Interpreting the Value Effect Through the Q-theory: An Empirical Investigation [1]

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Abstract

This paper interprets the well-known value effect through the implications of standard Q-theory. An investment growth factor, defined as the difference in returns between low-investment stocks and high-investment stocks, contains information similar to the Fama and French (1993) value factor (HML), and can explain the value effect about as well as HML. In the cross-section, portfolios of firms with low investment growth rates or low investment-to-capital ratios have significantly higher average returns than those with high investment growth rates or high investment-to-capital ratios. The value effect largely disappears after controlling for investment, and the investment effect is robust against controls for the marginal product of capital. These results are consistent with the predictions of a standard Q-theory model with a stochastic discount factor.

1 Introduction

A firm's capital investment reflects either changes in future discount rates or changes in future productivity. Traditional investment theory often assumes a constant discount rate, ignoring the effects of time-varying discount rates. However, overwhelming empirical evidence documents time variation in risk premiums. When a stochastic discount rate is introduced into the standard Q-theory model, Q varies with either the future discount rate or future productivity. The marginal Q, which is the present value of the future marginal product of investing one extra unit of capital today, determines the optimal capital investment. The value of Q can be high if either the future marginal productivity is high or if the future discount rate is low. Hence, with a stochastic discount rate standard Q-theory has rich implications for the relation between investment and equity returns. This paper interprets the value effect through the standard Q-theory framework, where by "value effect" I refer to the empirical fact that value stocks, or those with high book-to-market ratios, have higher average returns than growth stocks, or those with low book-to-market ratios (see Fama and French (1992)).

Employing a large firm-level data set (the intersection of CRSP and COMPUSTAT from 1964 to 2003), I find that a return-based investment factor can price the 25 Fama-French portfolios sorted on size and book-to-market ratios as well as the value factor (HML). This investment factor is the return on a zero-cost trading strategy that consists of a long position in stocks with low investment growth rates and a short position in stocks with high investment growth rates. The loadings of the 25 Fama-French portfolios on the investment factor display the same pattern as their loadings on HML. Moreover, replacing HML in the Fama-French model with the investment factor yields the same R^2 (77%) in the cross-sectional regression as the Fama-French model when pricing the size and book-to-market portfolios.

Consistent with Polk and Sapienza (2006), I find that current capital investment is negatively associated with future stock returns. I measure firm capital investment by both investment growth rates and investment-to-capital ratios. Small firms' investment growth rates are at least three times higher than the rates for large firms, and growth firms have investment growth rates that are twice as high as those of value firms. Sorting the firms by capital investment produces the same patterns in portfolio returns as sorting the firms by their book-to-market ratios. The negative relation between capital investment and future equity returns is robust to controls for the marginal product of capital where the ratio of sales and lagged value of fixed assets is used as a proxy for the marginal product of capital. Fama and French (1993) conjecture that book-to-market might be related to financial distress. However, the value effect disappears after controlling for capital investment. The results of this paper indicate that the value effect is consistent with a standard Q-theory model with a stochastic discount factor.

In the presence of a stochastic discount factor, standard Q-theory predicts a negative relation between capital investment and future returns. Intuitively, the optimal investment condition implies that the marginal cost of investment equals the marginal benefit of investment, which is the marginal Q. The value of Q reflects changes in both future productivity and future discount rates. Capital investment, optimally determined by marginal Q, should also reflect changes in both future productivity and future discount rates. Therefore, investment is high when future marginal productivity is high or when the discount rate is low. Controlling for expected marginal productivity, we should expect to see a negative relation between current investment and future equity returns on average. Hence, the link between investment and Q is explicitly predicted by the Q-theory. The book-to-market ratio is often used to proxy for the inverse of the average Q in the investment literature. Naturally, the Q-theory predicts a positive relation between the book-to-market ratio and future returns. Zhang (2005b) demonstrates that under linear homogeneity, marginal Q equals average Q, and there is a one-to-one mapping between the value effect and the investment effect. In this paper, I use the negative relation between returns and investment to explain the negative relation between expected return and Q, or the market-to-book ratio.

This paper is motivated by recent developments in the literature on investment-based asset pricing. A non-exhaustive list includes Berk, Green, and Naik (1999), Gomes, Kogan, and Zhang (2003), Carlson, Fisher, and Giammarino (2004), Cooper (2006), and Zhang (2005a, 2005b). While traditional asset pricing models tend to look at the demand-side of the economy taking production as exogenously determined, recent investment-based asset pricing models explicitly link asset returns to the real side of the economy, thus also linking firm characteristics, equity returns, and capital investment.

Zhang (2005a) explains the value effect based on asymmetric adjustment cost. In his neoclassical framework, value firms are riskier than growth firms, especially in bad times, since they are burdened with more unproductive capital stock. Because value firms and large firms have more unproductive capital, on average, they also have lower investment than growth firms and small firms. Zhang (2005a) predicts that value firms and large firms exhibit lower capital investment and higher expected returns.

Despite these recent theoretical developments, however, little attention has been paid to the empirical relations between capital investment, equity returns, and firm characteristics. Anderson and Garcia-Feijóo (2006) study the implications of the Berk, Green, and Naik (1999) model for capital investment. Anderson and Garcia-Feijóo(2006) focus on the evolution of firm characteristics around Fama-French style portfolio classification. This paper differs in that I investigate the extent to which the investment effect can explain the value effect in the setting of standard Q-theory. Titman, Wei, and Xie (2004) use the relation between capital investment and equity returns to distinguish between the over-investment and under-investment hypotheses, but they do not directly test the implications of standard Q-theory for the value effect. I also examine the conditional nature of the investment-return relation after controlling for marginal product of capital.

This paper is also closely related to Polk and Sapienza (2006), the first paper to document that returns are predicted by capital investment. Polk and Sapienza (2006) construct a mispricing metric and find that it is positively related to investment. They suggest that overpriced (underpriced) firms tend to overinvest (underinvest). Polk and Sapienza (2006) also show a negative relation between capital investment and future equity returns. However, they focus exclusively on an inefficient market explanation of the investment-return relation. In their study, a firm's valuation might deviate from its true value, and its investment is affected by the mispricing of its stock. Overinvestment will occur when firms are overpriced and similarly, underinvestment occurs when firms are underpriced. When overpricing (underpricing) is corrected, future returns are low (high), leading to a negative relation between investment and future returns. This paper focuses on efficient-market explanations for this phenomenon, testing the predictability of equity returns using investment in a framework where there is no mispricing and where investment is optimally determined to reflect changes in future discount rates. Although the evidence in this paper is consistent with the rational explanation based on Q-theory, it does not rule out the possibility of an inefficient market explanation of mispricing, such as that suggested by Polk and Sapienza (2006). Distinguishing between the two explanations is beyond the scope of this paper.

The rest of the paper is organized as follows: Section 2 develops the testable hypotheses, Section 3 describes the data and sample, Section 4 discusses the empirical results, and Section 5 concludes.

2 Testable Hypotheses

Standard Q-theory models typically assume that the discount rate is constant. Marginal Q is therefore a sufficient statistic for investment policy, reflecting only changes in future productivity.[1] Since all future cash flows are discounted at a constant rate, marginal Q will be high if and only if future marginal productivity is high. However, this is an inaccurate description of reality, since risk premia vary over time. By relating capital investment to the stochastic discount factor rather than the interest rate, we can study how capital investment responds to a time-varying risk premium. Consider a firm's capital budgeting process. The firm does not set its required rate of return to a constant, but rather according to its cost of capital, which typically varies over time. There are thus two channels through which marginal Q can be affected: future marginal productivity and future discount rates.

The book-to-market ratio is one of the most extensively studied variables in the finance literature. It is used to proxy for financial distress, managerial performance, growth options, and mispricing, among other things. In the Q-theory literature, the market-to-book ratio is frequently used as a proxy for average Q. Recent investment-based asset pricing models, such as

[1] The Q-theory was first proposed in Tobin (1969); Hayashi (1982) introduces adjustment cost into the Q-theory framework. According to the Q-theory, firm investment should be determined by its marginal Q.

Berk, Green, and Naik (1999), and Zhang (2005a, 2005b) make explicit predictions about the relation between capital investment and future equity returns — firms with high book-to-market ratios will invest less than firms with low book-to-market ratios. Zhang (2005a) introduces costly reversibility and a countercyclical price of risk into the neoclassical investment framework to illustrate that the value anomaly is, in principal, consistent with rational expectations.

In this paper, I test the following three hypotheses implied by standard Q-theory:

H1: Capital investment is negatively correlated with future equity returns.

This hypothesis follows from the relation between marginal Q and future equity returns. When future equity returns are relatively high, Q is relatively low today, since all of the marginal benefit of investing one extra unit of capital will be discounted at a higher rate and a low Q implies a low investment level.

Hypothesis 1 might also result from mispricing and firms' over-investment and under-investment, as suggested by Polk and Sapienza (2006). Constructing a mispricing metric from data on stock returns, market betas, book-to-market ratios, discretionary accruals, and equity issuance, Polk and Sapienza (2006) find that the metric is positively related to investment, after controlling for investment opportunities and financial slack. Polk and Sapienza (2006) also illustrate how mispricing and over-investment (under-investment) can lead to a negative relation between capital investment and future equity returns. I also examine this relation in Hypothesis 1, but assuming no systematic mispricing, over-investment, or under-investment.

H2: The book-to-market ratio and capital investment are correlated with future equity returns, after controlling for the marginal productivity of capital (mpk).

Analogous to the relation between the dividend yield, future dividend growth rates, and future stock returns, Q and investment are high if future mpk is high or if future equity returns are low. Given the future marginal product of capital, Q is negatively correlated with future returns. Therefore, the negative relation between capital investment and future returns is conditional on future mpk. Note also that mpk_t and r_t are contemporaneously positively correlated. An increase in future mpk also comes with a higher future equity return. A time-varying discount rate and the marginal product of capital have opposite effects on current Q, and it is unclear which effect will dominate. I test if capital investment is negatively correlated with future returns after controlling for marginal productivity of capital.

H3: The book-to-market ratio and investment variables contain similar information relevant to future equity returns.

Zhang (2005b) illustrates that, under the assumption of linear homogeneity, marginal Q equals average Q and there is a one-to-one mapping between the value effect and the investment effect. If average Q adequately summarizes the information salient to the capital investment decision, then we should expect to see that book-to-market ratios and capital investment contain largely the same information. That is, if a low average Q (or high book-to-market ratio) implies high future stock returns, then low capital investment should reflect the same. Sorting on book-to-market should be essentially the same as sorting on capital investment. Therefore, we should expect that the value effect disappears after controlling for capital investment and vice-versa.

In addition, I test if a return-based factor, constructed only from information on capital investment, contains information similar to that contained in the value factor (HML) in the Fama-French three-factor model. Fama and French (1993) define the value factor as the return on a zero-cost strategy that is long on stocks with high book-to-market ratios and short on stocks with low book-to-market ratios. This value factor, together with market and size factors, is shown to successfully explain the cross-sectional variation in equity returns. However, interpreting the value and size factors remains the focus of academic debate. If Q-theory can explain the value effect then one should expect that a factor constructed only from capital investment information can price value portfolios at least as well as the value factor.

3 Data

3.1 Firm-level Data

I employ firm-level data from COMPUSTAT, requiring firms to satisfy several standard requirements. First, firms in finance, insurance, and real estate are excluded, because the focus of this study is capital investment and it is typically difficult to interpret the capital investment of financial firms. Second, a firm must have a December fiscal-year end and at least five years of data to be included in the sample. The requirement of a December fiscal year-end is needed to align the accounting data across firms. Since most firms have a December year-end, this selection requirement does not bias the representativeness of the sample. Other studies, such as Vuolteenaho (2002), also use this requirement, and even with this restriction the sample consists of 43,277 firm-year observations from 1964 to 2003.

3.2 Variable Definitions

Monthly stock returns are from CRSP. The annual return of a stock is compounded from monthly returns, recorded from the beginning of June to the end of May. The market value of equity is taken from CRSP at the end of May. Following Fama and French (1993), I define book value of equity as the COMPUSTAT book value of common equity (data item 60) plus balance-sheet deferred taxes (data item 74) and investment tax credits (data item 208), minus the book value of preferred stock. Depending on availability, I use the redemption (data item 56), liquidation (data item 10), or par value (data item 130) of preferred stock. When data item 60 is not available, the liquidation value of common equity (data item 235) is used. The book-to-market ratio is then the book value of equity from calendar year $t-1$ divided by the market value of equity at the end of May in calendar year t. Negative or zero book values are treated as missing. The size of a firm is its market capitalization at the end of May, taken from CRSP.

COMPUSTAT data item 128 is used for capital expenditures, I, and the net book value of property, plant, and equipment (data item 8) is used for the net fixed assets, K. The one-year interest rate, r_t^f, is the yield on 1-year government bonds observed at the end of May, obtained from the Federal Reserve Bank of St. Louis. The monthly risk-free rate is from Kenneth French's website. I denote by IK the ratio of capital expenditures to the net book value of fixed assets at the beginning of each fiscal year. The investment growth is measured as the growth rate in a firm's capital expenditures. Marginal product of capital is the value of sales (data item 12) divided by the lagged book value of property, plant, and equipment, as in Gilchrist, Himmelberg, and Huberman (2005). Finally, I define manufacturing firms as those for which the first two digits of their SIC classification code fall between 20 and 39.

4 Empirical Results

I divide my empirical analysis into three parts. First, Section 4.1 provides descriptive statistics on firm-level investment growth rates and investment-to-capital ratios. Section 4.2 examines how capital investment is related to cross-sectional equity returns and whether this relation is robust to controls for firm size and the marginal product of capital, and I test whether the value effect disappears after controlling for investment and vice-versa. Finally, Section 4.3 examines whether a return-based factor constructed from capital investment can explain the value effect. Fama and French (1993) use a three-factor model (MKT, SMB, and HML) to explain the cross-sectional returns of size and book-to-market portfolios. Capital investments, if optimally determined by Tobin's Q, should contain the same information as the book-to-market ratio. Therefore, investment variables should perform similarly to the book-to-market ratio in asset pricing tests. I construct an investment growth factor, which is the return difference between low investment firms and high investment firms, and test whether this investment growth factor can price the 25 Fama-French portfolios sorted on firm size and the book-to-market ratio.

4.1 Descriptive Analysis

In the asset pricing literature, researchers often use the book-to-market ratio to categorize firms as value stocks (firms with high book-to-market ratios) or growth stocks (firms with low book-to-market ratios). Investment-based asset pricing models, such as those of Berk, Green, and

Naik (1999) and Zhang (2005a), explicitly predict the relations between capital investment and firm characteristics, such as size and book-to-market, i.e., small firms invest more than large firms and growth firms invest more than value firms. In Zhang (2005a), value firms are burdened with more unproductive capital, and therefore have lower levels of capital investment than growth firms.

In Table (1), I list the average investment-to-capital ratios (IK) and average investment growth rates (IG) of the size and book-to-market portfolios. The variable IG_t is defined as $I_t/I_{t-1} - 1$, and IK_t as I_t/K_{t-1}, where I_t is the capital expenditure at time t and K_{t-1} is the net fixed assets at time $t-1$.

Following Fama and French (1993), in May of each year I sort all of the firms independently on their market capitalization (size) and book-to-market ratios into 25 (5×5) portfolios using the NYSE breakpoints on size and book-to-market. For each portfolio, I compute the mean of the investment growth rate and the investment-to-capital ratio at the time of the sort. As can be seen in Table (1), a monotonic relationship exists between firm size and average investment growth rates, and as well as between book-to-market ratio and investment growth rates. For each book-to-market quintile, the average investment growth rate falls as the average firm size rises, and for each size quintile, average investment growth rate falls as the book-to-market ratio rises. There is also a monotonic relationship between investment-to-capital ratio and the book-to-market ratios. Small firms have higher investment-to-capital ratios than large firms, although this pattern is not monotonic.

The investment literature focuses mostly on firms in the manufacturing sector. To examine whether the relations among size, book-to-market, and capital investment are robust across manufacturing and non-manufacturing industries, I break the firms into manufacturing and non-manufacturing sub-samples. The manufacturing sub-sample consists of firms with two-digit SIC codes between 20 and 39. The non-manufacturing sub-sample consists of the rest of the firms in the sample. Panels B and C in Table (1) show that, across these two sub-samples, the book-to-market ratio remains monotonically and negatively correlated with average investment growth rate and the investment-to-capital ratio. With a few exceptions, size correlates negatively with the two capital investment measures.

In summary, on average, small firms have higher investment growth rates and higher investment-to-capital ratios than larger firms with similar book-to-market ratios. Moreover, low book-to-market firms have higher investment growth rates and higher investment-to-capital ratios than high book-to-market firms of similar size. Hence, capital investment is correlated with size and book-to-market ratios. These results are consistent with the predictions of investment-based asset pricing models, such as Zhang (2005b). Furthermore, the differences in investment growth rates and in investment-to-capital ratios are greatest among small firms. From Fama and French (1992, 1993), we know that the value effect is strongest for small firms. From Panel A in Table (1), we see that the difference in the average investment growth rate between value and growth firms is 0.78 (1.22-0.44) in the smallest size quintile, much higher than 0.16, the investment growth rate difference in the largest size quintile. This evidence suggests a close link between capital investment and the value effect.

Fama and French (1992 and 1993) show that small firms have higher average returns than large firms and that value firms have higher average returns than growth firms. While the size effect has mostly disappeared in recent data, the value effect remains significant. Table (1) shows that these two characteristics are related to one endogenous variable, capital investment. Given that firms with different sizes and book-to-market ratios have different investment behavior, one would naturally expect firm investments to be correlated with equity returns. Firm investment is an endogenous choice variable related to a firm's optimization problem; through capital investment, a firm can effectively change the evolutionary path of its own characteristics. Therefore, it is worthwhile to to explore the predictive power of capital investment in explaining equity returns, and try to explain the value effect through capital investment.

4.2 Capital Investment and Equity Returns

4.2.1 Portfolio Returns Sorted on Capital Investment

In this section, I investigate whether sorting firms by capital investment leads to significant variation in portfolio returns. Each year in June, the firms are sorted into 10 deciles by their previous fiscal year investment growth rate and investment-to-capital ratio. I then compute both equally-weighted and value-weighted simple returns for the 10 deciles. Panel A of Table (2) lists summary statistics of these investment portfolios at a monthly frequency.

Stocks with the lowest past investment-to-capital ratios have the highest returns, while stocks with the highest investment-to-capital ratios have the lowest returns. Going from decile 1, the portfolio of firms with the lowest investment-to-capital ratio, to decile 10, the average return decreases almost monotonically, for both the equally-weighted and value-weighted portfolios. The return difference between the lowest and highest deciles of the investment-to-capital ratio for the equally weighted portfolios is 0.46% per month, and is statistically significant at the 5% level (t-stat=2.37). However, the return difference for the value-weighted portfolios is smaller and is not statistically significant at the 5% level. In comparison, the return difference between high book-to-market and low book-to-market value-weighted portfolios in the same sample period is 0.56%.

The returns on portfolios formed by sorting on past investment growth rates exhibit a similar pattern to the returns on portfolios formed from the investment-to-capital ratio. The stocks of firms with low past investment growth rates have higher average returns than the stocks of firms with high past investment growth rates. The return differentials between the low and high investment growth rate deciles are 0.58% and 0.56% per month for equally weighted and value-weighted portfolios, respectively. Both are statistically significant at the 5% level. The magnitude of the return spread is close to the return spread sorted on book-to-market (0.56%) over the same sample period.

Panel B of Table (2) presents the intercept coefficient from the time-series regression, α, which represents the unexplained portion of excess returns. I list the values of α obtained in both the CAPM and the Fama-French three-factor models. The intercepts generally decrease from the low investment portfolios to the high investment portfolios. After controlling for market risk and the Fama-French factors, the low investment portfolios still earn higher excess returns than the high investment portfolios. The Fama-French factors help to explain the time-series variation in investment portfolio returns: in most of the regressions, the intercepts from the

Fama-French three-factor model are much lower than those from the CAPM, and the difference in α between the two extreme deciles is smaller. This evidence implies that SMB and HML actually pick up some of the investment effect and contain information similar to the capital investment variables.

4.2.2 The Investment Effect After Controlling for Firm Size

If capital investment and book-to-market contain similar information, then a double sort on size and capital investment should produce patterns similar to a double sort on size and book-to-market. Table (3) shows average returns on the 25 portfolios sorted on size and investment growth rates (investment-to-capital ratios). Following Fama and French (1993), I use the NYSE breakpoints to divide the firms into five size quintiles. Table (3) shows that, after controlling for size, portfolios formed from firms with high investment growth rates (investment-to-capital ratios) still have lower average returns than those with low investment growth rates (investment-to-capital ratios), using both equally-weighted and value-weighted returns. These portfolios are also highly correlated with the Fama and French 25 portfolios. For example, the correlations between the value-weighted portfolios sorted on size and investment-to-capital ratio and the 25 Fama and French portfolios range from 0.53 to 0.93, with an average of 0.85. However, although these portfolios are highly correlated with the Fama and French 25 portfolio, the return patterns are not exactly the same. In general, the investment effect gets weaker as we go from the small size quintile to the large size quintile, but the return spread does not decrease in a monotonic way. In contrast, the value spread decreases monotonically as size increases for the Fama and French 25 portfolios. Note that the strongest effect on capital investment is concentrated in the smaller size quintiles. This is consistent with the empirical fact that the value effect is most significant for small firms.

In addition to the above analysis, I also conduct Fama-MacBeth (1973) cross-sectional regressions. In each year from 1964 to 2003, excess equity returns are regressed on lags of the capital investment variables (investment-to-capital ratio and investment growth rate). As shown in Panel A of Table (4), the coefficients on the investment growth rate and the investment-to-capital ratio are both negative and statistically significant at the 5% level. In Panel B, I control for firm characteristics such as the lagged book-to-market ratio, lagged market capitalization (size), and lagged market β. The cross-sectional predictability of capital investment does not change in the presence of these additional explanatory variables. In fact, the capital investment variables and the book-to-market ratio are significant in all of the regressions.[2]

Taken together, these results suggest that there is a significant negative relation between current capital investment and future equity returns. Furthermore, it appears that this relation is robust to controls for size.[3] In the next section, I test hypothesis H2.

4.2.3 The Value and Investment Effects After Controlling for The Firm's Marginal Product of Capital

As noted earlier, a higher current Q could reflect either low expected returns or a high future marginal product of capital. If Q is completely driven by changes in the future marginal product of capital, then once we control for the marginal product of capital we should not expect to see any relation between the book-to-market ratio and equity returns. In Table (5), I investigate the value effect after controlling for the marginal product of capital. With the assumption of constant returns to scale, the expected marginal product of capital equals the expected average product of capital (see Zhang 2005b), which suggests that average productivity might be a good proxy for the marginal product of capital. For instance, Gilchrist, Himmelberg, and Huberman (2005) use the ratio of sales divided by lagged book value of property, plant, and equipment to proxy for marginal product of capital mpk. I follow Gilchrist, Himmelberg, and Huberman (2005) in defining mpk and, given that Fama and French (2006) show that current profitability is the most powerful predictor of future profitability, I employ mpk as a proxy for the expected future mpk.

[2] The Fama-MacBeth (1973) regression can also be conducted at monthly frequency. In results not reported here, I find that the capital investment variables are also significant at a monthly frequency in Fama-MacBeth (1973) regressions.

[3] Polk and Sapienza (2006) also show that there is an investment effect after controlling for the size characteristics.

Table (5) shows that the value effect is unchanged after controlling for mpk. For the equally-weighted portfolios, the return spreads between the low book-to-market portfolios and the high book-to-market portfolios are about 50 basis points per month and are statistically significant. On a value-weighted basis, only two out of five return spreads are significant. Interestingly, the value effect seems to be much stronger for firms with a low marginal product of capital.

From Table (2), we see that stocks with high investment-to-capital ratios or investment growth rates tend to have lower average returns. Here I examine whether the negative relation between investment and future returns is conditional on the marginal product of capital. Table (6) shows that the negative relation between investment and average return does not in fact depend on marginal product of capital. I first sort all of the firms into five quintiles by their marginal product of capital, and then within each quintile I sort the firms into five portfolios by their investment growth rates (investment-capital ratios). In Panel A, we see that, for equally-weighted portfolio returns, low investment growth and low investment-to-capital ratio portfolios still have significantly higher average returns than portfolios with high investment growth and high investment-to-capital ratios, even after controlling for the marginal product of capital. In Panel B, value-weighted portfolios display a similar but slightly weaker pattern. Table (6) suggests that higher Q and investment are more likely to result from lower expected returns in the future, rather than from a high marginal product of capital. From Table (5) we notice that the value effect is the strongest among firms with low marginal products of capital. In contrast, the investment effect seems the strongest among firms with high marginal products of capital. This result is inconsistent with Zhang (2005a) who predicts that the investment-to-capital and book-to-market ratios can be used interchangeably.

In summary, the evidence in this section suggests that the relation between the book-to-market ratio (capital investment) and future equity returns is not conditional on a firm's marginal product of capital. Furthermore, it suggests that firm-level capital investment is more likely to be driven by variation in future discount rates than variation in the future productivity of its capital.

4.2.4 Are the Value Effect and the Investment Effect the Same Phenomenon?

Hypothesis H3 suggests that the book-to-market ratio and capital investment contain similar information. To test H3, I first conduct an independent double sort on capital investment and book-to-market ratios. If the information content of these two variables is similar, then we should see both effects weaken after an independent double sort.

In Table (7), we see the value effect disappears after controlling for capital investment. The return spreads on book-to-market are statistically insignificant in all five capital investment quintiles. Table (7) also shows that the return differences between the low investment growth (investment-to-capital ratio) portfolio and high investment growth (investment-to-capital ratio) portfolio are significant in several cases. The investment effect after controlling for the book-to-market ratio seems much stronger than the value effect after controlling for the investment growth rate or the investment-to-capital ratio. While Polk and Sapienza (2006) find there is a value effect after controlling for investment characteristics in the Fama MacBeth (1973) framework, the results here suggests a weaker role for the value effect. The results in this section suggest that the value effect and the investment effect, although not exactly the same phenomenon, are closely related to each other. In the next section, I test if an investment-based return factor can price the size and book-to-market portfolios as effectively as the value factor HML.

4.3 Pricing the Size and book-to-market Portfolios using an Investment Factor

In order to shed further light on hypothesis H3, I first construct an investment growth factor from equity returns. I then test whether this investment factor can price the 25 Fama and French portfolios as effectively as the value factor HML.

4.3.1 Construction of the Investment Factor

In May of each year, all of the firms are first divided into two size groups, small and large, using the NYSE median market capitalization. Within each size group, the firms are split into three investment growth rate groups: low investment growth, medium investment growth, and high investment growth. The low investment growth group consists of the 30% of firms with the lowest investment growth rate, while the high investment growth group consists of the 30% of firms with the highest investment growth rate. Within each size group, taking the value-weighted return difference between the low investment growth groups and the high investment growth groups, then averaging over the two size groups, produces a series of zero-cost arbitrage portfolio returns. This factor captures the return difference between firms with different levels of investment growth. I denote this factor by IGR; at the same time, I also create a new size factor, denoted as SMB*, by computing the average difference in returns for small and large firms across the three investment growth groups. Created this way, SMB* is very similar to the SMB factor of Fama and French; the correlation coefficient for the two is 0.93. IGR starts in June 1964 and ends in December 2003, for a total of 476 observations.

Table (8) lists the summary statistics of the Fama-French factors and IGR [4] . Compared with the Fama-French factors, IGR has a slightly higher mean than SMB, is less volatile than MKT, SMB, and HML, and does not display any autocorrelation. IGR is also significantly different from zero, with a t-statistic of 3.38. Panel B of Table (8) lists the correlation matrix of the factors. The correlation between IGR and HML is 0.36.

4.3.2 Do the Size and Book-to-Market Portfolios Load on the Investment Factor?

I use the 25 Fama-French size and book-to-market portfolios as the base assets in the asset-pricing test. First, I run the following time-series regressions:

$$R_i - R_f = \alpha_i + b_i MKT + e_i \tag{1}$$

$$R_i - R_f = \alpha_i + b_i MKT + s_i SMB + h_i HML + e_i \tag{2}$$

$$R_i - R_f = \alpha_i + b_i MKT + c_i IGR + e_i \tag{3}$$

$$R_i - R_f = \alpha_i + b_i MKT + s_i SMB + c_i IGR + e_i \tag{4}$$

[4] Using investment-to-capital ratio to construct the investment factor, I obtain similar results.

Table (9) reports α—the estimate of the unexplained expected excess returns after controlling for risk factors—and robust t-statistics for each α for equations (1)-(4). By comparing the estimates of α in Panels C and A, we see that adding IGR to the CAPM helps to reduce the αs. For instance, the α for the large growth portfolio is 0.19% under the CAPM, but is reduced to 9% when IGR is added. In most cases, the αs from the linear model including MKT and IGR (Equation (3)) are larger than the αs in the Fama-French model (Equation (2)). Within each size quintile, I test the statistical significance of the difference in α between the highest book-to-market portfolios and the lowest book-to-market portfolios. Similar to the findings in Table (7), the value effect is statistically significant only for the first two size quintiles.

I also test whether the αs for the 25 portfolios are jointly significant. The Gibbon, Ross, and Shanken (1989) F-statistics for the CAPM, MKT, and IGR models vis-a-vis the Fama-French model are 4.17, 3.63, and 3.08, respectively. The p-values are all zero, indicating rejection of the null hypothesis that the αs are jointly equal to zero for all of the models. Hence although IGR helps to explain the time-series variation in returns, the models in which IGR appear are statistically rejected. Augmenting the two-factor model in equation (3) by SMB* helps to bring α closer to the Fama and French model α. Therefore, the size factor is still helpful in explaining the time-series variation in returns. Note that the αs in Panels C and D display patterns similar to those for the Fama and French model shown in Panel B. From size quintile 1 to 4, we see that α increases as we go from growth to value firms.

Next, I examine if the loadings on IGR exhibit patterns similar to those on HML. Figure (1) graphs the loadings of each size and book-to-market portfolio on IGR and on HML. The loading on IGR is estimated from the time-series regressions of the 25 portfolios on MKT and IGR, while the loading on HML is estimated using the Fama-French three-factor model. The loading on IGR in the model of MKT, SMB*, and IGR is also plotted in the graph, and is very close to the IGR loading in the two-factor model. For each size quintile, as one moves from the low book-to-market portfolio to the high book-to-market portfolio, the loadings on the IGR factor increase monotonically. These loadings are generally statistically significant, which implies that the book-to-market portfolios indeed have significant exposure to the investment factor. The loadings on IGR exhibit patterns that are strikingly similar to the loadings on HML.

4.3.3 Performance of the Investment Factor in the Fama-MacBeth Cross-Sectional Test

I turn now to estimate the formal cross-sectional relation between the investment-based factor and expected returns using the Fama-MacBeth (1973) methodology. I consider linear cross-sectional regression models of the form:

$$\mathrm{E}(r_{it}) = \lambda_0 + \lambda'\beta_i, \tag{5}$$

in which λ_0 is a scalar, λ is a $M \times 1$ vector of factor premia, and β_i is an $M \times 1$ vector of factor loadings for portfolio i. Estimates of the factor premia λ are used to test if $\lambda_0 = 0$ for various specifications, and to investigate whether the investment factor IGR performs similarly to the Fama and French factor HML.

In the first step, the entire sample is used to estimate the factor loadings, β_i:

$$r_{it} = \alpha_i + F_t'\beta_i + \varepsilon_{it}, \quad t = 1, 2, ...T, \tag{6}$$

where α_i is a scalar and F_t is a $M \times 1$ vector of factors. In the second step, we run a cross-sectional regression at each time t over N portfolios, holding the β_i values fixed at their estimated values, $\hat{\beta}_i$, from equation (6):

$$r_{it} = \lambda_0 + \lambda_t'\hat{\beta}_i + u_{it}, \quad i = 1, 2, ...N. \tag{7}$$

The factor risk premia, λ, are estimated as the average of the cross-sectional regression estimates:

$$\hat{\lambda} = \frac{1}{T}\sum_{t=1}^{T}\hat{\lambda}_t. \tag{8}$$

The covariance matrix of $\hat{\lambda}$, Σ_λ, is estimated by:

$$\hat{\Sigma}_\lambda = \frac{1}{T^2}\sum_{t=1}^{T}(\hat{\lambda}_t - \bar{\lambda})(\hat{\lambda}_t - \bar{\lambda})', \tag{9}$$

where $\bar{\lambda}$ is the mean of λ.

Since the factor loadings are estimated in the first stage, and these loadings are used as independent variables in the second stage, there is an errors-in-variables problem. To remedy this, I use Shanken's (1992) method to adjust the standard errors by multiplying $\hat{\Sigma}_\lambda$ by the adjustment factor $(1 + \hat{\lambda}'\hat{\Sigma}_f^{-1}\hat{\lambda})^{-1}$, where $\hat{\Sigma}_f$ is the estimated covariance matrix of the factors F_t. In Table (10), I report t-values using both unadjusted and adjusted standard errors.

Panel A of Table (10) reports estimates of the benchmark CAPM and Fama-French models. The risk premium for the market factor in the CAPM is negative and statistically insignificant. As has been shown in previous studies (Fama and French (1993, 1996)), the Fama-French model explains a large part of the cross-sectional variation in returns, with an adjusted R-squared of 77.06% and all three factors are jointly significant at the 5% level.

In Model C, the IGR factor is added the CAPM. The estimated premium on IGR is 10.20% per annum (0.85% per month) and is statistically significant at the 5% level. IGR together with MKT explain 58% of the cross-sectional variation in returns on the 25 portfolios. In Model D, SMB is added to MKT and IGR. IGR is still statistically significant, and the risk premia are jointly significant, with a p-value of 0.0002. The adjusted R-squared is 77%, which is close to the R-squared in the Fama-French three-factor model. The Results in Models C and D indicate that IGR and HML perform similarly in the Fama MacBeth (1973) pricing test.

In Model E, I test whether IGR has any additional information beyond that in SMB and HML in the context of the Fama-French (1996) three-factor model (MKT, SMB, HML). The results indicate that neither HML nor IGR has any additional explanatory power when taken together compared to the cases where they are each considered separately. This evidence again confirms that IGR and HML contain similar information for purpose of asset pricing.

Finally, to compare the performance of HML and IGR, I estimate a linear factor model including only MKT and HML. I find that these two factors explain approximately the same amount of cross-sectional return variation as the MKT and IGR model.

4.3.4 Performance of the Investment Factor in GMM Cross-Sectional Test

In this section, I use the GMM cross-sectional estimator to test whether the various models in Panel B of Table (10) can accommodate the size and value effects. The 25 Fama-French portfolios, together with the risk-free rate, are used as the base assets in these estimates.

I first turn to the CAPM in Model A. Unlike the Fama-MacBeth estimates in Model A of Table (10), the market has a significantly positive risk premium, rather than a negative risk premium. The Fama-French (Model B) estimates of risk premia for MKT, SMB, and HML are all positive, with all three factors jointly significant (p-value=0.0002); the risk premium for MKT is significant at the 5% level. In Model C, both MKT and IGR command positive factor premia that are statistically significant at the 1% level. In particular, the IGR premium is estimated to be 0.68% per month, with a t-statistic of 4.10. The Hansen-Jagannathan (HJ) distance for this model is 0.48, which is larger than the HJ distance estimate for the Fama-French model at 0.46. In Model D, when SMB is added to the linear factor model of MKT and IGR, the IGR remains significant at the 1% level (t-stat=4.10). In Model E, the Fama-French model augmented by the IGR factor, the factor premia for MKT, SMB, HML, and IGR are all positive, while MKT and HML have individually significant premia.

The joint significance test rejects the null hypothesis that all premia are zero. This model nests the MKT and IGR model in Panel C, and also nests the Fama-French model in Model B. The IGR insignificance in the presence of HML shows that IGR mostly picks up information already contained in HML.

Hansen's over-identification test (J-test) rejects all of the model specifications at the 5% significance level. Nor do any of the models pass the HJ test: the HJ statistic is generally large, around 0.40 in all cases, and the asymptotic p-values of the HJ test are less than 0.05. Hence, although the investment growth factor is priced by size and book-to-market portfolios, the pricing errors are still large, and the null hypothesis that the average pricing error is zero is rejected. Exposure to the investment growth factor accounts for a statistically significant portion of the value effect, but cannot fully explain it.

Finally, in Figure (2) I graph the average pricing errors for the above models, following

Hodrick and Zhang (2001). The pricing errors are computed using $W_T = \mathrm{E}[R_t R_t']^{-1}$, the same weighting matrix used to compute the HJ distance. Since the same weighting matrix is used in each case, I can compare the differences in the pricing errors across the different models. Figure (2) displays each of the 25 Fama-French portfolios on the x-axis, where the first 5 portfolios correspond to the smallest size quintile and the last 5 portfolios correspond to the largest size quintile. Within each size quintile, the book-to-market ratio increases from portfolio 1 to portfolio 5. The 26th asset is the risk-free asset. The figure plots two standard error bounds in solid lines, and the pricing errors for each asset using stars ('*').

Figure (2) shows that most of the CAPM pricing errors lie outside of the confidence bands for the high book-to-market portfolios. The Fama-French model has the most difficulty pricing the smallest growth portfolio.[5] The model including the MKT and IGR factors is the only one in which all of the pricing errors fall within the 95% confidence bands. Comparing the CAPM and the model with MKT and IGR factors reveals that adding IGR to the CAPM greatly helps to explain the size and book-to-market portfolios. The pricing errors decrease dramatically as one moves from the CAPM to the model with MKT and IGR. The model with MKT, SMB, and IGR produces pricing errors that are similar to those in the Fama-French model. Adding IGR to the Fama-French model does not significantly change the pricing errors. This is consistent with the fact that adding IGR to the Fama-French model does not help to decrease the HJ distance.

The results in this section show that the investment-based factor IGR contains information that is similar as that of the value factor HML in pricing the size and book-to-market portfolios. Cohen, Polk, and Vuoteenaho (2006) use a stochastic factor specified as a linear function of the aggregate return on equity (ROE) and find that the model explains the cross-section of stock prices quite well. The aggregate ROE factor mainly captures the cash-flow effect whereas the investment factor here mostly captures the discount rate effect.

In summary, I find that a return-based investment factor has significant power to explain the cross-sectional variation in returns on the size and book-to-market portfolios, and performs

[5] Previous studies have found the small growth portfolio the most difficult to price. See Davis, Fama, and French (2000) and Hodrick and Zhang (2001), among others

similarly to HML in asset pricing tests. The results in this section complement previous studies in which aggregate investment growth rates are used as factors in asset pricing models. In Cochrane (1996), a linear factor model with two investment returns (or two investment growth rates) is shown to perform reasonably well in pricing size-sorted portfolios compared to benchmark models such as the CAPM or the consumption-based CAPM. Li, Vassalou, and Xing (2004) extend Cochrane's model by using aggregate sector investment growth rates to price the 25 Fama and French portfolios. Their model, which includes only investment growth rates as factors, performs as well as return-based models such as the Fama-French three-factor model (1993). These studies indicate that asset prices are closely related to the real side of the economy, and investment and growth opportunities in particular.

5 Conclusion

In this paper, I test a standard Q-theory implication for the relation between investment and equity returns, interpreting the well-known value effect through the Q-theory. Considering the book-to-market ratio as the inverse of Tobin's Q allows the economic interpretation of the book-to-market ratio as a characteristic of the firm. Firm capital investment, determined by Tobin's Q, which is proxied by firms' market-to-book ratios, relates to future equity returns in the same way as the market-to-book ratio.

I also find that an investment growth factor, defined as the return difference between low investment stocks and high investment stocks, contains similar information to HML and explains the value effect as well as the Fama and French factor HML. This evidence demonstrates that, empirically, the value effect is consistent with a Q-theory model with no mispricing and no overreaction/underreaction by investors. Firm-level capital investment is negatively associated with future equity returns. Similar to the book-to-market ratio, investment can also predict equity returns in the cross-section. Portfolios with low investment growth rates or investment-to-capital ratios have significantly higher expected returns than portfolios with high investment growth rates or investment-to-capital ratios. The empirical evidence directly supports Zhang

(2005b), who says that value firms are burdened with more unproductive capital stock and thus have lower investment growth rates. Therefore, firms with low investment growth have higher expected returns. Furthermore, this investment effect is robust after controlling for the marginal product of capital. Although the evidence in this paper does not distinguish between a Q-theory story explanation and the mispricing explanation suggested by Polk and Sapienza (2002), it demonstrates direct empirical support for an investment-based explanation of the value effect.

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Table 1: Average Investment Growth Rates and Investment-to-Capital Ratios of Size and Book-to-Market Portfolios

Panel A: All Firms

Average Investment Growth Rate

	Low BM	BM 2	BM 3	BM 4	High BM
Small	1.22	1.02	0.69	0.81	0.44
Size 2	1.04	0.45	0.54	0.35	0.36
Size 3	0.67	0.45	0.32	0.16	0.17
Size 4	0.43	0.34	0.19	0.21	0.12
Big	0.30	0.21	0.13	0.09	0.14

Average Investment-to-Capital Ratio (IK)

	Low BM	BM 2	BM 3	BM 4	High BM
Small	0.63	0.45	0.36	0.29	0.23
Size 2	0.59	0.36	0.30	0.23	0.19
Size 3	0.53	0.31	0.25	0.19	0.17
Size 4	0.41	0.27	0.21	0.18	0.15
Big	0.33	0.26	0.21	0.17	0.16

Panel B: Manufacturing Firms

Average Investment Growth Rate

	Low BM	BM 2	BM 3	BM 4	High BM
Small	1.04	0.80	0.64	0.47	0.42
Size 2	0.79	0.42	0.37	0.36	0.27
Size 3	0.51	0.40	0.25	0.16	0.17
Size 4	0.40	0.31	0.17	0.15	0.17
Big	0.24	0.19	0.13	0.06	0.15

Average Investment-to-Capital Ratio (IK)

	Low BM	BM 2	BM 3	BM 4	High BM
Small	0.54	0.41	0.35	0.27	0.22
Size 2	0.53	0.35	0.29	0.23	0.19
Size 3	0.47	0.30	0.25	0.21	0.18
Size 4	0.39	0.27	0.22	0.20	0.18
Big	0.30	0.27	0.22	0.19	0.20

Panel C: Non-Manufacturing Firms

Average Investment Growth Rate

	Low BM	BM 2	BM 3	BM 4	High BM
Small	1.47	1.43	0.74	1.13	0.40
Size 2	1.31	0.50	0.79	0.42	0.52
Size 3	0.85	0.56	0.44	0.17	0.15
Size 4	0.46	0.44	0.23	0.27	0.06
Big	0.45	0.22	0.14	0.11	0.13

Average Investment-to-Capital Ratio (IK)

	Low BM	BM 2	BM 3	BM 4	High BM
Small	0.78	0.52	0.37	0.30	0.23
Size 2	0.66	0.39	0.31	0.23	0.19
Size 3	0.57	0.33	0.25	0.18	0.17
Size 4	0.44	0.27	0.21	0.17	0.13
Big	0.41	0.26	0.19	0.14	0.11

This table lists average investment growth rates and investment-to-capital ratios for different size and book-to-market portfolios constructed using NYSE size and book-to-market breakpoints. In Panel A, all firms except financial industry firms are included. Panel B includes manufacturing firms with two digit SIC codes between 20 and 39. In Panel C, all non-financial and non-manufacturing firms are included. The sample period is from 1964 to 2003.

Table 2: Portfolio Returns Sorted on Investment

Panel A: Summary on Investment Portfolios

	Sorted by IK		Sorted by IG	
	Mean(EW)	Mean(VW)	Mean(EW)	Mean(VW)
Low	1.59	1.09	1.71	1.19
2	1.37	1.07	1.46	1.12
3	1.34	1.05	1.37	1.05
4	1.40	1.07	1.36	0.99
5	1.41	1.09	1.30	0.94
6	1.36	0.98	1.33	1.02
7	1.32	0.92	1.24	0.91
8	1.29	0.89	1.31	0.92
9	1.24	0.84	1.19	0.82
High	1.12	0.65	1.12	0.62
Low-High	0.46	0.44	0.58	0.56
t-stat	2.37	1.25	5.04	2.81

Panel B: α in Time-series Regression

	IK EW		IK VW		IG EW		IG VW	
	CAPM	Fama-French	CAPM	Fama-French	CAPM	Fama-French	CAPM	Fama-French
Low	0.63	0.34	0.14	-0.04	0.62	0.35	0.01	-0.10
2	0.39	0.13	0.16	0.01	0.30	0.08	0.06	0.03
3	0.36	0.14	0.16	0.04	0.33	0.12	0.13	0.10
4	0.32	0.12	0.13	0.07	0.32	0.13	0.10	0.06
5	0.32	0.14	0.16	0.15	0.14	-0.03	0.05	0.01
6	0.25	0.05	0.06	0.07	0.28	0.10	0.12	0.14
7	0.18	0.01	0.01	0.04	0.19	0.02	-0.02	-0.01
8	0.11	-0.02	-0.01	0.08	0.19	0.04	0.01	0.02
9	0.04	-0.07	-0.15	-0.01	0.08	-0.04	-0.10	0.00
High	-0.06	-0.11	-0.33	-0.12	0.02	-0.13	-0.42	-0.36
Low-High	0.69	0.46	0.48	0.08	0.60	0.49	0.42	0.25
t-stat	4.77	3.86	1.92	0.34	4.92	4.02	2.35	1.38

Panel A lists summary statistics for equally-weighted and value-weighted investment portfolios at a monthly frequency. Each year in June, firms are sorted into 10 deciles by their previous fiscal year investment growth (IG) or investment-to-capital ratio (IK) and I compute equally-weighted and value-weighted simple percentage returns on each decile portfolio. The Low-High variable is the return difference between the lowest IK/IG decile and the highest IK/IG decile and t-stat denotes the t-statistic computed using Newey-West (1987) heteroskedastic-robust standard errors. The sample period is from June 1964 to December 2003. Panel B lists the αs from the time series regression. Under CAPM are the αs from the CAPM and under FF3 are the αs from the Fama-French three-factor model.

Table 3: The Investment Effect After Controlling for Firm Size

Panel A: Equally-weighted Returns

	Low IG	2	3	4	High IG	Low-High	t-stat
Small	1.81	1.58	1.51	1.45	1.22	0.58	5.01
2	1.59	1.33	1.59	1.31	1.21	0.38	2.32
3	1.41	1.50	1.35	1.18	0.99	0.41	2.71
4	1.20	1.16	1.14	1.26	1.05	0.15	1.07
Big	1.13	1.11	0.95	0.95	0.89	0.24	1.64

	Low IK	2	3	4	High IK	Low-High	t-stat
Small	1.72	1.64	1.52	1.43	1.37	0.35	2.11
2	1.45	1.42	1.49	1.36	1.25	0.21	1.01
3	1.38	1.41	1.31	1.26	1.08	0.31	1.39
4	1.14	1.13	1.27	1.23	1.08	0.06	0.25
Big	1.03	1.12	1.04	1.00	0.88	0.15	0.67

Panel B: Value-weighted Returns

	Low IG	2	3	4	High IG	Low-High	t-stat
Small	1.45	1.17	0.96	0.94	1.01	0.44	2.29
2	1.47	1.17	1.45	1.16	1.06	0.41	2.42
3	1.34	1.36	1.19	1.06	0.90	0.44	2.75
4	1.13	0.99	1.05	1.17	0.95	0.18	1.14
Big	1.02	0.99	0.85	0.82	0.75	0.27	1.83

	Low IK	2	3	4	High IK	Low-High	t-stat
Small	1.39	1.28	0.96	1.09	0.58	0.81	2.48
2	1.25	1.31	1.34	1.23	1.10	0.16	0.71
3	1.29	1.32	1.11	1.14	0.99	0.30	1.28
4	1.04	1.07	1.13	1.09	0.94	0.09	0.39
Big	0.94	1.04	0.96	0.90	0.72	0.22	1.05

Panel C: Correlation Matrix between
25 Fama and French Portfolios and 25 Portfolios on Size/IK

	Low IK High BM	2 2	3 3	4 4	High IK Low BM
Small	0.91	0.88	0.80	0.87	0.73
2	0.62	0.91	0.88	0.90	0.83
3	0.55	0.93	0.88	0.90	0.83
4	0.53	0.94	0.91	0.91	0.88
Big	0.82	0.91	0.91	0.92	0.88

This table lists summary statistics for equally-weighted and value-weighted investment portfolios controlling for size. Each year in June, the firms are first sorted into 5 quintiles based on NYSE market capitalization breakpoints at the end May; within each quintile, firms are sorted on previous fiscal year investment growth (IG) or investment capital ratio (IK). I compute the equally-weighted and value-weighted simple percentage returns for each quintile portfolio. The Low-High variable is the return difference between low investment growth(investment-to-capital ratio) quintile and high investment growth(investment-to-capital ratio) quintile within each size quintile. The column labelled "t-stat" shows t-statistics for the High-Low computed using Newey-West (1987) heteroskedastic-robust standard errors. Panel C reports correlations between the 25 portfolios sorted on size/book-to-market and the 25 portfolios sorted on size/investment-to-capital ratio. For instance, 0.91 is the correlation between the small/high book-to-market portfolio and the small/low investment-to-capital ratio portfolio. The sample period is from June 1964 to December 2003.

Table 4: Fama MacBeth Regressions Using All Firms

Panel A: Predicting Future Returns

	Constant	$IG_{i,t-1}$	R^2
	0.16	-2.31	0.53%
t-stat	5.06	-4.08	

	Constant	$IK_{i,t-1}$	R^2
	0.16	-4.75	1.27%
t-stat	5.62	-2.43	

Panel B: Predicting Future Returns

	Constant	$IG_{i,t-1}$	$BM_{i,t-1}$	$Size_{i,t-1}$	$\beta_{i,t-1}$	R^2
	0.15	-2.21	1.40	-1.38	-1.21	7.55%
t-stat	5.73	-4.58	3.68	-3.11	-0.68	

	Constant	$IK_{i,t-1}$	$BM_{i,t-1}$	$Size_{i,t-1}$	$\beta_{i,t-1}$	R^2
	0.17	-3.27	1.72	-1.74	-0.65	7.45%
t-stat	5.20	-2.79	3.27	-4.22	-0.86	

This Table lists Fama MacBeth (1973) cross-sectional regression results using all of the firm-level data. Newey-West t-statistics are provided under the parameter estimates. Sample period is from June 1964 to December 2003. In Panel A, excess returns are regressed on lagged investment variables. In Panel B, excess returns are regressed on lagged investment, lagged book-to-market ratio, lagged Size (firm market capitalization) and lagged β, where β is computed using previous year daily return data.

Table 5: The Value Effect After Controlling for Marginal Product of Capital (MPK)

Panel A: Equally-weighted Returns

	Low BM	2	3	4	High BM	High-Low	t-stat
Low mpk	0.93	1.19	1.14	1.46	1.75	0.82	3.37
2	1.14	1.33	1.42	1.54	1.65	0.51	2.44
3	1.17	1.50	1.44	1.65	1.76	0.59	2.69
4	1.19	1.39	1.42	1.53	1.65	0.45	1.90
High mpk	1.10	1.21	1.30	1.48	1.62	0.51	2.17

Panel B: Value-weighted Returns

	Low BM	2	3	4	High BM	High-Low	t-stat
Low mpk	0.72	0.79	0.94	1.12	1.26	0.54	2.27
2	1.00	0.90	1.04	1.04	1.51	0.50	2.18
3	1.00	1.16	1.08	1.24	1.13	0.13	0.48
4	0.90	1.07	1.17	1.18	1.17	0.26	1.89
High mpk	1.13	1.00	0.96	1.21	0.94	-0.19	-0.62

This table lists summary statistics for equally-weighted and value-weighted book-to-market portfolios controlling for mpk. Each year in June, the firms are first sorted into 5 quintiles by their marginal product of capital (mpk) which is proxied by the ratio of sales to assets at the end May; within each quintile, firms are sorted on previous fiscal year book-to-market ratio. I compute the equally-weighted and value-weighted simple percentage returns for each quintile portfolio. The High-Low variable is the return difference between high book-to-market quintile and low book-to-market quintile within each investment quintile. The column labelled “t-stat” shows t-statistics for the High-Low computed using Newey-West (1987) heteroskedastic-robust standard errors. The sample period is from June 1964 to December 2003.

Table 6: The Investment Effect After Controlling for Marginal Product of Capital (MPK)

Panel A: Equally-weighted Returns

	Low IG	2	3	4	High IG	Low-High	t-stat
Low mpk	1.59	1.30	1.21	1.29	0.94	0.65	3.32
2	1.72	1.36	1.31	1.16	1.09	0.62	3.98
3	1.83	1.56	1.46	1.40	1.19	0.63	4.32
4	1.77	1.50	1.38	1.33	1.21	0.56	3.36
High mpk	1.74	1.59	1.39	1.15	0.85	0.88	4.93

	Low IK	2	3	4	High IK	Low-High	t-stat
Low mpk	1.57	1.34	1.22	1.29	0.91	0.65	2.97
2	1.69	1.41	1.33	1.14	1.06	0.63	3.47
3	1.81	1.65	1.50	1.38	1.08	0.72	4.43
4	1.60	1.48	1.52	1.37	1.22	0.38	1.88
High mpk	1.78	1.43	1.42	1.31	0.78	1.00	4.31

Panel B: Value-weighted Returns

	Low IG	2	3	4	High IG	Low-High	t-stat
Low mpk	1.15	1.01	0.93	0.92	0.89	0.25	1.38
2	0.98	1.09	0.91	0.95	0.73	0.25	1.17
3	1.28	1.17	1.13	0.99	0.84	0.43	2.01
4	1.37	1.19	0.87	1.06	0.85	0.52	2.41
High mpk	1.39	1.04	1.02	0.97	0.76	0.62	2.20

	Low IK	2	3	4	High IG	Low-High	t-stat
Low mpk	1.12	1.01	0.89	0.92	0.62	0.50	2.31
2	1.03	1.17	1.07	0.74	0.84	0.19	0.74
3	1.18	1.26	1.09	0.94	0.88	0.29	1.24
4	1.30	1.01	0.93	0.81	0.81	0.49	2.07
High mpk	1.15	1.25	0.99	0.97	0.57	0.57	2.11

This table lists summary statistics for equally-weighted and value-weighted investment portfolios controlling for mpk. Each year in June, the firms are first sorted into 5 quintiles by their marginal product of capital (mpk) which is proxied by the ratio of sales to assets at the end May; within each quintile, firms are sorted on previous fiscal year investment growth (IG) or investment capital ratio (IK). I compute the equally-weighted and value-weighted simple percentage returns for each quintile portfolio. The Low-High variable is the return difference between low investment growth(investment-to-capital ratio) quintile and high investment growth(investment-to-capital ratio) quintile within each size quintile. The column labelled "t-stat" shows t-statistics for the High-Low computed using Newey-West (1987) heteroskedastic-robust standard errors. The sample period is from June 1964 to December 2003.

Table 7: The Value Effect After Controlling for Investment

Panel A: Equally-weighted Returns

	Low BM	2	3	4	High BM	High-Low	t-stat
Low IG	1.47	1.43	1.52	1.57	1.68	0.21	0.95
2	1.41	1.38	1.22	1.27	1.46	0.05	0.23
3	1.32	1.18	1.19	1.33	1.51	0.19	0.92
4	1.24	1.29	1.19	1.28	1.24	-0.00	-0.01
High IG	1.17	1.06	1.15	1.14	1.09	-0.08	-0.35
Low-High	0.30	0.37	0.37	0.43	0.59		
t-stat	1.70	2.51	2.44	3.00	4.16		
Low IK	1.45	1.45	1.45	1.33	1.60	0.15	0.60
2	1.51	1.38	1.22	1.24	1.44	-0.07	-0.36
3	1.37	1.36	1.23	1.48	1.31	-0.06	-0.30
4	1.30	1.22	1.27	1.27	1.27	-0.03	-0.13
High IK	1.19	1.12	1.09	1.21	1.20	0.01	0.04
Low-High	0.26	0.34	0.37	0.12	0.40		
t-stat	1.20	1.67	1.78	0.53	1.76		

Panel B: Value-weighted Returns

	Low BM	2	3	4	High BM	High-Low	t-stat
Low IG	0.87	1.16	1.26	1.15	1.29	0.42	1.60
2	1.08	1.02	0.95	0.95	1.20	0.11	0.49
3	1.05	0.95	0.97	0.85	1.23	0.18	0.73
4	0.96	1.01	0.81	1.06	0.91	-0.05	-0.19
High IG	0.82	0.59	0.81	0.91	0.94	0.12	0.46
Low-High	0.06	0.57	0.45	0.24	0.35		
t-stat	0.23	2.54	2.04	1.13	1.66		
Low IK	0.91	1.03	1.08	1.03	1.31	0.40	1.54
2	1.28	1.12	1.01	0.81	1.14	-0.14	-0.57
3	1.07	0.94	0.98	1.10	1.15	0.08	0.28
4	0.94	0.93	0.78	0.96	0.90	-0.04	-0.15
High IK	0.97	0.84	0.59	0.52	0.56	-0.41	-1.22
Low-High	-0.06	0.19	0.50	0.51	0.75		
t-stat	-0.18	0.70	1.64	1.71	2.37		

This table lists summary statistics for equally-weighted and value-weighted portfolios independently sorted on investment variables and book-to-market ratios. Each year in June, the firms are independently sorted into 5 quintiles by their previous fiscal year investment growth (IG) or investment capital ratio (IK) and also sorted into 5 book-to-market portfolios by their previous year's book-to-market ratio. I compute the equally-weighted and value-weighted simple percentage returns. The High-Low variable is the return difference between high BM quintile and low BM quintile within each investment quintile. The Low-High variable is the return difference between low investment portfolio and high investment portfolio. The column and row labelled with "t-stat" show t-statistics for the High-Low (Low-High) computed using Newey-West (1987) heteroskedastic-robust standard errors. The sample period is from June 1964 to December 2003.

Table 8: Summary Statistics of Factors

	MEAN	STD	SKEW	KURT	ρ
MKT	0.43*	4.54	-0.48	4.86	0.05
SMB	0.18	3.31	-0.63	8.50	0.17
HML	0.46*	2.99	0.30	5.14	0.17
IGR	0.20**	1.31	0.02	4.07	-0.02

Correlation Matrix of factors

	MKT	SMB	HML	IGR
MKT	1.00			
SMB	0.27	1.00		
HML	-0.41	-0.28	1.00	
IGR	-0.31	-0.09	0.36	1.00

Summary statistics of simple returns on MKT, SMB, HML, and IGR factors are listed. MKT is the CRSP value-weighted return on all stocks. SMB and HML are the size and value factors constructed by Fama and French. The IGR is constructed exactly the same way as HML is constructed, replacing the book-to-market ratio by capital investment growth rate. Skew refers to skewness and Kurt refers to kurtosis. ρ denotes the first-order autocorrelation coefficient. Factors that have means significant at the 5% (1%) level are denoted with * (**), using Newey-West (1987) standard errors with 3 lags. The sample period is from June 1964 to December 2003.

Table 9: Time-series Regression Results

	Book-to-Market Quintiles									
Size	Low	2	3	4	High	Low	2	3	4	High
Panel A: Regressions: $R_i - R_f = \alpha_i + b_i MKT + e_i$										
			α					t(α)		
Small	-0.38	0.30	0.41	0.68	0.73	-1.51	1.43	2.26	3.81	3.66
2	-0.23	0.14	0.43	0.53	0.55	-1.29	0.96	3.08	3.65	3.24
3	-0.16	0.22	0.28	0.46	0.57	-1.18	1.87	2.21	3.42	3.45
4	-0.02	0.02	0.28	0.41	0.43	-0.19	0.19	2.39	3.47	2.87
Big	-0.04	0.04	0.11	0.20	0.19	-0.49	0.43	1.10	1.68	1.29
Panel B: Regressions: $R_i - R_f = \alpha_i + b_i MKT + s_i SMB + h_i HML + e_i$										
			α					t(α)		
Small	-0.40	0.05	0.07	0.27	0.20	-2.72	0.49	0.83	3.57	2.87
2	-0.15	-0.08	0.11	0.10	-0.00	-1.55	-1.01	1.63	1.56	-0.01
3	-0.01	0.03	-0.06	0.04	0.05	-0.16	0.34	-0.82	0.55	0.59
4	0.16	-0.14	-0.02	0.03	-0.07	1.68	-1.60	-0.27	0.45	-0.73
Big	0.22	-0.01	-0.02	-0.11	-0.24	3.50	-0.12	-0.21	-1.57	-2.43
Panel C: Regressions: $R_i - R_f = \alpha_i + b_i MKT + c_i IGR + e_i$										
			α					t(α)		
Small	-0.34	0.32	0.36	0.59	0.62	-1.35	1.48	2.05	3.44	3.22
2	-0.13	0.14	0.38	0.45	0.42	-0.73	0.94	2.73	3.15	2.67
3	-0.07	0.20	0.21	0.37	0.45	-0.47	1.65	1.71	2.80	2.78
4	0.05	-0.02	0.20	0.33	0.32	0.36	-0.21	1.80	2.74	2.13
Big	0.03	-0.01	0.06	0.15	0.09	0.30	-0.16	0.57	1.14	0.65
Panel D: Regressions: $R_i - R_f = \alpha_i + b_i MKT + s_i SMB^* + c_i IGR + e_i$										
			α					t(α)		
Small	-0.45	0.22	0.28	0.51	0.53	-2.22	1.31	2.11	3.87	3.84
2	-0.21	0.07	0.31	0.39	0.36	-1.46	0.64	3.00	3.20	2.56
3	-0.13	0.15	0.18	0.34	0.41	-1.00	1.50	1.58	2.71	2.66
4	0.02	-0.04	0.19	0.32	0.30	0.18	-0.38	1.71	2.64	2.04
Big	0.04	0.00	0.08	0.17	0.10	0.53	0.06	0.76	1.29	0.72

This table reports portfolio alphas for the 25 Fama French size and book-to-market portfolios. The α's are from the CAPM, the Fama-French (1993) three-factor model, the linear factor model of MKT and IGR, and the linear factor model including MKT, SMB* and IGR. The sample period is June 1964 to December 2003.

Table 10: Cross-Sectional Asset Pricing Test Results

Panel A: Fama MacBeth Regression

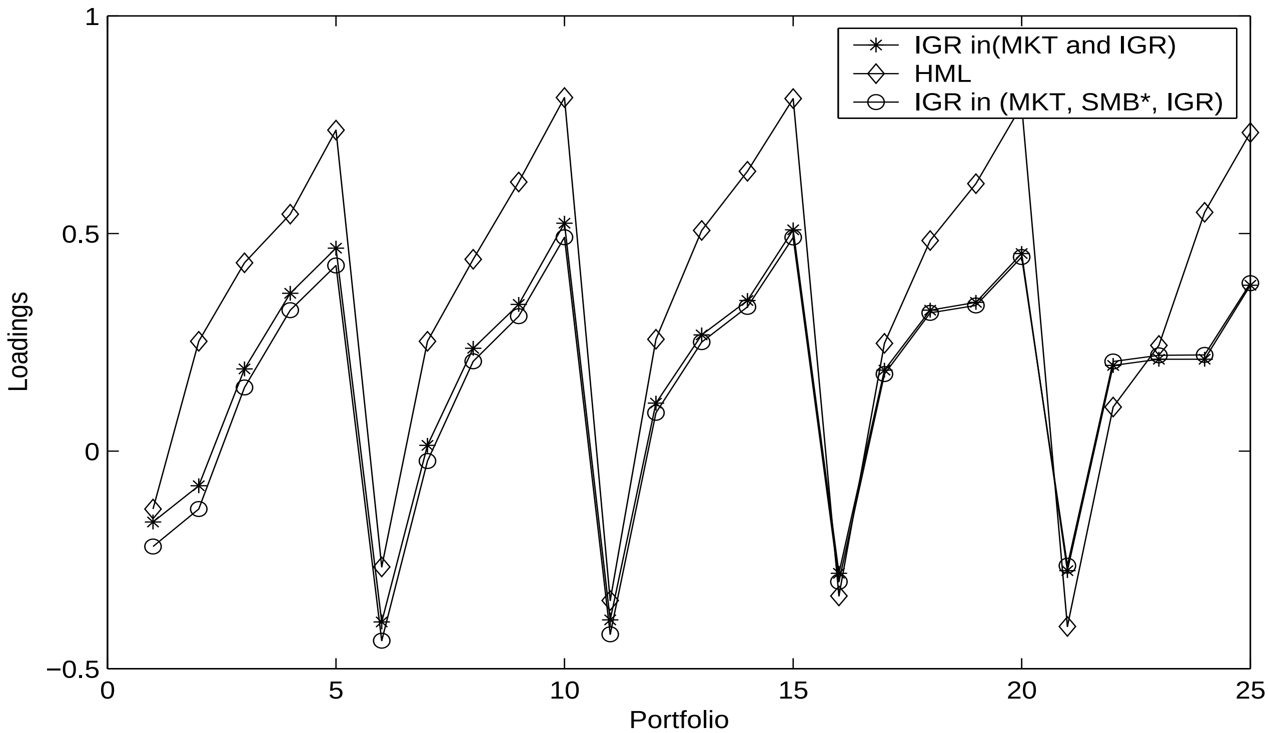
		Constant	MKT	SMB	HML	IGR	R^2	Joint Sig
Model A:	Premium	1.22	-0.48				0.12	0.27
	t-value(adj)	3.10	-0.98					
Model B	Premium	1.40	-0.92	0.31	0.38		0.77	0.00
	t-value(adj)	4.25	-2.08	1.19	1.65			
Model C:	Premium	-0.05	0.58			0.01	0.58	0.00
	t-value(adj)	-0.08	0.80			3.71		
Model D:	Premium	1.34	-0.85	0.34		0.41	0.77	0.00
	t-value(adj)	4.62	-2.02	1.27		1.99		
Model E:	Premium	1.34	-0.85	0.34	0.35	0.39	0.77	0.00
	t-value(adj)	4.07	-1.89	1.25	1.50	1.66		
Model F:	Premium	-0.18	0.69		0.49		0.51	0.00
	t-value(adj)	-0.33	1.09		2.22			

Panel B: GMM Estimation

		MKT	SMB	HML	IGR	Test	J	Joint	HJ
Model A:	Premium	0.98				Statistic	61.24		0.54
	t-value	4.34				p-value	0.00	0.00	0.00
Model B:	Premium	1.00	0.15	0.43		Statistic	52.39		0.46
	t-value	4.07	0.84	2.82		p-value	0.00	0.00	0.00
Model C:	Premium	0.96			0.71	Statistic	46.93		0.48
	t-value	3.62			4.23	p-value	0.00	0.00	0.00
Model D:	Premium	0.99	0.27		0.68	Statistic	46.95		0.48
	t-value	3.59	1.43		4.10	p-value	0.00	0.00	0.00
Model E:	Premium	1.01	0.16	0.42	0.05	Statistic	52.27		0.46
	t-value	4.04	0.90	2.62	0.30	p-value	0.00	0.00	0.00

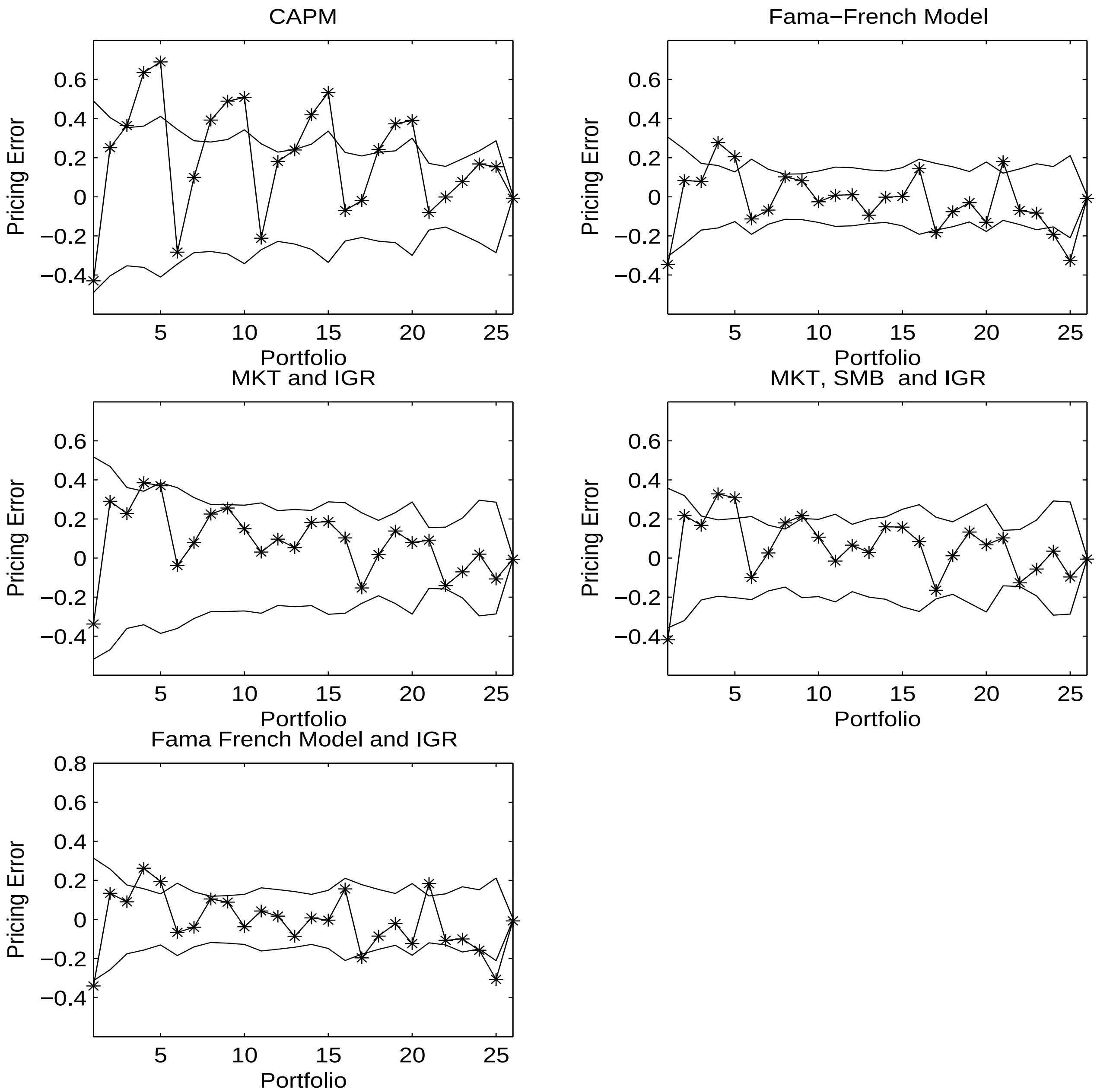
The Fama-MacBeth (1973) regression tests use Fama and French 25 size and book-to-market portfolio returns. MKT, SMB and HML are the market, size and value factors in the Fama and French (1993) three-factor model and the IGR is the investment factor. SMB* is constructed analogous to SMB while construcing IGR. In the first stage of the Fama-MacBeth precedure, we obtain the loadings on the factors using the full sample time-series data. In the second stage, each month, we regress the cross-sectional portfolio returns on the factor loadings from the first stage. The t-value is calculated using Shanken's (1992) adjusted standard errors. The R^2 is adjusted for the number of degrees of freedom. The last column of the table reports p-values from χ^2 tests on the joint significance of the betas of each model. Panel B lists the optimal GMM estimation results. "Coefficient " refers to factor coefficients in the pricing kernel, and "Premium" refers to the factor premium, which is expressed in percentage term. The J-test is Hansen's (1982) χ^2 test statistics on the over-identifying restrictions of the model. "HJ" denotes the Hansen-Jagannathan (1997) distance measure. The p-value of the HJ distance is obtained from 100,000 simulations. The estimation period is from June 1964 to December 2003.

Figure 1: Fama French 25 Portfolios: Loadings on IGR and HML



This plot shows the loadings of the Fama-French 25 portfolios on IGR and loadings on HML. The first 5 portfolios correspond to the smallest size quintile and the last 5 portfolios correspond to the largest size quintile. Within each size quintile, the book-to-market ratio increases from the first portfolio to the last portfolio. Factor loadings are estimated in the first step of the Fama-MacBeth (1973) procedure. The sample period is June 1964 to December 2003.

Figure 2: Pricing Errors of GMM Estimation (HJ method)



These plots show the pricing errors of the various models considered in Section 5. Each star in the graph represents one of the 25 Fama-French 25 portfolios and the 26th asset is the risk-free asset. The first 5 portfolios correspond to the smallest size quintile and the last 5 portfolios correspond to the largest size quintile. Within each size quintile, the book-to-market ratio increases from the first portfolio to the last portfolio. The graphs show the average pricing errors with asterisks, with two standard error bands in solid lines. The units on the y-axis are in percentage terms. The pricing errors are estimated following Hansen-Jagannathan (1997).