ABSTRACT

The presence of risky debt in a firm’s capital structure can lead to inefficient investment decisions when managers act in the interest of shareholders. Based on this agency cost perspective, I describe the market for debt repurchases and examine whether debt repurchase activity is consistent with a firm’s desire to mitigate debt overhang. I present an agency model of debt which demonstrates that when a firm faces a debt overhang problem, the value of a reduction in debt can outweigh the cost of the repurchase and increase the welfare of both stockholders and bondholders. Using a sample of debt repurchases initiated by U.S. firms over the period 1996 to 2004, I find evidence consistent with the agency cost model of corporate debt policy. Specifically, I find that firms are more likely to repurchase outstanding debt either by open market transactions or tender offers when potential transfers to bondholders are high. Employing a matching methodology based on propensity scores, I document significant increases in firm investment levels and efficiency for repurchasing firms relative to a control sample. This improvement is more pronounced for firms with higher expected transfers to bondholders (overhang). In addition, the efficiency improvements are concentrated in investment expenditures related to new investment projects, rather than in expenditures on maintaining existing assets. This finding is robust to corrections for selection bias and endogeneity, as well as various proxies for growth opportunities.

Keywords: Capital Structure; Debt Overhang; Investment Policy; Agency Costs; Cash Policy;
JEL Classification: G31; G32
I. Introduction

Why and when do firms repurchase publicly traded debt? Although debt retirement by open market repurchases and tender offers are rather common, very little is understood about the market for debt repurchases and the motives behind these financing activities. This is surprising, given the large amount of money involved in these transactions. In 2004, for example, total cash repurchases of publicly traded debt by 347 U.S. firms exceeded $60 Billion\(^1\). Debt repurchases tend to be quite large, averaging $120.67 million per transaction. The repurchase retires 61\% of the face value of the targeted bond on average, and reduces the repurchasing firm’s leverage ratio by more than 16\%. It is not obvious why a firm would choose to make non-required payments to bondholders rather than invest or pay the cash directly to the shareholders in the form of dividends or share repurchases. If a manager is acting in the interest of the shareholders, there must be some value to repurchasing debt from the perspective of the owners of the firm. This paper examines an agency-cost based explanation as one potential motive for why firms choose to repurchase outstanding public debt. Using a special sample of open market debt repurchases and tender offers by US firms over the period 1996 to 2004, I empirically test the predictions of the model and find evidence that the agency-cost model of debt predicts both the timing and investment impact of debt repurchases.

When a firm adds risky debt to its capital structure, it introduces a series of financial obligations, legal constraints, and incentives which can cause conflicts between managers, shareholders and debt holders. Myers (1977) showed that when a firm has risky debt in its capital structure, managers acting in the interest of shareholders may reject positive net present value investment opportunities. This "underinvestment" or "debt overhang" problem occurs when a positive net present value project decreases the value of equity because some of the value created goes to the debtholders. In other words, debt overhang increases the required rate of return to equity holders and makes it difficult for a firm to obtain external financing. Inefficiencies arising from potential transfers to bondholders represent a well-known agency cost of debt, which is especially troublesome when the outstanding debt is publicly traded and hence difficult or impossible to renegotiate.

If a firm’s existing debt structure causes deviations from its optimal investment policy, there will be gains associated with adjusting the level or composition of debt on the firm’s balance sheet. When these gains outweigh the costs of adjustment, we expect to observe changes in the firm’s capital structure. Building on this intuition, this paper argues that when potential transfers of investment payoffs

\(^1\)This represents only cash repurchases of publicly traded bonds. This does not include debt retirements by calls, puts, sinking funds, conversions, refundings or refinancings.
to bondholders are high, the gains to shareholders from improvements in investment efficiency and improved access to external capital are larger than the cost of foregone cash holdings used to repurchase outstanding debt. Thus, in describing the market for repurchasing debt, this paper sheds light on some interesting interactions between a firm’s investment, cash, and capital structure choices. I present a model in which the reduction of cash holdings in exchange for a reduction in the amount of public debt outstanding is motivated by the gains accruing to both shareholders and bondholders from the mitigation of debt overhang. Shareholders trade off the costs of repurchases against the benefits of improvements in investment efficiency. In deciding whether to tender a portion of debt, bondholders trade off the reduction in payoffs in good states against the higher expected payoffs due to improved investment. I also show the conditions which simultaneously improves both shareholder and bondholder welfare and avoids the free-rider problem associated with restructuring public debt. After showing the conditions under which this use of cash to repurchase debt is profitable from the perspective of the shareholders, I examine the investment decisions of firms around debt repurchases and test whether debt repurchases ease constraints on investment and equity financing brought on by debt overhang.

Employing a sample of 1,802 corporate debt repurchases completed by 1,052 U.S. industrial firms over the period 1996 to 2004, I test whether debt repurchase activity is consistent with the agency cost model of debt financing. After summarizing the debt repurchase data, I estimate a series of probit regressions and examine whether the timing of debt repurchases is consistent with the desire of a firm to mitigate debt overhang. I then test whether debt repurchases ease some of the constraints on investment and financing activity brought on by overhang. I estimate standard investment regressions to investigate whether the quantity and quality of investment increases following the debt repurchase. Quantity is simply measured as the level of investment expenditures, while quality is measured by examining the sensitivity of investment to growth opportunities. The intuition here is that when a firm is facing debt overhang, investment expenditures will be less sensitive to changes in growth opportunities because some positive NPV projects will be passed over. Thus, when constraints on investment are relieved, it is expected that the investment sensitivity to growth opportunities will increase.

There are a number of econometric issues I address in the empirical tests. Firms that repurchase debt are not randomly allocated across the population of firms. The endogeneity of the repurchase choice must be addressed, since firm characteristics which lead a firm to choose to repurchase debt may also lead the firm to change its investment policy. In that case, we may incorrectly conclude that the reduction in debt led to the change in investment. In addition, debt and investment decisions are made simultaneously, making identification of the effect of the debt repurchase on firm performance difficult. I control for the endogeneity problem using several different approaches. First, I use a two-stage least
squares approach using exogenous firm, industry, and economy-wide characteristics as instruments for the repurchase choice. I then look to the theory related to debt overhang to split the sample into firms that are more likely to have more significant overhang problems and test whether the changes in investment policy are larger for these subsamples of firms. Finally, I employ a matching-firm strategy based on propensity scores to create a sample of firms which have a high estimated probability of repurchasing debt but choose not to do so. The propensity score matching essentially attempts to create a control sample such that conditional on a vector of explanatory variables, the decision to repurchase debt (the treatment) appears to be randomly distributed across the two samples, allowing for estimates of average treatment effects.

My main empirical results are as follows: Firms tend to repurchase debt after periods of increasing leverage, bond rating downgrades, and following negative shocks to cash flows. Employing various proxies for potential transfers to bondholders (overhang), I show that controlling for leverage and other factors, firms are more likely to repurchase debt when the overhang measure is high. Interpreting investment sensitivity to industry investment and proxies for growth opportunities as investment efficiency, I show that efficiency improves significantly following the debt repurchase. This improvement is more pronounced for firms with higher overhang, lower credit ratings, higher leverage, and higher growth opportunities. This finding is robust to different proxies for growth opportunities. Using a matching strategy based on propensity scores, I show that these results are not due to selection bias. Specifically, firms that repurchase debt have both higher investment rates (quantity) and investment efficiency (quality) following a repurchase compared to the matching sample of control firms. Equity issuance is also found to be significantly higher for repurchasing firms relative to the control sample. Finally, I decompose investment expenditures into required investment on assets in place and expenditures in new investment projects and show that the efficiency improvements are concentrated in new investment expenditures.

This paper contributes to the literature in several ways. First, it represents one of the first empirical examinations of the market for repurchasing corporate debt by open market repurchase and tender offers. Second, this paper sheds some light on the relationship between debt financing and investment. Previous research has demonstrated a negative cross-sectional relationship between investment and leverage, consistent with the presence of agency costs of debt. I extend this evidence in a panel data setting to show that changes in leverage are associated with changes in investment levels and efficiency. This suggests that the market for repurchasing debt facilitates the reduction of debt-induced investment distortions. It also contributes to the literature on cash policy, showing that when a firm faces overhang,
the value to the firm of the reduction in debt is larger than the value of holding the cash. Thus, the value of cash to shareholders relative to debt depends on the financial condition of the firm.

This paper proceeds as follows: Section II discusses debt overhang and presents an agency model of debt and investment in the presence of overhang. Section III describes the debt repurchase data used in this paper. Section IV presents the main empirical results and robustness tests. Section V summarizes and concludes.

II. Overhang and the Repurchase Decision

The literature investigating the relationship between debt and the firm’s real investment policy began in earnest with the classic papers of Jensen and Meckling (1976) and Myers (1977). Jensen and Meckling (1976) show that the existence of debt generates agency costs which may lead to an inefficient investment policy. Specifically, the limited liability of shareholders combined with the priority of risky debt gives shareholders incentives to engage in asset substitution or risk-shifting behavior, leading the firm to invest in high-variance, negative net present value projects when the probability of default is high. Myers (1977) introduced the notion of underinvestment, or debt overhang. He showed that the presence of risky debt can lead equity-maximizing managers to reject positive net present value projects because a large proportion of the proceeds from new investment will accrue to bondholders.

Several mechanisms for eliminating investment distortions arising from debt financing have been proposed in the literature. These approaches can be classified into three broad groups. First, firms may design debt contracts \textit{ex ante} to avoid potential agency problems. Myers (1977) and Berkovitch and Kim (1990) are examples of this approach, suggesting that debt maturity, seniority and inclusion of specific covenants can minimize the agency costs of debt before the debt is in place. Empirical evidence related to the design of debt contracts is mostly consistent with the predictions of these models. For example, Guedes and Opler (1996) document that firms with more growth opportunities tend to issue debt with shorter maturity. Second, firms may attempt to renegotiate the terms of debt in order to resolve conflicts between security holders after the debt is in place and allow for more efficient investment choices (see Hart and Moore (1989)). Chatterjee, Dhillon and Ramirez (1996) and Gilson, John and Lang (1990) examine debt renegotiation empirically, documenting the factors that contribute to successful renegotiation. Renegotiation usually takes the form of a reduction in principal or interest, extension of debt maturity, changes in covenants, or debt-for-equity exchanges.
These two methods for alleviating agency costs may not completely eliminate the underinvestment problem in all states of the world. In the first case, while the design of debt contracts *ex ante* can be effective, incomplete contracting problems make this preventive action less than sure. Since it is impossible to ensure that managers will always accept positive NPV projects as they arise, optimal debt design at the time of issuance is insufficient. In the second case, debt renegotiation can be difficult when there is more than one debt holder or when the debt is publicly traded. With public debt outstanding, a firm faces coordination and free-riding problems that make renegotiation difficult or impossible. In addition, even in the absence of free-rider problems, the Trust Indenture Act of 1939 requires unanimous consent of debt holders to change the major features of publicly traded debt contracts.

A third proposed remedy is to devise ways to eliminate existing debt or change the structure of existing debt to minimize the distortions prior to the investment decision. Gertner and Scharfstein (1991) show the conditions under which it is profitable for a firm to exchange its outstanding public debt with equity or more senior debt securities. The value from exchanging securities is derived from the firm nearing an optimal investment policy and increasing the ability to obtain external financing when needed for investment. This paper falls into this third category.

### A. Agency Model of Debt Repurchases

The choice to repurchase debt involves a tradeoff between the gains from reducing a firm’s debt burden and the loss of valuable cash reserves used to repurchase publicly traded debt. A fundamental question regarding the choice to repurchase debt is whether the value of the reduction in debt is more valuable than the loss of the scarce resources (cash) involved in the transaction. Many standard valuation models assume that cash can be viewed as negative debt; that is, the value to the firm of a one dollar of cash should be the same as a reduction of one dollar of outstanding debt.

This section presents a model which demonstrates that when a firm is facing overhang (i.e. potential transfers to bondholders are high), cash repurchases of outstanding debt are profitable. The gains to the firm arise from improvements in investment efficiency arising from the reduction in debt and improved access to external financing. The costs of reducing cash balances are reduced by the fact that in the case of default, bondholders have priority on the firm’s assets, including cash. When the default probability is high, the value of the cash to shareholders is low since it is likely to be transferred to bondholders. Thus, in the case of debt overhang, the value of a reduction in debt increases, while at the same time the value of cash decreases, causing cash balances to no longer be equal to negative debt.
This model distinguishes the relationship between investors and the manager at the time financing is secured and the relationship after the firm’s capital structure is in place. As time since initial issuance passes, certain eventualities or unseen events may influence managerial behavior. Incomplete contracts arise because certain events or actions are difficult or impossible to describe at the time of contracting, so some operating decisions are left to the discretion of the manager. In the context of this model, the bondholders cannot induce the manager to accept every positive net present value opportunity that comes along. However, they can include covenants to restrict payments to shareholders or restrict the firm from purchasing the outstanding bonds prior to maturity. In addition, the bondholders may choose at the time of issuance to include a covenant prohibiting asset sales without paying down debt. Given this incompleteness of contracts, the model describes how future managerial decisions are made in response to operating shocks.

There is an analogy between a firm’s choice to repurchase corporate debt and the choice of a nation to repurchase outstanding sovereign debt. The ability of debt repurchases to mitigate overhang problems has long been debated in the international economics literature. While open market debt repurchases have been suggested as a way countries can mitigate debt overhang, Bulow and Rogoff (1991) argue that cash repurchases of outstanding debt may just be a giveaway to creditors. Since a country’s productive resources and cash reserves do not serve directly as collateral, the creditors’ collateral derives from their ability to threaten the country with reductions in trade credits and other measures. Since debt repayments are not tied directly to the country’s assets, the use of cash to repurchase debt may not be in the indebted country’s interest. However, in the case of a corporation, debtors have a legal claim to the firm’s productive assets, including cash, in the case of default. Thus, the debt repurchase motive should be stronger for firms since the value of the cash to shareholders should be decreasing as default probabilities increase.

I do not model incentive effects related to managerial effort as Krugman (1986) does in the case of sovereign debt repurchases, although it is certainly reasonable that managerial effort may be affected by the size of the debt burden. The main predictions of the model arise from maximizing payoffs across various financial decisions. Adding managerial incentives would not change the main implications of the model, but would increase the benefits of debt repurchases to both shareholders and bondholders. For example, the incentive effect could be incorporated by letting the probability of the good outcome be a function of managerial effort. Since this would change the magnitude but not the direction of the predicted outcomes, I do not add the additional complexity to the model. It turns out that modeling managerial effort is not necessary as it may be in the case of sovereign debt repurchases. Since the
firm’s cash balances can be transferred to bondholders in the case of default, the value of cash to the shareholders can drop sufficiently to induce a debt repurchase.

B. Setup and Timeline

The model has three types of participants: shareholders, public bondholders and a manager. To simplify matters and to focus on the conflict between shareholders and bondholders, the model assumes that the manager of the firm maximizes shareholder value and that her interests are perfectly aligned with the shareholders. All agents are risk-neutral, and the risk-free rate of interest is set at zero. For simplicity and exposition, assume that there are \( N \) bondholders, each holding an equal fraction \( \frac{1}{N} \) of the outstanding public debt\(^2\). Furthermore, it is assumed that all agents have access to the same information about cash flows and investment opportunities.

The model has three periods, illustrated in Figure 1. In the first period \((t = 0)\), the debt contract is negotiated and issued by the firm with a total face value of \( D \), which matures at \( t = 2 \). The debt is secured by the assets acquired by the firm with the proceeds of the debt issue. The assets are expected to generate uncertain cash flows of \( CF_{AIP} \) (cash flows from assets-in-place) at \( t = 2 \) such that \( E_0(CF_{AIP}) \geq D \). Thus, the bonds are issued at par and the market price is \( V_D = 1 \) for each dollar of face value. The firm also holds liquid assets (cash and marketable securities) in the amount \( C \). At this point, the firm is indifferent between holding cash and repurchasing debt; or, in other words, cash is equal to negative debt in the initial period. Just prior to \( t = 1 \), the firm receives information about an adverse shock to cash flows from assets in place. The shock is such that the total expected assets of the firm will not be sufficient to pay off the debt at \( t = 2 \), that is, \( E(CF_{AIP}) + C < D \).

In the intermediate period \((t = 1)\), the firm obtains an option to invest in an investment opportunity at a cost of \( I \). The payoff from the investment project depends on the state of the world at \( t = 2 \). There are two possible states, \( \{H,L\} \). The good state occurs with probability \( p_H \), in which case the project pays cash flows of \( X_H \). In the bad state, the project pays off an amount \( X_L \). Further, it is assumed that if the firm invests and the good state occurs, then the firm has enough cash to pay off the entire amount of debt. In the bad state, which occurs with probability \( 1 - p_H \), there is a deficit and the bondholders are assumed to take control of the assets. The project has a positive net present value: \( p_H X_H + (1 - p_H) X_L - I \geq 0 \).

---

\(^2\)This assumption is not necessary to obtain the main empirical predictions of the model. The important feature is that there are more than one creditors and thus efficient renegotiation is impossible.
C. Investment and Repurchase Decision

At $t=1$, the manager decides on an investment and debt policy. In particular, the manager must decide whether or not to invest and whether or not to repurchase a portion of outstanding debt (assuming for the moment that repurchases are not restricted by covenant). At $t=2$, the uncertainty is resolved and the firm is liquidated. Strict priority of claims is assumed, so bondholders take over the firm’s fixed assets and cash holdings if the debt is not paid in full.

Suppose $C < I$, so that the firm does not have enough cash to fully finance the investment and must raise new external financing. Will the firm obtain financing and invest? The optimal investment rule that maximizes the value of the firm is to accept any investment with a positive net present value. However, with risky debt outstanding, the shareholders will only realize a portion of the gains from investment. Given the assumptions of the model, the payoff to shareholders is \( \max[0,(CF_{AIP} + C + X_H - D) - I] \). The shareholders receive nothing in the bad state and receive \( CF_{AIP} + C + X_H - D - I \) in the good state. Thus, the manager will accept the investment project only if

\[
p_{H}[CF_{AIP} + C + X_H - D] - I \geq 0,
\]

otherwise, the project will be rejected.

This is the classic debt overhang problem of Myers (1977). Debt overhang essentially increases the threshold value for accepting investment projects. The net present value from the shareholders’ perspective is less than the net present value to the firm because a portion of the returns from investment are transferred to bondholders. If the potential transfer is too high, the firm will not be able to obtain financing and invest in the project.

Suppose the parameters of the model are such that the investment rule in equation (1) leads to rejection of the project, i.e., the firm is suffering from debt overhang. If the firm cannot change the amount of debt outstanding, the shareholders will not invest and will receive a payoff of zero in the terminal period, while bondholders will receive a total of \( E(B_0) = E[CF_{AIP}] + C \), where \( B_0 \) denotes total payments to bondholders if the investment project is not accepted. The market price of the bonds would then be \( \frac{E(B_0)}{D} \) per dollar of face value. Since the debt is publicly traded, efficient renegotiation is ruled out. Unless prohibited by bondholders at issuance, the manager still retains the option to use the firm’s cash to repurchase debt. The following proposition states the conditions under which it is profitable for the firm to repurchase a portion of outstanding debt:
Proposition 1. If $V_D \leq \overline{V_D} = C \left[ D - (CF_{AIP} + X_H) + \frac{1}{\eta} \right]^{-1}$, then the firm will repurchase debt with cash and invest in the project. In this case, the value to the shareholders from the reduction in debt is larger than the value of the foregone cash.

Proof. See appendix.

Here, $\overline{V_D}$ represents the maximum price per dollar of face value that shareholders are willing to pay bondholders. Since $\overline{V_D} < 1$, a repurchase of debt at a discount relative to face value reduces the face value of debt by an amount larger than the amount of cash used in the repurchase. In addition, the higher probability of default resulting from the shock to cash flows reduces the value to the shareholders of holding cash, essentially reducing the cost of the repurchase. Another way to think of it is by viewing the value of equity as a call option on the value of assets with a strike price of $D$, this means that the strike price is reduced by an amount $\frac{C}{\overline{V_D}}$, which is larger than $C$. If the bond price is attractive enough, the “strike price”, or face value of debt, is reduced enough to induce the shareholders to invest. The expected gain to the shareholders from the repurchase, $p_H C \overline{V_D}$, outweighs the expected value of retaining the cash to shareholders, $p_H C$, if they do not repurchase debt. Note that the shareholders will still receive nothing in the case of the bad state. However, the repurchase increases the payoff to shareholders if the good state is realized. In order to be profitable for the firm to repurchase debt, the reduction in face value must be large enough to pay off the remaining debt in the good state, while still providing a sufficient return to the new equity.

Proposition 1 states that the benefit to shareholders of a repurchase (manifested by willingness to pay) is decreasing in the level of debt and increasing in the project’s cash flows in the good state. The willingness to pay is also increasing in the probability of realizing the good state. Thus, it is not only the level of debt that matters. The crucial determinant of the value of a repurchase to shareholders is the size of the potential transfer to bondholders. When these potential transfers are large, the value of a reduction in debt is more valuable than holding cash. The benefits of the efficiency gains outweigh the cost of repurchase to shareholders. If, however, potential transfers are zero, then cash is the same as negative debt. In the presence of overhang, the benefits to the shareholders from a repurchase outweigh the costs. The empirical prediction here is that firms are more likely to repurchase debt when these potential transfers are high. In addition, the observed investment and financing behavior of the firm should change following the debt repurchase. Specifically, the level of investment should increase, as should the responsiveness of investment to growth opportunities as they arise.
Figure 2 illustrates the classic overhang problem, in which a firm underinvests relative to the optimal level of investment. $r(D^*)$ represents the cost of equity when the firm does not have an overhang problem, and $r(D^U)$ is the cost of equity under debt overhang. The shaded area represents the dead-weight loss incurred. If this loss is large enough, there are incentives for a firm to repurchase debt and move the firm closer to its optimal investment level. The debt repurchase itself can be a positive net present value project if it can ease the constraints brought on by debt overhang and claimholders capture the efficiency gains.

D. The Free-Rider Problem and Bondholder Welfare

Proposition 1 gave the conditions under which the shareholders become better off by repurchasing debt and investing at $t = 1$, assuming that the bondholders would be willing to sell a portion of their debt. However, part of the gain to shareholders comes from a lower level of debt to pay off at period $t = 2$. A reduction in the amount of debt outstanding implies that the payoffs to bondholders in the good state are reduced. If bondholders are hurt by a debt repurchase, they would refuse to tender a portion of their outstanding claim or just include a covenant at issuance prohibiting the shareholders from buying back the debt prior to maturity.

It turns out that bondholders as a group are better off if the firm repurchases a portion of outstanding debt. The reason is that the shareholders will not accept the profitable investment project without repurchasing debt. Since contracts are incomplete, the bondholders are not able to commit the firm to accept all positive net present value projects. The highest possible payoff to the bondholders results when the firm invests but does not repurchase debt. Repurchasing debt reduces the total payoff to bondholders in the good state. However, allowing the shareholders to repurchase debt prior to maturity maximizes bondholder wealth across feasible strategies. The payoff to bondholders is lowest if the firm does not invest. Bondholders find themselves in a prisoner’s dilemma. If they prohibit repurchases, the owners of the firm will not invest in the project and the value of debt will fall to its minimum value. Thus, it is in the interest of the bondholders as a group to allow repurchases and thus induce more efficient investment policies.

Although bondholders as a group are better off if the firm repurchases a portion of outstanding debt, each individual bondholder has an incentive to hold out since the value of their remaining bonds increase following the repurchase. If the incentives to hold out are strong enough, in equilibrium none of the bondholders will be willing to tender a portion of their claim. Suppose an individual bondholder...
is considering whether to sell a proportion $\beta < 1$ of their outstanding claim. The following proposition states the conditions under which the bondholder will sell part of their claim:

**Proposition 2.** If $\frac{C_F + C}{D} \leq V_D < \frac{p D + (1-p) (C_F + X_L)}{D} = V_{D^*}$, then the firm faces a hold-out problem from the bondholders and will not be able to repurchase debt. If $V_D \geq V_{D^*}$, then all bondholders will wish to tender a proportion $\beta$ of their claim.

*Proof.* See appendix.

If the repurchase price is at least as large as expected post-repurchase per dollar value of the remaining portion of outstanding debt, then each individual bondholder will be willing to tender at that price. In essence, the shareholders are paying a premium over the current market price to compensate bondholders for lowering their payoff in the good state. Propositions 1 and 2 demonstrate that if the repurchase price satisfies $V_D \leq V_D \leq V_{D^*}$, the firm will offer to repurchase debt, the bondholders will be willing to sell, and the firm will invest. The price at which the transaction actually takes place determines the allocation of the surplus efficiency gain between the shareholders and bondholders.

**E. Exchange or Repurchase?**

There are several ways in which a firm may choose to adjust its leverage. However, in the context of debt overhang, the issuance of new equity is ruled out unless the outstanding debt is restructured. Rather than using cash to repurchase debt, the firm could attempt to offer an exchange of debt for equity to reduce the debt burden sufficiently to mitigate the debt overhang problem. Debt-for-equity exchanges are common among financially distressed firms and have been shown to decrease the probability of bankruptcy. For example, Asquith, Gertner and Scharfstein (1994) find that 59% of their sample of debt-restructuring firms attempted an exchange offer. The firms that successfully completed an exchange were less likely to subsequently file for Chapter 11 protection relative to other types of restructurings. In an exchange, the shareholders would keep the cash and reduce the debt burden at the cost of diluting their equity claim. The following proposition establishes the relative preference between repurchases and exchanges:

**Proposition 3.** If a firm has an amount of cash $C$ available to repurchase a sufficient portion of debt and mitigate overhang, the shareholders will strictly prefer a debt repurchase over a debt-for-equity exchange.
Proof. See appendix.

It can be shown that there exists an equity-for-debt exchange ratio such that the shareholders’ and bondholders’ expected payoffs are the same as under the repurchase case. However, the preference for repurchases arises because the hold-out problem is more severe in the debt-for-equity exchange. If the firm does not repurchase debt, the cash remains on the balance sheet as collateral and is transferred to the bondholders in the case of default, whereas in the repurchase case the cash is no longer available to be recovered by bondholders in the bad state. This means that any feasible offer price from the shareholders will be lower than the per dollar value of non-exchanged debt. Hence, no individual bondholder will be willing to exchange a portion of their debt for equity.

F. Debt Contract Design at Issuance

Going back to $t = 0$, we can now analyze some of the contractual aspects of the issued debt. The debt contract will be designed to maximize bondholder welfare given the expected actions of the manager. While including a covenant forcing management to accept all value-enhancing projects is impossible, the bondholders can choose to include covenants to constrain certain actions through restrictive covenants. For example, the bond contract could restrict cash payouts to shareholders, prevent the manager from repurchasing debt, and restricting subsequent issuance of new debt.

It is clear from the analysis of the $t = 1$ choices of the manager that the bondholders would not prohibit debt repurchases. The bondholders prefer that the manager accepts all positive NPV projects, but they know that a shock to expected cash flows may create incentives not to invest. Allowing repurchases restores the incentives to invest and thus prevents the value of the bonds from falling to their default value.

The owners of a highly-levered firm facing a problem of debt overhang may have an incentive to “cash in and run”. That is, if

$$C \geq p_{H}[CF_{AIP} + X_{H} - (D - \frac{C}{D})] - I$$

the shareholders would prefer to receive the cash themselves in the form of a liquidating dividend rather than repurchase debt and invest. This would be the worst possible outcome for the bondholders as it not only prevents the implementation of the value-enhancing investment project, but it also shifts collateral to the shareholders. This would reduce the value of the bonds below the original default.
value. Thus, the bondholders would indeed include a covenant restricting payouts to shareholders if the firm is near default. In practice, this is usually accomplished by requiring the firm to maintain specified earnings-to-debt service ratios before cash payments to shareholders can be made.

Direct restrictions on debt repurchases are indeed rare in debt contracts. While the actual numbers on the inclusion of this specific type of covenant is not available, statements in the financial press and bulletins by law firms suggest that these covenants are very rare\(^3\). In their analysis of the pricing of bond covenants, Chava, Kumar and Warga (2005) find that the correlation coefficient between leverage and dividend and other payment restrictions is 0.36. This covenant has a higher correlation with leverage than any other type of covenant included in their study.

**G. Numerical Example**

As an example, consider a firm with $100 million in debt outstanding. The firm has assets in place which are at the time of issuance expected to generate cash flows of $100 million at the end of the period \(t = 2\) and currently holds $20 million in cash. Just prior to \(t = 1\), the firm receives a shock to expected cash flows, such that the assets in place are now expected to generate $60 million at the end of period \(t = 2\). At \(t = 1\), an investment project is available at the cost of $36 million. In the good state, the project pays cash flows of $90 million; in the bad state it pays $10 million. The probability of ending up in the good state is \(p_H = 0.50\).

Will the firm accept the investment project at \(t = 1\)? Note that the investment opportunity has a positive net present value: 
\[
NPV = 0.5(90) + 0.5(10) - 36 = 14
\]
(i.e. the value of the firm will increase by an expected $14 if the investment is made). The firm will generate $170 million in the good state and $90 million in the bad state. The bondholders have an expected repayment of $95 million if the firm invests. The expected cash flows to shareholders after considering expected payments to debt holders is $35. The NPV from the perspective of the shareholders is \(-1\). The firm will be unable to raise funds for the investment project and will choose not to invest. The expected payment to bondholders will then be $60 + $20 = $80 million and the price of debt will be $0.80 per dollar of face value. The different choices and outcomes are displayed in Figure 3.

\(^3\)Bulletin No. 162 by the law firm Latham and Watkins dated August 29, 2001 entitled *Bond Repurchase Programs* states “The issuer must also consider whether implementation of a bond repurchase program is consistent with the issuer’s contractual obligations. The indenture governing the high yield bonds being repurchased is unlikely to prohibit repurchases of the bonds issued under that indenture. However, if the issuer has any outstanding bank debt, the credit agreement may well prohibit repurchasing other debt, even pari passu, unsecured debt. Moreover, any repurchases of subordinated debt are likely to constitute Restricted Payments under high yield bond indentures governing senior securities as well as credit agreements”.
Now suppose the firm uses its cash to repurchase debt at the price of $0.85 per dollar of face value. The $20 million in cash purchases $23.53 million in face value of debt, reducing the total amount outstanding to $76.47 million. Now, the expected payments to bondholders is $93.24 million and the expected payoff to shareholders is $36.77 million, resulting in a shareholder NPV of $0.77 million. In this situation, the shareholders will repurchase debt and invest. Notice that the expected payments to bondholders dropped by $1.76 million from the non-repurchase case. It appears as though the shareholders were able to transfer wealth from the bondholders by increasing their own payoff in the case of the good state, while lowering that of the bondholders. However, since the firm would not invest without repurchasing debt, the expected payments of bondholders among feasible strategies is maximized.

The efficiency gain resulting from the repurchase is the difference between the value of the firm if debt is repurchased minus the value if they do not repurchase, which turns out to be $94-$80=$14 million, is split between the shareholders and bondholders. The division depends on the price at which the debt is repurchased. At $V_D = 0.85$, the bondholders get $13.24$ of the surplus, while at $V_D = 0.91$, the bondholders get the full $14 million surplus value. At any price below $V_D = 0.85$, there would be free-rider problems among the bondholders. At any price above $V_D = 0.91$, the shareholders would refuse to approve a debt repurchase.

III. Data

The overall sample of firms is taken from the combined annual research, full coverage, and industrial COMPSTAT files for the years 1992 to 2004. Utilities (SIC 4900–4999) and financial firms (SIC 6000–6999) are excluded from the analysis. Observations with missing data for the relevant variables (total assets, long term debt, cash, etc...) are deleted. Monthly stock returns are taken from the CRSP monthly stock price file. To be included in the sample, the firm must have a non-zero amount of long-term debt outstanding. The final sample includes 19,402 firm-years composed of 4,003 separate firms. The appendix contains a list of data definitions used in the following empirical tests.
A. Debt Repurchases

The debt repurchase data are obtained from several sources. In 1996, Moody’s began tracking changes in the outstanding amount of publicly traded corporate bonds. The 2005 version of the Mergent4 BondSource Corporate Bond Securities Database provides one source of repurchase information. This database contains detailed information related to corporate debt issued between 1980 to 2004. In addition to the characteristics of the debt at issuance, the data contain a detailed history of changes in the amount outstanding for debt issues in the database. Reductions in the amount outstanding can be due to calls, conversion to equity, refunding, defeasance, maturity, IPO clawbacks, repurchases by open market programs or tender offers, sinking funds, optional increases in sinking funds, or exchanges. The database contains the effective date of the change in amount outstanding, as well as the reduction amount and the remaining principal balance after the reduction in debt. Other debt repurchases were obtained by searching through financial reports, press releases, and discussions with investment bankers. My debt repurchase data cover the 1996–2004 period. In order to focus on cash repurchases of debt, I eliminate debt repurchases that appear to be part of a debt exchange or refunding program (if debt is issued around the same time of the repurchase). Excluding debt repurchases by financial firms and utilities, the repurchase sample is composed of 1,802 debt repurchases, of which 562 are open market repurchases and 1,246 are tender offers.

Table I summarizes the debt repurchase data. Panel A shows that total debt repurchase activity has been steadily increasing over time. The total amount of debt repurchase activity among the sample firms was $11.7 billion in 1996 and $61.7 billion in 2004. Of this total, $24.5 billion was repurchased through open market transactions, while $37.2 billion was repurchased through tender offers. Repurchase activity as a proportion of total debt issuance by US industrial firms increased from 6.75% of issuance in 1996 to 16.29% of total issuance in 2004. Unlike total debt issuance, which appears to be cyclical over the sample period, debt repurchase activity has been increasing at a relatively steady pace. Note also that the ratio of open market repurchases to tender offers increased significantly around the year 2000. However, it should be noted that these figures represent a lower bound on debt repurchase activity, as there is no assurance that I have collected all such events over the sample period.

Panel B of Table I describes the amount and maturity characteristics of repurchased debt. The mean repurchase size is $120.67 million, which corresponds to about 61.4% of the total outstanding face value of each bond repurchased. Open market repurchases are, not surprisingly, much smaller than tender offers. Open market repurchases average $61.68 million per repurchase compared to $147.27

---

4The Financial Information Services division of Moody's Investors Service was acquired by Mergent, Inc. in July of 1998.
for tender offers. Open market repurchases retire 31.9% of the outstanding issue on average, compared to 74.8% for tender offers. The maturity characteristics of repurchased debt are similar across both repurchase methods. The average initial maturity for repurchased debt is 10.84 years, while the remaining maturity after the repurchase is 6.90 years.

Panel C compares the seniority and redeemability characteristics of repurchased debt to all public bonds issued between 1980 and 2004. The vast majority (93.20%) of issued public debt is callable. Repurchased debt has slightly higher callable representation than the overall sample of issued bonds, with 97.16% of repurchased bonds featuring a call provision. Approximately 5% of all issued bonds are putable, about 10% are convertible, and about 11.82% contain sinking fund provisions. Repurchased bonds are similar to the overall population of bonds with respect to putability. Interestingly, convertible bonds make up 29% of the open market repurchase sample, compared to 6.58% for tender offers and 10.19% among all issued bonds. The overall sample of debt issues have a higher incidence of sinking fund provisions, suggesting that perhaps sinking funds achieve some of the same benefits as a debt repurchase and as such are less likely to be repurchased.

B. Empirical Proxy for Overhang

Hennessy (2004) employs a real-options approach to model the dynamic relationship between debt and investment. In his model, risky debt truncates equity’s otherwise infinite horizon and drives a wedge between a firm’s average and marginal $Q$, leading to underinvestment relative to the first-best. Using an empirical proxy for overhang, defined as the present value of creditors’ rights to recovery in default, he finds significant overhang effects on investment, particularly for firms with low credit quality. Hennessy, Levy and Whited (2005) extend the Hennessy (2004) analysis to incorporate other financial frictions and still find a significant overhang effect of debt on investment.

The model in Section II demonstrates that leverage itself is not sufficient in describing the value to repurchasing debt. A firm with a high degree of leverage but a small probability of default will not be faced with a wedge between the overall return to investment and the return accruing to shareholders. Likewise, a firm with low leverage but a high probability of default will be subject to possible investment distortions. The more relevant factor is the potential transfer to bondholders, or “overhang”. To proxy for overhang, I construct a measure similar to “overhang correction” of Hennesy, Levy and
Whited (2005). The overhang correction is an estimate of the expected proportion of assets claimed by bondholders in the case of default. It is calculated as

\[
h_t = \text{Leverage}_t \times \text{Recovery Ratio} \times \left[ \sum_{s=1}^{20} \rho_{t+s} \left( 1 - 0.05(s - 1) \right) \left( 1 + r \right)^{-s} \right],
\]

where \( \rho_{t+s} \) is the probability of default in period \( t+s \). I use historical default hazard rates by credit rating from Moody’s to proxy for the probability of default. If the credit rating for a firm is not available, I impute it using the method of Blume, Lim and MacKinlay (1998). For recovery ratios, I use a measure of the tangibility of assets similar to that of Berger et al. (1996) and Almeida and Campello (2005). Specifically, I define the recovery ratio for each firm each year as

\[
\text{Recovery}_{it} = 0.715(\text{Receivables}_{it}) + 0.547(\text{Inventory}_{it}) + 0.535(\text{Capital}_{it}) + \text{Cash}_{it},
\]
scaled by total assets. The measure assumes that the initial maturity of debt is 20 years, and assumes that the debt matures at a rate of 5% per year. Hennesy, Levy and Whited (2005) find evidence of underinvestment among firms with high overhang measures. Specifically, controlling for investment opportunities, firms with high overhang invest less.

One potential concern with using this measure of overhang is whether it adds any information not contained in leverage itself. Note that the measure is composed of three basic inputs: leverage, probability of default, and tangibility of assets. Higher tangibility is associated with higher leverage, and higher leverage is associated with higher default probabilities. It is reasonable to ask whether the measure of overhang provides and additional information beyond that contained in leverage itself. To get an initial sense if this is true, Table II provides means of the overhang measure by different leverage/overhang deciles. In the first panel, all firms are first sorted by leverage into deciles. Then, within each leverage decile, firms are sorted by overhang into deciles. The mean overhang within each leverage/overhang group is reported. Panel A reports that within each leverage decile, there is a good amount of variability in overhang. For example, the mean overhang measure ranges from 0.004 to 0.061 in the 7th leverage decile.

Panel B of Table II reports means across leverage/deciles formed from independent sorts. Again, there is a large amount of variability in overhang. The overhang measure is increasing within each of the leverage deciles. Note the empty cells among the low-leveraged deciles, indicating that leverage

---

5For robustness, I also used historical recovery ratios by industry reported by Altman and Kishore (1996). However, these ratios are limited in that they are reported only for selected industries, and they are all estimated prior to the sample period. Hence, I do not report these results, but they are similar to results reported below.
and overhang are indeed positively correlated. In the empirical tests that follow, the effect of overhang controlling for leverage will be investigated.

IV. Empirical Analysis

This section tests the main implications of the agency-cost model of debt with respect to debt repurchases. I first take a univariate approach, looking at the characteristics and credit quality of firms in event time around the debt repurchases. The second subsection tests whether the size of potential transfers to bondholders, or overhang, helps explain the choice and timing of a debt repurchase. Finally, the third subsection investigates whether debt repurchases have any impact on the real investment and financing activities of the firm.

A. Empirical Implications

The agency cost model of debt financing suggests that when existing debt distorts investment decisions, it becomes profitable for the shareholders to spend cash to repurchase a portion of outstanding debt. Thus, if the desire to mitigate debt overhang were indeed an important factor in the decision to repurchase debt, we should expect to observe the following:

1. Firms with larger expected transfers to bondholders (overhang) are more likely to repurchase debt.

2. Both the quantity and quality of investment should increase following a debt repurchase. That is, investment levels and efficiency will increase following a repurchase. By investment efficiency, it is meant that investment will become more sensitive to investment opportunities after the repurchase as in the \( Q \) theory of investment.

3. Firms that repurchase debt should have better access to equity financing compared to similar firms that do not repurchase debt. That is, it is expected that repurchasing firms will issue more equity relative to similar firms that do not repurchase.

4. Announcement of debt repurchases will be considered good news. Hence, announcement returns should be non-negative. Bond prices should also increase following the repurchase.

5. To the extent that tender offers require higher premiums to bondholders above the current market price, announcement returns will be higher for open market repurchases than for tender offers.
6. Given the choice between a debt repurchase and an exchange offer, the probability of a repurchase (relative to the exchange offer) is increasing in the amount of cash the firm holds. That is, exchange offers will be conducted by firms with a higher degree of financial distress.

The remaining sections in this paper will examine the investment and financing behavior of firms surrounding the debt repurchase. Other papers have found evidence largely consistent with the remaining predictions of the agency model of debt. With respect to prediction (4), several papers have documented positive stock market reactions to the announcement of tender offers. Kruse, Nohel and Todd (2005) find an average abnormal return of 1.47% around the announcement of tender offers. Chatterjee, Dhillon and Ramirez (1995) find positive announcement effects for both stocks and bonds around the announcement of tender offers, even though the tender offers are often coercive in nature. Julio (2005) finds abnormal announcement returns of 2.46% and 1.05% for open market repurchase and tender offers, respectively. Chatterjee, Dhillon and Ramirez (2005) also document that firms engaging in tender offers are less financially distressed than firms making exchange offers, consistent with prediction (5) that shareholders prefer debt repurchases to exchanges if the cash is available.

B. Univariate Analysis

The agency-cost model of debt predicts that, conditional on having sufficient cash, firms will repurchase debt when expected transfers to bondholders are high. It is expected that firms will repurchase debt after periods of rising leverage and increasing default probabilities. In addition, as discussed in Myers (1977), the underinvestment problem will be more severe for longer term debt since shorter maturity debt allows debt to be repriced prior to investment decisions. Table III summarizes some selected characteristics for firms around the year of the debt repurchase. Repurchasing firms tend to be highly levered. In the years leading up to the repurchase, the mean leverage ratio increases significantly from 0.387 four years prior to the repurchase to 0.456 in the year before the debt repurchase, an increase of 17.83%. The average leverage ratio drops significantly at the year of the repurchase and settles at 0.379 three years after. On average, leverage ratios decrease by 16.9% in the period following the repurchase. For comparison, the mean leverage ratio for all industrial firms in the Compustat sample is 0.229 over the 1996 to 2004 sample period. The average repurchasing firm is in the top quartile in terms of leverage.

While repurchasing firms tend to be highly levered in absolute terms, they are also highly levered relative to other firms in their industry. Here, the deviation from industry mean leverage is defined as the sample firm’s leverage minus the mean leverage ratio of firms with the same 3-digit SIC code in the
same year. The average repurchasing firm is significantly more levered than the average firm in the same industry. The deviation is 0.158 in the year prior to the repurchase. Interestingly, the average deviation from industry leverage remains significantly positive three years after the repurchase. The persistence of this deviation from the industry leverage ratio is not consistent with full target adjustment behavior, assuming the firm’s industry leverage is a decent proxy for a “target” leverage ratio for the firm. It is, however, more consistent with evidence by Flannery and Rangan (2005) that actual target adjustments tend to be incomplete. Table III shows that 25% of repurchasing firms are near or below the mean leverage for their industry.

The overall maturity structure of outstanding debt appears to change significantly around the repurchase. In the year prior to the repurchase, debt with more than 5 years to maturity makes up an average of 70.2% of total debt. In the year after the repurchase, this drops to 64.4% of total debt. While this is not too surprising given that repurchasing firms tend not to issue new debt following the repurchase, the rate of decrease suggests that the firm chooses to repurchase bonds with relatively longer maturity than other outstanding issues.

The empirical proxy for debt overhang changes as expected around the repurchase. Mean overhang increases by 25% from 0.32 to 0.40 prior to the repurchase and drops to 0.025 three years after the repurchase. This drop represents a 37.5% reduction in overhang following the debt repurchase. The same pattern appears across the distribution of overhang over time. This increase in overhang is coming from two factors. First, as seen earlier, leverage increases significantly prior to the debt repurchase. Secondly, default probabilities are increasing as well. Figure 4 displays a very interesting pattern in average credit ratings for repurchased bonds in the months leading up to and following the repurchase. Average credit ratings are declining significantly prior to the repurchase, with an abrupt drop appearing in the two months before the repurchase takes place. Following the repurchase, credit ratings stabilize and even increase on average. On average, credit ratings drop from a Moody’s Ba rating to a B rating. This erosion of credit ratings represents a significant change in expected default rates. Historically, the 10 year cumulative default rate on Ba rated bonds is 19.05%, compared to 31.90% for bonds with a B rating. These two factors imply that the potential transfers to bondholders have been increasing prior to the debt repurchase for this sample of firms.

Table III also summarizes changes in cash flows leading up to the repurchase. Cash flows drop by an average of 55.8% over the three years leading up to the debt repurchase. The average cash flow-to-assets ratio is 0.052 four years prior to the repurchase. This ratio drops to 0.023 in the year before the firm chooses to buy back debt. There is a slight recovery in cash flows following the repurchase,
though cash flows do not return to their pre-repurchase levels. The combination of increasing leverage and lower cash flows creates a situation in which the firm is likely to be facing an overhang problem.

C. Overhang and the Repurchase Choice

In this section, I estimate probit regressions to examine the factors which lead a firm to choose to repurchase debt. This estimation is done for two reasons. First, it allows me to test whether potential transfers to bondholders add incremental explanatory power to the firm’s debt repurchase decision in a multivariate setting. The idea is that firms are more likely to repurchase debt when facing debt overhang problems. Second, the predicted values obtained from the probit regressions will aid with the construction of control samples below, where I address selection and endogeneity issues.

Let $y^*_t$ be the unobserved value to the firm from repurchasing debt. Define

$$y_t = \begin{cases} 
1 & \text{if } y^*_t > 0 \\
0 & \text{otherwise}
\end{cases}$$

The main interest lies in estimating marginal effects of changes in the explanatory variables. In the context of a probit model, the marginal effects are defined as

$$\frac{\partial Pr[y_i = 1|X_i]}{\partial x_{ij}} = \Phi'(X_i'\beta)\beta_j,$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function. The marginal effects give the expected change in the probability of repurchasing debt when an explanatory variable changes by a small amount, holding the other explanatory variables constant at their mean values.

In addition to the measure for debt overhang and year effects, I include several explanatory variables which may help explain the debt repurchase choice based on existing theories of capital structure. They are as follows:

*Size:* Defined as the log of real total assets. Larger firms tend to have more outstanding public debt than smaller firms and hence are more likely to repurchase debt.

*Prior 12-month Stock Return:* According to the target adjustment models, firms are more likely to reduce debt following drops in stock prices to rebalance their market leverage ratio. On the other hand, to the extent that stock prices reflect future growth opportunities, firms may reduce debt after increases in stock prices.
NOLC: A dummy variable which takes the value of 1 if the firm has net operating loss carry-forwards in that year and zero otherwise. Firms with NOLCs are more likely to be facing a zero marginal tax rate. The static tradeoff model suggests that firms will decrease debt if the marginal tax rate decreases.

Cash: Firms with more cash available on hand are expected to be more likely to repurchase debt.

Cash Flow: Firms are hypothesized to face overhang problems if they have experienced negative shocks to cash flows. Thus, the marginal effect for lagged cash flow is expected to be negative.

Market-to-Book: The market-to-book ratio is a common proxy for the firm’s investment opportunity set. All else equal, firms with higher growth opportunities will be more affected by overhang. However, if the stock market knows that the firm is over-levered given its cash flows, the market-to-book ratio may reflect the constraints on investment and financing and be relatively low when a firm chooses to repurchase. Hence, the expected sign is ambiguous.

Investment: Lagged investment rates are included to capture the idea that firms with debt overhang problems have depressed investment rates. Controlling for other factors, the marginal effects are expected to be negative.

Leverage, Leverage\(^2\), Leverage\(^3\): The agency-cost model predicts that overhang, and not leverage per se, increases the value of a debt repurchase to the shareholders. Thus, it is interesting to see if overhang helps predict debt repurchases controlling for leverage. It is also expected that leverage itself will add explanatory power since more highly levered firms have more public debt outstanding. Squared and cubed transformations of leverage are also included to check whether overhang just captures transformations of leverage.

Overhang: This is an estimated of the expected proportion of assets claimed by bondholders in the case of default. It acts as a proxy for the wedge between the returns from investment to the firm and the returns from investment to equity.

A problem with a straightforward probit estimation in this setting is that many of the right hand side variables are choice variables for the firm. This endogeneity problem could lead to inconsistent estimates of marginal effects. Thus, in addition to standard probit regressions, I also estimate the debt repurchase choice equation above using an instrumental variables probit estimator. For instruments, I use the industry median cash, leverage, and investment levels.

Table IV reports the estimated marginal effects from the probit regressions. The first specification omits the overhang measure. Most of the estimated marginal effects have the expected signs. The
probability of repurchasing debt is increasing with firm size, prior returns, whether the firm has NOLCs, cash, and leverage. The probability of repurchase is higher after firms have experienced relatively low cash flows. In other words, firms with consistently strong cash flow are less likely to repurchase debt. The marginal effect on leverage is 0.0588. This value implies that increasing leverage from the first quartile to the third quartile increases the probability of repurchasing debt by 0.026 relative to the unconditional probability of 0.035. In other words, firms in the third quartile of leverage are about 74% more likely to repurchase debt than those in the first quartile.

The second specification in Table IV adds the measure of debt overhang to the regression. The estimated marginal effect is 0.1423 and is significant at the 0.01 level. The marginal effect for leverage remains about the same, and the pseudo $R^2$ increased from 0.158 to 0.167 from adding the overhang proxy. The magnitude of the marginal effect for overhang suggests that moving from the first to third overhang quartile increases the probability of repurchasing by 12.24%. Thus, controlling for leverage, firms are more likely to repurchase debt when expected transfers to bondholders are high. Specification 3 drops the year fixed effects. The estimated marginal effects on leverage and overhang remain relatively unchanged, while the importance of prior returns, NOLCs, and financing deficits increase slightly. The pseudo-$R^2$ drops to 0.141 when yearly fixed effects are omitted.

Specifications 4 and 5 include the squared and cubed transformations of leverage. In both models, the estimated marginal effects are strongly significant. This finding is not particularly surprising since, for example, as leverage increases to extremely high values firms are more likely too constrained to repurchase debt and hence the squared term has a negative coefficient. Note that the overhang marginal effects drop slightly, though not in a statistically significant sense. Even when including these higher order transformations of leverage, debt overhang remains a statistically significant explanatory variable. Specification 6 adds the difference between the firm’s leverage ratio and the median industry leverage as a measure of the deviation from the firm’s target leverage ratio. When included in the regression with the overhang measure, the target deviation doesn’t have a significant effect on the choice to repurchase debt. However, this should be interpreted cautiously as overhang and target deviation are highly correlated.

Specification 7 reports the results from the instrumental variables probit regression. I instrument for cash, investment, and leverage using the industry median value for each of these regressors. In order to be valid instruments, the median values should be correlated with the firm’s cash, leverage, and investment levels, while being uncorrelated with the error in the probit regression. The correlation of the firm’s own leverage with the median leverage ratio in the same industry is 0.52, for example,
suggesting that the first criteria for a good instrument is met. The results remain largely the same, except for a noticeable increase in the size of the standard errors. The effect of prior returns and lagged investment lose their significance in this regression. The effect of leverage and overhang both remain large and significant, even after controlling for potential endogeneity.

The probit regressions are estimated separately for open market repurchases and tender offers to see if the method for repurchasing reflects different underlying motivations. The results for specifications 8 and 9 in Table IV indicate that the effect of overhang on the decision to repurchase debt is essentially the same, regardless of the repurchase method employed.

In summary, the probit regression results are largely consistent with the agency-cost model of debt. Firms with cash and potentially large transfers of investment returns to bondholders are more likely to repurchase outstanding public debt, reflecting the latent value to the shareholders derived from a reduction in debt. In addition, repurchases tend to occur after cash flows have been relatively low. In the next subsection, I investigate whether investment and financing behavior changes following debt repurchases.

D. Changes in Firm Investment

The central question in the capital structure literature is whether the choice of financing affects the real value generating process of the firm. The main idea behind agency cost based models of financing is that debt can have an impact on both the level and efficiency of investment, where an efficient investment policy can be defined simply as one in which all positive NPV investment projects are funded and implemented, while all negative NPV projects are rejected. The agency cost model of debt predicts that investment efficiency will improve following debt repurchases as some of the potential transfers to bondholders from investment are bought back by the shareholders at a discount and firms become able to raise external financing. However, individual investment projects are not observed by the econometrician, so direct tests of investment efficiency are not possible. Empirical tests of investment efficiency are usually motivated by the \( Q \) theory of investment of Hayashi (1982). The basic idea is that the more efficient the firm’s investment policy, the more the firm’s investment expenditures should covary with investment opportunities. Similar approaches have been employed in studies related to the diversification discount (Gertner, Powers and Scharfstein (2002) and Colak and Whited (2005)) and capital overhang (Desai and Goolsbee (2005)).
Several econometric complexities arise in testing whether the reduction in leverage from debt repurchases improves the quality and quantity of investment by mitigating the debt overhang problem. First, firms that repurchase debt choose to do so and hence are different from the population of all firms. This endogeneity of the repurchase decision can bias estimates of changes in efficiency. Second, investment opportunities are not directly observed, and are usually proxied by a measure of average \( Q \) (usually the market-to-book ratio). To address the endogeneity/selection problem, I attempt to identify the effect of a debt repurchase using several strategies. First, I employ firm-fixed effects to control for any time-constant unobserved heterogeneity. Second, I use a two-stage least squares approach using exogenous firm, industry, and macroeconomic variables as instruments for the choice to repurchase debt. Third, I use predictions of the agency-cost model to split up the sample of repurchasing firms by various factors; repurchasing debt should have the largest impact on firms which have larger overhang problems. Finally, I construct a matching sample of firms based on propensity scores and estimate “treatment” effects due to debt repurchases. The second issue, measurement error in \( Q \), is less problematic in a panel data setting. Çolak and Whited (2005) note that investment sensitivity to \( Q \) is not contaminated by measurement error, but by variation in the measurement error variance over time. To address this, I re-estimate the results using several different proxies for firm’s investment opportunities.

The baseline regression to test for changes in investment efficiency around debt repurchases has the form:

\[
\frac{I_{it}}{A_{i,t-1}} = \beta_0 + \beta_1 Q_{i,t-1} + \beta_2 Q_{i,t-1} \times \text{After} + \beta_3 \text{After} + \beta_4 \frac{Cashflow_{it}}{A_{i,t-1}} + \sum \gamma_t Year_t + \epsilon_{it},
\]

(4)

where \( \frac{I_{it}}{A_{i,t-1}} \) is the ratio of investment expenditures scaled by beginning-of-period total assets, \( Q_{i,t-1} \) is the beginning-of-period market to book ratio, and \( Cashflow_{it} \) is cash flow scaled by total assets. The \( \beta_{ol} \) terms capture firm fixed-effects and the \( \gamma_t \) terms capture year effects. Here, the time index \( t \) represents the year relative to the repurchase year. The model is estimated over the years \(-2,-1,1,2\) and \(+2\), where the dummy variable \( \text{After} \) takes a value of 1 in the period \( \{1,2\} \) and zero otherwise.

The main parameters of interest are \( \beta_2 \), which is interpreted as the change in investment efficiency or the quality of investment following the debt repurchase, and \( \beta_3 \), which reflects changes in the level of the conditional mean of corporate investment after the repurchase. If a firm’s investment policy improves following the repurchase, investment levels should increase (\( \beta_3 > 0 \) and investment sensitivity to investment opportunities will increase (\( \beta_2 > 0 \)). Thus, these two parameters attempt to measure changes in both the quality and quantity of investment following a debt repurchase.
Table V displays the results of the investment regressions in equation (4). Each panel reports the regression results using different proxies for investment opportunities. Panel A uses firm average \( Q \) and Panel B uses industry \( Q \), defined as the median market-to-book ratio of firms with the same 3-digit SIC code. Panel C uses the asset-weighted mean investment rate for firms in the same industry. The investment equation is estimated using 5 different methods. First, I employ ordinary least squares. The second column reports results from a specification employing firm fixed-effects. The third and fourth columns report results from two-stage least squares estimation. The dummy variable \( After \) is endogenous in equation (4). To deal with this endogeneity, I first redefine the dependent variable as the difference between the firm’s investment rate and the median investment rate of firms in its own industry. Thus, changes in this dependent variable should be independent of factors that impact the investment behavior of all firms in the same industry. I then instrument for the repurchase choice using the following instruments: (1) whether or not the firm belongs to the S&P 500 index, (2) the proportion of other firms in the same industry industry repurchasing debt each year, (3) the number of months in the year that the economy was designated as being in a recession by NBER, and (4) concurrent and lagged gdp growth. S&P 500 membership is thought to be correlated with the repurchase choice since these firms are more likely to have bonds trading in relatively liquid markets and are more likely to have close relationship with investment banks who have an expertise in executing repurchase plans. The proportion of other firms in the industry repurchasing debt captures exogenous factors which make it attractive for the industry to restructure their debt. The economic variables are included to capture exogenous variation which may affect cash flows and influence the repurchase choice.

The fifth column reports results from estimating the standard Heckman two-stage selection model. I use predicted values from the probit regression in specification (2) of Table IV to construct the inverse mills ratio for the second stage investment regression.

The results generally support the hypothesis that debt repurchases help mitigate debt overhang problems. In Panel A, the estimated coefficients for the interaction between \( Q \) and the period after the repurchase is statistically significant and larger in magnitude than the coefficient on \( Q \) itself across all specifications; after the repurchase, firm investment is more sensitive to \( Q \). The positive coefficients on the \( After \) dummy suggests that firms experience an upward shift in investment following a repurchase in addition to improved efficiency. Note that the results are quite robust across estimation methods. The primary difference in the regressions in panel A is that the investment sensitivity of cash flows is significant only when the investment equation is estimated using ordinary least squares. The economic significance of these estimates is quite large. For example, looking at the 2SLS/Fixed Effects model, the sensitivity of investment to \( Q \) goes from 0.0221 in the pre-repurchase period to 0.0433 in the post-
repurchase period, a change of 96%. In most specifications, there appears to be an increase in the level of investment, as measured by the coefficient on the After dummy variable. These results are robust to the choice of proxy for investment opportunities. Panel B (industry Q) and Panel C (industry investment) provide similar evidence.

In order for the instruments described above to be valid, it must be that (1) the instruments are correlated with the repurchase choice dummy, and (2) the instruments are uncorrelated with the error in equation (4). To investigate the validity of the instruments for the repurchase choice, I regress the endogenous dummy variable on the instruments. The regressions yield an F-statistic of 53.31 for the joint hypothesis that all coefficients are zero, so requirement (1) appears to be met. I investigate requirement (2) by employing a test of overidentifying restrictions. In this setting, I have two endogenous variables in the investment regression and five instruments, leaving me with three overidentifying restrictions. I first obtain the residuals from the 2SLS regression. Then, I regress the residual on all exogenous variables. This procedure yields an F-statistic of 0.23 and an $R^2$ of 0.0012. The test statistic turns out to be 2.69, which under the null hypothesis that at least one of the instruments is not exogenous has a chi-squared distribution with three degrees of freedom. The 5% critical value for a $\chi^2_3$ distribution is 7.81. Therefore, the test of overidentifying restrictions does not rule out the exogeneity assumption for my choice of instruments. I also conduct a Hausman specification test to test for the endogeneity of the regressors in the investment regression. The Hausman test yields a p-value of 0.372 and hence I cannot reject the hypothesis of no endogeneity. Given these results, subsequent empirical tests will focus on OLS estimates with firm fixed effects to avoid the loss of efficiency associated with 2SLS.

I also estimate the cash-flow augmented regressions on an event time basis, rather than by a fixed effects panel regressions. I pool the sample into eight different cross sections corresponding to the year relative to the debt repurchase, $-4$ to $+3$, where $t = 0$ is the year of the repurchase. I estimate the sensitivity of investment to industry Q for each event year. The point estimates and 95% confidence bounds are displayed in Figure 5. Investment is seen to be relatively insensitive to growth opportunities leading up to the repurchase year. Investment efficiency appears to increase significantly after the repurchase and continues to remain significantly positive for at least three years.

### D.1. Subgroup Analysis

This subsection presents the regression results for different subsamples of repurchasing firms. This approach is employed to identify firms which are more likely to be repurchasing debt to remove constraints on investment. Those firms which are most likely to be facing severe overhang problems are the
same firms which are expected to show improvements in investment efficiency. I divide up the sample on six different pre-repurchase dimensions. First, I break up the sample into “high” and “low” overhang groups according to the median overhang of the repurchasing firms. I do the same for leverage. Overhang and leverage are expected to be positively correlated. In addition, Jensen (1989) notes that highly levered firms will trigger distress with smaller declines in profitability relative to low-levered firms. The third grouping is based on default probabilities; groups are divided according to whether their long-term debt ratings are investment grade or not. Since firms with more investment opportunities are going to have higher agency costs of debt, I divide the sample by firm average $Q$. Myers (1977) showed that the maturity structure of debt matters for underinvestment. Firms with shorter maturity structures are less likely to suffer from overhang. I accordingly split up the sample firms by the proportion of long-term debt expiring after 5 years. Finally, I estimate the investment regressions separately for open market repurchases and tender offers.

Table VI displays the estimation results for the subgroups. The two overhang groups reveal an interesting pattern. Firms in the high overhang category experience a large improvement in investment efficiency, while the low overhang group shows no improvement. The pre-repurchase sensitivity of investment to $Q$ is significantly positive for the low overhang group, but not for the high overhang group. Thus, improvements in investment efficiency appear to be concentrated among those firms for which investment was distorted prior to the debt repurchase. The results for the low overhang group suggest that mitigating overhang is not the sole reason to repurchase debt. Other reasons, such as disgorging free cash flow, may also motivate firms to repurchase debt. This same general pattern holds for the leverage, bond ratings, and maturity structure subgroups. Namely, investment is sensitive to $Q$ prior to the repurchase for the low leverage, investment grade and short maturity structure firms, while investment sensitivity increases for those firms expected to be suffering from overhang.

Investment sensitivity to $Q$ is significantly positive for both high and low $Q$ firms, but improves significantly for only the high $Q$ group. This result is consistent with the idea that highly-levered firms with higher growth prospects are more likely to suffer from overhang than low growth firms with similar leverage. The pre-repurchase sensitivity of both groups suggest that firms suffering overhang problems can be found in both high and low growth groups.

Finally, the main result appears to be independent of the repurchase method. Investment efficiency increases by 0.0086 for firms engaged in open market repurchases and 0.0221 for firms employing tender offers to reduce debt. Investment levels are seen to increase following repurchases of either
type. None of the coefficient estimates are significantly different from each other across these two repurchase-type groups.

D.2. Sample Selection Issues

As noted above, one problem with estimating the effect of debt repurchases on investment is that firms choose to repurchase debt rather than being assigned by random selection. This self-selection could induce a bias in the estimated changes in investment efficiency since firms choosing to repurchase debt are different from the entire population of firms. One can never observe the outcome if a firm had not repurchased debt. If repurchasing firms differ in fundamental ways, it is important to understand whether measured improvements in investment efficiency are still present after controlling for these differences. One approach for doing this is to estimate average treatment effects based on propensity score matching. In the context of this paper, the “treatment” is a debt repurchase. The idea behind treatment effects estimation is that if the assignment of the treatment is exogenous conditional on a set of control variables, then a sample of control firms can be constructed and treatment effects can be estimated by comparing averages across the two groups. This method has an advantage over traditional matching rules (e.g. industry/size) because it allows for matching on a large number of pre-repurchase firm characteristics, thus reducing the bias arising from fundamental differences the treatment and control samples.

Estimation of treatment effects by propensity score matching was proposed by Rosenbaum and Rubin (1983). They define the propensity score \( p(X) \) as the conditional probability of receiving a treatment given the pretreatment characteristics. That is, \( p(X) \equiv Pr(D = 1|X) = E(D|X) \) where \( D = \{0,1\} \) is an indicator of the presence of the treatment. Rosenbaum and Rubin (1983) show that if the allocation of the treatment across subjects is random conditional on the vector \( X \), then it is also random conditional on the scalar \( p(X) \). In practice, \( p(X) \) is typically computed based on predicted values of a probit or logit model, and a control sample is constructed based on these propensity scores. Intuitively, a control sample is formed by choosing non-repurchasing firms which are similar with respect to pre-repurchase firm characteristics and hence have a high predicted probability of repurchasing debt.

Matching on propensity scores solves the “curse of dimensionality” problem associated with other matching rules. The propensity score theorem states that if the treatment assignment can be ignored conditional on \( X \), then it can also be ignored conditional on the propensity score. This theorem implies that the observations with the same propensity score have the same distribution of the full vector
of variables $X$. This approach reduces the dimensionality of the matching problem to one, and the comparability between treatment and control firms is maximized.

To obtain propensity scores, I obtain predicted values from the probit model estimated as specification (2) reported in Table IV. I then construct a sample of control firms by matching on the probability of repurchase using a nearest-neighbor approach, sampling with replacement. The result is a control sample of firms are similar to repurchasing firms both at the time of the repurchase and the year leading up to the repurchase with respect to leverage, stock returns, size, cash, NOLCs, cash flows, and overhang. I then observe differences investment levels and efficiency one year after the repurchase. Since treatment effects are based on averages and investment efficiency is based on regression slope estimates, I calculate the following statistic for each firm among both repurchasing and control firms:

$$Q_i = \frac{(I_i - \bar{I})(Q_i - \bar{Q})}{\frac{1}{N} \sum_{i=1}^{N} (Q_i - \bar{Q})^2}$$  \hspace{1cm} (5)$$

This statistic is of interest because its average is the same as the slope coefficient in a simple regression of Investment on $Q$ and has the same interpretation as before.

Control firms are selected using a nearest-neighbor algorithm based on blocks and propensity scores. Specifically, for every repurchasing firm, I select a non-repurchasing firm in the same block with the closest propensity score. Sampling of control firms is done with replacement, with the only sampling constraint being that a firm cannot be matched to itself.

Panel A of Table VII reports estimated average treatment effects and difference-in-differences estimates. The difference-in-differences estimator controls for effects of any unobserved time-invariant firm characteristics, while the level treatment effects do not. These estimates represent average changes in investment and equity issuance for treatment relative to control firms from year $-1$ to year $+1$. In the year following the repurchase, treatment firms have investment levels averaging 0.1044, compared to 0.0942 for control firms. In addition, the difference-in-difference estimator for investment levels is 0.0942. Repurchasing firms experience a significant increase in investment levels following the repurchase relative to otherwise similar firms. An average $Q$ sensitivity (calculated as the average value from equation (5)) of 0.0359 compared to 0.0119 for control firms. Thus, the average treatment effect of a debt repurchase on $Q$ sensitivity is 0.0240, which is statistically significant at the 0.01 level. The difference-in-differences estimate for $Q$ sensitivity turns out to be 0.0272. The average treatment effects and difference-in-differences estimates also show a significant increase in the sensitivity of firm investment to industry investment for repurchasing firms relative to control firms.
Panel A also reports changes in equity issuance after the debt repurchase. According to theory, firms with debt overhang problems find it difficult to raise new equity to finance profitable investment because potential shareholders view debt overhang as a large marginal tax rate on investment. Thus, if debt repurchases help mitigate this problem, we expect to see increases in equity issuance for treatment firms. Panel A supports this hypothesis. Repurchasing firms issue equity in the amount of 2.99% of total assets, compared 1.88% for control firms. The difference-in-differences estimator is a significant 0.0272, suggesting that repurchasing firms increase equity issuance following the repurchase, while control firms tend to decrease equity-issuing activity.

Panel B reports the results the differences in estimated slope coefficients of equation (4) between treatment and control firms. For control firms, year zero is defined as the year in which the firm was selected into the control firm (the year the predicted probability of repurchasing was high). In Panel B, we can see that when firm Average $Q$ is used as a proxy for growth opportunities, there is no statistical difference in the pre-repurchase sensitivity to investment opportunities between the treatment and control firms. However, the change in sensitivity to $Q$ increases significantly for treatment firms. The coefficient on the After dummy is also positive and significant, suggesting that post-repurchase investment rates are higher for firms choosing to repurchase. It is interesting to note that the sensitivity of investment to cash flow is lower in the post-repurchase period for the treatment firms. The results are similar for the other two growth opportunity measures, with the exception that the difference in cash flow sensitivity is no longer significantly negative.

D.3. Decomposing Investment Expenditures

As a further robustness check, I attempt to decompose investment expenditures into two portions, one that is more sensitive to overhang, and the other portion which should not be as sensitive. Firm investment expenditures are composed of outlays on capital expenditures, acquisitions and research and development, net of sales of property, plant and equipment. Some portion of these expenditures are directed at maintenance of existing assets rather than on new investment. Problems with debt overhang arise from unaligned incentives with respect to marginal investment decisions. It is therefore likely that debt overhang will have a larger impact on expenditures related to new projects compared to maintenance expenditures.

Following Richardson (2005), I decompose total investment expenditures into investment in new projects and investment to maintain assets in place. Investment to maintain assets in place is defined as amortization and depreciation and investment on new projects is defined as total investment net
of amortization and depreciation. If a firm’s depreciation schedule corresponds closely with the use of assets, then the proxy for maintenance investment should be reasonable. As Richardson (2005) notes, this probably is not the case for all firms. In addition, maintenance and amortization will not be good at capturing maintenance expenditures on intangible assets and R&D. However, to the extent that maintenance expenditures are more constant than new investment expenditures, the decomposition may be instructive.

Table VIII reports the results of investment sensitivity regressions for three different dependent variables, total investment, maintenance investment, and new investment. I include firm average $Q$, industry median $Q$, and asset-weighted average industry investment as proxies for investment opportunities. The regressions for total investment are reproduced from Table V. Total investment expenditures become more sensitive to investment opportunities following a repurchase for all three proxies. The results for maintenance and new investment expenditures come out as expected. Maintenance investment efficiency does not improve following a debt repurchase, but new investment efficiency improves significantly. It appears that the improvements in total investment efficiency are concentrated on those expenditures directed at new investment.

In summary, after controlling for potential endogeneity and selection issues, I find evidence that debt repurchases appear to be effective in mitigating the effects of debt overhang. Specifically, investment levels increase by over 10% for firms choosing to repurchase debt relative to the control sample of firms. The sensitivity of investment to investment opportunities, my measure of investment quality, also increases following the debt repurchase. These results are stronger for firms which are expected to be most constrained by debt overhang. Finally, I find a significant increase in the use of equity financing following the debt repurchase, consistent with what we would expect if debt repurchases help improve investment and financing flexibility.

V. Conclusion

Despite the voluminous literature on capital structure choice, very little is known about corporate debt repurchase activity. This paper provides an agency-cost based explanation for why firms would choose to exchange cash on hand for a reduction in outstanding debt. The basic idea is that when a firm has risky debt outstanding, proceeds from new investment will accrue disproportionately to bondholders, providing managers an incentive to reject otherwise value-enhancing investment opportunities. In addition to the incentive effects, firms with a debt overhang will find it difficult to raise external financing.
Faced with this situation, the option to repurchase debt becomes valuable to both shareholders and bondholders. Using cash to repurchase debt increases expected payoffs to shareholders by an amount larger than the foregone cash and will induce investment, thus partially mitigating the debt overhang problem. The equilibrium price of debt in this case will be just high enough to avoid free-riding among the bondholders.

Using a new sample of debt repurchases, I find evidence consistent with the agency cost explanation for debt repurchases. Firms tend to repurchase debt when expected transfers to bondholders are high, even after controlling for leverage. The announcement of debt repurchases appears to be interpreted as good news to shareholders, as announcement returns are significantly positive. Bondholders also appear to be made better off as a result of the repurchase. As predicted by the model, I find evidence that both the quantity and quality of investment improve following a debt repurchase. This result is stronger among firms with higher potential agency costs as measured by relatively higher overhang, more leverage, longer maturity structures, and lower bond ratings. This finding is robust to alternative measures of investment opportunities and controls for endogeneity and selection bias.

This paper makes three main contributions to the literature. First, it is one of the first papers to systematically study the market for repurchasing debt. Second, it adds to the literature focusing on the agency costs of debt and the interaction of financing choices with investment, providing evidence that debt can negatively affect investment and demonstrating how firms adjust their capital structures in response to these frictions. Finally, this paper complements recent research by Acharya, Almeida and Campello (2005), providing situations in which cash is not always the same thing as negative debt.

While this agency cost rationale for buying repurchases is supported by the data, admittedly it isn’t the only reason why firms may choose to repurchase debt. For example, a firm may choose to engage in a tender offer along with a consent solicitation in order to remove restrictive covenants from the bond indenture. Another potential motive is that managers may view their bonds as being underpriced and view a repurchase as a good investment. These and other potential explanations are left as future research.
Appendix

Proof of Proposition 1: The shareholders will pursue a debt repurchase if the face value of debt declines enough so that the net present value of investment from the shareholders perspective is positive. The condition $V_D < 1$ is not sufficient to guarantee that the reduction in debt will be large enough to induce investment. The maximum price per dollar of face value that shareholders are willing to pay is the price $V_D$ such that

$$E(\pi_{\text{equity}}) = p_H \left[ CF_{\text{AIP}} + X_H - \left( D - \frac{C}{V_D} \right) - I \right] \geq 0. \quad \text{(A.1)}$$

Rearranging and solving for $V_D$ gives

$$V_D = \frac{C}{p_H + D - (CF_{\text{AIP}} + X_H)}^{-1}. \quad \text{(A.2)}$$

Thus, for any $V_D < \overline{V_D}$, the expected payoff to shareholders becomes positive and the shareholders will repurchase debt and invest.

Proof of Proposition 2: For simplicity, assume there are $N$ bondholders, each holding an equal fraction $\frac{1}{N}D$ of the face value of outstanding debt. Each individual bondholder must decide whether to tender a fraction $\beta$ of their outstanding claim, such that $\sum \beta_i D = \frac{C}{V_D}$. Note first that in the absence of a repurchase, the price of the bond will be the expected payment scaled by the face value of debt:

$$V_D = \frac{CF_{\text{AIP}} + C}{D}. \quad \text{(A.3)}$$

The bondholders choosing to tender part of their claim will have an expected total repayment of

$$\frac{1}{N} \left[ \beta V_D D + (1 - \beta) \left( p_H D + (1 - p_H)(CF_{\text{AIP}} + X_L) \right) \right], \quad \text{(A.4)}$$

while those who hold out will have an expected total repayment of

$$\frac{1}{N} \left[ p_H D + (1 - p_H)(CF_{\text{AIP}} + X_L) \right]. \quad \text{(A.5)}$$
Therefore, in order to prevent a hold-out problem, the shareholders must offer a price such that the expected repayment is higher for those who tender than for those who hold out. That is, $V_D$ must be such that

$$\beta V_D + (1 - \beta)p_H D + (1 - p_H)(CF_{AIP} + X_L) \geq p_H D + (1 - p_H)(CF_{AIP} + X_L).$$

(A.6)

Rearranging equation (A.6) and solving for $V_D$ gives the minimum price that gives every bondholder the incentive to tender and thus prevent a hold-out problem:

$$V_D \geq \frac{p_H D + (1 - p_H)(CF_{AIP} + X_L)}{D}.$$  \hspace{1cm} (A.7)

Note that if the offer price is greater than that given in equation (A.3) but less than $V_D$, the free-rider problem arises. Although bondholders as a group would be better off if the firm repurchased debt and invested, each individual has an incentive to hold out and not tender a portion of their debt.

Therefore, if $V_D \leq V_D \leq V_D$, shareholders will be willing to repurchase debt, bondholders will be willing to tender, and the investment project will be accepted.

Proof of Proposition 3: Suppose the shareholders offer a proportion $\alpha$ of equity for a proportion $\delta$ of outstanding debt. The terms of the debt-for-equity exchange must satisfy three conditions in order for both shareholders and bondholders to be better off relative to a cash repurchase of debt. First, the exchange must induce the firm to invest. That is, $\delta$ must be large enough such that

$$p_H(CF_{AIP} + C + X_H - (D - \delta D)) - I \geq 0.$$ \hspace{1cm} (A.8)

This condition states that the reduction in debt must be large enough so that the net present value of investment is positive from the shareholders perspective. Given a $\delta$ that satisfies equation (A.8), the share of offered equity $\alpha$ must satisfy

$$(1 - \alpha)[p_H(CF_{AIP} + C + X_H - (D - \delta D)) - I] - \frac{p_H(CF_{AIP} + X_H - (D - \frac{C}{V_D})) - I}{V_D} \geq 0.$$ \hspace{1cm} (A.9)

This condition states that the residual payoff to the original shareholders must be larger than their payoff in the repurchase case. The third condition states that $\alpha$ and $\delta$ must be chosen such that the bondholders are willing to exchange debt for equity. This can be stated as:

$$\alpha[p_H(CF_{AIP} + C + X_H - (D \delta D)) - I] - p_H \delta D \geq 0.$$ \hspace{1cm} (A.10)
equation (A.10) says that the expected total payments to bondholders agreeing to the exchange must be higher than the expected payments to those who hold out.

Assume that these three conditions hold. Let $\alpha$ be the proportion of equity offered to bondholders which makes the shareholders indifferent between an exchange and a repurchase. Using equation (A.9), this proportion of equity is

$$\alpha^* = \frac{p_H(C + \delta D) - \frac{C}{V_D}}{p_H(CF_{AIP} + C + X_H - (D - \delta D)) - I}.$$  \hspace{1cm} (A.11)

This $\alpha^*$ reflects the maximum amount of equity that shareholders are willing to exchange equity for debt rather than use the firm’s cash to repurchase debt. Substituting $\alpha^*$ into equation (A.10) and simplifying gives

$$p_H(C + \delta D) - \frac{C}{V_D} - p_H\delta D = p_H C - \frac{C}{V_D} \geq 0,$$  \hspace{1cm} (A.12)

which is a contradiction since $V_D < 1$ implies that $\frac{C}{V_D} > C > p_H C$. There are no values of $\alpha$ and $\delta$ that can simultaneously prevent a free-rider problem among bondholders and induce the shareholders to exchange. Therefore, when the firm has enough cash to repurchase debt, the shareholders will strictly prefer a debt repurchase to a debt-for-equity exchange. $\square$
References


Richardson, Scott, 2005, Over-investment of free cash flow, working paper, University of Pennsylvania.


Table I
Summary Statistics: Debt Repurchases

This table reports summary details for debt repurchases over the 1996 to 2004 time period for U.S. industrial firms. Bond ratings, initial maturity, amount outstanding at issuance, security level, and redemption characteristics are obtained from the Mergent Fixed Income Securities Database (FISD).

### Panel A: Total Real Dollar Expenditures ($Millions)

<table>
<thead>
<tr>
<th>Year</th>
<th>All Repurchases</th>
<th>Open Market</th>
<th>Tender Offers</th>
<th>Total Bond Issuance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>11,711.0</td>
<td>2,537.3</td>
<td>9,173.7</td>
<td>173,484.0</td>
</tr>
<tr>
<td>1997</td>
<td>18,181.8</td>
<td>1,191.3</td>
<td>16,990.5</td>
<td>302,184.4</td>
</tr>
<tr>
<td>1998</td>
<td>29,192.2</td>
<td>1,133.2</td>
<td>28,058.9</td>
<td>437,056.6</td>
</tr>
<tr>
<td>1999</td>
<td>21,749.2</td>
<td>3,316.4</td>
<td>18,432.9</td>
<td>510,068.1</td>
</tr>
<tr>
<td>2000</td>
<td>32,351.1</td>
<td>10,962.5</td>
<td>21,388.6</td>
<td>738,982.6</td>
</tr>
<tr>
<td>2001</td>
<td>35,464.4</td>
<td>18,903.9</td>
<td>16,560.5</td>
<td>783,248.8</td>
</tr>
<tr>
<td>2002</td>
<td>20,397.7</td>
<td>10,885.8</td>
<td>9,512.0</td>
<td>486,985.9</td>
</tr>
<tr>
<td>2003</td>
<td>36,576.0</td>
<td>20,198.5</td>
<td>16,377.6</td>
<td>427,538.3</td>
</tr>
<tr>
<td>2004</td>
<td>61,662.1</td>
<td>24,450.7</td>
<td>37,211.4</td>
<td>378,555.4</td>
</tr>
</tbody>
</table>

### Panel B: Issue Characteristics

<table>
<thead>
<tr>
<th></th>
<th>All Repurchases</th>
<th>Open Market</th>
<th>Tender Offers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>120.67</td>
<td>61.68</td>
<td>147.27</td>
</tr>
<tr>
<td>Median</td>
<td>79.35</td>
<td>20.32</td>
<td>104.48</td>
</tr>
<tr>
<td>Proportion of Issue Retired</td>
<td>Mean</td>
<td>0.614</td>
<td>0.319</td>
</tr>
<tr>
<td>Median</td>
<td>0.781</td>
<td>0.163</td>
<td>0.930</td>
</tr>
<tr>
<td>Initial Maturity (Years)</td>
<td>Mean</td>
<td>10.84</td>
<td>10.62</td>
</tr>
<tr>
<td>Median</td>
<td>9.71</td>
<td>9.61</td>
<td>9.77</td>
</tr>
<tr>
<td>Remaining Maturity (Years)</td>
<td>Mean</td>
<td>6.90</td>
<td>7.05</td>
</tr>
<tr>
<td>Median</td>
<td>5.75</td>
<td>5.83</td>
<td>5.70</td>
</tr>
</tbody>
</table>

### Panel C: Contractual Characteristics

<table>
<thead>
<tr>
<th>Seniority Level</th>
<th>All Repurchases (N = 1,808)</th>
<th>Open Market (N = 562)</th>
<th>Tender Offers (N = 1,246)</th>
<th>All Issued Bonds (N = 22,072)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Secured</td>
<td>5.48%</td>
<td>3.02%</td>
<td>6.58%</td>
<td>4.19%</td>
</tr>
<tr>
<td>Senior</td>
<td>51.22%</td>
<td>43.06%</td>
<td>54.90%</td>
<td>64.77%</td>
</tr>
<tr>
<td>Senior Subordinate</td>
<td>42.48%</td>
<td>52.31%</td>
<td>38.04%</td>
<td>23.07%</td>
</tr>
<tr>
<td>Junior Subordinate</td>
<td>0.11%</td>
<td>0.18%</td>
<td>0.08%</td>
<td>0.32%</td>
</tr>
<tr>
<td>None</td>
<td>0.72%</td>
<td>1.42%</td>
<td>0.40%</td>
<td>7.65%</td>
</tr>
<tr>
<td>Redemption Characteristics</td>
<td>Callable</td>
<td>97.16%</td>
<td>97.98%</td>
<td>96.74%</td>
</tr>
<tr>
<td>Putable</td>
<td>5.09%</td>
<td>7.83%</td>
<td>3.85%</td>
<td>5.04%</td>
</tr>
<tr>
<td>Convertible</td>
<td>13.55%</td>
<td>29.00%</td>
<td>6.58%</td>
<td>10.19%</td>
</tr>
<tr>
<td>Sinking Fund</td>
<td>5.12%</td>
<td>6.28%</td>
<td>4.53%</td>
<td>11.82%</td>
</tr>
</tbody>
</table>
### Table II

**Average Overhang Correction by Leverage Group**

This table reports the mean overhang correction across leverage and overhang deciles. In Panel A, all firms were first sorted by leverage. Then, within each leverage decile, firms are sorted by the overhang correction and placed into deciles. Panel B presents groups created by independent sorts of leverage and overhang. The overhang correction is calculated as in Hennessy and Whited (2005) as

\[
h_t = \text{Leverage}_t \times \text{Recovery Ratio} \times \left[ \sum_{s=1}^{20} \rho_{t+s}(1 - 0.05(s - 1))(1 + r)^{-s} \right]
\]

, where \(\rho_{t+s}\) is the probability of default in period \(t + s\), proxied by Moody’s default hazard rates for each credit rating. If the credit rating is unknown, it is imputed using the method of Blume, Lim and MacKinlay (1998). The *Recovery Ratio* is the expected proportion of assets reclaimed by debtholders in case of default. I use a proxy similar to that in Berger et al. (1996) based on the tangibility of assets, where the estimated recovery ratio is calculated as \(\text{Tangibility} = 0.715 \times \text{Receivables} + 0.547 \times \text{Inventory} + 0.535 \times \text{Capital} + \text{Cash}\).

<table>
<thead>
<tr>
<th>Overhang Decile</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVERAGE DECILE</td>
<td>1</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.001</td>
<td>0.001</td>
<td>0.002</td>
<td>0.003</td>
<td>0.004</td>
<td>0.005</td>
<td>0.006</td>
<td>0.007</td>
<td>0.009</td>
<td>0.013</td>
</tr>
<tr>
<td>3</td>
<td>0.001</td>
<td>0.003</td>
<td>0.004</td>
<td>0.005</td>
<td>0.008</td>
<td>0.010</td>
<td>0.012</td>
<td>0.016</td>
<td>0.019</td>
<td>0.024</td>
</tr>
<tr>
<td>4</td>
<td>0.002</td>
<td>0.003</td>
<td>0.005</td>
<td>0.006</td>
<td>0.011</td>
<td>0.014</td>
<td>0.017</td>
<td>0.022</td>
<td>0.027</td>
<td>0.034</td>
</tr>
<tr>
<td>5</td>
<td>0.002</td>
<td>0.004</td>
<td>0.007</td>
<td>0.008</td>
<td>0.014</td>
<td>0.018</td>
<td>0.021</td>
<td>0.027</td>
<td>0.035</td>
<td>0.042</td>
</tr>
<tr>
<td>6</td>
<td>0.003</td>
<td>0.005</td>
<td>0.008</td>
<td>0.010</td>
<td>0.019</td>
<td>0.023</td>
<td>0.026</td>
<td>0.035</td>
<td>0.043</td>
<td>0.050</td>
</tr>
<tr>
<td>7</td>
<td>0.004</td>
<td>0.007</td>
<td>0.010</td>
<td>0.014</td>
<td>0.024</td>
<td>0.028</td>
<td>0.032</td>
<td>0.045</td>
<td>0.053</td>
<td>0.061</td>
</tr>
<tr>
<td>8</td>
<td>0.005</td>
<td>0.010</td>
<td>0.013</td>
<td>0.024</td>
<td>0.031</td>
<td>0.035</td>
<td>0.043</td>
<td>0.056</td>
<td>0.063</td>
<td>0.073</td>
</tr>
<tr>
<td>9</td>
<td>0.007</td>
<td>0.014</td>
<td>0.024</td>
<td>0.035</td>
<td>0.041</td>
<td>0.047</td>
<td>0.061</td>
<td>0.072</td>
<td>0.079</td>
<td>0.091</td>
</tr>
<tr>
<td>10</td>
<td>0.012</td>
<td>0.028</td>
<td>0.045</td>
<td>0.056</td>
<td>0.069</td>
<td>0.085</td>
<td>0.095</td>
<td>0.106</td>
<td>0.124</td>
<td>0.200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Overhang Decile</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVERAGE DECILE</td>
<td>1</td>
<td>0.000</td>
<td>0.002</td>
<td>0.004</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>0.001</td>
<td>0.002</td>
<td>0.005</td>
<td>0.007</td>
<td>0.012</td>
<td>0.017</td>
<td>0.023</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>0.001</td>
<td>0.002</td>
<td>0.004</td>
<td>0.008</td>
<td>0.012</td>
<td>0.018</td>
<td>0.025</td>
<td>0.033</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>0.001</td>
<td>0.002</td>
<td>0.005</td>
<td>0.007</td>
<td>0.013</td>
<td>0.017</td>
<td>0.027</td>
<td>0.034</td>
<td>0.048</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>0.001</td>
<td>0.003</td>
<td>0.004</td>
<td>0.007</td>
<td>0.013</td>
<td>0.019</td>
<td>0.026</td>
<td>0.037</td>
<td>0.049</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>0.001</td>
<td>0.003</td>
<td>0.004</td>
<td>0.008</td>
<td>0.011</td>
<td>0.019</td>
<td>0.025</td>
<td>0.039</td>
<td>0.049</td>
<td>0.072</td>
</tr>
<tr>
<td>7</td>
<td>0.001</td>
<td>0.003</td>
<td>0.005</td>
<td>0.008</td>
<td>0.011</td>
<td>0.019</td>
<td>0.027</td>
<td>0.037</td>
<td>0.054</td>
<td>0.073</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>0.003</td>
<td>0.005</td>
<td>0.008</td>
<td>0.012</td>
<td>0.018</td>
<td>0.028</td>
<td>0.036</td>
<td>0.058</td>
<td>0.073</td>
</tr>
<tr>
<td>9</td>
<td>0.001</td>
<td>0.002</td>
<td>0.005</td>
<td>0.007</td>
<td>0.013</td>
<td>0.017</td>
<td>0.027</td>
<td>0.039</td>
<td>0.054</td>
<td>0.080</td>
</tr>
<tr>
<td>10</td>
<td>0.000</td>
<td>0.002</td>
<td>0.005</td>
<td>0.008</td>
<td>0.012</td>
<td>0.019</td>
<td>0.027</td>
<td>0.038</td>
<td>0.054</td>
<td>0.116</td>
</tr>
</tbody>
</table>
This table reports summary statistics for selected firm characteristics in event time surrounding the repurchase of corporate debt. Leverage is defined as the book value of total debt scaled by the sum of the market value of equity and the book value of total debt. Industry medians are based on 3-digit SIC codes. Overhang is measured as in Hennessy (2004). The proportion of debt expiring after 5 years is calculated as the ratio of total debt expiring after 5 years divided by total debt.

<table>
<thead>
<tr>
<th>Year</th>
<th>-4</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>%Δ_{-4,-1}</th>
<th>%Δ_{-1,+1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leverage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.387</td>
<td>0.427</td>
<td>0.450</td>
<td>0.456</td>
<td>0.414</td>
<td>0.412</td>
<td>0.406</td>
<td>0.379</td>
<td>17.83%</td>
<td>-9.65%</td>
</tr>
<tr>
<td>Upper Quartile</td>
<td>0.542</td>
<td>0.556</td>
<td>0.584</td>
<td>0.598</td>
<td>0.558</td>
<td>0.516</td>
<td>0.513</td>
<td>0.514</td>
<td>10.33%</td>
<td>-13.71%</td>
</tr>
<tr>
<td>Median</td>
<td>0.385</td>
<td>0.399</td>
<td>0.423</td>
<td>0.425</td>
<td>0.381</td>
<td>0.368</td>
<td>0.336</td>
<td>0.332</td>
<td>10.34%</td>
<td>-13.41%</td>
</tr>
<tr>
<td>Lower Quartile</td>
<td>0.245</td>
<td>0.288</td>
<td>0.303</td>
<td>0.308</td>
<td>0.264</td>
<td>0.256</td>
<td>0.198</td>
<td>0.187</td>
<td>25.71%</td>
<td>-16.88%</td>
</tr>
<tr>
<td>Deviation from Industry Median Leverage (= (LEV_{ikt} − M(LEV_{kt})))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.105</td>
<td>0.126</td>
<td>0.148</td>
<td>0.158</td>
<td>0.104</td>
<td>0.102</td>
<td>0.098</td>
<td>0.087</td>
<td>50.48%</td>
<td>-35.44%</td>
</tr>
<tr>
<td>Upper Quartile</td>
<td>0.209</td>
<td>0.230</td>
<td>0.253</td>
<td>0.269</td>
<td>0.217</td>
<td>0.214</td>
<td>0.197</td>
<td>0.189</td>
<td>28.71%</td>
<td>-20.45%</td>
</tr>
<tr>
<td>Median</td>
<td>0.088</td>
<td>0.103</td>
<td>0.119</td>
<td>0.129</td>
<td>0.097</td>
<td>0.075</td>
<td>0.073</td>
<td>0.074</td>
<td>46.59%</td>
<td>-41.86%</td>
</tr>
<tr>
<td>Lower Quartile</td>
<td>-0.025</td>
<td>-0.009</td>
<td>-0.001</td>
<td>0.006</td>
<td>-0.023</td>
<td>-0.031</td>
<td>-0.067</td>
<td>-0.073</td>
<td>124.00%</td>
<td>-616.67%</td>
</tr>
<tr>
<td>Overhang</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.032</td>
<td>0.035</td>
<td>0.038</td>
<td>0.040</td>
<td>0.034</td>
<td>0.031</td>
<td>0.027</td>
<td>0.025</td>
<td>25.00%</td>
<td>-22.50%</td>
</tr>
<tr>
<td>Upper Quartile</td>
<td>0.047</td>
<td>0.049</td>
<td>0.054</td>
<td>0.056</td>
<td>0.048</td>
<td>0.048</td>
<td>0.044</td>
<td>0.036</td>
<td>19.15%</td>
<td>-14.29%</td>
</tr>
<tr>
<td>Median</td>
<td>0.023</td>
<td>0.027</td>
<td>0.028</td>
<td>0.029</td>
<td>0.024</td>
<td>0.022</td>
<td>0.019</td>
<td>0.016</td>
<td>26.09%</td>
<td>-41.86%</td>
</tr>
<tr>
<td>Lower Quartile</td>
<td>0.008</td>
<td>0.009</td>
<td>0.010</td>
<td>0.010</td>
<td>0.008</td>
<td>0.007</td>
<td>0.005</td>
<td>0.004</td>
<td>25.00%</td>
<td>-30.00%</td>
</tr>
<tr>
<td>Proportion of Total Debt Expiring After 5 Years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.668</td>
<td>0.701</td>
<td>0.714</td>
<td>0.702</td>
<td>0.697</td>
<td>0.644</td>
<td>0.576</td>
<td>0.556</td>
<td>5.09%</td>
<td>-8.26%</td>
</tr>
<tr>
<td>Upper Quartile</td>
<td>0.934</td>
<td>0.943</td>
<td>0.946</td>
<td>0.946</td>
<td>0.948</td>
<td>0.932</td>
<td>0.892</td>
<td>0.858</td>
<td>1.28%</td>
<td>-1.48%</td>
</tr>
<tr>
<td>Median</td>
<td>0.742</td>
<td>0.789</td>
<td>0.802</td>
<td>0.790</td>
<td>0.801</td>
<td>0.752</td>
<td>0.656</td>
<td>0.643</td>
<td>6.47%</td>
<td>-4.81%</td>
</tr>
<tr>
<td>Lower Quartile</td>
<td>0.494</td>
<td>0.552</td>
<td>0.584</td>
<td>0.540</td>
<td>0.535</td>
<td>0.446</td>
<td>0.301</td>
<td>0.257</td>
<td>9.31%</td>
<td>-17.41%</td>
</tr>
<tr>
<td>Cash Flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.052</td>
<td>0.043</td>
<td>0.030</td>
<td>0.023</td>
<td>0.024</td>
<td>0.024</td>
<td>0.031</td>
<td>0.028</td>
<td>0.040</td>
<td>-55.77%</td>
</tr>
<tr>
<td>Upper Quartile</td>
<td>0.094</td>
<td>0.091</td>
<td>0.087</td>
<td>0.086</td>
<td>0.088</td>
<td>0.102</td>
<td>0.097</td>
<td>0.102</td>
<td>-9.57%</td>
<td>14.12%</td>
</tr>
<tr>
<td>Median</td>
<td>0.064</td>
<td>0.056</td>
<td>0.052</td>
<td>0.051</td>
<td>0.050</td>
<td>0.054</td>
<td>0.054</td>
<td>0.057</td>
<td>-21.54%</td>
<td>5.88%</td>
</tr>
<tr>
<td>Lower Quartile</td>
<td>0.032</td>
<td>0.023</td>
<td>0.012</td>
<td>0.003</td>
<td>0.007</td>
<td>0.010</td>
<td>0.003</td>
<td>0.022</td>
<td>-90.63%</td>
<td>233.33%</td>
</tr>
</tbody>
</table>
### Table IV

**Probit Regressions: Overhang and the Repurchase Choice**

This table reports estimated marginal effects \(\frac{dF}{dx}\) from probit regressions, where the binary choice variable is given the value of 1 in the year a firm repurchases debt, zero otherwise. Robust standard errors are reported in parentheses.

<table>
<thead>
<tr>
<th></th>
<th>All Debt Repurchases</th>
<th>IV Probit Repurchases</th>
<th>Open Market Repurchases</th>
<th>Tender Offer Repurchases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td><strong>Size(_{t-1})</strong></td>
<td>0.0082***</td>
<td>0.0089***</td>
<td>0.0095***</td>
<td>0.0081***</td>
</tr>
<tr>
<td></td>
<td>(0.0005)</td>
<td>(0.0006)</td>
<td>(0.0006)</td>
<td>(0.0006)</td>
</tr>
<tr>
<td><strong>Prior 12-month Return</strong></td>
<td>0.0033***</td>
<td>0.0033***</td>
<td>0.0039***</td>
<td>0.0029***</td>
</tr>
<tr>
<td></td>
<td>(0.0008)</td>
<td>(0.0009)</td>
<td>(0.0009)</td>
<td>(0.0009)</td>
</tr>
<tr>
<td><strong>NOLC(_t)</strong></td>
<td>0.0028</td>
<td>0.0036*</td>
<td>0.0051**</td>
<td>0.0032*</td>
</tr>
<tr>
<td></td>
<td>(0.0019)</td>
<td>(0.0020)</td>
<td>(0.0022)</td>
<td>(0.0019)</td>
</tr>
<tr>
<td><strong>Cash(_{t-1})</strong></td>
<td>0.0364***</td>
<td>0.0310***</td>
<td>0.0348***</td>
<td>0.0366***</td>
</tr>
<tr>
<td></td>
<td>(0.0059)</td>
<td>(0.0065)</td>
<td>(0.0067)</td>
<td>(0.0064)</td>
</tr>
<tr>
<td><strong>Cash Flow(_t)</strong></td>
<td>-0.0295***</td>
<td>-0.0179*</td>
<td>-0.0182*</td>
<td>-0.0116</td>
</tr>
<tr>
<td></td>
<td>(0.0087)</td>
<td>(0.0094)</td>
<td>(0.0097)</td>
<td>(0.0092)</td>
</tr>
<tr>
<td><strong>Cash Flow Volatility(_{t-1})</strong></td>
<td>0.0003</td>
<td>0.0009</td>
<td>0.0012</td>
<td>0.0011</td>
</tr>
<tr>
<td></td>
<td>(0.0009)</td>
<td>(0.0021)</td>
<td>(0.0021)</td>
<td>(0.0019)</td>
</tr>
<tr>
<td><strong>Average Q(_{t-1})</strong></td>
<td>-0.0006</td>
<td>-0.0015*</td>
<td>-0.0015*</td>
<td>-0.0008</td>
</tr>
<tr>
<td></td>
<td>(0.0004)</td>
<td>(0.0008)</td>
<td>(0.0007)</td>
<td>(0.0006)</td>
</tr>
<tr>
<td><strong>Investment(_{t-1})</strong></td>
<td>-0.0250**</td>
<td>-0.0351***</td>
<td>-0.0430***</td>
<td>-0.0347***</td>
</tr>
<tr>
<td></td>
<td>(0.0099)</td>
<td>(0.0111)</td>
<td>(0.0118)</td>
<td>(0.0104)</td>
</tr>
<tr>
<td><strong>Overhang(_{t-1})</strong></td>
<td>0.1423***</td>
<td>0.1523***</td>
<td>0.1200***</td>
<td>0.0862***</td>
</tr>
<tr>
<td></td>
<td>(0.0331)</td>
<td>(0.0333)</td>
<td>(0.0309)</td>
<td>(0.0307)</td>
</tr>
<tr>
<td><strong>Leverage(_{t-1})</strong></td>
<td>0.0588***</td>
<td>0.0454***</td>
<td>0.0475***</td>
<td>0.1076***</td>
</tr>
<tr>
<td></td>
<td>(0.0043)</td>
<td>(0.0057)</td>
<td>(0.0057)</td>
<td>(0.0139)</td>
</tr>
<tr>
<td><strong>Leverage(<em>2)(</em>{t-1})</strong></td>
<td></td>
<td>-0.0709***</td>
<td>-0.3426***</td>
<td>(0.0143)</td>
</tr>
<tr>
<td><strong>Leverage(<em>3)(</em>{t-1})</strong></td>
<td></td>
<td>0.2002***</td>
<td>(0.0511)</td>
<td></td>
</tr>
<tr>
<td><strong>Target Deviation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Year Dummies</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Pseudo R(^2)</strong></td>
<td>0.158</td>
<td>0.167</td>
<td>0.158</td>
<td>0.174</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>15,128</td>
<td>12,641</td>
<td>12,641</td>
<td>12,641</td>
</tr>
</tbody>
</table>

Note: ***,**, and * denote significance at the 1, 5 and 10 percent levels, respectively.
Table V
Investment Quality and Quantity Around Repurchases

This table reports estimated coefficients from investment regressions of the form

\[
\frac{I_t}{A_{i,t-1}} - M \left( \frac{I_{kt}}{A_{k,t-1}} \right) = \beta_0 + \beta_1 Q_{i,t-1} + \beta_2 Q_{i,t-1} \times \text{After} + \beta_3 \text{After} + \beta_4 \frac{\text{Cashflow}_{it}}{A_{i,t-1}} + \sum \gamma_t \text{Year}_t + \epsilon_{it},
\]

where \( M \left( \frac{I_{kt}}{A_{k,t-1}} \right) \) is the median investment rate for industry \( k \) in year \( t \). Industry medians are calculated based on 3-digit SIC codes. Firm fixed effects are captured in the firm-specific intercept terms \( \beta_{oi} \). t-statistics based on firm-clustered standard errors are reported in parentheses. The dependent variable is investment scaled by total assets minus the median investment rate in the firm’s industry, where investment includes capital expenditures, acquisitions and R&D expenses. \( \text{After} \) is a dummy variable set equal to zero for years -2 and -1 relative to the repurchase, and set equal to one for years +1 and +2.

<table>
<thead>
<tr>
<th></th>
<th>Panel A: Firm Average Q</th>
<th>Panel B: Median Industry Q</th>
<th>Panel C: Asset-Weighted Mean Industry Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Flow</td>
<td>0.1086*** 0.0592</td>
<td>0.0302</td>
<td>0.1007</td>
</tr>
<tr>
<td></td>
<td>(0.0276) (0.0423)</td>
<td>(0.1158)</td>
<td>(0.9674)</td>
</tr>
<tr>
<td>Q</td>
<td>0.0108*** 0.0116***</td>
<td>0.0164**</td>
<td>0.0221***</td>
</tr>
<tr>
<td></td>
<td>(0.0012) (0.0014)</td>
<td>(0.0078)</td>
<td>(0.0081)</td>
</tr>
<tr>
<td>Q×After</td>
<td>0.0185*** 0.0231***</td>
<td>0.0180***</td>
<td>0.0212**</td>
</tr>
<tr>
<td></td>
<td>(0.0037) (0.0041)</td>
<td>(0.0087)</td>
<td>(0.0101)</td>
</tr>
<tr>
<td>After</td>
<td>0.0202** 0.0144***</td>
<td>0.0625*</td>
<td>0.0105</td>
</tr>
<tr>
<td></td>
<td>(0.0096) (0.0046)</td>
<td>(0.0342)</td>
<td>(0.0255)</td>
</tr>
<tr>
<td>Lambda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry Q</td>
<td>0.1513*** 0.1427***</td>
<td>0.0143</td>
<td>0.0767</td>
</tr>
<tr>
<td></td>
<td>(0.0281) (0.0430)</td>
<td>(0.0629)</td>
<td>(0.1746)</td>
</tr>
<tr>
<td>Industry Q×After</td>
<td>0.0107*** 0.0147***</td>
<td>0.0108*</td>
<td>0.0161**</td>
</tr>
<tr>
<td></td>
<td>(0.0028) (0.0047)</td>
<td>(0.0057)</td>
<td>(0.0065)</td>
</tr>
<tr>
<td>After</td>
<td>0.0148** 0.0156***</td>
<td>0.0140**</td>
<td>0.0139**</td>
</tr>
<tr>
<td></td>
<td>(0.0066) (0.0043)</td>
<td>(0.0063)</td>
<td>(0.0066)</td>
</tr>
<tr>
<td>Lambda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry Investment</td>
<td>0.6786*** 0.4406***</td>
<td>0.4212***</td>
<td>0.5164***</td>
</tr>
<tr>
<td></td>
<td>(0.0509) (0.0608)</td>
<td>(0.1331)</td>
<td>(0.1421)</td>
</tr>
<tr>
<td>Industry Investment×After</td>
<td>0.0443*** 0.0906***</td>
<td>0.1077*</td>
<td>0.0951*</td>
</tr>
<tr>
<td></td>
<td>(0.0079) (0.0257)</td>
<td>(0.0611)</td>
<td>(0.0545)</td>
</tr>
<tr>
<td>After</td>
<td>0.0137** 0.0141**</td>
<td>0.0188**</td>
<td>0.0182**</td>
</tr>
<tr>
<td></td>
<td>(0.0059) (0.0061)</td>
<td>(0.0087)</td>
<td>(0.0093)</td>
</tr>
<tr>
<td>Lambda</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table VI
Investment Around Repurchases: Comparing Subgroups

This table reports estimated coefficients from investment regressions of the form

\[
\frac{I_{it}}{A_{it-1}} = \beta_0 + \beta_1 Q_{it-1} + \beta_2 Q_{it-1} \times \text{After} + \beta_3 \text{After} + \beta_4 \frac{\text{Cash Flow}_{it}}{A_{it-1}} + \sum \gamma_t Year_t + \epsilon_{it},
\]

where \(X_{it}\) is a vector of selected control variables. Firm fixed effects are captured in the firm-specific intercept terms \(\beta_{oi}\). t-statistics based on robust standard errors are reported in parentheses. The dependent variable is investment scaled by total assets, where investment includes capital expenditures, acquisitions and R&D expenses. \(\text{After}\) is a dummy variable set equal to zero for years -2 and -1 relative to the repurchase, and set equal to one for years +1 and +2. The overall sample is split into groups by overhang, leverage, bond ratings, growth opportunities, debt maturity, and method of repurchase.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment</strong></td>
<td><strong>Industry Q</strong></td>
</tr>
<tr>
<td><strong>SUBSAMPLE CRITERIA</strong></td>
<td></td>
</tr>
<tr>
<td>1. OVERHANG</td>
<td></td>
</tr>
<tr>
<td>High Overhang</td>
<td>0.0110***</td>
</tr>
<tr>
<td></td>
<td>(0.0031)</td>
</tr>
<tr>
<td>Low Overhang</td>
<td>0.0189***</td>
</tr>
<tr>
<td></td>
<td>(0.0073)</td>
</tr>
<tr>
<td>2. LEVERAGE</td>
<td></td>
</tr>
<tr>
<td>High Leverage</td>
<td>0.0096***</td>
</tr>
<tr>
<td></td>
<td>(0.0021)</td>
</tr>
<tr>
<td>Low Leverage</td>
<td>0.0129***</td>
</tr>
<tr>
<td></td>
<td>(0.0030)</td>
</tr>
<tr>
<td>3. BOND RATINGS</td>
<td></td>
</tr>
<tr>
<td>BB and Below</td>
<td>0.0107***</td>
</tr>
<tr>
<td></td>
<td>(0.0034)</td>
</tr>
<tr>
<td>BBB and Above</td>
<td>0.0165***</td>
</tr>
<tr>
<td></td>
<td>(0.0051)</td>
</tr>
<tr>
<td>4. GROWTH OPPORTUNITIES</td>
<td></td>
</tr>
<tr>
<td>High Q</td>
<td>0.0101***</td>
</tr>
<tr>
<td></td>
<td>(0.0025)</td>
</tr>
<tr>
<td>Low Q</td>
<td>0.0303***</td>
</tr>
<tr>
<td></td>
<td>(0.0108)</td>
</tr>
<tr>
<td>5. DEBT MATURITY</td>
<td></td>
</tr>
<tr>
<td>‘Long’ Maturity</td>
<td>0.0103***</td>
</tr>
<tr>
<td></td>
<td>(0.0042)</td>
</tr>
<tr>
<td>‘Short’ Maturity</td>
<td>0.0164***</td>
</tr>
<tr>
<td></td>
<td>(0.0047)</td>
</tr>
<tr>
<td>6. REPURCHASE METHOD</td>
<td></td>
</tr>
<tr>
<td>Open Market</td>
<td>0.0093***</td>
</tr>
<tr>
<td></td>
<td>(0.0023)</td>
</tr>
<tr>
<td>Tender Offer</td>
<td>0.0176**</td>
</tr>
<tr>
<td></td>
<td>(0.0083)</td>
</tr>
</tbody>
</table>

Note: ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.
Table VII
Propensity Score Matching: Treatment versus Control Firms

This table presents average treatment effects based on propensity scores and investment regressions for the sample of control firms. Panel A reports average treatment effects and difference-in-differences estimates for investment levels, investment quality, and equity issuance. Investment quality is measured as the sensitivity of investment to proxies for growth opportunities. For example, the sensitivity of investment to industry $Q$ is measured by taking the cross-sectional average of the statistic:

$$Q \text{ Sensitivity}_i = \frac{(I_i - \bar{I})(Q_i - \bar{Q})}{\frac{1}{N} \sum_{i=1}^{N} (Q_i - \bar{Q})^2}$$

The cross-sectional average of this statistic is the same as the slope coefficient from a simple regression of investment on industry $Q$. Industry investment sensitivity is calculated in a similar fashion. Panel B reports the difference in regression coefficients between the treatment and control groups for the following regression:

$$\frac{I_{it}}{A_{i,t-1}} = \beta_0 + \beta_1 Q_{i,t-1} + \beta_2 Q_{i,t-1} \times \text{After} + \beta_3 \text{After} + \beta_4 \frac{\text{Cashflow}_{it}}{A_{i,t-1}} + \sum \gamma_r \text{Year}_r + e_{it},$$

where all variables are as previously defined. The regression equation is estimated for both treatment and control firms. The table includes the point estimates of the differences in estimated regression coefficients and includes the standard errors for the difference in estimated coefficients.

<table>
<thead>
<tr>
<th>Panel A: Treatment Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Investment $+1$</td>
</tr>
<tr>
<td>Difference-in-Differences ${-1, +1}$</td>
</tr>
<tr>
<td>Q Sensitivity $+1$</td>
</tr>
<tr>
<td>Difference-in-Differences ${-1, +1}$</td>
</tr>
<tr>
<td>Industry Investment Sensitivity $+1$</td>
</tr>
<tr>
<td>Difference-in-Differences ${-1, +1}$</td>
</tr>
<tr>
<td>Equity Issuance $+1$</td>
</tr>
<tr>
<td>Difference-in-Differences ${-1, +1}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Differences in Regression Coefficients $(\beta_{Tj} - \beta_{Cj})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y$</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Firm Average Q</td>
</tr>
<tr>
<td>(0.0042)</td>
</tr>
<tr>
<td>Industry Q</td>
</tr>
<tr>
<td>(0.0062)</td>
</tr>
<tr>
<td>Industry Investment</td>
</tr>
<tr>
<td>(0.0471)</td>
</tr>
</tbody>
</table>

Note: ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.
Table VIII
Decomposing Investment Expenditures

This table reports estimated coefficients from investment regressions of the form

\[
\frac{\text{Investment}_{it}}{A_{t-1}} = \beta_0 + \beta_1 Q_{i,t-1} + \beta_2 Q_{i,t-1} \times \text{After} + \beta_3 \text{After} + \beta_4 \frac{\text{Cash Flow}_{it}}{A_{t-1}} + \sum \gamma_{\text{Year}_t} + \epsilon_{it},
\]

where all variables are as previously defined. Investment expenditures on the left-hand side of the above regression are decomposed as follows. Total investment is

\[
I_{\text{total,}it} = \text{CAPEX}_{it} + \text{Acquisitions}_{it} + \text{R&D}_{it} - \text{SalePPE}_{it}.
\]

Total investment expenditures are split into (i) required investment to maintain assets in place, \(I_{\text{maintenance,}it}\), is measured by amortization and depreciation; and (ii) investments in new projects, \(I_{\text{new,}it}\), which is defined as the difference between total investment and maintenance investment expenditures.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment</strong></td>
<td><em>Q</em></td>
</tr>
<tr>
<td><strong>INVESTMENT EXPENDITURE TYPE</strong></td>
<td></td>
</tr>
<tr>
<td>1. TOTAL INVESTMENT</td>
<td></td>
</tr>
<tr>
<td>Firm Q</td>
<td>0.0116***</td>
</tr>
<tr>
<td></td>
<td>(0.0014)</td>
</tr>
<tr>
<td>Industry Q</td>
<td>0.0175***</td>
</tr>
<tr>
<td></td>
<td>(0.0050)</td>
</tr>
<tr>
<td>Industry Investment</td>
<td>0.6786***</td>
</tr>
<tr>
<td></td>
<td>(0.0509)</td>
</tr>
<tr>
<td>2. MAINTENANCE INVESTMENT</td>
<td></td>
</tr>
<tr>
<td>Firm Q</td>
<td>-0.0008</td>
</tr>
<tr>
<td></td>
<td>(0.0005)</td>
</tr>
<tr>
<td>Industry Q</td>
<td>-0.0038*</td>
</tr>
<tr>
<td></td>
<td>(0.0022)</td>
</tr>
<tr>
<td>Industry Investment</td>
<td>-0.0193</td>
</tr>
<tr>
<td></td>
<td>(0.0228)</td>
</tr>
<tr>
<td>3. NEW INVESTMENT</td>
<td></td>
</tr>
<tr>
<td>Firm Q</td>
<td>0.0108**</td>
</tr>
<tr>
<td></td>
<td>(0.0041)</td>
</tr>
<tr>
<td>Industry Q</td>
<td>0.0119**</td>
</tr>
<tr>
<td></td>
<td>(0.0040)</td>
</tr>
<tr>
<td>Industry Investment</td>
<td>0.5141***</td>
</tr>
<tr>
<td></td>
<td>(0.0318)</td>
</tr>
</tbody>
</table>

Note: ***, ** and * denote significance at the 1, 5 and 10 percent levels, respectively.
Figure 1. Investment/Repurchase Model Timeline

$t = 0$

Debt Contract is designed and issued with a face value of $D$. Assets are installed with $E_0(CF_{AIP}) \geq D$.

$t = 1$

Information arrives about shock to cash flows from assets in place: $E_1(CF_{AIP}) + C < D$.

Investment opportunity available at cost of $I$.

Investment/repurchase decision made.

$t = 2$

Uncertainty resolved: Investment pays $(X_H, X_L)$; Firm liquidated.
**Figure 2. Debt Overhang and the Investment Opportunity Set**

This figure demonstrates the basic idea behind debt overhang. The concave line represents the firm’s investment opportunity set. The horizontal axis measures investment level, and the vertical axis measures the expected return for a given level of investment. \( r(D^*) \) is the required return to equity in the absence of overhang, \( r(D') \) is the required return to equity when the firm has a debt overhang problem. The shaded area represents the deadweight loss due to the inefficient investment choice.
Figure 3. Overhang and Debt Repurchases: Numerical Example

This figure demonstrates debt overhang and the effect of a debt repurchase on investment. At $t = 0$, the firm has debt outstanding with a face value of $D = 100$ and assets in place which are expected to generate cash flows at $t = 2$ of $E_0(CF_{AIP}) \geq 100$. The firm also has liquid assets in the form of cash with $C = 20$. Just prior to $t = 1$, the firm receives information about a shock to cash flows from assets to place such that $E_1(CF_{AIP}) = 60$. At $t = 1$, the firm obtains an option to invest at a cost of $I = 36$ which pays $X_H = 90$ in the good state of the world and $X_L = 10$ in the bad state. The probability of the good state occurring is $p_H = 0.5$. The firm makes the repurchase/investment choice at $t = 1$, and the firm is liquidated at $t = 2$ after the state of the world is revealed.

<table>
<thead>
<tr>
<th>t = 1</th>
<th>t = 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cash Flows {H, L}</strong></td>
<td><strong>Debt Outstanding</strong></td>
</tr>
<tr>
<td>$(150, 70)$</td>
<td>$76.47$</td>
</tr>
<tr>
<td>Invest?</td>
<td></td>
</tr>
<tr>
<td>$n \searrow$</td>
<td></td>
</tr>
<tr>
<td>$(60, 60)$</td>
<td>$76.47$</td>
</tr>
<tr>
<td><strong>Repurchase?</strong></td>
<td></td>
</tr>
<tr>
<td>$y \nearrow$</td>
<td></td>
</tr>
<tr>
<td>$(170, 90)$</td>
<td>$100$</td>
</tr>
<tr>
<td>Invest?</td>
<td></td>
</tr>
<tr>
<td>$n \searrow$</td>
<td></td>
</tr>
<tr>
<td>$(80, 80)$</td>
<td>$100$</td>
</tr>
</tbody>
</table>

$V_D = 0.91$

$V_B = 0.85$
Figure 4. Credit Ratings Around Repurchases

This figure displays the average credit ratings for 24 months prior to and after the debt repurchase. Ratings changes are obtained from the Mergent Fixed Income Securities Database. Credit ratings are assigned an integer value starting with Aaa ratings given a value of 1 and increasing with lower credit ratings. For example, a bond with a Ba rating has a numeric rating of 8.
**Figure 5. Sensitivity of Investment to Growth Opportunities**

This figure displays the sensitivity of investment to growth opportunities in event time, where the sensitivity of investment is the estimated coefficient $\hat{\beta}_1$ from the regression

$$\frac{I_i}{K_{i,j-1}} = \beta_0 + \beta_1 Q_i + \beta_2 \frac{Cashflow_i}{K_{i,j-1}} + \epsilon_i.$$

This regression is estimated by pooling firms into 8 different cross sections corresponding to $t = -4, -3, -2, -1, 0, 1, 2, 3$, where $t = 0$ corresponds to year of the debt repurchase. Upper and lower confidence bounds are given by the dotted lines.
Figure 6. Sensitivity of Equity Issuance to Investment Opportunities in Event Time

This figure displays the sensitivity of equity issuance to growth opportunities in event time, where the sensitivity of equity issuance is the estimated coefficient $\hat{\beta}_1$ from the regression

$$\text{Net Equity Issuance}_i = \beta_0 + \beta_1 Q_i + \beta_2 \frac{Cashflow_i}{K_{i,t-1}} + \epsilon_i.$$ 

This regression is estimated by pooling firms into 8 different cross sections corresponding to $t = -4, -3, -2, -1, 0, 1, 2, 3$, where $t = 0$ corresponds to year of the debt repurchase. Upper and lower confidence bounds are given by the dotted lines.