short-term debt burdens display higher sensitivity of investment to interest rates. I predict that for firms with high short-term debt levels, investment should decline more than the frictionless benchmark when the real interest rate or inflation is high. Since the nominal interest rate is equal to the product of the gross real interest rate and inflation, firms with high short-term debt levels should be *more* sensitive to *nominal* interest rates. I therefore use the nominal treasury bill yield as the baseline

---

[4] This argument closely follows Carpenter, Fazzari, and Petersen (1994), and is consistent with evidence in Kashyap, Lamont and Stein (1994). There is a large literature (e.g. Bils and Kahn (2001) and Ramey (1989, 1991)) analyzing fundamental determinants of inventory behavior.

measure of interest rates. The basic test is whether firms with more short-term debt show higher sensitivity to nominal interest rates and changes in interest rates. However, I later break the real long-term rate, and innovations in the real long-term rate, into its short-term real rate, inflation, and term spread components. In multivariate regressions, I examine the sensitivity of investment to these measures of interest rate conditions across short-term debt quartiles.

I test the presence of a debt financing channel against the null hypothesis that past financing decisions are irrelevant for future investment. In the model, investment opportunities, as well as the maturity structure of debt are held fixed. Therefore, after establishing the basic result, I relax assumptions concerning the exogeneity of the maturity structure of debt by introducing various controls.

The model assumes that the cost of short-term debt is determined by short-term nominal interest rates. In reality, firms may choose to hedge their interest rate exposure by purchasing swaps or by tying their long-term debt interest payments to floating rates. Guntay, Prabhala and Unal (2002) show that small firms are more likely to hedge interest rate risk by using call options on bonds. Some firms may even index interest payments to inflation, though this is rare in practice. Cash flow hedging of interest rate risk clearly reduces the effect that changing debt interest rates may have on investment, and thus would attenuate the results, if anything. Moreover, swaps and other instruments needed to hedge interest rate risk were largely unavailable before 1982 while the basic results hold in both halves of the sample.

As a final note, the model assumes that the maturity structure of debt should affect interest rate sensitivity of investment, conditional on the budget constraint binding. In other words, the effect should arise only for financially constrained firms. As a practical matter, however, leverage may be difficult to disentangle from other measures of financial constraints (see Kaplan and Zingales (1997)). Nevertheless, in the empirical implementation it will be important to check that the results are stronger among firms identified as "financially constrained". I perform this check with an off the shelf measure of financial constraints developed by Kaplan and Zingales (1997).

III. Data

a. Interest rates and inflation

Debt market conditions are represented by three variables: the nominal short-term rate, the term spread, and inflation. The nominal short-term rate (y_{GSt}) is the annualized yield of the three-month treasury bill, recorded at the end of each month. I also use the annualized Federal Funds rate ($ffunds_t$) as an alternate measure of the short-term nominal rate. Its advantage is that it is widely recognized as an indicator of the stance of monetary policy. On the other hand, the treasury bill yield is perhaps a better indicator of the actual cost of funding for commercial borrowers. The results do not hinge on which one of these variables is used.

Inflation (π_t) is calculated as the annual percentage change in the Consumer Price Index. Expected inflation in year t is measured alternately as realized inflation in year $t+1$ (π_{t+1}), or as the mean forecast of expected inflation from the Livingston Survey taken in June of each year (π_{Et}).[5] The short-term real rate is calculated as the difference between the treasury bill yield in year t and forecast expected inflation in year $t+1$ ($y_{GSt} - \pi_{Et}$), or as the difference between the treasury bill yield in year t and realized inflation in year $t+1$ ($y_{GSt} - \pi_{At+1}$). The term spread ($y_{GLt} - y_{GSt}$) is the difference between the Treasury bond yield and the annualized Treasury bill return. All of the above data series are based on Ibbotson (2001).

Debt market conditions are summarized in Table 1 and Figure 1. Panel A of Figure 1 reveals a loose negative correlation between the term spread and the treasury bill yield. It also

[5] The Livingston survey begins 1946 and summarizes the forecasts of economists from industry, government, banking, and academia. Data are available from the Federal Reserve Bank of Philadelphia at http://www.phil.frb.org/files/liv/datai.html. Because the data are not available monthly, I match treasury bill rates with expected inflation measured the previous June. As a result, this measure of expected inflation is stale for firms with non-June fiscal years. Realized inflation in the following year is thus my preferred measure of expected inflation.

displays the inversion of the yield curve at several points during the 1970s. Term spread inversions appear to portend recessions (Fama and French (1989)). Panel B shows the real short-term rate, calculated alternately as the difference between the treasury bill yield and forecast inflation and the difference between the treasury bill and realized inflation. The figure shows significant variation in the real interest rate.

Table 1 also reveals high variation in inflation and the short-term real rate. In particular, the treasury bill yield ranges from 1.00% in 1954 to a high of 16.86% in December 1980. Using the Livingston measure to adjust for inflation expectations, this gives a range from –2.51 to 8.82 percent in the real short-term rate.

Although the theory suggests the lagged nominal interest rate as the suitable independent variable, it displays a high degree of autocorrelation, which may bias estimates of interest rate sensitivity and the statistical significance I ascribe to these estimates (see West (1988), Stambaugh (1999)). As consequence, Table 1 also reports summary statistics for the innovations of the raw series, calculated as the difference of each series with its 12-month lag. For the remainder of the paper, these differences are the relevant right-hand-side variable.

b. Investment, financing, and debt maturity

I collect annual investment data from Compustat according to the following procedure.[6] I start with all manufacturing firms reporting complete data on inventory levels, lagged inventory levels, sales, capital expenditures, assets, and lagged assets between 1953 and 2001. Since my tests require me to hold leverage fixed, I restrict attention to firm-years in which debt at the end of the previous year was positive. To select only manufacturing firms, I follow industry

[6] Although quarterly data is available for a subset of the firms in my sample, only a small fraction report full data on the accounting variables required in this study. More importantly, accurate quarterly data is unavailable before 1975, thereby eliminating a large amount of variation in interest rate conditions.

definitions in Fama and French (1997).[7] I also draw a second sample that includes retail (SIC Codes 5200-5299) and wholesale (SIC 5000-5199) firms.[8]

I follow Kasyhap, Lamont and Stein (1994) and measure inventory investment as the change in the log of total inventories (Compustat item 3). I control for the lagged inventory to sales ratio, calculated as inventories divided by net sales (item 12). Fixed investment is measured alternately as capital expenditures (item 128) or the change in net assets (item 6), both scaled by lagged net assets. Operating cash flow (CF_t/A_{t-1}) is defined as net income (item 14) plus depreciation and amortization (item 18), also scaled by lagged assets. *Q* is the market value of equity at the end of the fiscal year, plus assets (item 6) minus the book value of equity (item 60 + item 74), all over assets. Since Compustat provides the book value of equity starting in 1963, *Q* is only available between 1963 and 2001 and the capital expenditure regressions are computed on the shorter panel.

I drop firm-years that report sign of merger or takeover activity, or when the firm reports non-zero debt in a finance subsidiary, since these are likely to give distort my balance sheet and investment measures.[9] To reduce the presence of outliers, I winsorize all of the firm-level data at the 1% and 99% levels.

Panel A of Table 2 summarizes the investment data. In total, there are 45,376 observations. The later sample years are more heavily represented (unreported), but there are more than 150 observations in every year, and more than 250 observations in every year after 1961. The table shows that the change in log inventories has been positive, on average, between 1953 and 2001. More importantly, changes in inventory are very volatile, especially in comparison with capital expenditure, but even in comparison with the change in net assets.

---

[7] From the 48 Fama & French (1999) industries, my sample includes food, soda, beer, smoke, toys, books, household consumer goods, clothes, medical equipment, drugs, chemicals, rubber and plastic products, textiles, construction materials, steel, fabricated products, machinery, electrical equipment, automobiles, aircraft, ships, guns, computers, electronic equipment, measuring and control equipment, business supplies, and shipping containers.
[8] Blinder and Maccini (1991) report that firms of this type hold a modest fraction of total inventories.
[9] I drop all observations for which Compustat item 129 (Acquisitions) is non-zero.

Tests of the theory require a number of measures of the structure of the balance sheet. I collect total debt D_{t-1}/A_{t-1} (item 34 + item 9), as well as short-term debt D_{St-1}/A_{t-1} (item 34), both scaled by assets (item 6). Short-term debt contains both the current portion of long-term debt and notes payable.[10] As an alternate measure, I use short-term debt net of cash and other marketable securities (item 1), scaled by assets (D^*_{St-1}/A_{t-1}). Finally, I calculate the ratio of the current portion of long-term debt, scaled by assets ($D_{Curr,t-1}/A_{t-1}$).

Since most of my tests require that I hold leverage fixed, I also construct measures of debt maturity that are independent of the *level* of debt. I construct the short-term share (D_{St-1}/D_{t1}), the short-term share net of cash (D^*_{St-1}/D_{t-1}), and the current share of long-term debt in total long-term debt ($D_{Curr,t-1}/D_{Long,t-1}$). The last measure is the percentage of long-term debt that must be refinanced in order to hold total long-term leverage fixed. The advantage of this variable vis-à-vis the short-term share is that it does not reflect debt that was originally short-term. Unfortunately, this measure of debt maturity is not available for as many firm years as the other measures because Compustat does not reliably distinguish between notes payable and the current portion of long-term debt in the early years of the sample. When available, this measure is approximately 65% correlated with the short-term share.

Panel C of Table 2 describes these balance sheet ratios. The typical firm has debt over assets ratio of about 20%, and in the typical year, about 33% of debt is short-term. It is important to note that the short-term share in new issues has been growing in the latter half of the sample (see also Baker, Greenwood, Wurgler (2003)). I account for the possibility of time-series trends in the maturity of new issues by sorting short-term debt *within* years.

To form the panel, I match each firm-year with innovations in real and nominal interest rates during the previous fiscal year. Thus for firms with fiscal years ending in December,

---

[10] Compustat defines "notes payable" (item 206) as the total amount of short-term notes, including bank acceptances, bank overdrafts, commercial paper, construction loans, debt due on demand, due to factor if interest bearing, interest payable, debt in default, lines of credit, loans payable to officers of the company, loans payable to parents or subsidiaries, loans payable to stockholders, and notes payable to banks and others.

innovations in nominal short-term rates are measured as the difference between nominal interest rates at the beginning of the year and interest rates at the beginning of the previous year. Slightly more than half of the firms in the sample have fiscal years ending in December.

IV. Investment and debt maturity during the 1982 recession

Before proceeding with analysis on the entire panel, it is worthwhile to briefly focus on the 1981-82 recession. The benefit of studying a single episode is that it allows for a simple illustration of the results. More importantly, there is a strong consensus among economists that 1982 was a monetary recession in that it came about because of an exogenous change in Fed policy.

Figure 1 shows that the short-term rate reached record highs in 1980 and 1981. The treasury bill peaked at 16.81% in December 1980, and remained high for the next few years. Figure 1 also shows that inflation was declining during this time, implying that the real rate was at an unprecedented high. This appears to be a good candidate for application of the theory.

The model predicts that when nominal interest rates are high, firms with high short-term debt reduce investment more than firms financed with long-term debt or with equity. Figure 2 takes a closer look at this prediction. I draw a subset of my larger sample that contains the 1279 firms with complete data in 1982, and sort these firms into quartiles based on their level of short-term debt at the end of the 1981 fiscal year. I measure short-term debt as the sum of notes payable and the current portion of long-term debt, scaled by assets (D_{St-1}/A_{t-1}), or as the short-term debt ratio (D_{St-1}/D_{t-1}). Investment is measured as capital expenditures ($CAPX_t/A_{t-1}$), the change in log ($\Delta Log(Inv)_{it}$) inventories, or the change in net assets ($\Delta A_t/A_{t-1}$).

Panel A shows average capital expenditures in 1982 for each short-term debt quartile. Sorting first short-term debt scaled by assets (solid), the figure shows investment declining uniformly across quartiles. The panel shows average investment when quartiles are formed based on the ratio of short-term debt to total debt, a scale-free measure of the liability structure of debt. Thus among firms with similar leverage, those with shorter-term maturity reduced investment more during this period of high nominal interest rates.

Panel B analyzes inventory investment. As in Panel A, investment declines across quartiles when I sort by the short-term debt over total assets. When I sort by the short-term debt to total debt ratio, there remains a significant relationship between firms in the first and last quartiles.

Panel C analyzes the change in net assets, the broadest measure of investment. Again, investment declines uniformly across short-term debt quartiles.

Figure 2 presents intriguing preliminary evidence of a relationship between changes in interest rates, the maturity structure of debt, and firm investment. But these univariate relationships omit important firm level determinants of investment. More importantly, even controlling for other investment determinants, the cross-sectional results may be consistent with other theories. For example, the negative relationship between short-term debt and investment may not be particular to 1982, or may be associated with a *planned* reduction in investment. In this case, firms with short-term debt will always have lower investment than firms with long-term debt or equity, independently of whether interest rates are high or low. It is impossible to account for this effect in a single cross-section, but it can be easily incorporated in a study of a panel of firms.

V. Investment and debt maturity 1953-2001

This section studies inventory investment and measures of fixed investment as a function of interest rates and the maturity structure of debt on an unbalanced panel of firms, and relates these results to the theory presented in section II. The next section considers the leading alternative explanation for the results.

I begin with baseline specifications that control for non-financial determinants of fixed and inventory investment, together with lagged nominal interest rates. Sorting on measures of short-term debt, I explore the interaction between short-term debt and exposure to nominal interest rates, as discussed in the theory. After establishing the basic result, I explore finer predictions of the model, and study the components of the *real* long-term interest rate separately.

a. Fixed investment: basic results

I first consider fixed investment. Figure 3 shows the time series of average fixed investment, measured as capital expenditures, by short-term debt quartile. Quartiles are formed by sorting observations based on lagged measures of short-term debt *within* each year. The advantage of this technique when compared with sorting the entire sample is that I avoid the possibility of capturing time series trends in the average maturity of debt.

In Panel A, short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by lagged assets. In Panel B, short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by total debt. This measure of maturity structure is unrelated to the total quantity of leverage.[11] The shaded bars indicate NBER recessions, defined by the NBER business cycle dating committee. In both panels, the difference in investment between firms with short- and long-term debt appears to grow during recessions.

To analyze this result more carefully, I estimate a single panel regression of capital expenditure on cash flows and lagged Tobin's Q ratio, including a measure of lagged nominal interest rates on the right hand side

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + \cdot\sum_{j=1}^{4}\sum_{k=1}^{2} d_{jk} 1_{i\in Q(j,k)} \cdot y_{GSt-1} + u_{it} \tag{4}$$

To estimate this regression, I sort firms into quartiles based on total leverage in the previous year. Within each leverage quartile, I next sort firms based on whether they are above or below

[11] In fact, the two measures are slightly negatively correlated since firms with heavy debt burdens tend to have disproportionately long-term debt.

median debt maturity in that year. Each year, a firm thus belongs to one of eight possible categories, denoted $Q(j,k)$, ranging from low leverage and longer-term maturity structure (i.e. low D_{St-1}/D_{t-1}) to high leverage and short-term maturity structure (i.e. high D_{St-1}/D_{t-1}). I then estimate equation (4) interacting dummy variables for each group ($1_{i \in Q(j,k)}$) with innovations in lagged nominal interest rates (y_{GSt}). The resulting coefficients (d_{jk}) can be interpreted as the sensitivity of investment to interest rates for firms of a given leverage and debt maturity. Although slightly cumbersome, this technique allows me to hold leverage fixed without imposing a specific functional form on the relationship between investment sensitivity, leverage, and maturity structure.

The reader will note that equation (4) also includes firm dummies, contemporaneous operating cash flow, and lagged Q. These standard controls are designed to capture firm- and firm-year specific determinants of the investment opportunity set (see Fazzari, Hubbard and Petersen (1988)).

Panel A shows the basic results of the double sort by leverage and debt maturity. In the first leverage quartile, capital expenditure is positively related to changes in nominal interest rates, with no significant difference between short- and long-term debt. As leverage increases, however, the difference in sensitivities between firms with short- and long-term debt grows. In the second leverage quartile, for example, the coefficient falls from 0.19 for firms with longer-term debt to –0.02 for firms with shorter-term debt. The difference of –0.24 is highly significant. The importance of this difference can be understood by noting that the historical standard deviation of nominal interest rates is about 3%. Therefore, a one standard deviation increase in the nominal interest rate reduces capital expenditure in firms with high short-term debt by about 0.75% more than firms in the first short-term debt quartile.

The second panel of Table 3 repeats the estimation, this time sorting first by the Kaplan and Zingales (1997) measure of financial constraints, and then by the short-term debt ratio within each quartile. The results strengthen somewhat, revealing that for firms with greater financial constraints, the distinction between short- and long-term leverage is crucial as it determines the sensitivity of their investment to changes in credit conditions.

There is a concern that in both Panel A and Panel B, I may be sorting on a measure of short-term debt that is correlated with investment opportunities, leaving the results open to a number of other explanations.[12] This return is reduced by ignoring short-term debt altogether and focusing only on the current portion of long-term debt. Put simply, I ask whether firms that retire large amounts of long-term debt when interest rates are high, cut their inventory investment relative to firms with comparable investment opportunities.

Panel C attempts to answer this question. I sort firms first by long-term leverage and then by the ratio of current long-term debt to total long-term debt. The difference between quartiles holds as before, and the results strengthen significantly for the highest leverage quartile.

b. Inventory investment: basic results

I next consider the sensitivity of fixed investment to innovations in lagged nominal interest rates. Figure 4 shows the time series of average inventory investment, measured as the change in log total inventories, by short-term debt quartile. As before, quartiles are formed by sorting firms on lagged measures of short-term debt *within* each year.

In Panel A, short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by lagged assets. In Panel B, short-term debt is measured as the short-term debt ratio. Similar to the results for fixed investment, I find that sorting by either measure of debt maturity, the difference in inventory investment between firms with short- and long-term debt appears to grow during recessions.

---

[12] See Section V.

To analyze this result more carefully, I estimate a single panel regression of capital expenditure on cash flows and lagged Tobin's *Q* ratio, including a measure of lagged nominal interest rates on the right hand side

$$\Delta LOG(Inv)_{it} = a_i + b \cdot LOG(Inv / Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + \sum_{j=1}^{4} \sum_{k=1}^{2} d_{jk} 1_{i \in Q(j,k)} \cdot y_{GSt-1} + u_{it} \quad (5)$$

Table 4 shows these results. Excluding interest rates from the right-hand-side, this specification follows directly from Kashyap, Lamont and Stein (1994) in their analysis of inventory investment during the 1982 recession. It is easy to rearrange terms and see that it estimates an autoregressive model of inventory stocks, with changes driven by increases or decreases in sales (see also Lovell (1961) for motivation of this framework. [13])

Panel A shows the basic results of the estimation performed with firms double sorted by leverage and debt maturity. In the first leverage quartile, inventory investment is positively related to nominal interest rates, with no significant difference between short- and long-term debt. As leverage increases, however, the difference in sensitivities between firms with short- and long-term debt grows. In the second leverage quartile, for example, the coefficient falls from 0.65 for firms with longer-term debt to –0.18 for firms with shorter-term debt. The difference of –0.83 is highly significant. Recalling that the historical (annual) standard deviation of nominal interest rates is about 3%, a one standard deviation increase in the nominal interest rate reduces inventory investment in firms with high short-term debt by about 2.5% more than firms in the first short-term debt quartile.

It is interesting to note that not only is inventory investment more sensitive to changes in lagged nominal interest rates, but the differential in interest rate sensitivity between firms with short- and long-term debt is both economically and statistically more meaningful than the same

---

[13] Inventory investment may also increase or decline because of unplanned changes in sales. This does not affect the interpretation of the results as long as the unplanned component of investment is uncorrelated with the maturity of debt.

differential with respect to fixed investment. This is consistent with the intuition that firms have more flexibility in adjusting inventory stocks than in adjusting the level of capital expenditure. It is also consistent with the view, first put forth in Kashyap, Lamont and Stein (1994), that financial constraints help explain the large changes in inventory investment historically observed during recessions.

c. Controlling for endogeneity: Two-stage regressions

Although the basic results shown in Tables 3 and 4 are consistent with my model, they may also be consistent with a theory in which debt maturity is endogenously related to the investment sensitivity to interest rates. To reduce this concern, I implement a two-step procedure in which I analyze the difference in investment sensitivity to interest rates as a function of deviations from optimal debt maturity. This is done as follows. In the first stage, I estimate an OLS regression of the short-term debt ratio on a constant, the market-to-book ratio, the log of firm assets, and a firm dummy. Following Barclay and Smith (1995), I select the market-to-book ratio and size as the most important determinants of debt maturity.[14] By including firm dummies, I additionally allow every firm to have its own optimal short-term debt ratio.

In the second stage, I calculate the difference between actual short-term debt ratio in any given year and the predicted short-term debt ratio from the first stage regression. The difference measures the deviation of the firm's debt maturity structure from *desired* debt maturity structure. I predict that firms that deviate from their optimum in the direction of short-term debt are more likely to cut investment following increases in interest rates, especially when compared with firms that deviate in towards holding too much long-term debt. I therefore sort firms first by

---

[14] I omit their regulatory dummy because there is no conceivable reason why regulation would dictate *optimal* maturity structure.

leverage, then by the deviations from optimal maturity structure. As before, I estimate the panel regression

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + \sum_{j=1}^{4}\sum_{k=1}^{2} d_{jk} 1_{i \in Q(j,k)} \cdot y_{GSt-1} + v_{it} \tag{6}$$

Panel B of Table 5a shows the results of the second stage regression for fixed investment. Panel B of Table 5b shows the same results for inventory investment. In both cases, the results hold as before, while the main results for inventory investment become stronger after this adjustment.

d. Other components of interest rate conditions

The theory predicts that the investment of firms with high levels of short-term debt should decline, relative to the frictionless benchmark, after increases in the real rate and increases in inflation for firms with high short-term debt levels. A meaningful decomposition of the nominal interest rate is thus to break it into its short-term real, term spread, and expected inflation components. Specifically, Table 6 repeats the baseline regression from Table 3 and Table 4, but breaks the long-term real rate into these components on the right hand side of the regression. I sort firms as before, and estimate

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + \sum_{j=1}^{4}\sum_{k=1}^{2}\left[e_{jk} 1_{i \in Q(j,k)} (y_{GSt-1} - \pi_{t-1}) + f_{jk} 1_{i \in Q(j,k)} (\pi_{t-1}) + g_{jk} 1_{i \in Q(j,k)} (y_{GLt-1} - y_{GSt-1})\right] + u_{it} \tag{7}$$

for capital expenditure and

$$\Delta LOG(Inv)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + \sum_{j=1}^{4}\sum_{k=1}^{2}\left[e_{jk} 1_{i \in Q(j,k)} (y_{GSt-1} - \pi_{t-1}) + f_{jk} 1_{i \in Q(j,k)} (\pi_{t-1}) + g_{jk} 1_{i \in Q(j,k)} (y_{GLt-1} - y_{GSt-1})\right] + u_{it} \tag{8}$$

for inventory investment.

Table 6 reports the results for capital expenditure. I measure expected inflation as the realized inflation one-year forward, and calculate the real short-term rate as the difference between the Treasury bill yield and expected inflation. The panel shows that firms with high levels of short-term debt are more sensitive to both the real and nominal components of interest rates. In the second leverage quartile, for example, the coefficient on the real interest rate falls from 0.34 for firms with low short-term debt ratios to 0.01 for firms with high short-term debt ratios. More interesting, however, are the results on inflation. In the same debt quartile, the coefficient on inflation falls from 0.44 to 0.04, a (significant) difference of –0.40 between quartiles.

Panel B repeats these investment regressions sorting first by financial constraints then by short-term debt ratio. Panel C repeats these regressions again, this time ignoring short-term debt and sorting first by long-term leverage then by the ratio of the current portion of long-term debt to total long-term debt. These results are stronger than in the other two panels, particularly for firms in the highest long-term debt quartile.

Table 7 repeats the basic tests performed in 6 for inventory investment. As in Table 4, the results are significantly stronger than for fixed investment. Examining the coefficients in the high leverage quartile in Panel A, for example, the sensitivity of investment to the real interest rate falls from 0.98 for firms with longer-term leverage to –1.24 for firms with short-term leverage. These same patterns are repeated for the sensitivity of investment to innovations in inflation and the term spread.

Finally, in Table 8, I repeat the two-step procedure implemented in Table 5, breaking apart the long-term nominal interest rate into its short-term real, expected inflation, and term spread components. Table 8a shows the results of the second stage regressions for capital investment, while Table 8b studies inventory investment. In both tables, firms with high short-term debt burdens display significantly higher sensitivity to increases in the real interest rate, inflation, and the term spread.

VI. Discussion

The fact that firms with large amounts of short-term debt are significantly more sensitive to interest rate conditions adds an important fact to corporate finance. While the results support my model, they may be also be consistent with a theory in which firms with short-term debt are more sensitive to changes in interest rates because the maturity structure of debt is endogenously related to the sensitivity of investment to interest rates.

This section discusses evidence for this theory, then returns to evidence for the specific mechanism suggested by my model.

The null hypothesis is that interest rates affect firms symmetrically, correctly controlling for opportunities. To the extent that my empirical results identify a link between debt maturity and the sensitivity of investment to interest rates, it is because debt maturity is related to opportunities not controlled for in my regressions. More generally, this theory says that cross-sectional variation in debt maturity may rationally be linked to time series variation in interest rates, or business conditions.

I consider several variants of this story. Firms may finance the most volatile components of investment, such as inventories, using short-term debt in an effort to match the maturity structure of debt with the maturity structure of assets. Inventories decline for business cycle reasons when interest rates are high, creating a rational connection between declines in inventory investment and high levels of short-term debt. This story also associates high *levels* of inventories with high levels of short-term debt.

There is enough evidence to dismiss this view. First, while high levels of inventories are positively correlated with the fraction of short-term debt, the correlation is only 10%. Second, although many managers claim to match the liability structure of assets with the maturity of debt (Graham and Harvey (2001)), there is little empirical evidence that they are successful in this endeavor (see Guedes and Opler (1996) for evidence on this hypothesis). Third, the baseline inventory investment regression estimates changes in the lagged inventory to sales ratio, effectively controlling for the level of inventories. In the capital expenditure regressions, it is hard to attribute short-term debt to maturity matching, since investment of this type tends to be long-term. Fourth, explanation 1 implies that the main results should weaken once I control for determinants of the *level* of short-term debt. However, in Table 3, I calculate short-term debt as a deviation from the industry-year mean and find that the results in fact grow statistically stronger.

I consider a second more general version of the frictionless story, in which opportunities are correlated with the interaction between nominal interest rates and debt maturity. First, I consider the obvious possibility that opportunities may be correlated at the industry level. I thus repeat the basline regressions demeaning all firm-level data by industry-year. Not surprisingly, the results hold as before. In other words, firms that have more short-term debt, relative to industry mean, experience larger declines in investment, relative to industry mean, when interest rates are high.

Ultimately, it is difficult to fully dismiss the possibility that there is an explanation for the results in which financing is frictionless, simply because I lack an instrument for debt maturity that is reliably unrelated to future investment opportunities. However, it is comforting that previous work on the maturity structure of debt shows that theoretically motivated determinants of optimal debt maturity have little explanatory power in the cross-section. Moreover, it is telling that the basic results hold within industries, as well as within firms. It is unlikely that any frictionless story survives these criteria.

Finally, although it is difficult to distinguish between the various possible mechanisms by which financing cash flows affect investment, there is some evidence outside of this paper that the right channel is through net worth. Although this is the first paper to study the differential effects of real interest rates on investment, the effects of expected and unexpected inflation on stock returns are well known (Kaplan (1977), Feldstein and Summers (1979)). Kessel (1956), Bach and Ando (1957), Alchian and Kessel (1959) and Hong (1977) study stock returns of net debtor and net creditor companies during periods with different inflation rates. They find that net debtor companies experience increases in net worth during periods of high inflation. However, French, Ruback and Schwert (1983) argue that previous studies do not distinguish between expected and unexpected inflation. They find little evidence that stockholders of net debtor firms benefit from unexpected inflation relative to the stockholders of net creditor firms, and conclude that the wealth effects of inflation are not an important factor explaining the behavior of stock prices. They argue that at least one explanation for their results may be that stockholders do not understand the effect of inflation on debt contracts (Modigliani and Cohn (1979)).

VII. Conclusions

This paper advances a simple theory of the mechanism by which changes in the cost of debt capital affect firm inventory- and fixed- investment, and tests the theory using annual investment data from U.S. manufacturing firms between 1953 and 2001. The theory says that increases in nominal interest rates decrease internal finance more severely for firms with large short-term debt obligations, simply because their obligations are tied to short-term nominal interest rates. Firms with short-term debt must continually re-enter the credit market for new financing, even if interest rates are high.

The basic finding is that controlling for sales and the lagged inventory to sales ratio, firms with debt about to retire after increases in nominal interest rates tend to cut inventory investment and capital expenditures more than firms without retiring debt. Second, within groups of firms with similar leverage, those with more short-term debt relative to long-term debt decrease investment more. Third, firms with high short-term debt display much higher sensitivity of investment to *both* nominal and real changes in short-term rates.

The results are largely inconsistent with the null hypothesis of frictionless capital markets, in which investment is independent of the form of financing. I conclude that the evidence favors my theory, but that other forms of the debt financing channel may exist. Irrespective of the interpretation, the results have important implications for monetary policy. To the extent that policy exerts its greatest influence on short-term nominal interest rates, it has significantly larger effects on firms with high levels of short-term debt.

References

Baker, Malcolm and Jeffrey Wurgler, 2000, The equity share in new issues and aggregate stock returns, *Journal of Finance* 55, 2219-2257.

Baker, Malcolm, Jeremy Stein, and Jeffrey Wurgler, 2001, When does the market matter? Stock prices and the investment of equity dependent Firms." NBER Working Paper Series, No. 8750.

Baker, Malcolm, Robin Greenwood and Jeffrey Wurgler, 2002, The maturity of debt issues and predictable variation in bond returns, forthcoming *Journal of Financial Economics*.

Barclay, Michael J., and Clifford W. Smith, Jr., 1995, The maturity structure of corporate debt, *Journal of Finance* 50, 609-631.

Bernanke, Ben S., 1982, The determinants of investment: Another look, *American Economic Review Papers and Proceedings* 73, 171-175.

Beranke, Ben S. and Mark Gertler, 1995, Inside the black box: The credit channel of monetary policy transmission, NBER working paper #5146.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist, 1996, The financial accelerator and the flight to quality, *The Review of Economics and Statistics* LXXVIII, 1-14.

Bernanke, Ben S, and Alan S. Blinder, 1988, Credit, money and aggregate demand, *American Economic Review, Papers and Proceedings* LXXVIII, 435-39.

Bernanke, Ben S, and Alan S. Blinder, 1992, The federal funds rate and the channels of monetary transmission," *American Economic Review*, LXXXII, 901-21.

Bosworth, Barry, 1971, Patterns of corporate external financing, *Brookings Papers on Economic Activity* 2, 253-279.

Mark Bils & James A. Kahn, 1999, What inventory behavior tells us about business cycles," Staff Reports 92, Federal Reserve Bank of New York.

Bach, G.L., and Albert Ando, 1957, The redistributional effects of inflation, *The Review of Economics and Statistics* 39(1), 1-13.

Brick, Ivan, and S. Abraham Ravid, 1985, On the relevance of debt maturity structure, *Journal of Finance* 40, 1423-1437.

Brick, Ivan, and S. Abraham Ravid, 1991, Interest rate uncertainty and the optimal debt maturity structure, *Journal of Financial and Quantitative Analysis* 26, 63-81.

Diamond, Douglas, 1991, Debt maturity and liquidity risk, *Quarterly Journal of Economics* 106, 709-737.

Eisner, R., and R.I. Nadiri, 1968, Investment behavior and neoclassical theory, *Review of Economics and Statistics* 50, 369-82.

Fama, Eugene and Kenneth French, 1989, Business conditions and expected returns on stocks and bonds, *Journal of Financial Economics* 25, 23-49.

Fama, Eugene F., and Kenneth R. French, 1997, Industry costs of equity, *Journal of Financial Economics* 43, 153-193.

Fama, Eugene F., and Michael R. Gibbons, 1982, Inflation, real returns and capital investment, *Journal of Monetary Economics* 9, 297-323.

Fama, Eugene F., and Robert Bliss, 1987, The information in long-maturity forward rates, *American Economic Review* 77, 680-692.

Fazzari, Steven, R. Glenn Hubbard , and Bruce Petersen, 1988, Financing constraints and corporate investments, *Brookings Papers on Economic Activity*, 141-95.

French, Kenneth R, Richard S. Ruback, and G. William Schwert, 1983, Effects of nominal contracting on stock returns, *Journal of Political Economy* 91(1), 70-96.

Gertler, Mark and R. Glenn Hubbard, 1988, Financial factors in business fluctuations, Financial market volatility (Kansas City: Federal Reserve Bank of Kansas City).

Graham, John R., and Campbell R. Harvey, 2001, The theory and practice of corporate finance: Evidence from the field, *Journal of Financial Economics* 60.

Guedes, Jose, and Tim Opler, 1996, The determinants of the maturity of corporate debt issues, *Journal of Finance* 51, 1809-1833.

Guntay, Levent, N.R. Prabhala and Haluk Unal, 2002, Callable bonds and hedging, mimeo University of Maryland.

Hart, Oliver and John Moore, 1994, A theory of debt based on the inalienability of human capital, *Quarterly Journal of Economics*, 109:841-79.

Hoshi, Takeo, Anil Kashyap and David Scharfstein, Corporate structure, liquidity and investment: Evidence from Japanese Industrial Groups, *Quarterly Journal of Economics*.

Kaplan, Robert S., 1977, Purchasing power gains on debt: The effect of expected and unexpected inflation, *Accounting Review* 52, 369-78.

Kaplan, Steven N., and Luigi Zingales, 1997, "Do investment-cash flow sensitivities provide useful measures of financing constraints?," *Quarterly Journal of Economics* 112, 169-215.

Kaplan, Steven N., and Luigi Zingales, 2000, "Investment-cash flow sensitivities are not valid measures of financing constraints," *Quarterly Journal of Economics* 115, 695-705.

Kashyap, Anil K, Jeremy C Stein, and David W. Wilcox, 1993, Monetary policy and credit conditions: Evidence from the composition of external finance" *American Economic Review,* LXXXIII, 78-98.

Kashyap, Anil K, Owen A Lamont and Jeremy C Stein, 1994, Credit conditions and the cyclical behavior of inventories, *Quarterly Journal of Economics*.

Kessel, Reuben A., 1956, Inflation-Caused Wealth Redistribution: A Test of a Hypothesis, *American Economic Review* 46,(1), 128-141.

Keynes, J. M. The general theory of employment, interest, and money. London: Macmillan 1936.

Lawrence, Colin and Aloysius Siow, 1985, Interest rates and investment spending: Some empirical evidence for postwar U.S. producer equipment, 1947-1980, *Journal of Business* 58(4), 359-375.

Lovell, Michael C., 1961, Manufacturers' inventories, sales expectations, and the acceleration principle, *Econometrica*, XXIX, 293-314.

Marsh, Paul, 1982, The choice between equity and debt: An empirical study, *Journal of Finance* 37, 121-144.

Modigliani, Franco, and Merton H. Miller, 1958, The cost of capital, corporation finance, and the theory of investment, *American Economic Review* 48, 655-669.

Modigliani, Franco and Richard Sutch, 1966a, Debt management and the term structure of interest rates: An empirical analysis of recent experience, *Journal of Political Economy* 75, 569-589.

Modigliani, Franco and Richard Sutch, 1966b, Innovations in interest rate policy, *American Economic Review* 56, 178-197.

Modigliani, Franco, and Cohn, Richard A., 1979, Inflation, rational valuation and the market, *Financial Analysts Journal* 35, 24-44.

Myers, Stewart, 1977, Determinants of corporate borrowing, *Journal of Financial Economics* 5, 147-75.

Opler, Tim, Lee Pinkowitz, Rene Stulz, and Rohan Williamson, 1999, The determinants and implications of corporate cash holdings, *Journal of Financial Economics* 52, 3-46.

Opler, Tim C. and Titman, Sheridan, 1992, The indirect costs of financial distress, mimeo, Cox school of Business, Southern Methodist University.

Sandmo, Agnar, 1970, Investment and the rate of interest, *Journal of Political Economy*,1335-1345.

Sharpe, Steven A., 1994, Financial market imperfections, firm leverage, and the cyclicality of employment, *American Economic Review* 84(4), 1060-1074.

Shiller, Robert J., 1996, Why do people dislike inflation? Christina Romer and David Romer (eds.), Reducing Inflation: Motivation and Strategy, National Bureau of Economic Research and University of Chicago Press.

Stambaugh, Robert F., 1999, Predictive regressions, *Journal of Financial Economics* 54 (3), 375-421.

Stein, Jeremy, 1989, Efficient capital markets, inefficient firms: A model of myopic corporate behavior, *Quarterly Journal of Economics* 104, 655-69.

Stiglitz, Joseph E., 1974, On the irrelevance of corporate financial policy, *American Economic Review* 64, 851-866.

Stohs, Mark Hoven, and David C. Mauer, 1996, The determinants of corporate debt maturity structure, *Journal of Business* 69, 279-312.

Taggart, Robert A., 1977, A model of corporate financing decisions, *Journal of Finance* 32, 1467-1484.

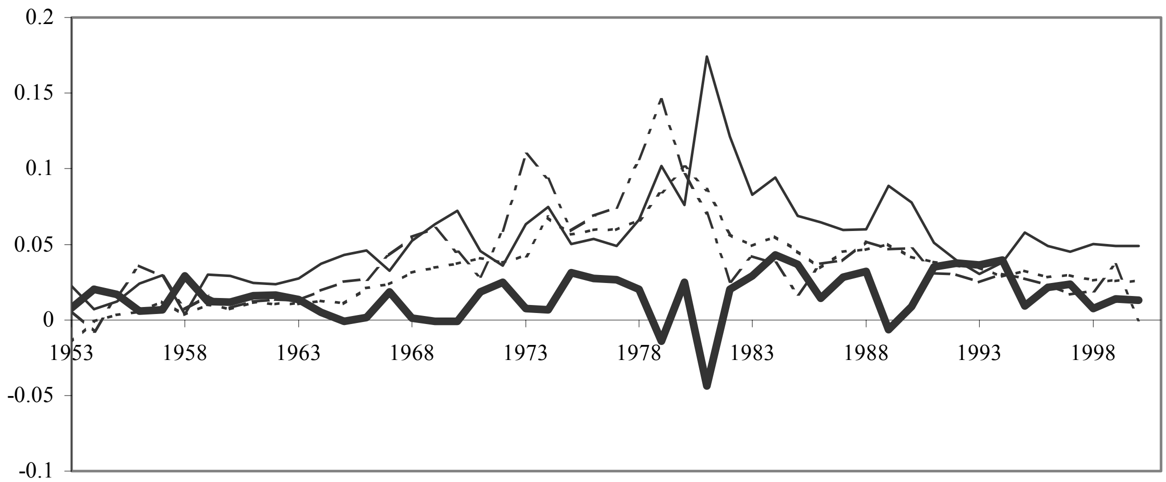
Titman, Sheridan, 2002, The Modigliani and Miller theorem and the integration of financial markets, *Financial Management* 31, 101-130.

West, Kenneth D., 1988, Asymptotic normality when regressors have a unit root, *Econometrica* 56(6), 1397-1417.

White, William L., 1974, Debt management and the form of business financing, *Journal of Finance* 29, 565-577.

Figure 1. Interest rate conditions 1953-2000. Panel A shows the annualized Treasury bill yield, the annualized term spread, and annualized expected inflation. Expected inflation is measured alternately as the average 12 month forecast inflation from the Livingston survey in June of the previous year, or as realized inflation one-year hence. Panel B shows the real short-term rate, calculated as the difference between the nominal treasury bill yield and expected inflation, measured in either of the two ways. All data come from Ibbotson (2001) and are summarized in Table 1.

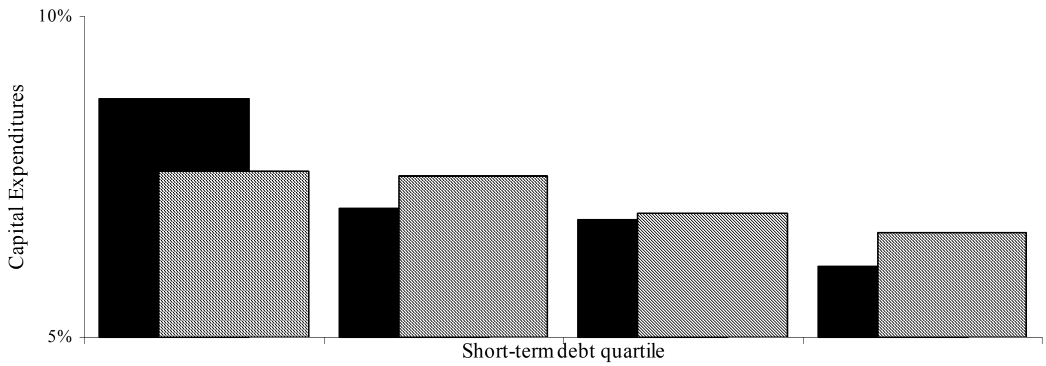
Panel A. The treasury bill (thin line), term spread (thick line), inflation (expected - dash, realized - long dash)



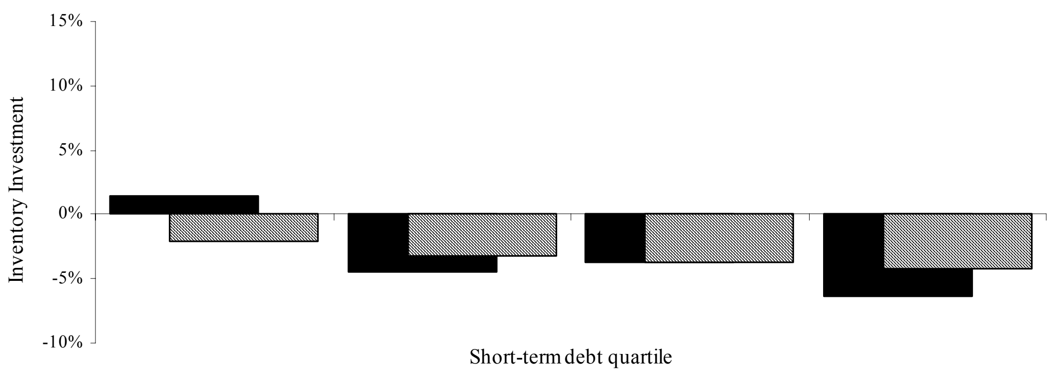
Panel B. The real short-term rate (expected - line, realized - dash)

Figure 2. Investment and the maturity structure of debt during the 1982 recession. The table shows average investment for the 1279 firms reporting complete data in 1982. I sort firms into quartiles based on short-term debt in the previous year. I sort alternately by notes payable plus the current portion of long-term debt, scaled by lagged assets (solid), or by short-term over total debt (thatched). These variables are described in Table 1. The table shows average investment by quartile. In Panel A, investment is measured as capital expenditures, scaled by lagged assets. In Panel B, inventory investment is measured as the change in the log of total inventories. In Panel C, investment is the change in net assets, scaled by lagged assets.

Panel A. Capital Expenditure by short-term debt quartile



Panel B. Inventory investment by short-term debt quartile



Panel C. Change in net assets by short-term debt quartile

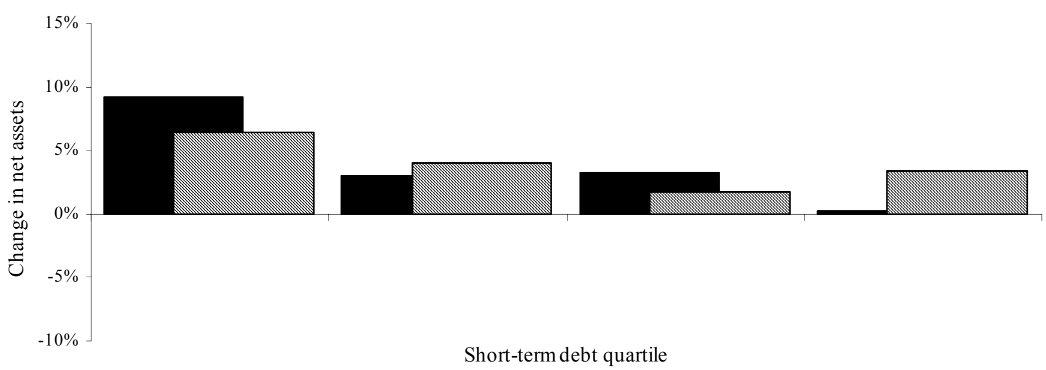
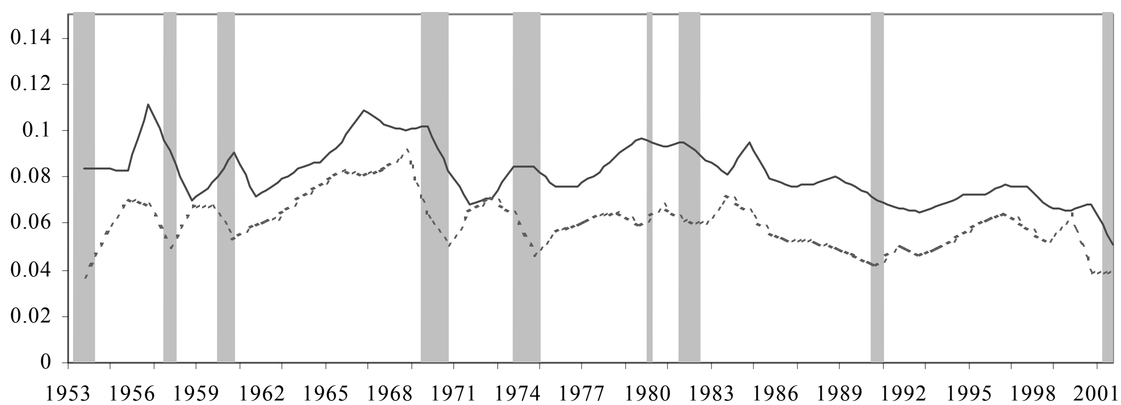


Figure 3. Fixed investment and the maturity structure of debt 1953-2001. Average fixed investment sorted by short-term debt quartile in the previous year. Each figure shows the time series of investment for the 1st (solid) and 4th (dash) quartiles. Fixed investment is measured as capital expenditures scaled by lagged assets. In Panel A, short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by lagged assets. In Panel B, short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by total debt. The shaded bars indicate NBER recessions, defined by the NBER business cycle dating committee.

Panel A. Fixed investment by short-term leverage quartile (1st Quartile solid, 4th Quartile dash)



Panel B. Fixed investment by short-term debt to total debt ratio (1st Quartile solid, 4th Quartile dash)

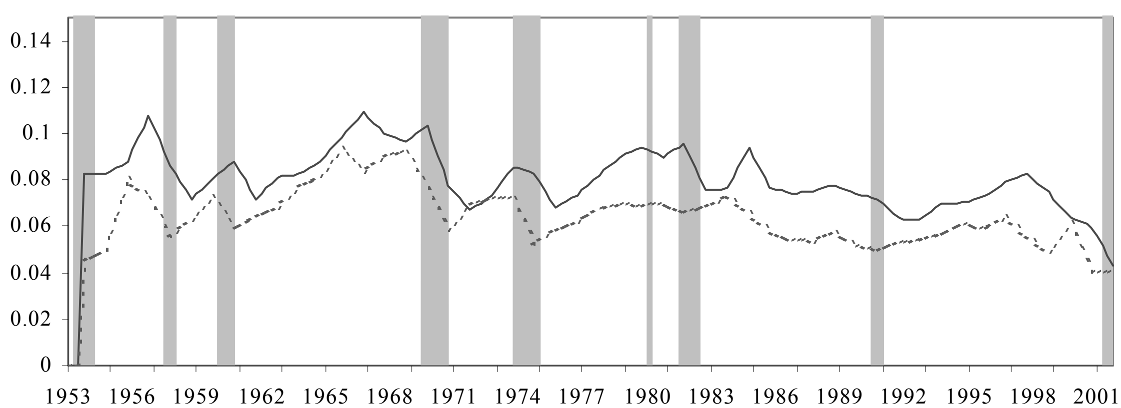
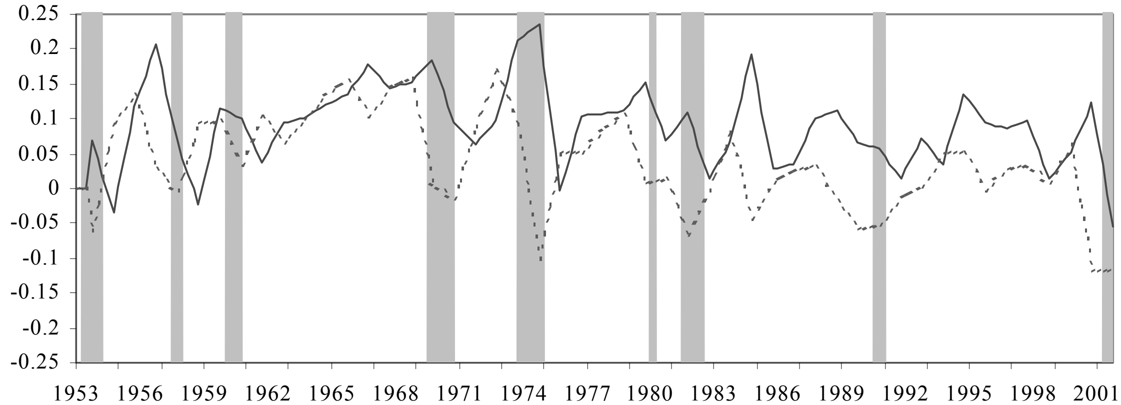


Figure 4. Inventory investment and the maturity structure of debt 1953-2001. Average inventory investment sorted by short-term debt quartile in the previous year. Each figure shows the time series of investment for the 1st (solid) and 4th (dash) quartiles. Inventory investment is measured as the change in log of inventories. In Panel A, short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by lagged assets. In Panel B, short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by total debt. The shaded bars indicate NBER recessions, defined by the NBER business cycle dating committee.

Panel A. Inventory investment by short-term leverage quartile (1st Quartile solid, 4th Quartile dash)



Panel B. Inventory investment by short-term debt to total debt ratio (1st Quartile solid, 4th Quartile dash)

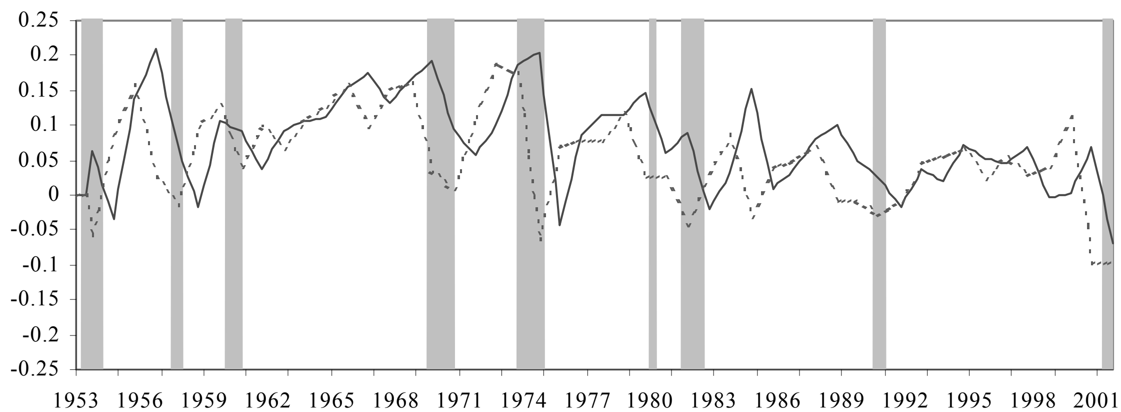


Table 1. Interest rate conditions, 1953-2000. Mean, median, standard deviation, and extreme values of monthly variables, all annualized and expressed in percentage terms. Panel A decomposes the long-term real interest rate into its components: the nominal treasury bill rate (y_{GSt}), plus the term spread ($y_{GLt} - y_{GSt}$), minus the expected annualized rate of inflation. The term spread is the difference between the long-term government bond yield and the treasury bill rate. Expected annual inflation is measured alternately as realized inflation during the next 12 months (π_{At+1}) or as the mean forecast inflation from the Livingston survey (π_{Et}). The real short-term rate is measured as the difference between the nominal treasury bill rate and realized inflation one year forward ($y_{GSt} - \pi_{At+1}$). The table includes the Federal Funds rate ($ffunds_t$) as an additional measure of the short-term nominal interest rate. This monthly series begins in 1954. Panel B summarizes innovations of these components, computed in each case as the difference between the series and its twelve month lag. All data are from Ibbotson (2001).

(%)	**N**	**Mean**	**Median**	**SD**	**Min**	**Max**
Panel A: Monthly Interest rate conditions 1953:1-2000:12						
y_{GSt}	576	5.44	5.03	2.95	0.71	17.42
$y_{GLt} - y_{GSt}$	576	1.42	1.40	1.48	-2.42	5.52
π_{At+1}	576	4.01	3.26	3.06	-0.50	14.68
π_{Et}	576	3.45	3.44	2.40	-1.44	10.1
$y_{GSt} - \pi_{At+1}$	576	1.37	1.33	2.74	-4.64	10.98
$ffunds_t$	558	6.09	5.49	3.33	0.93	19.10
Panel B: Innovations						
y_{GSt}	576	0.09	0.16	1.96	-5.51	9.84
$y_{GLt} - y_{GSt}$	576	0.00	0.00	0.02	-0.04	0.07
π_{At+1}	576	0.02	0.05	1.94	-4.97	6.15
π_{Et}	576	0.06	0.15	0.90	-2.90	2.54
$y_{GSt} - \pi_{At+1}$	576	0.09	0.16	1.96	-5.51	9.84
$ffunds_t$	576	0.00	0.00	0.02	-0.04	0.07

Table 2. Investment and the maturity structure of debt, 1953-2001. The sample is restricted to manufacturing firms for which Compustat reports data on all investment and leverage variables, except *Q*. Manufacturing firms are selected following industry definitions from Fama and French (1997). Inventory investment is measured as the change in log inventories (Compustat item 3). The inventory to sales ratio is given by total inventories over net sales (item 12). Fixed investment is measured alternately as capital expenditures (item 128) or the change in net assets (Δitem 6), both scaled by lagged assets (item 6). Operating cash flow (CF_t/A_{t-1}) is defined as net income plus depreciation and amortization (item 14 + item 18), scaled by lagged assets. *Q* is the market value of equity, plus assets minus the book value of equity (item 60 + item 74), over assets. Panel B describes firm leverage and the maturity structure of debt. Leverage (D_{t-1}/A_{t-1}) is defined as total debt (item 34 + item 9) over assets. The maturity structure of debt is described by current debt (item 34) over assets (D_{St-1}/A_{t-1}), or as current debt net of cash over assets (D^*_{St-1}/A_{t-1}). Current debt includes notes payable and the current portion of long-term debt. Holding the level of debt fixed, the short-term share of debt (D_{St-1}/D_{t-1}) is defined as current debt over total debt, as current debt net of cash over total debt (D^*_{St-1}/D_{t-1}), or as the current portion of long-term debt scaled by total long-term debt ($D_{Curr,t-1}/D_{Long,t-1}$). All data are winsorized at the 1% and 99% levels to reduce the effects of outliers, and with the exception of *Q* are all given in percentage terms.

	N	Mean	Median	SD	Min	Max
Panel A: Investment and determinants of investment (*t*)						
$\Delta Log(Inv)_{it}$	45,376	0.06	0.06	0.27	-0.64	0.78
$Log(Inv/Sales)_{it-1}$	45,376	-1.73	-1.67	0.59	-3.45	-0.56
$\Delta Log(Sales)_{it}$	45,376	0.08	0.08	0.21	-0.48	0.66
$CAPX_t/A_{t-1}$	45,376	0.07	0.05	0.06	0.00	0.30
$(A_t - A_{t-1})/A_{t-1}$	45,376	0.09	0.06	0.22	-0.34	0.90
CF_t/A_{t-1}	45,376	0.08	0.10	0.12	-0.35	0.30
Q_{t-1}	37,604	1.54	1.14	1.13	0.57	6.11
Panel B: Leverage and the maturity structure of debt (*t-1*)						
D_{t-1}/A_{t-1}	45,376	0.24	0.22	0.16	0.00	0.63
D_{St-1}/A_{t-1}	45,376	0.07	0.04	0.09	0.00	0.38
D^*_{St-1}/A_{t-1}	45,374	-0.03	-0.02	0.17	-0.52	0.34
$D_{Curr,t-1}/A_{t-1}$	45,376	0.02	0.01	0.03	0.00	0.14
D_{St-1}/D_{t-1}	45,374	0.34	0.23	0.31	0.00	1.00
D^*_{St-1}/D_{t-1}	37,765	0.36	0.25	1.46	-4.76	5.44
$D_{Curr,t-1}/D_{Long,t-1}$	45,376	0.17	0.09	0.21	0.00	0.98

Table 3. Capital investment and nominal interest rates by leverage and short-term debt, 1953-2001. Each year, firms are separated into quartiles based on leverage in the previous year and then again split within each leverage quartile by the short-term debt ratio (D_{St-1}/D_{t-1}). The results in each panel correspond to estimates from a single panel regression

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + \cdot\sum_{j=1}^{4}\sum_{k=1}^{2} d_{jk} 1_{i\in Q(j,k)} \cdot y_{GSt-1} + u_{it}$$

The table shows the coefficients on the interactions between the dummy variables for each group ($1_{i\in Q(j,k)}$) with innovations in lagged nominal interest rates (y_{GSt}). The right-hand columns report the difference between firms with high short-term debt ratios and low short-term debt ratios, within each leverage quartile, together with the t-statistic on the difference. In Panel A, firms are separated into quartiles based on total leverage in the previous year and then by the short-term debt ratio (D_{St-1}/D_{t-1}). In Panel B, firms are separated into quartiles based on leverage measured as a difference from the industry mean in that year, and then again by short-term debt to total debt ratio, expressed as a difference from the industry mean in that year. In Panel C, firms are separated into quartiles based on leverage in the previous year, and then again by the ratio of the current portion of long-term debt to total long-term debt. Each regression includes firm fixed effects. Standard errors are clustered by firm.

			Low D_{St-1}/D_{t-1}		High D_{St-1}/D_{t-1}		High - Low		
		N	d_{j1}	**[t-stat]**	d_{j2}	**[t-stat]**	$d_{j2}- d_{j1}$	**[t-stat]**	R^2
Panel A: Double sorts by leverage and short-term share									
Leverage Quartile	1	9,415	0.16	[4.06]	0.12	[3.07]	-0.05	[-0.81]	
	2	9,375	0.22	[5.96]	-0.02	[-0.38]	-0.24	[-3.65]	
	3	9,397	0.19	[5.54]	0.00	[0.08]	-0.19	[-3.12]	
	4	9,417	0.06	[1.44]	-0.01	[-0.24]	-0.07	[-1.07]	
	$4^{th} - 1^{st}$		-0.11	[-1.91]	-0.13	[-1.55]	-0.02	[-0.22]	0.48
Panel B: Double sorts by financial constraints and short-term share									
Financial Constraints Quartile	1	9,177	0.22	[5.91]	0.12	[3.91]	-0.10	[-2.11]	
	2	9,139	0.20	[5.52]	-0.02	[-0.43]	-0.22	[-3.65]	
	3	9,161	0.15	[4.01]	-0.01	[-0.26]	-0.16	[-2.60]	
	4	9,179	0.06	[1.61]	-0.02	[-0.39]	-0.08	[-1.32]	
	$4^{th} - 1^{st}$		-0.17	[-3.15]	-0.14	[-2.00]	0.03	[0.32]	0.48
Panel C: Double sorts by long-term leverage and maturing share of long-term debt									
Total Long-term debt Quartile	1	8,724	0.10	[2.36]	0.10	[3.01]	0.01	[0.14]	
	2	8,683	0.19	[5.83]	0.04	[0.65]	-0.16	[-2.41]	
	3	8,702	0.18	[5.52]	0.03	[0.53]	-0.15	[-2.54]	
	4	8,726	0.13	[3.45]	-0.02	[-0.44]	-0.15	[-2.38]	
	$4^{th} - 1^{st}$		0.03	[0.51]	-0.13	[-1.61]	-0.15	[-1.61]	0.48

Table 4. Inventory investment and nominal interest rates by leverage and short-term debt, 1953-2001. Each year, firms are separated into quartiles based on leverage in the previous year and then again split within each leverage quartile by the short-term debt ratio (D_{St-1}/D_{t-1}). The results in each panel correspond to estimates from a single panel regression

$$\Delta LOG(Inv)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + \sum_{j=1}^{4}\sum_{k=1}^{2} e_{jk} 1_{i \in Q(j,k)} \cdot y_{GSt-1} + u_{it}$$

The table shows the coefficients on the interactions between the dummy variables for each group ($1_{i \in Q(j,k)}$) with innovations in lagged nominal interest rates (y_{GSt}). The right-hand columns report the difference between firms with high short-term debt ratios and low short-term debt ratios, within each leverage quartile, together with the t-statistic on the difference. In Panel A, firms are separated into quartiles based on total leverage in the previous year and then by the short-term debt ratio (D_{St-1}/D_{t-1}). In Panel B, firms are separated into quartiles based on leverage measured as a difference from the industry mean in that year, and then again by short-term debt to total debt ratio, expressed as a difference from the industry mean in that year. In Panel C, firms are separated into quartiles based on leverage in the previous year, and then again by the ratio of the current portion of long-term debt to total long-term debt. Each regression includes firm fixed effects. Standard errors are clustered by firm.

			Low D_{St-1}/D_{t-1}		High D_{St-1}/D_{t-1}		High - Low		
		N	e_{j1}	**[t-stat]**	e_{j2}	**[t-stat]**	$e_{j2}- e_{j1}$	**[t-stat]**	R^2
Panel A: Double sorts by leverage and short-term share									
Leverage Quartile	1	11,365	0.40	[2.67]	0.46	[2.86]	0.06	[0.29]	
	2	11,310	0.65	[4.88]	-0.18	[-0.85]	-0.83	[-3.27]	
	3	11,336	0.47	[3.86]	-0.30	[-1.37]	-0.77	[-3.12]	
	4	11,365	0.36	[2.48]	-0.12	[-0.56]	-0.48	[-1.80]	
	$4^{th} - 1^{st}$		-0.04	[-0.19]	-0.58	[-1.64]	-0.54	[-1.31]	0.43
Panel B: Double sorts by financial constraints and short-term share									
Financial Constraints Quartile	1	10,199	0.49	[3.44]	0.60	[4.51]	0.11	[0.54]	
	2	10,162	0.50	[3.81]	-0.51	[-2.61]	-1.01	[-4.33]	
	3	10,178	0.52	[3.69]	-0.23	[-1.04]	-0.75	[-2.87]	
	4	10,201	0.21	[1.34]	-0.35	[-1.68]	-0.55	[-2.10]	
	$4^{th} - 1^{st}$		-0.28	[-1.36]	-0.94	[-3.08]	-0.66	[-1.74]	0.43
Panel C: Double sorts by long-term leverage and maturing share of long-term debt									
Total Long-term debt Quartile	1	9,906	0.29	[1.89]	0.30	[1.92]	0.01	[0.05]	
	2	9,854	0.51	[3.66]	0.18	[0.82]	-0.33	[-1.27]	
	3	9,880	0.56	[4.58]	-0.13	[-0.60]	-0.69	[-2.74]	
	4	9,906	0.45	[3.21]	-0.10	[-0.46]	-0.55	[-2.12]	
	$4^{th} - 1^{st}$		0.15	[0.73]	-0.40	[-1.16]	-0.56	[-1.37]	0.43

Table 5a. Capital expenditure and nominal interest rates by leverage and deviations from optimal maturity structure: two-stage regressions. Panel A reports the results of 1st stage OLS regressions of the short-term debt ratio on a constant, the market-to-book ratio, and the log of firm assets. In the second stage, firms are sorted first by leverage, then by the deviations from optimal maturity structure, measured as the residuals from the first stage regressions.

$$D_{St-1} / D_{t-1} = \beta_0 + \beta X + u_{it}$$

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + \sum_{j=1}^{4}\sum_{k=1}^{2} d_{jk} 1_{i\in Q(j,k)} \cdot y_{GSt-1} + v_{it}$$

Panel B shows the coefficients on the interactions between the dummy variables for each group ($1_{i\in Q(j,k)}$) with innovations in lagged nominal interest rates (y_{GSt}). The right-hand columns report the difference between firms with high short-term debt ratios and low short-term debt ratios, within each leverage quartile, together with the t-statistic on the difference. First stage regressions are run with (left hand columns) and without (right-hand columns) a constant, with the corresponding second stage regression directly below. Standard errors are clustered by firm.

Panel A: 1st stage regressions of debt maturity on market-to-book ratio and size

	β	**[t-stat]**	**β**	**[t-stat]**
Constant	0.38	[110.73]	0.41	[76.55]
M/B	0.05	[34.62]	0.02	[10.67]
Log(Assets)	-0.03	[41.30]	-0.03	[-18.73]
Firm Dummies		No		Yes
N		37,603		37,603
R^2		0.05		0.51

Panel B: 2nd stage regressions of investment on lagged interest rates sorting by residuals from stage 1

			Low D_{St-1}/D_{t-1}	High D_{St-1}/D_{t-1}	High - Low		Low D_{St-1}/D_{t-1}	High D_{St-1}/D_{t-1}	High - Low	
		N	d_{j1}	d_{j2}	d_{j2}- d_{j1}	**[t-stat]**	d_{j1}	d_{j2}	d_{j2}-d_{j1}	**[t-stat]**
Leverage Quartile	1	9,415	0.14	0.13	-0.01	[-0.19]	0.15	0.13	-0.01	[-0.23]
	2	9,375	0.20	-0.02	-0.23	[-3.47]	0.19	-0.01	-0.20	[-3.04]
	3	9,397	0.17	0.01	-0.16	[-2.69]	0.11	0.07	-0.05	[-0.76]
	4	9,417	0.04	-0.02	-0.06	[-0.97]	0.05	-0.02	-0.06	[-0.99]
	4th – 1st		-0.10	-0.15	-0.05	[-0.51]	-0.10	-0.15	-0.05	[-0.50]

Table 5b. Inventory investment and nominal interest rates by leverage and deviations from optimal maturity structure: two-stage regressions. Panel A reports the results of 1st stage OLS regressions of the short-term debt ratio on a constant, the market-to-book ratio, and the log of firm assets. In the second stage, firms are sorted first by leverage, then by the deviations from optimal maturity structure, measured as the residuals from the first stage regressions.

$$D_{St-1} / D_{t-1} = \beta_0 + \beta X + u_{it}$$

$$\Delta LOG(Inv)_{it} = a_i + b \cdot LOG(Inv / Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + \sum_{j=1}^{4}\sum_{k=1}^{2} e_{jk} 1_{i \in Q(j,k)} \cdot y_{GSt-1} + u_{it}$$

Panel B shows the coefficients on the interactions between the dummy variables for each group ($1_{i \in Q(j,k)}$) with innovations in lagged nominal interest rates (y_{GSt}). The right-hand columns report the difference between firms with high short-term debt ratios and low short-term debt ratios, within each leverage quartile, together with the t-statistic on the difference. First stage regressions are run with (left hand columns) and without (right-hand columns) a constant, with the corresponding second stage regression directly below. Standard errors are clustered by firm.

Panel A: 1st stage regressions of debt maturity on market-to-book ratio and size

	β	**[t-stat]**	**β**	**[t-stat]**
Constant	0.42	[132.74]	0.41	[83.26]
M/B				
Log(Assets)	-0.03	[-33.66]	-0.02	[-16.84]
Firm Dummies		No		Yes
N		41,852		41,852
$\mathbf{R^2}$		0.03		0.49

Panel B: 2nd stage regressions of investment on lagged interest rates sorting by residuals from stage 1

			Low D_{St-1}/D_{t-1}	High D_{St-1}/D_{t-1}	High - Low		Low D_{St-1}/D_{t-1}	High D_{St-1}/D_{t-1}	High - Low	
		N	e_{j1}	e_{j2}	$e_{j2}- e_{j1}$	**[t-stat]**	e_{j1}	e_{j2}	$e_{j2}-e_{j1}$	**[t-stat]**
Leverage Quartile	1	11,365	0.32	0.53	0.21	[0.97]	0.29	0.55	0.26	[1.18]
	2	11,310	0.56	-0.16	-0.72	[-2.79]	0.65	-0.27	-0.92	[-3.68]
	3	11,336	0.40	-0.28	-0.67	[-2.74]	0.30	-0.21	-0.51	[-2.12]
	4	11,365	0.48	-0.29	-0.77	[-2.86]	0.60	-0.41	-1.01	[-3.89]
	4th – 1st		0.16	-0.81	-0.98	[-2.37]	0.31	-0.96	-1.27	[-3.15]

Table 6. Capital investment and interest rate conditions. Each year, firms are separated into quartiles based on leverage in the previous year and then again split within each leverage quartile by the short-term debt ratio (D_{St-1}/D_{t-1}). The results in each panel correspond to estimates from a single regression

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + \sum_{j=1}^{4}\sum_{k=1}^{2}\left[e_{jk}1_{i\in Q(j,k)}(y_{GSt-1} - \pi_{t-1}) + f_{jk}1_{i\in Q(j,k)}(\pi_{t-1}) + g_{jk}1_{i\in Q(j,k)}(y_{GLt-1} - y_{GSt-1})\right] + u_{it}$$

The table shows the coefficients on the interactions between the dummy variables for each group ($1_{i\in Q(j,k)}$) with innovations in the real short-term rate ($y_{GSt} - \pi$), inflation (π) and the term spread ($y_{GLt} - y_{GSt}$). The right-hand columns report the difference between firms with high short-term debt ratios and low short-term debt ratios, within each leverage quartile, together with the t-statistic on the differences. In Panel A, firms are separated into quartiles based on total leverage in the previous year and then by the short-term debt ratio (D_{St-1}/D_{t-1}). In Panel B, firms are separated into quartiles based on leverage measured as a difference from the industry mean in that year, and then again by short-term debt to total debt ratio, expressed as a difference from the industry mean in that year. In Panel C, firms are separated into quartiles based on leverage in the previous year, and then again by the ratio of the current portion of long-term debt to total long-term debt. Each regression includes firm fixed effects. Standard errors are clustered by firm.

		Low D_{St-1}/D_{t-1}						High D_{St-1}/D_{t-1}						High - Low					
		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$	
		e_{j1}	[t]	f_{j1}	[t]	g_{j1}	[t]	e_{j2}	[t]	f_{j2}	[t]	g_{j2}	[t]	Δe	[t]	Δf	[t]	Δg	[t]
Panel A: Double sorts by leverage and short-term share																			
Leverage Quartile	1	0.37	[5.1]	0.43	[4.6]	0.29	[3.5]	0.28	[3.6]	0.27	[2.9]	0.20	[2.4]	-0.09	[-0.9]	-0.16	[-1.3]	-0.09	[-0.8]
	2	0.34	[4.8]	0.44	[5.2]	0.17	[2.3]	0.01	[0.1]	0.04	[0.3]	0.06	[0.5]	-0.33	[-2.6]	-0.40	[-2.6]	-0.11	[-0.8]
	3	0.42	[5.8]	0.58	[6.6]	0.36	[4.3]	-0.10	[-1.0]	0.03	[0.3]	-0.08	[-0.7]	-0.52	[-4.1]	-0.55	[-3.6]	-0.44	[-3.0]
	4	0.15	[1.8]	0.21	[2.2]	0.13	[1.5]	-0.07	[-0.7]	0.08	[0.6]	-0.05	[-0.5]	-0.22	[-1.7]	-0.13	[-0.9]	-0.18	[-1.3]
	4th – 1st	-0.22	[-2.0]	-0.22	[-1.6]	-0.16	[-1.3]	-0.35	[-2.1]	-0.19	[-1.0]	-0.26	[-1.4]	-0.13	[-0.6]	0.03	[0.1]	-0.09	[-0.4]
Panel B: Double sorts by financial constraints and short-term share																			
Financial Constraints Quartile	1	0.41	[6.0]	0.49	[5.8]	0.27	[3.4]	0.30	[4.0]	0.31	[3.4]	0.25	[2.9]	-0.11	[-1.1]	-0.19	[-1.6]	-0.02	[-0.2]
	2	0.36	[5.1]	0.47	[5.4]	0.22	[2.8]	-0.07	[-0.7]	-0.03	[-0.2]	-0.08	[-0.7]	-0.43	[-3.4]	-0.50	[-3.3]	-0.30	[-2.1]
	3	0.38	[4.9]	0.50	[5.5]	0.36	[3.9]	-0.11	[-1.0]	-0.03	[-0.3]	-0.11	[-0.9]	-0.49	[-3.7]	-0.53	[-3.4]	-0.46	[-3.1]
	4	0.15	[2.0]	0.26	[2.7]	0.14	[1.6]	-0.09	[-0.9]	0.01	[0.1]	-0.09	[-0.8]	-0.25	[-2.0]	-0.25	[-1.6]	-0.23	[-1.7]
	4th – 1st	-0.25	[-2.5]	-0.24	[-1.9]	-0.12	[-1.1]	-0.39	[-2.4]	-0.30	[-1.5]	-0.34	[-1.8]	-0.14	[-0.7]	-0.06	[-0.3]	-0.21	[-1.0]
Panel C: Double sorts by long-term leverage and maturing share of long-term debt																			
Long-term debt Quartile	1	0.31	[4.0]	0.39	[4.1]	0.30	[3.3]	0.28	[3.7]	0.28	[3.1]	0.23	[2.7]	-0.03	[-0.3]	-0.11	[-0.8]	-0.07	[-0.6]
	2	0.34	[5.2]	0.41	[5.4]	0.21	[2.9]	-0.10	[-0.9]	-0.08	[-0.6]	-0.17	[-1.4]	-0.43	[-3.3]	-0.49	[-3.1]	-0.38	[-2.6]
	3	0.34	[5.1]	0.49	[5.9]	0.27	[3.5]	-0.04	[-0.4]	0.05	[0.4]	-0.07	[-0.6]	-0.38	[-3.1]	-0.44	[-2.9]	-0.34	[-2.4]
	4	0.33	[4.3]	0.44	[4.8]	0.29	[3.4]	-0.11	[-1.0]	-0.01	[-0.1]	-0.09	[-0.7]	-0.45	[-3.3]	-0.45	[-2.8]	-0.38	[-2.4]
	4th – 1st	0.03	[0.2]	0.04	[0.3]	-0.01	[-0.1]	-0.39	[-2.3]	-0.29	[-1.4]	-0.32	[-1.6]	-0.41	[-2.0]	-0.34	[-1.4]	-0.30	[-1.3]

Table 7. Inventory investment and interest rate conditions. Each year, firms are separated into quartiles based on leverage in the previous year and then again split within each leverage quartile by the short-term debt ratio (D_{St-1}/D_{t-1}). The results in each panel correspond to estimates from a single regression

$$\Delta LOG(Inv)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1}$$
$$+ \sum_{j=1}^{4}\sum_{k=1}^{2}\left[e_{jk} 1_{i\in Q(j,k)}(y_{GSt-1} - \pi_{t-1}) + f_{jk} 1_{i\in Q(j,k)}(\pi_{t-1}) + g_{jk} 1_{i\in Q(j,k)}(y_{GLt-1} - y_{GSt-1})\right] + u_{it}$$

The table shows the coefficients on the interactions between the dummy variables for each group ($1_{i\in Q(j,k)}$) with innovations in the real short-term rate ($y_{GSt} - \pi$), inflation (π) and the term spread ($y_{GLt} - y_{GSt}$). The right-hand columns report the difference between firms with high short-term debt ratios and low short-term debt ratios, within each leverage quartile, together with the t-statistic on the differences. In Panel A, firms are separated into quartiles based on total leverage in the previous year and then by the short-term debt ratio (D_{St-1}/D_{t-1}). In Panel B, firms are separated into quartiles based on leverage measured as a difference from the industry mean in that year, and then again by short-term debt to total debt ratio, expressed as a difference from the industry mean in that year. In Panel C, firms are separated into quartiles based on leverage in the previous year, and then again by the ratio of the current portion of long-term debt to total long-term debt. Each regression includes firm fixed effects. Standard errors are clustered by firm.

		Low D_{St-1}/D_{t-1}						High D_{St-1}/D_{t-1}						High - Low					
		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$	
		e_{j1}	[t]	f_{j1}	[t]	g_{j1}	[t]	e_{j2}	[t]	f_{j2}	[t]	g_{j2}	[t]	Δe	[t]	Δf	[t]	Δg	[t]
Panel A: Double sorts by leverage and short-term share																			
Leverage Quartile	1	1.29	[4.1]	2.31	[6.2]	1.42	[3.9]	1.94	[5.8]	3.08	[8.0]	2.23	[5.8]	0.65	[1.5]	0.77	[1.5]	0.81	[1.6]
	2	1.45	[5.1]	2.63	[8.2]	1.37	[4.3]	-0.96	[-2.1]	-0.77	[-1.5]	-0.98	[-1.9]	-2.41	[-4.6]	-3.40	[-5.6]	-2.35	[-3.9]
	3	1.28	[4.8]	2.26	[7.3]	1.29	[4.1]	-0.94	[-2.1]	-0.67	[-1.3]	-0.76	[-1.5]	-2.22	[-4.3]	-2.92	[-4.9]	-2.05	[-3.5]
	4	0.98	[3.2]	2.02	[5.5]	1.12	[3.2]	-1.24	[-2.7]	-1.23	[-2.2]	-1.46	[-2.6]	-2.23	[-4.0]	-3.25	[-4.9]	-2.58	[-3.9]
	4th – 1st	-0.24	[-2.1]	-0.21	[-1.5]	-0.17	[-1.3]	-0.43	[-2.6]	-0.33	[-1.7]	-0.33	[-1.8]	-0.18	[-0.9]	-0.12	[-0.5]	-0.16	[-0.7]
Panel B: Double sorts by financial constraints and short-term share																			
Financial Constraints Quartile	1	1.27	[4.5]	2.24	[6.6]	1.25	[4.0]	1.75	[6.3]	2.86	[8.9]	1.83	[5.6]	0.49	[1.2]	0.62	[1.4]	0.58	[1.3]
	2	1.38	[4.7]	2.59	[7.5]	1.47	[4.3]	-0.81	[-1.9]	-0.57	[-1.1]	-0.34	[-0.7]	-2.19	[-4.3]	-3.16	[-5.3]	-1.81	[-3.0]
	3	1.23	[4.2]	2.14	[6.2]	1.13	[3.3]	-0.70	[-1.6]	-0.30	[-0.6]	-0.56	[-1.1]	-1.93	[-3.7]	-2.44	[-4.0]	-1.69	[-2.8]
	4	0.95	[3.0]	2.09	[5.4]	1.29	[3.5]	-0.97	[-2.2]	-1.06	[-2.0]	-0.88	[-1.7]	-1.93	[-3.5]	-3.15	[-4.8]	-2.17	[-3.5]
	4th – 1st	-0.32	[-0.7]	-0.15	[-0.3]	0.04	[0.1]	-2.73	[-4.2]	-3.92	[-5.1]	-2.71	[-3.5]	-2.41	[-3.1]	-3.77	[-4.1]	-2.75	[-3.1]
Panel C: Double sorts by long-term leverage and maturing share of long-term debt																			
Long-term debt Quartile	1	0.31	[4.0]	0.39	[4.1]	0.30	[3.3]	0.28	[3.7]	0.28	[3.1]	0.23	[2.7]	-0.03	[-0.3]	-0.11	[-0.8]	-0.07	[-0.6]
	2	0.34	[5.2]	0.41	[5.4]	0.21	[2.9]	-0.10	[-0.9]	-0.08	[-0.6]	-0.17	[-1.4]	-0.43	[-3.3]	-0.49	[-3.1]	-0.38	[-2.6]
	3	0.34	[5.1]	0.49	[5.9]	0.27	[3.5]	-0.04	[-0.4]	0.05	[0.4]	-0.07	[-0.6]	-0.38	[-3.1]	-0.44	[-2.9]	-0.34	[-2.4]
	4	0.33	[4.3]	0.44	[4.8]	0.29	[3.4]	-0.11	[-1.0]	-0.01	[-0.1]	-0.09	[-0.7]	-0.45	[-3.3]	-0.45	[-2.8]	-0.38	[-2.4]
	4th – 1st	0.03	[0.2]	0.04	[0.3]	-0.01	[-0.1]	-0.39	[-2.3]	-0.29	[-1.4]	-0.32	[-1.6]	-0.41	[-2.0]	-0.34	[-1.4]	-0.30	[-1.3]

Table 8a. Capital investment and interest rate conditions: two-stage regressions. In the first stage, I estimate OLS regressions of the short-term debt ratio on a constant, the market-to-book ratio, and the log of firm assets and a firm dummy variable. In the second stage, firms are put into groups by sorting first on leverage, then by the deviations from optimal maturity structure, measured as the residuals from the first stage regression. Each panel shows estimates from the single second stage regression of fixed investment on firm fixed effects, control variables, and interactions of group dummy variables with lagged interest rate conditions.

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + \sum_{j=1}^{4}\sum_{k=1}^{2}\left[e_{jk}1_{i\in Q(j,k)}(y_{GSt-1}-\pi_{t-1}) + f_{jk}1_{i\in Q(j,k)}(\pi_{t-1}) + g_{jk}1_{i\in Q(j,k)}(y_{GLt-1}-y_{GSt-1})\right] + u_{it}$$

The sets of coefficients *e*, *f* and *g* correspond to the sensitivity of investment of firms in each group to innovations in the real short-term rate ($y_{GSt}-\pi$), inflation (π) and the term spread ($y_{GLt}-y_{GSt}$), respectively. For each leverage quartile, the right-hand columns report the difference in coefficients between firms with high and low short-term debt ratios, together with the t-statistic. Each regression includes firm fixed effects. Standard errors are clustered by firm.

		Low D_{St-1}/D_{t-1}						High D_{St-1}/D_{t-1}						High - Low					
		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$		$y_{GSt}-\pi$		π		$y_{GLt}-y_{GSt}$	
		e_{j1}	[t]	f_{j1}	[t]	g_{j1}	[t]	e_{j2}	[t]	f_{j2}	[t]	g_{j2}	[t]	Δe	[t]	Δf	[t]	Δg	[t]
Panel A: Second stage regressions (1st Stage does not include firm dummy variables)																			
Leverage Quartile	1	0.34	[4.4]	0.37	[3.9]	0.26	[3.0]	0.33	[4.4]	0.35	[3.9]	0.26	[3.1]	-0.01	[-0.1]	-0.02	[-0.2]	0.00	[0.0]
	2	0.30	[4.1]	0.43	[4.7]	0.16	[2.0]	-0.04	[-0.4]	-0.04	[-0.3]	-0.02	[-0.2]	-0.34	[-2.6]	-0.47	[-3.0]	-0.18	[-1.3]
	3	0.41	[5.5]	0.59	[6.4]	0.37	[4.3]	-0.09	[-1.0]	-0.02	[-0.2]	-0.11	[-1.0]	-0.51	[-4.1]	-0.61	[-4.0]	-0.48	[-3.4]
	4	0.10	[1.2]	0.16	[1.7]	0.09	[1.0]	-0.09	[-0.9]	0.02	[0.2]	-0.07	[-0.6]	-0.19	[-1.5]	-0.14	[-0.9]	-0.16	[-1.1]
	4th – 1st	-0.24	[-2.1]	-0.21	[-1.5]	-0.17	[-1.3]	-0.43	[-2.6]	-0.33	[-1.7]	-0.33	[-1.8]	-0.18	[-0.9]	-0.12	[-0.5]	-0.16	[-0.7]
Panel B: Second stage regressions (1st Stage does include firm dummy variables)																			
Financial Constraints Quartile	1	0.25	[3.3]	0.28	[3.0]	0.14	[1.6]	0.42	[5.4]	0.44	[4.8]	0.38	[4.4]	0.18	[1.6]	0.16	[1.2]	0.24	[2.0]
	2	0.29	[4.2]	0.38	[4.4]	0.16	[2.0]	-0.12	[-1.1]	-0.08	[-0.6]	-0.14	[-1.1]	-0.42	[-3.2]	-0.46	[-2.9]	-0.29	[-2.0]
	3	0.36	[5.0]	0.50	[5.7]	0.36	[4.2]	-0.13	[-1.2]	-0.02	[-0.2]	-0.23	[-2.0]	-0.48	[-3.8]	-0.53	[-3.4]	-0.58	[-4.0]
	4	0.12	[1.5]	0.19	[2.1]	0.12	[1.4]	-0.21	[-2.0]	-0.10	[-0.8]	-0.21	[-1.8]	-0.33	[-2.5]	-0.29	[-1.9]	-0.33	[-2.3]
	4th – 1st	-0.13	[-1.1]	-0.09	[-0.6]	-0.02	[-0.2]	-0.63	[-3.7]	-0.54	[-2.6]	-0.59	[-3.1]	-0.50	[-2.5]	-0.45	[-1.9]	-0.57	[-2.5]

Table 8b. Inventory investment and changes in interest rate conditions: two-stage regressions. In the first stage, I estimate OLS regressions of the short-term debt ratio on a constant, the market-to-book ratio, the log of firm assets and a firm dummy variable. In the second stage, firms are put into groups by sorting first on leverage, then by the deviations from optimal maturity structure, measured as the residuals from the first stage regression. Each panel shows estimates from the single second stage regression of fixed investment on firm fixed effects, control variables, and interactions of group dummy variables with lagged interest rate conditions.

$$\Delta LOG(Inv)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1}$$
$$+ \sum_{j=1}^{4} \sum_{k=1}^{2} \left[e_{jk} 1_{i \in Q(j,k)} (y_{GSt-1} - \pi_{t-1}) + f_{jk} 1_{i \in Q(j,k)} (\pi_{t-1}) + g_{jk} 1_{i \in Q(j,k)} (y_{GLt-1} - y_{GSt-1}) \right] + u_{it}$$

The sets of coefficients e, f and g correspond to the sensitivity of investment of firms in each group to innovations in the real short-term rate ($y_{GSt} - \pi$), inflation (π) and the term spread ($y_{GLt} - y_{GSt}$), respectively. For each leverage quartile, the right-hand columns report the difference in coefficients between firms with high and low short-term debt ratios, together with the t-statistic. Each regression includes firm fixed effects. Standard errors are clustered by firm.

		Low D_{St-1}/D_{t-1}						High D_{St-1}/D_{t-1}						High - Low					
		$y_{GSt} - \pi$		π		$y_{GLt} - y_{GSt}$		$y_{GSt} - \pi$		π		$y_{GLt} - y_{GSt}$		$y_{GSt} - \pi$		π		$y_{GLt} - y_{GSt}$	
		e_{j1}	[t]	f_{j1}	[t]	g_{j1}	[t]	e_{j2}	[t]	f_{j2}	[t]	g_{j2}	[t]	Δe	[t]	Δf	[t]	Δg	[t]
Panel A: Second stage regressions (1st Stage does not include firm dummy variables)																			
Leverage Quartile	1	1.00	[3.1]	1.98	[5.2]	1.12	[2.9]	2.18	[6.6]	3.36	[9.0]	2.47	[6.7]	1.18	[2.6]	1.37	[2.6]	1.35	[2.6]
	2	0.99	[3.3]	2.14	[6.3]	0.85	[2.5]	-0.76	[-1.7]	-0.56	[-1.1]	-0.73	[-1.4]	-1.75	[-3.3]	-2.70	[-4.5]	-1.58	[-2.6]
	3	1.01	[3.7]	2.07	[6.4]	1.05	[3.2]	-0.93	[-2.1]	-0.78	[-1.6]	-0.79	[-1.6]	-1.94	[-3.8]	-2.85	[-4.8]	-1.84	[-3.2]
	4	1.18	[3.6]	2.32	[6.0]	1.23	[3.3]	-1.61	[-3.6]	-1.73	[-3.3]	-1.76	[-3.4]	-2.79	[-5.0]	-4.06	[-6.2]	-2.99	[-4.7]
	4th – 1st	0.18	[0.4]	0.34	[0.6]	0.11	[0.2]	-3.79	[-5.2]	-5.09	[-6.1]	-4.23	[-5.1]	-3.97	[-4.6]	-5.43	[-5.5]	-4.33	[-4.4]
Panel B: Second stage regressions (1st Stage does include firm dummy variables)																			
Financial Constraints Quartile	1	1.19	[3.5]	2.22	[5.5]	1.43	[3.6]	1.98	[6.3]	3.12	[8.6]	2.17	[5.9]	0.79	[1.7]	0.90	[1.7]	0.74	[1.4]
	2	1.45	[5.0]	2.68	[8.0]	1.35	[4.0]	-1.02	[-2.4]	-0.85	[-1.7]	-0.92	[-1.8]	-2.47	[-4.8]	-3.53	[-5.9]	-2.27	[-3.7]
	3	1.20	[4.1]	2.51	[7.4]	1.50	[4.2]	-0.90	[-2.1]	-0.95	[-2.0]	-0.91	[-1.9]	-2.10	[-4.1]	-3.46	[-5.9]	-2.41	[-4.0]
	4	1.09	[3.4]	2.38	[6.2]	0.98	[2.6]	-1.36	[-3.1]	-1.54	[-3.0]	-1.27	[-2.5]	-2.44	[-4.5]	-3.92	[-6.2]	-2.26	[-3.6]
	4th – 1st	-0.11	[-0.2]	0.16	[0.3]	-0.45	[-0.8]	-3.34	[-4.8]	-4.66	[-5.7]	-3.45	[-4.2]	-3.23	[-3.9]	-4.82	[-4.9]	-3.00	[-3.0]