Evidence for a debt financing channel in corporate investment

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Abstract

In the simplest frictionless theory, an increase in 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 that predicts cross-sectional differences in the response of investment to interest rates. Firms with high levels of short-term debt suffer a decline in net worth, relative to firms financed with long-term debt, when nominal interest rates increase. When collateral constraints are binding, these firms reduce investment relative to the frictionless benchmark. In U.S. firm-level data between 1953 and 2001, the investment of firms with a high current portion of debt is more sensitive to interest rates when compared with firms that have little debt or only long-term debt. Consistent with my predictions, firms with high levels of short-term debt also display higher investment sensitivity to inflation.

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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 interest rates leads to a decline in investment because firms discount new projects at a higher cost of capital. Controlling for opportunities, changes in 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 interest rates affect the cost of capital for 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 for a specific 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. 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. These firms 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. Second, the theory predicts that firms with long-term debt outstanding experience an increase in net worth, and hence an increase in their borrowing capacity, when inflation is unexpectedly high. By eroding the value of long-term debt, these firms may increase investment when inflation is high. To summarize, changes in both the nominal and real components of interest rates interact with past financing decisions to influence net worth, and in turn investment. I call the interaction between financial structure and interest rates the debt market financing channel.

I test the theory by studying inventory investment and capital expenditures in a large panel of U.S. manufacturing firms between 1953 and 2001.[1] Controlling for firm- and industry-level investment determinants, I find that firms with debt retiring when nominal interest rates are high, or 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. In particular, even if one ignores debt that was issued short-term, firms with a large amount of long-term debt retiring reduce investment more when interest rates are high. Third, I break the long-term nominal interest rate into its short-term real rate, term spread, and inflation components. In multivariate regressions, I then look at the sensitivity of investment to these components. Consistent with the theory, firms with high short-term debt display higher sensitivity to the real

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[1] I study capital expenditure during the shorter period of 1963-2001 since measures of book equity necessary to construct Q are only available beginning in 1963.

interest rate and expected inflation. Fourth, I find that all of the results hold across different measures of investment, such as the broader change in net assets.

The empirical results are subject to two general sets of explanations. Either financial structure causes the sensitivity of investment to interest rates, as I propose, or financial structure and the response of investment to interest rates are jointly determined by another factor. In the latter explanation, cash flows arising from past financing decisions have no influence on future investment. It 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 would normally cut their investment more when interest rates go up. Under this explanation, the direction of causality runs from interest rate sensitivity to the maturity structure of debt, rather than the reverse.

Although my primary focus is to reject the null hypothesis of frictionless capital markets in favor of my model, I also consider a second set of explanations. These assert that my results verify the existence of a debt market financing channel in which financial structure causes the sensitivity of investment to interest rates, but reject the specific mechanism in which the decline in investment comes from a reduction in net worth. I examine such alternate mechanisms because there is still an active debate as to whether investment sensitivity to operating cash flows is evidence of financial constraints, or perhaps reflects other mechanisms (see Fazzari, Hubbard and Petersen (1988,2000), Kaplan and Zingales (1997, 2000), Bertrand and Mullainathan (2002)).

In the first alternative explanation, I study the effect of inflation on debt contracts when long-term assets are financed with short-term liabilities. When inflation increases, nominal interest payments on short-term debt rise immediately, while the nominal cash flows associated with long-term assets grow only at the rate of inflation. The greater the discrepancy between the maturity of the debt used to finance the asset and the timing of the asset's cash flows, the more the firm will have to increase the *nominal* value of the principal. If lenders are unable to recognize that higher nominal interest rates will be met by higher nominal returns on the asset, they may be unwilling to increase the *nominal* quantity of debt, and the firm may cut investment as a result. I illustrate this mechanism with a simple example and examine how its predictions line up with the evidence.

I also consider a slightly more ad hoc explanation, which asserts that managers may secure financing for projects when interest rates are low, and spend when interest rates are high, perhaps because managers think that current interest rates do not reflect the right cost of capital. Under these assumptions, financing decisions and investment decisions are separate as long as the firm has internal funds to pay for projects. Market interest rates only bind when short-term debt must be refinanced, or when long-term debt matures. This explanation is motivated by evidence in Baker, Greenwood and Wurgler (2002) that firms attempt to time the debt market. It is also consistent with survey evidence in Graham and Harvey (2001). They find that 46.35% of managers find it important or very important to "issue debt when interest rates are particularly low." The theory predicts that firms raise more funds than they spend when interest rates are low, and spend more than they raise when interest rates are high.

To preview, I find little evidence in support of the null hypothesis that the results can be explained by the endogeneity of maturity structure or by any other explanation in which financing is frictionless. I find evidence in favor of the specific financing channel I propose, but also find some support for alternative versions of the financing channel.

The results in this paper provide further evidence in favor of the well-established balance sheet channel of monetary policy (Bernanke and Blinder (1995), Bernanke, Gertler and Gilchrist

(1996)).[2] 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 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.

The results in this paper also complement recent research in corporate finance that finds that fixed investment may depend on the cost of equity finance through an equity 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

[2] See either of these for an extensive set of references to the balance sheet channel.

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). Empirically, the important prediction is that new external finance (due to either refinancing of existing debt or financing of new projects) is more costly than old external finance. New lenders, who are junior to existing debt-holders, are unwilling to extend new finance 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). The model shows that the difference grows when interest rates are increasing, because higher real interest rates reduce the real present value of collateral. The basic model also considers the effects of inflation.

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.[3] To consider the effect of shifting debt from short- to long-term, I assume that existing debt has a face value b_0 ($b_0 \geq 0$), 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

[3] 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.

assumption that from period 0, the maturity structure of debt obligations is exogenous, even though it may have been optimal ex-ante.[4]

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

$$x = b_1 - \gamma r_0 b_0 \tag{1}$$

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. It may be convenient to think of θ as zero or very low, with the understanding that very little *future* output can be pledged to lenders.

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 to this model. 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

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[4] 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.

by $f'(x) = r_1$. In the second, the constraint is binding, and so (3) holds with equality. When (3) holds

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

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

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

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.

It is important to note that one could in principle relax the assumption that debt maturity is exogenous without changing the basic prediction. Consider the following: firms choose debt structure prior to period 0 to balance the potential cost of giving up future investment opportunities with the cost of excessive debt overhang. In this framework, expected refinancing costs do not affect investment in period 0. However, unexpected refinancing costs due to *unanticipated* changes in interest rates operate in exactly the same way as in the model, bringing firms unexpectedly closer to their borrowing constraint.

b. Changes in nominal interest rates

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 model is suitable for understanding the effects of changing inflation, holding the real rate fixed.

Firms with high 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. To fix ideas, suppose that expected inflation rises from 0 to π in period 0, so that the nominal interest rate between period 1 and period 0 rises from r_1 to $r_1 + \pi$. Nominal output in period 1 is $(1+\pi) f(x)$. We can rewrite (2) in nominal terms

$$b_1 \leq \frac{\theta f(x)(1+\pi) - (1-\gamma) b_0 r_0^2}{r_1(1+\pi)} \tag{4}$$

Substituting (1) into (4) gives

$$x - \frac{\theta f(x) 1+\pi)}{r_1(1+\pi)} \leq \frac{-(1-\gamma) b_0 r_0^2}{r_1(1+\pi)} - \gamma r_0 b_0 \tag{5}$$

When (5) binds,

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

$$\frac{\partial^2 x}{\partial \pi \partial \gamma} = \frac{-b_0 r_0^2}{(1+\pi)^2 (r_1 - \theta f'(x))} < 0$$

$$\frac{\partial^3 x}{\partial r_1 \partial \gamma \partial b_0} = \frac{-r_0^2}{(1+\pi)^2 (r_1 - \theta f'(x))} < 0$$

In words, inflation increases borrowing capacity less for firms with high short-term debt burdens, because the real value of their debt does not change when inflation increases- it is immediately translated into higher nominal interest rates. Similar to the previous case, the differential impact of inflation increases as we increase leverage.

c. 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 components of investment, but may be especially important for components of investment with low adjustment costs.[5] 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 sum of the real interest rate and inflation, firms with high short-term debt levels should be *more* sensitive to *nominal* interest rates. Using the nominal treasury bill yield as the baseline 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

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[5] 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.

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 those firms that are financially constrained. 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) and used for similar purposes in Baker, Wurgler, and Stein (2002).

The next section describes the data before presenting the results in Section IV and V.

III. Data

a. Interest rates and inflation

Debt market conditions are represented by three annual variables: the nominal short-term rate, the term spread, and inflation. The baseline interest rate measure is the nominal short-term rate (y_{GSt}) , measured as the annualized yield of the three-month treasury bill in June. I measure interest rates in June rather than in December because the investment data includes firms with fiscal years ending in July through September, and because inflation expectation data is available in June of each year.[6] 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

[6] This implies that interest rates are lagged more for some firms than for others. This lag is never more than 6 months.

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_{At+1}), or as the mean forecast of expected inflation from the Livingston Survey in June of each year (π_{Et}).[7] 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. Finally, I include, but do not report, the credit spread ($y_{CSt} - y_{GSt}$), the difference between the December commercial paper yield and the annualized December Treasury bill return. Most of the analysis omits this component due to concern about interpretation.[8] 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 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. It is worth noting that within each decade between 1953 and 2000, there appears to be substantial variation in both real and nominal interest rates.

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[7] 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

[8] Specifically, firms with high amounts of short-term debt may be a higher default risk. It is possible that business cycle changes in their ability to repay drive changes in the credit spread, rather than the reverse interpretation required by the theory. Because of the ambiguity in interpretation, I leave it out of the main analysis.

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.

The table also reports summary statistics for the innovations of these variables. For each variable, I estimate an autoregression with two lags of each variable and a moving average residual term, and report the mean, median, standard deviation and extreme values of these residuals. For all three series, the residuals calculated in this manner are highly correlated with simple differences. To address statistical concerns associated with serial correlation of the independent variable, some of the empirical work uses these innovations in place of levels.

b. Investment, financing, and debt maturity

I collect investment data from Compustat according to the following procedure. 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. I follow industry definitions follow from Fama and French (1997).[9] I also draw a second sample that includes retail (SIC Codes 5200-5299) and wholesale (SIC 5000-5199) firms.[10]

I follow Kasyhap, Lamont and Stein (1994) and measure inventory investment as the change in the log of the inventory to sales ratio. I scale inventories (item 3) 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 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 (taken from CRSP when available), plus assets (item 6) minus the

[9] 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.

[10] Blinder and Maccini (1991) report that firms of this type hold a modest fraction of total inventories.

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 observations with assets less than $1 million or with book equity less than $250,000. I also drop firm-years that report any 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.[11] Finally, to reduce the presence of outliers, I winsorize all of the firm-level data at the 1% and 99% levels.[12]

Panel A of Table 2 summarizes the investment data. In total, there are 37,296 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 the log inventory to sales ratio was positive, on average between 1953 and 2001, implying that firms have been increasing inventories relative to sales, counter to intuition that inventory management has been effective at reducing the number of days inventory. More importantly, changes in inventory are very volatile, especially in comparison with capital expenditure, but even in comparison with the change in net assets.

I next collect data on equity issues (Δitem 60 + Δitem 74 - Δitem 36), and equity plus debt issues (Δitem 6 + Δitem 74 - Δitem 36), both scaled by lagged assets. These variables are summarized in Panel B.

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. Short-term debt contains both the current portion of long-term debt and notes

[11] I drop all observations for which Compustat item 129 (Acquisitions) is non-zero.
[12] I follow this procedure primarily to remove extreme observations of Q, but also because my screens may not have selected out capital expenditure or changes in assets due to extraordinary activity.

payable[13]. 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 also calculate the ratio of the current portion of long-term debt, scaled by assets ($D_{Curr,t-1}/A_{t-1}$). I also require measures of debt maturity that are independent of the *level* of debt. I thus 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 share of current long-term debt in total long-term debt ($D_{Curr,t-1}/D_{Long,t-1}$). The advantage of the latter measure is that it does not reflect debt that was chosen to be short-term.

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 17% 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 (2002)). I account for the possibility of time-series trends in the maturity of new issues by sorting short-term debt *within* years.

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. In addition, the 1982 recession has been heavily studied by many authors (e.g. Kashyap, Lamont, Stein (1994)) and is in many senses a clean experiment in which short-term interest rates were temporarily very high.

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.

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[13] 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.

The model predicts that when nominal interest rates are high, firms with high short-term debt should 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 1050 firms with complete data in 1982, and sort these firms into quartiles based on their level of short-term debt at the beginning of the year. I measure short-term debt as the sum of notes payable and the current portion of long-term debt, both scaled by assets (D_{St-1}/A_{t-1}), or as the ratio of short-term debt (as before) scaled by total debt (D_{St-1}/D_{t-1}). Investment is measured as either the change in the inventory to sales ratio ($\Delta Log(Inv/Sales)_{it}$), or as capital expenditures scaled by assets ($CAPX_t/A_{t-1}$), or as the change in net assets scaled by assets ($\Delta A_t/A_{t-1}$),.

Panel A shows average investment in 1982 for each short-term debt quartile. Measuring investment as the change in the inventory to sales ratio, investment declines uniformly across quartiles. Panel A also 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. The theory relates investment-interest rate sensitivity to the level of short-term debt, and not the ratio of short-term to long-term debt. However, since the level of short-term debt is highly correlated with leverage, it is useful to check that leverage alone does not drive the results. [14]

Panel B analyzes capital expenditures. As in Panel A, investment declines uniformly 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. Investment again 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

[14] If leverage alone were driving the results, it would be consistent with more standard credit channel explanations of monetary policy in which agency problems or information asymmetries worsen during recessions.

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. Specifically, the negative relationship between short-term debt and investment may not be particular to 1982. For example, short-term debt 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 alternative explanations 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. Baseline specifications

I first consider determinants of inventory investment. The baseline regression studies the change in the log inventory to sales ratio as a function of the lagged log inventory to sales ratio, and the change in the log of firm sales of the current and previous year

$$\begin{aligned}\Delta LOG(Inv/Sales)_{i,t} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} \\ + d \cdot \Delta LOG(Sales)_{it-1} + u_{it}\end{aligned} \tag{6}$$

This specification follows Kashyap, Lamont and Stein (1994). It is easy to rearrange terms and see that it estimates an autoregressive model of the log inventory to sales ratio, with changes driven by increases or decreases in sales. Lovell (1961) provides a motivation for this framework – manufacturers adjust inventory stocks to a desired inventory-to-sales ratio, with changes driven by increases or decreases in sales.[15]

To start, I estimate this regression on the entire panel. Each year, I group residuals from the regression into quartiles based on short-term debt in the previous year. Short-term debt is measured as notes payable plus the current portion of long-term debt, all scaled by lagged assets. Panel A of Figure 3 plots the time series of average residuals for the 1st and 4th short-term debt quartile, and Panel B plots the difference between these two series. The figure shows that the difference in residual investment between firms in the 4th and 1st short-term debt quartiles tends to grow during recessions.

In Panel A of Figure 4, I plot the series of differences from Figure 3 against the lagged treasury bill yield in the previous year. The figure displays a strong negative correlation. This has a straightforward interpretation: the investment of firms with high short-term debt burdens is relatively lower during years when nominal interest rates are high.

To analyze this result more carefully, I estimate (6) including a measure of nominal interest rates on the right hand side.

$$\begin{aligned}\Delta LOG(Inv/Sales)_{i,t} &= a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} \\ &+ d \cdot \Delta LOG(Sales)_{it-1} + e \cdot y_{GSt-1} + u_{it}\end{aligned} \tag{7}$$

The regressions are run as follows. In each year, I sort firms into quartiles based on the ratio of short-term debt to assets. I estimate equation (7) for each quartile, and compare the estimated coefficient on lagged nominal interest rates between quartiles. Table 3 shows these results. For each quartile, the lagged short-term rate is significantly negatively related to inventory

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[15] 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.

investment. The coefficient ranges from –0.19 for the first quartile and increases in magnitude by a factor of three to –0.77 in the last quartile. Note that the coefficient falls monotonically across quartiles: the more short-term the maturity of a firm's debt, the more it is affected by interest rates. The difference between quartiles is –0.44 and is significant at the 1% level.

The second panel of Table 3 repeats the estimation, this time sorting on a different measure of short-term debt. I sort firms into quartiles according to the ratio of their current liabilities to assets. The results are almost unchanged, and the difference between quartiles remains a significant –0.64.

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.[16] I alleviate some of these concerns by sorting on a measure of the current portion of long-term debt, scaled by assets (Panel C). The results in this panel indicate that firms that retired a large amount of long-term debt when interest rates were high, cut their inventory investment in comparison with similar firms.

I next consider determinants of capital expenditure. I estimate a standard regression that includes cash flows, Q in the previous year, and firm fixed effects (see for example Fazzari, Hubbard, Petersen (1988))

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + u_{it} \tag{8}$$

I follow a procedure identical to that used to study inventory investment. Each year, I group residuals from (8) into quartiles based on my measure of short-term debt in the previous year. Panel A of Figure 4 plots the time series of average residuals for the 1st and 4th short-term debt quartile, and Panel B plots the difference between these two series. The figure shows that the

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[16] See Section V.

magnitude of the difference in residual investment between firms in the 4th and 1st short-term debt quartiles tends to grow during recessions.[17]

In Panel A of Figure 4, I plot the series of differences from Figure 3 against the lagged treasury bill yield in the previous year. Similar to the results with inventory investment, the figure displays a negative correlation. Capital expenditure of firms with high short-term debt burdens thus decline more during years when nominal interest rates are high.

To analyze this result more carefully, I estimate (8) including a measure of nominal interest rates at the beginning of the year on the right hand side

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + d \cdot y_{GSt-1} + u_{it} \tag{9}$$

Following the same procedure as before, I sort firms into quartiles based on short-term debt. I estimate equation (9) for each quartile, and compare the estimated coefficient on lagged nominal interest rates between quartiles. The two middle columns of Table 3 show these results. In the first three quartiles, capital expenditure is positively related to nominal interest rates, while it is negatively related in the fourth quartile. The coefficient ranges from 0.14 for the first quartile to –0.03 for the last quartile. The difference of –0.17 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 0.50% more than firms in the first short-term debt quartile.

There are two other noteworthy observations. First, the coefficient falls monotonically across quartiles, consistent with my predictions. Second, the magnitude of the coefficient, as well as the magnitude of the difference between the fourth and first quartiles, is lower than that

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[17] Note that these series do not begin until 1962. This is due to the impossibility of collecting sufficient data on equity prices from CRSP to measure Q between 1953-1961. In each of these years, there is insufficient data to calculate average investment in each quartile.

of inventory investment. This verifies the intuition that capital expenditure, due to its higher adjustment costs, is less sensitive to changes in credit market conditions.

The second panel of Table 3 repeats the estimation, this time sorting on the ratio short-term debt, net of cash, to assets. The results are almost unchanged, and the difference between quartiles remains a highly significant –0.25.

Finally, in Panel C, I sort firms by the current portion of long-term debt, scaled by assets. The difference between quartiles holds as before.

The last two columns of Table 3 analyze the change in net assets as a function of operating cash flows, lagged Q, and lagged nominal interest rates. It is hardly surprising that the results from inventory investment and capital expenditure carry through to the change in net assets. By definition, this measure of investment includes changes in inventories and capital expenditure. In Panel A, the difference in investment between the fourth and first short-term debt quartiles grows in economic and statistical significance compared with the other investment measures. In Panels B and C, the results are similar.

b. Industry-year controls

The baseline specifications do not include any industry or year fixed effects. The benefit of this approach is that the theory does not rule out the possibility that cash flow constraints operate at an industry level, and equation (7) allows these effects to enter. Indeed, wide variation in debt maturity structure across industries (see Opler and Titman (1992)) may have cross-sectional implications for financial distress during years of tight credit. It is reasonable to expect, for example, that industries that rely on short-term debt to finance growth opportunities experience financial distress when refinancing happens at higher than expected nominal interest rates. However, the drawback is that I may sort by a measure of short-term debt that captures investment sensitivity to the business cycle for reasons other than cash flow constraints. For example, firms in different industries may have assets of different maturities, and the maturity structure of debt may simply reflect firms' attempts to match the life-span of their assets with a mix of short- and long-term debt.

I control for rational variation in maturity structure of this type by sorting firms into quartiles of short-term debt expressed as a difference from the industry mean in that year. In addition, I include dummies for each industry in each year. These results are shown in Table 4. Within industries, the effects are still very strong. In all four quartiles, inventory investment is negatively related to nominal interest rates, with a large and significant difference of -0.51 between the fourth and first quartiles. As before, capital expenditure is positively related to interest rates in three of the four quartiles, with a significant difference of –0.12 between the first and fourth quartile. The interpretation is straightforward: firms with high short-term debt, relative to the industry mean in that year, suffer significantly larger declines in inventory investment relative to the industry decline, when interest rates are high. In Panel B I measure short-term debt net of cash holdings, the results are even stronger: the difference between the fourth and first quartiles grows to a highly significant -0.70 for inventory investment and grows to –0.20 for capital expenditure. Finally, by sorting on the current portion of long-term debt, the results remain strong.

c. Testing finer predictions of the model

Here I examine some finer predictions of the model. First, within a set of firms with similar total leverage, interest rates should matter more for firms with a greater short-term component of this leverage. The basic sorts in Table 3 and Table 4 are unsatisfactory for analyzing this interaction, because the baseline short-term debt measure (Panel A) blends leverage and maturity structure, while the additional sort (Panel C) considers maturity without controlling for leverage.

Table 5a tests the interaction in greater detail. I follow the same inference procedure as in Table 3 and Table 4, except that each year, firms are sorted first by lagged leverage (measured by total debt over assets, D_{t-1}/A_{t-1}), and then within leverage groups they are sorted by short-term debt to total debt ratio[18]. As before, the regressions include firm fixed effects.

Panel A describes the results when short-term debt is measured as the ratio of notes payable and the current portion of long-term debt to total debt (D_{St-1}/D_{t-1}). Because this ratio is meaningless for firms with zero leverage, I omit firms with no debt in the previous year. Nevertheless, the first leverage quartile contains mostly firms with very low leverage, so there is still little meaningful distinction between short- and long-term debt. In the second leverage quartile, however, firms with a higher short-term share of debt have a significantly higher sensitivity to interest rates when compared with firms with a low short-term share of debt. Firms with high short-term debt ratios are three times as sensitive to changes in interest rates (the coefficient changes from –0.18 to –0.54). The same result holds for the third and fourth quartiles. It is noteworthy that the difference in sensitivity to interest rates Δe is increasing in leverage. The difference between firms with a low short-term share and a high short-term share grows from zero in the first leverage quartile to –0.48 in the last leverage quartile. In short, these results confirm the interaction suggested by the model, in which both the quantity and maturity structure of debt play a role in financing constraints.

Panel B shows that the results also hold when I measure both leverage and the short-term debt to total debt ratio as a difference from the industry mean in that year. Within the second, third and fourth leverage quartiles, firms with a high short-term share of debt display higher sensitivity to interest rates.

Panel C recognizes that short-term debt may be a choice variable and instead sorts firms based first on leverage and then on the ratio of the current portion of long-term debt to total long-term debt. Firms that retired large portions of their long-term debt when interest rates were high reduced inventory investment compared with firms with similar leverage.

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[18] Whenever total debt is equal to zero, I set the ratio of short-term to long-term debt equal to zero.

I repeat this analysis for capital expenditure. These results are shown in Table 5b. In all four leverage quartiles, firms with a high short-term share of debt have a lower coefficient on lagged interest rates. The difference between firms with a high short-term share and firms with a low short-term share grows in magnitude from –0.02 in the first leverage quartile to –0.16 in the fourth leverage quartile. This technique therefore provides a richer sort than in Table 3 and Table 4, and better captures the intuition of the model.

d. Changes in nominal interest rates

So far, the regressions have studied the relationship between investment and the *level* of nominal interest rates. This approach has two potential problems. First, although the theory suggests the lagged nominal interest rate as the suitable independent variable, it displays a high degree of autocorrelation, which may bias the estimates of interest rate sensitivity and reduce the statistical significance I ascribe to these estimates (see West (1988), Stambaugh (1999)).

Second, my model attributes declines in investment to changes in net worth arising from the interaction of interest rates and debt maturity. However, if interest rates were permanently high, these declines would be fully planned because net worth is known already the period before. In short, there are both theoretical and econometric reasons to consider the question of whether the results can be attributed to levels, or changes in the levels of past interest rates.

In Table 6, I calculate innovations nominal interest rates, measured as the residuals from an autoregression of the annualized t-bill yield on two lags of itself and a moving average residual term. This variable is summarized in Panel B of Table 1. I then repeat the sorting procedures of Table 5a and Table 5b using these innovations as the right-hand-side interest rate measure.

Panel A analyzes inventory investment as a function of innovations in nominal interest rates. In three of the four leverage quartiles, firms with a high short-term share of debt are more sensitive to changes in interest rates, when compared with firms with a low short-term share of debt. In words, firms with high ratios of short-term debt to total debt reduce investment more after *increases* in the nominal interest rate. This difference grows monotonically across leverage quartiles, and the difference in differences is a significant –1.01. In short, firms with high ratios of short-term debt to total debt are proportionately more affected by increases in nominal interest rates when they also have a high level of debt.

Panel B analyzes capital expenditure. Compared with the results in Table 5b, the results are slightly weaker. Nevertheless, as before, within leverage quartiles, firms with a higher short-term share of debt are more sensitive to changes in nominal interest rates.

e. 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. Another meaningful decomposition of the interest rate is to break the long-term nominal rate into its short-term real rate, term spread, and expected inflation components. Specifically, Table 7 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 into quartiles by a measure of short-term debt, and for each quartile I estimate

$$\Delta LOG(Inv/Sales)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + e \cdot (y_{GSt-1} - \pi_{t-1}) + f \cdot (y_{GLt-1} - y_{GSt-1}) + g \cdot \pi_{t-1} + u_{it}$$

for inventory investment and

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + e \cdot (y_{GSt-1} - \pi_{t-1}) + f \cdot (y_{GLt-1} - y_{GSt-1}) + g \cdot \pi_{t-1} + u_{it}$$

for capital expenditure.[19]

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[19] These regressions include firm fixed effects, but all of the results below hold if I sort on short-term debt as a deviation from the industry-year mean, and add industry-year dummies.

Panel A reports the results for inventory investment. I measure expected inflation as the mean forecast inflation from Livingston, 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. The coefficient on the real interest rate falls monotonically from 0.55 in the first quartile to –1.12 in the fourth quartile. More interesting, however, are the results on inflation. The coefficient on inflation falls from –0.18 to –1.05, a (significant) difference of –0.87 between quartiles.

Panel B repeats these inventory investment regressions using alternate measures of the real interest rate and expected inflation. I instead measure realized inflation one year hence, and calculate the real short-term rate as the difference between the annualized nominal return on the treasury bill and this measure of inflation. The panel shows that the results are significantly stronger when inflation is calculated in this way. In fact, much of the relationship between investment and nominal interest rates appears to come from the inflation component.

Panel C and Panel D repeat the procedures for inventory investment with capital expenditure. Panel C shows that firms with high levels of short-term debt are more sensitive to the real and nominal components of interest rates. It is worth noting that inflation has a positive effect on firms in all short-term debt quartiles, but that this effect is declining as short-term debt increases. These results are strengthened somewhat when I measure inflation as realized inflation in the following year, in Panel D.

Table 8 shows the results of the final set of tests, in which I repeat the regressions summarized in Table 7 but replace interest rate variables with their innovations. As before, these innovations are calculated as the residuals from autoregressions of each variable on itself and a moving average error term.

Table 8 confirms that correcting for autocorrelation of the interest rate series does not eliminate the basic result. In Panel B, for example, the difference in coefficients between the fourth and first quartiles is –0.55 for the real interest rate series, and –0.50 for the series of innovations. Both are highly significant. The coefficient on innovations in inflation is now equal to 0.18 in the first quartile and –0.78 in the fourth quartile; the difference of –0.93 is highly statistically significant.

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 consistent with at least three other theories:

1. Firms with short-term debt may be more sensitive to changes in interest rates because the maturity structure of debt is endogenously related to the sensitivity of investment to interest rates.
2. The results provide evidence for a debt financing channel in which *nominal* lending rigidities worsen misalignment between the *nominal* cash flows of a firm's assets and nominal payments due on short-term debt. Lenders, who evaluate firms on current cash flows, do not lend firms new funds to replace the shortfall in nominal cash flows.
3. Managers secure financing when interest rates are low because they believe the debt market to be inefficient. When interest rates change, these managers continue to invest until short-term debt is due for refinancing, or long-term debt matures.

This section discusses evidence for each of these alternative theories, then returns to evidence for the specific mechanism suggested by my model.

a. Explanation 1

Explanation 1 is the null hypothesis of frictionless markets, in which 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 regressions from Table 4, adding dummies for each industry in each year. The results hold as before, and in fact become statistically stronger. 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. I also estimate the regressions in Table 3 measuring short-term debt as a deviation from the firm mean, and find that the results still hold. In other words, changes in interest rates have stronger effects on the *same firm* in years when it has a higher proportion of short-term debt. I also repeat the regressions from Table 3 (see Table 9), including *future* sales on the right hand side of the inventory regressions, and future cash flows on the right hand side of the capital expenditure regressions. Controlling for future changes in opportunities, the results hold as before.

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.

b. Explanation 2

In the model, inflation has a positive effect on firms with long-term debt, and no effect on firms holding short-term debt. However, increases in inflation, through their effect on *nominal* interest rates, may be detrimental to firms with short-term debt if there are nominal contracting rigidities. Nominal contracting rigidities arise because inflation may worsen misalignment between the nominal cash flows of an asset and nominal payments due on short-term debt. This is the first alternative debt financing channel mentioned in section 1. It is best understood in a simple example.

Consider a firm that finances the purchase of a $100 million asset with short-term debt rolled over every period at a real interest rate of 10%. Suppose that inflation is zero and that the asset produces a *real* income of $15 million after taxes every period. Both its nominal and real interest coverage are 15/10 = 1.5, and the project has a net present value of 15/.10 = $150 million, in real terms. Suppose now that expected inflation rises permanently from 0 to 10%. The nominal interest rate rises to 20%, and expected nominal income next period rises with inflation to $16.5 million (1.1 x $15 million). The present value of the asset is unchanged in real terms, while the nominal present value increases by 10% to 16.5/(0.20-0.10) = $165. However, since the nominal level of debt is fixed, the firm must refinance its $100 million debt at a nominal interest rate of 20%. Interest coverage falls to 16.5 / 20 = 0.83. In other words, inflation increases the "financing gap", the difference between the firm's sources and uses of funds, and the firm is no longer able to make its interest payments in the next period (see Bernanke and Gertler (1995)). Since interest coverage is below 1, the firm would be required to borrow additional funds the next period to make up for the shortfall.[20] If lenders are able to perfectly align increases in nominal interest rates with growing nominal returns on assets, the quantity of the loan increases. However, if lenders evaluate borrowers on the basis of *current* interest coverage, they may refuse to rollover the loan, not recognizing that the higher nominal interest rates will be offset by higher nominal returns on the asset in the future.

There are two key elements in the argument for such nominal lending rigidities. First, the maturity of the assets and the maturity of the liabilities must not be perfectly matched. In the previous example, the asset produced cash flows indefinitely, while the debt was rolled over every period. Second, lenders must evaluate firms' creditworthiness on the basis of current interest coverage, and thus fail to take into account inflation.

[20] If we assume that all income was devoted to paying off interest, the principal would have to grow by $3.5 million in the first year, $2.55 million in year 2, $1.25 million in year 3, and would shrink after that.

The predictions of this setup are similar to those coming from the model in Section II: firms with long-term debt benefit, relative to firms with short-term debt, during periods of high inflation. However, in that model, there was no drawback to short-term debt. The discussion above, however, suggests that not only should firms with long-term debt benefit, but firms with short-term debt may actually cut investment during periods of high inflation due to lending rigidities.

There is some evidence to support these predictions. First, Table 5a reveals that firms with short-term debt not only increase investment less when interest rates are high, but their investment declines when interest rates are high. These results also hold in three out of four leverage quartiles in Table 5b, as well as the basic results from Tables 3 and 4.

It is difficult to distinguish between the cash flow mechanism discussed here and the net worth channel in my model. Both have the same predictions on the differential effects of changes in real interest rates and inflation on short- versus long-term borrowers. The distinction comes from whether firms with short-term debt are unaffected, or hurt, in an *absolute* sense by declines in nominal cash flows. While the evidence in this paper confirms that this does indeed occur, it is unclear what the direction of causality is, since changes in interest rates are themselves driven by expectations about future economic activity.

c. Explanation 3

The third explanation says that managers believe the debt market is inefficient, and secure financing when interest rates are low. When interest rates are high, they ignore market conditions and continue with investment plans, unless their debt is short-term or their long-term debt is maturing, in which case they must refinance at the new rates. This theory holds whether managers rationally believe that the debt market is inefficient, or because they are over-optimistic in their assessment of risk for their firm.

The proposition that managers rationally attempt to time the debt market is consistent with survey evidence from Graham and Harvey (2001) that managers issue debt when interest rates are low. Over a third of managers consider it important or very important to “issue short-term when short-term interest rates are low compared to long-term rates” and 28.7% of managers consider it important or very important to “issue short-term when we are waiting for long-term market interest rates to decline.” Indeed, Table 7 shows that firms cut back on investment when both the short-term nominal rate and the long-term nominal rate are high. This proposition is also consistent with evidence on financing patterns in Baker, Greenwood, and Wurgler (2002). They show that managers attempt to time the debt market in aggregate.

If I rest on this explanation of the results, they highlight an important aspect of debt market timing: even if managers can save costs in the short-run by timing the bond market, investment is affected when their short-term debt comes due for refinancing when interest rates are high.

A sub case of explanation 3 is that managers irrationally time the bond market. This may be because they are over optimistic about the required rate of return on projects for their firm, or because they irrationally think that interest rates do not reflect the right cost of capital.

Explanation 3 implies that firms hoard cash when interest rates are low, and spend cash when interest rates are high. Empirically, I find some weak evidence that firms increase cash holdings following increases in interest rates (unreported).

d. Implications for net worth

Although it is difficult to distinguish between the various possible mechanisms by which financing cash flows affect investment, there is at least 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 macroeconomic 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.

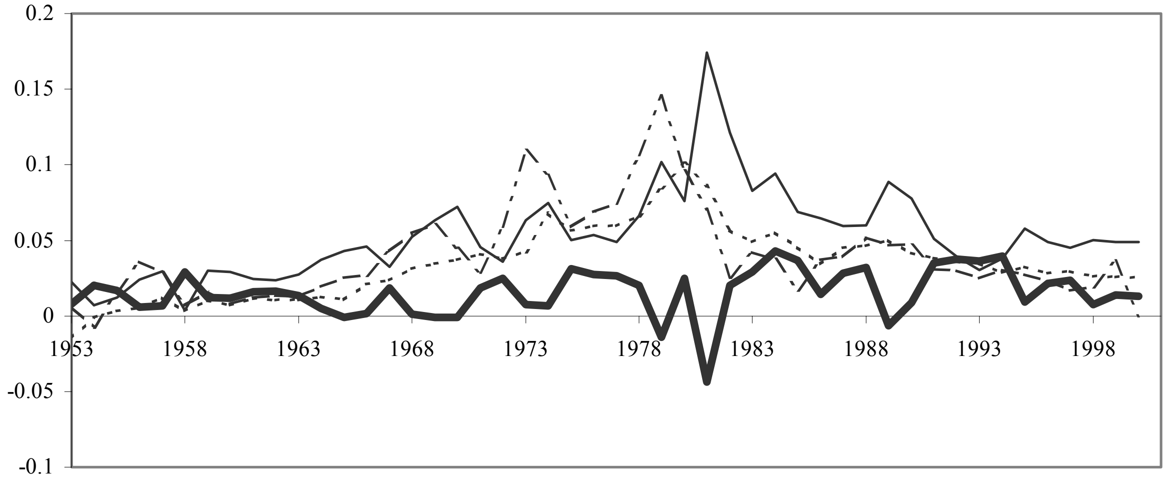
Titman, Sheridan, 2002, The Modigliani and Miller theorem and the integration of financial markets, *Financial Management* 31, 101-130.

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. Debt market conditions 1953-2000. Panel A shows the annualized Treasury bill yield, the annualized term spread, and annualized expected inflation, all measured at the end of June each year. Expected inflation is measured alternately as the average 12 month forecast inflation from the Livingston survey, 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.

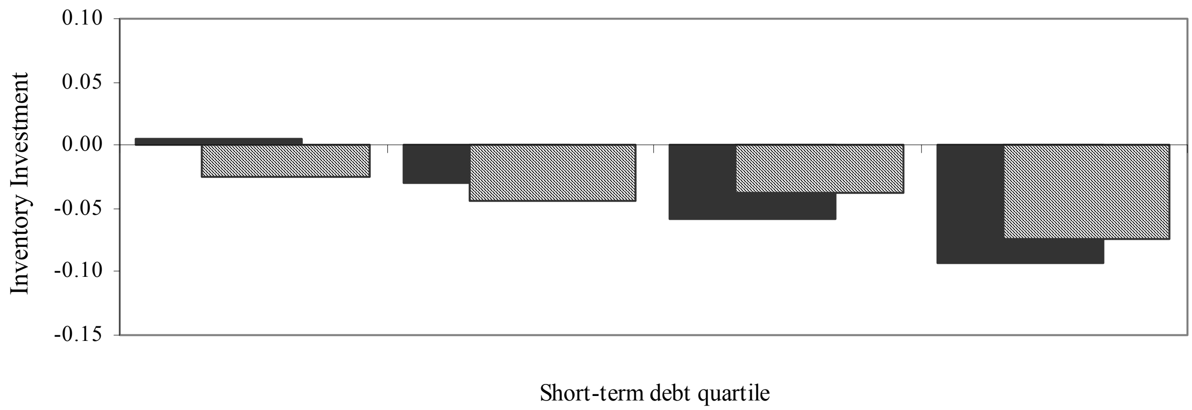
Panel A. The treasury bill (thin line), term spread (thick line), inflation (expected - dash, realized - long dash)



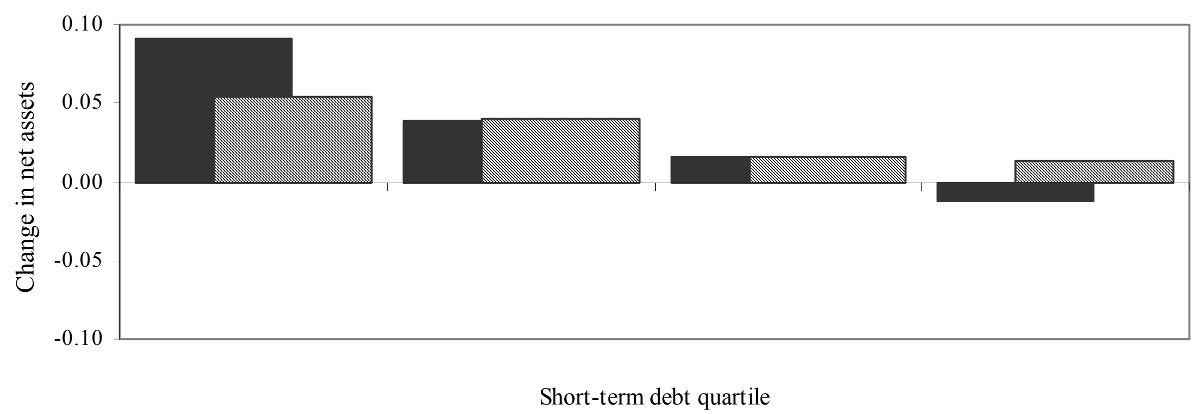
Panel B. The real short-term rate (expected - line, realized - dash)

Figure 2. Investment and the maturity structure of debt during the 1982 recession. The table shows average investment for the 1050 firms reporting full data in 1982. I sort firms into quartiles based on short-term debt in the previous year. I sort alternately by short-term debt over assets (solid) and 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 inventory investment, measured as the change in the log of the inventory-to-sales ratio. In Panel B, investment is measured as capital expenditures, scaled by lagged assets. In Panel C, investment is measured as the change in net assets, scaled by lagged assets.

Panel A. Inventory investment by short-term debt quartile



Panel B. Capital Expenditure by short-term debt quartile



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

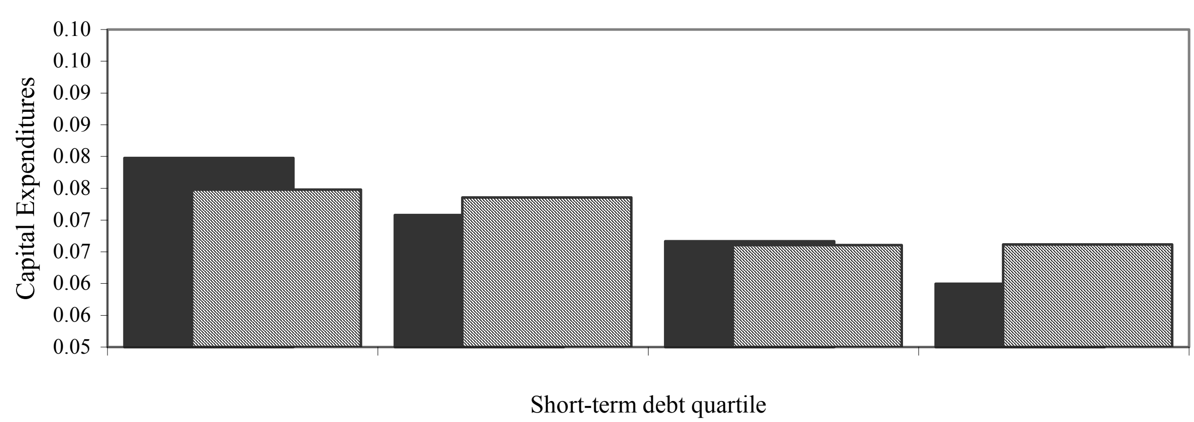
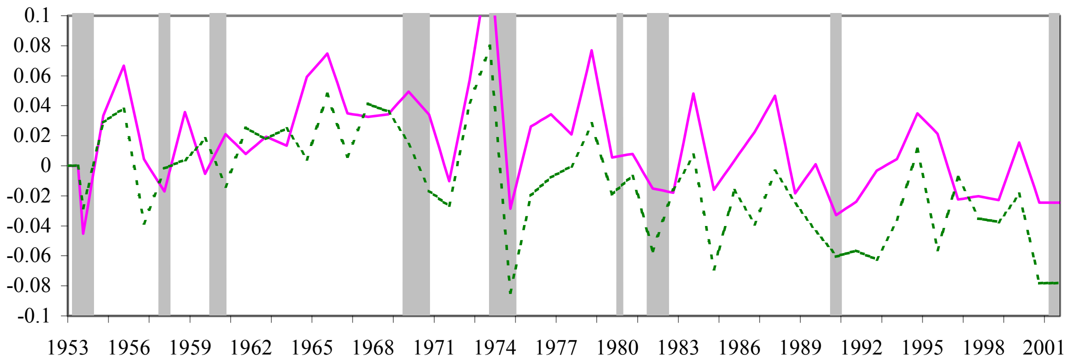


Figure 3. Inventory investment and the maturity structure of debt 1953-2001. I estimate inventory investment on changes in sales and other firm characteristics

$$\Delta LOG(Inv/Sales)_{i,t} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + u_{it}$$

Each year, residuals are cumulated into quartiles based on short-term debt in the previous year. Short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by lagged assets. Panel A plots the time series of average residuals of firms in the first (solid) and fourth (dashed) quartiles of short-term debt. Panel B plots the time series of the difference between the fourth and first quartiles. The shaded bars indicate NBER recessions, defined by the NBER business cycle dating committee.

Panel A. Residual inventory investment by short-term debt quartile (1st Quartile solid, 4th Quartile dash)



Panel B. Differences

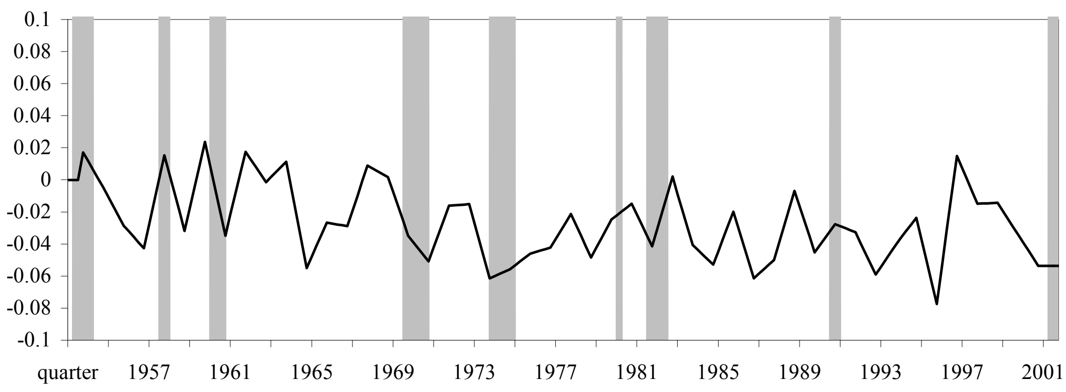
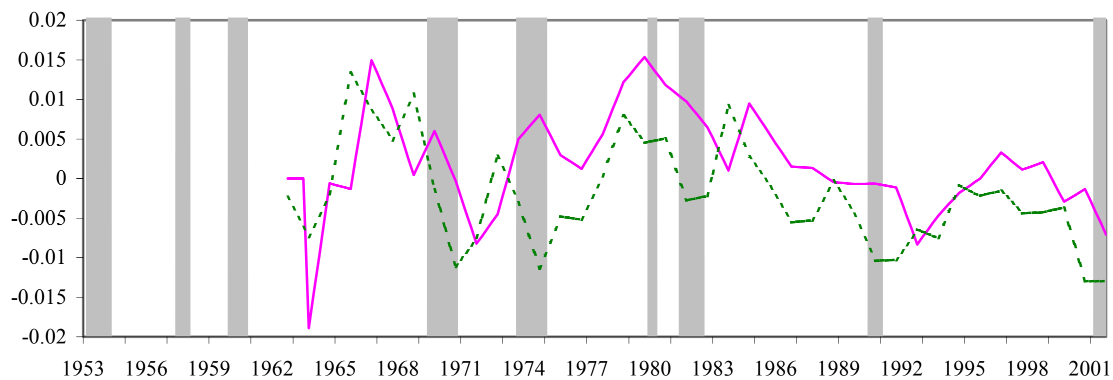


Figure 4. Fixed investment and the maturity structure of debt 1963-2001. I estimate capital expenditure on operating cash flows and lagged Q

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + u_{it}$$

Each year, residuals are cumulated into quartiles based on short-term debt in the previous year. Short-term debt is measured as notes payable plus the current portion of long-term debt, scaled by lagged assets. Panel A plots the time series of average residuals of firms in the first (solid) and fourth (dashed) quartiles of short-term debt. Panel B plots the time series of the difference between the fourth and first quartiles. The shaded bars indicate NBER recessions, defined by the NBER business cycle dating committee.

Panel A. Residual fixed investment by short-term debt quartile (1st Quartile solid, 4th Quartile dash)



Panel B. Differences

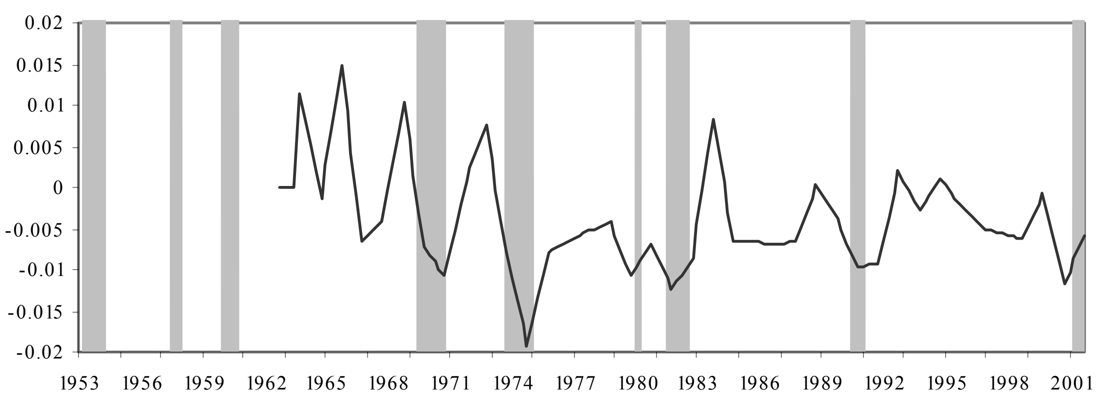


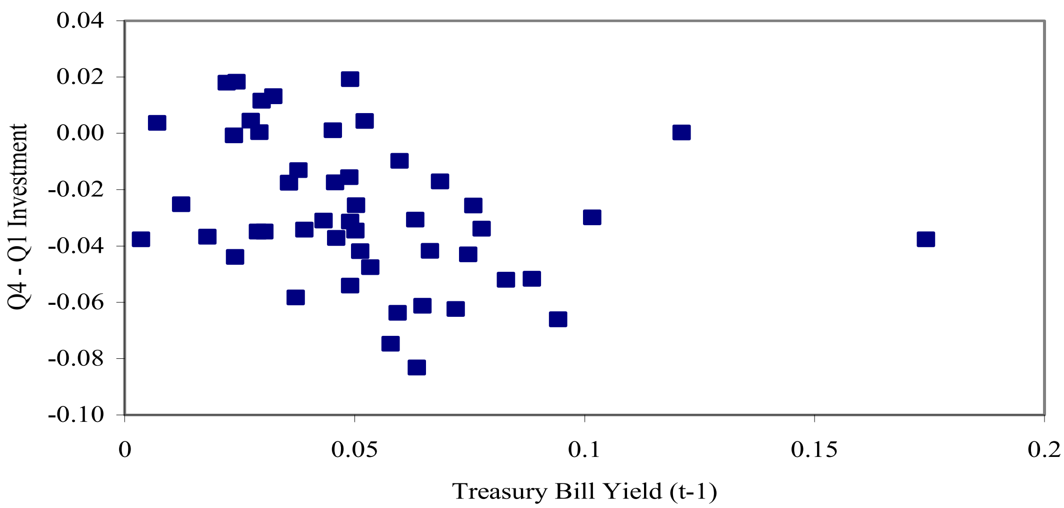
Figure 5. Short-term debt, investment, and short-term interest rates 1953-2001. I estimate inventory investment on changes in sales and other firm characteristics

$$\Delta LOG(Inv/Sales)_{it} = a_i + b \cdot LOG(Inv/Sales)_{i,t-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + u_{it}$$

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + u_{it}$$

Each year, I group residuals from this estimation into quartiles based on short-term debt in the previous year. Short-term debt is measured as notes payable plus the current portion of long-term debt, all scaled by lagged assets. I then calculate the average of the residuals in each short-term debt quartile. The figure plots the difference between the fourth and first quartile against the yield on the treasury bill at the beginning of the year.

Panel A: Inventory investment



Panel B. Capital Expenditure

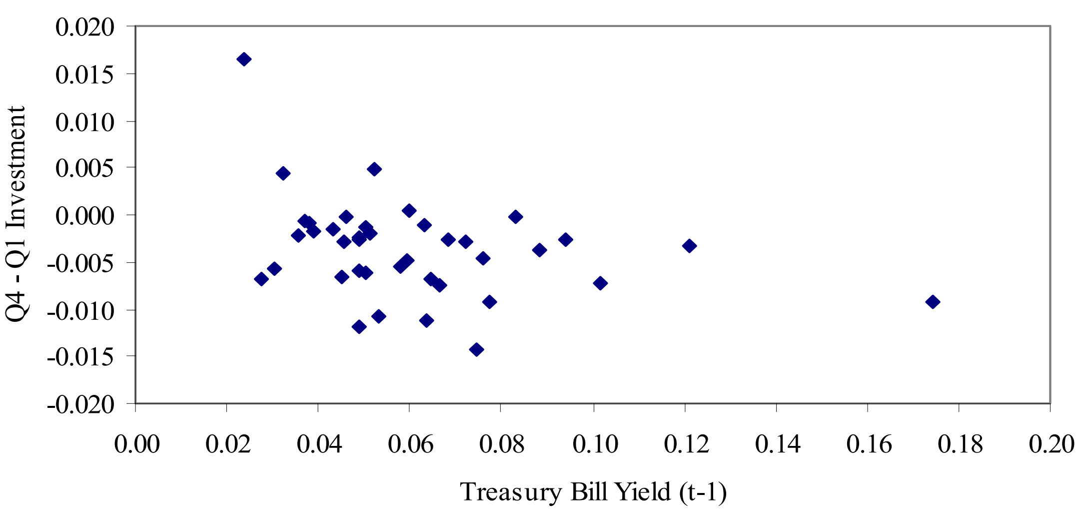


Table 1. Interest rate conditions, 1953-2000. Mean, median, standard deviation, and extreme values of annual variables, measured at the end of June in each year. All variables are expressed in percentage terms. Panel A decomposes the long-term real interest rate into its components: the nominal June 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 annualized June long-term government bond yield and the annualized June treasury bill return. Expected annual inflation is measured alternately as realized inflation in the next year (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 either of the two measures of expected inflation ($y_{GSt} - \pi_{At+1}$ or $y_{GSt} - \pi_{Et}$). The table includes the Federal Funds rate ($ffunds_t$) as an additional measure of the short-term nominal interest rate. This series begins in 1954. Panel B summarizes innovations of these components, computed in each case as the residuals from an autoregression with two lagged terms and an MA(1) residual. All data are from Ibbotson (2001).

(%)	**N**	**Mean**	**Median**	**SD**	**Min**	**Max**
Panel A: Interest rate conditions						
y_{GSt}	48	5.30	4.91	3.01	0.36	17.42
$y_{GLt} - y_{GSt}$	48	1.56	1.62	1.56	-4.39	4.32
π_{Et}	48	0.03	0.03	0.02	-0.01	0.10
π_{At+1}	48	4.02	3.06	3.08	-0.74	14.58
$y_{GSt} - \pi_{Et}$	48	1.85	1.81	1.86	-2.51	8.82
$y_{GSt} - \pi_{At+1}$	48	1.24	1.41	2.92	-4.60	10.31
$ffunds_t$	46	6.21	5.56	3.45	0.93	19.10
Panel B: Innovations						
y_{GSt}	48	-0.05	-0.38	2.04	-2.98	10.22
$y_{GLt} - y_{GSt}$	48	0.00	0.11	1.54	-5.82	2.49
π_{Et}	48	0.00	0.00	0.02	-0.03	0.05
π_{At+1}	48	0.03	-0.18	1.77	-3.31	4.76
$y_{GSt} - \pi_{Et}$	48	0.01	0.04	1.78	-4.33	8.22
$y_{GSt} - \pi_{At+1}$	48	0.02	-0.02	2.10	-3.07	10.17
$ffunds_t$	44	0.09	-0.18	2.29	-4.97	9.35

Table 2. Investment, financing, and the maturity structure of debt, 1953-2001. The sample is restricted to manufacturing firms with fiscal years in June or later for which Compustat reports data on all investment and leverage variable, except *Q*. Manufacturing firms are classified using industry definitions from Fama and French (1997). The inventory to sales ratio is given by total inventories (item 3) over net sales (item 12), with changes defined accordingly. Fixed investment is measured alternately as capital expenditures (item 128) or the change in net assets (Δitem 6), both scaled by lagged assets. 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 from CRSP, plus assets minus the book value of equity (item 60 + item 74), over assets. All of these data, with the exception of Q are expressed in percentage terms. Panel B summarizes financing variables, expressed in percentage terms. Equity issues are defined as the change in book equity minus the change in retained earnings (Δitem 60 + Δ item 74 - Δ item 36), scaled by lagged assets. Total issues additionally include debt issues (Δitem 6 + Δitem 60 - Δitem 74) . The table also defines debt issues net of retiring debt, equal to the change in total debt plus the current portion (D^*_t/A_{t-1}). Panel C describes firm leverage and the maturity structure of debt, all in percentage terms. 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}). 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, or as current debt net of cash over total debt (D^*_{St-1}/D_{t-1}). All data are winsorized at the 1% and 99% levels to remove outliers.

	N	Mean	Median	SD	Min	Max
Panel A: Investment and determinants of investment (t)						
$Log(Inv/Sales)_{it}$	37,296	-175.53	-168.88	59.49	-346.25	-58.58
$\Delta Log(Inv/Sales)_{it}$	37,296	5.34	5.51	26.07	-66.57	72.82
$\Delta Log(Sales)_{it}$	37,296	7.40	7.59	20.29	-48.64	61.53
$CAPX_t/A_{t-1}$	37,296	6.97	5.33	5.84	0.40	27.52
$(A_t - A_{t-1})/A_{t-1}$	37,296	8.37	6.09	20.08	-33.40	79.08
CF_t/A_{t-1}	37,296	8.42	9.82	11.61	-33.66	30.50
Q_{t-1}	33,876	1.55	1.14	1.18	0.53	6.39
Panel B: Financing (t)						
e_t/A_{t-1}	33,450	3.66	0.45	11.72	-7.52	63.57
$(e_t+d_t)/A_{t-1}$	33,560	2.97	1.57	12.63	-25.79	44.18
Panel C: Leverage and the maturity structure of debt (t-1)						
D_{t-1}/A_{t-1}	37,296	20.52	19.16	15.97	0.00	59.62
D_{St-1}/A_{t-1}	37,296	5.84	2.57	7.85	0.00	34.66
D^*_{St-1}/A_{t-1}	37,296	-6.70	-3.27	18.27	-60.06	31.29
$D_{Curr,t-1}/A_{t-1}$	33,330	1.69	0.83	2.34	0.00	11.42
D_{St-1}/D_{t-1}	37,296	28.45	17.09	30.33	0.00	100.00
D^*_{St-1}/D_{t-1}	37,296	41.07	34.88	133.11	-437.56	483.14
$D_{Curr,t-1}/D_{Long,t-1}$	32,163	13.67	7.06	19.01	0	90.57

Table 3. Investment and nominal interest rates by short-term debt quartile, 1953-2001. In each year, firms are separated into quartiles based on their lagged fraction of short-term debt. Quartiles are aggregated across years, and for each quartile, the table reports results of the panel regressions of investment on the determinants of investment and the lagged short-term nominal interest rate

$$\Delta LOG(Inv/Sales)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + e \cdot y_{GSt-1} + u_{it}$$

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + d \cdot y_{GSt-1} + u_{it}$$

$$\frac{\Delta A_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + d \cdot y_{GSt-1} + u_{it}$$

The estimations are performed separately for inventory investment, capital expenditure, and the change in net assets. For each measure, the table reports the coefficient on the lagged short-term nominal interest rate, and the t-statistic. The table also reports the difference between the coefficient on the lagged nominal interest rate between short-term debt quartiles 1 and 4, together with the t-statistic. Panel A sorts firms based on the fraction of short-term debt in the previous year, measured as current debt over assets (DS_{t-1}/A_{t-1}). Panel B sorts firms based on current debt net of cash, over assets (DS^*_{t-1}/A_{t-1}). Panel C sorts the remaining firms based on the ratio of the current portion of long-term debt to total assets. Each regression includes firm-fixed effects, restricted to be equal if the same firm appears in different quartiles. All four regressions are run simultaneously, with standard errors clustered by firm.

		Inventory Investment		Capital Expenditure		ΔNet Assets	
	N	**e**	**[t-stat]**	**d**	**[t-stat]**	**d**	**[t-stat]**
Panel A: Short-term debt = (Current Portion of Long-term debt + Notes Payable) / Assets							
Quartile 1	9,610	-0.19	[-1.99]	0.14	[6.77]	0.24	[3.94]
2	9,028	-0.31	[-3.82]	0.06	[3.54]	-0.04	[-0.72]
3	9,317	-0.44	[-5.58]	0.00	[-0.04]	-0.23	[-4.18]
4	9,341	-0.77	[-8.66]	-0.03	[-1.50]	-0.62	[-9.36]
4th Quartile – 1st Quartile		-0.58	[-4.65]	-0.17	[-6.96]	-0.85	[-10.45]
R^2			0.42		0.49		0.48
Panel B: Short-term debt = (Current Portion of Long-term debt + Notes Payable - Cash) / Assets							
Quartile 1	9,340	0.04	[0.36]	0.19	[8.95]	0.12	[1.85]
2	9,298	-0.44	[-5.74]	0.08	[4.18]	0.01	[0.09]
3	9,318	-0.55	[-7.22]	-0.03	[-1.74]	-0.15	[-2.75]
4	9,340	-0.76	[-8.57]	-0.06	[-3.26]	-0.57	[-8.83]
4th Quartile – 1st Quartile		-0.80	[-6.02]	-0.25	[-9.86]	-0.69	[-8.03]
R^2			0.42		0.49		0.48
Panel C: Short-term debt = (Current Portion of Long-term debt) / Assets							
Quartile 1	8,245	-0.18	[-1.72]	0.14	[6.86]	0.10	[1.67]
2	7,516	-0.38	[-4.18]	0.08	[4.25]	0.02	[0.26]
3	8,290	-0.30	[-3.33]	0.03	[1.95]	-0.21	[-3.93]
4	9,279	-0.53	[-5.72]	-0.03	[-1.36]	-0.33	[-5.17]
4th Quartile – 1st Quartile		-0.36	[-2.67]	-0.16	[-6.71]	-0.43	[-5.27]
R^2			[0.42]		[0.48]		[0.49]

Table 4. Investment within industries and nominal interest rates by short-term debt quartile, 1953-2001. In each year, firms are separated into quartiles based on their lagged fraction of short-term debt expressed as a difference from the industry mean in that year. Quartiles are aggregated across years, and for each quartile, the table reports results of panel regressions of investment on the determinants of investment and the lagged short-term nominal interest rate

$$\Delta LOG(Inv/Sales)_{ijt} = a_i + a_{jt} + b \cdot LOG(Inv/Sales)_{ijt-1} + c \cdot \Delta LOG(Sales)_{ijt} + d \cdot \Delta LOG(Sales)_{ijt-1} + e \cdot y_{GSt-1} + u_{ijt}$$

$$\frac{CAPX_{ijt}}{A_{ijt-1}} = a_i + a_{jt} + b\frac{CF_{ijt}}{A_{ijt-1}} + cQ_{ijt-1} + d \cdot y_{GSt-1} + u_{ijt}$$

$$\frac{\Delta A_{ijt}}{A_{ijt-1}} = a_i + a_{jt} + b\frac{CF_{ijt}}{A_{ijt-1}} + cQ_{ijt-1} + d \cdot y_{GSt-1} + u_{ijt}$$

The estimations are performed separately for inventory investment, capital expenditure, and the change in net assets. For each measure, the table reports the coefficient on the lagged short-term nominal interest rate, and the t-statistic. The table also reports the difference between the coefficient on the lagged nominal interest rate between short-term debt quartiles 1 and 4, together with the t-statistic. Panel A sorts firms based on the fraction of short-term debt in the previous year, measured as current debt over assets (DS_{t-1}/A_{t-1}), expressed as a difference from the industry mean in that year. Panel B sorts firms based on current debt net of cash, over assets (DS^*_{t-1}/A_{t-1}) also expressed as a difference from the industry mean in that year. Panel C sorts the remaining firms based on the ratio of the current portion of long-term debt to total assets, expressed as a difference from the industry mean in that year. Each regression includes firm-fixed effects, restricted to be equal if the same firm appears in different quartiles. All four regressions are run simultaneously, with standard errors clustered by firm.

		Inventory Investment		Capital Expenditure		ΔNet Assets	
	N	**e**	**[t-stat]**	**d**	**[t-stat]**	**d**	**[t-stat]**
Panel A: Short-term debt = (Current Portion of Long-term debt + Notes Payable) / Assets							
Quartile 1	9,333	-0.74	[-10.54]	0.06	[3.85]	-0.26	[-4.76]
2	9,093	-0.73	[-12.30]	0.04	[2.89]	-0.29	[-6.18]
3	9,258	-1.05	[-17.04]	0.00	[-0.28]	-0.44	[-9.00]
4	9,251	-1.41	[-20.32]	-0.06	[-3.44]	-0.69	[-12.35]
4th Quartile – 1st Quartile		-0.67	[-9.13]	-0.12	[-7.19]	-0.44	[-7.36]
R^2			[0.39]		[0.46]		[0.44]
Panel B: Short-term debt = (Current Portion of Long-term debt + Notes Payable - Cash) / Assets							
Quartile 1	9,251	-0.33	[-4.52]	0.08	[4.73]	-0.37	[-6.49]
2	9,207	-0.96	[-15.81]	0.03	[2.16]	-0.36	[-7.58]
3	9,226	-1.18	[-19.20]	-0.01	[-0.93]	-0.35	[-7.19]
4	9,251	-1.46	[-21.13]	-0.06	[-3.71]	-0.60	[-10.50]
4th Quartile – 1st Quartile		-1.13	[-14.06]	-0.14	[-7.86]	-0.23	[-3.52]
R^2			[0.39]		[0.46]		[0.44]
Panel C: Short-term debt = (Current Portion of Long-term debt) / Assets							
Quartile 1	8,227	-0.75	[-10.81]	0.06	[3.49]	-0.19	[-3.69]
2	7,865	-0.94	[-14.70]	0.03	[1.91]	-0.27	[-5.35]
3	8,039	-0.97	[-14.84]	0.02	[1.51]	-0.27	[-5.54]
4	8,629	-1.22	[-16.86]	-0.05	[-3.19]	-0.45	[-8.09]
4th Quartile – 1st Quartile		-0.47	[-6.46]	-0.11	[-6.29]	-0.26	[-4.40]
R^2			[0.40]		[0.45]		[0.47]

Table 5a. Inventory investment and nominal interest rates by leverage and short-term debt, 1953-2001. I drop firms with lagged leverage (D_{t-1}/A_{t-1}) equal to zero. In Panel A, firms are then separated into quartiles based on leverage in the previous year. Each year and within each leverage quartile, firms are again separated by their short-term debt to total 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. Bins are aggregated across years, and for each quartile, the table reports results of the panel regression

$$\Delta LOG(Inv/Sales)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it}$$
$$+ d \cdot \Delta LOG(Sales)_{it-1} + e \cdot y_{GSt-1} + u_{it}$$

Each panel reports the estimated coefficient on lagged nominal interest rates (*e*) for low short-term share firms and high short-term share firms within each quartile. 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. All eight regressions are run simultaneously, restricting firm fixed effects to be the same if the same firm appears in different quartiles or different short-term share groupings. Standard errors are clustered by firm.

		Low short-term share		**High short-term share**		**Difference**		
Leverage Quartile	**N**	**e**	**[t-stat]**	**e**	**[t-stat]**	**Δe**	**[t-stat]**	**R^2**
Panel A: No controls								
1	8,300	0.15	[1.78]	0.14	[1.64]	0.00	[-0.04]	
2	8,251	-0.18	[-2.37]	-0.54	[-6.04]	-0.36	[-3.11]	
3	8,274	-0.54	[-7.33]	-0.87	[-9.26]	-0.33	[-2.85]	
4	8,300	-0.70	[-8.24]	-1.18	[-10.68]	-0.48	[-3.66]	
4th Quartile – 1st Quartile		-0.85	[-8.34]	-1.32	[-7.44]	-0.47	[-2.56]	0.44
Panel B: Industry-year controls								
1	8,300	0.15	1.87	0.06	[0.69]	-0.10	[-1.12]	
2	8,251	-0.17	-2.32	-0.35	[-4.22]	-0.18	[-1.64]	
3	8,274	-0.51	-6.80	-0.73	[-7.81]	-0.22	[-1.92]	
4	8,300	-0.63	-7.32	-1.08	[-10.27]	-0.45	[-3.57]	
4th Quartile – 1st Quartile		-0.78	-7.74	-1.14	[-6.74]	-0.36	[-2.02]	0.44
Panel C: Long-term debt only								
1	8,300	0.06	[0.77]	0.23	[2.69]	0.17	[1.84]	
2	8,251	-0.29	[-3.93]	-0.51	[-5.83]	-0.22	[-1.94]	
3	8,274	-0.66	[-9.15]	-0.83	[-8.98]	-0.17	[-1.49]	
4	8,300	-0.80	[-9.53]	-1.15	[-10.82]	-0.35	[-2.85]	
4th Quartile – 1st Quartile		-0.86	[-8.50]	-1.38	[-7.96]	-0.52	[-2.90]	

Table 5b. Capital expenditure and nominal interest rates by leverage and short-term debt, 1963-2001. I drop firms with lagged leverage (D_{t-1}/A_{t-1}) equal to zero. In Panel A, firms are then separated into quartiles based on leverage in the previous year. Each year and within each leverage quartile, firms are again separated by their short-term debt to total 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. The bins are aggregated across years, and for each quartile, the table reports results of the panel regression

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + d \cdot y_{GSt-1} + u_{it}$$

Each panel reports the estimated coefficient on lagged nominal interest rates (*e*) for low short-term share firms and high short-term share firms within each quartile. 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. All eight regressions are run simultaneously, restricting firm fixed effects to be the same if the same firm appears in different quartiles or different short-term share groupings. Standard errors are clustered by firm.

		Low short-term share		**High short-term share**		**Difference**		
Leverage Quartile	**N**	**d**	**[t-stat]**	**d**	**[t-stat]**	**Δd**	**[t-stat]**	**R^2**
Panel A: No controls								
1	7,608	0.17	[7.76]	0.15	[6.96]	-0.02	[-0.80]	
2	7,542	0.09	[4.79]	-0.03	[-1.47]	-0.12	[-4.37]	
3	7,565	0.04	[1.97]	-0.13	[-5.80]	-0.17	[-5.94]	
4	7,590	-0.11	[-5.24]	-0.28	[-11.03]	-0.16	[-5.37]	
4th Quartile – 1st Quartile		-0.28	[-10.59]	-0.43	[-10.18]	-0.15	[-3.48]	0.50
Panel B: Industry-year controls								
1	7,608	0.14	[7.02]	0.14	[6.69]	0.00	[-0.12]	
2	7,542	0.11	[5.71]	-0.04	[-2.14]	-0.15	[-5.48]	
3	7,565	0.06	[2.93]	-0.13	[-5.99]	-0.19	[-6.70]	
4	7,590	-0.09	[-4.10]	-0.27	[-10.86]	-0.18	[-5.83]	
4th Quartile – 1st Quartile		-0.23	[-9.24]	-0.41	[-9.89]	-0.17	[-4.20]	0.50
Panel C: Current portion of long-term debt only								
1	7,608	0.14	[6.69]	0.17	[7.74]	0.02	[1.09]	
2	7,542	0.11	[5.60]	-0.06	[-2.94]	-0.17	[-6.04]	
3	7,565	0.04	[2.11]	-0.15	[-6.58]	-0.19	[-6.70]	
4	7,590	-0.11	[-5.54]	-0.30	[-11.35]	-0.19	[-6.17]	
4th Quartile – 1st Quartile		-0.26	[-10.18]	-0.47	[-10.81]	-0.21	[-4.87]	0.50

Table 6. Investment and unexpected changes in nominal interest rates. In each year, firms are separated into quartiles based on their lagged fraction of short-term debt. Quartiles are aggregated across years, and for each quartile, the table reports results of the panel regression of the change in the log inventory-sales ratio of firm *i* in industry *j* in year *t* on lags of itself, changes in sales, and expected and unexpected costs of refinancing.

$$\Delta LOG(Inv/Sales)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + e \cdot (y_{GSt-1} - \hat{y}_{GSt-1}) + u_{it}$$

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + e \cdot (y_{GSt-1} - \hat{y}_{GSt-1}) + v_{it}$$

In Panel A, the regression includes a separate dummy for each firm; in Panel B, the regression includes a separate dummy for each firm and for each industry-year, with industry definitions following Fama and French (1997). The fraction of short-term debt is measured alternately as current debt over assets, current liabilities over assets, or short-term debt over total debt. All four regressions are run simultaneously, restricting firm fixed effects to be equal if the same firm appears in different quartiles. Each panel also reports the difference in the coefficient on lagged nominal interest rates across quartiles, together with the significance level. Standard errors are clustered by firm.

		Low short-term share		**High short-term share**		**Difference**		
Leverage Quartile	**N**	**e**	**[t-stat]**	**e**	**[t-stat]**	**Δe**	**[t-stat]**	R^2
Panel A: Inventory investment 1953-2001								
1	8,191	-0.02	[-0.10]	0.36	[2.13]	0.38	[1.62]	
2	8,132	-0.13	[-0.86]	-0.51	[-2.21]	-0.38	[-1.36]	
3	8,164	-0.29	[-2.01]	-0.83	[-3.60]	-0.54	[-1.99]	
4	8,191	-0.26	[-1.70]	-0.89	[-3.62]	-0.63	[-2.13]	
4th Quartile – 1st Quartile		-0.25	[-1.11]	-1.25	[-3.27]	-1.01	[-2.25]	0.43
Panel B: Capital Expenditure 1963-2001								
1	7,552	0.14	[3.42]	0.14	[3.67]	0.00	[-0.01]	
2	7,492	0.06	[1.74]	-0.06	[-1.08]	-0.12	[-1.88]	
3	7,501	0.04	[1.00]	-0.15	[-3.12]	-0.19	[-3.04]	
4	7,535	-0.01	[-0.36]	-0.17	[-3.44]	-0.16	[-2.64]	
4th Quartile – 1st Quartile		-0.15	[-2.83]	-0.31	[-3.77]	-0.16	[-1.62]	0.49

Table 7. Investment and interest rate conditions. In each year, firms are separated into quartiles based on their lagged fraction of short-term debt. Quartiles are aggregated across years, and for each quartile, the table reports results of panel regressions of investment on determinants of investment and lagged interest rate conditions.

$$\Delta LOG(Inv/Sales)_{it} = a_i + b \cdot LOG(Inv/Sales)_{i,t-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1}$$
$$+ e \cdot (y_{GSt-1} - \pi_{t-1}) + f \cdot (y_{GLt-1} - y_{GSt-1}) + g \cdot \pi_{t-1} + u_{it}$$
$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b \frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + e \cdot (y_{GSt-1} - \pi_{t-1}) + f \cdot (y_{GLt-1} - y_{GSt-1}) + g \cdot \pi_{t-1} + u_{it}$$

Interest rate conditions are summarized by the real short-term rate ($y_{GSt} - \pi$), the term spread ($y_{GLt} - y_{GSt}$), and expected inflation (π). Expected inflation is measured alternately as the mean forecast inflation from the Livingston survey, or as realized inflation in the following year. The fraction of short-term debt is measured as current debt over assets. All four regressions are run simultaneously, with firm fixed-effects restricted to be equal for the same firm if it appears in different short-term debt quartiles. Each panel also reports the difference in coefficients between changes in nominal interest rates across quartiles, together with the significance level. Standard errors are clustered by firm.

		$y_{GSt}-\pi$		$y_{GLt}-y_{GSt}$		π		
	N	**e**	**[t-stat]**	**f**	**[t-stat]**	**g**	**[t-stat]**	**R^2**
Panel A: Inventory Investment ($\pi = \pi_{Et}$)								
Quartile 1	9,610	-0.55	[-3.32]	-0.24	[-1.13]	-0.18	[-1.31]	
2	9,028	-0.58	[-4.34]	-0.69	[-3.76]	-0.55	[-4.49]	
3	9,317	-0.61	[-4.39]	-0.70	[-3.76]	-0.76	[-6.61]	
4	9,341	-1.12	[-7.59]	-0.94	[-4.86]	-1.05	[-7.59]	
4th – 1st Quartile		-0.58	[-2.65]	-0.70	[-2.51]	-0.87	[-4.91]	0.42
Panel B: Inventory Investment ($\pi = \pi_{At+1}$)								
Quartile 1	9,610	-0.49	[-4.16]	0.04	[0.19]	0.18	[1.34]	
2	9,028	-0.57	[-5.47]	-0.39	[-2.29]	-0.18	[-1.45]	
3	9,317	-0.78	[-7.50]	-0.54	[-3.07]	-0.32	[-2.85]	
4	9,341	-1.00	[-8.87]	-0.50	[-2.72]	-0.75	[-5.66]	
4th – 1st Quartile		-0.50	[-3.23]	-0.54	[-2.08]	-0.93	[-5.53]	0.42
Panel C: Capital Expenditure ($\pi = \pi_{Et}$)								
Quartile 1	8,508	0.03	[0.66]	0.07	[1.51]	0.32	[8.91]	
2	8,419	-0.03	[-0.77]	0.04	[1.01]	0.21	[6.53]	
3	8,462	-0.05	[-1.54]	0.00	[-0.01]	0.12	[3.92]	
4	8,487	-0.06	[-1.50]	-0.04	[-1.00]	0.08	[2.20]	
4th – 1st Quartile		-0.08	[-1.65]	-0.11	[-1.98]	-0.24	[-6.13]	0.49
Panel D: Capital Expenditure ($\pi = \pi_{At+1}$)								
Quartile 1	8,508	-0.03	[-0.28]	0.27	[1.95]	0.68	[6.83]	
2	8,419	-0.19	[-2.00]	0.17	[1.38]	0.30	[3.34]	
3	8,462	-0.24	[-2.47]	0.20	[1.60]	0.02	[0.20]	
4	8,487	-0.64	[-5.15]	-0.20	[-1.34]	-0.38	[-3.46]	
4th – 1st Quartile		-0.61	[-3.86]	-0.46	[-2.45]	-1.06	[-8.82]	0.48

Table 8. Investment and changes in interest rate conditions. In each year, firms are separated into quartiles based on their lagged fraction of short-term debt. Quartiles are aggregated across years, and for each quartile, the table reports results of panel regressions of investment on determinants of investment and innovations in lagged interest rate conditions

$$\Delta LOG(Inv/Sales)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + e \cdot (y_{GSt-1} - \pi_{t-1}) + f \cdot (y_{GLt-1} - y_{GSt-1}) + g \cdot \pi_{t-1} + u_{it}$$

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + e \cdot (y_{GSt-1} - \pi_{t-1}) + f \cdot (y_{GLt-1} - y_{GSt-1}) + g \cdot \pi_{t-1} + u_{it}$$

Interest rate conditions are summarized by innovations in the real short-term rate ($y_{GSt} - \pi$), innovations in the term spread ($y_{GLt} - y_{GSt}$), and innovations in expected inflation (π). Expected inflation is measured alternately as the mean forecast inflation from the Livingston survey, or as realized inflation in the following year. These variables are summarized in Table 1. The fraction of short-term debt is measured as current debt over assets. All four regressions are run simultaneously, with firm fixed-effects restricted to be equal for the same firm if it appears in different short-term debt quartiles. Each panel also reports the difference in coefficients between changes in nominal interest rates across quartiles, together with the significance level. Standard errors are clustered by firm.

Innovations in:		$y_{GSt} - \pi$		$y_{GLt} - y_{GSt}$		π		
	N	**e**	**[t-stat]**	**f**	**[t-stat]**	**g**	**[t-stat]**	**R^2**
Panel A: Inventory Investment ($\pi = \pi_{Et}$)								
Quartile 1	9,610	-0.69	[-3.19]	-0.47	[-1.81]	-0.17	[-1.12]	
2	9,028	-0.42	[-2.24]	-0.43	[-1.95]	0.02	[0.12]	
3	9,317	-0.65	[-3.37]	-0.63	[-2.82]	-0.34	[-2.48]	
4	9,341	-1.12	[-5.57]	-0.67	[-2.81]	-0.66	[-4.30]	
4th – 1st Quartile		-0.43	[-1.45]	-0.20	[-0.57]	-0.49	[-2.26]	0.41
Panel B: Inventory Investment ($\pi = \pi_{At+1}$)								
Quartile 1	9,610	-0.49	[-4.16]	0.04	[0.19]	0.18	[1.34]	
2	9,028	-0.57	[-5.47]	-0.39	[-2.29]	-0.18	[-1.45]	
3	9,317	-0.78	[-7.50]	-0.54	[-3.07]	-0.32	[-2.85]	
4	9,341	-1.00	[-8.87]	-0.50	[-2.72]	-0.75	[-5.66]	
4th – 1st Quartile		-0.50	[-3.23]	-0.54	[-2.08]	-0.93	[-5.53]	0.42
Panel C: Capital Expenditure ($\pi = \pi_{Et}$)								
Quartile 1	8,508	-0.02	[-.40]	-0.07	[-1.25]	0.09	[2.64]	
2	8,419	0.01	[0.24]	0.01	[0.19]	0.12	[3.71]	
3	8,462	-0.02	[-.46]	-0.01	[-.17]	0.03	[0.97]	
4	8,487	-0.05	[-1.09]	-0.05	[-.89]	-0.02	[-.51]	
4th – 1st Quartile		-0.03	[-0.48]	0.02	[0.26]	-0.11	[-2.25]	0.48
Panel D: Capital Expenditure ($\pi = \pi_{At+1}$)								
Quartile 1	8,508	0.13	[4.60]	0.18	[4.34]	0.34	[10.97]	
2	8,419	0.06	[2.40]	0.15	[4.09]	0.24	[8.83]	
3	8,462	0.01	[0.55]	0.10	[2.64]	0.15	[5.62]	
4	8,487	0.01	[0.28]	0.06	[1.36]	0.10	[3.38]	
4th – 1st Quartile		-0.12	[-3.60]	-0.12	[-2.26]	-0.24	[-7.56]	0.49

Table 9. Robustness: Investment and nominal interest rates by short-term debt quartile, 1953-2001. The table performs basic robustness tests on the results in Tables 2 and 3. In each year, firms are separated into quartiles based on their lagged fraction of short-term debt, measured as current debt over assets. Quartiles are aggregated across years, and for each quartile, I estimate

$$\Delta LOG(Inv/Sales)_{it} = a_i + b \cdot LOG(Inv/Sales)_{it-1} + c \cdot \Delta LOG(Sales)_{it} + d \cdot \Delta LOG(Sales)_{it-1} + e \cdot y_{GSt-1} + u_{it}$$

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + b\frac{CF_{it}}{A_{it-1}} + cQ_{it-1} + e \cdot y_{GSt-1} + u_{it}$$

All four regressions are run simultaneously, restricting firm fixed effects to be equal across quartiles. Where applicable, industry-year fixed effects are restricted to be equal across quartiles. The table reports the coefficient *e* for each quartile, and the difference in this coefficient between the fourth and first quartiles, together with the associated t-statistic. Panel A shows the results for inventory investment. Panel B shows the results for capital expenditure. The basic specification (1) includes firm fixed effects from Table 2. Specification (2) sorts firms based on short-term debt, expressed as a difference from industry mean in that year. Specification (3) repeats (2) with additional fixed effects for each industry-year. Specification (4) repeats (3), except sorting by short-term debt, net of cash, over assets. Specifications (5) & (6) analyze 1953-1975 and 1976-2001 separately using the basic specification from (1). Specification (7) redraws the sample to include trade firms. Specification (8) sorts by short-term debt over assets from (1), except demeaned by firm. Industry definitions follow Fama and French (1997). Standard errors are clustered by firm.

		1st Quartile		2nd Quartile		3rd Quartile		4th Quartile		4th-1st Quartile		
	N	**e**	**[t-stat]**	**e**	**[t-stat]**	**e**	**[t-stat]**	**e**	**[t-stat]**	**Δe**	**[t-stat]**	**R^2**
Panel A: Inventory Investment												
1. Basic specification (Table 2)	37,296	-0.19	[-1.99]	-0.31	[-3.82]	-0.44	[-5.58]	-0.77	[-8.66]	-0.58	[-4.65]	0.42
2. Sort within industry-years (Table 3)	36,935	-0.25	[-2.62]	-0.30	[-3.58]	-0.39	[-4.92]	-0.76	[-8.42]	-0.51	[-4.02]	0.42
3. Same as above + industry-year fixed effects	36,935	-0.74	[-10.54]	-0.73	[-12.30]	-1.05	[-17.04]	-1.41	[-20.32]	-0.67	[-9.13]	0.39
4. Same as above + Net out cash	36,935	-0.33	[-4.52]	-0.96	[-15.81]	-1.18	[-19.20]	-1.46	[-21.13]	-1.13	[-14.06]	0.39
5. 1953-1975	10,461	0.68	[2.89]	-0.12	[-0.53]	-0.17	[-0.79]	-0.83	[-2.89]	-1.52	[-4.18]	0.52
6. 1976-2001	26,835	0.06	[0.56]	0.08	[0.87]	-0.09	[-0.97]	-0.49	[-4.75]	-0.55	[-3.66]	0.44
7. Include trade firms	40,121	-0.16	[-1.75]	-0.36	[-4.60]	-0.45	[-5.89]	-0.79	[-9.21]	-0.63	[-5.24]	0.42
8. Demean short-term debt by firm	37,296	-0.19	[-1.99]	-0.31	[-3.82]	-0.44	[-5.58]	-0.77	[-8.66]	-0.58	[-4.65]	0.42
Panel B: Capital Expenditure												
1. Basic specification (Table 2)	33,876	0.14	[6.77]	0.06	[3.54]	0.00	[-0.04]	-0.03	[-1.50]	-0.17	[-6.96]	0.49
2. Sort within industry-years (Table 3)	33,664	0.09	[4.56]	0.09	[5.11]	0.01	[0.71]	-0.02	[-1.28]	-0.12	[-4.93]	0.49
3. Same as above + industry-year fixed effects	33,619	0.06	[3.85]	0.04	[2.89]	0.00	[-0.28]	-0.06	[-3.44]	-0.12	[-7.19]	0.46
4. Same as above + Net out cash	33,619	0.08	[4.73]	0.03	[2.16]	-0.01	[-0.93]	-0.06	[-3.71]	-0.14	[-7.86]	0.46
5. 1953-1975	7,602	0.14	[2.05]	0.07	[1.15]	-0.08	[-1.32]	-0.12	[-2.01]	-0.26	[-3.66]	0.59
6. 1976-2001	26,274	0.15	[6.41]	0.07	[3.60]	0.02	[1.26]	-0.01	[-0.28]	-0.15	[-5.74]	0.51
7. Include trade firms	36,576	0.14	[6.92]	0.06	[3.82]	0.00	[-0.10]	-0.02	[-0.93]	-0.16	[-6.60]	0.49
8. Demean short-term debt by firm	33,876	0.14	[6.77]	0.06	[3.54]	0.00	[-0.04]	-0.03	[-1.50]	-0.17	[-6.96]	0.49