Does Insider Trading Better Explain Firm-Level Investment?

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Abstract

Previous research on insider trading suggests that trades by upper-level management may be motivated by differences in the managers' and equity market's valuation of the firm's stock price. If managers make the right bets, they can expect to earn excess returns on trading shares in their own firms. Thus we use insider trades as a proxy for the manager's estimate of the firm's stock-price misvaluation, and put this proxy into the investment-q equation. With certain simplifying assumptions, q-theory states that the rate of investment depends on average q. Average q is the firm's market value – as measured by the equity market – divided by the replacement cost of its capital stock. Since it is the manager who makes the investment decisions, we believe that it may be more appropriate to use the manager's valuation of the firm when constructing average q. Consequently, using the manager's estimate of the stock-price misvaluation in addition to the equity market valuation should better explain investment. Using insider ownership data from the Securities and Exchange Commission during the 1980s, we find that the percentage change in company shares held by the firm's insiders is positively and significantly correlated with investment. When insiders increase their holdings of company shares, investment is greater than what the stock price would predict. We find that this effect is largest for small firms, which is consistent with the insider trading literature. Lakonishok and Lee (2001), for example, find that ex-post excess returns are largest for insiders trading in small firms.

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1 Introduction

Financial theory tells us that the firm's stock market price should fairly reflect the profitability of its capital stock. We also then expect share prices to signal the correct level of capital investment to firm managers. In fact, results of the q-theory model of investment state that there should be a direct relationship between the firm's level of investment and stock price. The q investment model derives the optimal rate of investment from the profit maximization condition, yielding the result that investment depends on the statistic marginal q – which is the firm's shadow price of an additional unit of capital. With the assumption of perfectly competitive output markets, and constant returns to scale in both capital stock adjustment costs and production, Hayashi (1982) showed that marginal q can be replaced by average q in the investment equation. Average q is the firm's market value divided by the replacement cost of its capital stock, and economists use the stock market to measure firm value.

There are problems, however, with using the firm's stock price to model investment. Anecdotal evidence suggests that investment does not always fall in line with equity prices. For example, Blanchard, Rhee and Summers (1993) study the response of aggregate investment to the stock market crashes of 1929 and 1987. Both crashes should have signalled lower levels of investment if firm managers made investment decisions based on stock market prices. However, investment recovered after the 1987 crash, but fell even below what the stock market price would have predicted after the 1929 crash. In fact, q-theory has been disappointing empirically. Chirinko (1993) outlines the failures: equation estimates generate low R^2 statistics along with significant serial correlation in the error terms.[1] In addition, Fazarri, Hubbard and Petersen (1988) find that cash flow enters

[1] Actually, serial correlation may be consistent with the investment-q equation if one interprets the residuals as autocorrelated technology shocks. See Blundell, Bond, Devereux and Schiantarelli (1992) for a discussion.

significantly into the investment-q equation, while the theory states that q should be a sufficient statistic for investment.[2] Simply put, average q does not successfully explain investment dynamics.

The discussion in Sparks (2001) gives impetus to our current investigation. This article reports on the large cash reserves earned by technology companies during the 1990s from selling put options on their own shares. Firm managers expected stock prices to continue to rise, leaving the options to expire worthless. These were risky bets – in fact, when share prices later declined, these companies were responsible for paying out large amounts of cash and firm shares to settle the options contracts. If these managers expected their firms to profit from selling put options, we might conclude that they were more bullish than the general market on their firm's profitability. We then ask the question: if firm management invests with regard to expected profits, can data on sales of these put options provide better forecastability of investment than just using the stock market price? Unfortunately, this specific question will have to remain unanswered because we do not have data on company put option sales.[3] However, we will continue on this path of inquiry using data on insider trades. The Securities and Exchange Commission (SEC) requires upper-level managers to report all trades on their personal holdings of company shares, and it is likely that managers trade their own shares to profit from expected stock-price misvaluations.

We will therefore use insider trading data to better measure management's estimate of the firm's fundamental value. Because managers are experienced in their own industries and are more in tune with the daily operations of their companies, we expect them to have a more accurate picture of investment returns. Insider trades are a unique variable in that they will move with the manager's

[2]There is a large literature on the relationship between cash flow and investment. See also Fazarri, Hubbard and Petersen (2000), Kaplan and Zingales (1997) and Kaplan and Zingales (2000).

[3]When companies sell put options on their own shares or repurchase shares, they are making similar bets – that the firm's stock price will increase. Because we can easily obtain data on share repurchases, we will investigate this idea further in a future paper.

estimate of the share-price misvaluation.[4] For example, if managers believe that their firm shares are underpriced, they can expect to earn positive excess returns if they increase their holdings. In this scenario, we would also expect managers invest at a higher rate in the firm's capital stock than what the stock market price would predict. Thus, adding an insider trading variable to the traditional investment-q equation should increase predictability of investment.

The insider trading literature supports our hypothesis that firm management more accurately prices firm shares. Using cross-sectional data, both Lakonishok and Lee (2001) and Seyhun (1986) find that insiders earn positive excess returns in the year following their trades. Lakonishok and Lee find positive excess returns for small- and medium-sized firms, with the largest returns resulting from small-firm trades. Seyhun also finds that insiders closest to company management earn relatively larger returns; these insiders are more likely to be privy to information on the firm's future profitability. Thus, we focus our analysis on trades by company officers.[5] In the remainder of this paper, we use the terms officer, firm manager and insider interchangeably.

Bond and Cummins (2000) is similar in spirit to our research. Instead of constructing a measure of management's estimate of the firm's fundamental value, they use analyst earnings forecasts to determine the firm's value. Calculating average q from data on earnings forecasts, they find an increase in the predictability of investment expenditures. In fact, including in the investment equation both the traditional q and the analysts' q, the authors find that traditional q loses all significance.

Malmendier and Tate (2005) also use insider trading data to model firm investment. They test

[4] It is important to note that the SEC prohibits trading when the insider is in the possession of "material, nonpublic information". Examples of illegal insider trading are trades based on upcoming earnings or dividends announcements. Bettis, Coles and Lemmon (2000), in addition, find that most corporations have their own policies limiting insider trading. Thus, we expect insider trades to capture management's perception of future general market or company trends, and not short-run private information.

[5] Insiders, as defined by the SEC, include officers, directors and large shareholders.

the hypothesis that overconfident CEOs overinvest when their firms have positive levels of cash flow. CEOs are characterized as overconfident if they consistently purchase company shares or delay the exercise of company stock options. Overconfidence is defined to be a permanent quality that does not vary over time. The authors find that firms with overconfident CEOs do in fact have a greater sensitivity of investment to cash flow. The focus of our research, however, is considerably different. We will study the short-term variability of insider trading. We presume that sometimes firm managers have higher expectations of firm returns than the market, and that they sometimes also have lower expectations.

We use q-theory as the basis to explore the relationship between insider trading and investment. In section 2 we assume that we can directly measure the manager's estimate of the firm's share-price misvaluation. We then incorporate this misvaluation into the investment-q equation – it enters as multiplicative measurement error of average q. In section 3, we use a one-period portfolio optimization model to determine how insiders will trade company shares when they believe that the shares are mispriced. The result is an equation that relates the firm's share-price misvaluation to our insider trading variable and a proxy error. We discuss the effect of the proxy error on our investment-q equation coefficient estimates. Section 4 reports the results of including the insider trading variable in the investment-q equation. Using insider ownership data from the Securities and Exchange Commission during the 1980s, we find that the percentage change in company shares held by the firm's insiders is positively and significantly correlated with investment. When insiders increase their holdings of company shares, investment is greater than what the stock price would predict. The final section concludes.

2 Main Investment-q Equation with Share-Price Misvaluation

In this section we revise the investment-q equation to include management's estimate of the firm's stock-price misvaluation. We start with the traditional linear investment-q equation,

$$\begin{aligned}\frac{I_{it}}{K_{it}} &= \alpha_i + \beta\left(\frac{V_{it}}{K_{it}}\right) + \varepsilon_{it} \\ &= \alpha_i + \beta q_{it} + \varepsilon_{it},\end{aligned}$$

where I_{it}/K_{it} is the investment-capital ratio and V_{it} the firm's equity market valuation. Average q is denoted q_{it}, where $q_{it} \equiv V_{it}/K_{it}$. This equation describes the optimal rate of investment when firm managers maximize the present discounted value of net profits, and there are costs to adjusting the capital stock.[6] The linearity of the investment-q relationship is a result of capital stock adjustment costs that are quadratic in the investment-capital ratio. Coefficients α_i and β are parameters of the adjustment cost function, and error ε_{it} represents adjustment-cost shocks.[7] Variable α_i is usually specified as a firm fixed effect.

Now we suppose that the equity market's valuation of the firm, which we label V_{it}^E, differs from the insider's valuation, V_{it}^I. Firm managers and the equity market do not share similar information sets, so they price the firm differently. The q investment model assumes that firm managers choose the level of investment to maximize the present discounted value of firm profits; we still hold this assumption to be true. Thus, the linear investment-q equation will explain the firm's optimal rate of investment if we replace the equity market's valuation of the firm with the firm manager's

[6] As discussed in the introduction, Hayashi (1982) details the conditions where we can specify the investment-q equation with average q rather than marginal q. See also Bond and Cummins (2000) for a review of q-theory.

[7] We will assume that these shocks are independently and identically distributed over i and t.

valuation, V_{it}^I. Therefore, our main investment equation is

$$\frac{I_{it}}{K_{it}} = \alpha_i + \beta q_{it}^I + \varepsilon_{it}, \tag{1}$$

where $q_{it}^I \equiv V_{it}^I / K_{it}$.

We usually estimate equation (1) with the equity market's value of average q, or $q_{it}^E \equiv V_{it}^E / K_{it}$. The insider's valuation, q_{it}^I, is not measurable. Because

$$q_{it}^E = q_{it}^I \left(\frac{V_{it}^E}{V_{it}^I} \right), \tag{2}$$

the insider's estimate of average q is measured with multiplicative error V_{it}^E / V_{it}^I. We discuss in section 3.3 that similar to the additive measurement error model, multiplicative measurement error results in an inconsistent estimate of the q-coefficient that is biased towards zero.

Substituting (2) into (1), we get the result that

$$\frac{I_{it}}{K_{it}} = \alpha_i + \beta q_{it}^E \left(\frac{V_{it}^I}{V_{it}^E} \right) + \varepsilon_{it}. \tag{3}$$

If we had data on the variable V_{it}^I / V_{it}^E, we could simply include it as an independent variable in the investment equation along with q_{it}^E, and all results of classical regression analysis would be valid. It is this idea that motivates our current investigation. We will use insider trading as a proxy for the firm misvaluation, V_{it}^I / V_{it}^E. If insiders trade their holdings of firm shares based on the misvaluation, then we expect insider trading to be positively correlated with V_{it}^I / V_{it}^E. As V_{it}^I / V_{it}^E increases, insiders believe that firm shares are worth even more than their market value, thus we expect that they will increase their holdings of company shares.

To conclude, we expect insider trading to be a significant explanatory variable in our estimation of equation (3). Also, in section 3.3 we show that including the insider trading variable as a proxy for the stock-price misvaluation reduces the inconsistency of the q-coefficient estimate that results from the measurement error.

3 Insider Trading as a Proxy for the Stock-Price Misvaluation

Now we consider how insiders trade their holdings of company shares when they believe that the shares are misvalued. The misvaluation may be firm-specific or market-wide. We study the problem in the context of a one-period portfolio optimization model. Insiders decide how much of their wealth to invest in the risk-free asset, market portfolio, and company shares. We also assume that firm managers incur reputation costs that are increasing in the size of their trades of company shares. Shareholders and the board of directors generally expect high-level managers to own equity in the firm – this ensures that managers have a payoff structure consistent with profit maximization. When managers deviate from the optimal level of incentive shareholdings, we posit that they bear costs equivalent to the value of the damage in reputation with shareholders.

The first-order conditions for our model specify that the percentage change in the insider's shareholdings is increasing in the firm-specific misvaluation. Total shareholdings in our portfolio optimization model include the insider's ownership of common shares, as well as shares held implicitly in the form of stock options. Our SEC data, however, only report the insider's holdings of common shares – stock option ownership is excluded from the data file. Thus, in the second subsection, we translate our first-order conditions into a model of the insider's percentage change in ownership of common shares only. This is our main insider trading variable that we put into the investment-q equation. In the last subsection we develop the resulting panel data investment-q

equation.

3.1 The Insider's Trading Decision in a One-Period Model

We solve the portfolio optimization problem for one insider of an individual firm. To keep the notation simple and because we are working with a one-period model, we drop the time t subscript and firm subscript i from the data variables. We begin with the assumption that the insider maximizes expected utility over end-of-period wealth. We specify the power utility function,

$$U(W) = \frac{W^{1-\gamma}}{1-\gamma},$$

where end-of-period wealth is W, and γ is the constant coefficient of relative risk aversion.

We let R^i and R^m denote the equity market's belief of stochastic returns on company shares and the market portfolio. The insider expects to earn return R^I on company shares when purchased at the equity market price V^E. We assume

$$R^I = \left(\frac{V^I}{V^E}\right) R^i. \tag{4}$$

That is, the insider expects to earn a return on company shares that is equal to the product of the share price misvaluation and the market's expected return.[8]

The firm's share price may be misvalued simply because the entire market is mispriced. In this case we would not expect insiders to trade company shares on the expectation of earning excess returns. If the general market is undervalued, for example, the insider would do better to increase

[8] We need to assume a specific form of the insider's belief in share-price misvaluation in order for equation (4) to hold. If the equity market's belief in the firm's end-of-period stochastic payoff is X, then $R^i = X/V^E$. We assume that the insider believes that the firm's end-of-period stochastic payoff is aX where a is a positive constant. Then $V^I = aV^E$, and given that $R^I = (aX)/V^E$, we conclude that $R^I = R^i\left(V^I/V^E\right)$.

holdings in the market portfolio rather than purchase more company shares. The market portfolio is diversified and therefore minimizes the insider's portfolio risk. Therefore, we break down the firm misvaluation V^I/V^E so that

$$\frac{V^I}{V^E} = \left(\frac{V^I}{V^E}\right)^F \left(\frac{V^I}{V^E}\right)^M, \tag{5}$$

where $\left(V^I/V^E\right)^F$ represents the firm-specific misvaluation, and $\left(V^I/V^E\right)^M$ the insider's forecast of the market-level misvaluation. We expect that $\left(V^I/V^E\right)^M$ will vary across firms since managers of different companies do not receive the same information about the general market environment. When the entire market is misvalued, the insider also expects to earn return R^M on the market portfolio, where

$$R^M = \left(\frac{V^I}{V^E}\right)^M R^m. \tag{6}$$

We continue with the wealth constraint

$$W = R^p W_0 (1 - F),$$

where W_0 is beginning-of-period wealth. The insider's portfolio return R^p is equal to

$$(1 - a - b)R^f + aR^M + bR^I.$$

The risk-free rate is R^f and the insider chooses to allocate fraction a of wealth to the market portfolio and fraction b of wealth to company shares. As mentioned in the introduction to this section, b represents the insider's total exposure to company shares. In addition to holdings of company stock, b includes shares implicitly held in the form of stock options.

The wealth constraint also assumes a cost F, which insiders bear when they change their holdings of company shares.[9] As previously discussed, managers are generally expected to hold shares in their own firms so that they have an incentive to maximize profits. Thus managers cannot sell off all shares if they believe that the firm's equity is overvalued, for instance, without bearing a reputational cost with shareholders. Costs F may also represent actual monetary losses. If shareholders expect the manager to maintain a target level of company equity holdings, the firm's board may punish any deviation below this target by adjusting the following year's compensation package.[10]

Becker (2006) finds in a sample of Swedish CEOs that the dollar level of incentive holdings, measured as the sum of the value of company stock and stock options, is increasing in wealth. We find it very likely that incentive targets are tied to the manager's level of wealth. Thus, we specify

$$F = 1 - \exp\left[-\frac{\theta}{2}\frac{(b - b_{-1})^2}{b_{-1}}\right],$$

where b_{-1} is the fraction of wealth the manager holds in company shares before the start of the trading period.[11] Reputation costs are equal to zero when managers choose to hold the same percentage of wealth in company shares that they held at the beginning of the trading period ($b = b_{-1}$). They are strictly increasing with the absolute value of the change in percentage of wealth held in company shares, and are always less than 100 percent of the insider's total wealth.

[9] When we use this structure for trading costs, we assume that costs are imposed at the beginning of the period and thus cannot be invested. Given that we consider these costs to be a type of reputational punishment on firm managers, this functional form is a bit restrictive. It might make more sense to use costs F such that $W = R^p W_0 - FW_0$. With power utility, this functional form does not give a closed-form solution.

[10] Gogoi (1999) and Lublin (1993) discuss firm-mandated stock ownership guidelines – these are guidelines that require executives to own a target level of company shares. Lower levels of future compensation are often stipulated if executives do not meet the targets. While these mandates were initiated in the early 1990s and are not relevant for our sample period, we believe that these guidelines were likely tacitly enforced prior to the 1990s.

[11] Notice that we assume costs are symmetric. That is, insiders incur costs both when they sell and purchase shares. Given the spirit of what these costs represent, it would be more correct to assume no costs when insiders purchase additional shares. This cost structure will be considered in a later version of the paper.

We approximate the log of the portfolio return, R^p, as a function of the log of the firm and market return. We follow Campbell and Viceira (2002) and use a continuous-time approximation. Assuming R^i and R^m are lognormal continuous stochastic processes, we extend the analysis in Campbell and Viceira by including the non-stochastic share price misvaluations V^I/V^E and $(V^I/V^E)^M$ in the insider's portfolio returns. Appendix 6.1 shows that the continuous-time approximation for the log portfolio return is

$$\begin{aligned} r^p \quad &\approx \quad r^f + a\left[r^m + \left(\frac{v^I}{v^E}\right)^M - r^f\right] + b\left[r^i + \frac{v^I}{v^E} - r^f\right] \\ &\quad + \frac{1}{2}\left[a(1-a)\mathrm{Var}\,(r^m) + b(1-b)\mathrm{Var}\,(r^i) - 2ab\mathrm{Cov}\,(r^i, r^m)\right], \end{aligned} \tag{7}$$

where lowercase notation denotes log returns. For example, $r^p \equiv \log(R^p)$ and $v^I/v^E \equiv \log(V^I/V^E)$.

The resulting first-order condition for b is

$$\frac{v^I}{v^E} - \beta_{im}\left(\frac{v^I}{v^E}\right)^M - \gamma c_i b - \theta\left(\frac{b - b_{-1}}{b_{-1}}\right) = 0, \tag{8}$$

where $\beta_{im} \equiv \mathrm{Cov}\,(r^i, r^m)/\mathrm{Var}\,(r^m)$ (see appendix 6.2). Firm-specific constant c_i is defined as $\mathrm{Var}\,(r^i) - \beta_{im}\mathrm{Cov}\,(r^i, r^m)$. This is equivalent to the firm's idiosyncratic risk in the CAPM model. Taking the log of equation (5), we know that $v^I/v^E = (v^I/v^E)^F + (v^I/v^E)^M$. The intuition behind the first-order condition is very clear if we substitute this relation into (8) and consider the case where $\beta_{im} = 1$. Then,

$$\left(\frac{v^I}{v^E}\right)^F = \gamma c_i b + \theta\left(\frac{b - b_{-1}}{b_{-1}}\right),$$

and the insider chooses b so that the excess return from holding an additional percentage share of wealth in the firm's equity is equal to the marginal cost. The excess return is equivalent to the firm-specific misvaluation. The marginal cost is the sum of the manager's reputation cost and the increase in portfolio risk. The marginal portfolio risk is increasing in the firm's idiosyncratic risk, c_i, and the level of insider holdings, b.

Working from (8), we solve for the change in holdings, b/b_{-1}, and take a first-order Taylor approximation around $v^I/v^E = 0$, $\left(v^I/v^E\right)^M = 0$ and $c_i b_{-1} = \overline{cb}$, where $\overline{cb}$ is the average value of $c_i b_{-1}$ across firms. This yields the solution

$$\frac{b}{b_{-1}} = \frac{1}{\gamma\overline{cb} + \theta}\left[\theta + \frac{v^I}{v^E} - \beta_{im}\left(\frac{v^I}{v^E}\right)^M - \frac{\theta\gamma}{\gamma\overline{cb} + \theta}\left(c_i b_{-1} - \overline{cb}\right)\right]. \tag{9}$$

3.2 Tradable and Non-Tradable Share Ownership

We next investigate how insiders change their holdings of common shares. Recall that b, in addition to shares of stock, includes holdings of unexercised stock options. To separate changes in common-share holdings from stock option holdings, we set $b = b^T + b^{NT}$, and $b_{-1} = b^T_{-1} + b^{NT}_{-1}$, where superscript T denotes shares of stock that are tradable, and NT denotes nontradable stock options.[12] We take a first-order Taylor expansion of b/b_{-1} around $b^{NT} = 0$ and $b^{NT}_{-1} = 0$, which yields

$$\frac{b}{b_{-1}} \approx (1-d)\left(\frac{b^T}{b^T_{-1}}\right) + d\left(\frac{b^{NT}}{b^{NT}_{-1}}\right),$$

where $d \equiv b^{NT}_{-1}/b^T_{-1}$. Thus, the change in the insider's percentage of wealth invested in the company is a weighted average of the change in the percentage of wealth held in shares of stock and the change in the percentage of wealth held in stock options. We substitute this relation into (9), which results

[12] Our data on common shares held also include holdings of restricted shares – these are shares companies grant to executives which cannot be sold until after a vesting period. As long as the total number of non-restricted shares held is positive, this does not affect our analysis.

in

$$(1-d)\left(\frac{b^T}{b^T_{-1}}\right) = -d\left(\frac{b^{NT}}{b^{NT}_{-1}}\right) + \frac{1}{\gamma\overline{cb}+\theta}\left[\theta + \frac{v^I}{v^E} - \beta_{im}\left(\frac{v^I}{v^E}\right)^M - \frac{\theta\gamma}{\gamma\overline{cb}+\theta}\left(c_i b_{-1} - \overline{cb}\right)\right]. \quad (10)$$

The change in the insider's holdings of common shares is b^T/b^T_{-1}. This variable will be the focus of the rest of our analysis.

The change in the percentage of wealth the insider holds in non-tradable stock options, b^{NT}/b^{NT}_{-1}, will vary in two situations. It will increase if the officer receives a new stock option grant, and will decrease if the insider exercises a stock option grant that has vested, and then sells off the shares. Ofek and Yermack (2000) study options exercises from 1993 to 1995 and find that executives sell almost immediately all shares acquired through exercise.[13] We see from (10) that a new stock option grant will prompt the insider to sell an increasing amount of tradable shares. This is because an increase in the amount of non-tradable shares increases the insider's total percentage of wealth invested in the company. Similarly, an options exercise will prompt a decrease in the sale of tradable shares. Lacking data on the change in stock option holdings, we set this variable equal to an error, $(1+z)$. We posit that z is independently and identically distributed over insiders, firms and time with zero mean.

Hall and Liebman (1998), using a sample of CEOs from the Forbes 500 list, find that during the first half of our sample, 1980-1984, stock option grants were not a large component of executive compensation. In fact, the median value of stock option grants during this time period was \$0. The median value, however, started to rise in the latter half of the 1980s, though not near to the levels seen in the 1990s.

[13] Options exercises before 1991 (our data sample is 1981-1989) were subject to the SEC 6-month short-swing rule – shares acquired from options exercises had to be held for 6 months before being sold. We discuss this rule further in section 4.

We make one additional revision to the first-order condition. Our insider trading data provide the total number of company shares each insider holds, not measured as a percentage of wealth. For small changes in the firm's share price, the change in the number of shares held will be approximately equal to the change in the percentage of wealth invested in firm shares. Thus, if we let S denote the total number of shares held by the insider, we can rewrite the above equation as

$$(1-d)\left(\frac{S}{S_{-1}}\right) = -d + \frac{1}{\gamma\overline{cb}+\theta}\left[\theta + \frac{v^I}{v^E} - \beta_{im}\left(\frac{v^I}{v^E}\right)^M - \frac{\theta\gamma}{\gamma\overline{cb}+\theta}\left(c_i b_{-1} - \overline{cb}\right) - \tilde{z}\right], \tag{11}$$

where $\tilde{z} \equiv dz\left(\gamma\overline{cb}+\theta\right)$, which is also an independently and identically distributed random variable with zero mean.

3.3 Main Regression Equation

Equation (11) holds for each firm insider. Now we more carefully define the notation to develop a panel regression model. We also put the focus on what drives the change in the number of shares held by the insider, S/S_{-1}. This is the insider trading variable that we eventually add to the investment-q equation as a proxy for V^I/V^E.

We once again let i denote the firm-level observation, and now j the individual insider observation. Each firm in our data set will have several officers trading at every time period. Thus, we rewrite the first-order condition as

$$(1-d)\left(\frac{S_{ijt}}{S_{ij,t-1}}\right) = -d + \frac{1}{\gamma\overline{cb}+\theta}\left[\theta + \frac{v^I_{it}}{v^E_{it}} - \beta_{im}\left(\frac{v^I_{it}}{v^E_{it}}\right)^M - \frac{\theta\gamma}{\gamma\overline{cb}+\theta}\left(c_i b_{ij,t-1} - \overline{cb}\right) - \tilde{z}_{ijt}\right].$$

We hold constant across i, j and t the marginal trading cost parameter θ, the coefficient of relative risk aversion γ and the ratio of insiders' non-tradable to tradable shareholdings, d. In addition, we assume that the average value of $c_i b_{-1}$ across firms, $\overline{cb}$, is constant over time.

Because insiders within the firm share a joint information set, we assume that they agree on the level of firm-specific and market misvaluation, $\left(v^I/v^E\right)^F$ and $\left(v^I/v^E\right)^M$. However, because companies have different information sets with respect to the general market environment, we let the market misvaluation vary by firm. Thus, we set

$$\left(\frac{v_{it}^I}{v_{it}^E}\right)^M = \left(\frac{v^I}{v^E}\right)_t^M + m_{it},$$

where $\left(v^I/v^E\right)_t^M$ is the expected value of the market misvaluation across firms for year t. This variable is a time effect in our model. Random variable m_{it} is independently and identically distributed over i and t with zero mean.

Lacking data on the wealth of the firm's officers, we cannot measure variable $b_{ij,t-1}$. We posit that the firm's shareholders expect managers on average to hold a constant level of percentage of wealth in company shares. Therefore $b_{ij,t-1}$ is likely to remain close to its long-run target value. The board of directors may even calibrate management compensation packages so that upper-level managers maintain this level of shareholdings. Core and Guay (1999) find evidence that firms use new options and restricted stock grants to target optimal CEO incentive levels. Specifically, we assume

$$c_i b_{ij,t-1} = (cb)_i^* + w_{ijt},$$

where $(cb)_i^*$ is firm i's long-run incentive shareholding target. Insiders of firm i will have holdings that randomly deviate around the target level by error w_{ijt}. This assumption also implies that

$$c_i b_{ij,t-1} - \overline{cb} = \left[(cb)_i^* - \overline{cb}\right] + w_{ijt}.$$

We approximate the difference between the firm's target level of incentive holdings, $(cb)_i^*$, and the level of holdings for insiders of the average firm, $\overline{cb}$, as

$$(cb)_i^* - \overline{cb} = \textit{industry effects}_i + \textit{size effects}_{it} + \textit{recent IPO}_{it},$$

where *recent* IPO_{it} is a dummy variable indicating whether the firm recently went public.[14] Evidence from Murphy (1999) and Jensen and Murphy (1990) indicates that executive shareholdings are likely to vary by industry and firm size. Thus, we use variables *industry* $\textit{effects}_i$ and *size* $\textit{effects}_{it}$ to model the firm's target level of shareholdings. In addition, we expect that officers of firms that have recently gone public hold more shares than is typical. Boone, Field, Karpoff and Raheja (2004) find this result in a sample of IPO firms during the sample period 1988-1992. They also find that executive ownership steadily decreases in the years following the IPO.

Insiders also randomly trade for personal liquidity demands, thus we add a mean-zero independently and identically distributed error u_{ijt} to the specification of $(1-d)\,(S/S_{-1})$. Including all of these non-measurable effects in our first-order condition results in the following relationship between the insider trading variable and $\left(v^I/v^E\right)$:

$$\begin{aligned}(1-d)\left(\frac{S_{ijt}}{S_{ij,t-1}}\right) &= -d + \frac{1}{\gamma\overline{cb}+\theta}\left[\theta + \frac{v_{it}^I}{v_{it}^E} - \beta_{im}\left(\frac{v^I}{v^E}\right)_t^M\right. \\ &\quad \left. -\frac{\theta\gamma}{\gamma\overline{cb}+\theta}\left(\textit{industry effects}_i + \textit{size effects}_{it} + \textit{recent IPO}_{it}\right) - v_{ijt}\right],\end{aligned}$$

where $v_{ijt} \equiv \left[(\theta\gamma)/(\gamma\overline{cb}-\theta)\right] w_{ijt} + \beta_{im} m_{it} + \tilde{z}_{ijt} - \left(\gamma\overline{cb}+\theta\right) u_{ijt}$.

[14]Notice that $c_i b_{ij,t-1}$ is assumed relatively constant across firms rather than $b_{ij,t-1}$. This implies that firms with higher idiosyncratic risk set lower incentive-level targets for their executives. Murphy (1999) reviews the executive incentive contract literature – a main result is that the optimal level of pay-performance incentives is decreasing in firm risk. Jin (2002) shows that when the CEO can trade the market portfolio, optimal incentive levels should decrease in idiosyncratic risk, but not systematic risk. Empirical tests confirmed this result.

We conduct our analysis at the firm level. Thus, we average over the firm's insiders for each time period, and then solve for the misvaluation term.[15] The result is

$$\frac{v_{it}^I}{v_{it}^E} = \tilde{\theta}\,\%\Delta S_{it} + \beta_{im}\left(\frac{v^I}{v^E}\right)_t^M + \gamma\left(\mathit{industry\ effects}_i + \mathit{size\ effects}_{it} + \mathit{recent\ IPO}_{it}\right) + v_{it},$$

where $\%\Delta S_{ijt} \equiv (S_{ijt}/S_{ij,t-1}) - 1$, and $\%\Delta S_{it}$ and v_{it} represent firm averages over officers trading at time t. Also, $\tilde{\theta} \equiv (1-d)\,\theta$ and we assume without loss of generality that $\gamma\overline{cb}$ is small. Our original equation requires a model for V^I/V^E and not the log of the firm misvaluation. We use the approximation $x \approx \log(1+x)$ for x small. Therefore,

$$\begin{aligned}\frac{V_{it}^I}{V_{it}^E} \approx\ & 1 + \tilde{\theta}\,\%\Delta S_{it} + \beta_{im}\left(\frac{v^I}{v^E}\right)_t^M \\ & +\gamma\left(\mathit{industry\ effects}_i + \mathit{size\ effects}_{it} + \mathit{recent\ IPO}_{it}\right) + v_{it}. \end{aligned} \tag{12}$$

We interpet the coefficient $\tilde{\theta}$ as the change in our forecast of the insider's belief in share-price misvaluation as a result of a change in the insider trading variable. When we estimate the investment-q equation in section 4, we also report estimates of $\tilde{\theta}$.

Our main investment-q equation is $I_{it}/K_{it} = \alpha_i + \beta q_{it}^E(V_{it}^I/V_{it}^E) + \varepsilon_{it}$. We substitute in the above solution for V^I/V^E, which yields the new investment regression,

$$\begin{aligned}\frac{I_{it}}{K_{it}} =\ & \alpha_i + \beta q_{it}^E + \left(\beta\tilde{\theta}\right) q_{it}^E\,\%\Delta S_{it} + \beta q_{it}^E \times \mathit{CAPM\ beta}_i \times \mathit{time\ effects} + \\ & + (\beta\gamma)\left(\mathit{industry\ effects}_i + \mathit{size\ effects}_{it} + \mathit{recent\ IPO}_{it}\right) + e_{it}, \end{aligned} \tag{13}$$

where $e_{it} \equiv \beta q_{it}^E v_{it} + \varepsilon_{it}$. We change the notation on β_{im} to $\mathit{CAPM\ beta}_i$, and variable *time effects*

[15]Note that the number of officers for each firm may vary over time.

is equal to $\left(v^I/v^E\right)_t^M$. Our main interest is the estimate of the coefficient on q_{it}^E, and the effect of insider trading on investment (represented by the coefficient on $q_{it}^E\,\%\Delta S_{it}$). These two coefficient estimates will also allow us to identify the size of $\tilde{\theta}$.

In our new investment-q equation, the proxy error, v_{it}, remains in the regression error term. In appendix 6.3 we show that, despite the remaining proxy error, using insider trading as an estimate of the firm's share-price misvaluation reduces the downward asymptotic bias of the q coefficient that results from the misvaluation. However, the improvement in consistency of the q-coefficient estimate is decreasing in the variance of the proxy error. In addition, we show that our estimate of the coefficient on $q_{it}^E\%\Delta S_{it}$, and our estimate of $\tilde{\theta}$ will also be asymptotically biased downward. The bias is again increasing in the variance of the proxy error, v_{it}.

4 Results

4.1 Investment Equation Estimates

We use data from the Securities and Exchange Commission's Ownership Reporting System (ORS) to measure officer shareholdings for all publicly traded firms. Details are in appendix 6.4.1. We measure $\%\Delta S_{ijt}$ as the percentage change in the stock of shares held by officer j of firm i from end-of-fiscal year $t-1$ to end-of-fiscal year t. Data are available for fiscal years 1979-1989. One lag of both the insider trading and q variables are in the investment equation, thus the estimation period is 1981-1989.

Some of our regression specifications use the firm's cash flow normalized by the level of capital stock, CF_{it}/K_{it}. Data on the investment-capital ratio, average q and cash flow are from Compustat. Appendix 6.4.2 gives the details. Variable $industry\ effects_i$ is set equal to the firm's 2-digit SIC code as reported by Compustat. Variable *size effects*$_{it}$ is measured from the CRSP Stock File Capitalization Decile Indices. We define three size categories – small firms are defined as deciles 1 through 3, medium firms are deciles 4 through 7, and large firms 8 through 10. Note that the firm may change size categories over time. As an approximation for the firm's IPO date, we define the IPO year as the first year that Compustat reports valid data for the firm's market value of equity. Dummy variable *recent IPO*$_{it}$ takes on the value of one if it has been less than or equal to 5 years since the firm's IPO. Lastly, $CAPM\ beta_i$ is from CRSP. CRSP reports annual CAPM betas, which are calculated from daily returns, for NYSE and AMEX exchange-traded companies. We use both the firm's time-varying annual betas as reported by CRSP, and the firm's sample-period average of the annual betas.

The data panel is unbalanced, with 3232 non-financial firms. Observations with an investment-capital ratio greater than one or average q greater than 30 are deleted. This is standard in the literature and rids the sample of Compustat data entry errors as well as large acquisitions. In addition, we delete observations for any officer with a change in insider holdings greater than 500 percent or less than negative 95 percent. An upper threshold of 750 percent was tested and our results did not change.

Table 1 gives a summary of our main data variables. We report statistics for the entire sample of firms, and by firm-size class. The data indicate that average q is slightly increasing in firm size. The investment-capital ratio also appears to be lower for small firms. Small firms, in addition, have lower levels of retained earnings – CF_{it}/K_{it} is on average negative for this group. We also see that firm officers were net purchasers of shares during the sample period. On average, insiders increased their shareholdings by 16.3 percent annually. Officers of large firms purchased more shares than their small- and medium-class counterparts. Firms are in the sample period for an average of 4.4

years, and officers an average of 3.0 years. Large firms are in the sample for a longer period of time – an average of 5.9 years. Small firms have an average of 1.9 officers in the sample each year. Medium firms have 3.1, and large firms have 7.6 officers in the sample every year. We also report officers' average dollar holdings of company shares in 1992 constant dollars. We use the level of the CRSP value-weighted index as the price deflator. Dollar shareholdings are highly skewed. The median officer across all size classes holds between $350,000 to $500,000 in company shares. Average holdings for the entire sample of firms is $4,223,026, with large-firm officers having the greatest average dollar shareholdings.

Tables 2 through 5 give results for different specifications of our main investment-q equation with insider trading,

$$\begin{aligned}\frac{I_{it}}{K_{it}} &= \alpha_i + \beta q_{it}^E + \left(\beta\tilde{\theta}\right) q_{it}^E \,\%\Delta S_{it} + \beta q_{it}^E \times CAPM\ beta_i \times time\ effects\ + \\ &\quad + (\beta\gamma)\,(industry\ effects_i + size\ effects_{it} + recent\ IPO_{it}) + e_{it}. \end{aligned} \tag{14}$$

All regressions use lagged q_{it}^E, $\%\Delta S_{it}$, and CF_{it}/K_{it}.

Table 2 gives estimation results without the time effects, and also excludes the industry, size and recent IPO effects. We regress the investment-capital ratio on the firm fixed effects, average q and the product of average q and the insider trading variable. The investment equation is estimated across three subsamples of firm officers: the entire sample of officers, officers who hold more than $100,000 in company shares on average, and officers who hold more than $250,000 in shares on average. In addition, we estimate the investment equation over subsamples of firms with varying numbers of years in the data set: the entire sample of firms, and firms with greater than or equal to 3 or 5 sample years.

The investment-capital ratio is regressed on firm fixed effects and $q^E_{i,t-1}$ for one specification in Table 2, and the insider trading variable $q^E_{i,t-1}\%\ \Delta S_{i,t-1}$ is added to a second specification. The q-coefficients are significant at the one-percent level in all equation estimates; the largest coefficients are in the subsample of firms that have at least 5 years of data. The insider trading variable is positive and significant in subsamples with firms that have at least 3 years of data. Thus, as officers increased their ownership of company shares, they also invested at a higher rate than what the stock price would predict. The size of the coefficient on the insider trading variable is increasing in the size of average officer shareholdings. The subsamples with officers who hold \$250,000 in shares on average report the largest coefficients. The lack of significance of the insider trading variable in the samples including firms with less than 3 data years is not surprising. Firms with only one to two years of data are likely to be very young, or have exited due to bankruptcy or a takeover. These scenarios will likely cause changes in insider trading unrelated to share-price misvaluations.

Coefficients on the insider trading variable are scaled to represent the effect of a standard deviation change in insider trading. Previously we interpreted the coefficient $\tilde{\theta}$ as the change in the insider's belief of the share-price misvaluation with respect to a change in the insider trading variable. Significant coefficients on $\tilde{\theta}$ indicate that a standard deviation change in insider trading is equivalent to a 3.4 to 7.7 percent change in the share-price misvaluation. Thus, insider trading has a sizable and significant effect on investment for most of our sample. The only disappointing result is that the inclusion of the insider trading variable does not increase the coefficient estimate of the average q variable.

Table 3 reports equation estimates with time effects for the subsample with officers who hold more than \$100,000 in shares on average and firms that have at least 5 years of data. As with Table 2, we neglect from the industry, size and recent IPO effects. We also assume that the CAPM beta is equal to one for all firms. In addition, we include cash flow in most specifications to ensure that our insider trading results are robust. We find that all independent variables are significant at the one-percent level, and the coefficient on the insider trading variable increases when we include the time effects. Estimates of $\tilde{\theta}$ range from 6.5 to 7.1 percent, and these estimates are not affected by the addition of cash flow. As an additional check, instead of using the average percentage change in share ownership across firm officers, we include an alternative measure of insider trading that weights average officer trades by the officer's share of total ownership during the firm-year. We do this to make sure that officers with smaller holdings are not driving our results. This weighted variable is in Table 3 as $q^E_{i,t-1}\%\ \Delta S^w_{i,t-1}$ and the coefficient estimate does not change.

Table 4 replicates the results of Table 3 using the subsamples with officers who hold more than \$100,000 and \$250,000 in shares on average and firms that have at least 5 years of data. Because previous research on insider trading indicates that insiders of small firms earn the largest returns on trades, we test this hypothesis with our data. If small-firm officers do have more inside information, then we would expect to see a larger effect of insider trades on investment for small firms. And in fact, our results support this finding. We include firm-size interactions on both $q^E_{i,t-1}$ and $q^E_{i,t-1}\%\ \Delta S_{i,t-1}$ in the bottom panel of Table 4. The insider trading variable is very large and highly significant for small and medium firms, despite the small sample size for the small firm subgroup. The insider trading variable for large firms is significant only in the sample with average officer holdings greater than \$100,000. An additional interesting result is that the q coefficient is not significant for small firms. However, the size of the coefficient on the insider trading variable is largest for this subsample. Thus, despite the fact that q does not predict investment for the small-firm size class, the insider trading variable is still highly significant.

In Table 5 we run the full investment equation specification from (14). When we include the

CAPM beta, industry, firm size and IPO effects the estimate of the coefficient on the insider trading variable gets slightly smaller, but our results are robust to the inclusion of these additional variables. We do not report the average q coefficient estimates for the full equation specification because the effect of the average q variable on investment is spread out over the industry and size classes.

4.2 Stock Option Exercises Revisited

We return once again to the topic of stock option exercises, because the effect of these exercises on our insider trading variable, $\%\Delta S_{it}$, is a bit more complicated than earlier discussed in section 3.2. We assumed that when insiders exercise stock options, they immediately sell the shares. Recall that Ofek and Yermack (2000) find that executives sell almost immediately all shares acquired from options exercises during the sample period 1993-1995. In our model, this simply reduces the stock of non-tradable shares in the insider's portfolio.

However, there is a change in law in May 1991 that complicates our analysis. Prior to May 1991, the SEC required insiders to hold shares acquired from options exercises for at least six months. After May 1991, the shares could be sold immediately. Ofek and Yermack's results are likely also relevant for the time period prior to May 1991 – that is, we can assume that insiders sell all shares acquired from options exercises after the six-month waiting period. However, when insiders exercise stock options and hold the shares for six months, $\%\Delta S_{it}$ may temporarily increase, if only for a short period of time. If the six-month waiting period occurs within the fiscal year, then there will be no change in the insider trading variable. There will be an increase, then decrease in tradable shares from options exercises, leaving no net change in the number of shares held. However, if the insider exercises the stock options near the end of the fiscal year, and sells the shares the following year (six months later), this will directly affect the insider trading variable $\%\Delta S_{it}$.

Results from Carpenter and Remmers (2001), however, suggest that if we consider the fact that insiders are allowed to time their options exercises, then exercises prior to 1991 might also be related to the firm's-share price misvaluation. Because insiders are required to hold the shares in their portfolios for at least six months, the authors argue that insiders should time their exercises before an expected share price increase. And in fact, they find that insiders earn positive excess returns on shares acquired from options exercises during the six-month waiting period.

Thus, in our data, we are likely to see temporary increases in shareholdings due to options exercises. This adds noise to the insider trading variable. Results from Carpenter and Remmers, however, suggest that this effect might not be as bad as expected since options exercises during our sample period may also have been motivated by inside information.

5 Concluding Remarks

We thus find that insider trading is a significant predictor of firm-level investment, especially for small- and medium-sized firms. Our results are robust to the inclusion of market-level misvaluation effects on average q, and firm-size and industry effects on insider trading. We are less successful, however, on one point. We had hoped that including the insider trading variable in the investment-q equation would increase the coefficient estimate on average q. Our econometric model, however, indicates that our success on this point will depend on the variance of the proxy error of the insider trading variable. It is likely that the insider trading variable is just too noisy. Note that this proxy error also causes the coefficient esimate on the insider trading variable to understate the effect of insider trading on investment.

6 Appendix

6.1 A Continuous-Time Approximation of the Log Portfolio Return

We begin by assuming that the equity market's belief of returns on the firm and market shares are lognormally distributed in continuous time. More specifically, share price processes X_t^i and X_t^m satisfy the stochastic differential equations

$$
\begin{aligned}
dX_t^i &= \mu_i \, X_t^i \, dt + \boldsymbol{\sigma_i} \, X_t^i \, d\mathbf{W_t}, \\
dX_t^m &= \mu_m \, X_t^m \, dt + \boldsymbol{\sigma_m} \, X_t^m \, d\mathbf{W_t},
\end{aligned}
$$

where $\mathbf{W_t}$ is an n-dimensional Brownian motion, and $\boldsymbol{\sigma_i}$ and $\boldsymbol{\sigma_m}$ are both $1 \times n$. The price of the risk-free asset, B_t, follows the differential equation

$$dB_t = r^f B_t dt.$$

Next we consider the case where the insider believes that there is both a firm-specific and market misvaluation. We translate the simple one-period returns of equations (4) and (6) into a continuous-time framework. When we take logs of the one-period returns, we see that the insider's continuously-compounded returns on company shares and the market portfolio must satisfy

$$
\begin{aligned}
r^I &= \frac{v^I}{v^E} + r^i, \\
r^M &= \left(\frac{v^I}{v^E} \right)^M + r^m.
\end{aligned}
\tag{15}
$$

Thus, the misvaluation terms v^I/v^E and $(v^I/v^E)^M$ affect the means, but not the variances of the continuously-compounded returns. If we let dX_t^I and dX_t^M denote the price index processes that generate the returns with misvaluation, then (15) is similar to assuming

$$\begin{aligned} dX_t^I &= \left(\mu_i + \frac{v^I}{v^E}\right) X_t^I dt + \boldsymbol{\sigma_i} X_t^I \mathbf{dW_t}, \\ dX_t^M &= \left[\mu_m + \left(\frac{v^I}{v^E}\right)^M\right] X_t^M dt + \boldsymbol{\sigma_m} X_t^M \mathbf{dW_t}. \end{aligned} \tag{16}$$

We let the intertemporal budget constraint for the portfolio value V_t at time t be

$$\frac{dV_t}{V_t} = a\,\frac{dX_t^M}{X_t^M} + b\,\frac{dX_t^I}{X_t^I} + (1-a-b)\,\frac{dB_t}{B_t}.$$

We neglect putting the time subscript on the portfolio holding variables a and b because we are considering a one-period trading model, and for our situation these variables will remain constant. Substituting in (16) results in

$$\frac{dV_t}{V_t} = a\left[\frac{dX_t^m}{X_t^m} + \left(\frac{v^I}{v^E}\right)^M dt\right] + b\left(\frac{dX_t^i}{X_t^i} + \frac{v^I}{v^E}dt\right) + (1-a-b)\frac{dB_t}{B_t}. \tag{17}$$

Our measure of r^p, the log of the portfolio return, will be $d\log V_t$. Using Ito's Lemma, we know that

$$d\log V_t = \frac{dV_t}{V_t} - \frac{1}{2}\left(\frac{dV_t}{V_t}\right)^2. \tag{18}$$

Also by Ito's lemma,

$$d\log X_t^i = \frac{dX_t^i}{X_t^i} - \frac{1}{2}\boldsymbol{\sigma_i}\boldsymbol{\sigma_i'}dt,$$

$$\begin{aligned} d\log X_t^m &= \frac{dX_t^m}{X_t^m} - \frac{1}{2}\boldsymbol{\sigma_m \sigma_m'} dt, \\ d\log B_t &= \frac{dB_t}{B_t}. \end{aligned}$$

Substituting these last relations into equation (17), we find that

$$\begin{aligned} \frac{dV_t}{V_t} &= a\left[d\log X_t^m + \frac{1}{2}\boldsymbol{\sigma_m \sigma_m'} dt + \left(\frac{v^I}{v^E}\right)^M dt\right] + b\left(d\log X_t^i + \frac{1}{2}\boldsymbol{\sigma_i \sigma_i'} dt + \frac{v^I}{v^E} dt\right) \\ &\quad +(1-a-b)d\log B_t. \end{aligned}$$

Using the Ito multiplication rules $(dt)^2 = 0, dt\, d\mathbf{W_t} = 0, dW_{it}\, dW_{jt} = 0$ and $(dW_{it})^2 = dt$ results in

$$\left(\frac{dV_t}{V_t}\right)^2 = \left(a^2\boldsymbol{\sigma_m \sigma_m'} + 2ab\boldsymbol{\sigma_m \sigma_i'} + b^2\boldsymbol{\sigma_i \sigma_i'}\right) dt.$$

Referring back to (18), we find as a last step that

$$\begin{aligned} d\log V_t &= a\left[d\log X_t^m + \frac{1}{2}\boldsymbol{\sigma_m \sigma_m'} dt + \left(\frac{v^I}{v^E}\right)^M dt\right] + b\left(d\log X_t^i + \frac{1}{2}\boldsymbol{\sigma_i \sigma_i'} dt + \frac{v^I}{v^E} dt\right) \\ &\quad +(1-a-b)d\log B_t - \frac{1}{2}\left(a^2\boldsymbol{\sigma_m \sigma_m'} + 2ab\boldsymbol{\sigma_m \sigma_i'} + b^2\boldsymbol{\sigma_i \sigma_i'}\right) dt. \end{aligned}$$

We define $r^p = d\log V_t$, $r^m = d\log X_t^m$, $r^i = d\log X_t^i$ and $r^f = d\log B_t$. Also, $\mathrm{Var}\,(r^i) = \boldsymbol{\sigma_i \sigma_i',}$ $\mathrm{Var}\,(r^m) = \boldsymbol{\sigma_m \sigma_m'}$ and $\mathrm{Cov}\,\boldsymbol{(r^i, r^m) = \sigma_m \sigma_i'}$. Thus,

$$\begin{aligned} r^p &= a\left[r^m + \frac{1}{2}\mathrm{Var}\,(r^m)dt + \left(\frac{v^I}{v^E}\right)^M dt\right] + b\left[r^i + \frac{1}{2}\mathrm{Var}\,(r^i)dt + \frac{v^I}{v^E}dt\right] + (1-a-b)r^f \\ &\quad -\frac{1}{2}\left[a^2\mathrm{Var}\,(r^m) + 2ab\mathrm{Cov}\,(r^i, r^m) + b^2\mathrm{Var}\,(r^i)\right] dt. \end{aligned}$$

Using a discrete-time Euler approximation, we set $dt = 1$, and conclude

$$
\begin{aligned}
r^p \approx\; & r^f + a\left[r^m + \left(\frac{v^I}{v^E}\right)^M - r^f\right] + b\left(r^i + \frac{v^I}{v^E} - r^f\right) \\
& + \frac{1}{2}\left[a(1-a)\mathrm{Var}\left(r^m\right) + b(1-b)\mathrm{Var}\left(r^i\right) - 2ab\mathrm{Cov}\left(r^i, r^m\right)\right].
\end{aligned}
$$

6.2 The Insider's One-Period Portfolio Optimization Problem

The insider maximizes expected utility, so we substitute the wealth constraint, $W = R^p W_0(1-F)$, into the expected utility function, which results in the objective function

$$
E\left[U(W)\right] = \frac{\left[W_0\left(1-F\right)\right]^{1-\gamma}}{1-\gamma} E\left(R^{p\,1-\gamma}\right).
$$

Factor $W_0^{1-\gamma}/(1-\gamma)$ does not affect the solution to the maximization problem, so can assume that the insider chooses a and b to maximize

$$
\left(1-F\right)^{1-\gamma} E\left(R^{p\,1-\gamma}\right).
$$

Given the assumption that R^m and R^i are distributed lognormal, equation (7) shows that the portfolio return R^p is also approximately lognormal. We take the log of the objective function, and with the properties of the lognormal distribution, we conclude that the insider maximizes

$$
E(r^p) + \frac{1}{2}\left(1-\gamma\right)\mathrm{Var}\left(r^p\right) + \log(1-F).
$$

We use the continuous-time approximation in (7) to find the following moments for r^p:

$$
\begin{aligned}
E(r^p) &= r^f + a\left[E(r^m) + \left(\frac{v^I}{v^E}\right)^M - r^f\right] + b\left[E(r^i) + \frac{v^I}{v^E} - r^f\right] \\
&\quad + \frac{1}{2}\left[a(1-a)\mathrm{Var}\,(r^m) + b(1-b)\mathrm{Var}\,(r^i) - 2ab\mathrm{Cov}\,(r^i, r^m)\right], \\
\mathrm{Var}\,(r^p) &= a^2\mathrm{Var}\,(r^m) + b^2\mathrm{Var}\,(r^i) + 2ab\mathrm{Cov}\,(r^i, r^m).
\end{aligned}
$$

Substituting this result into the objective function gives us

$$
\begin{aligned}
& a\left[E(r^m) + \left(\frac{v^I}{v^E}\right)^M - r^f\right] + b\left[E(r^i) + \frac{v^I}{v^E} - r^f\right] + \frac{1}{2}a\mathrm{Var}\,(r^m) + \frac{1}{2}b\mathrm{Var}\,(r^i) \\
& \quad -\gamma ab\mathrm{Cov}\,(r^i, r^m) - \frac{1}{2}\gamma a^2\mathrm{Var}\,(r^m) - \frac{1}{2}\gamma b^2\mathrm{Var}\,(r^i) - \frac{d}{2}\frac{(b-b_{-1})^2}{b_{-1}}.
\end{aligned}
$$

First-order conditions with respect to a are

$$
\left[E(r^m) + \left(\frac{v^I}{v^E}\right)^M - r^f\right] + \frac{1}{2}\mathrm{Var}\,(r^m) - \gamma b\mathrm{Cov}\,(r^i, r^m) - \gamma a\mathrm{Var}\,(r^m) = 0,
$$

and with respect to b they are

$$
\left[E(r^i) + \frac{v^I}{v^E} - r^f\right] + \frac{1}{2}\mathrm{Var}\,(r^i) - \gamma a\mathrm{Cov}\,(r^i, r^m) - \gamma b\mathrm{Var}\,(r^i) - d\left(\frac{b-b_{-1}}{b_{-1}}\right) = 0.
$$

Solving the first-order conditions for b alone results in

$$
\begin{aligned}
\left[E(r^i) + \frac{v^I}{v^E} - r^f\right] &- \beta_{im}\left[E(r^m) + \left(\frac{v^I}{v^E}\right)^M - r^f\right] + \frac{1}{2}\left[\mathrm{Var}\,(r^i) - \mathrm{Cov}\,(r^i, r^m)\right] \\
&-\gamma\left[\mathrm{Var}\,(r^i) - \beta_{im}\mathrm{Cov}\,(r^i, r^m)\right]b - \theta\left(\frac{b-b_{-1}}{b_{-1}}\right) = 0, \qquad (19)
\end{aligned}
$$

where $\beta_{im} \equiv \text{Cov}\,(r^i, r^m)/\text{Var}\,(r^m)$.

In the power utility model with lognormal returns, the mutual fund theorem holds. That is, it is optimal for investors to hold a linear combination of the market portfolio and risk-free asset.[16] Thus, the insider should completely diversify away all company shares in the absence of trading costs ($\theta = 0$), the share-price misvaluation ($v^I/v^E = 0$) and market-level misvaluation ($(v^I/v^E)^M = 0$). We set $b = 0$ in equation (19), and find that mutual fund separation implies

$$\left[E(r^i) - r^f\right] - \beta_{im}\left[E(r^m) - r^f\right] + \frac{1}{2}\left[\text{Var}\,(r^i) - \text{Cov}\,(r^i, r^m)\right] = 0.$$

Thus our first-order condition reduces to

$$\frac{v^I}{v^E} - \beta_{im}\left(\frac{v^I}{v^E}\right)^M - \gamma c_i b - \theta\left(\frac{b - b_{-1}}{b_{-1}}\right) = 0,$$

where c_i is a positive firm-specific constant defined as $\text{Var}\,(r^i) - \beta_{im}\text{Cov}\,(r^i, r^m)$.

6.3 Econometrics Appendix

In this section, we determine whether the coefficient estimates on average q and insider trading in the investment-q equation are consistent. In the first subsection, we show that the estimate of the q coefficient is asymptotically biased downward when there is no attempt to proxy for the firm's stock-price misvaluation. In the second subsection, we find that when we add insider trading to the investment-q equation, the estimates of the coefficients on average q and insider trading are also asymptotically biased downward. This bias is increasing in the variance of the proxy error of the insider trading variable. However, the consistency of the q-coefficient estimate improves.

[16] See Campbell and Viceira (2002), p. 30.

The inclusion of the insider trading variable in the investment-q equation reduces the size of the downward asymptotic bias of the q-coefficient estimate.

We abstract from the details of final regression (13) and consider a much simpler scenario. As a reminder, we model the firm misvaluation as

$$\begin{aligned}\frac{V_{it}^{I}}{V_{it}^{E}} &= 1+\tilde{\theta}\,\%\Delta S_{it}+\beta_{im}\left(\frac{v^{I}}{v^{E}}\right)_{t}^{M} \\ &\quad +\gamma\left(\textit{industry effects}_{i}+\textit{size effects}_{it}+\textit{recent IPO}_{it}\right)+v_{it}.\end{aligned}$$

We will assume that the market-level misvaluation is always equal to zero. This implies that $\left(v^{I}/v^{E}\right)_{t}^{M}=0$, $m_{it}=0$, and V_{it}^{I}/V_{it}^{E} is equivalent to the firm-specific misvaluation. We also abstract from the industry, size and IPO effects. Thus, the misvaluation reduces to

$$\frac{V_{it}^{I}}{V_{it}^{E}}=1+\tilde{\theta}\,\%\Delta S_{it}+v_{it},$$

where $v_{it}=-\gamma w_{it}+\tilde{z}_{it}-\theta u_{it}$.[17] To ease the econometric analysis, we use the notation

$$\frac{V_{it}^{I}}{V_{it}^{E}}=1+\tilde{\theta}x_{it}+v_{it},$$

where $x_{it}\equiv\%\Delta S_{it}$. The insider trading variable, x_{it}, partially explains the firm misvaluation. However, we will need to study the effect of the proxy error, v_{it}, on our coefficient estimates.

[17] Errors w_{it}, $\tilde{z}_{it}$ and u_{it} are firm averages over random variables w_{ijt}, $\tilde{z}_{ijt}$ and u_{ijt}. Because the number of officers varies for each firm-year, v_{it} is no longer identically distributed over i and t. Its variance will depend on the number of officers in each firm-year. We overlook this result for now, and assume that v_{it} is independently and identically distributed over i and t.

6.3.1 Consistency Results without the Insider Trading Data

The investment-q equation is

$$y_{it} = \alpha_i + \beta q_{it}^I + \varepsilon_{it},$$

were we define y_{it} as I_{it}/K_{it}. However, we estimate the coefficient on average q using the equity market valuation,

$$q_{it}^E \quad = \quad q_{it}^I \left(\frac{V_{it}^E}{V_{it}^I} \right).$$

To simplify the algebra, we set $E(q_{it}^I)$ and $E\left(V_{it}^E/V_{it}^I\right)$ equal to one. The theoretical equilibrium value of q_{it}^I is one, and the assumption that $E\left(V_{it}^E/V_{it}^I\right)$ is equal to one implies that the equity market on average prices correctly. In addition, we assume independence of q_{it}^I, V_{it}^E/V_{it}^I and ε_{it}. The proxy error, v_{it}, is also independent of the misvaluation V_{it}^E/V_{it}^I, as well as q_{it}^I and ε_{it}. Random variable v_{it} is the sum of w_{it}, $\tilde{z}_{it}$, and u_{it}. Variable w_{it} is defined as the insider's random deviation from the firm's shareholding target, $\tilde{z}_{it}$ is the change in the insider's non-tradable shareholdings, and u_{it} represents the insider's random liquidity trades. All of these components of v_{it} are independent of the firm's misvaluation – though they are a determining factor of the insider trading variable, x_{it}. A final simplying assumption is that all variables are independently and identically distributed over i and t.

The ordinary least squares estimate of the q-coefficient is

$$b = \frac{\sum_i \left[\sum_t \left(q_{it}^E - \overline{q^E}_i \right) (y_{it} - \bar{y}_i) \right]}{\sum_i \left[\sum_t \left(q_{it}^E - \overline{q^E}_i \right)^2 \right]},$$

where $\bar{y}_i$ is the within-firm average of y_{it} and $\overline{q^E}_i$ is the within-firm average of q^E_{it}. Consistency results for the estimate of the q-coefficient are that[18]

$$
\begin{aligned}
\text{plim}\, b &= \beta\left[\text{Var}\,(q^I)/\text{Var}\,(q^E)\right] \\
&= \beta\,\frac{\text{Var}\,(q^I)}{\text{Var}\,(q^I) + E\left({q^I}^2\right)\text{Var}\,(V^E/V^I)},
\end{aligned}
\tag{20}
$$

where $\text{Var}\,(q^E) = \text{Var}\,(q^I) + E\left({q^I}^2\right)\text{Var}\,(V^E/V^I)$. We conclude that if we do not control for the firm's stock price misvaluation, then the q-coefficient is asymptotically biased downwards. This bias increases with the variance of the measurement error, V^E/V^I.

6.3.2 Consistency Results with the Insider Trading Data

Now suppose we include in the regression the insider trading variable, x_{it}. Once again the investment-q equation is

$$
\begin{aligned}
y_{it} &= \alpha_i + \beta q^I_{it} + \varepsilon_{it} \\
&= \alpha_i + \beta q^E_{it}\left(\frac{V^I_{it}}{V^E_{it}}\right) + \varepsilon_{it} \\
&= \alpha_i + \beta q^E_{it}\left(1 + \tilde{\theta} x_{it} + v_{it}\right) + \varepsilon_{it} \\
&= \alpha_i + \beta q^E_{it} + \lambda q^E_{it} x_{it} + e_{it},
\end{aligned}
$$

where $\lambda \equiv \beta\tilde{\theta}$ and $e_{it} \equiv \beta q^E_{it} v_{it} + \varepsilon_{it}$. Thus, when we include x_{it} in the estimation model, we end up with an ordinary least squares regression with independent variables q^E_{it} and $q^E_{it} x_{it}$. The remaining unmeasurable component of V^I_{it}/V^E_{it}, v_{it}, remains in the model as measurement error.

[18] Proof is available from the author upon request.

If we let b' and l denote the least squares coefficients of β and λ, then

$$\begin{aligned}\operatorname{plim} b' &= \beta \frac{E\left({q^E}^2\right)\mathrm{Var}\,(q^I)\mathrm{Var}\,(1+v) + E\,(1+v)\,E\left({q^I}^2\right)\mathrm{Var}\,(q^I)\mathrm{Var}\,(V^E/V^I)}{E\left({q^E}^2\right)\mathrm{Var}\,(q^E)\mathrm{Var}\,(1+v) + E\left({q^I}^2\right)\mathrm{Var}\,(q^I)\mathrm{Var}\,(V^E/V^I)}, \\ \operatorname{plim} l &= \lambda \frac{E\left({q^I}^2\right)\mathrm{Var}\,(q^I)\mathrm{Var}\,(V^E/V^I)}{E\left({q^E}^2\right)\mathrm{Var}\,(q^E)\mathrm{Var}\,(1+v) + E\left({q^I}^2\right)\mathrm{Var}\,(q^I)\mathrm{Var}\,(V^E/V^I)}.\end{aligned}$$

Also, we estimate $\tilde{\theta}$ as l/b'. If we let t denote this estimate, then[19]

$$\operatorname{plim} t = \tilde{\theta} \frac{E\left({q^I}^2\right)\mathrm{Var}\,(q^I)\mathrm{Var}\,(V^E/V^I)}{E\left({q^E}^2\right)\mathrm{Var}\,(q^I)\mathrm{Var}\,(1+v) + E\,(1+v)\,E\left({q^I}^2\right)\mathrm{Var}\,(q^I)\mathrm{Var}\,(V^E/V^I)}.$$

We interpret these results when $E\,(1+v) = 1$. This occurs when v is a mean-zero random variable, and thus $1+\tilde{\theta}x$ is an unbiased estimator of the stock price misvaluation, V^I/V^E. Because $\mathrm{Var}\,(q^E) > \mathrm{Var}\,(q^I)$, we can clearly see that the coefficient on average q is still asymptotically biased downward, that is $\operatorname{plim} b' < \beta$. It is also easy to show that $\operatorname{plim} b' > \operatorname{plim} b$, where b is the q-coefficient estimate of the investment-q equation without insider trading (see equation (20) of the previous subsection). Thus, including the insider trading variable improves the consistency of the q-coefficient estimate. It is also important to note that $\operatorname{plim} b'$ is decreasing in the variance of the proxy error, $1+v$. Therefore, any expected benefits from including the insider trading variable in the investment-q equation on the q coefficient will depend on the size of this variance. In addition, the coefficients on l and t will also be asymptoticaly biased downward. The size of their downward asymptotic bias is also increasing in the variance of the proxy error.

[19]Proof is available from the author upon request.

6.4 Data Appendix

6.4.1 Insider Trading Data

We use data from the Securities and Exchange Commission's Ownership Reporting System (ORS). The ORS data file contains selected variables from Form 3 and Form 4 filings required by Section 16(a) of the Securities Exchange Act of 1934. Insiders, defined as officers, directors and large shareholders are required by the SEC to file an initial statement of ownership (Form 3) and statements of changes in ownership (Form 4) for all equity, debt and derivative securities. Form 3 filings contain total number and types of securities held. Form 4 filings contain details of transactions by insiders after the initial Form 3: sales and purchases of securities, transaction prices, and the resulting stock of securities held. The observation unit is the individual insider's transaction. We focus our analysis solely on common shares held by officers. Insiders are required to report ownership data on derivative securities, such as stock options, but the ORS does not include this data. We also restrict our analysis to shares that are directly held. Shares indirectly held by officers – for example, shares owned by family members – are difficult to track in the data.

Insiders, when filing their holdings, choose from a list of codes to identify their relationship with the firm. For example, codes include Director (D), Officer (O) and Officer and Director (OD). We include all insiders filing under the categories labeled Officer, Chairman of the Board, Controlling Person, General Partner and Limited Partner. Because insiders often have more than one relationship with respect to their company, we define an officer as any person who declares the officer relationship at any point in the sample period. For example, an insider who is both an officer and director may switch between reporting categories (O), (D) and (OD) through time. Thus, if an (O) or (OD) code is observed even once for that insider, she is categorized as an officer.

CRSP and Compustat databases are used to identify companies in the ORS data set. Firms are uniquely identified in the SEC data by their CUSIP codes. CRSP is used as an intermediary to map ORS CUSIPs to Compustat company codes. Compustat also reports CUSIP identifiers, however, it only stores the last known CUSIP code for each company. The ORS CUSIP codes are as they were originally reported at the time of the trade, and CUSIPs frequently change for the same firm. CRSP tracks CUSIP code changes. We first merge the ORS data set with the CRSP U.S. Stock Database in order to assign unique CRSP company codes. Then each CRSP company is mapped into a Compustat company by use of the most recently assigned CUSIP. We are able to match 94 percent of all ORS data observations to a unique CRSP company. From that sample, 78 percent of CRSP companies are matched to a Compustat company. We also use CRSP to identify firms with multiple classes of common shares. Because it is difficult to identify ownership of different classes of shares in the ORS data, we exclude firms with more than one share class from our analysis. Multiple share-class firms represent only 1.4 percent of the firms in our sample.

We track trades over time for each officer in the data set so that we can construct variable $\%\Delta S_{ijt}$. We define $\%\Delta S_{ijt}$ as the percentage change in the stock of shares held by officer j in firm i from end-of-fiscal year $t-1$ to end-of-fiscal year t. Each time the officer trades, she must report the resulting total number of shares held. We use the officer's last trade of the year to identify end-of-year shareholdings. If an officer does not report a trade during the fiscal year, then the total number of shares held is set equal to a missing value, with the exception of one case. Suppose that the insider reports a trade in 1983 and 1985, though not in 1984. In this case, we assume that end-of-year shareholdings in 1984 are equal to the total number of shares held in 1983. Only when there is a one-year gap between years with valid data do we assume total shareholdings in the absence of a trade. We adjust all reported shares held for changes in the firm's total shares outstanding. We use CRSP to identify events, such as stock splits, that change the firm's number of outstanding shares.

There is one additional technical fact about the ORS data file that makes tracking insiders over time difficult. While CUSIP codes uniquely identify each company through time, insiders are identified by name only. The name of each insider is formatted into one data field – first, middle and last name are not parsed. Thus, as we move through the sample, and the data entry changes for insider names, it becomes difficult to track trades for the same officer. Thus, a significant amount of time was spent programming an algorithm to match names over time. Name changes were successfully matched for all officers but 3.5 percent of the sample. These remaining officers are left out of the results.

6.4.2 Compustat Data

The investment-capital ratio and average q are constructed using the standard Compustat data variables. The investment-capital ratio is defined as capital expenditures (item 128) divided by the lagged value of net property, plant and equipment (item 8). Average q is constructed as the market value of assets divided by the book value of assets (item 6). The market value of assets is set equal to the book value of assets plus the market value of common equity (item 25 $\times$ item 199) less the book value of common equity (item 60) and deferred taxes (item 74). Cash flow is the sum of income before extraordinary items (item 18) and depreciation (item 14).

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Table 1. Data summary statistics, 1981-1989

	Mean	25th percentile	Median	75th percentile	Standard deviation
	A. All firms				
q_{it}^E	1.53	0.96	1.18	1.63	1.32
I_{it}/K_{it}	0.25	0.12	0.21	0.33	0.19
$\%\Delta S_{it}$	16.3%	-6.8%	1.7%	27.6%	51.3%
CF_{it}/K_{it}	0.27	0.13	0.30	0.52	4.29
Number of years firm is in sample	4.4	2.0	4.0	7.0	2.9
Number of years officer is in sample	3.0	1.0	2.0	4.0	2.0
Number of officers trading by firm-year	5.0	2.0	3.0	6.0	5.4
Average dollar holdings of officer[b]	$4,223,026	$135,144	$458,132	$1,544,733	$53,437,486
	B. Small firms[a]				
q_{it}^E	1.31	0.86	1.02	1.34	1.10
I_{it}/K_{it}	0.22	0.08	0.16	0.30	0.20
$\%\Delta S_{it}$	14.6%	-5.7%	0.0%	15.3%	58.6%
CF_{it}/K_{it}	-0.26	-0.11	0.15	0.39	8.90
Number of years firm is in sample	3.5	2.0	3.0	5.0	2.4
Number of years officer is in sample	2.6	1.0	2.0	3.0	1.8
Number of officers trading by firm-year	1.9	1.0	1.0	2.0	1.45
Average dollar holdings of officer[b]	$1,863,709	$81,363	$347,436	$1,583,048	$5,783,534
	C. Medium Firms[a]				
q_{it}^E	1.55	0.94	1.14	1.54	1.64
I_{it}/K_{it}	0.26	0.12	0.21	0.35	0.19
$\%\Delta S_{it}$	14.4%	-9.1%	0.0%	22.6%	54.7%
CF_{it}/K_{it}	0.32	0.13	0.30	0.53	3.64
Number of years firm is in sample	4.4	2.0	4.0	7.0	2.7
Number of years officer is in sample	2.8	1.0	2.0	4.0	1.9
Number of officers trading by firm-year	3.1	1.0	2.0	4.0	2.4
Average dollar holdings of officer[b]	$2,913,795	$103,946	$390,583	$1,621,811	$11,237,980
	D. Large firms[a]				
q_{it}^E	1.58	1.02	1.28	1.78	1.07
I_{it}/K_{it}	0.26	0.15	0.22	0.33	0.17
$\%\Delta S_{it}$	18.5%	-5.7%	7.7%	33.5%	45.5%
CF_{it}/K_{it}	0.45	0.19	0.34	0.54	0.73
Number of years firm is in sample	5.9	3.0	6.0	9.0	2.9
Number of years officer is in sample	3.2	1.0	3.0	5.0	2.1
Number of officers trading by firm-year	7.6	3.0	6.0	10.0	6.7
Average dollar holdings of officer[b]	$4,933,966	$153,704	$493,226	$1,512,861	$62,543,766

[a] Small firms are deciles 1 through 3 of the CRSP Stock File Capitalization Decile Indices. Medium firms are deciles 4 through 7, and large firms 8 through 10.
[b] Data are in 1992 dollars – share prices are deflated by the level of the CRSP value-weighted index.

Table 2. OLS regression results, 1981-1989
Dependent variable I/K on q and $q \times$ insider trading

	Size of average officer holdings					
	$\geq \$0$		$\geq \$100,000$		$\geq \$250,000$	
	A. All firms					
$q^E_{i,t-1}$	.035***	.035***	.036***	.036***	.036***	.036***
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
$q^E_{i,t-1}\%\Delta S_{i,t-1}$ [a]		.0002		-.0000		.0006
		(.0007)		(.0008)		(.0008)
Implied $\tilde{\theta}$ [a,b]		.005		-.000		.018
		(.021)		(.022)		(.022)
R^2	.503	.503	.501	.501	.502	.502
N	14082		13197		12296	
Number of firms	3232		3047		2888	
	B. Firms with ≥ 3 sample years					
$q^E_{i,t-1}$	.042***	.042***	.043***	.043***	.045***	.045***
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
$q^E_{i,t-1}\%\Delta S_{i,t-1}$ [a]		.0015*		.0016**		.0034***
		(.0008)		(.0008)		(.0009)
Implied $\tilde{\theta}$ [a,b]		.034*		.038**		.077***
		(.018)		(.020)		(.020)
R^2	.446	.446	.443	.443	.441	.441
N	12407		11607		10752	
Number of firms	2066		1942		1815	
	C. Firms with ≥ 5 sample years					
$q^E_{i,t-1}$	.047***	.047***	.047***	.047***	.049***	.048***
	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)
$q^E_{i,t-1}\%\Delta S_{i,t-1}$ [a]		.0020**		.0026***		.0035***
		(.0009)		(.0009)		(.0010)
Implied $\tilde{\theta}$ [a,b]		.043**		.056***		.072***
		(.019)		(.021)		(.021)
R^2	.411	.412	.408	.408	.407	.408
N	9884		9224		8439	
Number of firms	1338		1252		1149	

Note: All regressions are specified with firm-level fixed effects. Standard errors are in parentheses.

[a] Coefficient reflects the effect of a standard deviation change of the insider trading variable.
[b] Coefficient $\tilde{\theta}$ represents the change in our forecast of management's expectation of the percentage stock price misvaluation with respect to a change in the insider trading variable. We estimate $\tilde{\theta}$ by dividing the coefficient on $q^E_{i,t-1}\%\Delta S_{i,t-1}$ by the coefficient estimate of $q^E_{i,t-1}$. We use the delta method to calculate the standard error.

$^{*}p < .10$ $\quad$ $^{**}p < .05$ $\quad$ $^{***}p < .01$

Table 3. OLS regression results, 1981-1989[a]
Dependent variable I/K on $q \times$ time effects and $q \times$ insider trading

$q^E_{i,t-1} \times t_{1981}$	.077***	.077***	.077***	.077**	.077***
	(.004)	(.004)	(.004)	(.004)	(.004)
$q^E_{i,t-1} \times t_{1982}$	.059***	.059***	.058***	.059***	.060***
	(.004)	(.004)	(.004)	(.004)	(.004)
$q^E_{i,t-1} \times t_{1983}$	.046***	.046***	.046***	.046**	.047***
	(.003)	(.003)	(.003)	(.003)	(.003)
$q^E_{i,t-1} \times t_{1984}$	.047***	.048***	.047***	.047***	.048***
	(.003)	(.003)	(.003)	(.003)	(.003)
$q^E_{i,t-1} \times t_{1985}$	.054***	.054***	.053***	.053***	.054***
	(.004)	(.004)	(.004)	(.004)	(.004)
$q^E_{i,t-1} \times t_{1986}$	.033***	.034***	.033***	.034***	.034***
	(.003)	(.003)	(.003)	(.003)	(.003)
$q^E_{i,t-1} \times t_{1987}$	.028***	.029***	.027***	.028***	.029***
	(.003)	(.003)	(.003)	(.003)	(.003)
$q^E_{i,t-1} \times t_{1988}$	.039***	.040***	.038***	.039***	.039***
	(.004)	(.004)	(.004)	(.004)	(.004)
$q^E_{i,t-1} \times t_{1989}$	.036***	.037***	.036***	.036***	.037***
	(.004)	(.004)	(.004)	(.004)	(.004)
Average $q^E_{i,t-1}$	.047***	.047***	.046***	.046***	.047***
	(.002)	(.002)	(.002)	(.002)	(.002)
$q^E_{i,t-1}\%\Delta S_{i,t-1}$ [b]			.0033***	.0032***	
			(.0009)	(.0009)	
$q^E_{i,t-1}\%\Delta S^w_{i,t-1}$ [b,d]					.0031***
					(.0011)
Implied $\tilde{\theta}$ [b,c]			.071***	.070***	.065***
			(.021)	(.021)	(.024)
$CF_{i,t-1}/K_{i,t-1}$		.001***		.001***	.001***
		(.000)		(.000)	(.000)
R^2	.425	.427	.426	.428	.427
N	9224	9218	9224	9218	9218
Number of firms	1252	1252	1252	1252	1252

Note: All regressions are specified with firm-level fixed effects. Standard errors are in parentheses.

[a] Results reflect use of the subsample where average officer holdings $\geq \$100,000$ and firms have ≥ 5 sample years.
[b] Coefficient reflects the effect of a standard deviation change of the insider trading variable.
[c] Coefficient $\tilde{\theta}$ represents the change in our forecast of management's expectation of the percentage stock price misvaluation with respect to a change in the insider trading variable. We estimate $\tilde{\theta}$ by dividing the coefficient on $q^E_{i,t-1}\%\Delta S_{i,t-1}$ by the coefficient estimate of $q^E_{i,t-1}$. We use the delta method to calculate the standard error.
[d] Variable constructed using the weighted average of the firm's insider trades. Weights are the officer's share of total shares owned by all of the firm's officers during the firm-year.

$^{*}p < .10$ $\quad$ $^{**}p < .05$ $\quad$ $^{***}p < .01$

Table 4. OLS regression results by firm size, 1981-1989 [a,b]
Dependent variable I/K on $q \times$ time effects and $q \times$ insider trading

	Size of average officer holdings	
	$\geq \$100,000$	$\geq \$250,000$
	A. All firms	
Average $q^E_{i,t-1}$	.046***	.050***
	(.002)	(.003)
$q^E_{i,t-1}\%\Delta S_{i,t-1}$ [c]	.0032***	.0038***
	(.0009)	(.0010)
$CF_{i,t-1}/K_{i,t-1}$	.001***	.001***
	(.000)	(.000)
R^2	.428	.431
N	9218	8433
Number of firms	1252	1149
	B. Results with firm-size interactions	
Small firms [b]		
Average $q^E_{i,t-1}$	.003 [d]	.002 [d]
	(.007)	(.007)
$q^E_{i,t-1}\%\Delta S_{i,t-1}$ [c]	.0062**	.0073*** [d]
	(.0029)	(.0027)
N	983	824
Medium firms [b]		
Average $q^E_{i,t-1}$	.024*** [d]	.028*** [d]
	(.003)	(.003)
$q^E_{i,t-1}\%\Delta S_{i,t-1}$ [c]	.0043***	.0064*** [d]
	(.0016)	(.0018)
N	2950	2599
Large firms [b]		
Average $q^E_{i,t-1}$	.068***	.070***
	(.003)	(.003)
$q^E_{i,t-1}\%\Delta S_{i,t-1}$ [c]	.0021*	.0016
	(.0013)	(.0012)
N	5285	5010
$CF_{i,t-1}/K_{i,t-1}$	.001***	.001***
	(.000)	(.000)
R^2	.448	.451

Note: All regressions are specified with firm-level fixed effects. Standard errors are in parentheses.

[a] Results reflect firms with ≥ 5 sample years.
[b] Small firms are deciles 1 through 3 of the CRSP Stock File Capitalization Decile Indices. Medium firms aredeciles 4 through 7, and large firms 8 through 10.
[c] Coefficient reflects the effect of a standard deviation change of the insider trading variable.
[d] Coefficient estimate is significantly different than the large-firm coefficient estimate.

$^*p < .10$ $\quad$ $^{**}p < .05$ $\quad$ $^{***}p < .01$

Table 5. OLS regression results, 1981-1989[a]
Dependent variable I/K on q, $q \times$ CAPM beta $\times$ time effects and $q \times$ insider trading

	NYSE/AMEX Firms				
	A. Time-varying CAPM betas				
$q^E_{i,t-1}$	.075***	.074***	–	–	–
	(.004)	(.004)	–	–	–
$q^E_{i,t-1}\%\Delta S_{i,t-1}$[b]		.0039***	.0033***	.0034***	.0029**
		(.0012)	(.0012)	(.0012)	(.0012)
$CF_{i,t-1}/K_{i,t-1}$	.109***	.108***	.089***	.100***	.084***
	(.006)	(.006)	(.005)	(.006)	(.006)
$q \times$ CAPM beta $\times$ time effects	N	N	Y	N	Y
$q \times$ industry effects	N	N	N	Y	Y
$q \times$ firm size effects	N	N	N	Y	Y
$q \times$ recent IPO	N	N	N	Y	Y
R^2	.476	.478	.519	.498	.528
N	5848	5848	5848	5821	5821
Number of firms	808	808	808	806	806
	B. Average CAPM betas				
$q^E_{i,t-1}$	.075***	.074***	–	–	–
	(.004)	(.004)	–	–	–
$q^E_{i,t-1}\%\Delta S_{i,t-1}$[b]		.0039***	.0035***	.0034***	.0031***
		(.0012)	(.0012)	(.0012)	(.0012)
$CF_{i,t-1}/K_{i,t-1}$	.109***	.108***	.089***	.100***	.085***
	(.006)	(.006)	(.005)	(.006)	(.006)
$q \times$ beta $\times$ time effects	N	N	Y	N	Y
$q \times$ industry effects	N	N	N	Y	Y
$q \times$ firm size effects	N	N	N	Y	Y
$q \times$ recent IPO	N	N	N	Y	Y
R^2	.476	.478	.517	.498	.527
N	5848	5848	5848	5821	5821
Number of firms	808	808	808	806	806

Note: All regressions are specified with firm-level fixed effects. Standard errors are in parentheses.

[a] Results reflect use of the subsample where average officer holdings $\geq$ \$100,000 and firms have $\geq$ 5 sample years.
[b] Coefficient reflects the effect of a standard deviation change of the insider trading variable.

$^{*}p < .10$ $^{**}p < .05$ $^{***}p < .01$