Fundamentals, Misvaluation, and Investment: The Real Story

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Abstract: Is real investment fully determined by fundamentals or is it sometimes affected by stock market misvaluation? We introduce three new tests that: measure the reaction of investment to shocks for firms that may be overvalued; use Fama-MacBeth regressions to determine whether measured overinvestment affects subsequent returns; and analyze the time path of the marginal product of capital in reaction to fundamental and misvaluation shocks. Besides these qualitative tests, we introduce a measure of misvaluation into standard investment equations to estimate the quantitative effect of misvaluation on investment. Overall, the evidence suggests that both fundamental and misvaluation shocks affect investment.

Keywords: investment, stock market, fundamentals, misvaluation, bubbles, real effects of financial markets

JEL codes: E44, E22, E32, G3

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"Perhaps the crucial, and relatively neglected, issues have to do with real consequences of financial markets. ... Does market inefficiency have real consequences, or does it just lead to the redistribution of wealth from noise traders to arbitragers and firms?"

Andrei Shleifer, *Inefficient Markets*, p. 178

1 Introduction

Some observers believe that the 2001 U.S. recession was the culmination of a stock market bubble that led to unusually high levels of business fixed investment in the late 1990s (especially in the sectors of the economy that were most affected by the bubble) and the collapse of investment as some firms attempted to reverse bubble-induced excesses. If correct, this account has important implications for finance theory and policy. In fact, there has been a lively debate about the appropriate policy response to a possible bubble and, more generally, the role of asset prices in policy formulation.[1] In this paper, we examine whether capital expenditures are determined solely by fundamentals or whether stock market misvaluation sometimes affects investment.

For most economists, some skepticism seems appropriate about the idea that misvaluation leads to overinvestment. Before the late 1990s, many economists doubted that stock prices deviated much from fundamentals. Even if one is now prepared to recognize that the shares of firms may sometimes be misvalued, it is far from obvious that this will have any meaningful effect on real investment.

Our prior is that fundamentals play a large role in determining investment. The role of misvaluation is less clearly established. At the level of basic finance theory, even if managers believe that their firms' shares are overvalued, they could issue shares and invest the proceeds in cash or fairly priced securities (such as T-bills) without increasing real investment. We refer to this as the "passive financing mechanism." On the other hand, overvaluation may suggest a low cost of equity finance. If managers perceive the

[1] For example, see Bean (2004), Bernanke (2003), Bernanke and Gertler (1999), Borio and White (2003), Cecchetti (2006), Dupor (2002, 2005), Gilchrist and Leahy (2002), Hunter, Kaufman, and Pomerleano (2003), and references cited therein for a discussion of these policy issues.

cost of capital as low, they may proceed with investment projects that would have negative net present value in the absence of overvaluation. We refer to this as the "active financing mechanism." The passive financing mechanism implies that misvaluation does not affect investment, while the active financing mechanism implies that misvaluation does affect investment.[2]

The debate concerning the relevance of passive vs. active financing remains unsettled in theoretical models. Blanchard, Rhee, and Summers (1993) and Morck, Shleifer, and Vishny (1990) argue for the passive financing mechanism, suggesting that firms should engage in financial arbitrage without letting misvaluation affect investment. In contrast, in the De Long, Shleifer, Summers, and Waldmann (1989) model, firms must precommit to their investment plans, and it is rational for managers to let misvaluation influence investment. Stein (1996), Baker, Stein, and Wurgler (2003), Gilchrist, Himmelberg, and Huberman (2005) and Polk and Sapienza (2006) all provide models in which rational managers increase investment in response to overvaluation of their firm's shares. Panageas (2005a, 2005b) develops a model in which the response of investment to overvaluation depends on investors' horizons and ownership stakes. Given this diversity of views, even if one is prepared to accept that firms are sometimes misvalued, finance theory does not provide a definitive answer on whether overvalued firms will overinvest. Empirical evidence is required.

The existing empirical evidence is also mixed. Some papers have found evidence that misvaluation affects investment, while others have not.[3] This suggests that power may be an important issue. Through much of the paper, we therefore focus on a set of firms that are more likely to be misvalued. If we fail to find evidence of the effect of misvaluation on investment among these firms, we are unlikely to find it anywhere.

We focus on growth firms, which have been defined as firms with high stock market prices (relative to an accounting-based measure of the firm, such as book equity, earnings, or sales). In contrast, value firms have been defined as firms with relatively low stock market prices. Value firms substantially outperform growth firms, with 8-10%

[2] The link between overvaluation and investment has been discussed by Keynes (1936), Bosworth (1975), Fischer and Merton (1984), Galeotti and Schiantarelli (1994), Chirinko and Schaller (1996, 2001), and Stein (1996), among others.
[3] We review the empirical evidence in more detail in Section 6.

higher annual returns averaged over the five years subsequent to portfolio formation. A leading interpretation is that investor sentiment affects stock market prices and growth portfolios include many temporarily overvalued firms. An alternative explanation is that the risk characteristics of growth and value portfolios differ. [4] The possibility that risk explains differences in returns between portfolios of growth and non-growth firms will feature in our tests.

According to both the active financing and passive financing stories, overvalued firms should issue equity. Do growth firms issue shares? Using a large, unbalanced panel data set of almost 100,000 observations of U.S. firms over the period 1980-2004, we find that the median growth firm issues enough new shares to finance 75% of its annual investment spending. In contrast, the median value firm issues no shares.

While the data on equity issuance do not directly contradict the idea that misvaluation exists and affects real investment, they do not provide definitive evidence. Growth firms might simply be firms that have received favorable fundamental shocks. These shocks would raise the firms' marginal Q, increase their investment, and perhaps induce them to issue new shares to finance their increased investment spending.

The main contribution of this paper is to introduce three new tests that are designed to determine whether investment is fully determined by fundamentals or whether misvaluation sometimes affects investment.

First, some models suggest agents have extrapolative expectations. In these models, agents may overreact to a sequence of positive or negative shocks. Barberis, Schleifer, and Vishny (1998) propose this mechanism as a possible explanation for the difference in returns between growth and value firms. If some investors have extrapolative expectations and if the financing mechanism is active, then growth firms will tend to overreact to a sales shock. By estimating Vector Autoregressions (VARs) and plotting the associated impulse response functions, we find that the investment of growth firms responds strongly to sales shocks. We use propensity score matching to test whether the magnitude of the growth firms' reaction can be accounted for by risk (or other fundamentals) and find that misvaluation plays a significant role.

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[4] See, for example, Campbell and Vuolteenaho (2004) and Cohen, Polk, and Vuolteenaho (2003).

Second, we examine stock market returns. Under the efficient markets hypothesis, information available last year should have no affect on stock market returns in future years. Even if there is misvaluation and returns are predictable to some extent, as long as misvaluation does not affect investment, a measure of overinvestment should have no significant predictive power for future returns. On the other hand, suppose a firm enters the growth portfolio as the result of a misvaluation shock. If misvaluation influences investment decisions, the firm will tend to overinvest. Eventually, this excess investment will become apparent to investors, leading to lower stock market returns for overinvesting growth firms. We test for the effect of measured overinvestment on the returns of growth firms using Fama-MacBeth regressions. We find that measured overinvestment at the time of portfolio formation has significant predictive power for future excess returns. The economic magnitude is substantial: a one-standard-deviation increase in measured overinvestment reduces cumulative excess returns over the next five years by about 500 basis points per year.

Third, we analyze how the time path of the marginal product of capital reacts to fundamental shocks and misvaluation shocks. A favorable fundamental shock increases a firm's stock price and shifts up its *demand curve* for capital (i.e., its marginal product of capital schedule). At the original capital stock, the marginal product of capital is higher. As the firm increases its capital stock in response to the shock, the marginal product of capital gradually declines. In contrast, if the active financing mechanism is operative, a misvaluation shock shifts down the *supply curve* for capital (due to cheaper equity financing). The marginal product of capital declines around the time of portfolio formation (as firms increase their capital stock to equate the marginal product of capital to the lower cost of capital) and later rises as the misvaluation gradually dissipates. In the data, the marginal product of capital for growth firms follows such an "elongated U" pattern, falling around the time of portfolio formation and then gradually rising back to its pre-shock level. We use two additional approaches in an effort to draw out the respective roles of fundamental and misvaluation shocks.

While the above qualitative evidence is suggestive of some role for misvaluation, it does not address the question of how large an effect misvaluation has on investment. An additional contribution of the paper is to directly estimate the effect of misvaluation on investment. We present parametric estimates based on four standard investment specifications -- a generic investment specification, the neoclassical model, the flexible accelerator model, and the Tobin's Q model. Coefficient estimates imply that a one-standard-deviation increase in misvaluation raises investment by more than 30%.

The paper is organized as follows. Section 2 describes the data and provides summary statistics for the full sample. Section 3 explains the idea of extrapolative expectations and presents the "overreaction test," the test based on the response of the growth portfolio to a shock. Section 4 presents Fama-MacBeth tests of the effect of a measure of measured overinvestment on future returns. Section 5 examines the time path of the marginal product of capital. Section 6 presents quantitative estimates of the effect of misvaluation on investment. Section 7 concludes and discusses the implications of the results.

2 Data Description

2a Data Sources and Construction

The data is primarily drawn from CompuStat and CRSP. The sample period is 1980-2004. To minimize survivorship biases, we use unbalanced panel data.

We measure whether a firm is a growth or value firm in a given year using the price/sales ratio (i.e., the ratio of market value of equity to sales). The price/sales ratio has two key advantages: sales is a relatively straightforward accounting concept and is never negative.[5] Portfolios are formed by sorting all the firms for which the necessary data is available in a given year by the price/sales ratio. The two deciles with the highest stock market value (relative to sales) in a given year are classified as growth firms. The next six deciles are classified as "typical" firms. The two deciles with the lowest stock market value (again, relative to sales) are classified as value firms. The portfolio formation procedure allows a firm to be a growth firm this year, a typical firm next year,

[5] Other valuation measures are problematic. Market/book (equity value/book value) is used in the literature, but it has many disadvantages noted by Lakonishok, Shleifer, and Vishny (1994, p. 1547). The equity value/cash flow ratio suffers from the frequent occurrence of negative values for cash flow and the resulting ambiguity. (A similar concern applies to price/earning ratios.) For example, negative cash flow might characterize a very young firm with excellent growth prospects but substantial current expenses or a mature firm whose current and future profitability is in doubt.

and a value firm the year after. In fact, it is common for firms to move from one portfolio to another.

The primary variable we analyze is the ratio of investment (I) to the capital stock (K). The capital stock is calculated using a standard perpetual inventory algorithm.

There are a few extreme outliers in the data. This is a common issue in panel data studies, resulting from mergers and other accounting changes. We use standard techniques to address the issue, specifically trimming the sample by deleting the 1% tails of I/K, Sales/K, Cost/K, and real sales growth.

Further details of data construction are provided in the Appendix. Summary statistics for several of the main variables are presented in Panel A of Table 1.

2b Equity Finance

If overvaluation exists, overvaluation may give the firm the impression that equity finance is cheap. In fact, some in the field of finance believe that firms time the market to take advantage of overvaluation.[6] If this affects the firm's discount rate, some formerly negative NPV projects will become worthwhile.[7]

We normalize new share issues by investment spending. This allows us to readily address the following question: what percentage of capital expenditures in the current year is financed by new share issues? As shown in Panel B of Table 1, the median growth firm raises about 75% of its investment spending from new share issues. In contrast, the median value firm does not raise any funds from equity markets.

In the aggregate, growth firms raise about 56 percent of their investment spending from new share issues. Value firms raise only 12 percent from new share issues. The difference is highly statistically significant; the t-statistic (based on 25 annual observations) is 6.23.

[6] See, for example, Baker and Wurgler (2000) and the references cited therein.

[7] Baker, Stein, and Wurgler (2003) investigate a related issue. Like us, they are interested in whether stock market misvaluation might affect real investment, but their focus is somewhat different. They look at firms that are dependent on equity because they do not have an alternative source of external finance. They find that the investment of equity-dependent firms is more responsive to Tobin's Q.

3 Overreaction?

The Barberis, Shleifer, and Vishny model is motivated by the results of Tversky and Kahneman (1974) on the behavioral heuristic of representativeness -- the tendency for people to view events as typical or representative of a category (and to neglect the laws of probability). They suggest, for example, that "investors might classify some stocks as growth stocks based on a history of consistent ... growth" (page 308-9) without taking into account that high initial growth rates are rarely maintained into the indefinite future. In their model, the dividends that flow from the asset follow a random walk, but the investor believes that the firm moves between two regimes. In the first regime, dividends are mean reverting, while in the second regime dividends have an upward trend. Each regime is persistent, so dividends are more likely to remain in the current regime than to switch to the other regime. In assessing the probability of being in a given regime, the investor is Bayesian. This means that two successive pieces of good news make the investor more likely to believe that the firm is in the trending regime, while good news followed by bad news makes the investor think it is more likely that the firm is in the mean-reverting regime.

Barberis, Shleifer, and Vishny define overreaction in terms of the effect of sequences of good and bad news on subsequent returns. In their model, the investor receives news z_t at time t. There can be either good news (GN) or bad news (BN). Their formal definition of overreaction is an average return that is lower in the period following a sequence of good news than in the period following a sequence of bad news:

$$E[r_{t+1} \mid z_t = GN, z_{t-1} = GN, ..., z_{t-j} = GN) < E(r_{t+1} \mid z_t = BN, z_{t-1} = BN...., z_{t-j} = BN), \quad (1)$$

where r_{t+1} is the return in t+1, E[] is the investor’s expectation, and j is at least one. In their model, the investor becomes overly optimistic after a sequence of good news and thus overreacts, pushing the stock price above the level that is justified by the stochastic process for dividends. On average, subsequent pieces of news fail to confirm the investor's optimism, leading to a lower stock price than would otherwise have been the case (and thus lower returns).

In the Barberis, Shleifer, and Vishny interpretation, firms enter the growth portfolio because they have received a sequence of good news. Their model therefore predicts that a positive shock will increase the stock market price more at the time of the shock for the growth than the non-growth portfolio. In the Barberis, Shleifer, and Vishny model, this large increase in stock market price for growth firms represents overreaction. As a result, growth stocks will tend to be overvalued.[8]

Suppose for the moment that the Barberis, Shleifer, and Vishny model applies and some nontrivial number of investors make extrapolative errors. To the extent that investors make extrapolative errors (and the resulting higher stock prices push firms into the growth portfolio) and there is an active financing mechanism at work, then the response of investment to a positive shock will be stronger for growth firms than it would be if only fundamentals determined investment. Why? If investors make extrapolative errors, a positive shock will have two effects. First, since shocks contain information about future earnings, a positive shock will increase marginal Q (and thus investment). This is the conventional effect due to fundamental shocks. Second, the Barberis, Shleifer, and Vishny model implies that a positive shock will cause those with extrapolative expectations to unduly increase their estimate of the firm's value, pushing the stock price above the level that is justified by the stochastic process for earnings.[9] If there is an active financing mechanism at work, (i.e., if misvaluation affects investment), the additional increase in the stock market price will lead to an additional increase in investment beyond the conventional effect of the shock. Since the Barberis, Shleifer, and Vishny model predicts overreaction for growth firms, our test focuses on the stock price and investment reaction of the growth portfolio to shocks. Our test of whether investment responds more to a shock than is justified by fundamentals (the overreaction

[8] As shown in equation (1), the overreaction can be defined in terms of relatively low future returns. According to the Barberis, Shleifer, and Vishny model, overreaction (and the resulting misvaluation) is the reason for the relatively low future returns to growth portfolios.

[9] This implies that Tobin's Q will increase more than marginal Q. The difference between the increase in Tobin's Q and the increase in marginal Q will be the increase in overvaluation (normalized by the replacement value of the capital stock).

test) is especially appealing because it is closely linked to the Barberis, Shleifer, and Vishny (1998) model.

We implement the overreaction tests by estimating a vector autoregression (VAR) of Sales/K, Tobin's Q, and I/K using two lags. Sales is ordered first in the VAR. Under the assumption that the only shocks are to fundamentals, firms base their investment on fundamental shocks that are reflected in sales. We estimate the VAR for growth and non-growth firms separately.[10] In estimating the VAR, we are careful to include the necessary lagged values of variables for a firm that is in the growth portfolio in period t even though that firm may not have been in the growth portfolio in t-1 or t-2.

We begin with a simple test of the Barberis, Shleifer, and Vishny model. We test whether good news increases the stock market price more at the time of the news for growth than non-growth portfolios. We use the shock to sales (based on the VAR) as the measure of news. Figure 1 plots the response of Tobin's Q to good news for growth and non-growth portfolios.[11] The response of Tobin's Q is a much larger for growth than non-growth firms.

Do extrapolative expectations impact real investment? Figure 2 presents the impulse response functions of investment for growth and non-growth firms. The investment of growth firms responds about twice as much as that of non-growth firms to a one-standard-deviation sales shock. For growth firms, the peak increase in I/K is about 0.07. For non-growth firms, the peak increase in I/K is about 0.035.

Two potential alternative explanations for the difference in response between growth and non-growth portfolios are the volatility and persistence of shocks. In principle, the response could be larger for the growth portfolio because the shock is bigger. In the data, however, the difference is small. The standard deviation of the shock is 1.50 for the growth portfolio and 1.46 for the non-growth portfolio. If the shock to fundamentals were more persistent for the growth portfolio, the effect on the present

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[10] Gilchrist, Himmelburg, and Hubermann (2005) also estimate firm-level VARs to evaluate the effect of misvaluation on investment. Their empirical work is aimed at finding a link between a measure of misvaluation (dispersion in analysts' forecasts) and investment in a single VAR. By contrast, our test, which offers complementary evidence, is based on two separate VARs (estimated for portfolios that differ in the likelihood of misvaluation) and on the differential response to a shock between these portfolios.

[11] Since the numerator of Tobin's Q is the stock market value of the firm and the denominator is the replacement value of the capital stock (which moves very slowly relative to the stock market price), the impulse response function is largely driven by the reaction of the stock market price.

value of earnings (and therefore the effect on stock market price) would be larger. In fact, the persistence of the shocks is also about the same for the growth and non-growth portfolios.[12]

Another possible explanation is a difference in risk – or perhaps production technology or financial characteristics – between the growth and non-growth portfolios. To examine whether any such difference can explain the magnitude of the growth portfolio response to a sales shock, we use the propensity score matching technique developed by Rosenbaum and Rubin (1983), refined by Heckman, Ichimura, and Todd (1997, 1998), and Abadie and Imbens (2006a), and used recently in the finance literature by Druker and Puri (2005). The idea of the technique is to identify "treatment" and "control" groups. Our "treatment" group is the growth portfolio. The "control" group consists of non-growth firms. The technique uses the "control" group as a source of firms that match those in the "treatment" group in many dimensions. In our case, we want to match growth firms with non-growth firms that are as similar as possible in risk, production technology, and financial characteristics, but that are less likely than growth firms to be overvalued.

We begin by estimating a Probit regression where the dependent variable is whether an observation is in the growth portfolio. We use the following independent variables in the Probit regression: the Fama-French three-factor model betas (calculated by industry) on the excess market return factor, the size (small minus big) factor, and the book/market (high minus low) factor, as well as size, cash flow, dividends, cash, and leverage. Size is a measure of differences in production technology.[13] Cash flow, dividends, cash (all of which are normalized by beginning-of-period assets), and leverage are important financial variables; moreover, all are used in the KZ index [Kaplan-Zingales (1997)] and by Baker, Stein, and Wurgler (2003) in their index of equity dependence.[14] Details of variable construction are described in the appendix.

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[12] We checked this by calculating the impulse response of sales to a sales shock in the three-variable VAR on which Figures 1-3 are based. In the 10 years following the shock, there is no significant difference in the remaining effect of the shock between growth and non-growth portfolios.

[13] We use market capitalization as the measure of size.

[14] As a robustness check, we also estimated specifications that included marginal Q and real sales growth (over the previous three years), two measures of investment opportunities. Unfortunately, the inclusion of these variables substantially reduces our sample because many growth observations lack the required data (partly because a substantial number of growth observations are relatively new firms). Since Tobin's Q is

Table 2 presents the results from the Probit regression. The results show that the variables included in the specification are statistically significant in predicting whether a firm will be in the growth portfolio.

The propensity score is the predicted probability of being in the growth portfolio from the Probit regression.[15] We match each growth observation with the *m* closest non-growth observations (where closest is defined as the smallest absolute difference in estimated propensity scores) for the same year to form the matched non-growth portfolio. The objective of the propensity score matching is to form a portfolio of firms that are similar to the growth portfolio in risk and other characteristics but in which any potential misvaluation in the growth portfolio has been stripped out (by only including non-growth firms in the matched portfolio). We follow previous work in the finance literature (specifically, Drucker and Puri (2005)) in setting $m = 10$.[16]

Next, we use the propensity score matching technique to determine whether the response of investment to a sales shock can be accounted for by the risk, production technology, and financial characteristics of the firms in the growth portfolio. The alternative hypothesis is that misvaluation, which is excluded from the matched firms by construction, accounts for part of the response of investment by growth firms. If the response of investment can be fully accounted for by fundamentals, the movement of investment should be insignificantly different for growth and matched non-growth observations. This is not the case, as shown in Figure 3. The response of investment for the growth portfolio lies well outside the 95% confidence interval for the matched non-growth portfolio.[17]

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one of the variables in the VAR, the inclusion of marginal Q and real sales growth in the Probit doesn't justify a substantial decrease in the sample. In any case, the results were very similar when we included marginal Q and real sales growth.

[15] Heckman et al. (1997) show that using observations for which the propensity score falls outside the common support for the growth and non-growth portfolios can bias the results, so we omit observations for which the propensity score does not fall into the intersection of propensity score distributions for the growth and non-growth portfolios.

[16] Like Drucker and Puri, we find that our results are robust to other choices of m.

[17] We use a bootstrapping procedure (described in the appendix) to calculate the confidence interval.

4 Returns

4a Introduction

If the active financing mechanism is operative for a firm (i.e., if misvaluation exists and affects investment), the firm will tend to overinvest. It is hard to imagine that the consequences of sub-optimal investment will forever remain hidden from investors. If misvaluation exists and affects investment, this implies that future stock market returns will be lower for firms that are both overvalued and overinvest at the time of portfolio formation. This suggests that it might be useful to examine returns.

We are aware of two other papers that use returns in testing for an effect of misvaluation on investment. Baker, Stein, and Wurlger (2003) find a negative relationship between investment and future returns. Their specification is quite different than the specification we introduce below. They regress current investment on future returns (rather than future returns on current investment) and they include cash flow but do not include any measure of risk. Their findings are relevant, however, since their model predicts that, if misvaluation affects investment, equity-dependent firms will display a more negative relationship between current investment and future returns. Their empirical results, including their regressions of current investment on future returns, are consistent with this prediction.

Polk and Sapienza (2006) also use returns to test whether misvaluation affects investment. They focus on one period ahead returns, use six control variables (investment/assets ratio, Tobin's Q, cash flow/assets ratio, market capitalization, book equity/market equity ratio, and firm momentum), two misvaluation variables (discretionary accruals and equity issues), and sort the sample by R&D intensity, share turnover, and the Kaplan-Zingales measure of finance constraints. Like Baker, Stein, and Wurgler (2003), they conclude that misvaluation affects investment.

We address three issues in designing our returns test. First, lower future returns for growth portfolios cannot simply be accepted as evidence of overinvestment. It is necessary to show a relationship between measured overinvestment and low future returns. To address this point, we use economic theory to construct a measure of the appropriate level of investment, based on the firm's investment opportunities. Measured overinvestment is the difference between this level of investment and the firm's actual level of investment (each scaled by the firm's capital stock). We test whether measured overinvestment at the time of portfolio formation affects future returns.

Second, finance theory suggests that misvaluation will have asymmetric effects. Overvaluation may make equity financing appear cheap and thus induce managers to use too low a discount rate in evaluating investment projects. The pecking order hypothesis suggests that internal finance is typically the cheapest source of finance for firms, followed by debt, with equity financing the most expensive source. This implies that the best place to detect the active financing mechanism (in which misvaluation affects investment) is in portfolios that are more likely to contain overvalued firms, not in portfolios dominated by correctly valued or undervalued firms. We address this issue in three ways: 1) We sort firms into portfolios based on two criteria: i) likelihood of containing overvalued firms (as measured by the price/sales ratio); and ii) degree of measured overinvestment; 2) Our returns test interacts measured overinvestment with a dummy variable for growth portfolios; 3) We check whether measured overinvestment affects the returns of portfolios that are relatively unlikely to contain overvalued firms.

Third, under the semi-strong form of the efficient markets hypothesis (as defined by Fama (1991)), measured overinvestment should have no predictable effect on future returns. There is, however, a paper in the finance literature that suggests that high investment could lead to low future returns without any role for misvaluation. Titman, Wei, and Xie (2004) argue that corporate governance problems could lead to empire building by managers, specifically excessively high investment. The Titman, Wei, and Xie (2004) emphasis on the importance of corporate governance issues for investment choices is consistent with some other evidence. For example, Blanchard, Lopez-de-Silanes, and Shleifer (1994) find that firms that receive cash windfalls tend to increase investment more than can be justified by either their investment opportunities or the relaxation of finance constraints. Using a revealed preference approach, Chirinko and Schaller (2004) find that the firms that are the most likely to suffer from managerial agency problems (firms with high free cash flow and poor investment opportunities) use risk-adjusted discount rates that are 300-400 basis points lower than other firms in discounting the cash flows from investment projects. Empirically, Titman, Wei, and Xie find that substantial increases in investment, relative to past investment, are associated with low returns over the next five years. Before proceeding to our returns test, we therefore check for the Titman, Wei, and Xie effect in our data, using a variant of Fama-MacBeth (1973) regressions.

4b Corporate Governance and Investment Relative to the Past

To test for the Titman, Wei, and Xie effect, we estimate the following specification:

$$ret_{pt}^{h} = \gamma_t + \gamma_{IRP,t} IRP_{pt} + \gamma_{\beta EMR,t}\beta_{EMR,p} + \gamma_{\beta SMB,t}\beta_{SMB,p} + \gamma_{\beta HML,t}\beta_{HML,p} + \eta_{pt} \qquad (2)$$

where ret_{pt}^{h} is the cumulative excess return for horizon h, IRP_{pt} is "investment relative to the past" (the key variable in the Titman, Wei, and Xie study), β_{EMR} is the excess market return beta, β_{SMB} is the size beta, β_{HML} is the book-to-market beta, based on the Fama-French (1993) three-factor model, η_{pt} is the error term in the regression, and *t* and *p* index time and portfolio, respectively. "Investment Relative to the Past" is defined as *I/K* in the year of portfolio formation divided by the sum of *I/K* over the three years before portfolio formation. The horizon is defined such that, e.g., the two-year horizon refers to returns from the beginning of the first year after portfolio formation to the end of the second year after portfolio formation.

In each year, we divide the firms into 25 portfolios based on quintiles of the price/sales ratio and measured overinvestment and calculate the mean of IRP for each portfolio in the year of portfolio formation. We then calculate the Fama-French β s for each of the 25 portfolios. A cross-sectional regression is run for each year. The Fama-Macbeth procedure tests whether the mean of the estimated values of $\gamma_{IRP,t}$ (i.e., the mean over *t*) is significantly different from 0.

The results are presented in Panel A of Table 3 and are consistent with the findings of Titman, Wei, and Xie. High investment (relative to the past) leads to low future returns.

Although it is not obvious why the Fama-French three-factor model would cause a bias in γ_{IRP}, we check the robustness of the results in Table 3 – and in the remaining tables in this section – to an alternative model of risk. Campbell and Vuolteenaho (2004) argue that returns on the market portfolio have a cash flow component and a discount rate component and that the price of risk for the cash flow beta will be larger than the price of risk for the discount rate beta for a conservative investor (i.e., an investor with a coefficient of relative risk aversion greater than one). Empirically, they find that value stocks have higher cash flow betas than growth stocks. In contrast, growth stocks have high betas with the market portfolio, but their high market betas are predominantly discount rate betas, which have low risk prices. Campbell and Vuolteenaho's two-beta model can therefore account for the difference in returns between growth and value portfolios.[18] In Panel B, we report results from the following regression:

$$ret_{pt}^{h} = \gamma_t + \gamma_{IRP,t} IRP_{pt} + \gamma_{\beta CF,t}\beta_{CF,p} + \gamma_{\beta DR,t}\beta_{DR,p} + \eta_{pt} \qquad (3)$$

where $\beta_{CF,p}$ and $\beta_{DR,p}$ are the cash flow and discount rate betas for portfolio p, respectively. The results are similar to those in Panel A (which are based on the Fama-French three-factor model): overall, high IRP leads to low future returns.

4c Overinvestment

We now turn to our main returns test, which is designed to determine whether overinvestment (due to misvaluation) affects returns. We begin with a discussion of measuring overinvestment and then test whether measured overinvestment affects returns.

(i) Measuring Overinvestment

We begin by describing how we measure overinvestment. An obvious possibility is to use Tobin's Q. For example, we could regress investment on Tobin's Q and measure overinvestment as the amount of investment not accounted for by Tobin's Q. This would be inappropriate. If misvaluation exists, it will be reflected in the market valuation of the firm, which is the numerator of Tobin's Q. If misvaluation affects investment, the predicted value of investment (from a regression of investment on Tobin's Q) will include

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[18] A large literature discusses possible explanations for the failures of CAPM (such as the value premium) and alternative asset pricing models. See Adrian and Franzoni (2004), Campbell and Vuolteenaho (2004), Fama and French (1993), Jagannathan and Wang (1996), La Porta (1996), La Porta, Lakonishok, Shleifer, and Vishny (1997), Lakonishok, Shleifer, and Vishny (1994), Lettau and Ludvigson (2001), Lewellen and Nagel (2006), Lewellen and Shanken (2002), Petkova and Zhang (2005), and the references cited in these papers.

the effect of both fundamentals and misvaluation. Thus, using a measure of overinvestment based on Tobin's Q would systematically bias our returns test against finding an effect of misvaluation on investment.

Instead, we measure overinvestment using the macroeconomic investment literature. Abel and Blanchard (1986) present a method of constructing marginal Q that does not depend on the stock market.[19] Originally applied to aggregate data, the Abel and Blanchard technique was extended to panel data by Gilchrist and Himmelberg (1995). In their implementation, Gilchrist and Himmelberg (1995) assume a constant discount rate. Risk is a leading explanation for the difference in returns between growth and value portfolios, so this is a potential problem because variation in risk-adjusted interest rates might account for differences in investment between growth and value portfolios. We therefore extend the work of Abel and Blanchard (1986) and Gilchrist and Himmelberg (1995) so that it applies to panel data and allows for variation in discount rates, both over time and across industries. We use the Fama-French three-factor model to account for systematic risk when we calculate marginal Q.[20]

We measure overinvestment as follows. For all observations where the required data are available, we regress I/K on marginal Q. A natural question is: How well does marginal Q work in predicting investment, compared to Tobin's Q? To test this, we regress I/K on marginal Q and Tobin's Q, respectively. The fit of the two equations is about the same. The R^2 from the regression of I/K on marginal Q is 0.50 and the R^2 from the regression of I/K on Tobin's Q is 0.49. Measured overinvestment is the difference between actual I/K and the predicted value of I/K from the regression of I/K on marginal Q.

Table 4 provides evidence on two points. First, how prevalent is overinvestment among growth firms? Second, is there a systematic difference in the incidence of overinvestment between growth firms and other firms in the sample? As shown in the first row, slightly more than two-fifths of the observations for growth firms show evidence of overinvestment of 25% or more. The likelihood of overinvestment of at least 25% is about twice as high for growth firms as for non-growth firms. Extreme overinvestment -- defined as measured overinvestment of 100% or more -- is considerably more likely for growth

[19] Marginal Q is the expected present value of future marginal products of capital, which is the determinant of investment in standard economic theory.
[20] The appendix provides details of how we construct marginal Q.

firms than other firms. More than one-quarter of growth firms show evidence of extreme overinvestment. Less than one-tenth of non-growth firms show evidence of extreme overinvestment -- and less than one in twenty value firms show evidence of extreme overinvestment.

(ii) Measured Overinvestment and IRP

Since the results in subsection 4b confirm Titman, Wei, and Xie's (2004) finding that IRP affects returns, it is clear that we must control for the effect of IRP in our returns test. We therefore consider a variant of equation (2) that tests whether measured overinvestment affects the returns of growth firms, after controlling for both IRP and risk:

$$\begin{aligned} ret^h_{pt} &= \gamma_t + \gamma_{O,G,t} O_{pt} G_{pt} + \gamma_{IRP,G,t} IRP_{pt} G_{pt} \\ &\quad + \gamma_{\beta EMR,t} \beta_{EMR,p} + \gamma_{\beta SMB,t} \beta_{SMB,p} + \gamma_{\beta HML,t} \beta_{HML,p} + \eta_{pt} \end{aligned} \qquad (6)$$

where O_{pt} is the amount of measured overinvestment in the period of portfolio formation.[21]

As shown in Table 5, measured overinvestment has a strongly negative effect on the returns of growth firms.[22] Based on the Fama-French three-factor model, the estimated effect of a one-standard-deviation increase in measured overinvestment is a decrease in returns of about 300-500 basis points per year for growth firms.[23] Based on the Campbell-Vuolteenaho model, the effects of measured overinvestment are larger (as shown in Panel B of Table 5). A one-standard-deviation increase in measured

[21] Although our measure of overinvestment is based on economic theory and previous empirical work, any measure of investment opportunities is imperfect. To the extent that the classical errors-in-variables analysis applies, $\gamma_{O,G,t}$ will be biased toward zero.

[22] The results on overinvestment for growth firms in Table 5 are consistent with other evidence from the corporate finance literature. Loughran and Ritter (1995) find that returns are substantially lower for the five years following a seasoned equity offering. Since the active financing mechanism involves equity issuance (and since growth firms are heavy issuers of new shares, as shown in Table 1, Panel B), part of the explanation for the low returns Loughran and Ritter document could be that some overvalued firms overinvest.

[23] Shanken (1992) introduces a technique to correct the standard errors in Fama-MacBeth for the fact that the betas are estimated. In our application, the Shanken adjustment has a modest effect on the main result: the adjusted standard errors on $\gamma_{O,G}$ for Panel A (with the usual Fama-MacBeth standard errors in parentheses for comparison) are: 0.1466 (0.1404), 0.1588 (0.1530), 0.1434 (0.1380), 0.1715 (0.1647), for the 2-year through 5-year horizons, respectively.

overinvestment for growth firms decreases future returns by about 800-1100 basis points per year.

Is measured overinvestment capturing the same corporate governance issues that are reflected in IRP? It appears not. The coefficient on IRP for growth portfolios $\gamma_{IRP,G,t}$ is *positive* -- and significant -- when we estimate equation (6). (See Table 5, Panel A for estimates of equation (6) based on the Fama-French three-factor model.) The coefficient on IRP remains positive (and significant) for growth portfolios if we omit measured overinvestment from the regression. The empirical results suggest that measured overinvestment captures very different economic behaviour for growth firms than investment relative to the past. It is inappropriate for firms that are overvalued to carry out projects that have negative NPV based on the appropriately risk-adjusted discount rate (but positive NPV based on the low discount rate suggested by overvalued shares). In contrast, for firms that have received favorable fundamental shocks, high investment relative to the past is appropriate. The divergence between measured overinvestment and IRP is evident in the data: the correlation between O_{pt} and IRP_{pt} is positive but much less than 1 (about 0.35).

As noted above, economic theory suggests that misvaluation will have asymmetric effects. Under the pecking order hypothesis, firms that are correctly valued (or undervalued) will tend to use internal finance or debt, unless they have very promising investment opportunities.[24] Under the active financing mechanism (which implies that misvaluation exists and affects investment), we would expect to see less measured overinvestment in portfolios that are less likely to contain overvalued firms. This is consistent with the results in Table 4. Finally, a sharp prediction associated with the active financing mechanism is that, in portfolios with few overvalued firms, measured overinvestment should have little predictive power for returns. In contrast, if measured overinvestment captures something other than the active financing mechanism (e.g., corporate governance problems or managerial mistakes), then measured overinvestment

[24] This is consistent with Table 1B, which shows that the median value firm issues no equity (whereas the median growth firm issues enough new equity to finance three-quarters of its investment spending). Of course, the results in Table 1B are also consistent with the possibility that only fundamental shocks affect investment, since improvements in investment opportunities will increase the market value of firms and may induce them to issue more shares to finance these investment opportunities.

will tend to predict negative future returns for all portfolios, not just portfolios that are more likely to contain overvalued firms. We test these competing predictions by estimating the following specification:

$$\begin{aligned} ret_{pt}^{h} &= \gamma_t + \gamma_{O,NG,t} O_{pt} NG_{pt} + \gamma_{IRP,NG,t} IRP_{pt}\, NG_{pt} \\ &+ \gamma_{\beta EMR,t} \beta_{EMR,p} + \gamma_{\beta SMB,t} \beta_{SMB,p} + \gamma_{\beta HML,t} \beta_{HML,p} + \eta_{pt} \end{aligned} \quad (7)$$

This is similar to the specification in Table 5, except that we now focus on non-growth portfolios, rather than growth portfolios. The results are presented in Table 6. Measured overinvestment does not have a significant effect on returns for non-growth portfolios.

5 The Time Path of the Marginal Product of Capital

Misvaluation shocks and fundamental shocks have different implications for the time path of the marginal product of capital. As illustrated on the left-hand side of Figure 4, a favorable fundamental shock shifts out the firm's demand for capital as measured by the marginal product of capital schedule. At the existing capital stock (K_0), the marginal product of capital (MPK) rises. In the steady state, the marginal product of capital equals the user cost of capital (r in the figure). In order to restore this equality, the firm increases its capital stock, causing the marginal product of capital to decline. In the presence of adjustment costs, this process will take several years, leading to a time path of gradually declining marginal products of capital in the wake of a favorable fundamental shock. Thus, fundamental shocks have a clear implication for the time path of the marginal product of capital, as illustrated in the graph on the right hand side of Figure 4. A favorable fundamental shock leads to an increasing marginal product of capital around the time of portfolio formation and a declining marginal product of capital in subsequent years.

If a positive misvaluation shock affects the cost of equity financing, it will shift down the capital supply curve, as illustrated in Figure 5. If the user cost of capital (at least as perceived by managers) decreases, the firm will tend to increase its capital stock in an effort to equate the marginal product of capital to the new, lower cost of capital (r_1). Such increases in the capital stock cause the marginal product of capital to decline around the time of portfolio formation. As the misvaluation dissipates, the perceived cost of capital rises and the desired capital stock falls. As firms adjust their capital stock downward, the marginal product of capital rises. Thus misvaluation shocks also have a clear empirical implication for the time path of the marginal product of capital -- exactly the opposite implication from fundamental shocks. A positive misvaluation shock leads to a decrease in the marginal product of capital around the time of portfolio formation and an increase in the marginal product of capital in subsequent years.

Figure 6 plots the marginal product of capital for the growth portfolio. The time path of the marginal product of capital corresponds more closely with misvaluation shocks than fundamental shocks. The marginal product of capital falls around the time of entry into the growth portfolio and rises in subsequent years.

A caveat is in order. The discussion above focuses on realized fundamental shocks. If a firm anticipates a fundamental shock at some point in the future, it begins increasing its capital stock at the time the news of the future fundamental shock arrives. This increase in the capital stock reduces the firm's marginal product of capital. When the fundamental shock is realized, it increases the marginal product of capital. As the firm continues to increase its capital stock, the marginal product of capital again declines. Thus, an anticipated fundamental shock would lead the marginal product of capital to fall, then rise above its initial level, then fall again. (The second fall would be avoided if the firm fully adjusted its capital stock before the anticipated shock was realized, but this seems implausible in view of the widespread evidence on the sluggishness of the capital stock in adjusting to shocks.)

The fall and subsequent rise of the marginal product of capital illustrated in Figure 6 bears some resemblance to an anticipated fundamental shock, but two features of the time path are at odds with an anticipated fundamental shock. First, the marginal product of capital should rise above its original level. There is no sign of this in Figure 6. Second, the marginal product of capital should decline when the shock is realized. Five years after entry into the portfolio, there is still no sign of this decline.

The time path of the marginal product of capital for the growth portfolio supports the idea that misvaluation exists and affects investment. But we have strong priors that fundamental shocks must play an important role. We use two additional approaches in an effort to draw out the respective roles of fundamental and misvaluation shocks.

First, we note that there may be heterogeneity: some firms could be affected solely by fundamental shocks while other firms are substantially affected by misvaluation shocks. To assess the role of heterogeneity, we move to the individual firm level and classify the path of the marginal product of capital as corresponding to either a fundamental shock or a misvaluation shock. If the marginal product of capital rises from period -1 to period 0 and is less than or equal to the period 0 level in period +3, we classify the shock as fundamental. (Period "0" here refers to the year of portfolio formation. In Figure 6, this corresponds to the year the firm first enters the growth portfolio.) If the marginal product of capital falls from period -1 to period 0 and is greater than the period 0 level at period +3, we classify the shock as a misvaluation shock. All other time paths are counted as "not classifiable." We then tabulate the number of fundamental and misvaluation shocks as a percentage of all the classifiable shocks. The classifiable shocks are split nearly evenly between fundamental shocks (51%) and misvaluation shocks (49%). This suggests that both fundamental shocks and misvaluation shocks play a role in determining the investment of growth firms.

Second, we make use of propensity score matching to control for risk, production technology, and financial characteristics, as we did earlier (in Section 3). The dashed line in Figure 6 shows the marginal product of capital for the matched non-growth portfolio. At time 0 (the year of portfolio formation), the marginal product of capital of the matched non-growth portfolio rises, the response to a favorable fundamental shock predicted by economic theory. Again, as economic theory predicts in the case of a realized fundamental shock, the marginal product of capital declines after the shock, gradually returning to its pre-shock level. This provides empirical evidence that confirms the predictions of economic theory regarding the effects of a fundamental shock and suggests that realized fundamental shocks play an important role for firms that are similar to those in the growth portfolio (except for the fact that they do not have such high stock market prices). As shown by the dark line in Figure 6, the marginal product of capital for the growth portfolio behaves in the opposite way, dropping relatively sharply at time 0 and then gradually rising back to its pre-shock level. The dotted lines in Figure 6 show the 95% confidence interval for the matched non-growth path.[25] At time 0, the marginal

[25] See the Appendix for technical details about the bootstrap used to calculate the confidence interval.

product of capital for the growth portfolio moves well outside the confidence interval and it remains outside the confidence interval until three years after the shock. Together with the evidence on the proportion of fundamental and misvaluation shocks, the results in Figure 6 suggest that firms enter the growth portfolio due to both fundamental and misvaluation shocks and that this is reflected in the investment behavior of the firms and resulting path of their marginal products of capital. Neither fundamental shocks nor misvaluation shocks can be ignored if we want to understand the economic behavior of these firms.

6 How Large an Effect Does Misvaluation Have on Investment?

The evidence in preceding sections is qualitative in nature. In this section, we provide quantitative estimates of the effect of misvaluation on investment. In order to do this, we must construct a measure of misvaluation. The measure of misvaluation is Tobin's Q minus marginal Q (both measured at the beginning of the period). Tobin's Q is the market value of the firm's shares divided by the replacement cost of the firm's capital stock. Details are provided in the Appendix.

A number of earlier empirical studies have examined the relationship between stock market misvaluation and investment. Using aggregate US data, Blanchard, Rhee, and Summers (1993) find that Tobin's Q has a significant effect on investment after using a simple control for fundamentals, but they conclude that non-fundamentals have little effect on investment. Also using US aggregate data, Chirinko and Schaller (1996) find no evidence that misvaluation affects investment. In contrast, Galeotti and Schiantarelli (1994) find that non-fundamentals have a significant effect on investment, and Chirinko and Schaller (2001) obtain qualitatively similar results using aggregate Japanese data. Using firm-level US data, Morck, Shleifer, and Vishny (1990) find that movements in relative share prices are associated with statistically significant investment changes, but they conclude that misvaluation has a minor impact on investment because of low incremental R^2 s. Baker, Stein, and Wurgler (2003) find that the investment of equity-dependent firms is relatively more sensitive to Tobin's Q. Gilchrist, Himmelberg, and Huberman (2005) find that shocks to dispersion in analysts' forecasts (a proxy for misvaluation) affect investment. Polk and Sapienza (2006) find that various proxies for misvaluation affect investment after controlling for, among other variables, Tobin's Q (their proxy for fundamentals). On the other hand, Bond and Cummins (2001), after controlling for fundamentals using analysts' forecasts, find a statistically weak effect of Tobin's Q, and Bakke and Whited (2006), using a measurement-error-consistent estimator to separate fundamentals and non-fundamentals, find that the non-fundamental information in stock prices only influences small firms that have low levels of market mispricing and rely on equity finance.

In standard models of investment, key variables in the determination of investment are the interest rate, the relative price of investment goods, and output. In Table 7, we present a generic investment specification in which I/K is regressed on misvaluation and the lagged percentage changes in real sales, the relative price of investment goods, and the interest rate for the full sample of observations for which all the necessary data are available.[26] The coefficient on misvaluation in the generic investment specification is positive and highly significant (with a t-statistic of 42). The coefficient estimate of 0.0031 implies that a one-standard-deviation increase in misvaluation increases I/K by 0.039 (about 37% of the median I/K of 0.104).

Much recent research has suggested that investment is sensitive to cash flow, so in the second column of Table 7 we estimate a similar specification, this time including the ratio of cash flow to the capital stock.[27] Including cash flow in the specification has little effect on the misvaluation coefficient.

The neoclassical investment model [(Jorgenson (1963), Hall and Jorgenson (1971), Eisner and Nadiri (1968)] suggests a specification in which investment is regressed on distributed lags of the percentage change in output and the user cost of capital. In Table 8, we add misvaluation to a neoclassical investment specification. The

[26] The regression includes both fixed firm effects and time effects. The inclusion of fixed effects raises an econometric issue. Sufficiently high serial correlation of the errors may lead to biased estimates of the coefficient on the misvaluation term with fixed effects estimation. Since the residual serial correlation coefficient (about 0.25 in Tables 7-9) is approximately equal to the coefficient on the lagged dependent variable, we can use the simulation results of Judson and Owen (1999, Table 1) to evaluate coefficient bias. For T equal to five (about the average number of observations per firm in our sample), the bias in the coefficient on the regressor is less than 1%.

[27] A leading interpretation is that cash flow enters due to finance constraints, as suggested by Fazzari, Hubbard, and Petersen (1988). This interpretation has been contested by Abel and Eberly (2003), Gomes (2001), and Kaplan and Zingales (1997, 2000). See Fazzari, Hubbard, and Petersen (2000) for a reply to the Kaplan and Zingales critique and Hubbard (1998) and Schiantarelli (1995) for surveys.

coefficient on misvaluation is smaller than the coefficient in the generic investment specification. The coefficient estimate of 0.0026 implies that a one-standard-deviation increase in misvaluation increases I/K by 0.031 (about 30 percent of the median I/K of 0.104). The effect of misvaluation is again highly significant, with a t-statistic of 33. Including cash flow in the specification has little effect on the misvaluation coefficient.

The flexible accelerator model is similar to the neoclassical model except that the user cost of capital terms are omitted. As columns 3 and 4 of Table 8 show, misvaluation also has an economically and statistically significant effect on investment in the flexible accelerator model.

Finally, in Table 9, we estimate a Q model of investment. A conceptual advantage of the Q model is that Q, unlike the variables that appear in the generic, neoclassical, or flexible accelerator specifications, is explicitly forward-looking. A potential problem with the Q model is that Tobin's Q will be affected by any misvaluation in the stock market. To avoid this problem, we use marginal Q in the regression. Like Tobin's Q, marginal Q reflects expectations of future discount rates and the future stream of marginal products of capital.

The coefficient on misvaluation in the Q specification is close to the estimated coefficient in the generic investment specification. The estimated coefficient on misvaluation is 0.0029. This implies that a one-standard-deviation increase in misvaluation raises I/K by 0.036 -- about 35%, relative to the sample median of I/K. Again, the estimated effect of misvaluation is highly significant, with a t-statistic of 39. Specifications including and excluding cash flow are presented in the table; the coefficient estimate for misvaluation is similar whether or not cash flow is included in the specification.

The parametric estimates in Tables 7 to 9 indicate misvaluation has a quantitatively large effect on investment, with a one standard deviation increase in misvaluation leading to a 30% or so increase in investment. The effects in Tables 7 to 9 are more striking -- both statistically and economically -- then those found in many previous studies. There are at least three potential explanations. First, we directly estimate the effect of misvaluation. Some previous studies have used indirect approaches such as orthogonality tests (e.g., Chirinko and Schaller (1996)) or plausible proxies for misvaluation. (See the studies discussed earlier in this section.) Second, the measures of fundamentals (marginal Q) and misvaluation (which is based on marginal Q) have strong foundations in investment theory and are constructed with careful attention to issues like risk, discount rate variation, and information sets. Sharper measures of fundamentals and misvaluation should lead to sharper empirical estimates. Third, the coverage of firms in this paper is considerably more extensive than in previous studies, including many newer (and more short-lived) firms for which misvaluation (and its effect on investment) may be relatively important.

7 Conclusion and Implications

In this paper, we introduce three new tests designed to evaluate whether investment is fully determined by fundamentals or whether stock market misvaluation plays some role. We look carefully for the effect of both fundamental and misvaluation shocks and find considerable evidence that fundamental shocks play an important role in determining the investment of growth firms. However, none of the three new tests -- overreaction, returns, and marginal product of capital -- yields evidence that is consistent with the null hypothesis that investment is fully determined by fundamentals.

In Section 7, we estimate the quantitative effect of misvaluation on investment using standard investment equations. We estimate four types of investment equations -- neoclassical, accelerator, Q, and a generic specification. Consistent with the evidence in Sections 3-5, the fundamental variables (such as user cost and marginal Q) have a highly significant effect on investment. The effect of misvaluation on investment is also statistically significant. As a measure of economic significance, the estimated coefficients imply that a one-standard-deviation increase in misvaluation increases investment by about 30% relative to the median level of investment in the sample. The estimated effect of misvaluation is robust across the four types of investment equations.

Recognizing the possibility that overvaluation may lead to overinvestment opens up interesting research questions. How much distortion in capital allocation results from misvaluation? Are there institutional changes that would make misvaluation less likely? Are there institutional or policy changes that could decrease the misallocation of capital induced by misvaluation? One example of such an institutional change would be greater transparency, perhaps through reform of accounting procedures. Blanchard and Watson (1982) argue that misvaluation is more likely when agents do not know economic fundamentals. Another example flows from the evidence in this paper that the active financing mechanism plays an important role. This suggests that it might be helpful to reduce conflicts of interest that may tempt financial intermediaries to misleadingly promote securities.

A very large question is whether overvaluation can sometimes play a positive role in attenuating finance constraints and fostering economic growth. Jermann and Quadrini (2003), for example, provide a model in which small firms are finance constrained.[28] Overvaluation lowers the cost of finance and relaxes finance constraints for these firms, leading to more investment and the reallocation of capital and labor to constrained firms. The result is an increase in productivity. Much earlier, in a discussion of the 1920s, Keynes (1931) expressed similar sentiments: "While some part of the investment which was going on ... was doubtless ill judged and unfruitful, there can, I think, be no doubt that the world was enormously enriched by the constructions of the quinquennium from 1925 to 1929." Can we measure the extent to which overvaluation reduces finance constraints? If we could, it might be possible to more carefully investigate possible trade-offs between the advantages of misvaluation (fostering growth) and the disadvantages (misallocation of capital, potential for a subsequent crash and resulting recession or depression).

There are also implications for how we understand the economics of financial markets, growth, and economic fluctuations. Cochrane (1994) argues that is hard to account for macroeconomic fluctuations with conventional demand and technology shocks. The evidence presented in this paper suggests that misvaluation shocks have an effect on real variables. Can misvaluation shocks help to account for aggregate economic fluctuations? Are there other channels through which misvaluation shocks significantly affect real variables (e.g., stock price or housing price misvaluations affecting consumption, commercial property misvaluations affecting investment)? Have misvaluation shocks played a significant role in noteworthy macroeconomic episodes,

[28] See also Caballero, Farhi, and Hammour (2006).

such as the Great Depression or the late 1980s boom in Japan and the subsequent decade of stagnation?

There are important policy implications of evidence that misvaluation has real consequences. Central banks may need to pay some attention to possible stock market misvaluation. Misvaluation shocks affect asset prices but may have relatively little impact on broad measures of inflation. If misvaluation shocks can lead to overinvestment and subsequent, possibly dramatic, retrenchment, central banks may need to move beyond Taylor rules (which treat inflation and unemployment as the only legitimate inputs for monetary policy rules).

Tax policy may also have a role to play if misvaluation distorts the efficient allocation of capital. Both informal accounts and the most sophisticated recent asset pricing models suggest that the prospect of capital gains plays a key role in driving misvaluation. Agents buy assets not for their intrinsic value but because they believe that they will be able to resell the asset at a still higher price to some other agent. (See, e.g., Scheinkman and Xiong (2003).) Stiglitz (2003) argues that a relatively simple way to defuse this sort of misvaluation is by increasing the capital gains tax rate and thus reducing the speculative motive for asset acquisition.

Simply recognizing the possibility of misvaluation -- and that misvaluation can have real consequences -- might conceivably lead to more prudent fiscal decisions. Projections of tax revenues based on periods of significant misvaluation (and the associated increase in real activity) may be misleading, resulting in subsequent fiscal imbalances.

The evidence presented in this paper suggests that the questions raised in this section are relevant for developed economies with strong capital markets (such as the US). Arguably, they are even more important for developing economies with relatively weak capital markets.

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Appendix

This appendix details the construction of and data sources for several of the variables, stock portfolios, and statistics analyzed in the paper: growth and value portfolios; capital stock and investment; the user cost of capital; the real risk-adjusted market discount rate; the marginal product of capital; misvaluation, Tobin's Q, and marginal Q; and the empirical bootstrap procedures for the overreaction and marginal product of capital tests.

A. Growth and Value Portfolios

We construct the growth and value portfolios using the price/sales ratio. The price/sales ratio is Common Shares Outstanding (CompuStat item 25) times Price – Fiscal Year – Close (CompuStat item 199) divided by Net Sales (CompuStat item 12). Observations with missing or non-positive values for the price/sales ratio are dropped. Additionally, firms with a value of GPLANT less than $1 million are dropped, where GPLANT is gross property, plant, and equipment (CompuStat item 7), and the first observation for each firm is excluded. We then trim the sample, eliminating the 1% most extreme observations in each tail for the following four variables: I/K, Sales/K, Cost/K, and real sales growth. Cost is equal to Cost of Goods Sold (CompuStat item 41) plus Selling, General, and Administrative Expense (CompuStat item 189). After trimming, the remaining observations for a given year are sorted into deciles by the price/sales ratio. The top two deciles are classified as growth firms (i.e., firms with high stock market prices relative to sales). The bottom two deciles are classified as value firms (i.e., firms with low stock market prices relative to sales), and the remaining deciles are classified as typical firms.

B. Capital Stock and Investment

For the first observation for firm f, the capital stock is based on the net plant (NPLANT), the nominal book value of net property, plant, and equipment (CompuStat item 8). To convert this to real terms, we divide by the sector-specific price index for investment (p^I). Since book value is not adjusted for changes in the value of capital goods purchased in the past, we adjust the initial capital stock using the sector-specific ratio of nominal replacement cost to historical cost:

$$K_{f,t_0^f} = \frac{NPLANT_{f,t_0^f}}{p^I_{s,t_0^f}} \frac{K\$_{s,t_0^f}}{KHIST_{s,t_0^f}} \qquad \text{(B1)}$$

where K$ is the current-cost net stock of private fixed assets by sector (BEA, Table 3.1ES), KHIST is historical-cost net stock of private fixed assets by sector (BEA, Table 3.3ES), s is a sector index (for firm f's sector), and t_0^f is the year of the first observation for firm f.

For subsequent observations, a standard perpetual inventory method is used to construct the capital stock,

$$K_{f,t+1} = (1-\delta_{s,t})K_{f,t} + \frac{I_{f,t+1}}{p^I_{s,t+1}} \quad \text{(B2)}$$

where δ is the depreciation rate (defined below) and I is gross investment, which is capital expenditures in the firm's financial statements (CompuStat item 128). The firm reports capital expenditures in nominal terms, so we divide by p^I to convert to real terms.[29]

In some cases, there is a data gap for a particular firm. In this case, we treat the first new observation for that firm in the same way as we would if it were the initial observation. This avoids any potential sample selection bias that would result from dropping firms with gaps in their data.

We construct sector-specific, time-varying depreciation rates using data from the BEA. Specifically,

$$\delta_{s,t} = \frac{D\$_{s,1996} DQUANT_{s,t}}{K\$_{s,1996} KQUANT_{s,t}} \quad \text{(B3)}$$

where D$ is current-cost depreciation of private fixed assets by sector (BEA, Table 3.4ES), DQUANT is the chain-type quantity index of depreciation of private fixed assets by sector (BEA, Table 3.5ES), K$ is the current cost net stock of private fixed assets by sector (as defined above), and KQUANT is the chain-type quantity index of the net stock of private fixed assets by sector (BEA, Table 3.2ES).

We construct the sector-specific price index for investment using BEA data:

$$p^I_{s,t} = \frac{100(I\$_{s,t} / I\$_{s,1996})}{IQUANT_{s,t}} \quad \text{(B4)}$$

where I$ is historical-cost investment in private fixed assets by sector (BEA, Table 3.7ES) and IQUANT is the chain-type quantity index of investment in private fixed assets by sector (BEA, Table 3.8ES).

The variables obtained from the BEA for constructing depreciation rates and price indices for investment are calculated for 2002, 2003, and 2004 by extending the corresponding 1950 to 2001 data series, which are reported with a somewhat different classification scheme. (The data for 1950 to 2001 are on a SIC basis, while the data for

[29] The BEA tables beginning with a 3 cited in this Appendix contain data for private fixed assets, equal to the sum of nonresidential fixed assets (relevant for this study) and residential fixed assets. Residential fixed assets only enter the Real Estate and Farm industries. Since we exclude firms in the Real Estate industry and the number of firms in the Farm industry is tiny, data drawn from the BEA private fixed asset tables (those beginning with a 3) for this study pertain to nonresidential fixed assets.

2002 to 2004 are on a NAICS basis.) This extension uses BEA data for 2002 through 2004 to calculate the percentage change in a given variable between two years and then multiplies by the previous observation in the existing series to get the new value. For example, for 2002, the variable K$ is calculated for each industry as:

$$K\$_{s,2002} = K\$_{s,2001}\left(\frac{K\$^{MR}_{s,2002}}{K\$^{MR}_{s,2001}}\right) \qquad \text{(B5)}$$

where the superscript MR denotes the more recent version of the variable. The validity of this procedure was evaluated by comparing values estimated by the procedure represented in equation (B5) for 2001 with data on the prior classification for 2001. The relations among the SIC codes, BEA SIC industries, and BEA NAICS industries are detailed in the following correspondence table,

SIC Codes	BEA SIC Industries	BEA NAICS Industries
	Agriculture, forestry, & fishing	**Agriculture, forestry, fishing, & hunting**
0100-0799	Farms	Farms
0800-0999	Ag. services, forestry, & fishing	Forestry, fishing, & related activities
	Mining	**Mining**
1000-1199	Metal mining	Mining (except oil & gas) + Support activities for mining[1]
1200-1299	Coal mining	Mining (except oil & gas) + Support activities for mining[1]
1300-1399	Oil & gas extraction	Oil & gas extraction
1400-1499	Nonmetallic minerals, except Fuels	Mining (except oil & gas) + Support activities for mining[1]
1500-1799	**Construction**	**Construction**
1800-1999	No Match To BEA SIC Industries	
	Manufacturing	
	Durable goods	
2400-2499	Lumber & wood products	Wood products
2500-2599	Furniture & fixtures	Furniture & related products
3200-3299	Stone, clay, & glass products	Nonmetallic mineral products
3300-3399	Primary metals industries	Primary metals
3400-3499	Fabricated metal products	Fabricated metal products
3500-3599	Industrial mach. & equipment	Machinery
3600-3699	Electronic & other electrical Equipment	Electrical equipment, appliances, & Components
3711, 3714	Motor vehicles and equipment	Motor vehicles, bodies & trailers, & Parts
3700-3799[2]	Other transportation equipment	Other transportation equipment
3800-3899	Instruments & related products	Computer & electronic products

3900-3999	Miscellaneous mfg. industries	Miscellaneous manufacturing
	Nondurable goods	
2000-2099	Food & kindered products	Food & beverage & tobacco prods.
2100-2199	Tobacco products	Food & beverage & tobacco prods.
2200-2299	Textile mill products	Textile mills & textile prod. mills
2300-2399	Apparel & other textile prods.	Apparel & leather & allied prods.
2600-2699	Paper & allied products	Paper products
2700-2799	Printing & publishing	Printing & related support activities
2800-2899	Chemicals & allied products	Chemical products
2900-2999	Petroleum & coal products	Petroleum & coal products
3000-3099	Rubber & misc. plastic prods.	Plastics & rubber products
3100-3199	Leather & leather products	Apparel & leather & allied prods.
	Transportation & public utils.	
4300-4399	No Match To BEA SIC Industries	
	Transportation	
4000-4099	Railroad transportation	Railroad transportation
4100-4199	Local & interurban passenger Transit	Transit & ground passenger Transportation
4200-4299	Trucking & warehousing	Truck transportation + Warehousing & storage[3]
4400-4499	Water transportation	Water transportation
4500-4599	Transportation by air	Air transportation
4600-4699	Pipelines, except natural gas	Pipeline transportation
4700-4799	Transportation services	Other transportation & support Activities
4800-4899	**Communications**	Publishing industries (including software) + Broadcasting & telecommunications + Information & data processing services
4900-4999	**Electric, gas & sanitary services**	**Utilities**
5000-5199	**Wholesale trade**	**Wholesale trade**
5200-5999	**Retail trade**	**Retail trade**
6000-6799	**Finance, insurance, & real estate**	**Finance & insurance + Real estate & rental & leasing**
6800-6999	No Match To BEA SIC Industries	
	Services	
7000-7099	Hotels & other lodgings	Accommodation
7100-7199	No Match To BEA SIC Industries	

7200-7299	Personal services	**Other services, except government**
7300-7399	Business services	Computer systems design & related services and Miscellaneous professional, scientific, & technical services, + **Management of companies & enterprises + Administrative & waste management services**[4]
7400-7499	No Match To BEA SIC Industries	
7500-7599	Auto repair, services & parking	**Other services, except government**
7600-7699	Miscellaneous repair services	**Other services, except government**
7700-7799	No Match To BEA SIC Industries	
7800-7899	Motion pictures	Motion picture & sound recording Industries
7900-7999	Amusement & recreational svcs.	**Arts, entertainment, & recreation**
	Other services	
8000-8099	Health services	**Health care & social assistance**
8100-8199	Legal services	Legal services
8200-8299	Educational services	Educational services
8300-8999	Other	**Other services, except government**

Notes to the correspondence table:

1. The indexes for KQUANT (BEA, Table 3.2ES), DQUANT (BEA, Table 3.5ES), and IQUANT (BEA, Table 3.8ES) can not be added together across NAICS categories. The components are combined by taking a weighted-average of the growth rates of the NAICS indexes. The weights used to allocate Mining (except oil & gas) + Support activities for mining are (66%, 34%) for KQUANT, (59%, 41%) for DQUANT, and (57%, 43%) for IQUANT.

2. Excludes industries 3711 and 3714.

3. See note 1. The weights used to allocate Truck transportation + Warehousing & storage are (73%, 27%) for KQUANT, (87%, 13%) for DQUANT, and (82%, 18%) for IQUANT.

4. See note 1. The weights used to allocate Computer systems design & related services and Miscellaneous professional, scientific, & technical services (the indexes for Professional, scientific, and technical services are used for these computations), + Management of companies & enterprises + Administrative & waste management services are (34%, 42%, 24%) for KQUANT, (54%, 25%, 21%) for DQUANT, and (55%, 24%, 21%) for IQUANT.

C. The User Cost of Capital

The user cost of capital is calculated as follows

$$C_{f,t} = (r_{f,t} + \delta_{s,t})\left(\frac{1 - z_t - u_t}{1 - \tau_t}\right)\frac{p^I_{s,t}}{p^Y_{s,t}} \tag{C1}$$

where r is the real, risk-adjusted interest rate, z is the present value of depreciation allowances, u is the investment tax credit rate, τ is the corporate tax rate, p^I is the price of investment goods, and p^Y is the price of output. C is expressed as an annual rate, so r and δ are both expressed as annual rates. Where variables are available at a monthly or quarterly frequency, we take the average for the calendar year. The corporate tax rate is the U.S. federal tax rate on corporate income. The present values of depreciation allowances for non-residential equipment and structures were provided by Dale Jorgenson. (The data provided by Dale Jorgenson end in 2001; for 2002-04, we use 2001 values.) To calculate z, we took the weighted sum of Jorgenson's z's for equipment and structures, where the weights are the share of equipment investment and the share of structures investment (for a given year) in nominal gross private nonresidential investment in fixed assets from the Bureau of Economic Analysis (from table 1IHI, where equipment investment is referred to as equipment and software). Because the investment tax credit applies only to equipment, u=0 for structures, we multiply the statutory ITC rate for each year by the ratio of equipment investment to the sum of structures and equipment investment for that year. The corporate tax rates were provided directly by the Treasury Department, and investment tax credit rates are drawn from Pechman (1987, p.160-161). For the years 1980 to 2001, the sector-specific price index for output, p^Y, is the implicit price deflator for Gross Domestic Product by industry produced by the BEA, normalized to 1 in 1996. For 2002 through 2004, the sector-specific price index is recursively extended forward by:

$$p^Y_{s,t+1} = p^Y_{s,t}\left(\frac{p^A_{t+1}}{p^A_t}\right) \tag{C2}$$

where p^A is the aggregate non-farm business price index for gross value added (BEA Table 1.3.4).

In Table 9, the cost of capital is divided into two components -- the relative price of investment goods (including tax adjustments), defined as

$$(1 - z_t - u_t)\frac{p^I_{s,t}}{p^Y_{s,t}} \tag{C3}$$

and the real, risk-adjusted interest rate (including depreciation and the adjustment for the corporate income tax rate),

$$\left(\frac{r_{f,t}+\delta_{s,t}}{1-\tau_t}\right) \qquad \text{(C4)}$$

D. The Real Risk-Adjusted Market Discount Rate

The real, risk-adjusted market discount rate is defined as follows,

$$r_{f,t} = ((1+r_{f,t}^{NOM}) / (1+\pi_t^e)) - 1.0. \qquad \text{(D1)}$$

The equity risk premium is calculated using the Fama-French three-factor model. The components of $r_{f,t}$ are defined and constructed as follows,

$r_{f,t}^{NOM}$ = Nominal, short-term, risk-adjusted cost of capital
= $\lambda_s (1-\tau_t)\ r_t^{NOM,DEBT} + (1-\lambda_s)\ r_{s,t}^{NOM,EQUITY}$.

$r_t^{NOM,DEBT}$ = Nominal corporate bond rate (Moody's Seasoned Baa Corporate Bond Yield)

$r_{s,t}^{NOM,EQUITY}$ = Nominal, short-term, risk-adjusted cost of equity capital for firms in sector s.
= $r_t^{NOM,F} + \sigma_s$.

$r_t^{NOM,F}$ = Nominal, one-year, risk-free rate (One-Year Treasury Constant Maturity Rate)

$\pi_{s,t}^e$ = Sector-specific capital goods price inflation rate from t to t+1. Sector-specific data was not yet available for 2005 at the time of data construction, so $\pi_{s,t}^e$ for 2003 was also used for 2004.

σ_s = Equity risk premium.

τ_t = Marginal rate of corporate income taxation.

λ_s = Sector-specific leverage ratio calculated as the mean of book debt for the sector divided by the mean of (book debt + book equity) for the sector.

Under the Fama-French three-factor model,

$$\sigma_s = \beta_s^{EMR} \mu^{EMR} + \beta_s^{SMB} \mu^{SMB} + \beta_s^{HML} \mu^{HML} \tag{D2}$$

where μ denotes a mathematical expectation (the sample mean, in an empirical context), EMR is the excess market return, SMB is the size risk factor, and HML is the book-to-market risk factor. These factors and the data used to produce them are described below. We estimate the betas for each sector s.

Construction of Fama-French three-factor model betas

We calculate the Fama & French (1993) three-factor model betas by estimating the regression

$$EFR_{f,t} = \alpha_p + \beta_p^{EMR} EMR_t + \beta_p^{SMB} SMB_t + \beta_p^{HML} HML_t + \varepsilon_{f,t} \tag{F1}$$

over all firms in each portfolio p, where $EFR_{f,t}$ is the excess firm return (the monthly return of firm f minus the risk free rate), EMR_t is the excess market return (value-weighted market return minus the risk free rate), SMB_t is the size risk factor (average return on three small portfolios minus the average return on three big portfolios), and HML_t is the book-to-market risk factor (average return on two value portfolios minus the average return on two growth portfolios).

The risk free rate is the one-month treasury bill rate. The three factors and the risk free rate are taken from Kenneth French's website.[30] The monthly firm returns are taken from the CRSP database.

Construction of Campbell-Vuolteenaho betas[31]

To construct the Campbell & Vuolteenaho (2004) cash flow and discount rate betas, we first estimate a first-order VAR:

$$\mathbf{z}_{t+1} = \mathbf{a} + \mathbf{\Gamma} \mathbf{z}_t + \mathbf{u}_{t+1} \tag{E1}$$

where **z** is a state vector containing the following four variables in the following order: the excess market return, the yield spread between short-term and long-term bonds, the smoothed market price-earnings ratio, and the small-stock value spread.

The excess market return is calculated as the value-weighted CRSP market index return minus the one-year treasury constant maturity rate. The yield spread between short-term and long-term bonds is defined as the difference between the ten-year treasury

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30 Available as "Fama/French Factors" at:
http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

31 Although use the Campbell-Vuolteenaho betas in the returns test, not in calculating the discount rate, we describe their construction here for convenience.

constant maturity rate and the three-month treasury bill secondary market rate. All of the treasury rate data were obtained from FRED. The smoothed market price-earnings ratio is defined as the log of the ratio of the S&P 500 price index to a ten-year trailing moving average of as-reported S&P 500 earnings, obtained from Global Financial Data. The small-stock value spread is constructed using data from Kenneth French[32]. At the end of June of each year, portfolios are formed as the intersection between two portfolios formed on size (market equity, denoted by ME) and three portfolios formed on the ratio of book equity to market equity (denoted by BE/ME). The small-stock value spread is constructed at the end of each June as log(BE/ME) of the small high-BE/ME portfolio minus log(BE/ME) of the small low-BE/ME portfolio. For July to May, the small-stock value spread is constructed as the June small-stock value spread plus the cumulative log return (from June) on the small low-BE/ME portfolio minus the cumulative log return (from June) on the small high-BE/ME portfolio.

The cash flow and discount rate news functions are estimated as:

$$\begin{aligned}\hat{N}_{t+1}^{CF} &= (\mathbf{e1}' + \mathbf{e1}'\boldsymbol{\lambda})\mathbf{u}_{t+1} \\ \hat{N}_{t+1}^{DR} &= \mathbf{e1}'\boldsymbol{\lambda}\mathbf{u}_{t+1}\end{aligned} \tag{E2}$$

where **e1** is the first column of the 4 by 4 identity matrix **I**, $\boldsymbol{\lambda} = \rho\hat{\boldsymbol{\Gamma}}(\mathbf{I} - \rho\hat{\boldsymbol{\Gamma}})^{-1}$, and ρ is a discount factor. Following Campbell & Vuolteenaho (2004), we set ρ equal to 0.95.

The cash flow and discount rate betas are then calculated, for each portfolio *p*, using the following formulas:

$$\begin{aligned}\hat{\beta}_p^{CF} &= \frac{\text{Cov}(r_{f,t}, \hat{N}_t^{CF})}{\text{Var}(\hat{N}_t^{CF} - \hat{N}_t^{DR})} + \frac{\text{Cov}(r_{f,t}, \hat{N}_{t-1}^{CF})}{\text{Var}(\hat{N}_t^{CF} - \hat{N}_t^{DR})} \\ \hat{\beta}_p^{DR} &= \frac{\text{Cov}(r_{f,t}, -\hat{N}_t^{DR})}{\text{Var}(\hat{N}_t^{CF} - \hat{N}_t^{DR})} + \frac{\text{Cov}(r_{f,t}, -\hat{N}_{t-1}^{DR})}{\text{Var}(\hat{N}_t^{CF} - \hat{N}_t^{DR})}\end{aligned} \tag{E3}$$

where Cov and Var denote the sample covariance and variance functions, respectively, and $r_{f,t}$ is the return on firm *f* for month *t*, taken from the CRSP database. (The denominator looks different than the corresponding denominator in Campbell and Vuolteenaho (2004), but the two expressions for the denominator are the same, as discussed in the appendix to Campbell and Vuolteenaho (2004). Here we follow the notation in that appendix, which provides a detailed description of their procedures for constructing $\hat{\beta}_p^{CF}$ and $\hat{\beta}_p^{DR}$.)

[32] Available as "6 Portfolios Formed on Size and Book-to-Market (2 x 3)" at: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

E. The Marginal Product of Capital

We assume that production possibilities are described by the following CES technology that depends on capital ($K_{i,t}$), labor ($L_{i,t}$), and labor-augmenting technical progress ($A_{i,t}$) for firm i at time t,

$$Y_{i,t} = Y[K_{i,t}, L_{i,t}, A_{i,t}] = \left\{\omega K_{i,t}^{[(\sigma-1)/\sigma]} + (1-\omega)(A_{i,t}L_{i,t})^{[(\sigma-1)/\sigma]}\right\}^{[((1+\eta)\sigma)/(\sigma-1)]} \quad \text{(E1)}$$

where ω is the share parameter, σ is the elasticity of substitution between labor and capital (this σ differs from the one defined in Section D as the equity risk premium), and η represents deviations from constant returns to scale. In order to allow for the effects of imperfect competition in the product market, we embed equation (E1) into the following revenue function,

$$REV[K_{i,t}, A_{i,t}L_{i,t}] = p[Y[K_{i,t}, A_{i,t}L_{i,t}]]\ Y[K_{i,t}, A_{i,t}L_{i,t}], \quad \text{(E2)}$$

and assume that the inverse demand schedule, p[.], has a constant elasticity,

$$\mu \equiv -(p'[Y_{i,t}]Y_{i,t} / p[Y_{i,t}] \qquad 1 > \mu \geq 0, \quad \text{(E3)}$$

Differentiating equation (E3) with respect to capital, we obtain the following expression for the value marginal product of capital, which, with some violation of convention, we simply refer to as the marginal product of capital (MPK),

$$MPK[Y_{i,t}, K_{i,t} : \sigma, \omega, \eta, \mu] \equiv (\partial REV / \partial K) / p, \quad \text{(E4)}$$

$$= \Gamma\ [Y_{i,t} / K_{i,t}]^{[1/\sigma]}\ Y_{i,t}^{\zeta}, \quad \text{(E5)}$$

$$\Gamma \equiv (1-\mu)(1+\eta)\,\omega, \quad \text{(E6)}$$

$$\zeta \equiv [(\eta(\sigma-1))/(1+\eta)\sigma]. \quad \text{(E7)}$$

As shown in equation (E5), the MPK depends on three separate elements:

i) three parameters combined in Γ representing product market competition (μ), returns to scale (1+η), and the factor share of capital (ω);

ii) the output/capital ratio raised to the inverse of the elasticity of substitution (σ);

iii) output raised to a power determined by a parameter (ζ) that reflects non-constant returns to scale and the substitution elasticity. Note that ζ = 0 if returns to scale are constant or the substitution elasticity is unity.

The frequently used Cobb-Douglas production function is a special case of equation (E5). The Cobb-Douglas is defined by an elasticity of substitution of unity (σ =

1) and constant returns to scale ($\eta = 0$). With either of these restrictions, the output term (elements iii)) disappears, and the output/capital ratio is no longer raised to a power. If we further assume that market power is absent in the product market ($\mu = 0$), then the MPK for the Cobb-Douglas production function is written as follows,

$$MPK[Y_{i,t}, K_{i,t} : \sigma = 1, \omega, \eta = 0, \mu = 0] = \omega\, [Y_{i,t} / K_{i,t}]. \qquad \text{(E8)}$$

In this case, the MPK is proportional to the output/capital ratio with the constant of proportionality equal to the capital share parameter.

Equation (E5) assumes that three parameters – μ, η, and ω – are constant across all firms. This assumption seems restrictive. We allow these parameters to vary by sector and represent their product by Γ_j, where j denotes the sector in which firm i operates. Equation (E5) can be rewritten in terms of Γ_j, the output/capital ratio raised to $[1/\sigma]$, and an additional output term that differs from unity whenever returns to scale are not constant ($\eta_j \neq 0$) or the elasticity of substitution differs from unity ($\sigma \neq 1$),

$$MPK[Y_{i,t}, K_{i,t} : \sigma, \omega_j, \eta_j, \mu_j] = \Gamma_j\, [Y_{i,t} / K_{i,t}]^{[1/\sigma]}\, Y_{i,t}^{\zeta_j}, \qquad \text{(E9a)}$$

$$\Gamma_j \equiv (1 - \mu_j)(1 + \eta_j)\, \omega_j, \qquad \text{(E9b)}$$

$$\zeta_j \equiv [(\eta_j(\sigma - 1)) / ((1 + \eta_j)\sigma)]. \qquad \text{(E9c)}$$

In order to make equation (E9a) operational, two decisions need to be made concerning the unknown parameters. First, we will assume that σ equals 1.0. Second, following Gilchrist and Himmelberg (1998, Section 2.1), we estimate Γ_j by utilizing the long-run relation between MPK and the user cost of capital ($UC_{i,t}$) for all firms in sector j. Specifically, we compute Γ_j for all firms in sector j ($i \in I(j)$) for all available time periods t ($t \in T(j)$) as follows,

$$\sum_{i \in I(j)} \sum_{t \in T(j)} MPK_{i,t} = \sum_{i \in I(j)} \sum_{t \in T(j)} UC_{i,t}, \qquad \text{(E10a)}$$

$$\sum_{i \in I(j)} \sum_{t \in T(j)} \Gamma_j[\sigma, \eta_j]\, [Y_{i,t} / K_{i,t}]^{[1/\sigma]} = \sum_{i \in I(j)} \sum_{t \in T(j)} UC_{i,t}, \qquad \text{(E10b)}$$

$$\Gamma_j[\sigma, \eta_j] = \left\{ \frac{1}{N_{UC}} \sum_{i \in I(j)} \sum_{t \in T(j)} UC_{i,t} \right\} \Big/ \left\{ \frac{1}{N_{YK}} \sum_{i \in I(j)} \sum_{t \in T(j)} [Y_{i,t} / K_{i,t}]^{[1/\sigma]} \right\} \qquad \text{(E10c)}$$

where N_{UC} is the number of nonmissing observations over which the sum in the numerator of the right hand side of (E10c) is taken and N_{YK} is the number of nonmissing observations over which the sum in the denominator of the right hand side of (E10c) is taken. The MPK for firm i at time t equals equation (E9a) with the estimate of

Γ_j given in equation (E10c).

F. Misvaluation, Tobin's Q, and Marginal Q

Misvaluation (MV) is defined as the difference between Tobin's Q (Q^T) and marginal Q (Q^M).

Tobin's Q is defined as the market value of common equity divided by the replacement cost of the capital stock. Common equity is defined as Common Shares Outstanding (CompuStat item 25) times Price – Fiscal Year – Close (CompuStat item 199). The replacement cost of capital is K, as described above. The nominal value of common equity is converted to real terms by dividing by p^Y.

Define λ_t as the expected present value of future marginal products of capital,

$$\lambda_t = E_{t-1} \; \Sigma_{j=0}^{\infty} \; \Pi_{s=0}^{j-1} \; R_{t+s} \left(F_{K,t+j} - C_{K,t+j} \right) \tag{F1}$$

where E_{t-1} is the expectations operator, conditional on the information set in period t-1, R is the discount factor, F_K is the marginal product of capital, narrowly defined, and C_K is the derivative of the adjustment cost function with respect to the capital stock. Marginal Q is defined in the empirical work as $Q_t^M = \lambda_t - p_t^I / p_t^Y$, where p^I is the price of investment goods and p^Y is the price of output. (For expositional simplicity, we focus on λ in the equations below.) Define the marginal product of capital (broadly defined to include the marginal reduction in adjustment costs from an additional unit of capital) as,

$$M_t \equiv \left(F_{K,t} - C_{K,t} \right) \tag{F2}$$

We can then define the ex post present value of future marginal products of capital as:

$$\tilde{\lambda}_t \equiv \Sigma_{j=0}^{\infty} \left(\Pi_{s=0}^{j-1} R_{t+s} \right) M_{t+j} \tag{F3}$$

and the ex ante present value of future marginal products of capital as:

$$\lambda_t = E_{t-1} \left[\tilde{\lambda}_t \right] \tag{F4}$$

Note that λ is the sum of products of random variables, but we can simplify by linearizing $\tilde{\lambda}$ around $R_{t+s} = \overline{R}$ and $M_{t+s} = \overline{M}$, where $\overline{R}$ and $\overline{M}$ are the respective sample means.

$$\tilde{\lambda}_t \approx \overline{M}(1 - \overline{R})^{-1} + \overline{M}(1 - \overline{R})^{-1} \; \Sigma_{j=0}^{\infty} \overline{R}^j (R_{t+j} - \overline{R}) + \Sigma_{j=0}^{\infty} \overline{R}^j (M_{t+j} - \overline{M}) \tag{F5}$$

We can then find observable counterparts to R and M by using linear combinations of economic variables.

$$M_t = a' Z_t \tag{F6}$$

$$R_t = b' Z_t \tag{F7}$$

Suppose Z has an auto-regressive structure. For specificity, consider the example where there are two variables in Z and where all the variables in Z are measured as deviations from their sample means,

$$\begin{bmatrix} Z_{1,t} \\ Z_{2,t} \end{bmatrix} = \begin{bmatrix} a(L) & b(L) \\ c(L) & d(L) \end{bmatrix} \begin{bmatrix} Z_{1,t-1} \\ Z_{2,t-1} \end{bmatrix} + \begin{bmatrix} v_{1,t} \\ v_{2,t} \end{bmatrix}. \tag{F8}$$

Stacking the vectors defined in (F8),

$$\begin{bmatrix} Z_{1,t} \\ . \\ . \\ Z_{1,t-\ell+1} \\ Z_{2,t} \\ . \\ . \\ Z_{2,t-\ell+1} \end{bmatrix} = \begin{bmatrix} a_1 & . & . & . & a_\ell & b_1 & . & . & . & b_\ell \\ 1 & 0 & . & . & 0 & 0 & . & . & . & 0 \\ \vdots & & & & & \vdots & & & & \\ 0 & . & 0 & 1 & 0 & 0 & . & . & . & 0 \\ c_1 & . & . & . & c_\ell & d_1 & . & . & . & d_\ell \\ 0 & . & . & . & 0 & 1 & . & . & . & 0 \\ \vdots & & & & & \vdots & & & & \\ 0 & . & . & . & 0 & 0 & . & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} Z_{1,t-1} \\ . \\ . \\ Z_{1,t-\ell} \\ Z_{2,t-1} \\ . \\ . \\ Z_{2,t-\ell} \end{bmatrix} + \begin{bmatrix} v_{1t} \\ 0 \\ . \\ 0 \\ v_{2t} \\ 0 \\ . \\ 0 \end{bmatrix} \tag{F9}$$

In the empirical work, we set $\ell=2$. Equation (F9) can be re-written in companion matrix form,

$$\tilde{Z}_t = A\tilde{Z}_{t-1} + \tilde{v}_t. \tag{F10}$$

Under the assumption of rational expectations, the expectations can be represented as linear projections on variables in the information set,

$$E_{t-1}\left[M_{t+j}\right] = aA^{j+1}\tilde{Z}_{t-1}, \tag{F11}$$

$$E_{t-1}\left[R_{t+j}\right] = bA^{j+1}\tilde{Z}_{t-1}. \tag{F12}$$

The infinite sums that constitute marginal Q can be calculated as follows, using the last term in the expression for marginal Q (equation (F5)) as an example:

$$E_{t-1} \Sigma_{j=0}^{\infty} \overline{R}^{j} M_{t+j} = \Sigma_{j=0}^{\infty} \overline{R}^{j} aA^{j+1} \tilde{Z}_{t-1} = a(I - \overline{R}A)^{-1} A \tilde{Z}_{t-1} \quad \text{(F13)}$$

Evaluating all of the terms in (F5), we obtain the following equation for λ_t :

$$\lambda_t = \overline{M}(1-\overline{R})^{-1} + \overline{M}(1-\overline{R})^{-1}\overline{R}\ b\left(I - \overline{R}A\right)^{-1} A\tilde{Z}_{t-1} + \overline{R}a\left(I - \overline{R}A\right)^{-1} A\tilde{Z}_{t-1} \quad \text{(F14)}$$

In our empirical work, the variables that enter Z are R, Sales/K, Cost/K, p^I / p^Y, and I/K. R is a natural candidate. Under a variety of assumptions (including constant and non-constant returns to scale, fully competitive markets, and imperfect competition, Sales/K and Cost/K are components of the marginal product of capital. We follow Abel and Blanchard in including them as separate variables. The relative price ratio p^I / p^Y is a component of Q. Finally, under some assumptions, I/K is a useful forecasting variable; to the extent that investment is determined by fundamentals, I/K reflects the expected present value of future marginal products of capital.[33] With the variables in Z in the order listed above, we can define the vectors a and b as follows,

$$a = [0 \ \ 1 \ \ -1 \ \ 0 \ \ 0], \quad \text{(F15)}$$

$$b = [1 \ \ 0 \ \ 0 \ \ 0 \ \ 0]. \quad \text{(F16)}$$

G. Empirical Bootstrap for the Overreaction Test

Abadie and Imbens (2006a) derive the large sample properties of matching estimators. They show that the matching estimator will be consistent when $k = 1$, where k is the number of continuous variables used to form the matches. (See Theorem 5.) In our case, $k = 1$, since we select the matches using a single (continuous) variable, the propensity score.

We use the following bootstrapping procedure. First, we draw observations with replacement from the matched non-growth portfolio to construct a bootstrapped growth portfolio the same size as the original growth portfolio. We calculate the impulse response of investment to a sales shock for the bootstrapped growth portfolio for horizons 0 through 10. We construct 1000 bootstrapped growth portfolios and calculate the corresponding impulse response functions in this way. The resulting distribution of the impulse response functions is the bootstrapped empirical distribution. The 95% confidence band that is shown in Figure 3 is formed by plotting the 97.5% and 2.5% points of the empirical distribution for each horizon.

In a related paper, Abadie and Imbens (2006b) provide an example in which the bootstrap does not work well for a matching estimator, so we used a Monte Carlo simulation to check the size of the bootstrap and found that it was undersized. The

[33] This follows directly in models based on convex adjustment costs. In models with fixed costs, irreversibility, or other nonconvexities, investment will still depend on the expected present value of future marginal products of capital over some range. See Abel and Eberly (1994).

results presented in the paper incorporate a size correction based on the Monte Carlo simulation. The size correction effectively sets the nominal size at 2% in order to achieve an actual size of 5%. This has only a small effect on the resulting confidence interval.

H. Empirical Bootstrap for the Marginal Product of Capital

We use the following bootstrapping procedure to contrast the 95% confidence interval for the time path of the mean marginal product of capital. First, we draw observations with replacement from the propensity score matched non-growth portfolio to construct a bootstrapped growth portfolio the same size as the original growth portfolio. We calculate the mean marginal product of capital for the bootstrapped growth portfolio for horizons -3 through 5 (where time index 0 is the time of portfolio formation). We construct 1000 bootstrapped growth portfolios and calculate the corresponding time path of the mean marginal product of capital in this way. The resulting distribution of the time path of the mean marginal product of capital is the bootstrapped empirical distribution. The 95% confidence band that is shown in Figure 6 is formed by plotting the 97.5% and 2.5% points of the empirical distribution for each horizon. A size correction (similar to that described in the previous subsection of the appendix) has been incorporated into the figure for the mean marginal product of capital.

Table 1
Summary Statistics

Panel A: Statistics for the Full Sample

	N	Mean	25%	50%	75%	Std Deviation	Skew-ness	Kurtosis
I	97713	143.830	1.447	8.442	52.416	736.694	23.091	1196.679
K	97713	5335.914	14.363	76.900	584.853	31250.133	20.146	769.693
I/K	97713	0.161	0.042	0.104	0.203	0.191	2.789	10.583
SG	97713	0.118	-0.048	0.056	0.201	0.348	2.872	15.177
Sales/K	97713	3.903	0.808	2.308	4.868	5.063	2.930	11.363
Cost/K	97713	3.644	0.754	2.155	4.544	4.758	2.972	11.789
MPK	97713	0.167	0.054	0.105	0.198	0.206	5.127	63.312
NSI	95826	20.910	0.000	0.224	4.034	160.839	41.249	2966.890
Returns	63363	0.165	-0.236	0.052	0.365	0.831	9.023	210.090

I is investment in millions of 1996 dollars. K is the replacement value of the capital stock in 1996 dollars. SG is real sales growth. Sales/K is the ratio of real sales to K. Cost/K is the ratio of the real cost of goods sold to K. MPK is the marginal product of capital. NSI is new share issues, measured as the proceeds from equity issues in millions of 1996 dollars. Returns are nominal annual stock market returns. See the Appendix for details of variable definitions.

Panel B: New Share Issues by Portfolio

	Growth	Value	Difference	Test Statistic [p-value]
Median	0.7534	0.0000	0.7534	91.15 [0.000]
Aggregated (standard deviation)	0.5556 (0.3460)	0.1194 (0.0544)	0.4362 (0.2916)	6.23 [0.000]

Scaled by investment spending. The test statistic for the difference in medians is a nonparametric test based on analysis of variance on ranks. Aggregated new share issues equal (sum of new share issues)/(sum of investment spending), where the sums are taken over firms in a given portfolio in a particular year. The t-test statistics for the aggregated variable is therefore based on 25 annual observations for each portfolio (1980-2004). See the Appendix for details of variable definitions and portfolio construction.

Table 2
Probit Regression for Propensity Score Matching

	Full Sample
β^{EMR}	-1.330850 (0.021276)
β^{SMB}	-0.198927 (0.024229)
β^{HML}	-0.603230 (0.015192)
Size	0.000010 (0.000001)
Cash Flow	-0.417672 (0.016103)
Dividends	0.292148 (0.078658)
Cash	2.680820 (0.027717)
Leverage	-0.018163 (0.003207)
Number of Observations	105197

The dependent variable is membership in the growth portfolio (in a given year). Each cell contains the point estimate and corresponding standard error (in parentheses). The variables β^{EMR}, β^{SMB}, and β^{HML} are the betas on the excess market return, the size (small minus big) factor, and the book/market (high minus low) factor from the Fama-French three-factor model. Other variables are defined in the text.

Table 3
Fama-MacBeth Tests with IRP

Panel A: Fama-French Three-Factor Model

Horizon	γ_{IRP} (std. error)	Effect on Returns (one std. dev. increase in IRP)
2 year	-0.4303 (0.0792)	-0.0686
3 year	-0.4142 (0.1010)	-0.0661
4 year	-0.4352 (0.0947)	-0.0694
5 year	-0.4611 (0.0914)	-0.0736

Panel B: Campbell-Vuolteenaho Model

Horizon	γ_{IRP} (std. error)	Effect on Returns (one std. dev. increase in IRP)
2 year	-0.4444 (0.0889)	-0.0583
3 year	-0.4265 (0.0978)	-0.0560
4 year	-0.4305 (0.0943)	-0.0565
5 year	-0.4629 (0.0865)	-0.0608

The parameter γ_{IRP} is the mean coefficient on IRP (Investment Relative to the Past) from Fama-MacBeth regressions of cumulative excess returns on IRP and measures of risk. In Panel A, the risk measures are β_{EMR} (excess market return beta), β_{SMB} (size beta), and β_{HML} (book-to-market beta), based on the Fama-French (1993) three-factor model. In panel B, the risk measures are the Campbell-Vuolteenaho (2004) β_{CF} and β_{DR}; i.e., cash flow beta ("bad" beta) and discount rate beta ("good" beta). The horizon is defined such that the two-year horizon, e.g., refers to returns from the beginning of the first year after portfolio formation to the end of the second year after portfolio formation. See the section entitled "Returns" and the Appendix for details of the regression specification, variable definitions, and portfolio construction.

Table 4
Overinvestment Percentage by Portfolio

	Percentage of observations with:		
	Overinvestment of 25 %	Overinvestment of 50 %	Overinvestment of 100 %
Growth	42.95%	36.15%	25.46%
Non-growth	21.66%	15.60%	8.58%
Value	13.04%	8.80%	4.33%

Each cell in the table reports the percent of observations with measured overinvestment of a given percentage; e.g., the first column reports the percentage of observations in which I/K is 25% higher than justified by measured fundamentals, where I is investment and K is the capital stock. Portfolios are constructed for each year in the sample. The percent of observations is calculated over all portfolios of a given type; e.g., the first row calculates the percent of observations over the growth portfolios for all years in the sample. Measured overinvestment is the difference between actual investment and the investment justified by marginal Q, as described in Section 4c and the Appendix (which provides further details of variable definitions and portfolio construction).

Table 5
Fama-MacBeth Tests with Measured Overinvestment and IRP
Growth Portfolios

Panel A: Fama-French Three-Factor Model

Horizon	Measured Overinvestment		IRP	
	$\gamma_{O,G}$ (std. error)	Effect on Returns (one std. dev. increase in measured overinvestment)	$\gamma_{IRP,G}$ (std. error)	Effect on Returns (one std. dev. increase in IRP)
2 year	-0.2492 (0.1404)	-0.0327	0.3359 (0.1032)	0.0441
3 year	-0.3591 (0.1530)	-0.0471	0.4213 (0.1257)	0.0553
4 year	-0.2850 (0.1380)	-0.0374	0.4155 (0.1251)	0.0545
5 year	-0.3825 (0.1647)	-0.0502	0.4117 (0.1337)	0.0540

Panel B: Campbell-Vuolteenaho Model

Horizon	Measured Overinvestment		IRP	
	$\gamma_{O,G}$ (std. error)	Effect on Returns (one std. dev. increase in measured overinvestment)	$\gamma_{IRP,G}$ (std. error)	Effect on Returns (one std. dev. increase in IRP)
2 year	-0.6353 (0.1933)	-0.0834	-0.0802 (0.0809)	-0.0105
3 year	-0.6759 (0.1965)	-0.0887	0.0290 (0.0836)	0.0038
4 year	-0.7169 (0.2127)	-0.0941	-0.0285 (0.0786)	-0.0037
5 year	-0.8303 (0.2344)	-0.1090	-0.0601 (0.0788)	-0.0079

The parameter $\gamma_{O,G}$ is the coefficient on measured overinvestment for growth firms and the parameter $\gamma_{IRP,G}$ is the coefficient on IRP (Investment Relative to the Past) for growth firms in a Fama-MacBeth regression of cumulative excess returns on these two variables and measures of risk. In Panel A, the risk measures are β_{EMR} (excess market return beta), β_{SMB} (size beta), and β_{HML} (book-to-market beta), based on the Fama-French (1993) three-factor model. In panel B, the risk measures are the Campbell-Vuolteenaho (2004) β_{CF} and β_{DR}; i.e., cash flow beta ("bad" beta) and discount rate beta ("good" beta). The horizon is defined such that the two-year horizon, e.g., refers to returns from the beginning of the first year after portfolio formation to the end of the second year after portfolio formation. See the section entitled "Returns" and the Appendix for details of the regression specification, variable definitions, and portfolio construction.

Table 6
Fama-MacBeth Tests with Measured Overinvestment and IRP
Non-Growth Portfolios

Panel A: Fama-French Three-Factor Model

Horizon	Measured Overinvestment		IRP	
	$\gamma_{O,NG}$ (std. error)	Effect on Returns (one std. dev. increase in measured overinvestment)	$\gamma_{IRP,NG}$ (std. error)	Effect on Returns (one std. dev. increase in IRP)
2 year	-0.1782 (0.1079)	-0.0234	-0.2368 (0.0854)	-0.0311
3 year	-0.1851 (0.0970)	-0.0243	-0.2348 (0.0868)	-0.0308
4 year	-0.1969 (0.1172)	-0.0258	-0.2482 (0.0944)	-0.0326
5 year	-0.1201 (0.1239)	-0.0158	-0.2876 (0.0835)	-0.0378

Panel B: Campbell-Vuolteenaho Model

Horizon	Measured Overinvestment		IRP	
	$\gamma_{O,NG}$ (std. error)	Effect on Returns (one std. dev. increase in measured overinvestment)	$\gamma_{IRP,NG}$ (std. error)	Effect on Returns (one std. dev. increase in IRP)
2 year	-0.1014 (0.1046)	-0.0133	-0.2421 (0.0905)	-0.0318
3 year	-0.0957 (0.1037)	-0.0126	-0.2447 (0.0831)	-0.0321
4 year	-0.0469 (0.1301)	-0.0062	-0.2996 (0.1116)	-0.0393
5 year	0.0550 (0.1479)	0.0072	-0.3583 (0.1076)	-0.0470

The parameter $\gamma_{O,NG}$ is the coefficient on measured overinvestment for non-growth firms and the parameter $\gamma_{IRP,NG}$ is the coefficient on IRP (Investment Relative to the Past) for non-growth firms in a Fama-MacBeth regression of cumulative excess returns on these two variables and measures of risk. In Panel A, the risk measures are β_{EMR} (excess market return beta), β_{SMB} (size beta), and β_{HML} (book-to-market beta), based on the Fama-French (1993) three-factor model. In panel B, the risk measures are the Campbell-Vuolteenaho (2004) β_{CF} and β_{DR}; i.e., cash flow beta ("bad" beta) and discount rate beta ("good" beta). The horizon is defined such that the two-year horizon, e.g., refers to returns from the beginning of the first year after portfolio formation to the end of the second year after portfolio formation. See the section entitled "Returns" and the Appendix for details of the regression specification, variable definitions, and portfolio construction.

Table 7

Quantitative Estimates of the Effect of Misvaluation on Investment
Generic Investment Specification

	(1)	(2)
Misvaluation	0.0030802 (0.0000734) [41.96]	0.0031116 (0.0000734) [42.41]
Output	0.1023250 (0.0021128) [48.43]	0.1012410 (0.0021111) [47.96]
Relative Price of Investment Goods	-0.1076500 (0.0063537) [-16.94]	-0.1075410 (0.0063403) [-16.96]
Interest rate	-0.0021006 (0.0010794) [-1.95]	-0.0020461 (0.0010766) [-1.90]
Cash Flow		0.0100470 (0.0006392) [15.72]
Number of Observations Number of Firms R^2	58260 8340 0.5084	58192 8335 0.5108

Each cell shows the point estimate, standard error (in parenthesis), and t statistic (in brackets). Output, the relative price of investment goods, and the interest rate enter as lagged percentage changes. Cash flow is the ratio of cash flow to the capital stock. Misvaluation is the difference between Tobin's Q and marginal Q (both beginning of period), as defined in the text. The regressions include both fixed effects and year effects. See the Appendix for details of variable definitions.

Table 8

**Quantitative Estimates of the Effect of Misvaluation on Investment
Neoclassical and Accelerator Specifications**

	Neoclassical		Accelerator	
	(1)	(2)	(3)	(4)
Misvaluation	0.0025543 (0.0000779) [32.80]	0.0025613 (0.0000780) [32.84]	0.0025692 (0.0000781) [32.89]	0.0025762 (0.0000782) [32.93]
Output $_t$	0.1101280 (0.0022139) [49.74]	0.1080040 (0.0022340) [48.35]	0.1071700 (0.0021860) [49.03]	0.1050270 (0.0022054) [47.62]
Output $_{t-1}$	0.0928240 (0.0021651) [42.87]	0.0925130 (0.0021663) [42.71]	0.0874230 (0.0021342) [40.96]	0.0871110 (0.0021353) [40.80]
Output $_{t-2}$	0.0529310 (0.0020117) [26.31]	0.0527950 (0.0020141) [26.21]	0.0517750 (0.0020107) [25.75]	0.0516590 (0.0020131) [25.66]
Cost of Capital $_t$	-0.0318840 (0.0031507) [-10.12]	-0.0315630 (0.0031535) [-10.01]		
Cost of Capital $_{t-1}$	-0.0489380 (0.0033117) [-14.78]	-0.0488760 (0.0033139) [-14.75]		
Cost of Capital $_{t-2}$	-0.0133590 (0.0012043) [-11.09]	-0.0133460 (0.0012042) [-11.08]		
Cash Flow		0.0040445 (0.0006380) [6.34]		0.0041588 (0.0006399) [6.50]
Number of Observations	49891	49835	49891	49835
Number of Firms	7261	7256	7261	7256
R^2	0.5391	0.5392	0.5363	0.5363

Each cell shows the point estimate, standard error (in parenthesis), and t statistic (in brackets). Output and the cost of capital enter as percentage changes. Cash flow is the ratio of cash flow to the capital stock. Misvaluation is the difference between Tobin's Q and marginal Q (both beginning of period), as defined in the text. The regressions include both fixed effects and year effects. See the Appendix for details of variable definitions.

Table 9

Quantitative Estimates of the Effect of Misvaluation on Investment
Q Specification

	(1)	**(2)**
Misvaluation	0.0028764 (0.0000737) [39.05]	0.0029112 (0.0000738) [39.42]
Marginal Q	0.0303490 (0.0005832) [52.04]	0.0294570 (0.0005939) [49.60]
Cash Flow		0.0049949 (0.0006495) [7.69]
Number of Observations	58260	58192
Number of Firms	8340	8335
R^2	0.5115	0.5119

Each cell shows the point estimate, standard error (in parenthesis), and t statistic (in brackets). Cash flow is the ratio of cash flow to the capital stock. Misvaluation is the difference between Tobin's Q and marginal Q (both beginning of period), as defined in the text. The regressions include both fixed effects and year effects. See the Appendix for details of variable definitions.

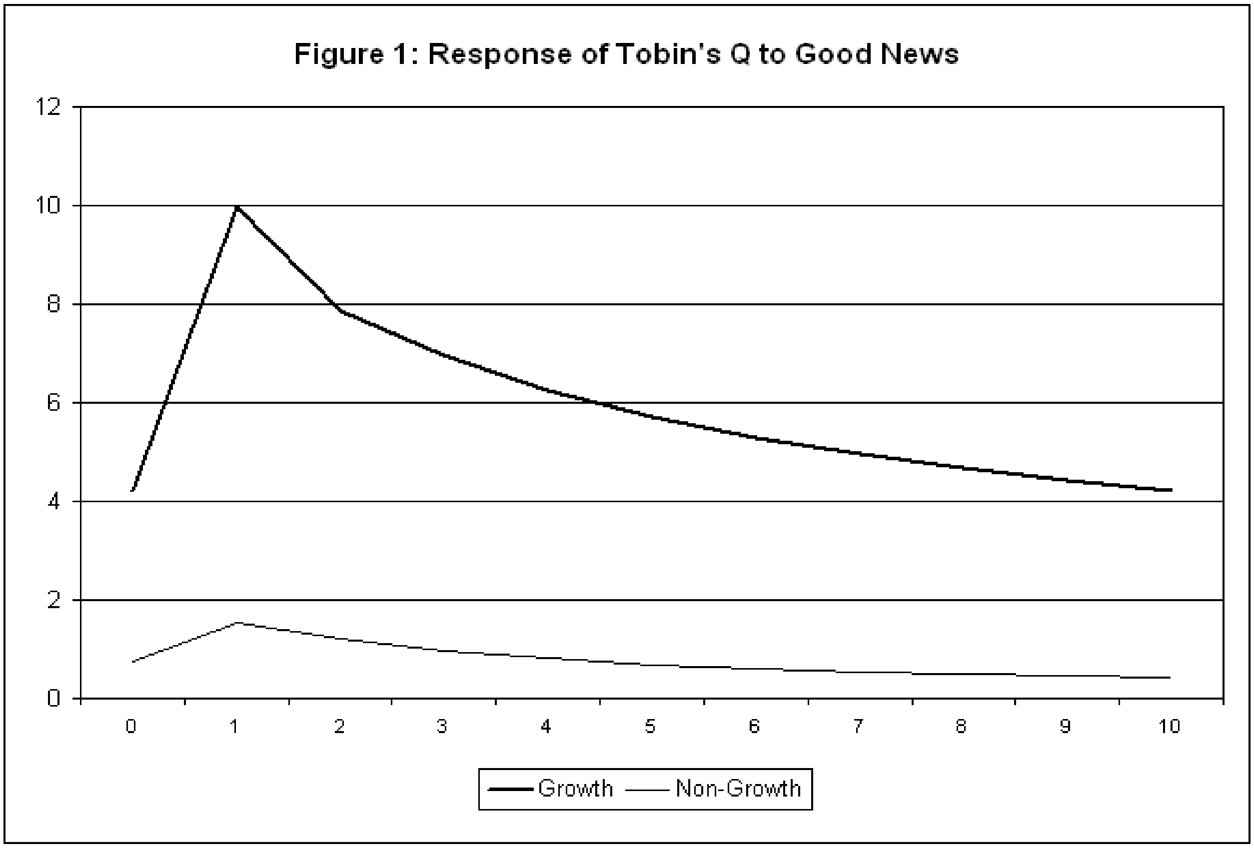


Figure 1: Response of Tobin's Q to Good News
12
10
8
6
4
2
0
0
1
2
3
4
5
6
7
8
9
10
Growth
Non-Growth

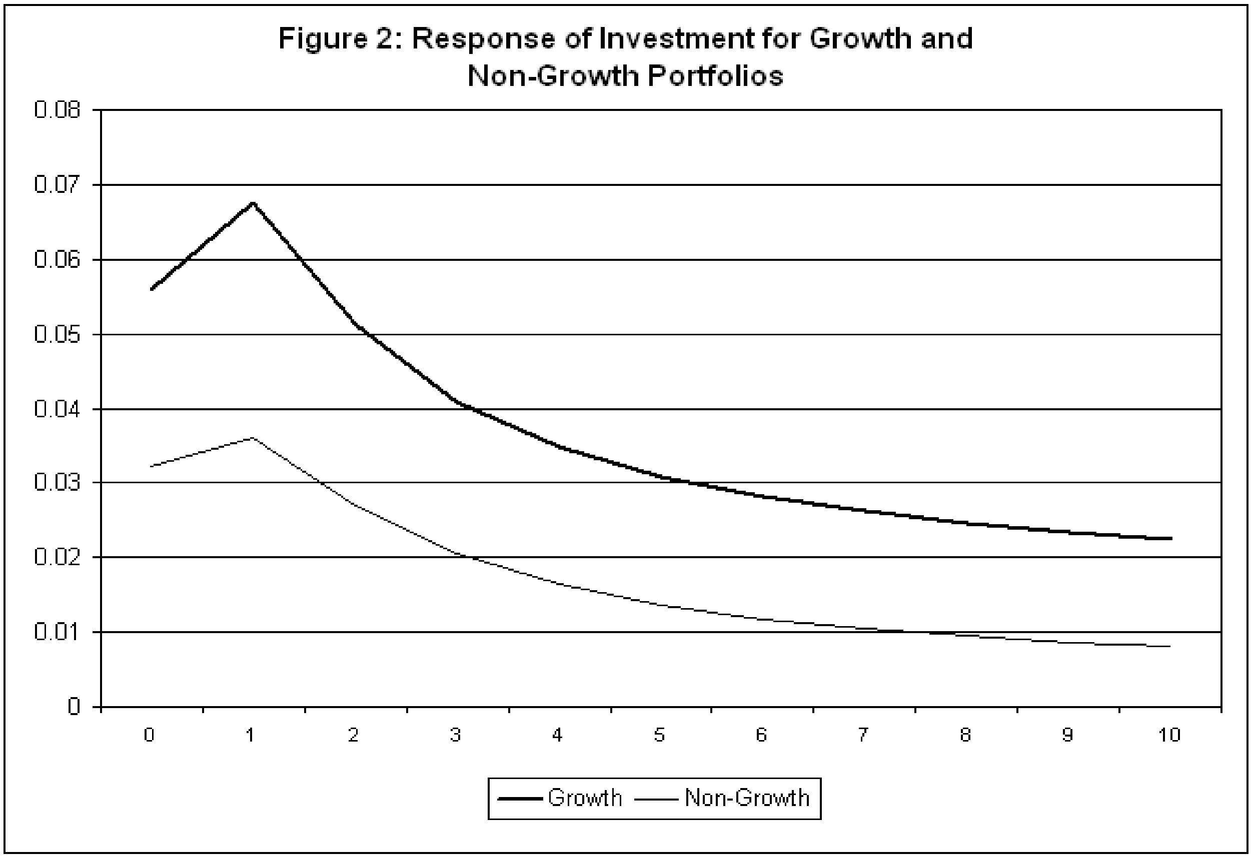


Figure 2: Response of Investment for Growth and Non-Growth Portfolios
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
1
2
3
4
5
6
7
8
9
10
Growth
Non-Growth

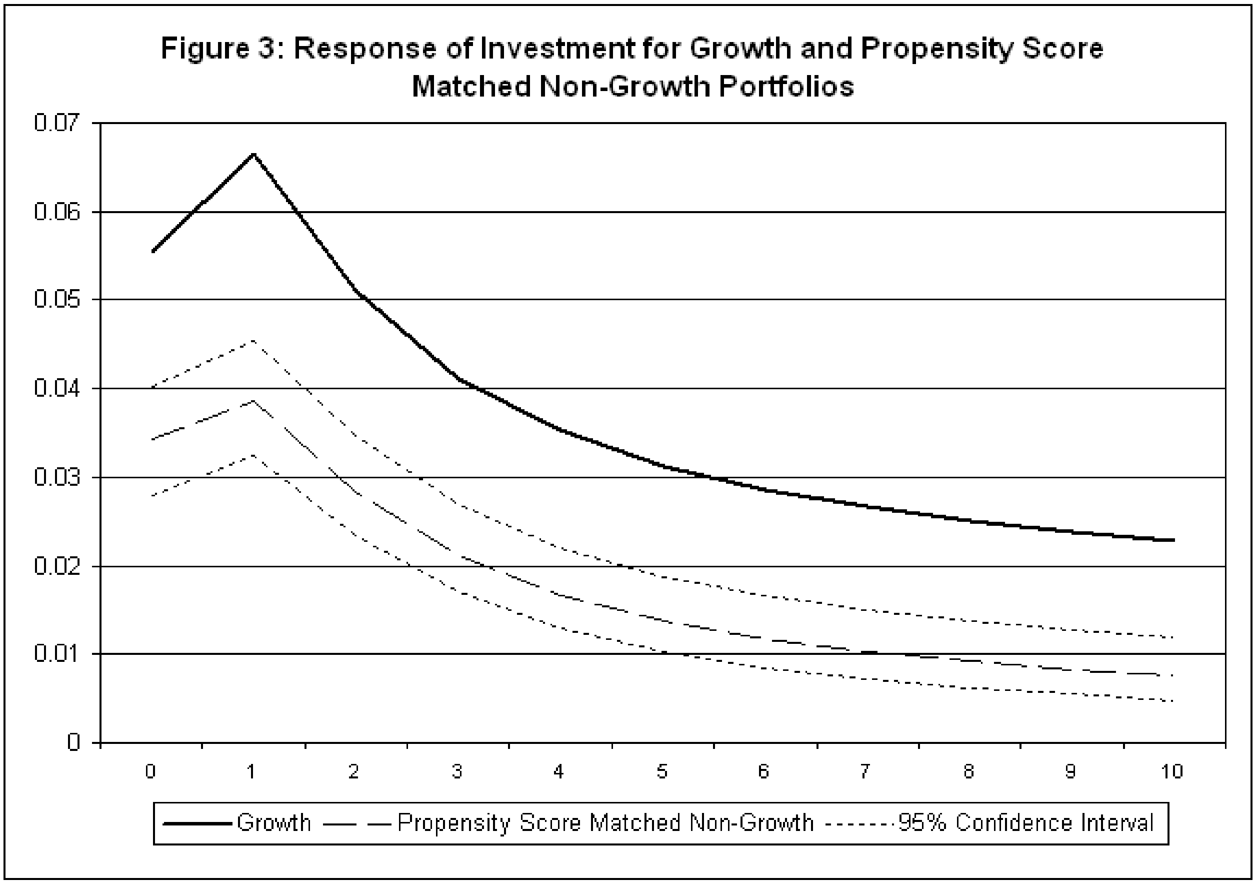


Figure 3: Response of Investment for Growth and Propensity Score Matched Non-Growth Portfolios
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
1
2
3
4
5
6
7
8
9
10
Growth
Propensity Score Matched Non-Growth
95% Confidence Interval

Figure 4
Supply and Demand for Capital
Fundamental Shock

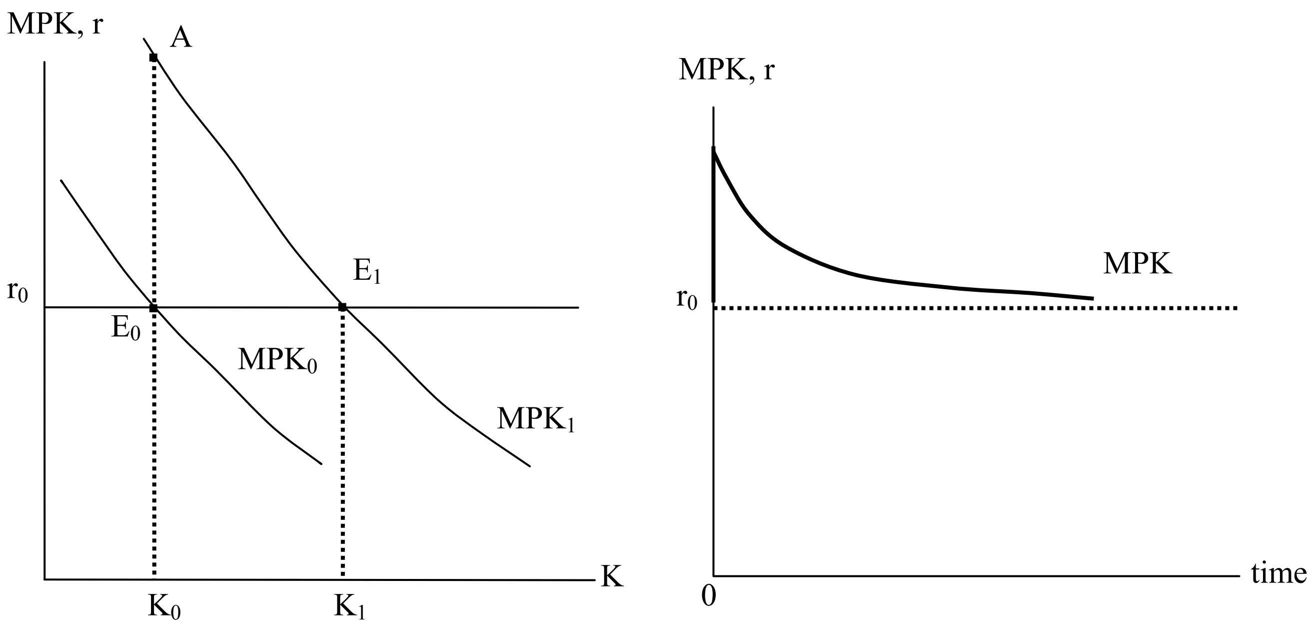
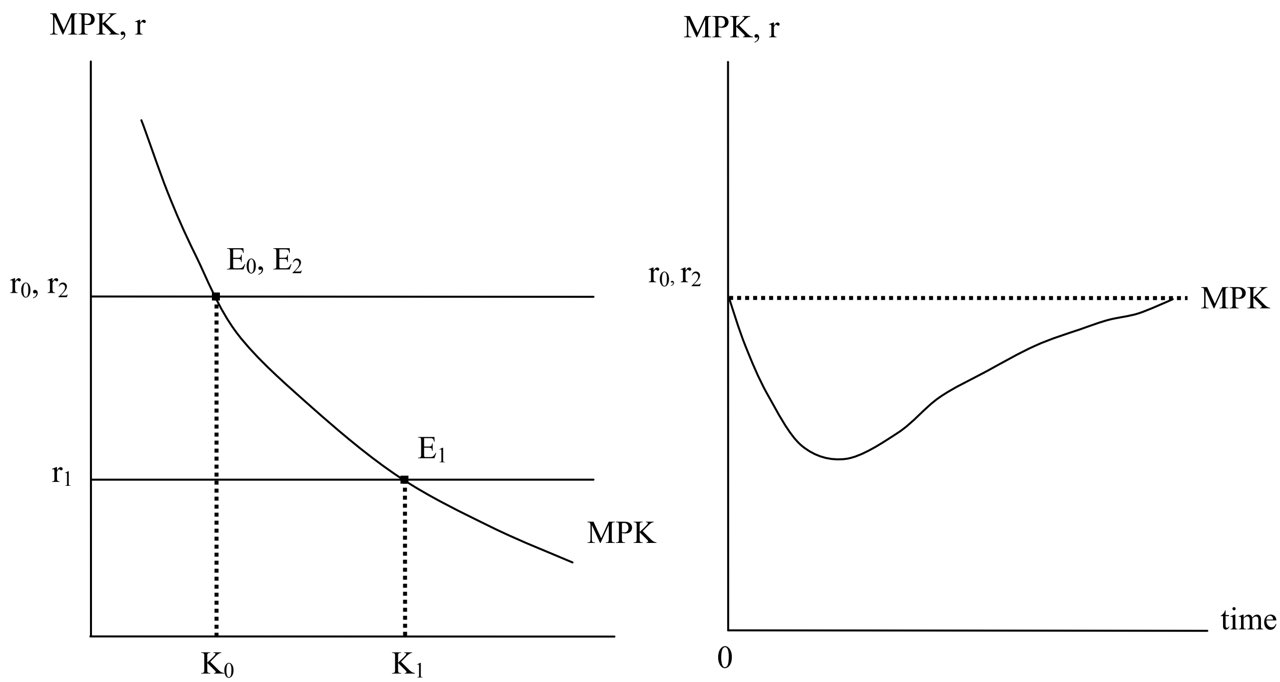


Figure 5
Supply and Demand for Capital
Misvaluation Shock



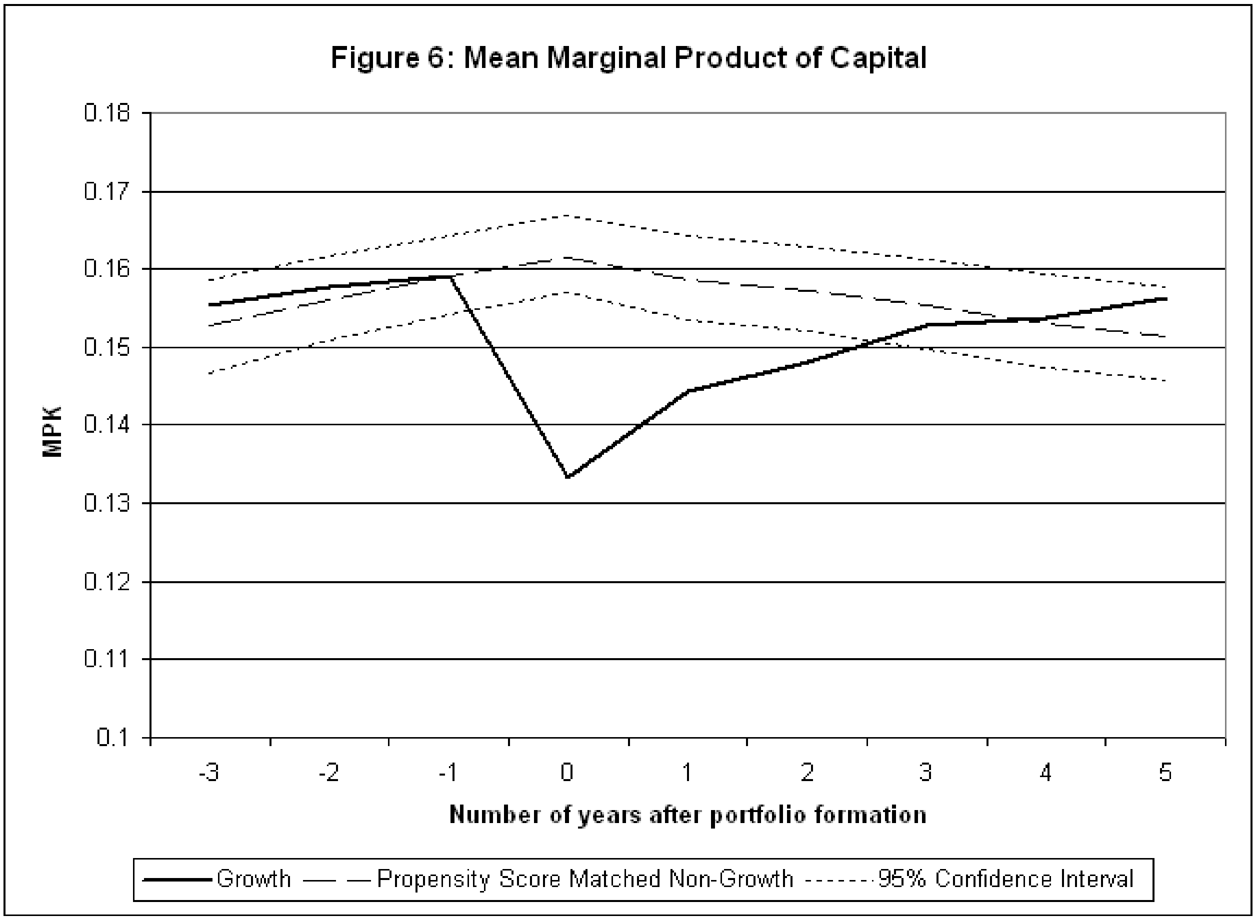


Figure 6: Mean Marginal Product of Capital
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
MPK
-3
-2
-1
0
1
2
3
4
5
Number of years after portfolio formation
Growth
Propensity Score Matched Non-Growth
95% Confidence Interval