WHEN DOES THE MARKET MATTER? STOCK PRICES AND THE INVESTMENT OF EQUITY-DEPENDENT FIRMS*

MALCOLM BAKER
JEREMY C. STEIN
JEFFREY WURGLER

We use a simple model to outline the conditions under which corporate investment is sensitive to nonfundamental movements in stock prices. The key prediction is that stock prices have a stronger impact on the investment of "equity-dependent" firms—firms that need external equity to finance marginal investments. Using an index of equity dependence based on the work of Kaplan and Zingales, we find support for this hypothesis. In particular, firms that rank in the top quintile of the KZ index have investment that is almost three times as sensitive to stock prices as firms in the bottom quintile.

I. INTRODUCTION

Corporate investment and the stock market are positively correlated, in both the time series and the cross section. The traditional explanation for this relationship is that stock prices reflect the marginal product of capital. This is the interpretation given to the relationship between investment and Tobin's Q, for example, as in Tobin [1969] and von Furstenberg [1977].

Keynes [1936] suggests a very different explanation. He argues that stock prices contain an important element of irrationality. As a result, the effective cost of external equity sometimes diverges from the cost of other forms of capital. This affects the pattern of equity issues and in turn corporate investment. This "equity financing channel" has been further developed by Bosworth [1975], Fischer and Merton [1984], Morck, Shleifer, and Vishny [1990], Blanchard, Rhee, and Summers [1993], and Stein [1996].

It has proved difficult to determine the relative merits of these explanations. This is partly because the equity financing channel has not been articulated in a form that can be sharply distinguished

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from the traditional view. Tests have had to focus on indirect implications of the two views, or else have had to impose structural assumptions on the data. For example, researchers taking the former approach have examined whether the stock market forecasts investment over and above other measures of the marginal product of capital, such as profitability or cash flow. If it does not, they argue, then the stock market is probably connected to investment only insofar as it reflects fundamentals.

This empirical strategy has yielded mixed results. Barro [1990, p. 130] attributes an important independent role to the stock market: "Even in the presence of cash flow variables, such as contemporaneous and lagged values of after-tax corporate profits, the stock market variable retains significant predictive power for investment." In contrast, Morck, Shleifer, and Vishny [1990, p. 199] conclude from their analysis of firm-level data that "the market may not be a complete sideshow, but nor is it very central," and Blanchard, Rhee, and Summers [1993, p. 132] summarize their study of the aggregate data by stating that "market valuation appears to play a limited role, given fundamentals, in the determination of investment decisions."

Another empirical strategy is to try to measure inefficiency directly as the difference between market prices and a structural model of efficient prices, and then test whether investment is sensitive to this measure of inefficiency. In a study of aggregate Japanese data, Chirinko and Schaller [2001] find evidence for an equity financing channel using this approach. As they point out, however, their conclusions depend on several structural assumptions.

In this paper we take a new approach. We return to the theory to derive several cross-sectional predictions that are unique to a specific equity financing channel. In particular, the model in Stein [1996] implies that those firms that are in need of external equity finance will have investment that is especially sensitive to the nonfundamental component of stock prices. Intuitively, a firm with no debt and a stockpile of cash can insulate its investment decisions from irrational gyrations in its stock price. But an "equity-dependent" firm that needs equity to fund its marginal investments will be less likely to proceed if it has to issue undervalued shares.[1]

1. A recent working paper by Polk and Sapienza [2002] also explores the link between stock-market inefficiency and corporate investment. However, their model assumes that all firms are financially unconstrained, and so they focus on a different set of empirical implications.

We test several implications of this financing channel. To get started, we need a proxy for the concept of equity dependence. This concept requires some financing friction, or combination of frictions, which makes certain firms more reliant on outside equity at the margin. Standard corporate-finance considerations suggest that equity-dependent firms will tend to be young, and to have high leverage, low cash balances, and cash flows, high cash-flow volatility (and hence low incremental debt capacity), and strong investment opportunities.[2] One off-the-shelf measure which satisfies most of these criteria is an index based on the work of Kaplan and Zingales [1997]. This "KZ index" has already been adapted for use in large-sample empirical work by Lamont, Polk, and Saa-Requejo [2001], so we can follow their methodology. By taking this approach, as opposed to building our own measure of equity dependence from scratch, we hope to minimize any concerns about data mining.

Next, we rank firms according to this proxy for equity dependence, and test in a variety of ways whether those that are classified as most likely to be equity dependent have the strongest correlation between stock prices (as measured by Q) and subsequent investment. We find strong support for this prediction. In our baseline specification, firms that rank in the top quintile of the sample in terms of the KZ index have a sensitivity of investment to Q that is almost three times as large as firms that rank in the bottom quintile.[3] In fact, in some specifications the investment of equity-dependent firms is more sensitive to Q than to cash flow. This is noteworthy because it is generally believed that the cash-flow effect dominates the Q effect in investment equations.

While the heightened Q-sensitivity of equity-dependent firms is consistent with the equity financing channel in our model, it also admits other interpretations. The ambiguity arises because the theory predicts that the investment of equity-depen-

2. Morck, Shleifer, and Vishny [1990] look for a financing channel using firm size as their only proxy for equity dependence. They argue that the "hypothesis predicts that the influence of the stock market should be particularly great for smaller firms, which rely to a greater extent on external financing" [p. 182]. However, they find little evidence that the investment of smaller firms is especially sensitive to stock prices, and conclude that there is no support for the hypothesis. As we show, the use of a more fully developed measure of equity dependence leads to quite different conclusions.

3. The result that investment is more sensitive to Q for high-KZ firms actually shows up in the small Kaplan and Zingales [1997] sample. However, their focus is on a different question—how investment-cash flow sensitivities vary with financial constraints—and they never discuss or interpret this particular finding.

dent firms should be more sensitive to the *nonfundamental* component of stock prices. But Q contains more than just this nonfundamental component. It also embodies information about future profitability—and hence about the quality of investment opportunities—as well as measurement error arising from accounting discrepancies between book capital and economic replacement costs. As we describe in detail below (see subsection II.D), one can tell stories in which these other components of Q covary with our measure of equity dependence in such a way as to induce the patterns we find in the investment-Q regressions.

Ideally, in order to provide a more focused test of the theory that gets around these problems, we would like to isolate the nonfundamental component of stock prices, and verify that the investment of equity-dependent firms responds more sensitively to this component. This is a difficult task, but we try to tackle it by using future realized stock returns—specifically, returns over the three years subsequent to the year in which we measure investment. The idea is that future realized returns are a noisy estimate of the future returns expected by managers, which in turn include their views about over- or undervaluation. As a result, in the same way that the investment-Q sensitivity is predicted to be positive on average and increasing in equity dependence, the investment-future returns sensitivity should be negative on average and increasingly negative in equity dependence. We confirm this prediction.

Finally, we also look briefly at financing patterns. The model implies that equity-dependent firms should have a pronounced correlation between the nonfundamental component of stock prices and the volume of new equity issues. We find support for this hypothesis as well: firms with high values of the KZ index also have equity issuance that responds positively to Q and negatively to future returns.

Overall, our results offer support for a specific equity financing channel in corporate investment. They also complement other evidence that the cost of external equity has an important, independent effect on corporate financing and investment decisions. For example, Ritter [1991], Ikenberry, Lakonishok, and Vermaelen [1995], Loughran and Ritter [1995], Speiss and Affleck-Graves [1995], and Baker and Wurgler [2000] find evidence that equity financing patterns depend on the cost of equity, and Baker and Wurgler [2002] use these results to motivate an alternative view of capital structure. Shleifer and Vishny [forthcoming] argue that the cost of equity is a strong determinant of merger activity, explaining the form of financing in mergers as well as merger waves themselves. Whereas the capital structure findings could be viewed as financial phenomena without significant real effects, however, our results suggest a specific mechanism through which market inefficiency may affect the real economy.

The remainder of the paper is organized as follows. In Section II we develop several testable hypotheses in the context of a simple model. The model gives some guidance as to how to measure equity dependence in practice, and also provides a framework for thinking about competing explanations. In Section III we describe the data, and in Section IV we present the empirical results. Section V concludes.

II. Hypothesis Development

II.A. A Simple Model

We use a simplified version of the model in Stein [1996] to develop several testable hypotheses about equity dependence and investment. There is a firm that can invest K at time 0, which yields a gross return of $f(K)$ at time 1, where $f(\cdot)$ is an increasing, concave function. The efficient-market discount rate is r, so the net present value of this investment is $f(K)/(1 + r) - K$. The first-best level of investment K^{fb} is therefore given by $f'(K^{fb})/(1 + r) = 1$.

The firm also has financing considerations. Its equity may be mispriced by a percentage δ relative to the efficient-market value, either overpriced ($\delta > 0$) or underpriced ($\delta < 0$), while its debt is fairly priced.[4] The firm can issue equity e subject to the constraints that $0 \leq e \leq e^{\max}$. In other words, it cannot repurchase equity, and there is an upper bound on how much it can issue. Financing and investment are linked by a leverage constraint, $e + W - K(1 - \bar{D}) \geq 0$, where W is the firm's preexisting wealth (such as cash on hand, or untapped debt capacity) and $\bar{D}$ is the

4. One interpretation, suggested by a referee, is that the debt and equity markets are segmented, and have expected-return premiums that vary independently. This would also fall under our definition of mispricing, as it implies that the Modigliani-Miller theorem is violated in a way that creates a motive for active market timing.

fractional debt capacity of the new assets. This constraint implies that the firm's debt ratio can fall below $\bar{D}$ but cannot exceed it.[5]

Putting all this together, the firm's optimization problem is given by

$$\max_{e,K} \frac{f(K)}{1+r} - K + \delta e, \tag{1}$$

subject to

$$e + W - K(1 - \bar{D}) \geq 0 \tag{2}$$

and

$$0 \leq e \leq e^{\max}. \tag{3}$$

Proposition 1 summarizes the solution to this problem.

PROPOSITION 1. Assume that $e^{\max} > K^{fb}(1 - \bar{D})$. Then the possible outcomes are as follows.

i) If $\delta > 0$, then $K = K^{fb}$ and $e = e^{\max}$: an overvalued firm invests at the first-best level and issues as much equity as possible.
ii) If $\delta < 0$ and $W - K^{fb}(1 - \bar{D}) \geq 0$, then $K = K^{fb}$, and $e = 0$: an undervalued firm with sufficient wealth W invests at the first-best level and avoids issuing equity.
iii) If $\delta < 0$ and $W - K^{fb}(1 - \bar{D}) < 0$, then $K < K^{fb}$: an undervalued firm with insufficient wealth underinvests. This case admits two subcases.
   a) Define K^{ec} by $f'(K^{ec})/(1 + r) = 1 - \delta(1 - \bar{D})$. If $W - K^{ec}(1 - \bar{D}) < 0$, it follows that $K = K^{ec}$ and $e = K^{ec}(1 - \bar{D}) - W > 0$: the firm issues equity, and both investment and the size of the equity issue are functions of the degree of undervaluation δ and debt capacity $\bar{D}$.
   b) If $W - K^{ec}(1 - \bar{D}) \geq 0$, then $K = W/(1 - \bar{D})$, and $e = 0$: the firm does not issue equity and invests as much as it can subject to its wealth W and the leverage constraint.

5. These constraints simplify the exposition, but can be dispensed with in a fuller model. For example, both repurchases and equity issues could be bounded endogenously by assuming that there are price-pressure effects that increase with the size of the repurchase or issue. The simple form of the leverage constraint can also be generalized by having costs of financial distress that increase continuously whenever the debt ratio exceeds $\bar{D}$. These generalizations are considered in Stein [1996].

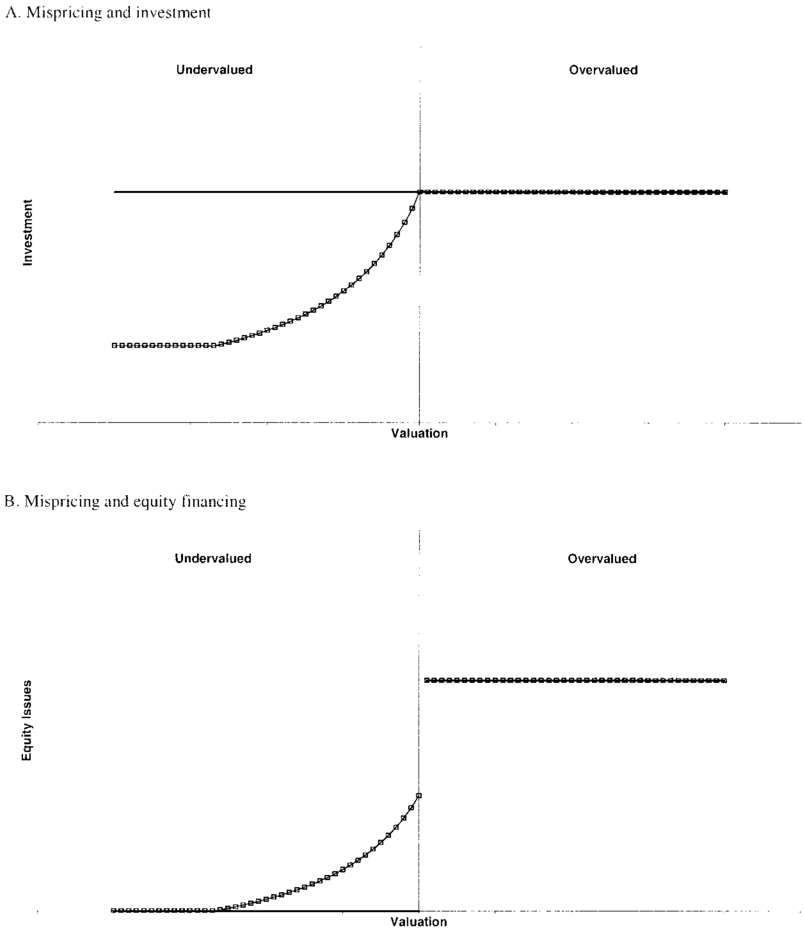

FIGURE I
Graphical Illustration of Proposition 1

The horizontal axis measures the degree of stock-price misvaluation δ. The vertical axis shows investment K (in Panel A) and equity financing e (in Panel B). The square markers show the policy of an equity-dependent firm. The solid line is the policy of a nonequity-dependent firm.

The proposition, which is illustrated in Figure I, makes it clear when investment depends on the nonfundamental component of stock prices δ. This happens only in region (iii.a), where two necessary conditions are satisfied: the stock is undervalued, and available wealth is so low that the firm would have to issue undervalued equity to invest at the first-best level.[6] We therefore define a firm as "equity dependent" if $W < K^{fb}(1 - \bar{D})$. The basic message of Proposition 1 is that for equity-dependent firms, market inefficiency can act like a financial constraint, discouraging investment when stock prices are too low.

More precisely, for firms in region (iii.a) the sensitivity of investment to δ is governed by $(1 - \bar{D})$. So for a given starting value of K, firms with less debt capacity have investment that reacts more strongly to stock prices. Intuitively, for a firm facing a binding leverage constraint, the lower is $\bar{D}$, the more equity must be issued for each marginal dollar of investment. Hence the stronger is the effect of stock prices on investment.

II.B. Testable Hypotheses

We use Proposition 1 to generate three empirical predictions. The first two are about investment behavior, and the third is about financing. We develop these predictions in the context of the model, and discuss competing interpretations afterward.

HYPOTHESIS 1. Define a firm as equity dependent if $W < K^{fb}(1 - \bar{D})$. Equity-dependent firms display a more positive sensitivity of investment to Q than do nonequity-dependent firms.

In Hypothesis 1, Q is taken to be an empirical proxy for δ, the nonfundamental component of the stock price. Hypothesis 1 is therefore a joint hypothesis about the sources of variation in measured Q and the validity of the equity dependence mechanism. Note also that Hypothesis 1 does not condition on whether firms are over- or undervalued. It averages over the overvaluation region (i), where equity dependence does not matter, and the undervaluation region (iii.a), where it does. (Graphically, the hypothesis averages over both sides of Figure I.) This is an appealing feature of our empirical approach, because we do not have

6. The conclusion that investment is sensitive to stock prices only when $\delta < 0$ is a result of the one-sided nature of the leverage constraint. One could also impose the constraint that an equity issue not cause leverage to fall *below* some critical value, in which case investment may vary with stock prices even when $\delta > 0$. The model of Shleifer and Vishny [forthcoming] implicitly embodies such a feature—they assume that overvalued firms wishing to issue equity cannot simply park the proceeds in T-bills, and must do something concrete, like acquiring another firm, to justify the issue. Hence overvaluation leads to more investment in the form of mergers.

to take a stand on whether a given firm is over- or undervalued in absolute terms in order to test the model.[7]

Our second hypothesis uses future stock returns, instead of current Q, as a proxy for the nonfundamental component δ in stock prices. The intuition is that overpriced stocks have lower expected returns going forward, as mispricing is corrected, while undervalued stocks have higher expected returns. This leads to the following somewhat sharper prediction.

HYPOTHESIS 2. Equity-dependent firms display a more negative sensitivity of investment to future stock returns than do nonequity-dependent firms.

If we were to look on average across all types of firms, there are a couple of reasons to expect the sensitivity of investment to future returns to be negative. Such a relationship might reflect either rational variation in the cost of capital, or the sort of mispricing assumed in our model. Thus, if we want to generate more specific support for the model, we need to focus on the cross-sectional prediction associated with equity dependence.

The main impediment to testing Hypothesis 2 is that realized returns are likely to be a very noisy proxy for expected returns, and hence for mispricing. For this reason, and because our main goal is to understand the relationship between investment and Q, we focus much of our attention on Hypothesis 1. As we discuss below, however, Hypothesis 2 is particularly useful in ruling out alternative explanations for our findings with respect to Hypothesis 1.

Note that both hypotheses involve comparisons between firms that are equity dependent and those that are not—that is, comparisons *across* the regions in Proposition 1. We can also ask what happens *within* region (iii.a) as firms become "more" equity dependent; i.e., as W falls farther and farther below $K^{fb}(1 - \bar{D})$. It turns out that a globally monotonic relationship between the degree of equity dependence and the sensitivity of investment to stock prices only obtains if we put certain restrictions on the form

7. In our earlier NBER working paper [Baker, Stein, and Wurgler 2002] we provide evidence consistent with the more precise prediction that investment is most sensitive to stock prices for *undervalued* equity-dependent firms. We use the level of Q as a proxy for over- or undervaluation, and find that Hypothesis 1 holds more strongly for low-Q than for high-Q firms as predicted. However, this result could also reflect the fact that there is more measurement error in Q for high-Q firms, a possibility that is hard to refute. Because of this ambiguity, we focus here on predictions that do not require us to identify the absolute level of mispricing.

of the production function.[8] (This situation is reminiscent of the discussion by Kaplan and Zingales [1997, 2000] and Fazzari, Hubbard, and Petersen [2000].) Nevertheless, the theory is testable as long as we can plausibly identify some firms that are not dependent on equity at all, because the theory unambiguously predicts that the sensitivity of investment to stock prices will rise over at least this first part of the range of measured equity dependence. Whether the sensitivity continues to increase over the whole range is an empirical question, however, and not one for which the theory leaves us with strong priors.

Finally, our model also makes predictions about financing behavior, although they are not as crisp as those for investment. The reason is apparent from Figure I. As the mispricing δ goes from very negative levels (extreme undervaluation) to positive ones (overvaluation), both types of firms see their equity issuance e go from 0 to $e^{\max}$. Thus, averaging over the entire range of δ's, both types of firms have equity issuance that is equally responsive to mispricing.[9] Consequently, the strongest unconditional statement for financing patterns is the following.

HYPOTHESIS 3. Equity-dependent firms have equity issuance that is positively related to Q and negatively related to future stock returns.

Hypothesis 3 does not have the same cross-sectional content as the first two hypotheses. It is a prediction of the model, but it should not carry too much inferential weight on its own. Rather, it should be viewed as a complement to the evidence that we develop for investment.[10]

8. Define the "degree" of equity dependence as $\Phi = K^{fb}(1 - \bar{D}) - W$, and the percentage sensitivity of investment to stock prices as $S = 1/K \cdot dK/d\delta$. (This measure of the sensitivity matches our empirical implementation, where we scale investment by existing assets.) It is straightforward to show that a sufficient condition for $dS/d\Phi$ to be positive in region (iii.a)—and hence for the sensitivity S to become ever greater as W declines relative to $K^{fb}(1 - \bar{D})$—is that $Kf'''(K) + f''(K) < 0$. Among the functions that satisfy this condition are the quadratic, and anything of the form $f(K) = K/(K + A)$, where $A > 2K$. Note also that in our setup, S depends on Φ within region (iii.a) only through D and not through W, since dK/dW is zero in this region. Nevertheless, the sufficient condition applies even in a modified version of the model where $dK/dW > 0$ in the region of interest.

9. Figure I shows that a sharper prediction emerges if we condition on undervaluation. Given undervaluation, the equity issuance of equity-dependent firms is especially sensitive to the nonfundamental component of stock prices. Using the level of Q to proxy for over- and undervaluation, our NBER working paper finds some support for this prediction (see also footnote 7).

10. In fact, we should not be surprised if Hypothesis 3 holds, because a large literature (cited in the Introduction) has already documented that, on average,

II.C. Competing Explanations

As discussed in the Introduction, differences in the sensitivity of investment to Q can arise for reasons other than those emphasized in the model. Broadly speaking, ambiguities arise because Q potentially contains three sources of variation: (i) mispricing; (ii) information about the profitability of investment; and (iii) measurement error. Our theory is about the first of these components, so the other two can create problems for our inferences. Here we discuss these problems in more detail, and describe how they might be addressed in our auxiliary tests.

It is possible that equity-dependent firms could have a greater sensitivity of investment to Q even in an efficient market where all variation in Q comes from variation in the profitability of investment. Perhaps most notably, the investment of equity-dependent firms may be constrained by adverse-selection problems in the market for new issues [Myers and Majluf 1984]. Several authors have suggested that these problems are worse when firms have weak investment prospects [Lucas and McDonald 1990; Choe, Masulis, and Nanda 1993; Bayless and Chaplinsky 1996]. If so, equity-dependent firms could have investment that is more sensitive to Q simply because a lower value of Q indicates more adverse selection in the new-issues market.

This explanation can be addressed with our tests of Hypothesis 2, which focus on the link between investment and future stock returns. Given that the adverse-selection models are set in an efficient market, they do not share our prediction that the sensitivity of investment to future returns will be stronger for equity-dependent firms.[11]

Another competing explanation is that different firms have different technologies, which imply inherently different sensitivities of investment to future profitability.[12] For example, if investment is concave in Q and equity-dependent firms tend to have low Q values, then we would also observe equity-dependent firms having a higher sensitivity of investment to Q. A straightforward

equity issuance is positively correlated with Q and negatively correlated with future returns. The hypothesis simply adds that these patterns should hold for equity-dependent firms in particular.

11. In a similar vein, the tests involving future returns can help to separate our theory from one in which the market is in fact efficient, but managers believe that it is not, and mistakenly associate high stock prices with overvaluation. See Jenter [2001] for a discussion of the overlap between these two stories.

12. We thank Nick Barberis for suggesting this possibility.

way to address this possibility is to control directly for nonlinearities in the investment-Q sensitivity, by including Q^2 in the investment equation. We can then ask whether our equity dependence measure still has a residual connection to this sensitivity. Our tests of Hypothesis 2 are also helpful in discriminating against production-function explanations, since like the adverse-selection stories, they have no implications for future returns.

The effects predicted in Hypothesis 1 might also show up if measurement error in Q were more pronounced for firms that are less equity dependent. However, it is important to note that such a pattern in measurement error is precisely the *reverse* of that which has for many years been discussed in the literature on liquidity constraints. For example, in his discussion of Fazzari, Hubbard, and Petersen [1988], Poterba [1988] points out that their results "could be explained on this view because Q is measured with more error for smaller firms, which tend to be lower-dividend firms" [p. 202]. Erickson and Whited [2000] and Alti [2003] further develop this point; the latter builds a formal model to show why measurement error in Q is likely to be greater for young, faster-growing, low-dividend firms. Clearly, if these arguments are correct, our approach stands on safe ground. The KZ index scores low-dividend, high-growth firms as more likely to be equity dependent. If these attributes are associated with more measurement error in Q, our tests of Hypothesis 1 will be biased toward being excessively conservative.

Nevertheless, it is possible to concoct measurement-error stories that go in the opposite direction. We address such stories in two ways. The first is to "unpack" the KZ index. The definition of equity dependence leads to specific predictions for how *each* of the components of the KZ index should affect the sensitivity of investment to stock prices. If these predictions hold up, advocates of the measurement-error explanation would need to explain why measurement error in Q should be positively correlated with certain of the KZ components and negatively correlated with certain others. Our further tests that look at how the sensitivity of investment to stock prices varies with firm age and debt capacity can be thought of in a similar spirit.

The tests of Hypothesis 2 also address this critique. Measurement error in Q is typically thought to arise from an inability to accurately measure the replacement cost of capital. In our context, the concern is that nonequity-dependent firms do more intangible investment, which leads to more measurement error and hence a bias in the sensitivity toward zero. Replacing Q with future returns in the investment equations eliminates this type of measurement error.

III. Data

We study a large, unbalanced panel of Compustat firms that covers 1980 through 1999. The panel excludes financial firms (i.e., firms with a one-digit SIC of six), and firm-years with a book value under \$10 million, but otherwise it includes all observations with data on investment, financing, equity dependence, and other investment determinants, as described below. The full sample includes 52,101 observations, for an average of 2,605 observations per year.

III.A. Investment

We consider four measures of investment. Our baseline measure is $CAPX_{it}/A_{it-1}$, the ratio of capital expenditures in year t (Compustat Annual Item 128) to start-of-year book assets (Item 6).[13] In addition, we look at $(CAPX_{it} + RD_{it})/A_{it-1}$, which includes research and development expenses (Item 46), and at $(CAPX_{it} + RD_{it} + SGA_{it})/A_{it-1}$, which further includes selling, general, and administrative expenses (Item 189). Finally, we also examine the percentage change in book assets over the year, $\Delta A_{it}/A_{it-1}$. To reduce the influence of outliers, we Winsorize each of these variables at the first and ninety-ninth percentile; i.e., we set all observations beyond these tolerances to the first and ninety-ninth percentile values, respectively.[14] Panel A of Table I presents summary statistics for these variables.

13. We scale our measures of investment and cash flow by book assets. This contrasts with some of the literature (e.g., Fazzari, Hubbard, and Petersen [1988] and Kaplan and Zingales [1997]), where the denominator is net plant, property, and equipment (PP&E). Our approach matches our sample, which includes smaller and nonmanufacturing firms with modest fixed assets, and our alternative measures of investment, which include intangible assets. Nevertheless, we show in our robustness tests that scaling by PP&E leads to very similar results.

14. We have conducted a variety of tests to determine whether our particular treatment of outliers makes any difference. As it turns out, all that matters is that we do something to tamp down the most extreme realizations of Q, which in the raw data attains a maximum value of 52.5. An alternative to Winsorizing is to replace the book value of equity in Q with 0.9 times the book value plus 0.1 times the market value, thereby bounding the transformed value of Q below 10. This procedure gives virtually identical results to those we report. We thank Tuomo Vuolteenaho for suggesting this procedure.

TABLE I
SUMMARY STATISTICS FOR INVESTMENT AND FINANCING VARIABLES

	Full sample						Subsample means	
	N	Mean	SD	Median	Min	Max	1980–1989	1990–1999
				Panel A: Investment				
$CAPX_t/A_{t-1}\%$	52,101	8.23	7.85	6.00	0.18	45.22	8.81	7.79
$+RD_t/A_{t-1}$	52,101	11.41	10.46	8.45	0.24	58.43	10.96	11.76
$+RD_t$ $+ SGA_t/A_{t-1}$	52,101	40.09	28.93	34.21	1.65	144.04	39.23	40.76
$\Delta A_t/A_{t-1}\%$	52,101	11.10	28.03	6.41	−43.76	153.73	10.30	11.73
				Panel B: Financing				
$e_t/A_{t-1}\%$	52,101	4.38	14.48	0.64	−15.90	92.28	3.00	5.44
$+d_t/A_{t-1}$	52,101	10.51	27.32	4.03	−33.70	161.59	8.48	12.08

Source: Compustat, 1980–1999.

a. Investment is alternately defined as capital expenditures (Item 128) over assets (Item 6); capital expenditures plus research and development expenses (Item 46) over assets; capital expenditures plus research and development expenses plus selling, general, and administrative expenses (Item 189) over assets; and growth in assets.

b. Financing is alternately defined as equity issues (ΔItem 60 + ΔItem 74 − ΔItem 36) (i.e., the change in book equity minus the change in retained earnings) over assets, and equity issues plus debt issues (ΔItem 6 − ΔItem 60 − ΔItem 74) over assets.

c. All variables are Winsorized at the first and ninety-ninth percentiles.

III.B. Financing

We consider two measures of external financing activity. For equity issuance we use e_{it}/A_{it-1}, the ratio of external equity issues to start-of-year book assets. External equity issues are constructed as the change in book equity minus the change in retained earnings (ΔItem 60 + ΔItem 74 − ΔItem 36). Total external finance is measured as $(e_{it} + d_{it})/A_{it-1}$, which includes both equity and debt issues. Debt issues are constructed as the change in assets minus the change in book equity (ΔItem 6 − ΔItem 60 − ΔItem 74). These variables are also Winsorized at the first and ninety-ninth percentile.

Panel B of Table I presents summary statistics for the financing variables. The mean values are sensitive to major financing events such as acquisitions and divestitures, despite the Winsorization and the restriction on minimum book assets. The medians look more familiar, and are stable across the 1980s and 1990s (not reported).

III.C. Equity Dependence

According to our theory, a firm is more likely to be dependent on equity when W is low (which translates into low profitability, cash balances, or previously untapped debt capacity), when K^{fb} is high (growth opportunities are good), and when the incremental debt capacity of new assets $\bar{D}$ is low.[15] Therefore, a sensible empirical measure of equity dependence should probably be negatively related to operating cash flow, positively related to proxies for growth opportunities, positively related to actual leverage net of cash on hand, and negatively related to the debt capacity of assets. Firm age may also be a factor, to the extent that young firms without established reputations may have a harder time raising bond-market finance [Diamond 1991].

These observations motivate our interest in the work of Kaplan and Zingales [1997], who undertake an in-depth study of the financial constraints faced by a sample of 49 low-dividend manufacturing firms. Using both subjective and objective criteria, they rank these firms on an ordinal scale, from least to most obviously constrained. Most useful for our purposes, they then estimate an ordered logit regression which relates their qualitative ranking to five Compustat variables. This regression attaches positive weight to Q and leverage, and negative weight to operating cash flow, cash balances, and dividends. The parameters of this regression allow one to create a synthetic "KZ index" of financial constraints for a broader sample of firms, as done in Lamont, Polk, and Saa-Requejo [2001]. Following these authors, we construct the five-variable KZ index for each firm-year as the following linear combination:

$$(4)\quad KZ_{it}\text{ (five-variable)} = -1.002\,\frac{CF_{it}}{A_{it-1}} - 39.368\,\frac{DIV_{it}}{A_{it-1}} - 1.315\,\frac{C_{it}}{A_{it-1}} + 3.139 LEV_{it} + 0.283 Q_{it},$$

where CF_{it}/A_{it-1} is cash flow (Item 14 + Item 18) over lagged assets; DIV_{it}/A_{it-1} is cash dividends (Item 21 + Item 19) over assets; C_{it}/A_{it-1} is cash balances (Item 1) over assets; LEV_{it} is leverage ((Item 9 + Item 34)/(Item 9 + Item 34 + Item 216)); and Q is the market value of equity (price times shares outstanding from CRSP) plus assets minus the book value of equity (Item 60 + Item 74) all over assets. We Winsorize the ingredients of the index before constructing it.

15. These first two factors closely parallel the notion of "financial dependence" in Rajan and Zingales [1998].

One disadvantage of this index is that the model's concept of equity dependence requires a proxy for investment opportunities K^{fb} that is distinct from mispricing δ. Of the five variables in the index, both low dividends and high values of Q can be thought of as proxies for strong investment prospects. However, Q will also contain information about mispricing δ. This dual role for Q is problematic, since the model has the opposite predictions for the effects of K^{fb} and δ. In light of this ambiguity, our baseline specifications use a modified four-variable version of the KZ index that omits Q. We stress that this is for conceptual cleanness rather than because it has any real effect on the results; as we show in a robustness check, leaving Q in the index does not alter our basic results. We denote the four-variable version of the index simply by KZ_{it}:

$$(5)\quad KZ_{it} = -1.002\frac{CF_{it}}{A_{it-1}} - 39.368\frac{DIV_{it}}{A_{it-1}} - 1.315\frac{C_{it}}{A_{it-1}} + 3.139LEV_{it}.$$

Henceforth, when we refer to the "KZ index," we mean this version, unless stated otherwise.

Several other aspects of our use of the index deserve further discussion. First, we do not view the KZ index as a precise measure of equity dependence for our sample of firms, nor the coefficients in equation (5) as exactly the "right" weights for this sample. Rather, we think of Kaplan and Zingales [1997] as having nominated several variables that plausibly ought to be indicative of equity dependence, and having shown that each of these variables enters with the expected sign. Our use of the index is simply an effort to restrict ourselves to these previously nominated variables, so as to avoid data mining. The precise weights are not really the issue. As we show in a robustness test, very similar results obtain if we reset the weights so that each of the four variables explains one-fourth of the variation in the index.

Second, Kaplan and Zingales [1997] focus on a small sample of low-dividend manufacturing firms. Our sample is much broader, so one might worry about the appropriateness of applying the KZ index to it. However, in our robustness checks, we show that we get very similar results when the index is applied either to a subsample similar to that originally studied by Kaplan and Zingales—i.e., low-dividend manufacturing firms—or to its exact complement.[16]

Third, when we modify the KZ index by dropping Q, we do not adjust the coefficients on the other four variables. We have reestimated the four-variable version on the original KZ sample using the data provided in the appendix of Kaplan and Zingales [1997], and found that the coefficients on the other four variables are virtually identical whether or not Q is included in the regression. In other words, Q is approximately orthogonal to the linear combination of the other four variables implied by the index, so as a practical matter there is no need to adjust those coefficients when excluding Q.

Fourth, the index does not include every characteristic that seems likely to be associated with equity dependence. In auxiliary tests, we therefore supplement the index with two other variables. AGE_{it} is the number of years since the firm's IPO, defined as the current year minus the first year Compustat reports a nonmissing market value of equity. As noted above, this variable may serve as a proxy for reputation and access to lending markets. $Industry\ \sigma(CF/A)_i$ is the industry average standard deviation of cash flows, a proxy for industry debt capacity. In combination with the raw level of leverage in equation (5), this variable helps us to get closer to the notion of debt capacity suggested by the model, which is the firm's current leverage *relative* to its debt capacity. We calculate the standard deviation of cash flows across the subset of firm-year observations for each industry using the industry definitions in Fama and French [1997].

Panel A of Table II shows summary statistics for the KZ index, its four ingredients, and the other two equity-dependence proxies. By multiplying the coefficients in equation (5) by the standard deviation of the components, one can see that the index is especially sensitive to variation in dividends and leverage.

III.D. Other Investment Determinants

Following Fazzari, Hubbard, and Petersen [1988] and others, our baseline investment equation includes year fixed effects, firm

16. Relatedly, our baseline approach also differs from that of Kaplan and Zingales [1997] in that we scale the components of the KZ index by assets rather than by net plant, property, and equipment (Item 8). Again, this is because our sample includes small and nonmanufacturing firms. Although scaling by assets produces fewer outliers in the raw KZ index, the results are similar with either denominator, as we show in our robustness tests.

TABLE II
SUMMARY STATISTICS FOR EQUITY DEPENDENCE AND OTHER INVESTMENT DETERMINANTS

	Full sample						Subsample means	
	N	Mean	SD	Median	Min	Max	1980–1989	1990–1999
	Panel A: Equity dependence variables ($t-2$)							
KZ Index	52,101	−0.04	2.60	0.28	−18.43	3.68	−0.12	0.03
$CF_{t-2}/A_{t-3}\%$	52,101	12.57	28.75	8.97	−39.81	225.92	13.31	11.99
$DIV_{t-2}/A_{t-3}\%$	52,101	1.98	4.67	0.60	0.00	37.65	2.34	1.71
$C_{t-2}/A_{t-3}\%$	52,101	14.95	30.13	5.01	0.01	223.79	12.80	16.61
$LEV_{t-2}\%$	52,101	35.33	25.62	34.29	0.00	124.13	35.76	35.00
AGE_{t-2}	52,101	10.72	6.08	9.00	1.00	31.00	8.86	12.17
Industry $\sigma(CF/A)$	52,101	144.49	223.89	64.89	11.34	914.11	142.44	146.08
	Panel B: Other investment determinants							
Q_{t-1}	52,101	1.47	0.93	1.17	0.53	6.15	1.28	1.62
$R_{it,t+3}\%$	41,819	58.37	111.70	36.96	−92.32	565.24	54.79	62.63
$CF_t/A_{t-1}\%$	52,101	8.20	11.68	9.19	−42.43	36.52	9.25	7.39

Source: Compustat and CRSP, 1980–1999.

a. Equity dependence is defined using the Kaplan and Zingales [1997] index of financial constraints (excluding Q from the index). This modified version of the index has four components: cash flow (Item 14 + Item 18) over assets; cash dividends (Item 21 + Item 19) over assets; cash balances (Item 1) over assets; and leverage ((Item 9 + Item 34)/(Item 9 + Item 34 + Item 216)). We also consider two additional measures of equity dependence, firm age and the industry standard deviation of cash flow over assets between 1980 and 1999. Industry definitions follow Fama and French [1997]. Age is equal to the current year minus the IPO year.

b. Q is defined as the market value of equity (price times shares outstanding from CRSP) plus assets minus the book value of equity (Item 60 + Item 74) over assets. $R_{it,t+3}$ is the cumulative stock return in years $t+1$, $t+2$ and $t+3$ from CRSP.

c. All variables are Winsorized at the first and ninety-ninth percentiles except for firm age and the industry standard deviation of cash flow.

fixed effects, start-of-year Q, and contemporaneous cash flow. Q and cash flow are as defined above. Our tests of Hypothesis 2 also require future stock returns. We use the raw three-year cumulative return from CRSP, beginning at the end of the period in which investment is measured. The choice of three years is based on evidence which suggests that equity-issuance-related mispricing tends to unwind over roughly this horizon (e.g., Loughran and Ritter [1995] and Baker and Wurgler [2000]).

IV. EMPIRICAL RESULTS

IV.A. Hypothesis 1: Investment and Stock Prices

We begin with a simple test of Hypothesis 1, which predicts that the investment of equity-dependent firms is more sensitive to stock prices than that of nonequity-dependent firms. We assign

TABLE III
EQUITY DEPENDENCE AND THE LINK BETWEEN INVESTMENT AND STOCK PRICES

	Q_{t-1}				CF_t/A_{t-1}			
KZ index	N	b	(se)	[t-stat]	c	(se)	[t-stat]	R^2
Quintile 1	10,427	0.012	(0.0013)	—	0.110	(0.0146)	—	0.62
2	10,415	0.018	(0.0015)	[2.86]	0.124	(0.0133)	[0.74]	0.61
3	10,421	0.024	(0.0024)	[4.45]	0.117	(0.0140)	[0.38]	0.58
4	10,418	0.032	(0.0030)	[6.17]	0.137	(0.0130)	[1.42]	0.62
5	10,420	0.033	(0.0042)	[4.80]	0.145	(0.0134)	[1.80]	0.62

a. Regressions of investment on Q and cash flow by equity dependence quintile. We sort firms into five quintiles according to the firm median Kaplan and Zingales [1997] index of financial constraints (excluding Q from the index), performing separate regressions for each group. Year and firm fixed effects are included.
b. Investment is defined as capital expenditures over assets. Q is defined as the market value of equity plus assets minus the book value of equity over assets. Cash flow is defined as operating cash flow over assets.
c. t-statistics test the hypothesis of no difference between the coefficient in each quintile and quintile 1.
d. Standard errors and t-statistics are heteroskedasticity-robust, clustered by firm, with all five regressions estimated simultaneously.

each firm to a quintile according to its median value of KZ_{it} over the full sample period.[17] For each KZ quintile we then estimate the following investment equation:

$$\frac{CAPX_{it}}{A_{it-1}} = a_i + a_t + bQ_{it-1} + c\,\frac{CF_{it}}{A_{it-1}} + u_{it}. \tag{6}$$

Hypothesis 1 predicts that the coefficient b will generally increase as KZ increases.

Table III shows that there is indeed a strong relationship between KZ and the effect of stock prices on investment. The coefficient b rises from 0.012 in the first quintile to 0.033 in the fifth quintile. Thus, the firms that are most likely to be equity dependent according to the KZ index have a sensitivity of investment to stock prices that is almost three times as large as firms that are unlikely to be equity dependent.

This pattern in the b coefficients is our main result, but as an aside it is also interesting to look at the pattern of c coefficients in Table III. Consistent with the small-sample results of Kaplan and

17. Our results are not sensitive to the technique used to classify firm-year observations. In our robustness checks below, we experiment with two alternatives. In the first, we allow a firm's KZ quintile to vary from year to year, so, for example, if its leverage increases, it may move to a higher quintile. In the second, we assign firms to quintiles based on their median values of the index over five-year subperiods, rather than over the full sample period. Each of these alternatives lead to very similar results.

Zingales [1997], we find no discernible pattern in this coefficient across the KZ quintiles. It is almost the same in quintile 1 (0.110) as in quintile 5 (0.145), and bounces around nonmonotonically in between. This particular result, however, is sensitive to the nature of the specification. If we keep everything else the same and lag the cash-flow term one year (so that we are using CF_{it-1}/A_{it-2} instead of CF_{it}/A_{it-1}), the cash-flow coefficient c now shows a pronounced increasing pattern, going from 0.037 in quintile 1 to 0.134 in quintile 5 (not reported). The pattern of b coefficients, on the other hand, is essentially unaffected by this variation: it now goes from 0.014 to 0.034 across the five quintiles (not reported).[18]

To get a better understanding of economic magnitudes, note from Table II that the standard deviation of Q in our sample is 0.93. Thus, in the highest KZ quintile the impact of a one-standard-deviation shock to Q is to alter the ratio of capital expenditures to assets by 0.031 ($0.033 \times 0.93 = 0.031$). When compared with either the median or the standard deviation of this investment measure (0.060 and 0.079, respectively), this effect is substantial. As another benchmark, note that the standard deviation of the cash-flow-to-assets ratio is 0.12, so that in the highest KZ quintile, a one-standard-deviation shock to cash flow moves the investment ratio by 0.017 ($0.145 \times 0.12 = 0.017$). Thus, among the firms most likely to be equity dependent, stock prices have a larger effect on investment than does cash flow. This stands in contrast to the general belief that the effect of cash flow dominates that of Q in investment equations.

Turning to statistical, as opposed to economic significance, there are a couple of ways to evaluate the precision of our results. First, and most simply, we report a t-test of the difference between our quintile 1 and quintile 5 b coefficients in Table III. When we estimate these five regressions simultaneously (with residuals clustered at the firm level in an effort to deal with potential serial correlation and with heteroskedasticity-robust

18. We use the specification with a contemporaneous cash-flow term as our baseline for two reasons. First, this seems to be the convention in the literature. Second, we are interested in having the cash-flow term be as good a control as possible for fundamentals, not in making structural inferences with respect to it. This suggests that we should use the most recent cash-flow information available. In contrast, if the goal were to test whether cash flow has a causal impact on investment controlling for investment prospects, this approach might be less palatable, precisely because of contemporaneous cash flow's informativeness about future profitability.

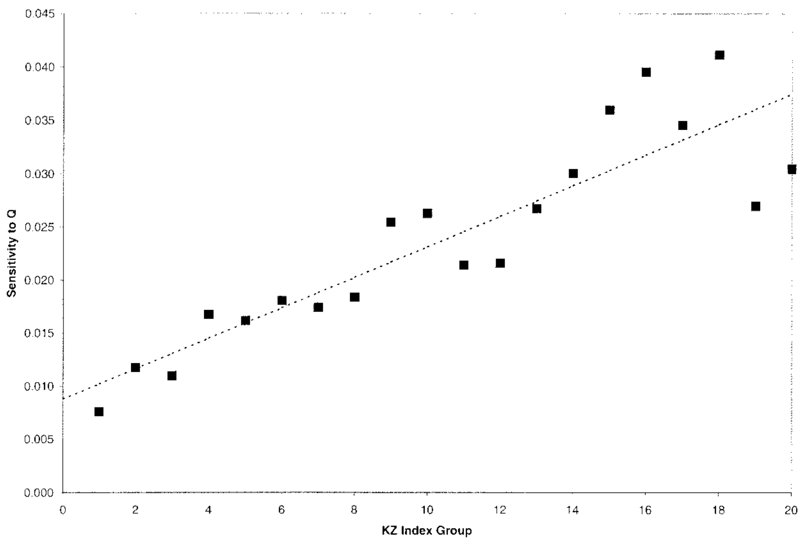

FIGURE II

Equity Dependence and the Link between Investment and Stock Prices

The figure shows the sensitivity of investment to Q by equity dependence group. We sort firms into twenty groups according to the firm median Kaplan and Zingales [1997] index of financial constraints (excluding Q from the index) over the period from 1980 to 1999, performing separate regressions for each group.

standard errors), the t-statistic for this difference is a significant 4.80.

An alternative approach, in the spirit of Fama and MacBeth [1973], can be used if one is very concerned about serial correlation at the firm level and does not trust the cluster adjustment to deliver proper standard errors. This approach is illustrated in Figure II. Using the same methodology as before, we now divide firms into twenty KZ-index groups, instead of five. For each group we estimate the b coefficient of investment on Q. We then regress these twenty b estimates against their respective ordinal KZ-index rankings. In other words, we treat each b coefficient simply as a data point, without making any assumptions about the precision with which it is estimated. This twenty-data-point regression yields a point estimate of 0.0014 and a t-statistic of 8.44. Intuitively, this methodology infers that the b coefficients are precisely estimated by virtue of the fact that most of them cluster close to the fitted regression line in Figure II. One can show that the point estimate obtained with this approach is roughly consistent in magnitude with the pattern of coefficients in the quintile regressions.

IV.B. Robustness of Hypothesis 1 Results

In Tables IV and V we explore the robustness of our basic result. We alter various aspects of the specification such as the variables included in the KZ index, the scaling of these index components, the horizons over which firms are classified by the index, the other variables in the investment equations, the composition of the sample, and the definition of investment.

In Row 1 of Table IV we reproduce our baseline specification for reference: recall that the coefficient b rises from 0.012 to 0.033 as we move from the bottom to the top quintile of the KZ index. In Row 2 we revert to the original five-variable version of the index used in Lamont, Polk, and Saa-Requejo [2001], which includes Q. In this case, the b coefficient goes from 0.011 in quintile 1 to 0.027 in quintile 5, which differs little from the baseline result.

In Row 3, we go back to the four-variable version of the index, but classify firms based on their five-year median value of KZ, rather than their median value over the entire sample period. In Row 4 we push this time-varying classification further, and reclassify firms every year. Specifically, we assign a firm to a KZ quintile in any given year t based on its value of the index in year $t - 2$. These changes in the classification horizon do not affect the results.

In Row 5 we scale the elements of the KZ index by property, plant, and equipment (PP&E), as opposed to by assets.[19] This strengthens the results somewhat, with b now almost quadrupling from the first quintile to the fifth quintile. In Row 6 we add the lagged value of the capital-expenditure ratio to the right-hand side of the regressions. This brings down the b coefficients a bit, but does not change their relative proportions. In Row 7 we delete the cash-flow term from the regression entirely, so that Q is the only explanatory variable for investment. Again, the results are very similar to those in the base case.

In Row 8 we restrict ourselves to a subsample similar to the low-dividend manufacturing sample used by Kaplan and Zingales [1997] to fit the index weights. More precisely, we focus on manu-

19. In Row 5, capital expenditures and cash flow are still scaled by assets. When we scale the variables in the investment equation by PP&E as well, b rises from 0.063 to 0.113 from the first to the fifth quintile. The difference of 0.050 has a t-statistic of 4.05.

TABLE IV
EQUITY DEPENDENCE AND THE LINK BETWEEN INVESTMENT AND STOCK PRICES: ROBUSTNESS

	Bottom quintile		2		3		4		Top quintile		Top − bottom	
	b	(se)	b	(se)	b	(se)	b	(se)	b	(se)	Δb	[t-stat]
1. KZ (base case)	0.012	(0.0013)	0.018	(0.0015)	0.024	(0.0024)	0.032	(0.0030)	0.033	(0.0042)	0.021	[4.80]
2. KZ (five-variable index)	0.011	(0.0015)	0.019	(0.0017)	0.020	(0.0020)	0.028	(0.0024)	0.027	(0.0030)	0.016	[4.74]
3. KZ (five-year median)	0.011	(0.0014)	0.019	(0.0017)	0.024	(0.0022)	0.030	(0.0029)	0.034	(0.0046)	0.023	[4.72]
4. KZ (annual)	0.010	(0.0016)	0.019	(0.0019)	0.024	(0.0029)	0.033	(0.0036)	0.035	(0.0045)	0.026	[5.40]
5. KZ (PP&E scaling)	0.010	(0.0012)	0.015	(0.0014)	0.025	(0.0021)	0.032	(0.0030)	0.039	(0.0039)	0.030	[7.28]
6. Lagged *CAPX/A* included	0.009	(0.0012)	0.012	(0.0014)	0.019	(0.0021)	0.025	(0.0027)	0.028	(0.0037)	0.019	[4.96]
7. *CF/A* excluded	0.016	(0.0013)	0.022	(0.0016)	0.028	(0.0025)	0.037	(0.0033)	0.038	(0.0048)	0.022	[4.47]
8. Low-div. mfg., PP&E scaling	0.008	(0.0012)	0.013	(0.0019)	0.015	(0.0023)	0.025	(0.0033)	0.024	(0.0040)	0.016	[3.69]
9. Complement sample to #8	0.018	(0.0026)	0.024	(0.0031)	0.028	(0.0043)	0.042	(0.0045)	0.047	(0.0068)	0.030	[4.12]
10. KZ (reset to equal weights)	0.014	(0.0012)	0.020	(0.0018)	0.027	(0.0027)	0.035	(0.0035)	0.031	(0.0047)	0.017	[3.60]

a. Regressions of investment on Q and cash flow by equity dependence quintile. We sort firms into five quintiles according to various modifications of the Kaplan and Zingales [1997] index of financial constraints, performing separate regressions for each group. The cash-flow coefficients are not reported. Year and firm fixed effects are included.

b. Investment is defined as capital expenditures over assets. Q is defined as the market value of equity plus assets minus the book value of equity over assets. Cash flow is defined as operating cash flow over assets.

c. The first row is our baseline specification, which classifies firms according to their median four-variable KZ index (excluding Q). The second row uses the firm median five-variable KZ index (including Q). The third row uses a five-year median KZ index (excluding Q). The fourth row uses an annual KZ index measured at time $t-2$ (excluding Q). The fifth row scales the KZ-index components by fixed assets instead of total assets. The sixth row includes lagged investment as an independent variable. The seventh row excludes cash flow. The eighth row restricts the sample to manufacturing firms (SIC codes 2000 through 3999) with a ratio of dividends to net income of less than 10 percent, and also scales the KZ-index components by fixed assets. The ninth row studies the complement sample to that studied in the eighth row, again scaling by fixed assets. The tenth row resets the KZ-index weights so that each variable explains the same portion of the index variation.

d. Standard errors and t-statistics are heteroskedasticity-robust, clustered by firm, with all five regressions in a row estimated simultaneously.

TABLE V
EQUITY DEPENDENCE AND THE LINK BETWEEN INVESTMENT AND STOCK PRICES: INTERACTIVE SPECIFICATIONS

		Q_{t-1}		$Q_{t-1} \cdot KZ$		CF_t/A_{t-1}		
	N	b	[t-stat]	c	[t-stat]	d	[t-stat]	R^2
CAPX/A	52,101	0.021	[22.04]	0.011	[6.87]	0.129	[20.96]	0.61
+*RD/A*	52,101	0.028	[21.63]	0.013	[6.71]	0.109	[12.89]	0.69
+*RD* + *SGA/A*	52,101	0.049	[18.01]	0.021	[4.19]	0.258	[14.64]	0.84
$\Delta A/A$	52,101	0.080	[20.43]	0.058	[10.16]	1.117	[38.00]	0.41

a. Regressions of investment on Q, Q interacted with equity dependence, and cash flow. Year and firm fixed effects are included.

b. Investment is alternately defined as capital expenditures over assets; capital expenditures plus research and development expenses over assets; capital expenditures plus research and development expenses plus selling, general, and administrative expenses over assets; and growth in assets. Q is defined as the market value of equity plus assets minus the book value of equity over assets.

c. The measure of equity dependence is the firm median Kaplan and Zingales [1997] index of financial constraints (excluding Q from the index), standardized to have unit variance.

d. Cash flow is defined as operating cash flow over assets.

e. t-statistics use heteroskedasticity-robust standard errors, clustered by firm.

facturing firms in SIC codes 2000 to 3999, and further require that these firms have a ratio of dividends to net income of less than 10 percent (the dividend criterion Kaplan and Zingales apply to approximate a subsample studied in Fazzari, Hubbard, and Peterson [1988]); this screen reduces the number of observations from 52,101 to 26,725. We also follow Kaplan and Zingales more literally by using PP&E scaling in the components of the KZ index.[20] Row 8 shows that the b coefficient in this subsample again just about triples from the bottom to the top quintile. Row 9 further shows that the complementary subsample—i.e., firms that are not low-dividend manufacturers—also generates similar results. Taken together, these results suggest that our previous findings are not an artifact of having applied the KZ index outside of its original setting.

Finally, in Row 10 we show that the results are not overly sensitive to the exact weights that the KZ index gives to its four components. We reset the weights so that each component explains an equal amount of the variation in the index. This again gives similar results.

20. In Row 8, capital expenditures and cash flow are still scaled by assets. When we scale the variables in the investment equation by PP&E as well, b rises from 0.054 to 0.090 from the first to the fifth quintile. The difference of 0.037 has a t-statistic of 2.90.

In Table V we consider how our basic results carry over to the three other measures of investment. To do this in a compact fashion, we pool the observations and run a series of interactive specifications of the form,

$$\text{(7)} \qquad \frac{I_{it}}{A_{it-1}} = a_i + a_t + bQ_{it-1} + cQ_{it-1} \cdot KZ_i + d\,\frac{CF_{it}}{A_{it-1}} + u_{it},$$

where I_{it} denotes one of the four measures of investment, and KZ_i is the sample-median value of the KZ index for firm i.[21] The coefficient of interest in this case is c. As predicted, c is positive for each of the four investment measures, with strong statistical significance in each case.

Equation (7) also provides a convenient specification within which to examine one of the competing explanations for our results discussed earlier. That is, different types of firms may have different production technologies, which imply different sensitivities of investment to Q in the absence of mispricing. More specifically, investment may be naturally concave in Q, and so if equity-dependent firms tend to have lower Q values, they would be expected to have higher sensitivities. A simple way to examine this explanation is to add a Q^2 term to the specification and examine whether c changes. In unreported results we find that, while the coefficient on Q^2 does turn out to be significantly negative, the c coefficient is barely affected. This is true for each measure of investment considered in Table V.[22]

IV.C. Decomposing KZ and the Effect of Other Equity-Dependence Indicators

The KZ index results may appear to be something of a black box. We know the sign that each variable takes in the index, and we have established the overall effect of the index on the sensitivity of investment to stock prices. Here we examine how each component of the index individually affects this sensitivity. We also examine the effect of other variables, not in the KZ index, that may help to identify equity dependence. As argued above,

21. Including the interaction between cash flow and KZ in equation (7) does not affect the results. The interaction term is statistically insignificant in three out of four regressions in Table V, and c is virtually unchanged in all four cases. In the second row, c drops from 0.012 to 0.011. In the fourth row, c drops from 0.058 to 0.056. In the first and third rows, c is unchanged.

22. The first c coefficient in Table V drops from 0.011 to 0.08; the second from 0.013 to 0.010; the third from 0.021 to 0.018; and, the fourth from 0.058 to 0.053. All four remain statistically significant at the 1 percent level.

demonstrating that the sensitivity responds in the expected direction to each of a number of variables forces an advocate of competing explanations—based on, for example, measurement error in Q, or differences in production technologies across firms—to tell a somewhat more convoluted story.

To perform the KZ index decomposition, it is again convenient to pool all observations, and run the following interactive specification:

$$\text{(8)} \quad \frac{I_{it}}{A_{it-1}} = a_i + a_t + bQ_{it-1} + Q_{it-1} \cdot \left[c_1 \frac{CF}{A} + c_2 \frac{DIV}{A} + c_3 \frac{C}{A} + c_4 LEV \right] + d \frac{CF_{it}}{A_{it-1}} + u_{it},$$

where the unsubscripted versions of the variables CF/A, DIV/A, C/A, and LEV refer to sample-median values for firm i. We run this regression for each of four measures of investment. The definition of equity dependence makes predictions for the signs of the interactions: c_1 should be negative, as should c_2 and c_3. In contrast, c_4 should be positive.

Panel A of Table VI shows that the predictions for c_1, c_2, c_3, and c_4 are largely borne out. The sharpest results are for c_4, the interaction on the leverage term. Across all four definitions of investment, c_4 is always significantly positive, indicating a strong tendency for levered firms to have investment that is more sensitive to stock prices. The results for c_1, c_2, and c_3 are somewhat weaker, but generally consistent with the theory—they take on the predicted sign in eight of twelve cases altogether, and in seven of the eight cases where they are statistically significant.

In Panel B we consider two other proxies for equity dependence that are not included in the KZ index: firm age and industry cash-flow volatility. We reestimate (8) augmented with the interactions of these two variables with Q, denoting the interaction coefficients as c_5 and c_6, respectively. The level of firm age is also included, but its coefficient is not reported. We predict that c_5 will be negative, on the premise that younger firms are more likely to be dependent on equity, and c_6 will be positive, since higher cash flow volatility implies lower debt capacity, which again contributes to equity dependence. The results in Panel B strongly support these predictions. Both c_5 and c_6 have the expected sign for all four measures of investment, and are significant in all but one case.

TABLE VI
EQUITY DEPENDENCE DECOMPOSITION

	CF/A		*DIV/A*		*C/A*		*LEV*		$\log(AGE_t)$		Industry $\sigma(CF/A)$	
	c_1	[t-stat]	c_2	[t-stat]	c_3	[t-stat]	c_4	[t-stat]	c_5	[t-stat]	c_6	[t-stat]
KZ index	−		−		−		+					
prediction	−		−		−		+		−		+	
Panel A: KZ index variables												
CAPX/A	0.006	[3.68]	−0.006	[−4.07]	−0.006	[−5.66]	0.007	[4.79]				
+*RD/A*	−0.000	[−0.03]	−0.006	[−3.36]	−0.004	[−2.47]	0.008	[4.14]				
+*RD* + *SGA/A*	−0.020	[−3.69]	0.003	[0.59]	0.002	[0.68]	0.022	[5.92]				
$\Delta A/A$	−0.025	[−2.92]	−0.030	[−6.17]	0.002	[0.34]	0.027	[4.93]				
Panel B: Additional measures of equity dependence												
CAPX/A	0.006	[4.16]	−0.004	[−3.31]	−0.006	[−6.26]	0.005	[3.43]	−0.004	[−5.67]	0.007	[4.93]
+*RD/A*	0.000	[0.17]	−0.005	[−2.73]	−0.004	[−2.85]	0.006	[3.08]	−0.004	[−3.98]	0.007	[4.14]
+*RD* + *SGA/A*	−0.019	[−3.47]	0.006	[1.22]	0.000	[0.10]	0.022	[5.34]	−0.008	[−3.65]	0.004	[1.67]
$\Delta A/A$	−0.024	[−2.84]	−0.026	[−5.35]	0.000	[0.00]	0.025	[4.23]	−0.011	[−4.02]	0.010	[2.77]

a. Regressions of investment on Q, Q interacted with the components of equity dependence, and cash flow. Only the coefficients on the Q interaction terms are reported. Year and firm fixed effects are included.

b. Investment is alternately defined as capital expenditures over assets; capital expenditures plus research and development expenses over assets; capital expenditures plus research and development expenses plus selling, general, and administrative expenses over assets; and growth in assets. Q is defined as the market value of equity plus assets minus the book value of equity over assets.

c. The first panel decomposes the effect of the Kaplan and Zingales [1997] index (excluding Q) into its four components: firm median operating cash flow over assets; firm median dividends over assets; firm median cash balance over assets; and firm median leverage. The second panel adds two additional measures of equity dependence, firm age, and the industry standard deviation of cash flow over assets between 1980 and 1999. The level of firm age is included along with the interaction between firm age and Q.

d. All components of equity dependence are standardized to have unit variance.

e. t-statistics use heteroskedasticity-robust standard errors, clustered by firm.

Overall, these results paint a detailed picture of the type of firm that is likely to have a high sensitivity of investment to stock prices: a young, nondividend-paying firm, with low cash flow and cash balances, and with high leverage *relative* to the debt capacity of its assets. This picture fits the theoretical definition of equity dependence rather well. And while it does not definitively rule out competing explanations for our results, it does suggest that such explanations would have to be quite intricate and multidimensional.

IV.D. Hypothesis 2: Investment and Future Stock Returns

We now turn to Hypothesis 2. The basic strategy for testing this hypothesis is to replace Q in the investment equations with future stock returns. More precisely, we now run regressions of the following form:

$$\frac{CAPX_{it}}{A_{it-1}} = a_t + bR_{it,t+3} + c\,\frac{CF_{it}}{A_{it-1}} + u_{it}, \tag{9}$$

where $R_{it,t+3}$ is the return on firm i's stock over the three-year period from the end of year t to the end of year $t + 3$. As discussed above, one might expect b to be negative on average whether variation in $R_{it,t+3}$ reflects either mispricing or differences in the rational cost of capital. The unique prediction of our theory is again a cross-sectional prediction—b should be *more negative* for equity-dependent firms. Note that such a prediction does not follow from any of the alternative explanations of our Hypothesis 1 results, such as differences in measurement error in Q across firms, differences in production technologies, or adverse selection that varies with Q.

Nevertheless, it is worth pointing out another type of measurement error problem that might arise in this setting. The realized return $R_{it,t+3}$ is a noisy proxy for what we want to capture, which is the expected return. If the signal-to-noise ratio in this proxy—i.e., the ratio of forecastable return variance to unexpected return variance—varies systematically with the degree of equity dependence, this could bias our results. Vuolteenaho [2002] provides a variance decomposition of stock returns which is very helpful in addressing this issue. It turns out that the signal-to-noise ratio is in fact greater for smaller stocks—in other words, a greater fraction of small stocks' returns are predictable based on the set of variables in his vector autoregression.

This could potentially pose a problem for us, since there is a weak connection between the KZ index and firm size. Fortunately, however, we are able to use Vuolteenaho's results to explicitly calibrate the signal-to-noise ratio for each of our KZ categories; as it turns out, the differences across categories are much too small to account for the results we report below.[23]

Equation (9) drops the firm fixed effect that we included in our previous Q specifications. The results to follow are actually stronger if we keep the fixed effect in, but using a fixed effect that is effectively fitted over the firm's entire sample period makes the interpretation of the future-returns term problematic.[24] By leaving out the fixed effect, we have all the variables set up in such a way that if we were to put future returns on the left-hand side instead of the right, we would be in a position to conduct a legitimate no-look-ahead return-forecasting exercise. Indeed, the full-sample results that we have are isomorphic to such a forecasting exercise, implying that, controlling for cash flow, higher investment forecasts lower returns.[25] If one wants to preserve the spirit of a fixed effect, but avoid the "look-ahead" problems that it entails, another approach is to measure the investment and cash-flow terms relative to their contemporaneous industry averages. Demeaning in this way leads to estimates similar to those reported here.

Table VII presents the results for investment and future returns. (The requirement of returns data reduces the number of observations from 52,101 to 41,819.) The table shows that the basic prediction of Hypothesis 2 is supported. The coefficients on future returns are negative and significant in each KZ quintile, and they go from -0.004 in the first quintile to -0.007 in the fifth

23. Vuolteenaho's Table IV [p. 247] allows us to calculate the ratio of forecastable return variance to unexpected return variance separately for each size (market capitalization) decile. For each year in our sample, we assign every firm to its closest size decile. We can then compute the average value of this signal-to-noise ratio over the entire sample period for each KZ category, taking into account the fact that stocks in different KZ categories have different size distributions. The ratios are 0.193, 0.203, 0.209, 0.226, and 0.236 for KZ quintiles 1 through 5, respectively.

24. For example, if returns are negative in the past, a fixed effect will make subsequent returns look high even if they are in fact zero.

25. In a recent paper, Titman, Wei, and Xie [2001] do this kind of forecasting exercise explicitly, demonstrating that one can earn high benchmark-adjusted returns by buying the stocks of low-investment firms and shorting the stocks of high-investment firms. They are interested in a different set of issues than we are, however, and so they do not explore the cross-sectional predictions that we focus on. See also Polk and Sapienza [2002].

TABLE VII
EQUITY DEPENDENCE AND THE LINK BETWEEN INVESTMENT AND FUTURE RETURNS

		$R_{it,t+3}$			CF_t/A_{t-1}			
KZ index	N	b	(se)	[t-stat]	c	(se)	[t-stat]	R^2
Quintile 1	8307	−0.004	(0.0009)	—	0.228	(0.0169)	—	0.14
2	8292	−0.004	(0.0011)	[−0.33]	0.215	(0.0165)	[−0.57]	0.07
3	8449	−0.006	(0.0010)	[−1.66]	0.250	(0.0207)	[0.82]	0.07
4	8407	−0.008	(0.0009)	[−3.08]	0.311	(0.0204)	[3.11]	0.08
5	8364	−0.007	(0.0009)	[−2.40]	0.290	(0.0186)	[2.44]	0.08

a. Regressions of investment on future returns and cash flow by equity dependence quintile. We sort firms into five quintiles according to the firm median Kaplan and Zingales [1997] index of financial constraints (excluding Q from the index), performing separate regressions for each group. Year fixed effects are included.

b. Investment is defined as capital expenditures over assets. $R_{it,t+3}$ is the cumulative stock return in years $t+1$, $t+2$, and $t+3$ from CRSP. Cash flow is defined as operating cash flow over assets.

c. t-statistics test the hypothesis of no difference between the coefficient in each quintile and quintile 1.

d. Standard errors and t-statistics are heteroskedasticity-robust, clustered by firm, with all five regressions in a panel estimated simultaneously.

quintile. The t-statistic on the difference of these estimates is −2.40.

As before, another simple and robust way to assess the statistical significance of the coefficient pattern across KZ categories is with the type of scatter plot that we introduced in Figure II. We repeat this exercise for future returns in Figure III. A regression of the twenty individual b coefficients against their ordinal KZ-index rankings yields a slope of −0.0002, with a t-statistic of −3.23. In spite of this significant t-statistic, however, a visual comparison of Figures II and III suggests that our estimates of b are markedly less precise in the future-returns regressions than they were in the Q-based regressions. This is not surprising, since future realized returns are bound to be a very noisy proxy for mispricing.

In unreported regressions, we have also replicated the robustness analysis of Tables IV and V, as well as the KZ-index decomposition of Table VI, with future returns inserted everywhere in place of Q. The results generally hold up to different measures of investment, and to variations in scaling techniques and other details. The most noteworthy wrinkle is that because of the greater noise inherent in working with future returns, we no longer have the power to do much with the KZ-index decomposition—when we interact future returns with each of the index

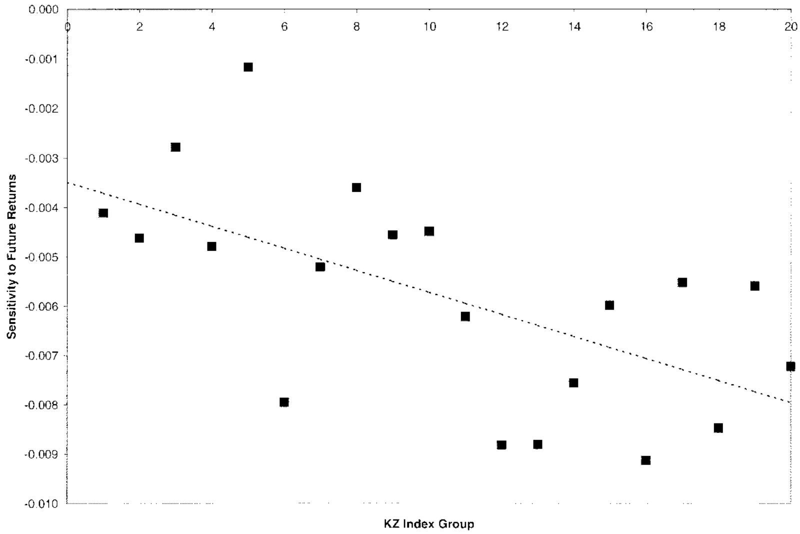

FIGURE III

Equity Dependence and the Link between Investment and Future Returns

The figure shows the sensitivity of investment to future stock returns by equity dependence group. We sort firms into twenty groups according to the firm median Kaplan and Zingales [1997] index of financial constraints (excluding Q from the index) over the period from 1980 to 1999, performing separate regressions for each group.

components separately, the individual interaction coefficients are often statistically insignificant.[26]

Finally, we have tried using both Q and future returns together in the same regression (along with cash flow) to explain investment. This is arguably a too stringent test, in the sense that the future-return term will now only attract a significant coefficient to the extent that it contains information about expected returns *above and beyond* that in Q. Nevertheless, the patterns across KZ categories are similar—albeit slightly muted—to those

26. We have also tried a variant of the analysis mentioned in footnote 7, splitting the sample based on whether future returns are positive or negative, and running the Q-based regressions separately for each subsample. Again, the idea here is to explore a subtler prediction of our model—that Hypothesis 1 should hold more strongly for undervalued firms, i.e., those with higher future returns. This appears to be the case: for firms with positive future returns, the coefficient on Q goes from 0.011 to 0.032 as we move from KZ quintile 1 to 5, a 191 percent increase. For firms with negative future returns, the coefficient on Q goes from 0.016 to 0.030, an 88 percent increase. However, given the imprecision associated with splitting the sample on future returns, this difference-in-difference is not significant.

we obtain when we enter Q and future returns separately. In particular, the coefficients on Q continue to be positive and increasing in the KZ index, while the coefficients on future returns continue to be negative and decreasing.[27] This is consistent with the view that both Q and future realized returns contain independent noisy information about future expected returns, and hence about mispricing.

IV.E. Hypothesis 3: Financing, Stock Prices, and Stock Returns

Our last hypothesis is that the equity issuance of equity-dependent firms is positively related to Q and negatively related to future returns. Verifying this hypothesis would lend further support to the model's premise that financing considerations are at the heart of the link between investment and stock prices. It would also further justify our assumption that the KZ index is a useful indicator of equity dependence; i.e., it would establish that high-KZ firms do in fact issue meaningfully more equity when their stock prices are high. We test Hypothesis 3 with the same regression framework used for the previous hypotheses, simply changing the dependent variable from investment to financing.

Panel A of Table VIII looks at the relationship between financing and Q. In the first row the financing variable is equity issues over assets, e_{it}/A_{it-1}. The sensitivity of equity issuance to Q is strongly significant across all KZ quintiles, and rises from 0.021 in the first quintile to 0.064 in the fifth quintile. Thus, firms classified as most likely to be equity dependent have equity issuance that is strongly tied to their stock prices, as predicted in Hypothesis 3.[28]

The model does not imply that equity-dependent firms finance 100 percent of their marginal investment with equity issues, of course. According to Proposition 1, in the relevant region of the parameter space (iii.a) the leverage constraint is binding, so at the margin new equity and debt are raised in proportions $(1 - \bar{D})$ and $\bar{D}$, respectively. This suggests that equity-dependent

27. The coefficients on future returns are now -0.003, -0.003, -0.004, -0.006, and -0.005 for KZ quintiles 1 through 5, respectively. The difference between quintiles 1 and 5 has a t-statistic of 1.53; that between quintiles 1 and 4 has a t-statistic of 1.94.

28. As discussed earlier, the theory makes a clear-cut prediction for the relative strength of the effect across different KZ classes only if one conditions on undervaluation. See the NBER working paper version for empirical tests along these lines.

TABLE VIII

EQUITY DEPENDENCE AND THE LINK BETWEEN EXTERNAL FINANCE, STOCK PRICES, AND RETURNS

	Bottom quintile		2		3		4		Top quintile		Top − bottom	
	b	(se)	b	(se)	b	(se)	b	(se)	b	(se)	Δb	[t-stat]
Panel A: Financing and Q												
External equity—all firms	0.021	(0.0040)	0.051	(0.0050)	0.040	(0.0056)	0.056	(0.0069)	0.064	(0.0085)	0.043	[4.59]
External equity plus debt—all	0.036	(0.0065)	0.077	(0.0080)	0.087	(0.0090)	0.104	(0.0115)	0.136	(0.0161)	0.100	[5.75]
Panel B: Financing and future returns												
External equity—all firms	−0.007	(0.0018)	−0.013	(0.0021)	−0.012	(0.0020)	−0.012	(0.0012)	−0.008	(0.0010)	−0.001	[−0.71]
External equity plus debt—all	−0.008	(0.0030)	−0.019	(0.0031)	−0.020	(0.0033)	−0.026	(0.0025)	−0.020	(0.0026)	−0.012	[−2.94]

a. Regressions of external finance on Q and cash flow, by equity dependence quintile (Panel A), and regressions of external finance on future returns and cash flow, by equity dependence quintile (Panel B). We sort firms into five quintiles according to the firm median Kaplan and Zingales [1997] index of financial constraints (excluding Q), performing separate regressions for each group.

b. External financing is alternately defined as equity issues over assets and as equity plus debt issues over assets. Q is defined as the market value of equity plus assets minus the book value of equity over assets. $R_{it,t+3}$ is the cumulative stock return in years $t + 1$, $t + 2$, and $t + 3$ from CRSP. Cash flow is defined as operating cash flow over assets.

c. Year fixed effects are included in both panels. Firm fixed effects are included in the first panel only.

d. Standard errors and t-statistics are heteroskedasticity-robust, clustered by firm, with all five regressions in a row estimated simultaneously.

firms should also be raising a significant amount of debt on the margin.

We examine this prediction using a total external finance variable that includes both equity and debt issues, $(e_{it} + d_{it})/A_{it-1}$. The results are in the second row of Panel A. They show that for firms in KZ quintile 5, the sensitivity of total finance to Q is 0.136, whereas for equity issues alone it is 0.064. In other words, for high-KZ firms, a marginal increase in the stock price leads to roughly equal increases in equity and debt finance. This seems consistent with the model's prediction that equity-dependent firms issue equity and debt in lockstep. Moreover, the quantitative response of equity issues to stock prices is substantial relative to the response of total finance, consistent with the spirit of the equity financing channel.

Panel B changes the proxy for mispricing from Q to future returns. The conclusions are much the same as in Panel A. Equity issuance is significantly negatively related to future returns for high-KZ firms, and the response of equity issues to future returns in this group again accounts for roughly half of the response of total external finance to future returns.

Finally, because of the difficulty of measuring equity and debt issues from Compustat data, we have examined whether the results in Table VIII are robust to alternative definitions of financing variables. Those used in Table VIII are backed out from balance sheet data. In unreported regressions we find very similar results using equity and debt issues taken from the cash flow statement.[29]

V. Conclusion

Rather than restating our results, we close with a final caveat regarding interpretation. If one takes our model literally, it might be tempting to conclude that the investment behavior of equity-dependent firms must necessarily be less efficient than that of nonequity-dependent firms. After all, according to the model, nonfundamental movements in stock prices introduce volatility into the investment of equity-dependent firms, thereby mov-

29. Specifically, we remeasure net equity issues as Compustat Item 108 minus Item 115, and debt issues as the change in long-term debt (Item 111 − Item 114). With these definitions, the sensitivity of equity issuance to Q goes from 0.017 in the first KZ quintile to 0.042 in the fifth quintile, and sensitivity of total external finance to Q from 0.026 in the first quintile to 0.107 in the fifth quintile.

ing them away from the first best. But we caution readers against jumping to this sort of welfare conclusion, because it is quite sensitive to the perhaps unrealistic assumption that, absent financial constraints, managers always act in the interest of their stockholders.

Consider the following embellishment of the model. Everything is as before, except that unconstrained managers are subject to an agency problem that leads them to prefer excessively smooth investment in the face of changes in fundamentals. If one layers on top of this agency problem our equity financing channel, the same basic *positive* implications emerge: all else equal, the investment of equity-dependent firms will respond more to stock prices than that of nonequity-dependent firms. But the *normative* implications of the model will be very different. Since the nonequity-dependent firms are now underreacting to stock prices, the investment of the equity-dependent firms may actually be closer to efficient on average.[30] In other words, starting from a second-best situation, the distortion inherent in the equity financing channel may help to alleviate the distortion coming from managers' tendency to smooth investment.

Graduate School of Business, Harvard University, and National Bureau of Economic Research
Department of Economics, Harvard University, and National Bureau of Economic Research
Stern School of Business, New York University

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30. Indeed, researchers commonly associate a greater sensitivity of investment to stock prices with a *higher* degree of efficiency. See, e.g., Scharfstein [1998] and Rajan, Servaes, and Zingales [2000] for examples in the context of internal capital markets.

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