A Model of Momentum

Laura Xiaolei Liu*
Hong Kong University of Science and Technology
and Cheung Kong Graduate School of Business

Lu Zhang†
The Ohio State University
and NBER

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Abstract

We offer an investment-based interpretation of price and earnings momentum. The neoclassical theory of investment implies that expected stock returns are tied with the expected marginal benefit of investment divided by the marginal cost of investment. Winners have higher expected growth and expected marginal productivity (two major components of the marginal benefit of investment), and earn higher expected stock returns than losers. The investment model succeeds in capturing average momentum profits, reversal of momentum in long horizons, as well as the interaction of momentum with size, firm age, trading volume, stock return volatility, credit ratings, and book-to-market. However, the model fails to reproduce procyclical momentum profits.

*School of Business and Management, Hong Kong University of Science and Technology, Kowloon, Hong Kong. Tel: (852) 2358-7661, fax: (852) 2358-1749, and e-mail: fnliu@ust.hk.

†Fisher College of Business, The Ohio State University, 760A Fisher Hall, 2100 Neil Avenue, Columbus OH 43210; and NBER. Tel: (614) 292-8644, fax: (614) 292-7062, and e-mail: zhanglu@fisher.osu.edu.

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1 Introduction

Momentum is a major puzzle in finance and accounting. Bernard and Thomas (1989) document that stocks with high earnings surprises earn higher average returns over the next twelve months than stocks with low earnings surprises (earnings momentum). They conclude that their evidence "cannot plausibly be reconciled with arguments built on risk mismeasurement but is consistent with a delayed price response (p. 34)." Jegadeesh and Titman (1993) document that stocks with high recent performance continue to earn higher average returns over the next three to twelve months than stocks with low recent performance (price momentum). They suggest that "the market underreacts to information about the short-term prospects of firms (p. 90)."[1] The bulk of the existing literature has followed the behavioral interpretation. In particular, Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), and Hong and Stein (1999) have constructed behavioral models to explain momentum using psychological biases such as conservatism, self-attributive overconfidence, and slow information diffusion.

As a fundamental departure from the existing literature, we use the neoclassical theory of investment to examine whether momentum is correctly connected to economic fundamentals through first-order conditions of firms. We find that the answer is yes. Under constant returns to scale, the stock return equals the (levered) investment return. The investment return, defined as the next-period marginal benefit of investment divided by the current-period marginal cost of investment, is tied with firm characteristics via firms' optimality conditions. Intuitively, winners have higher expected growth and higher expected marginal productivity (two major components of the expected marginal benefit of investment). As such, winners earn higher expected stock returns than losers.

[1] Many subsequent studies have confirmed and refined this finding. Asness (1997) shows that momentum is stronger in growth firms than in value firms. Rouwenhorst (1998) documents momentum profits in international markets. Moskowitz and Grinblatt (1999) report large momentum profits in industry portfolios. Hong, Lim, and Stein (2000) show that small firms with low analyst coverage display stronger momentum. Lee and Swaminathan (2000) document that momentum is more prevalent in stocks with high trading volume. Jegadeesh and Titman (2001) show that momentum remains large in the post-1993 sample. Jiang, Lee, and Zhang (2005) and Zhang (2006) report that momentum profits are higher among firms with higher information uncertainty measured by, for example, size, firm age, and stock return volatility. Avramov, Chordia, Jostova, and Philipov (2007) document that momentum profits are large and significant among firms with low credit ratings, but are nonexistent among firms with high credit ratings.

We use generalized method of moments (GMM) to match average levered investment returns to average stock returns across momentum portfolios. For price momentum, the winner-minus-loser decile has a small model error (alpha) of 0.51% per annum, which is negligible compared to the alpha of 15.13% from the capital asset pricing model (CAPM) and the alpha of 17.26% from the Fama-French (1993) three-factor model. The alphas of individual deciles are also substantially smaller in the investment model. The mean absolute error across the price momentum deciles is 0.87% in the investment model, but is 3.45% in the CAPM and 3.64% in the Fama-French model. For earnings momentum, the winner-minus-loser decile has an alpha of −0.90% per annum in the investment model, and is smaller in magnitude than the CAPM alpha of 8.80% and the Fama-French alpha of 10.91%. The mean absolute error across the earnings momentum deciles is 0.72% in the investment model, and is lower than 4.22% in the CAPM and 3.47% in the Fama-French model.

The investment model suggests several connections between momentum and economic fundamentals. All else equal, firms with low investment-to-capital, high expected investment-to-capital growth, high expected sales-to-capital, high market leverage, low expected rates of depreciation, and low expected corporate bond returns should earn high expected stock returns. Using extensive comparative statics, we show that expected investment-to-capital growth is the most important component of momentum. In particular, without the cross-sectional variation in the expected growth, the winner-minus-loser alpha jumps from 0.51% per annum in the benchmark estimation to 10.08% for price momentum, and the alpha jumps from −0.90% to 4.21% for earnings momentum.

Going beyond matching average momentum profits, the investment model is also consistent with several other stylized facts of momentum. Momentum predicted in the model reverts beyond the first year after portfolio formation. The low persistence of the expected investment-to-capital growth is the underlying force of this reversal. Further, as in the data, the cash flow component of the investment returns across the price momentum deciles also displays long run risks similar to the dividend component of the stock returns per Bansal, Dittmar, and Lundblad (2005). However, contrary to Cooper, Gutierrez, and Hameed's (2004) evidence, price momentum in the model is not substantially higher following up markets than down markets.

Finally, the investment model goes a long way toward fitting the average returns across two-way portfolios from interacting momentum with size, firm age, trading volume, stock return volatility, credit ratings, and book-to-market. The alphas in the investment model do not vary systematically with either price or earnings momentum. Across the small, median, and big size terciles, for example, the price momentum winner-minus-loser alphas are -0.82%, -0.90%, and -1.01% per annum, which are smaller in magnitude than the Fama-French alphas of 10.52%, 8.54%, and 6.84%, respectively. Across the same three size terciles, the earnings momentum winner-minus-loser alphas are 1.96%, -3.86%, and -1.87%, all of which are again smaller in magnitude than those from the Fama-French model: 11.87%, 3.89%, and 3.59%, respectively.

Our work is built on Cochrane (1991), who is the first to use the investment model to study asset prices. Lettau and Ludvigson (2002) examine the impact of time-varying risk premiums on aggregate investment. Belo (2010) uses the marginal rate of transformation as the stochastic discount factor. Gourio (2010) examines the effect of putty-clay technology on stock market volatility. Jermann (2010) studies the equity premium derived from firms' optimality conditions. While these prior studies focus on aggregate stock market, we focus on momentum in the cross section. Liu, Whited, and Zhang (2009) start to use the investment model to examine how stock returns relate to earnings surprises, book-to-market, and investment in the cross section. We deepen greatly the analysis on earnings momentum, and more important, expand the scope of analysis to price momentum. Our work is also related to Berk, Green, and Naik (1999), Sagi and Seasholes (2007), Cooper (2006), and Tuzel (2010), who construct dynamic models to study cross-sectional returns. We differ by doing structural estimation on the closed-form investment return equations.

The rest of the paper unfolds as follows. Section 2 sets up the model. Section 3 describes our research design and data. Section 4 presents our estimation results. Section 5 concludes.

2 The Model of the Firms

Firms use capital and costlessly adjustable inputs to produce a homogeneous output. These inputs are chosen each period to maximize operating profits, defined as revenue minus the expenditure on these inputs. Taking operating profits as given, firms choose investment to maximize the market value of equity. Let $\Pi(K_{it}, X_{it})$ denote the operating profits of firm i at time t, in which K_{it} is capital, and X_{it} is a vector of exogenous aggregate and firm-specific shocks. We assume that $\Pi(K_{it}, X_{it})$ exhibits constant returns to scale, i.e., $\Pi(K_{it}, X_{it}) = K_{it}\partial\Pi(K_{it}, X_{it})/\partial K_{it}$. In addition, firms have a Cobb-Douglas production function, meaning that the marginal product of capital is $\partial\Pi(K_{it}, X_{it})/\partial K_{it} = \kappa Y_{it}/K_{it}$, in which $\kappa > 0$ is the capital's share in output, and Y_{it} is sales.

Capital evolves as $K_{it+1} = I_{it} + (1 - \delta_{it})K_{it}$, in which δ_{it} is the exogenous proportional rate of capital depreciation. We allow δ_{it} to be firm-specific and time-varying. Firms incur adjustment costs when investing. The adjustment costs function, denoted $\Phi(I_{it}, K_{it})$, is increasing and convex in I_{it}, decreasing in K_{it}, and of constant returns to scale in I_{it} and K_{it}. We adopt the standard quadratic functional form: $\Phi(I_{it}, K_{it}) = (a/2)(I_{it}/K_{it})^2 K_{it}$, in which $a > 0$.

Firms can borrow with one-period debt. At the beginning of time t, firm i issues debt, B_{it+1}, which must be repaid at the beginning of $t+1$. When borrowing, firms take as given the (gross) risky interest rate on B_{it}, denoted r^B_{it}, which varies across firms and over time. Taxable corporate profits equal operating profits less capital depreciation, adjustment costs, and interest expenses: $\Pi(K_{it}, X_{it}) - \delta_{it}K_{it} - \Phi(I_{it}, K_{it}) - (r^B_{it} - 1)B_{it}$. Let τ_t be the corporate tax rate, $\tau_t\delta_{it}K_{it}$ be the depreciation tax shield, and $\tau_t(r^B_{it} - 1)B_{it}$ be the interest tax shield. Firm i's payout is then given by:

$$D_{it} \equiv (1 - \tau_t)[\Pi(K_{it}, X_{it}) - \Phi(I_{it}, K_{it})] - I_{it} + B_{it+1} - r^B_{it}B_{it} + \tau_t\delta_{it}K_{it} + \tau_t(r^B_{it} - 1)B_{it}. \quad (1)$$

Let M_{t+1} be the stochastic discount factor from t to $t + 1$. Taking M_{t+1} as given, firm i

maximizes its cum-dividend market value of equity:

$$V_{it} \equiv \max_{\{I_{it+\triangle t}, K_{it+\triangle t+1}, B_{it+\triangle t+1}\}_{\triangle t=0}^{\infty}} E_t \left[\sum_{\triangle t=0}^{\infty} M_{t+\triangle t} D_{it+\triangle t} \right], \tag{2}$$

subject to a transversality condition: $\lim_{T\to\infty} E_t\left[M_{t+T}\, B_{it+T+1}\right] = 0$. The firm's first-order condition for investment implies $E_t[M_{t+1} r^I_{it+1}] = 1$, in which r^I_{it+1} is the investment return:

$$r^I_{it+1} \equiv \frac{(1-\tau_{t+1})\left[\kappa \frac{Y_{it+1}}{K_{it+1}} + \frac{a}{2}\left(\frac{I_{it+1}}{K_{it+1}}\right)^2\right] + \tau_{t+1}\delta_{it+1} + (1-\delta_{it+1})\left[1 + (1-\tau_{t+1})a\left(\frac{I_{it+1}}{K_{it+1}}\right)\right]}{1 + (1-\tau_t)a\left(\frac{I_{it}}{K_{it}}\right)}. \tag{3}$$

Intuitively, the investment return is the marginal benefit of investment at $t+1$ divided by the marginal cost of investment at t. The optimality condition says that the marginal cost of investment equals the marginal benefit of investment discounted to t. In the numerator of the investment return (the marginal benefit of investment), $(1-\tau_{t+1})\kappa(Y_{it+1}/K_{it+1})$ is the after-tax marginal product of capital, $(1-\tau_{t+1})(a/2)(I_{it+1}/K_{it+1})^2$ is the after-tax marginal reduction in adjustment costs, and $\tau_{t+1}\delta_{it+1}$ is the marginal depreciation tax shield. The last term in the numerator is the marginal continuation value of an extra unit of capital net of depreciation, in which the marginal continuation value equals the marginal cost of investment in the next period, $1 + (1-\tau_{t+1})a(I_{it+1}/K_{it+1})$.

Define the after-tax corporate bond return as $r^{Ba}_{it+1} \equiv r^B_{it+1} - (r^B_{it+1} - 1)\tau_{t+1}$. Firm i's first-order condition for new debt implies $E_t[M_{t+1} r^{Ba}_{it+1}] = 1$. Define $P_{it} \equiv V_{it} - D_{it}$ as the ex-dividend market value of equity, $r^S_{it+1} \equiv (P_{it+1} + D_{it+1})/P_{it}$ as the stock return, and $w_{it} \equiv B_{it+1}/(P_{it} + B_{it+1})$ as the market leverage. The investment return then equals the weighted average of the stock return and the after-tax corporate bond return (e.g., Liu, Whited, and Zhang (2009)):

$$r^I_{it+1} = w_{it}\, r^{Ba}_{it+1} + (1-w_{it})\, r^S_{it+1}. \tag{4}$$

Equations (3) and (4) provide the microfoundation for the weighted average cost of capital approach to capital budgeting in corporate finance (e.g., Berk and DeMarzo (2010, chapter 18)). Intuitively, firm i will choose investment optimally such that the marginal benefit of investment at

$t+1$ discounted by the weighted average cost of capital equals the marginal cost of investment. At the margin, the net present value of the last infinitesimal project is zero. Solving for the stock return, r^S_{it+1}, from equation (4) yields:

$$r^S_{it+1} = r^{Iw}_{it+1} \equiv \frac{r^I_{it+1} - w_{it}\, r^{Ba}_{it+1}}{1 - w_{it}}, \tag{5}$$

in which r^{Iw}_{it+1} is the levered investment return. If $w_{it} = 0$, equation (5) collapses to the equivalence between the stock return and the investment return, a relation due to Cochrane (1991).

3 Econometric Design

We lay out the GMM application in Section 3.1, and describe our data in Section 3.2.

3.1 GMM Estimation and Tests

We use GMM to test the first moment restriction implied by equation (5):

$$E\left[r^S_{it+1} - r^{Iw}_{it+1}\right] = 0. \tag{6}$$

In particular, we define the model error (alpha) from the investment model as:

$$\alpha^q_i \equiv E_T\left[r^S_{it+1} - r^{Iw}_{it+1}\right], \tag{7}$$

in which $E_T[\cdot]$ is the sample mean of the series in the brackets.

We estimate the parameters a and κ using GMM on equation (6) applied to momentum portfolios. We use one-stage GMM with the identity weighting matrix to preserve the economic structure of the portfolios (e.g., Cochrane (1996)). This choice befits our economic question because short-term prior returns and earnings surprises are economically important in providing a wide spread in the cross section of average stock returns. Following the standard GMM procedure (e.g., Hansen and Singleton (1982)), we estimate the parameters, $\mathbf{b} \equiv (a, \kappa)$, by minimizing a weighted combination of the sample moments (6). Let $\mathbf{g}_T$ be the sample moments. The GMM objective function is a weighted sum of squares of the model errors across a given set of assets, $\mathbf{g}_T'\mathbf{W}\mathbf{g}_T$, in which $\mathbf{W}=\mathbf{I}$, the identity matrix. Let $\mathbf{D}=\partial\mathbf{g}_T/\partial\mathbf{b}$ and $\mathbf{S}$ a consistent estimate of the variance-covariance matrix of the sample errors $\mathbf{g}_T$. We estimate $\mathbf{S}$ using a standard Bartlett kernel with a window length of five. The estimate of $\mathbf{b}$, denoted $\hat{\mathbf{b}}$, is asymptotically normal with variance-covariance matrix:

$$\text{var}(\hat{\mathbf{b}}) = \frac{1}{T}(\mathbf{D}'\mathbf{W}\mathbf{D})^{-1}\mathbf{D}'\mathbf{W}\mathbf{S}\mathbf{W}\mathbf{D}(\mathbf{D}'\mathbf{W}\mathbf{D})^{-1}. \tag{8}$$

To construct the standard errors for the alphas of individual portfolios, we use the variance-covariance matrix for the model errors, $\mathbf{g}_T$:

$$\text{var}(\mathbf{g}_T) = \frac{1}{T}\left[\mathbf{I}-\mathbf{D}(\mathbf{D}'\mathbf{W}\mathbf{D})^{-1}\mathbf{D}'\mathbf{W}\right]\mathbf{S}\left[\mathbf{I}-\mathbf{D}(\mathbf{D}'\mathbf{W}\mathbf{D})^{-1}\mathbf{D}'\mathbf{W}\right]'. \tag{9}$$

We follow Hansen (1982, lemma 4.1) to form a χ^2 test that all model errors are jointly zero:

$$\mathbf{g}_T'\left[\text{var}(\mathbf{g}_T)\right]^{+}\mathbf{g}_T \quad \sim \quad \chi^2(\#\,\text{moments} - \#\,\text{parameters}), \tag{10}$$

in which χ^2 denotes the chi-square distribution with the degrees of freedom given by the number of moments minus the number of parameters. The superscript $^+$ denotes pseudo-inversion.

3.2 Data

Firm-level data are from the Center for Research in Security Prices (CRSP) monthly stock file and the annual 2010 Standard and Poor's Compustat industrial files. We omit firms with primary SIC classifications between 4900 and 4999 (regulated firms) or between 6000 and 6999 (financial firms). The sample is from 1963 to 2010. We keep only firm-year observations with positive total assets, positive sales, nonnegative debt, positive market value of assets (the book value of debt plus the market value of equity), and positive capital stock at the most recent fiscal yearend as of portfolio formation, as well as positive capital stock one year prior to the most recent fiscal year. We impose this sample selection criterion because these data items are required to calculate levered investment returns.

3.2.1 Testing Portfolios

We use ten price momentum deciles and ten earnings momentum deciles as the benchmark testing portfolios. To construct the price momentum deciles, we sort all stocks at the end of each month t on their prior six-month returns from $t-6$ to $t-1$, denoted R^6, and hold the resulting deciles for six months from $t+1$ to $t+6$. We skip one month between the end of the ranking period and the beginning of the holding period (month t) to avoid microstructure biases. Following Jegadeesh and Titman (1993), we exclude stocks with prices per share less than \$5 at the portfolio formation month, and we equal-weight all stocks within a given portfolio. Because we use the six-month holding period when forming the portfolios monthly, we have six sub-portfolios for each decile in a given month. We average across these six sub-portfolios to obtain the monthly returns of a given decile.

We define the standardized unexpected earnings (SUE) as the change in quarterly earnings per share (Compustat quarterly item EPSPXQ) from its value four quarters ago divided by the standard deviation of the change in quarterly earnings per share over the prior eight quarters. To construct the SUE deciles, at the end of each month t, we rank all the NYSE-Amex-Nasdaq stocks into ten deciles based on the SUEs calculated with the most recently announced earnings. We calculate the equal-weighted monthly portfolio returns over the subsequent six months from $t+1$ to $t+6$, and rebalance the portfolios monthly. The sample is from January 1972 to December 2010. The starting point of the sample is restricted by the availability of quarterly earnings data. Different from price momentum, we do not impose a one-month lag between the sorting period and the holding period, or exclude stocks with prices per share lower than \$5 at the portfolio formation.

3.2.2 Variable Measurement

The capital stock, K_{it}, is net property, plant, and equipment (Compustat annual item PPENT). Investment, I_{it}, is capital expenditures (item CAPX) minus sales of property, plant, and equipment (item SPPE). We set SPPE to be zero if this item is missing. The capital depreciation rate, δ_{it}, is the amount of depreciation (item DP) divided by the capital stock. Output, Y_{it}, is sales (item SALE).

Total debt, B_{it+1}, is long-term debt (item DLTT) plus short term debt (item DLC). Market leverage, w_{it}, is the ratio of total debt to the sum of total debt and market value of equity. The tax rate, τ_t, is the statutory corporate income tax rate from the Commerce Clearing House's annual publications.

In the model time-t stock variables are at the beginning of year t, and time-t flow variables are over the course of year t. But both stock and flow variables in Compustat are recorded at the end of the year. We take, for example, for the year 2003 time-t stock variables (such as K_{i2003}) from the 2002 balance sheet, and flow variables (such as I_{i2003}) from the 2003 income or cash flow statement.

Firm-level corporate bond data are rather limited, and few or even none of the firms in several testing portfolios have corporate bond returns. To measure the pre-tax corporate bond returns in a broad sample, we follow Blume, Lim, and MacKinlay (1998) to impute the credit ratings for firms with no crediting ratings data in Compustat. After the credit ratings are imputed, we assign the corporate bond returns for a given credit rating from Ibbotson Associates to all the firms with the same credit rating.[2] The Ibbotson data on corporate bond returns by credit ratings end in 2005, after which we obtain the data from Barclays U.S. aggregate corporate bond series via Datastream. Finally, we calculate equal-weighted corporate bond returns across the firms in a given portfolio.

3.2.3 Timing Alignment

Momentum portfolios are rebalanced monthly, but accounting variables in Compustat are available annually. Aligning the timing of portfolio stock returns with the timing of portfolio investment re-

[2]Specifically, we first estimate an ordered probit model that relates credit ratings to observed explanatory variables. The model is estimated using all the firms that have data on credit ratings (Compustat annual item SPLTICRM). We then use the fitted value to calculate the cutoff value for each credit rating. For firms without credit ratings we estimate their credit scores using the coefficients estimated from the ordered probit model and impute credit ratings by applying the cutoff values of different credit ratings. We assign the corporate bond returns for a given credit rating from Ibbotson Associates to all the firms with the same credit rating. The ordered probit model contains the following explanatory variables: interest coverage, the ratio of operating income after depreciation (item OIADP) plus interest expense (item XINT) to interest expense; the operating margin, the ratio of operating income before depreciation (item OIBDP) to sales (item SALE), long-term leverage, the ratio of long-term debt (item DLTT) to assets (item AT); total leverage, the ratio of long-term debt plus debt in current liabilities (item DLC) plus short-term borrowing (item BAST) to assets; the natural logarithm of the market value of equity (item PRCC_C times item CSHO) deflated to 1973 by the consumer price index; as well as the market beta and residual volatility from the market regression. We estimate the beta and residual volatility for each firm in each calendar year with at least 200 daily returns from CRSP. We adjust for nonsynchronous trading with one leading and one lagged values of the market return.

turns is intricate because the portfolio composition changes monthly. This measurement difficulty should, ex ante, go against any effort to identify fundamental forces behind momentum profits. Also, timing misalignment should affect less the magnitude than the dynamics of momentum.[3]

We design a more elaborate timing alignment procedure than that in Liu, Whited, and Zhang (2009). Specifically, we construct monthly levered investment returns of a momentum portfolio from its annual accounting variables to match with the portfolio's monthly stock returns. Consider the loser decile. In any given month we have six sub-portfolios for the decile because of the six-month holding period. For instance, for the loser decile in July of year t, the first sub-portfolio is formed at the end of January of year t based on the prior six-month return from July to December of year $t-1$. Skipping the month of January of year t, this sub-portfolio's holding period is from February to July of year t. The second sub-portfolio is formed at the end of February of year t, based on the prior six-month return from August of year $t-1$ to January of year t, and its holding period is from March to August of year t. The last (sixth) sub-portfolio is formed at the end of June of year t, and its holding period is from July to December of year t.

Our timing alignment contains three steps. First, we determine the timing of firm-level characteristics at the sub-portfolio level. The general principle is to combine the holding period information with the time interval from the midpoint of the current fiscal year to the midpoint of the next fiscal year to decide the fiscal yearend from which we take firm-level characteristics. As noted, in Compustat stock variables are measured at the end of the fiscal year and flow variables are over the course of the fiscal year. As such, the investment return constructed from annual accounting variables goes roughly from the midpoint of the current fiscal year to the midpoint of the next fiscal year. For firms with December fiscal yearend, this midpoint time interval is from July of year t to June of year

[3]We have explored the use of quarterly Compustat data set. The results on matching average momentum profits are largely similar to those obtained with annual Compustat data. We opt to use the annual data for several reasons. First, doing so provides a longer sample starting from 1963. In contrast, because of data availability of quarterly property, plant, and equipment, the quarterly sample can only start from 1977. Second, quarterly data display strong seasonality that affects the dynamics of momentum profits. A common way of controlling for seasonality is to average the quarterly observations within a given year. But doing so is (virtually) equivalent to using the annual data. Finally, the annual data are of higher quality than the quarterly data because quarterly accounting statements are not required by law to be audited by an independent auditor.

$t+1$. For firms with June fiscal yearend, the time interval is from January to December of year $t+1$.

Figure 1 illustrates the timing of firm-level characteristics for firms with December fiscal yearend.[4] Take, for example, the first sub-portfolio of the loser decile in July of year t. As noted, this sub-portfolio's holding period is from February of year t to July of year t. For firms in this sub-portfolio with December fiscal yearend, the first five months (February to June) lie to the left of the applicable time interval. For these five months we use accounting variables at the fiscal yearend of calendar year t to measure economic variables dated $t + 1$ in the model, and use accounting variables at the fiscal yearend of $t - 1$ to measure economic variables dated t in the model.

However, for the last month in the holding period (July), because the month is within the midpoint time interval, we use accounting variables at the fiscal yearend of $t+1$ to measure economic variables dated $t+1$ in the model, and use accounting variables at the fiscal yearend of t to measure economic variables dated t in the model. For firms with December fiscal yearend in the sixth sub-portfolio of the loser decile in July of year t, all the holding period months (July to December of year t) lie within the applicable time interval. As such, we use accounting variables at the fiscal yearend of $t+1$ to measure economic variables dated $t+1$ in the model, and use accounting variables at the fiscal yearend of t to measure economic variables dated t in the model. We apply the same general approach to firms with non-December fiscal yearend (see Appendix A for more details).

Second, we construct the components of the levered investment return at the sub-portfolio level. For each month we calculate characteristics for a given sub-portfolio by aggregating firm characteristics over the firms in the sub-portfolio, as in Fama and French (1995). For example, the sub-portfolio investment-to-capital for month t, I_{it}/K_{it}, is the sum of investment for all the firms within the sub-portfolio in month t divided by the sum of capital for the same set of firms in month t. Other components are aggregated analogously. Because the portfolio composition changes from month to month, the sub-portfolio characteristics also change from month to month.

[4] In the Compustat sample from 1963 to 2010, the five most frequent months in which firms end their fiscal year are December (61.7%), June (8.2%), September (6.6%), March (5.6%), and January (3.7%).

Third, we construct the levered investment returns for a given testing portfolio. Continue to use the loser decile as the example. After obtaining the decile's sub-portfolio characteristics, in each month we take the cross-sectional average characteristics over the six sub-portfolios to obtain the characteristics for the loser decile for each month. We then use these characteristics to construct the investment returns using equation (3). The investment returns are in annual terms but vary monthly because the sub-portfolio characteristics change monthly. After obtaining firm-level corporate bond returns from Blume, Lim, and MacKinlay's (1998) imputation procedure, we construct portfolio bond returns for a testing portfolio in the same way as we construct portfolio stock returns. Finally, we calculate levered investment returns at the portfolio level using equation (5).

4 Estimation Results

We study average momentum profits in Section 4.1, the dynamics of momentum in Section 4.2, and the interaction of momentum with firm characteristics in Section 4.3.

4.1 Average Momentum Profits

We ask whether the investment model captures average momentum profits, and compare the model's performance with the performance of the CAPM and the Fama-French model.

4.1.1 Tests of Asset Pricing Models on the Price and Earnings Momentum Deciles

Tables 1 and 2 report the results for the price and earnings momentum deciles, respectively. From Panel A of Table 1, the average returns of the price momentum deciles increase monotonically from 4.12% per annum for the loser decile to 19.43% for the winner decile. The average return spread of 15.31% is more than six standard errors from zero. The CAPM alpha and the Fama-French alpha of the winner-minus-loser decile are 15.13% and 17.26%, respectively, both of which are more than six standard errors from zero. (The data for the Fama-French factors are from Kenneth French's Web site.) Both models are strongly rejected by the Gibbons, Ross, and Shanken (1989, GRS) test.

From Panel A of Table 2, earnings momentum is somewhat weaker than price momentum, consistent with Chan, Jegadeesh, and Lakonishok (1996). In particular, the average returns of the SUE deciles increase from 10.74% per annum for the loser decile to 19.22% for the winner decile. The average return spread of 8.48% is more than six standard errors from zero. The CAPM alpha and the Fama-French alpha of the winner-minus-loser decile are 8.80% and 10.91%, respectively, both of which are more than five standard errors from zero. Both are again rejected by the GRS test.

There are only two parameters in the investment model: the adjustment cost parameter, a, and the capital's share, κ. Using the price momentum deciles, we estimate a to be 2.51 with a standard error of 0.98 and κ to be 0.12 with a standard error of 0.02. Both estimates are reasonable in terms of economic magnitude. The overidentification test shows that the model is not formally rejected. Panel A of Table 1 shows that the p-value of the χ^2-test is 0.09. The mean absolute error (m.a.e. hereafter) across the deciles is 0.87% per annum in the investment model. In contrast, the m.a.e. is 3.45% for the CAPM and 3.64% for the Fama-French model. Using the earnings momentum deciles, we estimate a to be 5.50 with a standard error of 2.53 and κ to be 0.17 with a standard error of 0.03. Panel A of Table 2 reports that the p-value of the χ^2-test is 0.22, meaning that the investment model is not rejected. The m.a.e. across the earnings momentum deciles is 0.72%, which is smaller than those from the CAPM (4.22%) and the Fama-French model (3.47%).

We also report individual alphas from the investment model, α_i^q, defined in equation (7), in which the levered investment returns are constructed using the estimates of a and κ from one-stage GMM. The t-statistics testing that a given α_i^q equals zero are also reported, with standard errors calculated from one-stage GMM. For price momentum, Panel A of Table 1 shows that the individual alphas range from -1.67% per annum for the loser decile to 1.46% for the fifth decile. In contrast, the CAPM alphas range from -8.20% to 6.94%, and the Fama-French alphas range from -10.90% to 6.36%, as we move from the loser decile to the winner decile. The winner-minus-loser alpha in the investment model is 0.51%, which is within 0.2 standard errors from zero. This alpha is negligible compared to those from the CAPM (15.13%) and the Fama-French model (17.26%), both of which are more than six standard errors from zero.

For earnings momentum, Panel A of Table 2 shows that the individual alphas from the investment model range from -1.46% per annum for the winner decile to 0.93% for the fifth decile. The winner-minus-loser alpha is -0.90%, which is within 0.4 standard errors of zero. These errors are smaller than those from the CAPM and the Fama-French model. In particular, the CAPM alphas go from -1.13% for the loser decile to 7.67% for the winner decile, and the spread of 8.80% is more than five standard errors from zero. The Fama-French alphas go from -4.58% for the loser decile to 6.33% for the winner decile. The spread of 10.91% is more than six standard errors from zero.

In Figures 2 and 3, we illustrate the performance of different models by plotting the average predicted returns of the testing portfolios against their average realized returns. If a model is perfect, all the observations should lie exactly on the 45-degree line. From Panel A of both figures, the scatter plots from the investment model are closely aligned with the 45-degree line. In contrast, Panels B and C show that the scatter plots from the CAPM and the Fama-French model are roughly horizontal. As such, the investment alphas do not vary systematically with price or earnings momentum, whereas the CAPM alphas and the Fama-French alphas do.[5]

4.1.2 Expected Return Components

What are the economic mechanisms via which our model matches average momentum profits? The investment return equations (3) and (5) identify several components of expected returns.

The first component is investment-to-capital, I_{it}/K_{it}, in the denominator of the investment return. The second component is the growth rate of marginal q, defined as $q_{it} \equiv 1+(1-\tau_t)a(I_{it}/K_{it})$. The growth rate of q can be interpreted as the "capital gain" portion of the investment return be-

[5] In untabulated results, we also find that the investment model fits well Moskowitz and Grinblatt's (1999) industry (price) momentum quintiles. Moskowitz and Grinblatt document that trading strategies buying stocks from past winning industries and selling stocks from past losing industries are profitable. Excluding financial firms and regulated utilities from their 20 industry classifications, we have 18 industries left in our sample. At the end of each portfolio formation month t, we sort the 18 industry portfolios into quintiles based on their prior six-month value-weighted returns from $t-6$ to $t-1$. The top and bottom quintiles each have three industries while the other three quintiles each have four industries. We form quintiles instead of deciles because the number of industries is too small to construct deciles. We hold the resulting quintile portfolios (value-weighted across industry portfolios) for the subsequent six months from $t+1$ to $t+6$. The alphas in the investment model range from -0.97% to 0.88% per annum, all of which are within 0.4 standard errors from zero. The winner-minus-loser quintile has a small alpha of 0.44%, which is within 0.2 standard errors from zero. This alpha is smaller than 9.15% from the CAPM and 9.40% from the Fama-French model.

cause marginal q is related to the stock price. The third component is the marginal product of capital, Y_{it+1}/K_{it+1}, in the numerator of the investment return. The fourth component is the depreciation rate, δ_{it+1}, which has a negative relation with the investment return. The fifth component is the market leverage, w_{it}, in the levered investment return, which shows a positive relation with the expected stock return. The sixth component is the after-tax corporate bond return, r^{Ba}_{it+1}. In sum, all else equal, firms with low I_{it}/K_{it}, high expected q_{it+1}/q_{it}, high expected Y_{it+1}/K_{it+1}, low expected δ_{it+1}, high w_{it}, and low expected r^{Ba}_{it+1} should earn higher expected stock returns at time t.

Panel B of Table 1 reports the averages for the components of levered investment returns across the price momentum deciles. For the growth rate of q_{it}, because q_{it} involves the unobserved adjustment cost parameter, a, we instead report the average growth rate of investment-to-capital, $(I_{it+1}/K_{it+1})/(I_{it}/K_{it})$. We observe that the winner decile has a higher average (gross) growth rate of investment-to-capital than the loser decile: 1.15 versus 0.83 per annum. The winner decile also has a higher next-period sales-to-capital than the loser decile: 4.13 versus 3.15. Both components go in the right direction to capture average momentum profits. However, going in the wrong direction, the winner decile has a higher current-period investment-to-capital, 0.26 versus 0.22, and a lower market leverage, 0.22 versus 0.34, than the loser decile. Finally, the averages of the depreciate rate and the after-tax corporate bond return are largely flat across the price momentum deciles.[6]

Panel B of Table 2 reports the averages of levered investment return components across the earnings momentum deciles. Winners have a higher average growth rate of investment-to-capital, 1.05 versus 0.95 per annum, and a higher next-period sales-to-capital, 3.50 versus 2.99, than losers. Both go in the right direction to capture average momentum profits. Going in the wrong direction, winners have a slightly higher current-period investment-to-capital, 0.20 versus 0.19, and a lower

[6]The evidence that the average corporate bond returns are flat across the momentum deciles contrasts with Gebhardt, Hvidkjaer, and Swaminathan (2005), who show that stock momentum spills over to corporate bond returns. Our evidence differs for several reasons. First, Gebhardt et al. use a small sample from the Lehman Brothers Fixed Income Database, which is substantially smaller in the coverage of the cross section than the CRSP-Compustat universe. Second, Gebhardt et al. consider only investment grade corporate bonds, while we use both investment grade and non-investment grade credit ratings. Finally, to study the broader cross section in the CRSP-Compustat universe, we follow Blume, Lim, and MacKinlay (1998) to assign the corporate bond returns for a given credit rating to all the firms with the same credit rating. This procedure likely restricts the cross-sectional variation in average corporate bond returns.

market leverage, 0.20 versus 0.30, than losers. The averages of the depreciate rate and the after-tax corporate bond return are again flat. In all, the cross-sectional variations in the components across the earnings momentum deciles display the same pattern as, but are somewhat weaker than the cross-sectional variations across the price momentum deciles. The pattern is consistent with the evidence that earnings momentum is weaker than price momentum.

4.1.3 Accounting for Average Momentum Profits

To quantify the sources of price and earnings momentum, we conduct the following comparative static experiments. We set a given levered investment return component to its cross-sectional average in each month at the sub-portfolio level. We then use the estimates of a and κ to reconstruct levered investment returns, while keeping all the other components unchanged. We examine the resulting change in the magnitude of the model error. A large change in the error would mean that the component in question is quantitatively important for the investment model's performance.

From Panel C of Table 1, the growth rate of marginal q is the most important, and sales-to-capital is the second most important source of price momentum. Without the cross-sectional variation in the growth rate of q, the winner-minus-loser alpha in the investment model jumps to 10.08% per annum. Without the cross-sectional variation in sales-to-capital, the winner-minus-loser alpha becomes 7.15%. In contrast, this model error is only 0.51% in the benchmark estimation. Panel C of Table 2 reports the comparative statics for earnings momentum. The growth rate of marginal q and sales-to-capital continue to be important. Without the cross-sectional variation in the growth rate of q, the winner-minus-loser alpha jumps to 4.21%. Without the cross-sectional variation in sales-to-capital, the winner-minus-loser alpha becomes 3.39%. In contrast, this model error is only -0.90% in the benchmark estimation. Finally, despite its small spread, fixing investment-to-capital to its cross-sectional average produces a winner-minus-loser alpha of -5.21%.

These comparative statics contrast with those in Liu, Whited, and Zhang (2009), who show that investment-to-capital is the most important source of the value premium. Asness (1997) argues that book-to-market and momentum are negatively correlated, yet each forecasts stock returns with a positive slope. Asness stresses that any interpretation of value and momentum must make sense of this puzzling evidence. Using a coherent economics-based framework, we provide such an interpretation based on the investment return equation (3). The value premium can be interpreted via investment-to-capital in the denominator of the investment return. In particular, the value premium is consistent with the pattern that value firms invest less than growth firms. In contrast, momentum can be interpreted via profitability and the expected growth rate of investment-to-capital in the numerator of the investment return. In particular, momentum is consistent with the pattern that winners are more profitable, and have higher expected growth rates than losers.

4.2 The Dynamics of Momentum

We have so far only examined average momentum profits. However, several stylized facts of momentum profits involve their dynamics. The dynamics are particularly interesting because the model parameters are estimated from matching only average momentum profits. As such, the dynamics of momentum serve as additional diagnostics on the model's performance.

4.2.1 Reversal of Momentum Profits in Long Horizons

Chan, Jegadeesh, and Lakonishok (1996, Tables II and III) show that momentum is short-lived. In particular, at the six-month horizon after the portfolio formation, the winner-minus-loser return is on average 8.8% per annum for price momentum and 6.8% for earnings momentum. At the one-year horizon, the winner-minus-loser return is on average 15.4% for price momentum and 7.5% for earnings momentum. However, these profits largely converge to zero during the second year and the third year after the portfolio formation.

Table 3 replicates the long-term reversal of price momentum in our sample. From the first row in each panel, the winner-minus-loser return is on average 8.13% over the first six-month period, 9.20% for the first year, −6.48% for the second year, and −5.52% for the third year after the portfolio formation. The second row in each panel of the table shows that the investment model succeeds in reproducing this long-term reversal. The levered investment return, r^{Iw}_{it+1}, for the winner-minus-loser decile is on average 7.49% for the first six-month period and 10.67% for the first year after the portfolio formation. Afterward, the average predicted return turns negative: −1.40% for the second year and −4.58% for the third year after the portfolio formation.

The remaining three rows in each panel show that it is the expected growth component of the levered investment return that drives the short-lived nature of momentum profits. Using the average growth rate of marginal q to measure the expected growth, we observe that it starts at 8% for the first six-month period, weakens to 5% at the one-year horizon, and turns negative, −2% and −3% at the two-year and the three-year horizons, respectively. Using the average growth rate of investment-to-capital yields a similar pattern: 32% at the six-month horizon, 22% at the one-year horizon, −7% for the second year, and −11% for the third year after the portfolio formation. In contrast, the sales-to-capital ratio is more persistent. Starting at 1.01 for the first six-month period, the sales-to-capital ratio remains at 0.44 for the third year after the portfolio formation.

Table 4 reports the long-term reversal of earnings momentum in our sample. The first row in each panel shows that the winner-minus-loser return is on average 4.23% at the six-month horizon, 2.95% at the one-year horizon, −2.10% at the two-year horizon, and −2.63% at the third-year horizon after the portfolio formation. The investment model again replicates this reversal pattern. From the second row in each panel, the levered investment return for the winner-minus-loser decile is on average 4.55% at the six-month horizon, 6.04% at the one-year horizon, −0.52% at the two-year horizon, and −2.07% at the third-year horizon after the portfolio formation. The remaining rows in each panel again show that it is the expected growth component (not sales-to-capital) of the levered investment return that drives the long-term reversal.

Related to the reversal, Bernard and Thomas (1989, Table 1) show that a disproportionately large amount of earnings momentum occurs within five days of earnings announcements. Jegadeesh and Titman (1993, Table IX) document that the average three-day returns (from day −2 to 0) around quarterly earnings announcement dates represent about 25% of momentum for the first six-month holding period. Further, the announcement returns also display reversal in long horizons.

Alas, we cannot replicate this announcement returns pattern quantitatively because daily data on characteristics are not available due to data limitations. However, equation (5) implies that levered investment returns should equal stock returns in realization, state by state and period by period. If daily investment returns were available, it is not inconceivable that their ex post pattern mimics that of daily stock returns. Intuitively, positive earnings shocks at $t+1$ would increase the marginal product of capital at $t+1$, and increase the investment returns from t to $t+1$. The positive earnings shocks should also increase the investment-to-capital growth from t to $t+1$ because investment increases with the marginal product of capital. As such, stock returns should move in the same direction as earnings shocks. Further, because of the low persistence of the expected investment-to-capital growth, the investment returns around earnings announcement dates should also inherit the reversal of announcement date stock returns.

4.2.2 Long Run Risks in Investment Returns

Bansal, Dittmar, and Lundblad (2005) show that aggregate consumption risks in cash flows help interpret the average return spread across the price momentum deciles. We replicate their basic results in our 1963–2010 sample. Specifically, we perform the following regression:

$$g_{i,t} = \gamma_i \left(\frac{1}{K} \sum_{k=1}^{K} g_{c,t-k} \right) + u_{i,t}, \tag{11}$$

in which $K = 8$, $g_{i,t}$ is demeaned log real dividend growth rates on momentum decile i, and $g_{c,t}$ is demeaned log real growth rate of aggregate consumption. The slope, γ_i, measures the cash flow's exposure to the long-term aggregate consumption growth (long run risks).[7]

[7] Aggregate consumption is seasonally adjusted real per capital consumption of nondurables and services. The quarterly real per capita consumption data are from NIPA at the Bureau of Economic Analysis. We use personal consumption expenditures (PCE) deflator from NIPA to convert nominal variables to real variables. Following Bansal, Dittmar, and Lundblad (2005, p. 1648–1649), we take into account stock repurchases in calculating dividends. We also use a trailing four-quarter average of the quarterly cash flows to adjust for seasonality in quarterly dividends.

Consistent with Bansal, Dittmar, and Lundblad (2005), Panel A of Table 5 shows that price momentum winners have a higher slope than price momentum losers: 14.94 versus −3.54. The risk spread between the two extreme deciles is 19.82, albeit with a large standard error of 11.99. Winners also have a higher cash flow growth rate than losers: 2.44% versus −1.63% per annum, but the spread again has a large standard error.[8] For earnings momentum, Table 6 shows that the evidence of long run risks is substantially weaker. The risk spread between winners and losers is only 4.87, which has a large standard error of 3.48. Winners also have a higher cash flow growth rate than losers: 0.84% versus 0.12%, but the spread again has a large standard error.

To examine long run risks in investment returns, we define a new fundamental cash flow measure, $D^{\star}_{it+1} \equiv (1-\tau_{t+1})\left[\kappa\frac{Y_{it+1}}{K_{it+1}} + \frac{a}{2}\left(\frac{I_{it+1}}{K_{it+1}}\right)^2\right] + \tau_{t+1}\delta_{it+1}$, based on the investment return equation (3). Because the denominator of the investment return equals marginal q, equation (3) implies that $D^{\star}_{it+1}/\left[1+(1-\tau_t)a\frac{I_{it}}{K_{it}}\right]$ is analogous to the dividend yield, and the remaining piece of the investment return, $(1-\delta_{it+1})\left[1+(1-\tau_{t+1})a\frac{I_{it+1}}{K_{it+1}}\right] / \left[1+(1-\tau_t)a\frac{I_{it}}{K_{it}}\right]$, is analogous to the rate of capital gain. As such, $D^{\star}_{it+1}$ in the investment return is analogous to dividends in the stock return.

For price momentum, the first column in Panel B of Table 5 shows that the fundamental cash flow growth has higher long run risks in winners than in losers: 16.04 versus 4.39. The spread of 11.65 is significant with a small standard error of 2.77. The fundamental cash growth is also higher in winners than in losers: 15.87% versus −2.35%, and the spread of 18.22% is highly significant. The remainder of Panel B shows that winners have significantly higher cash flow risks than losers in the sales-to-capital growth and in the growth of depreciation rate, but not in the growth rate of squared investment-to-capital. For earnings momentum, Panel B of Table 6 shows higher long run risks in the fundamental cash flow growth in winners than in losers. However, the spread of 2.90 has a large standard error of 1.76. The fundamental cash flow growth is again higher on average in winners than in losers: 7.33% versus 0.34%, and the spread is highly significant.

[8] Because of a few negative cash flows (dividends plus net repurchases) observations, which we treat as missing, the slope, γ_i, for the winner-minus-loser decile is not identical to the spread in γ_i between winners and losers. Similarly, the cash flow growth rate of the winner-minus-loser decile is not exactly the growth rate spread between winners and losers.

Overall, our evidence connects long run risks in dividends documented in Bansal, Dittmar, and Lundblad (2005) to long run risks in fundamentals. As such, the evidence helps interpret why winners have higher long run risks than losers, especially for price momentum.

4.2.3 Market States and Momentum Profits

Momentum profits depend on market states. Cooper, Gutierrez, and Hameed (2004) show that for price momentum, the average winner-minus-loser decile return during the six-month period after the portfolio formation is 0.93% per month following non-negative prior 36-month market returns (UP markets), but is −0.37% following negative prior 36-month market returns (DOWN markets).

The first six rows in each panel of Table 7 replicate Cooper, Gutierrez, and Hameed's (2004) evidence in our updated sample. If we categorize the UP and DOWN markets based on the value-weighted CRSP index returns over the prior 12-month period, Panel A shows that for price momentum, the winner-minus-loser decile return over the six-month period after the portfolio formation is on average 10.01% following the UP markets, but 2.24% following the DOWN markets. Over the 12-month period after the portfolio formation, the winner-minus-loser return is on average 11.99% following the UP markets but 0.11% following the DOWN markets.

The investment model fails to reproduce the procyclicality of price momentum. From rows seven to 12 in each panel of Table 7, if anything, the model predicts that price momentum is stronger in DOWN markets. In particular, Panel B shows that based on prior 12-month market returns, the predicted winner-minus-loser return over the 12-month period after portfolio formation is 9.23% following the UP markets, but 15.37% following the DOWN markets.

Lettau and Ludvigson (2002) argue that investment lags (time lags between investment decision and actual investment expenditure) can temporally shift the correlation between investment returns and stock returns. The contemporaneous correlation is negative, but the correlation between lagged stock returns and current investment returns is positive. However, the temporal shift in the correlation structure between stock and investment returns cannot account for the model's failure in replicating the procyclicality of momentum. In particular, if we lead the levered investment returns by six months, the predicted winner-minus-loser return over the six-month holding period is still countercyclical: 6.55% following the UP markets and 11.23% following the DOWN markets.

The first six rows of Table 8 extend Cooper, Gutierrez, and Hameed's (2004) evidence to earnings momentum. In particular, if we categorize the UP and DOWN markets based on the value-weighted CRSP index returns over the prior 36-month period, Panel A shows that the winner-minus-loser SUE decile return over the six-month period after the portfolio formation is on average 5.76% following the UP markets but −6.25% following the DOWN markets. Over the 12-month period after the portfolio formation, the winner-minus-loser return is on average 5.59% following the UP markets but −17.23% following the DOWN markets.

The investment model again fails to reproduce the procyclicality of earnings momentum. In particular, rows seven to 12 in Panel A of Table 8 report that based on prior 36-month market returns, the predicted earnings momentum profits over the six-month horizon are 4.11% after the UP markets, but 7.57% after the DOWN markets. As such, the model predicts earnings momentum to be countercyclical. This counterfactual prediction disappears if we categorize the market states based on prior 12-month market returns: The predicted earnings momentum profits are 4.59% following the UP markets but 4.43% following the DOWN markets. However, the degree of procyclicality for earnings momentum in the model falls short of that in the data.

4.3 The Interaction of Momentum with Firm Characteristics

Beyond the one-way deciles, the momentum literature has documented stylized facts on the interaction of momentum with firm characteristics (see footnote 1). By applying the investment model to two-way sorted momentum portfolios, we evaluate its performance in matching these patterns.

4.3.1 Two-Way Momentum Portfolios: Construction

We use six sets of two-way (three-by-three) portfolios by interacting prior six-month returns (R^6) or earnings surprises (SUE) with size, firm age, trading volume, stock return volatility, credit ratings, and book-to-market. Size is market capitalization at the end of the portfolio formation month t. We require firms to have positive market capitalization before including them in the sample. Firm age is the number of months elapsed between the month when a firm first appears in the monthly CRSP database and the portfolio formation month t. Trading volume is the average daily turnover during the past six months from $t-6$ to $t-1$, in which daily turnover is the ratio of the number of shares traded each day to the number of shares outstanding at the end of the day. Following Lee and Swaminathan (2000), we restrict our sample to include only NYSE and AMEX stocks when forming the trading volume and momentum portfolios (the number of shares traded for Nasdaq stocks is inflated relative to NYSE and AMEX stocks because of double counting of dealer trades).

We measure stock return volatility as the standard deviation of weekly excess returns over the past six months as in Lim (2001). Weekly returns are from Thursday to Wednesday to mitigate bid-ask effects in daily prices. We calculate weekly excess returns as raw weekly returns minus weekly risk-free rates. The daily risk-free rates are from Kenneth French's Web site. The daily rates are available only after July 1, 1964. For days prior to that date, we use the monthly rate for a given month divided by the number of trading days within the month to obtain daily rates. We require a stock to have at least 20 weeks of data to enter the sample.

We measure book-to-market as the book value of equity divided by the market value of equity. The market equity is market capitalization measured at the most recent month from CRSP. The book equity is common equity (Compustat annual item CEQ) plus balance sheet deferred tax (item TXDB) at the fiscal yearend from at least six months ago. We impose the six-month lag because the book equity is obtained from annual financial statements, which can take several months to be released to the public. Credit ratings in Compustat start only in 1985, and more than 50% of the firms do not have credit ratings data. To measure credit ratings in a broad sample, we follow Blume, Lim, and MacKinlay's (1998) imputation procedure (see Section 3.2.2). Because the imputed credit ratings also require annual accounting data, we again impose the six-month lag by using the imputed credit ratings based on the accounting information at the fiscal yearend from at least six months ago.

To form the two-way price momentum portfolios such as, for example, the size and price momentum portfolios, we sort stocks into terciles at the end of each month t on the market capitalization at the end of the month, and independently on prior six-month returns from $t-6$ to $t-1$. Taking intersections of the three size and the three price momentum terciles, we form nine size and price momentum portfolios. Skipping the current month t, we hold the resulting portfolios for the subsequent six months from month $t+1$ to $t+6$. We equal-weight all stocks within a given portfolio. We again exclude stocks with prices per share less than \$5 at the portfolio formation when constructing two-way price momentum portfolios. To form the two-way SUE portfolios such as, for example, the size and SUE portfolios, we sort stocks into terciles at the end of each month t on the market capitalization at the end of the month, and independently on the SUEs calculated with the most recently announced earnings. Taking intersections of the resulting portfolios, we obtain nine size and SUE portfolios. We calculate the equal-weighted monthly portfolio returns over the subsequent six months from month $t+1$ to $t+6$, and rebalance the portfolios monthly.

When forming two-way portfolios involving credit ratings, we sort stocks into three categories in each month based on their imputed credit ratings calculated with accounting information at the fiscal yearend from at least six months ago. The high ratings category contains firms with credit ratings of Aaa, Aa, and A; the median ratings category contains firms with the Baa rating; and the low ratings category contains firms with ratings lower than Baa. Also, following Avramov, Chordia, Jostova, and Philipov (2007), we use sequential sorts by first grouping stocks into three ratings categories, and then splitting each ratings category further into three R^6 or SUE terciles. In contrast, we use independent sorts in forming all the other two-way momentum portfolios.

4.3.2 Two-Way Momentum Portfolios: Factor Regressions

From Panel A of Table 9, price momentum is stronger in small firms than in big firms. The winner-minus-loser tercile in small firms has a Fama-French alpha of 10.52% per annum, which is larger than that in big firms, 6.84%.[9] From Panel B, price momentum decreases with firm age. The Fama-French alpha of the winner-minus-loser tercile in young firms is 12.19%, which is higher than that in old firms, 5.24%. Consistent with Lee and Swaminathan (2000), price momentum also increases with trading volume. The Fama-French alpha of the winner-minus-loser tercile in low volume firms is 7.33%, which is lower than that in high volume firms, 11.80%. Finally, price momentum increases with stock return volatility, but decreases with credit ratings and book-to-market. The evidence is largely consistent with prior studies (see footnote 1). Across all sets of the testing portfolios, the Fama-French model is strongly rejected by the GRS test.

Panel A of Table 10 extends the evidence of interaction with firm attributes to earnings momentum. Earnings momentum is stronger in small firms, young firms, firms with high stock return volatilities, and firms with low credit ratings. The pattern is similar to that of price momentum. In particular, the Fama-French alpha of the winner-minus-loser tercile is 11.87% per annum in small firms versus 3.59% in big firms, 9.65% in young firms versus 5.55% in old firms, 5.71% in firms with low stock return volatility versus 11.93% in firms with high stock return volatility, and 11.81% in low credit ratings firms versus 3.66% in high credit ratings firms. However, unlike price momentum, earnings momentum seems stronger in value firms rather than in growth firms. The winner-minus-loser decile has a Fama-French alpha of 7.15% in growth firms but 10.11% in value firms. In addition, earnings momentum does not seem to vary with trading volume. The winner-minus-loser decile has a Fama-French alpha of 8.81% in low volume firms, and is close to 8.48% in high volume firms.

[9] Because of the large number of testing portfolios, we only report the Fama-French alphas. The tests based on average returns and the CAPM alphas are quantitatively similar, and are omitted to save space.

4.3.3 GMM Parameter Estimates and Tests of Overidentification

Table 11 reports the GMM estimation and tests of overidentification for the two-way momentum portfolios. (For comparison, we also report the results for the one-way deciles.) Panel A reports the results for price momentum, R^6. The estimates of the adjustment cost parameter, a, range from 2.10 for the size-R^6 portfolios to 3.42 for the book-to-market and R^6 portfolios. The standard errors are between 0.76 and 0.98. As such, the estimates of a are all significantly positive, meaning that the adjustment costs function is increasing and convex in investment. The estimates are close to 2.51 from the benchmark price momentum deciles. The estimates of the capital's share, κ, are between 0.09 to 0.13, close to 0.12 in the benchmark estimation.

The mean absolute errors in the investment model are mostly smaller than those from the Fama-French model. In particular, the m.a.e. of the age-R^6 portfolios is 1.26% per annum in the investment model, and is smaller than that from the Fama-French model, 3.22%. The m.a.e. of the volume-R^6 portfolios is 1.64% in the investment model, and is smaller than 3.60% in the Fama-French model. The m.a.e. of the volatility-R^6 portfolios is 1.94% in the investment model, and is smaller than 4.50% in the Fama-French model. The only exception is the size-R^6 portfolios. The investment model produces an m.a.e. of 3.29%, which is higher than 3.15% in the Fama-French model.

In contrast to the benchmark estimation with the price momentum deciles, the investment model is strongly rejected using the two-way portfolios. This evidence means that our test has sufficient power to reject the null hypothesis that all the alphas for a given set of testing portfolios are jointly zero. This benefit stems from our more polished timing alignment procedure, which allows the construction of monthly levered investment returns to match with monthly stock returns.[10]

Panel B of Table 11 reports the estimation results for the earnings momentum portfolios. The estimates of the adjustment cost parameter, a, range from 1.25 to 7.36, most of which are

[10]We verify in untabulated results that the χ^2 test fails to reject the investment model with the two-way testing portfolios, using the timing alignment procedure from Liu, Whited, and Zhang (2009). The reason is that the alternative procedure only allows us to construct annual levered investment returns to match with annual stock returns.

significantly positive. The estimates of the capital's share, κ, range from 0.09 to 0.17, all of which are significantly positive. The mean absolute errors from the investment model are again mostly smaller than those from the Fama-French model. The m.a.e. of the age-SUE portfolios, for example, is 1.04% per annum in the investment model, and is smaller than 3.23% in the Fama-French model. The m.a.e. of the volume-SUE portfolios is 2.23% in the investment return, and is smaller than 3.25% in the Fama-French model. The only exception is again the size-SUE portfolios. The investment model produces an m.a.e. of 4.03%, which is higher than 2.52% in the Fama-French model. Finally, the χ^2 test shows that the investment model is rejected using the two-way SUE portfolios interacted with size, volume, and crediting ratings, but is not rejected with the other three attributes.

4.3.4 Individual Alphas

The m.a.e.'s and χ^2 tests indicate only overall model performance. To paint a more complete picture, we examine individual alphas for the two-way portfolios. The main finding is that the individual alphas do not vary systematically with price or earnings momentum.

From the last two rows in Panel A of Table 9, the alphas from the investment model for the nine size-R^6 portfolios range from -3.92% to 5.68% per annum. Although not small, all but one of the alphas are insignificant at the 5% level, likely due to measurement errors in characteristics. As such, we only stress the economic magnitude of the alphas, instead of their statistical insignificance.

More important, the alphas do not vary systematically with R^6. Across the small, median, and big size terciles, the winner-minus-loser alphas are $-0.82\%, -0.90\%$, and -1.01%, all of which are within 0.5 standard errors from zero. The alphas are smaller in magnitude than those from the Fama-French model: 10.52%, 8.54%, and 6.84%, respectively. Panel A of Figure 4 shows that the scatter plot from the investment model is largely aligned with the 45-degree line, although the individual alphas are not small. In contrast, the scatter plot from the Fama-French model is largely horizontal (Panel B), meaning that the Fama-French alphas vary systematically with R^6.

Panel B of Table 9 report smaller individual alphas for the firm age-R^6 portfolios. The alphas range from −2.43% to 2.28% per annum. Across the young, median, and old age terciles, the winner-minus-loser alphas are 2.32%, −1.28%, and −3.97%, all of which are smaller in magnitude than the Fama-French alphas, 12.19%, 8.03%, and 5.24%, respectively. The scatter plots in Panels C and D of Figure 4 confirm the superior performance of the investment model over the Fama-French model. From the remainder of Table 9 and Figure 4, the quantitative fit of the investment model in matching R^6 interacted with trading volume and credit ratings is similar to the fit of the model in matching R^6 interacted with firm age. The model's fit for the volatility-R^6 portfolios and the book-to-market and R^6 portfolios is roughly in line with the model's fit for the size-R^6 portfolios (see Figure 5).

The pattern from the two-way SUE portfolios is largely similar. In particular, from the last two rows in Panel A of Table 10, the alphas from the investment model for the nine size-SUE portfolios range from −6.24% to 6.63% per annum. Although large, these individual alphas again do not vary systematically with earnings momentum. Across the small, median, and big size terciles, the winner-minus-loser alphas are 1.96%, −3.86%, and −1.87%, all of which are smaller in magnitude than those from the Fama-French model: 11.87%, 3.89%, and 3.59%, respectively. Panel A of Figure 6 shows that the scatter plot from the investment model is largely aligned with the 45-degree line, although the individual alphas can be large. In contrast, the scatter plot from the Fama-French model is largely horizontal (Panel B), indicating a strong relation between their alphas and SUE.

Panel B of Table 10 shows that the individual alphas range from −1.58% to 1.45% per annum for the firm age-SUE portfolios. The winner-minus-loser alphas are 0.46%, −0.22%, and −1.18% across the young, median, and old age terciles, all of which are smaller in magnitude than the Fama-French alphas, 9.65%, 6.53%, and 5.55%, respectively. The scatter plots in Panels C and D of Figure 6 also indicate the superior performance of the investment model over the Fama-French model. The remainder of Table 10 and Figure 6 shows that the investment model's fit for earnings momentum interacted with volume, stock return volatility, and credit ratings is similar to the model's fit for earnings momentum interacted with firm age. The model's fit for the book-to-market and SUE portfolios is similar to the model's fit for the size-SUE portfolios (see Figure 7).

5 Summary and Interpretation

We provide an investment-based interpretation of momentum. Optimal investment implies that expected stock returns are tied with the expected marginal benefit of investment divided by the marginal cost of investment. We show via GMM that the investment model captures average price and earnings momentum profits. Intuitively, winners have higher expected investment-to-capital growth and expected sales-to-capital (two major components of the expected marginal benefit), and earn higher expected stock returns than losers. The model also captures the reversal of momentum in long horizons, long run risks in price momentum, as well as the interaction of momentum with market capitalization, firm age, trading volume, stock return volatility, credit ratings, and book-to-market. However, the model fails to reproduce procyclical momentum profits.

Momentum is often interpreted as a sign of investor irrationality. Our results show that firms' investment decisions are connected properly to momentum profits. This observation directly says nothing about investor rationality or irrationality. A low cost of capital could reflect rationally low market prices of risk demanded by investors or sentiment of investors who are irrationally optimistic.

However, our results do provide some implications for the "rationality" of asset prices. Firms invest more when prices are high. Such investment expands the supply of capital to match the demand, whatever the sources of such demand. If adjustment costs were zero and firms acted rationally, no amount of investor sentiment could affect prices: It would only affect quantities. Our finding that firms react with greater, but not infinite investment, reflecting adjustment costs, indicates that the room for any investor irrationality to affect prices is limited by firms' offsetting response.

In contrast to standard asset pricing theories that have predictions only about expected returns, equation (5) speaks to not only expected returns but also ex-post realized returns. The equation predicts that the levered investment return should equal the stock return for every stock, every period, and every state of the world. Because no choice of parameters satisfies such an extremely refutable prediction, the equation is rejected at any level of significance. Although we only use

GMM to test the first momentum prediction that expected levered investment returns equal expected stock returns across momentum portfolios, this test design befits our economic question, i.e., why winners earn higher returns *on average* than losers. As noted, the ex-post prediction also helps us interpret the ex-post pattern of earnings announcement returns (see Section 4.2.1).

We do not claim that the investment model "explains" momentum. The investment model is based on first-order conditions of firms, which do not establish causality from investment to expected returns. The model is as consistent with the view that investment growth "explains" expected returns as with the view that expected returns "explain" investment growth.

However, our finding is no more and no less important or "explanatory" than a would-be finding that momentum was consistent with consumption Euler equation, $E_t[M_{t+1} r^S_{it+1}] = 1$ (equivalent to a risk factor model). Suppose one found a utility function, some consumption data, or a set of risk factors such that $E_t[M_{t+1} r^S_{it+1}] = 1$ holds across momentum portfolios. It is tempting to claim that the consumption model "explains" momentum. However, the would-be finding does not support this claim. Consumption first-order conditions say that consumers adjust consumption correctly in response to asset price movements. If the stock price moves arbitrarily with the lunar cycle, consumption first-order conditions just line up consumption accordingly. Consumption is as endogenous to consumption first-order conditions as investment to investment first-order conditions.

In general equilibrium, consumption (consumption betas), expected returns, and investment (firm characteristics) are all endogenous variables determined by a system of simultaneous equations (see Lin and Zhang (2011)). Neither betas nor characteristics *cause* expected returns to vary across firms. Neither betas nor characteristics are more primitive than the other in "explaining" expected returns. Instead of causality, we can only learn about structural *correlations* between betas, expected returns, and characteristics from equilibrium conditions.

The investment approach complements the consumption approach in general equilibrium. The consumption approach tries to figure out unobservable and hard-to-measure expected returns from equally unobservable and hard-to-measure consumption betas. The investment approach tries to figure out expected returns from observable characteristics. Standard finance textbooks teach students to estimate the discount rate from the CAPM or multifactor models, and then use the estimated discount rate to calculate net present values for new projects to decide which ones to take. The investment approach turns finance on its head. Because the levered investment return equals the weighted average cost of capital, we can back out the discount rate from observable investment decisions.

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A Timing Alignment: Further Details

Section 3.2.3 describes the timing alignment for firms with December fiscal yearend. This appendix details how we handle firms with non-December fiscal yearend. We use firms with June (and September) fiscal yearend as examples to illustrate our procedure. Firms with fiscal year ending in other months are handled in an analogous way.

Panel A of Figure A1 shows the timing of firm-level characteristics for firms with June fiscal yearend. Their applicable midpoint time interval is from January to December of year $t+1$. For those firms in the first sub-portfolio of the loser decile in July of year t, all the holding period months (February to July of year t) lie to the left of the time interval. As such, we use accounting variables at the fiscal yearend of t to measure economic variables dated $t+1$ in the model, and use accounting variables at the fiscal yearend of $t-1$ to measure economic variables dated t in the model. For firms with June fiscal yearend in the sixth sub-portfolio of the loser decile in July of year t, their holding period months (July to December of year t) also lie to the left of the applicable time interval. As such, their timing is exactly the same as the timing for the firms in the first sub-portfolio.

Panel B of Figure A1 shows the timing of firm-level characteristics for firms with September fiscal yearend. Their midpoint time interval is from April of year $t+1$ to March of year $t+2$. For those firms in the first sub-portfolio of the loser decile in July of year $t+1$, two months out of the holding period (February and March of year $t+1$) lie to the left of the time interval, and the remaining four months (from April to July) lie within the time interval. For February and March of year $t+1$, we use accounting variables at the fiscal yearend of t to measure economic variables dated $t+1$ in the model, and use accounting variables at the fiscal yearend of $t-1$ to measure economic variables dated t in the model. For the months from April to July of $t+1$, we use accounting variables at the fiscal yearend of $t+1$ to measure economic variables dated $t+1$ in the model, and use accounting variables at the fiscal yearend of t to measure economic variables dated t in the model. For the firms in the sixth sub-portfolio of the loser decile in July of year $t+1$, all the holding period months (from July to December of $t+1$) lie within the midpoint time-interval. As such, we use accounting variables at the fiscal yearend of $t+1$ to measure economic variables dated $t+1$ in the model, and use accounting variables at the fiscal yearend of t to measure economic variables dated t in the model.

Table 1 : The Price Momentum Deciles, Tests of Asset Pricing Models, Economic Characteristics, and Comparative Statics on the Investment Model

For each price momentum decile, we report (in annual percent) average stock return, r_i^S, stock return volatility, σ_i^S, the CAPM alpha from monthly market regressions, α_i, the alpha from monthly Fama-French (1993) three-factor regressions, α_i^{FF}, and their t-statistics adjusted for heteroscedasticity and autocorrelations. α_i^q is the alpha from the investment model, calculated as $E_T[r_{it+1}^S - r_{it+1}^{Iw}]$, in which E_T is the sample mean, and r_{it+1}^{Iw} is the levered investment return. m.a.e. is the mean absolute error. The p-values (p) are from the Gibbon, Ross, and Shanken (1989) tests of the null that the alphas across the ten deciles are jointly zero. Panel B reports average characteristics for each decile including current-period investment-to-capital, I_{it}/K_{it}; the growth rate of investment-to-capital, $\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$; next-period sales-to-capital, Y_{it+1}/K_{it+1}; market leverage, w_{it}; the next-period rate of depreciation, δ_{it+1}; and the corporate bond returns in annualized percent, r_{it+1}^B. In Panel C, we perform four comparative static experiments on the investment model: $\overline{I_{it}/K_{it}}$, $\overline{q_{it+1}/q_{it}}$, $\overline{Y_{it+1}/K_{it+1}}$, and $\overline{w}_{it}$, in which $q_{it+1}/q_{it} = [1 + (1 - \tau_{t+1})a(I_{it+1}/K_{it+1})]/[1 + (1 - \tau_t)a(I_{it}/K_{it})]$. In the experiment denoted $\overline{Y_{it+1}/K_{it+1}}$, Y_{it+1}/K_{it+1} is set for all the ten deciles to be its cross-sectional average in year $t+1$. We use the model parameters from one-stage GMM to reconstruct the levered investment returns, while keeping all the other characteristics unchanged. The other three experiments are designed analogously. α_i^q is the average difference between stock returns and reconstructed levered investment returns. In the table, 1 denotes the loser decile, 10 the winner decile, and 10−1 is the winner-minus-loser decile.

Panel A: Tests of the CAPM, the Fama-French model, and the investment model

	1	2	3	4	5	6	7	8	9	10	10−1	m.a.e.	p
r_i^S	4.12	8.66	10.48	11.51	12.41	13.09	13.32	14.94	16.58	19.43	15.31		
σ_i^S	26.62	21.85	20.09	19.09	18.74	18.68	19.17	20.34	22.45	27.39	16.93		
α_i	−8.20	−2.68	−0.46	0.78	1.72	2.38	2.50	3.83	5.03	6.94	15.13	3.45	0.00
$[t]$	−3.53	−1.43	−0.26	0.48	1.12	1.58	1.69	2.45	2.85	2.83	6.25		
α_i^{FF}	−10.90	−5.93	−3.82	−2.39	−1.29	−0.36	−0.05	1.80	3.54	6.36	17.26	3.64	0.00
$[t]$	−7.24	−5.53	−3.78	−2.75	−1.65	−0.54	−0.09	3.14	3.95	3.80	6.70		
α_i^q	−1.67	0.57	0.98	1.08	1.46	0.58	−0.10	−0.52	−0.55	−1.16	0.51	0.87	0.09
$[t]$	−0.38	0.15	0.28	0.33	0.46	0.19	−0.03	−0.17	−0.16	−0.27	0.14		

Panel B: Economic characteristics

	1	2	3	4	5	6	7	8	9	10	10−1	$[t_{10-1}]$
I_{it}/K_{it}	0.22	0.21	0.20	0.20	0.20	0.20	0.20	0.21	0.22	0.26	0.04	3.72
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	0.83	0.92	0.94	0.97	0.99	1.01	1.03	1.06	1.09	1.15	0.32	14.97
Y_{it+1}/K_{it+1}	3.15	3.01	2.98	2.96	2.98	3.12	3.20	3.40	3.60	4.13	0.98	5.79
w_{it}	0.34	0.29	0.27	0.25	0.25	0.24	0.23	0.22	0.21	0.22	−0.12	−7.29
δ_{it+1}	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.17	0.03	1.93
r_{it+1}^B	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.59	0.00	0.17

Panel C: The investment-based alphas, α_i^q, from comparative static experiments

	1	2	3	4	5	6	7	8	9	10	10−1
$\overline{I_{it}/K_{it}}$	−2.58	1.02	2.46	3.51	3.93	2.55	1.31	−0.21	−2.49	−7.47	−4.89
$\overline{q_{it+1}/q_{it}}$	−7.36	−1.86	−0.57	0.32	1.11	1.00	0.67	1.16	1.71	2.72	10.08
$\overline{Y_{it+1}/K_{it+1}}$	−2.68	−1.22	−1.02	−1.05	−0.54	−0.46	−0.60	0.42	1.71	4.46	7.15
$\overline{w}_{it}$	−1.27	0.33	1.04	0.93	1.29	0.41	−0.19	−0.88	−0.97	−1.41	−0.14

Table 2 : The Earnings Momentum Deciles, Tests of Asset Pricing Models, Economic Characteristics, and Comparative Statics on the Investment Model

For each earnings momentum decile, we report (in annual percent) average stock return, r_i^S, stock return volatility, σ_i^S, the CAPM alpha from monthly market regressions, α_i, the alpha from monthly Fama-French (1993) three-factor regressions, α_i^{FF}, and their t-statistics adjusted for heteroscedasticity and autocorrelations. α_i^q is the alpha from the investment model, calculated as $E_T[r_{it+1}^S - r_{it+1}^{Iw}]$, in which E_T is the sample mean, and r_{it+1}^{Iw} is the levered investment return. m.a.e. is the mean absolute error. The p-values (p) are from the Gibbon, Ross, and Shanken (1989) tests of the null that the alphas across the ten deciles are jointly zero. Panel B reports average characteristics for each decile including current-period investment-to-capital, I_{it}/K_{it}; the growth rate of investment-to-capital, $\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$; next-period sales-to-capital, Y_{it+1}/K_{it+1}; market leverage, w_{it}; the next-period rate of depreciation, δ_{it+1}; and the corporate bond returns in annualized percent, r_{it+1}^B. In Panel C, we perform four comparative static experiments on the investment model: $\overline{I_{it}/K_{it}}$, $\overline{q_{it+1}/q_{it}}$, $\overline{Y_{it+1}/K_{it+1}}$, and $\overline{w}_{it}$, in which $q_{it+1}/q_{it} = [1 + (1 - \tau_{t+1})a(I_{it+1}/K_{it+1})]/[1 + (1 - \tau_t)a(I_{it}/K_{it})]$. In the experiment denoted $\overline{Y_{it+1}/K_{it+1}}$, Y_{it+1}/K_{it+1} is set for all the ten deciles to be its cross-sectional average in year $t + 1$. We use the model parameters from one-stage GMM to reconstruct the levered investment returns, while keeping all the other characteristics unchanged. The other three experiments are designed analogously. α_i^q is the average difference between stock returns and reconstructed levered investment returns. In the table, 1 denotes the loser decile, 10 the winner decile, and 10−1 is the winner-minus-loser decile.

Panel A: Tests of the CAPM, the Fama-French model, and the investment model

	1	2	3	4	5	6	7	8	9	10	10−1	m.a.e.	p
r_i^S	10.74	10.87	12.59	13.69	15.67	16.34	18.36	18.14	19.42	19.22	8.48		
σ_i^S	24.49	22.87	23.16	23.52	22.82	22.50	22.17	21.80	22.00	21.12	9.46		
α_i	−1.13	−0.76	0.90	1.97	4.04	4.67	6.72	6.54	7.77	7.67	8.80	4.22	0.00
$[t]$	−0.42	−0.34	0.38	0.82	1.71	2.13	3.27	3.21	3.54	4.01	5.33		
α_i^{FF}	−4.58	−3.73	−2.29	−1.14	0.94	1.58	3.90	4.26	5.92	6.33	10.91	3.47	0.00
$[t]$	−2.68	−3.11	−1.99	−0.85	0.79	1.56	3.88	4.75	5.41	6.04	6.26		
α_i^q	−0.56	−0.78	0.27	0.61	0.93	0.34	0.89	−0.83	0.59	−1.46	−0.90	0.72	0.22
$[t]$	−0.11	−0.18	0.06	0.14	0.21	0.08	0.21	−0.21	0.15	−0.39	−0.34		

Panel B: Economic characteristics

	1	2	3	4	5	6	7	8	9	10	10−1	$[t_{10-1}]$
I_{it}/K_{it}	0.19	0.20	0.20	0.19	0.19	0.19	0.19	0.19	0.19	0.20	0.01	2.08
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	0.95	0.94	0.96	0.97	1.00	1.01	1.01	1.04	1.05	1.05	0.10	4.74
Y_{it+1}/K_{it+1}	2.99	2.97	2.91	2.94	3.05	3.15	3.25	3.21	3.16	3.50	0.51	3.48
w_{it}	0.30	0.27	0.30	0.28	0.28	0.25	0.25	0.25	0.25	0.20	−0.09	−7.14
δ_{it+1}	0.14	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.00	−0.47
r_{it+1}^B	0.67	0.67	0.68	0.68	0.69	0.68	0.68	0.67	0.68	0.67	0.00	0.10

Panel C: The investment-based alphas, α_i^q, from comparative static experiments

	1	2	3	4	5	6	7	8	9	10	10−1
$\overline{I_{it}/K_{it}}$	0.68	−2.17	0.03	2.19	2.70	0.88	0.93	0.28	0.63	−4.53	−5.21
$\overline{q_{it+1}/q_{it}}$	−3.38	−3.59	−1.70	−0.72	0.82	0.83	1.61	1.40	2.92	0.83	4.21
$\overline{Y_{it+1}/K_{it+1}}$	−1.89	−2.11	−1.52	−1.03	0.16	0.62	1.89	−0.14	0.91	1.50	3.39
$\overline{w}_{it}$	−0.69	−0.80	0.81	0.94	1.17	−0.04	0.69	−1.08	0.35	−2.69	−2.00

Table 3 : Reversal of Price Momentum in Long Horizons

As in Chan, Jegadeesh, and Lakonishok (1996), we report for each price momentum decile the average buy-and-hold stock returns, r^S_{it+1}, over periods following portfolio formation in the following six months as well as in the first, second, and third subsequent years. We also report the levered investment return, r^{Iw}_{it+1}, sales-to-capital, Y_{it+1}/K_{it+1}, the growth rate of q, q_{it+1}/q_{it}, and the investment-to-capital growth, $\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$, over the same time horizons. Stock returns and levered investment returns are in semi-annual percent in Panel A, and are in annual percent in Panels B–D. The three characteristics are in annual terms. In the table, 1 denotes the loser decile, 10 the winner decile, and 10−1 is the winner-minus-loser decile.

	1	2	3	4	5	6	7	8	9	10	10−1
Panel A: Six months after portfolio formation											
r^S_{it+1}	2.25	4.64	5.56	6.08	6.53	6.89	6.97	7.83	8.75	10.39	8.13
r^{Iw}_{it+1}	2.83	3.94	4.71	5.15	5.41	6.24	6.69	7.76	8.58	10.32	7.49
Y_{it+1}/K_{it+1}	3.13	3.01	2.98	2.96	2.98	3.13	3.20	3.41	3.61	4.14	1.01
q_{it+1}/q_{it}	0.96	0.98	0.99	0.99	1.00	1.00	1.01	1.01	1.02	1.04	0.08
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	0.83	0.92	0.94	0.97	0.99	1.01	1.03	1.07	1.09	1.15	0.32
Panel B: First year after portfolio formation											
r^S_{it+1}	7.64	10.91	12.27	12.83	13.37	13.86	14.11	14.71	15.67	16.84	9.20
r^{Iw}_{it+1}	7.45	8.76	9.83	10.52	10.76	12.20	12.91	14.68	15.97	18.12	10.67
Y_{it+1}/K_{it+1}	3.15	3.02	2.98	2.96	2.98	3.12	3.19	3.40	3.59	4.11	0.96
q_{it+1}/q_{it}	0.97	0.98	0.99	0.99	1.00	1.00	1.00	1.01	1.01	1.02	0.05
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	0.87	0.93	0.95	0.97	0.98	1.01	1.02	1.05	1.06	1.09	0.22
Panel C: Second year after portfolio formation											
r^S_{it+1}	17.04	15.10	14.58	14.46	14.22	14.14	13.73	13.54	12.58	10.56	−6.48
r^{Iw}_{it+1}	13.90	11.54	11.30	11.20	10.94	11.30	11.59	11.98	12.47	12.50	−1.40
Y_{it+1}/K_{it+1}	3.27	3.08	3.02	2.98	2.98	3.09	3.16	3.34	3.52	3.93	0.66
q_{it+1}/q_{it}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98	−0.02
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	1.03	0.99	0.99	0.99	0.99	0.98	0.99	0.97	0.97	0.95	−0.07
Panel D: Third year after portfolio formation											
r^S_{it+1}	18.01	16.39	15.66	15.04	14.80	14.68	14.49	14.17	13.83	12.49	−5.52
r^{Iw}_{it+1}	15.88	12.81	12.11	11.42	11.42	11.49	11.51	11.87	11.65	11.31	−4.58
Y_{it+1}/K_{it+1}	3.37	3.13	3.04	2.97	3.00	3.10	3.16	3.32	3.47	3.81	0.44
q_{it+1}/q_{it}	1.01	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.98	−0.03
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	1.05	1.02	1.01	1.00	1.01	0.99	0.98	0.97	0.96	0.93	−0.11

Table 4 : Reversal of Earnings Momentum in Long Horizons

As in Chan, Jegadeesh, and Lakonishok (1996), we report for each earnings momentum decile the average buy-and-hold stock returns, r^S_{it+1}, over periods following portfolio formation in the following six months as well as in the first, second, and third subsequent years. We also report the levered investment return, r^{Iw}_{it+1}, sales-to-capital, Y_{it+1}/K_{it+1}, the growth rate of q, q_{it+1}/q_{it}, and the investment-to-capital growth, $\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$, over the same time horizons. Stock returns and levered investment returns are in semi-annual percent in Panel A, and are in annual percent in Panels B–D. The three characteristics are in annual terms. In the table, 1 denotes the loser decile, 10 the winner decile, and 10−1 is the winner-minus-loser decile.

	1	2	3	4	5	6	7	8	9	10	10−1
Panel A: Six months after portfolio formation											
r^S_{it+1}	5.93	5.82	6.71	7.33	8.44	8.81	9.81	9.68	10.40	10.16	4.23
r^{Iw}_{it+1}	5.62	5.80	6.16	6.50	7.31	7.96	8.67	9.42	9.41	10.17	4.55
Y_{it+1}/K_{it+1}	3.00	2.98	2.92	2.94	3.05	3.15	3.25	3.21	3.16	3.48	0.48
q_{it+1}/q_{it}	0.98	0.98	0.98	0.99	1.00	1.00	1.01	1.02	1.02	1.02	0.04
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	0.95	0.94	0.96	0.97	1.00	1.01	1.01	1.05	1.05	1.05	0.09
Panel B: First year after portfolio formation											
r^S_{it+1}	14.83	14.61	15.97	16.51	18.26	17.71	18.63	18.22	18.21	17.78	2.95
r^{Iw}_{it+1}	13.04	12.62	12.94	12.93	14.53	15.71	17.27	17.66	17.67	19.08	6.04
Y_{it+1}/K_{it+1}	3.04	2.99	2.92	2.94	3.06	3.16	3.25	3.20	3.14	3.45	0.41
q_{it+1}/q_{it}	0.99	0.98	0.99	0.99	1.00	1.00	1.00	1.01	1.01	1.01	0.02
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	0.98	0.95	0.97	0.97	0.99	1.00	1.01	1.03	1.03	1.03	0.04
Panel C: Second year after portfolio formation											
r^S_{it+1}	18.94	17.84	19.62	19.14	18.60	18.49	18.09	17.80	18.50	16.83	−2.10
r^{Iw}_{it+1}	16.31	14.94	14.55	14.51	14.61	15.31	16.46	15.99	15.44	15.79	−0.52
Y_{it+1}/K_{it+1}	3.12	3.04	2.94	2.96	3.06	3.16	3.26	3.21	3.11	3.40	0.28
q_{it+1}/q_{it}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	−0.01
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	1.02	1.00	1.00	0.99	0.99	0.99	1.00	0.99	1.00	0.97	−0.05
Panel D: Third year after portfolio formation											
r^S_{it+1}	20.50	19.66	20.05	20.03	20.22	19.25	19.22	18.78	19.36	17.86	−2.63
r^{Iw}_{it+1}	17.23	16.26	15.09	14.92	14.50	14.59	15.71	15.69	13.96	15.16	−2.07
Y_{it+1}/K_{it+1}	3.20	3.07	2.97	2.99	3.05	3.14	3.25	3.20	3.07	3.37	0.18
q_{it+1}/q_{it}	1.01	1.00	1.00	1.00	1.00	1.00	0.99	1.00	0.99	0.99	−0.02
$\frac{I_{it+1}/K_{it+1}}{I_{it}/K_{it}}$	1.03	1.01	1.00	1.00	0.99	0.99	0.98	1.00	0.98	0.98	−0.05

Table 5 : Long Run Risks in Price Momentum Profits

Panel A reports the long run risk measure per Bansal, Dittmar, and Lundblad (2005) across the price momentum deciles. γ_i is the projection coefficient from the regression: $g_{i,t} = \gamma_i \left(\frac{1}{8} \sum_{k=1}^{8} g_{c,t-k} \right) + u_{i,t}$, in which $g_{i,t}$ is demeaned log real cash flow growth rates on portfolio i, and $g_{c,t}$ is demeaned log real growth rate in aggregate consumption. Negative cash flow observations are treated as missing. $\bar{g}_i$ is the sample average log real dividend growth rate. Standard errors are reported in the columns denoted "ste." In Panel B, $\gamma_i^\star$ is the projection coefficient from the regression: $g_{i,t}^\star = \gamma_i^\star \left(\frac{1}{8} \sum_{k=1}^{8} g_{c,t-k} \right) + u_{i,t}$, in which $g_{i,t}^\star$ is demeaned log real fundamental cash flow growth rates on decile i. This cash flow is defined as $D_{it+1}^\star \equiv (1-\tau_{t+1}) \left[\kappa \frac{Y_{it+1}}{K_{it+1}} + \frac{a}{2} \left(\frac{I_{it+1}}{K_{it+1}} \right)^2 \right] + \tau_{t+1}\delta_{it+1}$, in which τ_{t+1} is corporate tax rate, Y_{it+1} is sales, K_{it+1} is capital, I_{it+1} is investment, δ_{it+1} is the rate of depreciation, κ is the estimated capital's share, and a is the estimated adjustment cost parameter. $\bar{g}_i^\star$ is the sample average of log real fundamental cash flow growth rates. $\gamma_{1i}^\star$ is the slope from regressing $g_{1i,t}^\star$, demeaned log real growth rates of $(1-\tau_{t+1})\kappa \frac{Y_{it+1}}{K_{it+1}}$, $\gamma_{2i}^\star$ is the slope from regressing $g_{2i,t}^\star$, demeaned log real growth rates of $(1-\tau_{t+1})\frac{a}{2}\left(\frac{I_{it+1}}{K_{it+1}} \right)^2$, and $\gamma_{3i}^\star$ is the slope from regressing $g_{3i,t}^\star$, demeaned log real growth rates of $\tau_{t+1}\delta_{it+1}$ on $\frac{1}{8}\sum_{k=1}^{8} g_{c,t-k}$. We convert nominal to real variables using the personal consumption expenditures (PCE) deflator. The growth rates are in annual percent. In the table, 1 denotes the loser decile, 10 the winner decile, and 10−1 is the winner-minus-loser decile.

	Panel A: Stock returns				Panel B: Investment returns									
	γ_i	ste	$\bar{g}_i$	ste	$\gamma_i^\star$	ste	$\bar{g}_i^\star$	ste	$\gamma_{1i}^\star$	ste	$\gamma_{2i}^\star$	ste	$\gamma_{3i}^\star$	ste
1	−3.54	4.51	−1.63	1.28	4.39	2.09	−2.35	0.60	5.16	1.72	12.92	7.93	0.04	2.05
2	−3.83	2.40	−0.32	0.68	6.08	1.45	1.35	0.43	5.48	1.33	19.19	6.42	1.30	1.54
3	−2.36	1.71	−0.23	0.49	5.39	1.40	2.39	0.42	4.63	1.29	21.44	5.95	0.07	1.48
4	−0.83	1.76	−0.01	0.50	6.32	1.21	3.25	0.37	5.90	1.21	17.56	5.18	1.52	1.38
5	0.46	1.30	−0.04	0.37	5.56	1.21	4.11	0.37	4.84	1.21	17.86	5.38	2.23	1.42
6	2.06	1.67	0.19	0.47	6.14	1.23	5.27	0.37	5.91	1.25	14.30	5.21	2.09	1.42
7	3.11	2.55	0.33	0.73	6.10	1.23	6.31	0.38	5.47	1.17	16.56	5.37	3.38	1.53
8	3.04	3.49	0.64	0.99	6.41	1.38	8.08	0.42	6.07	1.29	12.79	5.48	4.20	1.69
9	2.93	4.84	1.00	1.37	8.85	1.78	10.79	0.54	7.72	1.43	14.96	6.37	7.20	2.25
10	14.94	9.30	2.44	2.64	16.04	2.88	15.87	0.89	11.85	1.95	15.97	8.38	14.26	3.67
10−1	19.82	11.99	3.71	3.40	11.65	2.77	18.22	0.83	6.68	1.77	3.05	9.21	14.22	3.20

Table 6 : Long Run Risks in Earnings Momentum Profits

Panel A reports the long run risk measure per Bansal, Dittmar, and Lundblad (2005) across the earnings momentum deciles. γ_i is the projection coefficient from the regression: $g_{i,t} = \gamma_i \left(\frac{1}{8}\sum_{k=1}^{8} g_{c,t-k}\right) + u_{i,t}$, in which $g_{i,t}$ is demeaned log real cash flow growth rates on portfolio i, and $g_{c,t}$ is demeaned log real growth rate in aggregate consumption. Negative cash flow observations are treated as missing. $\bar{g}_i$ is the sample average log real dividend growth rate. Standard errors are reported in the columns denoted "ste." In Panel B, $\gamma_i^\star$ is the projection coefficient from the regression: $g_{i,t}^\star = \gamma_i^\star \left(\frac{1}{8}\sum_{k=1}^{8} g_{c,t-k}\right) + u_{i,t}$, in which $g_{i,t}^\star$ is demeaned log real fundamental cash flow growth rates on decile i. This cash flow is defined as $D_{it+1}^\star \equiv (1-\tau_{t+1})\left[\kappa\frac{Y_{it+1}}{K_{it+1}} + \frac{a}{2}\left(\frac{I_{it+1}}{K_{it+1}}\right)^2\right] + \tau_{t+1}\delta_{it+1}$, in which τ_{t+1} is corporate tax rate, Y_{it+1} is sales, K_{it+1} is capital, I_{it+1} is investment, δ_{it+1} is the rate of depreciation, κ is the estimated capital's share, and a is the estimated adjustment cost parameter. $\bar{g}_i^\star$ is the sample average of log real fundamental cash flow growth rates. $\gamma_{1i}^\star$ is the slope from regressing $g_{1i,t}^\star$, demeaned log real growth rates of $(1-\tau_{t+1})\kappa\frac{Y_{it+1}}{K_{it+1}}$, $\gamma_{2i}^\star$ is the slope from regressing $g_{2i,t}^\star$, demeaned log real growth rates of $(1-\tau_{t+1})\frac{a}{2}\left(\frac{I_{it+1}}{K_{it+1}}\right)^2$, and $\gamma_{3i}^\star$ is the slope from regressing $g_{3i,t}^\star$, demeaned log real growth rates of $\tau_{t+1}\delta_{it+1}$ on $\frac{1}{8}\sum_{k=1}^{8} g_{c,t-k}$. We convert nominal to real variables using the personal consumption expenditures (PCE) deflator. The growth rates are in annual percent. In the table, 1 denotes the loser decile, 10 the winner decile, and 10−1 is the winner-minus-loser decile.

	Panel A: Stock returns				Panel B: Investment returns									
	γ_i	ste	$\bar{g}_i$	ste	$\gamma_i^\star$	ste	$\bar{g}_i^\star$	ste	$\gamma_{1i}^\star$	ste	$\gamma_{2i}^\star$	ste	$\gamma_{3i}^\star$	ste
1	−1.42	2.53	0.12	0.69	8.01	2.34	0.34	0.67	6.00	1.91	31.06	8.88	0.80	2.36
2	−5.32	3.77	−0.10	1.03	7.17	2.13	1.94	0.61	6.12	1.86	19.07	7.02	1.06	2.21
3	−3.27	2.95	−0.37	0.81	7.70	1.98	2.92	0.57	6.61	1.66	22.21	7.41	0.84	1.87
4	−3.78	2.79	−0.26	0.76	5.49	2.10	2.05	0.59	5.03	1.67	14.99	8.16	−0.67	1.90
5	1.26	2.28	0.13	0.62	6.86	1.75	3.02	0.51	4.68	1.45	22.11	6.79	1.86	2.09
6	−0.07	1.81	0.24	0.49	9.60	1.75	4.11	0.53	6.16	1.51	31.59	6.08	3.31	1.80
7	0.46	1.80	0.86	0.49	7.75	1.64	4.65	0.49	6.98	1.37	18.46	5.69	−0.29	1.75
8	5.25	3.49	0.71	0.96	9.37	1.74	6.27	0.52	8.31	1.55	20.37	5.58	2.40	1.88
9	6.92	2.01	0.97	0.57	10.28	1.75	6.81	0.54	9.16	1.61	22.38	5.36	2.14	1.87
10	3.45	1.98	0.84	0.55	10.91	1.67	7.33	0.52	9.29	1.43	21.20	5.78	3.49	1.83
10−1	4.87	3.48	0.73	0.95	2.90	1.76	6.99	0.49	3.29	1.30	−9.86	7.25	2.69	1.87

Table 7 : Market States and Price Momentum Profits

At the end of each month t, all NYSE, AMEX, and NASDAQ firms are sorted into deciles based on their prior six-month returns from $t-5$ to $t-1$, skipping month t. Stocks with prices per share under \$5 at month t are excluded. We categorize month t as UP (DOWN) markets if the value-weighted CRSP index returns over months $t-N$ to $t-1$ with $N = 36, 24$, or 12 are nonnegative (negative). Price momentum profits of the winner-minus-loser decile are cumulated across two holding periods: months $t+1$ to $t+6$ (Panel A) and months $t+1$ to $t+12$ (Panel B). Profits (average returns) are in semi-annual percent in Panel A and in annual percent in Panel B. We report average stock returns (r^S), average contemporaneous levered investment returns (r^{Iw}), and average six-month leading levered investment returns ($r^{Iw}_{[+6]}$).

Panel A: Months 1–6					Panel B: Months 1–12				
State	Profits	[t]	N-month market	Returns	State	Profits	[t]	N-month market	Returns
DOWN	−5.23	−1.17	36	r^S	DOWN	−15.44	−2.17	36	r^S
DOWN	−2.45	−0.56	24	r^S	DOWN	−9.13	−1.09	24	r^S
DOWN	2.24	0.63	12	r^S	DOWN	0.11	0.02	12	r^S
UP	9.95	8.96	36	r^S	UP	12.25	5.73	36	r^S
UP	9.78	8.74	24	r^S	UP	11.82	5.49	24	r^S
UP	10.01	8.36	12	r^S	UP	11.99	5.16	12	r^S
DOWN	9.15	5.53	36	r^{Iw}	DOWN	14.74	4.21	36	r^{Iw}
DOWN	10.22	4.57	24	r^{Iw}	DOWN	17.29	4.07	24	r^{Iw}
DOWN	9.27	3.47	12	r^{Iw}	DOWN	15.37	3.40	12	r^{Iw}
UP	7.26	5.15	36	r^{Iw}	UP	10.16	3.86	36	r^{Iw}
UP	7.06	5.15	24	r^{Iw}	UP	9.72	3.76	24	r^{Iw}
UP	6.92	5.15	12	r^{Iw}	UP	9.23	3.48	12	r^{Iw}
DOWN	8.45	4.21	36	$r^{Iw}_{[+6]}$	DOWN	15.97	3.89	36	$r^{Iw}_{[+6]}$
DOWN	9.44	4.92	24	$r^{Iw}_{[+6]}$	DOWN	17.29	4.45	24	$r^{Iw}_{[+6]}$
DOWN	11.23	5.48	12	$r^{Iw}_{[+6]}$	DOWN	19.48	5.68	12	$r^{Iw}_{[+6]}$
UP	7.55	5.46	36	$r^{Iw}_{[+6]}$	UP	10.41	3.99	36	$r^{Iw}_{[+6]}$
UP	7.40	5.30	24	$r^{Iw}_{[+6]}$	UP	10.15	3.86	24	$r^{Iw}_{[+6]}$
UP	6.55	4.71	12	$r^{Iw}_{[+6]}$	UP	8.48	3.17	12	$r^{Iw}_{[+6]}$

Table 8 : Market States and Earnings Momentum Profits

At the beginning of each month t, all NYSE, AMEX, and NASDAQ firms are sorted into deciles on the most recent SUEs. We categorize month t as UP (DOWN) markets if the value-weighted CRSP index returns over months $t-N$ to $t-1$ with $N = 36, 24$, or 12 are nonnegative (negative). Earnings momentum profits of the winner-minus-loser decile are cumulated across two holding periods: months $t+1$ to $t+6$ (Panel A) and months $t+1$ to $t+12$ (Panel B). Profits (average returns) are in semi-annual percent in Panel A and in annual percent in Panel B. We report the averages of stock returns (r^S), contemporaneous levered investment returns (r^{Iw}), and six-month leading levered investment returns ($r^{Iw}_{[+6]}$).

Panel A: Months 1–6					Panel B: Months 1–12				
State	Profits	[t]	N-month market	Returns	State	Profits	[t]	N-month market	Returns
DOWN	−6.25	−1.32	36	r^S	DOWN	−17.23	−2.31	36	r^S
DOWN	−3.24	−0.65	24	r^S	DOWN	−12.62	−1.49	24	r^S
DOWN	1.25	0.38	12	r^S	DOWN	−4.89	−0.86	12	r^S
UP	5.76	9.59	36	r^S	UP	5.59	4.52	36	r^S
UP	5.45	8.63	24	r^S	UP	5.26	4.26	24	r^S
UP	5.18	6.78	12	r^S	UP	5.34	3.91	12	r^S
DOWN	7.57	6.54	36	r^{Iw}	DOWN	9.27	2.86	36	r^{Iw}
DOWN	8.17	5.45	24	r^{Iw}	DOWN	10.43	2.49	24	r^{Iw}
DOWN	4.43	2.40	12	r^{Iw}	DOWN	5.00	1.34	12	r^{Iw}
UP	4.11	4.85	36	r^{Iw}	UP	5.62	3.88	36	r^{Iw}
UP	3.96	4.84	24	r^{Iw}	UP	5.39	3.86	24	r^{Iw}
UP	4.59	6.05	12	r^{Iw}	UP	6.36	4.82	12	r^{Iw}
DOWN	7.27	5.41	36	$r^{Iw}_{[+6]}$	DOWN	10.25	2.75	36	$r^{Iw}_{[+6]}$
DOWN	8.25	6.61	24	$r^{Iw}_{[+6]}$	DOWN	11.63	2.94	24	$r^{Iw}_{[+6]}$
DOWN	5.75	3.93	12	$r^{Iw}_{[+6]}$	DOWN	7.12	2.29	12	$r^{Iw}_{[+6]}$
UP	4.18	4.91	36	$r^{Iw}_{[+6]}$	UP	5.47	3.70	36	$r^{Iw}_{[+6]}$
UP	3.99	4.76	24	$r^{Iw}_{[+6]}$	UP	5.21	3.65	24	$r^{Iw}_{[+6]}$
UP	4.17	5.24	12	$r^{Iw}_{[+6]}$	UP	5.63	3.90	12	$r^{Iw}_{[+6]}$

Table 9 : Tests for Two-Way Sorted Price Momentum Portfolios

For each testing portfolio, we report (in annual percent) the Fama-French alphas, α_i^{FF}, and their t-statistics adjusted for heteroscedasticity and autocorrelations. m.a.e. is the mean absolute error. The p-values (p) are from the Gibbon, Ross, and Shanken (1989) tests of the null that the alphas for a given set of testing portfolios are jointly zero. The investment-based alphas and t-statistics are from one-stage GMM with an identity weighting matrix. These alphas are calculated as $\alpha_i^q \equiv E_T\left[r_{it+1}^S - r_{it+1}^{Iw}\right]$, in which $E_T[\cdot]$ is the sample mean of the series in brackets, r_{it+1}^S is stock returns, and r_{it+1}^{Iw} is levered investment returns. In the table, we use a, b, and c to denote the terciles formed in the ascending order on the firm attribute other than momentum, and 1, 2, and 3 to denote the terciles formed in the ascending order on momentum. For two-way portfolios, for example, a1 is the portfolio formed as the interaction of terciles a and 1, and a3−1 is the winner-minus-loser tercile in portfolio a. Other two-way portfolios are defined analogously.

	a1	a2	a3	a3−1	b1	b2	b3	b3−1	c1	c2	c3	c3−1	m.a.e.	p
Panel A: Nine size and price momentum portfolios														
α_i^{FF}	−7.05	−0.90	3.48	10.52	−5.60	−1.14	2.94	8.54	−3.51	−0.39	3.33	6.84	3.15	0.00
$[t]$	−6.26	−1.11	3.57	7.58	−4.17	−1.23	3.09	5.01	−2.70	−0.51	3.34	3.67		
α_i^q	−3.10	−3.75	−3.92	−0.82	1.67	0.71	0.76	−0.90	5.68	5.34	4.67	−1.01		
$[t]$	−0.74	−1.07	−1.00	−0.44	0.44	0.23	0.23	−0.47	1.71	1.99	1.49	−0.50		
Panel B: Nine firm age and price momentum portfolios														
α_i^{FF}	−9.44	−1.94	2.75	12.19	−5.64	−0.68	2.39	8.03	−4.28	−0.90	0.96	5.24	3.22	0.00
$[t]$	−5.49	−1.45	1.89	7.80	−4.44	−0.67	2.40	5.97	−3.29	−0.97	1.09	4.04		
α_i^q	−2.43	−0.43	−0.11	2.32	0.56	1.11	−0.72	−1.28	2.28	1.98	−1.69	−3.97		
$[t]$	−0.58	−0.12	−0.03	1.06	0.14	0.36	−0.23	−0.65	0.65	0.71	−0.61	−1.96		
Panel C: Nine trading volume and price momentum portfolios														
α_i^{FF}	−3.52	0.70	3.81	7.33	−5.58	−0.57	2.95	8.53	−9.84	−3.49	1.96	11.80	3.60	0.00
$[t]$	−2.76	0.68	3.36	6.49	−4.12	−0.52	2.71	6.71	−5.56	−2.55	1.29	5.92		
α_i^q	2.46	4.74	0.29	−2.17	0.33	0.53	−0.54	−0.87	−2.09	−1.71	−2.05	0.04		
$[t]$	0.71	1.63	0.10	−1.22	0.08	0.17	−0.18	−0.43	−0.47	−0.45	−0.54	0.02		
Panel D: Nine stock return volatility and price momentum portfolios														
α_i^{FF}	−2.56	1.09	4.99	7.55	−6.40	−0.95	5.14	11.53	−11.72	−5.77	1.84	13.56	4.50	0.00
$[t]$	−2.29	1.21	5.85	7.22	−5.75	−1.26	5.88	8.27	−7.80	−6.03	1.19	6.31		
α_i^q	3.32	3.67	0.53	−2.79	0.62	0.59	1.12	0.50	−0.75	−3.74	−3.11	−2.36		
$[t]$	1.03	1.36	0.21	−1.56	0.16	0.17	0.34	0.26	−0.16	−0.86	−0.68	−0.94		
Panel E: Nine credit ratings and price momentum portfolios														
α_i^{FF}	−7.52	−1.37	3.60	11.12	−2.84	−0.23	3.87	6.72	−0.97	0.75	3.07	4.04	2.69	0.00
$[t]$	−6.59	−1.76	3.28	7.02	−2.45	−0.25	5.12	5.45	−0.87	0.87	4.85	3.91		
α_i^q	−2.50	−2.27	−0.82	1.68	−0.01	−0.70	−0.34	−0.33	4.33	3.49	1.87	−2.46		
$[t]$	−0.55	−0.59	−0.21	0.76	0.00	−0.25	−0.12	−0.19	1.51	1.43	0.79	−1.75		
Panel F: Nine book-to-market and price momentum portfolios														
α_i^{FF}	−10.46	−2.18	4.13	14.59	−5.62	−0.84	3.86	9.48	−5.10	−0.07	3.38	8.48	3.96	0.00
$[t]$	−7.68	−2.94	3.14	6.96	−4.76	−1.07	4.43	6.28	−4.43	−0.08	3.74	6.34		
α_i^q	−5.82	−4.70	−2.37	3.45	0.88	1.44	0.41	−0.47	5.26	5.10	−1.83	−7.09		
$[t]$	−1.43	−1.37	−0.59	1.56	0.24	0.46	0.12	−0.27	1.15	1.37	−0.50	−2.83		

Table 10 : Tests for Two-Way Sorted Earnings Momentum Portfolios

For each testing portfolio, we report (in annual percent) the Fama-French alphas, α_i^{FF}, and their t-statistics adjusted for heteroscedasticity and autocorrelations. m.a.e. is the mean absolute error. The p-values (p) are from the Gibbon, Ross, and Shanken (1989) tests of the null that the alphas for a given set of testing portfolios are jointly zero. The investment-based alphas and t-statistics are from one-stage GMM with an identity weighting matrix. These alphas are calculated as $\alpha_i^q \equiv E_T\left[r_{it+1}^S - r_{it+1}^{Iw}\right]$, in which $E_T[\cdot]$ is the sample mean of the series in brackets, r_{it+1}^S is stock returns, and r_{it+1}^{Iw} is levered investment returns. In the table, we use a, b, and c to denote the terciles formed in the ascending order on the firm attribute other than momentum, and 1, 2, and 3 to denote the terciles formed in the ascending order on momentum. For two-way portfolios, for example, a1 is the portfolio formed as the interaction of terciles a and 1, and a3−1 is the winner-minus-loser tercile in portfolio a. Other two-way portfolios are defined analogously.

	a1	a2	a3	a3−1	b1	b2	b3	b3−1	c1	c2	c3	c3−1	m.a.e.	p
Panel A: Nine size and earnings momentum portfolios														
α_i^{FF}	−6.99	−1.35	4.89	11.87	−2.58	−1.87	1.31	3.89	−1.39	−0.10	2.21	3.59	2.52	0.00
[t]	−8.15	−1.71	4.61	9.97	−2.76	−2.02	1.20	3.65	−1.92	−0.13	2.84	3.87		
α_i^q	−4.22	−6.24	−2.26	1.96	4.61	−0.13	0.76	−3.86	6.62	6.63	4.75	−1.87		
[t]	−0.98	−1.48	−0.57	1.42	1.18	−0.03	0.22	−2.96	1.85	2.05	1.57	−1.34		
Panel B: Nine firm age and earnings momentum portfolios														
α_i^{FF}	−8.32	−3.72	1.33	9.65	−4.47	−1.53	2.06	6.53	−3.94	−2.10	1.61	5.55	3.23	0.00
[t]	−5.67	−2.35	0.76	7.51	−3.94	−1.35	1.61	5.52	−3.58	−1.80	1.42	6.16		
α_i^q	−1.54	−1.58	−1.08	0.46	0.97	−0.45	0.75	−0.22	1.45	1.31	0.27	−1.18		
[t]	−0.36	−0.38	−0.27	0.24	0.26	−0.12	0.22	−0.13	0.41	0.40	0.09	−0.69		
Panel C: Nine trading volume and earnings momentum portfolios														
α_i^{FF}	−3.69	−0.22	5.12	8.81	−4.16	−1.70	1.84	6.00	−7.87	−4.06	0.62	8.48	3.25	0.00
[t]	−2.89	−0.17	4.10	10.71	−3.26	−1.40	1.34	6.77	−5.19	−2.88	0.36	5.10		
α_i^q	1.91	4.50	4.63	2.71	−0.03	0.21	−1.39	−1.35	−1.96	−3.40	−2.04	−0.09		
[t]	0.57	1.28	1.38	1.65	−0.01	0.06	−0.42	−0.89	−0.44	−0.78	−0.51	−0.05		
Panel D: Nine stock return volatility and earnings momentum portfolios														
α_i^{FF}	−2.15	0.12	3.55	5.71	−4.16	−0.89	3.10	7.26	−9.10	−3.28	2.83	11.93	3.24	0.00
[t]	−1.96	0.11	3.13	6.95	−4.80	−1.18	2.94	7.83	−6.48	−2.71	1.98	8.05		
α_i^q	2.38	3.55	2.66	0.28	1.12	0.25	0.34	−0.78	−0.81	−4.30	−2.48	−1.67		
[t]	0.77	1.15	0.91	0.20	0.29	0.07	0.10	−0.59	−0.16	−0.84	−0.50	−1.10		
Panel E: Nine credit ratings and earnings momentum portfolios														
α_i^{FF}	−7.63	−1.27	4.18	11.81	−2.28	−0.52	2.55	4.84	−0.82	−0.01	2.84	3.66	2.46	0.00
[t]	−8.51	−1.63	3.67	8.63	−2.06	−0.54	2.37	5.12	−0.85	−0.01	2.60	4.36		
α_i^q	−2.29	−3.08	0.68	2.96	−0.23	−0.38	−1.20	−0.97	3.41	3.50	2.15	−1.26		
[t]	−0.48	−0.68	0.16	1.63	−0.06	−0.11	−0.40	−0.64	1.12	1.26	0.83	−0.92		
Panel F: Nine book-to-market and earnings momentum portfolios														
α_i^{FF}	−4.53	−1.51	2.62	7.15	−4.43	−1.42	3.47	7.90	−6.02	−1.13	4.09	10.11	3.25	0.00
[t]	−4.97	−1.76	2.53	8.30	−4.64	−1.68	3.35	7.39	−5.20	−1.03	3.25	8.75		
α_i^q	−4.30	−4.74	−4.93	−0.62	1.79	0.53	0.81	−0.97	4.72	3.34	0.10	−4.62		
[t]	−1.01	−1.16	−1.23	−0.43	0.47	0.14	0.23	−0.64	0.96	0.72	0.02	−1.76		

Table 11 : GMM Parameter Estimates and Tests of Overidentification

Results are from one-stage GMM with an identity weighting matrix. a is the adjustment cost parameter and κ is the capital's share. The standard errors, denoted [ste], are beneath the point estimates. χ^2, d.f., and p are the statistic, the degrees of freedom, and the p-value testing that the expected return errors across a given set of testing assets are jointly zero. m.a.e. is the mean absolute error in annualized percent for a given set of testing portfolios. R^6 denotes prior six-month returns, the sorting variable for price momentum. SUE denotes standardized unexpected earnings, the sorting variable for earnings momentum.

	Panel A: Price momentum portfolios						
	R^6	Size and R^6	Age and R^6	Volume and R^6	Volatility and R^6	Credit ratings and R^6	Book-to-market and R^6
a	2.51	2.10	2.42	2.79	3.11	2.01	3.42
[ste]	0.98	0.76	0.98	0.96	0.84	0.80	0.93
κ	0.12	0.09	0.12	0.12	0.12	0.11	0.13
[ste]	0.02	0.01	0.01	0.02	0.02	0.01	0.01
χ^2	13.53	21.45	23.97	18.87	20.85	21.93	25.33
d.f.	8	7	7	7	7	7	7
p	0.09	0.00	0.00	0.01	0.00	0.00	0.00
m.a.e.	0.87	3.29	1.26	1.64	1.94	1.82	3.09
	Panel B: Earnings momentum portfolios						
	SUE	Size and SUE	Age and SUE	Volume and SUE	Volatility and SUE	Credit ratings and SUE	Book-to-market and SUE
a	5.50	2.23	3.32	3.00	3.03	1.25	7.36
[ste]	2.53	0.63	1.71	1.42	0.79	0.69	2.49
κ	0.17	0.09	0.13	0.13	0.12	0.11	0.17
[ste]	0.03	0.01	0.02	0.02	0.02	0.01	0.03
χ^2	10.76	28.93	5.71	20.20	11.30	22.08	12.17
d.f.	8	7	7	7	7	7	7
p	0.22	0.00	0.57	0.01	0.13	0.00	0.10
m.a.e.	0.72	4.03	1.04	2.23	1.99	1.88	2.81

Figure 1: Timing of Firm-Level Characteristics, Firms with December Fiscal Yearend

This figure illustrates the timing alignment between monthly stock returns and annual accounting variables from Compustat for firms with December fiscal yearend. r^I_{it+1} is the investment return of firm i constructed from characteristics from the current fiscal year and the next fiscal year. τ_t and I_{it} are the corporate income tax rate and firm i's investment for the current fiscal year, respectively. δ_{it+1} and Y_{it+1} are the depreciate rate and sales from the next fiscal year, respectively. K_{it} is firm i's capital observed at the end of the last fiscal year (or at the beginning of the current fiscal year).

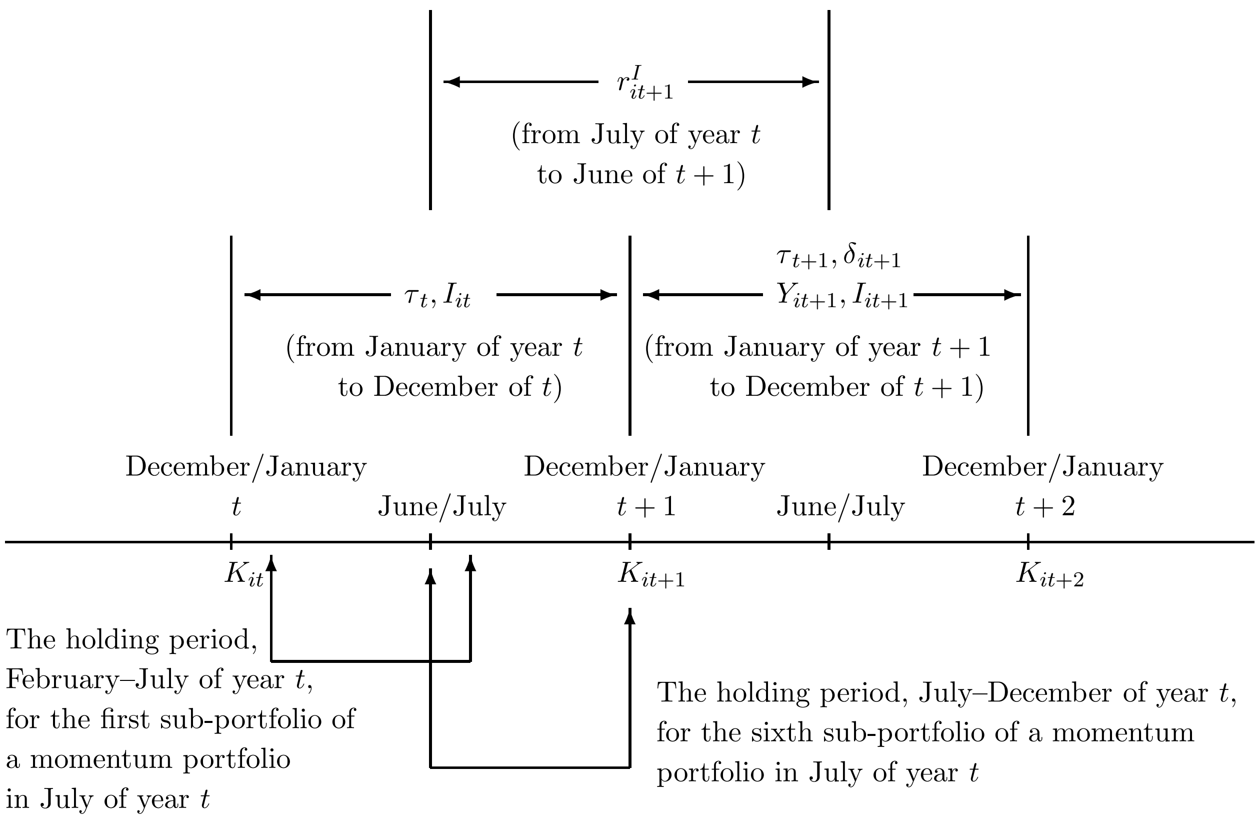


Figure 2 : Average Predicted Stock Returns versus Average Realized Stock Returns, Ten Price Momentum Deciles

In the investment model, the average predicted stock returns are given by $E_T[r^{Iw}_{it+1}]$, in which E_T is the sample mean, and r^{Iw}_{it+1} is levered investment returns given by equation (5). We use the parameter estimates from one-stage GMM to construct the levered investment returns. In the CAPM, the average predicted stock returns are the time series average of the product between the market beta and market excess returns. In the Fama-French model, the average predicted stock returns are the time series average of the sum of three products: the market beta times market excess returns, the size factor loading times the size factor returns, and the value factor loading times the value factor returns. All the average returns are in annual percent. The deciles are formed in the ascending order: 1 is the loser decile, and 10 is the winner decile.

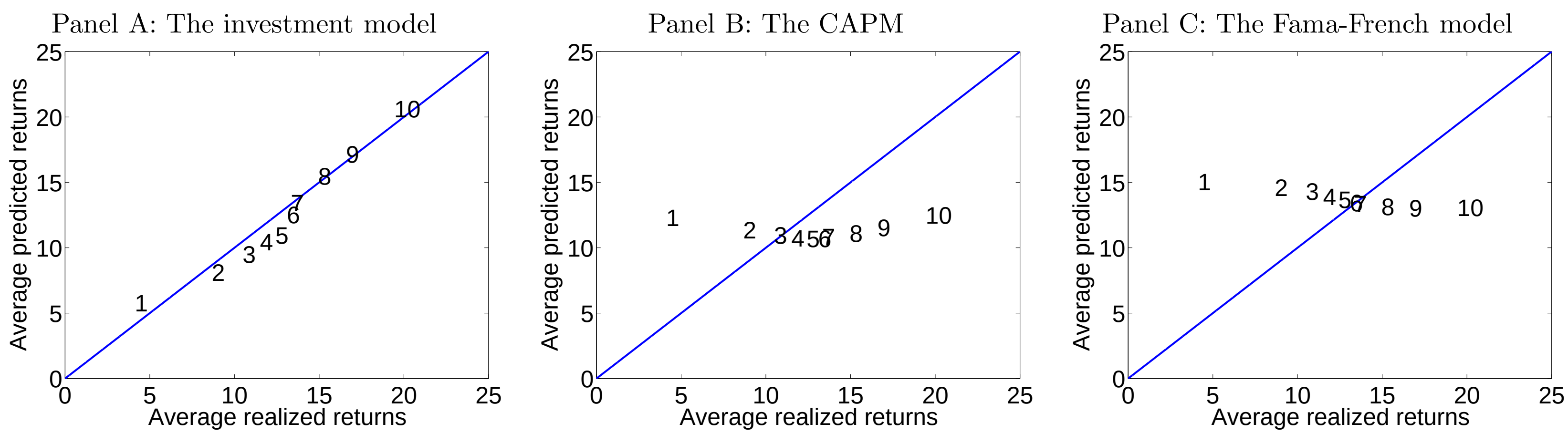


Figure 3 : Average Predicted Stock Returns versus Average Realized Stock Returns, Ten Earnings Momentum Deciles

In the investment model, the average predicted stock returns are given by $E_T[r^{Iw}_{it+1}]$, in which E_T is the sample mean, and r^{Iw}_{it+1} is levered investment returns given by equation (5). We use the parameter estimates from one-stage GMM to construct the levered investment returns. In the CAPM, the average predicted stock returns are the time series average of the product between the market beta and market excess returns. In the Fama-French model, the average predicted stock returns are the time series average of the sum of three products: the market beta times market excess returns, the size factor loading times the size factor returns, and the value factor loading times the value factor returns. All the average returns are in annual percent. The deciles are formed in the ascending order: 1 is the loser decile, and 10 is the winner decile.

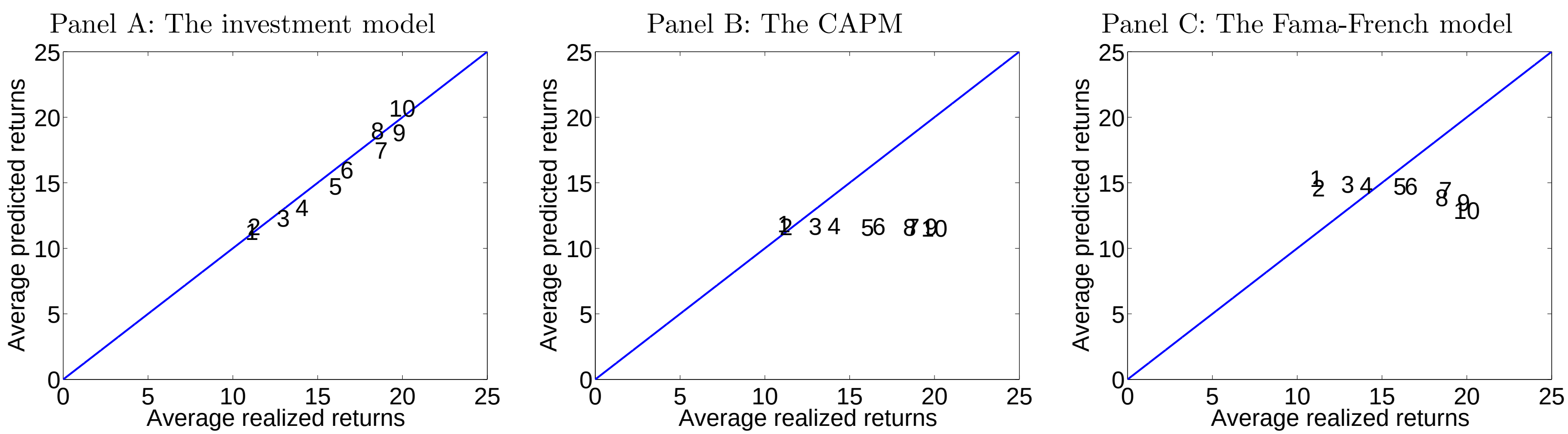
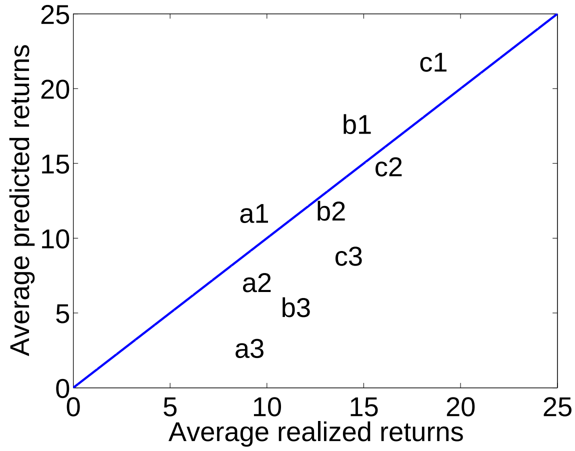


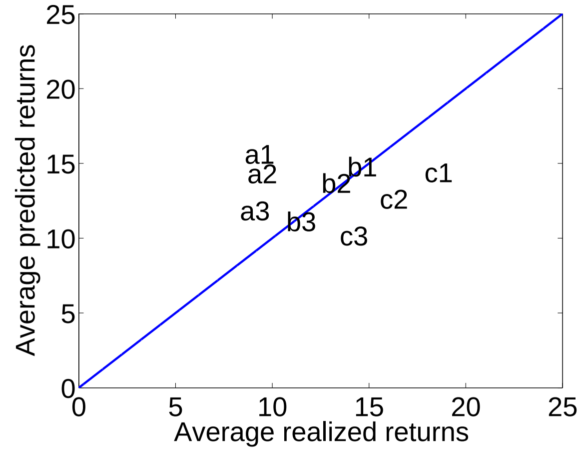
Figure 4 : Average Predicted Stock Returns versus Average Realized Stock Returns, Two-Way Portfolios of Price Momentum Interacted with Size, Firm Age, and Trading Volume

All the average returns are in annual percent. We use a, b, and c to denote the terciles formed in the ascending order on the firm attributes other than momentum, and 1, 2, and 3 to denote the terciles formed in the ascending order on price momentum (R^6). For example, a1 is the portfolio formed as the interaction of terciles a and 1. The other two-way portfolios are denoted analogously.

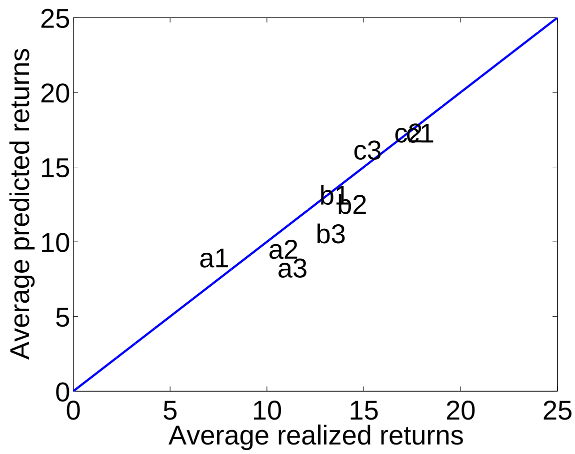
Panel A: The investment model, size-R^6



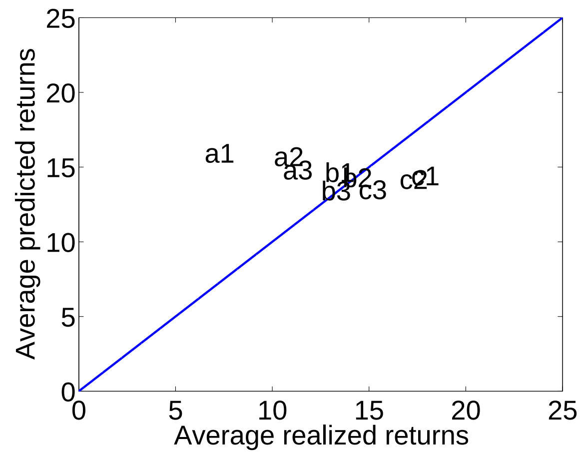
Panel B: The Fama-French model, size-R^6



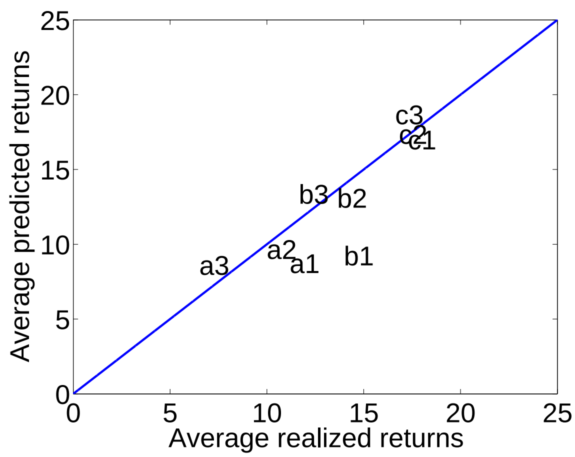
Panel C: The investment model, firm age-R^6



Panel D: The Fama-French model, firm age-R^6



Panel E: The investment model, trading volume-R^6



Panel F: The Fama-French model, trading volume-R^6

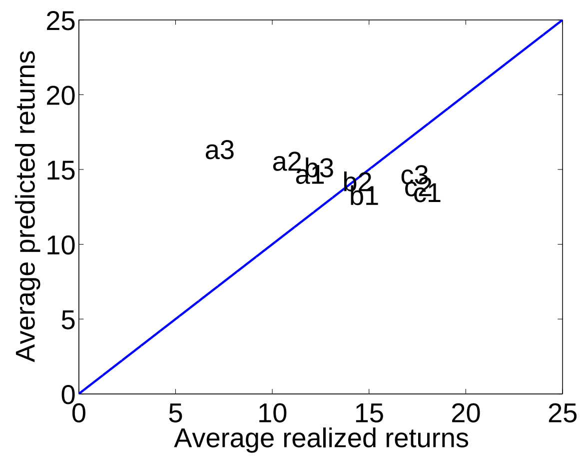
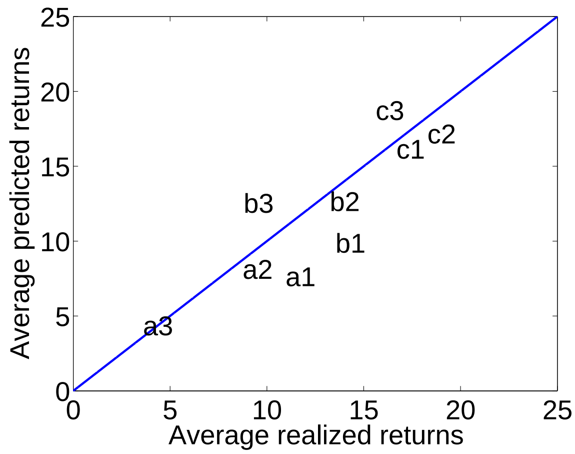


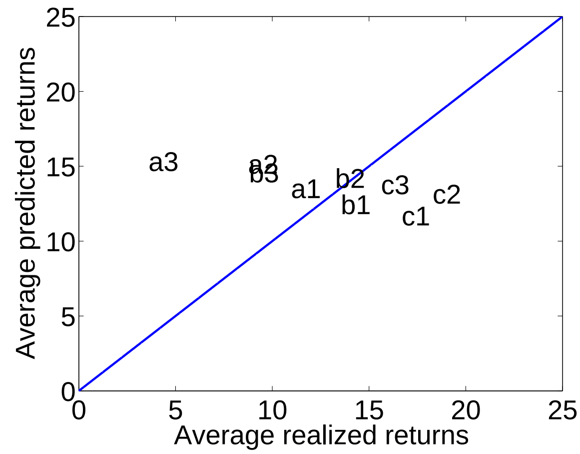
Figure 5 : Average Predicted Stock Returns versus Average Realized Stock Returns, Two-Way Portfolios of Price Momentum Interacted with Stock Return Volatility, Credit Ratings, and Book-to-Market

All the average returns are in annual percent. We use a, b, and c to denote the terciles formed in the ascending order on the firm attributes other than momentum, and 1, 2, and 3 to denote the terciles formed in the ascending order on price momentum (R^6). For example, a1 is the portfolio formed as the interaction of terciles a and 1. Other two-way portfolios are denoted analogously.

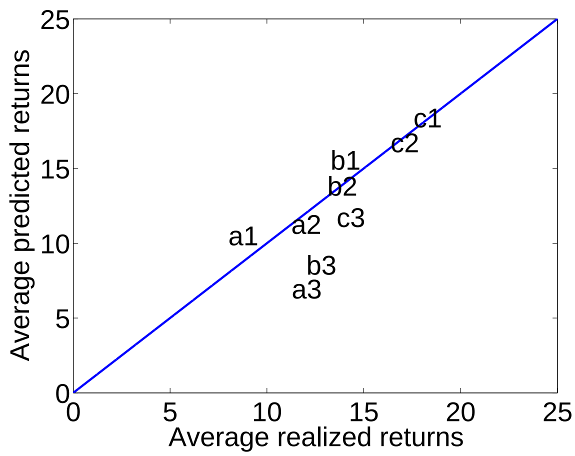
Panel A: The investment model, stock return volatility-R^6



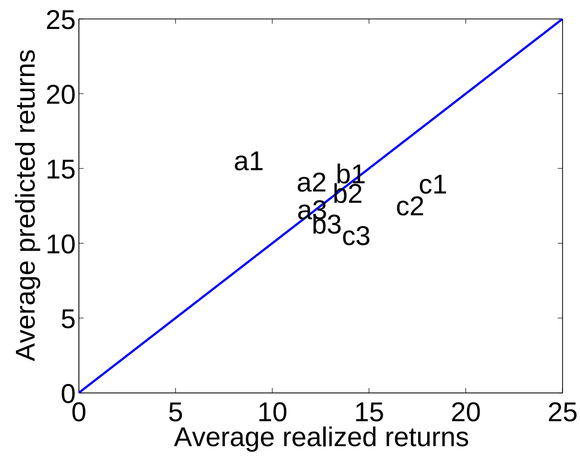
Panel B: The Fama-French model, stock return volatility-R^6



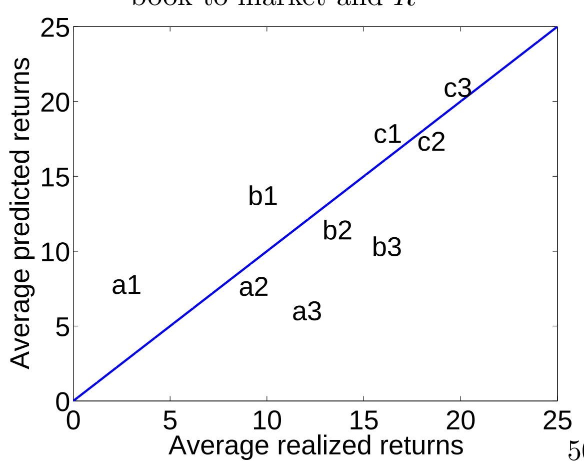
Panel C: The investment model, credit ratings-R^6



Panel D: The Fama-French model, credit ratings-R^6



Panel E: The investment model, book-to-market and R^6



Panel F: The Fama-French model, book-to-market and R^6

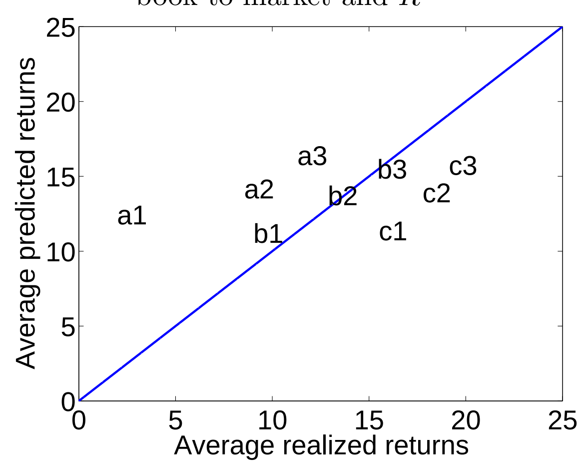
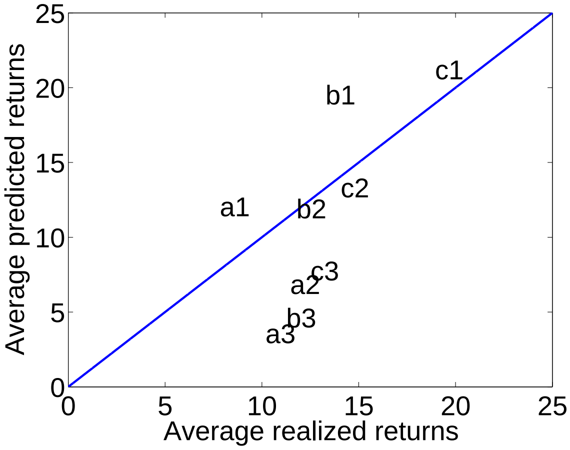


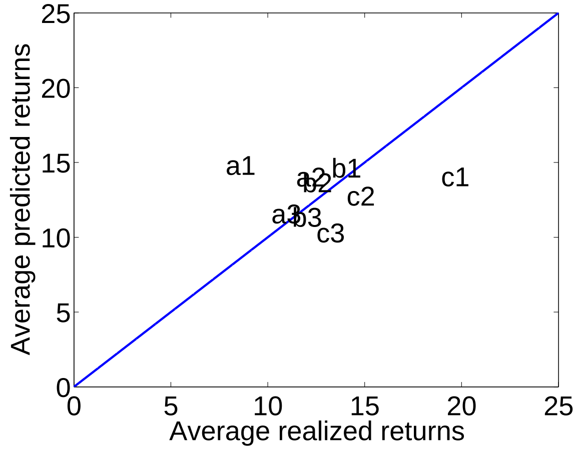
Figure 6 : Average Predicted Stock Returns versus Average Realized Stock Returns, Two-Way Portfolios of Earnings Momentum Interacted with Size, Firm Age, and Trading Volume

The average returns are in annual percent. We use a, b, and c to denote the terciles formed in the ascending order on the firm attributes other than momentum, and 1, 2, and 3 to denote the terciles formed in the ascending order on earnings momentum (SUE). For example, a1 is the portfolio formed as the interaction of terciles a and 1. The other two-way portfolios are denoted analogously.

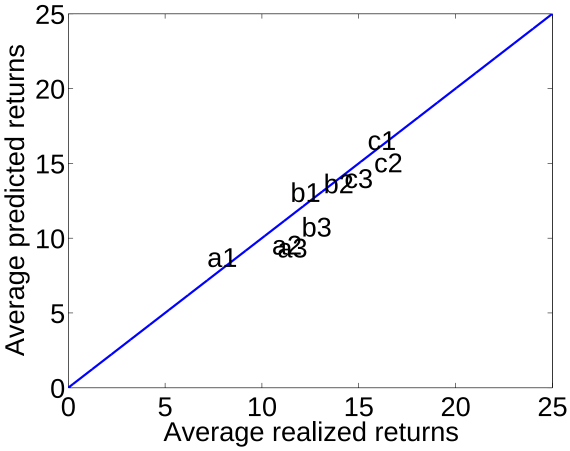
Panel A: The investment model, size-SUE



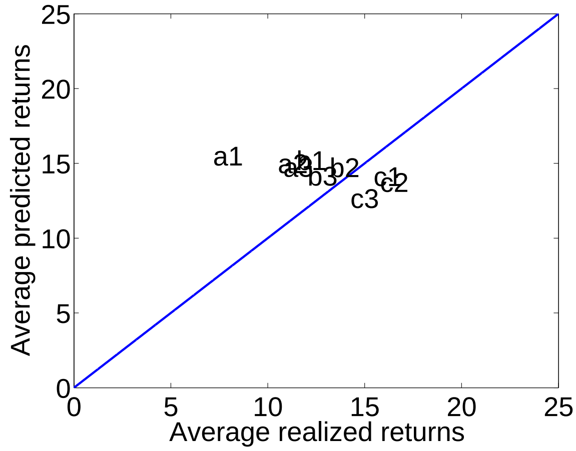
Panel B: The Fama-French model, size-SUE



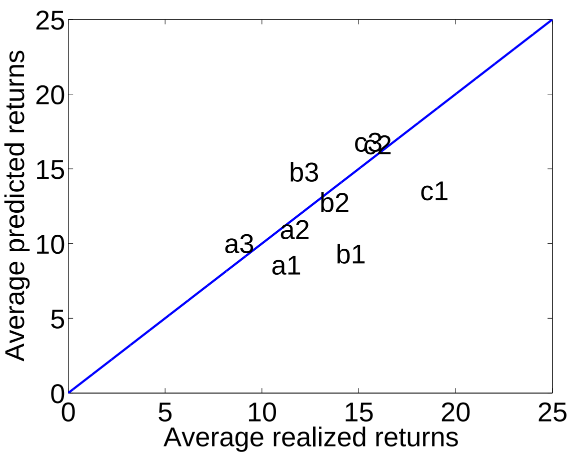
Panel C: The investment model, firm age-SUE



Panel D: The Fama-French model, firm age-SUE



Panel E: The investment model, trading volume-SUE



Panel F: The Fama-French model, trading volume-SUE

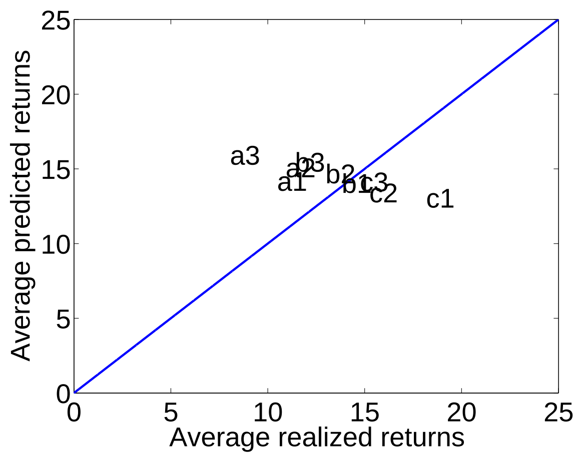
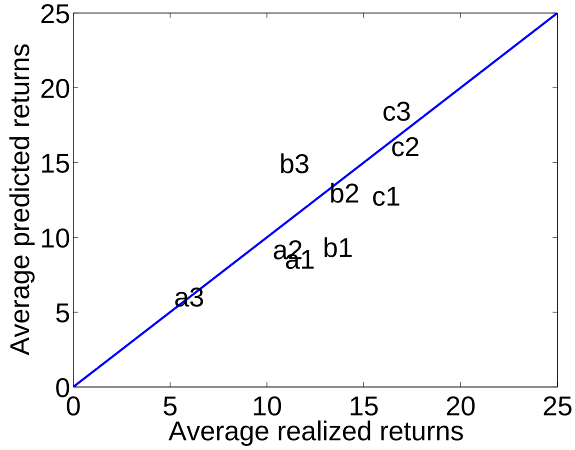


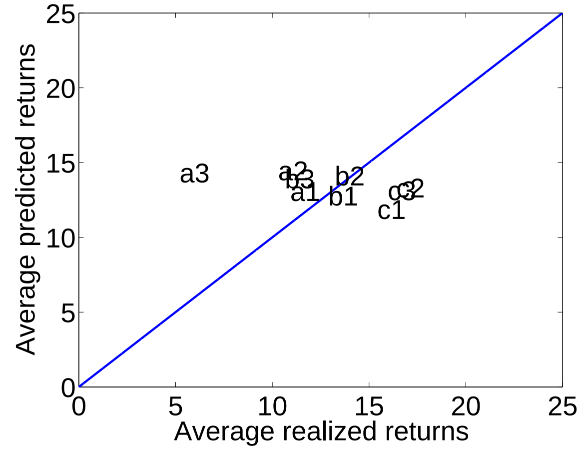
Figure 7 : Average Predicted Stock Returns versus Average Realized Stock Returns, Two-Way Portfolios of Earnings Momentum Interacted with Stock Return Volatility, Credit Ratings, and Book-to-Market

The average returns are in annual percent. We use a, b, and c to denote the terciles formed in the ascending order on the firm attributes other than momentum, and 1, 2, and 3 to denote the terciles formed in the ascending order on earnings momentum (SUE). For example, a1 is the portfolio formed as the interaction of terciles a and 1. The other two-way portfolios are denoted analogously.

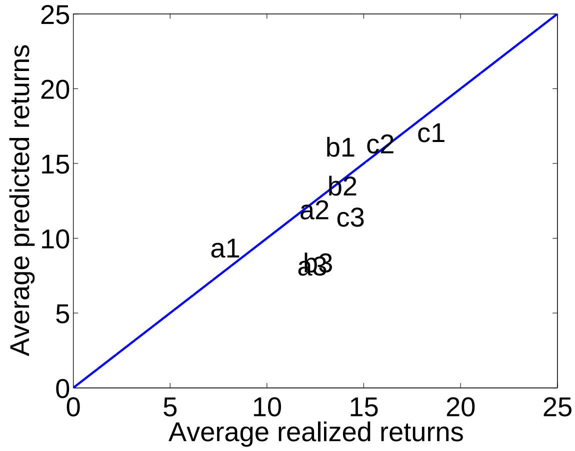
Panel A: The investment model, stock return volatility-SUE



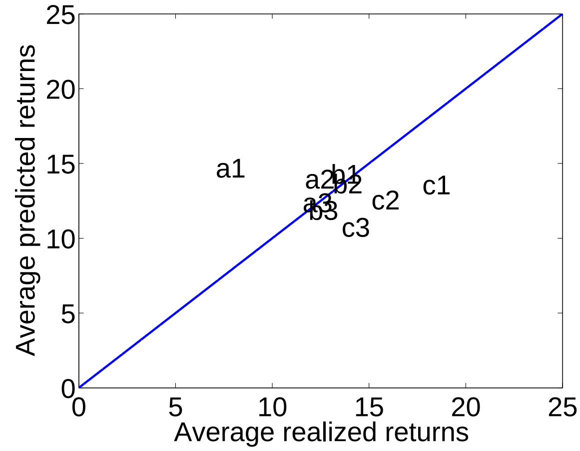
Panel B: The Fama-French model, stock return volatility-SUE



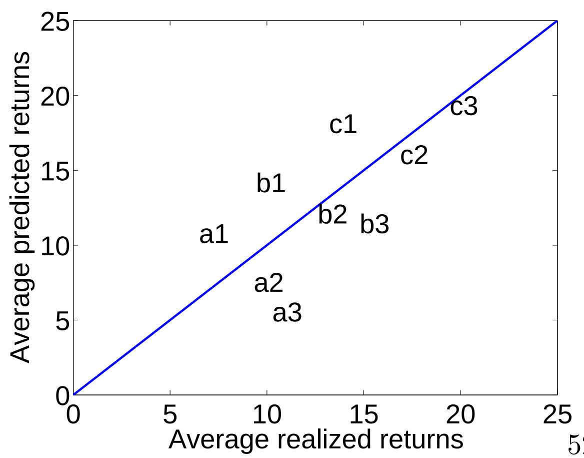
Panel C: The investment model, credit ratings-SUE



Panel D: The Fama-French model, credit ratings-SUE



Panel E: The investment model, book-to-market and SUE



Panel F: The Fama-French model, book-to-market and SUE

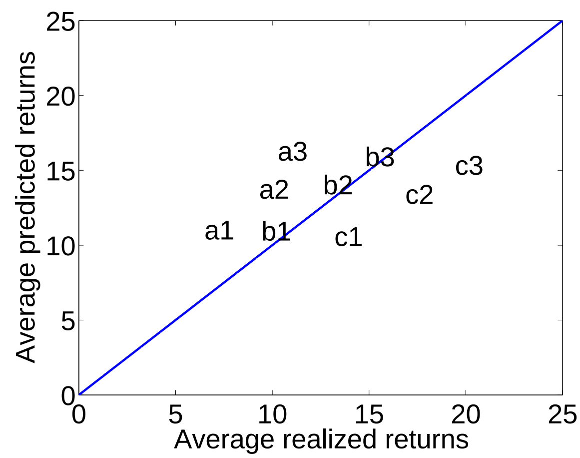
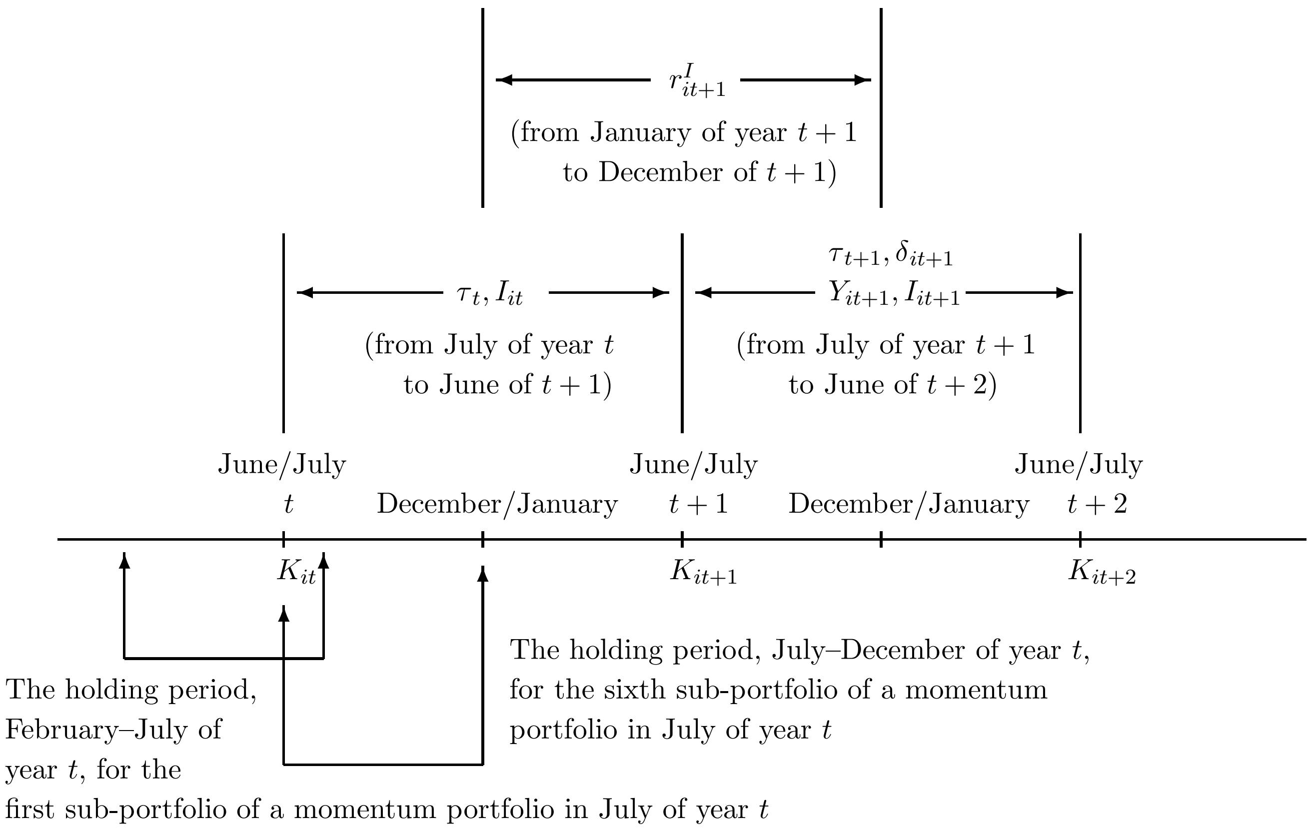


Figure A1: Timing of Firm-Level Characteristics, Firms with Non-December fiscal yearend

This figure illustrates the timing alignment between monthly stock returns and annual accounting variables from Compustat for firms with June fiscal yearend (Panel A) and September fiscal yearend (Panel B). r^I_{it+1} is the investment return of firm i constructed from characteristics from the current fiscal year and the next fiscal year. τ_t and I_{it} are the corporate income tax rate and firm i's investment for the current fiscal year, respectively. δ_{it+1} and Y_{it+1} are the depreciate rate and sales from the next fiscal year, respectively. K_{it} is firm i's capital observed at the end of the last fiscal year (or at the beginning of the current fiscal year).

Panel A: Firms with June fiscal yearend



Panel B: Firms with September fiscal yearend