Labor Hiring, Investment and Stock Return Predictability in the Cross Section[*]

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Abstract

We document that the firm level hiring rate predicts stock returns in the cross-section of US publicly traded firms even after controlling for investment, size, book-to-market and momentum as well as other known predictors of stock returns. The predictability shows up in both Fama-MacBeth cross sectional regressions and in portfolio sorts and it is robust to the exclusion of micro cap firms from the sample. We propose a production-based asset pricing model with adjustment costs in labor and capital that replicates the main empirical findings well. Labor adjustment costs makes hiring decisions forward looking in nature and thus informative about the firms' expectations about future cash-flows and risk-adjusted discount rates. The model implies that the investment rate and the hiring rate predicts stock returns because these variables proxy for the firm's time-varying conditional beta.

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We examine the relationship between firms' hiring decisions and stock return predictability in the cross-section of stock returns. We find that firms with current high rates of labor hiring have low future stock returns. The predictability holds after controlling for investment, size, book-to-market and momentum as well as other known predictors of stock returns. The predictability shows up in both Fama-MacBeth cross sectional regressions and in portfolio sorts and the results are robust to the exclusion of micro cap firms from the sample.

Why does hiring predict stock returns? In this paper, we argue that in an economy with time-varying risk, the firm level hiring and investment rate are proxies for the firm's conditional beta. To establish this link, we propose a production-based asset pricing model that treats the firms' hiring decision as analogous to an investment decision. We then specifiy adjustment costs in both labor and capital inputs, similar in spirit to the q-theory models of investment and akin to Merz and Yashiv (2007). Labor adjustment costs makes hiring decisions forward looking in nature thus making the firm level hiring rate informative about the firms' expectations about future cash-flows and risk-adjusted discount rates. Optimal hiring and investing determine firms' profits, including both rents from capital and labor. In turn, these decisions determine the firm's stock return, which can be expressed in terms of firm characteristics, including the firm's investment and hiring rate. Thus the model implies that the firm's investment and hiring rates proxy for the firm's conditional beta.

The key assumption that differentiates our model from standard q-theory is that of labor adjustment costs. Intuitively, these costs include training and screening of new workers and advertising of job positions as well as output that is lost through time taken to readjust the schedule and pattern of production. This assumption has both theoretical and empirical support. The search and matching models of Diamond (1982), Mortensen (1981), and Pissarides (1985) emphasize the existence of frictions in the labor markets. Shapiro (1984) and Merz and Yashiv (2007) show that reasonably large estimates of labor adjustment costs are important to match several facts in the data.[1] The addition of adjustment costs in labor inputs is essential for our results. Without these costs, the firms' market value does not reflect the value of the labor inputs since labor is costlessly adjusted and thus receives its share in output. Because the stock of labor is freely adjusted every period, hiring decisions are not informative about the firms expectations about future conditions and hence stock returns. With adjustment costs in labor, a component of the firm's market value is determined by the value of the firm's labor force (see Merz and Yashiv 2007 and the discussion in Danthine and Donaldson 2002). The quasi-fixed nature of labor allows firms to extract rents and make operational profits. Thus, by linking the market value of the firm to its labor force, labor adjustment costs establish a link between the firm's stock returns and its hiring decisions.

Our motivation for examining the predictive content of hiring for stock returns follows from a large empirical literature documenting strong correlations between stock market returns and labor market variables. For example, Campbell (1996), Jagannathan and Wang (1996), Jagannathan

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[1] A partial list of additional studies that investigate adjustment costs include Hamermesh (1989), Caballero, Engel and Haltiwanger (1997), Cooper and Willis (2004), and Hall (2004). Hamermesh (1993) reviews a set of direct estimates of the costs of adjusting labor.

et al. (1998), and Santos and Veronesi (2000) all find that labor income and stock returns are related. Boyd, Hu and Jagannathan (2005) find a relationship between unemployment news and stock market returns and Lustig and Van Nieuwerburgh (2008) find that human wealth returns and financial asset returns are negatively correlated.[2] These studies focus on aggregate measures of labor market conditions however, and the motivation and the interpretation of the empirical findings is made through the lens of a consumption-based approach to asset pricing. Instead, we focus on firm specific labor market variables, the firm level hiring rate, and we interpret the empirical findings through the lens of a production-based approach to asset pricing thus focusing on the characteristics of the firms' technologies.

In the empirical section, we run standard Fama-MacBeth cross sectional regressions to examine how the predictability of the hiring rate for stock returns varies over time and across different groups of firms. We find that the predictive content of the hiring rate for stock returns has significantly increased over our sample period from 1965 to 2006, and it is particularly strong after the late 70's. In addition, we show that the predictive power of the hiring rate for stock returns varies with the characteristics of the firms' technology as measured by the firms' capital intensity or by its industry classification. The predictability content of the hiring rate is higher for labor intensive firms than for capital intensive firms.

We also document new facts regarding the well known relationship between the investment rate and future stock returns.[3] We first confirm that the firm level investment rate predicts stock returns: firms with high investments rate tend to have subsequently low stock returns. Our novel finding is that the predictability of the investment rate varies with the firms' technology, as measured by the firms' capital intensity or industry classification. Complementing the results about hiring and labor intensity, we find that the predictive power of the investment rate is high for capital intensive firms but low for labor intensive firms. Finally, we document that over our sample period the predictive power of investment for stock returns has decreased over time, the exact opposite pattern of what we find for the hiring rate.

The results from the Fama-MacBeth cross sectional regressions are confirmed in portfolio sorts. We construct nine value-weighted and equally-weighted portfolios double sorted on investment and hiring rates. We find that the average returns on these portfolios are decreasing in both the investment and hiring rate, and the sorting procedure generates an impressive spread in average returns. For example, the portfolio composed of firms with low investment rates and low hiring rates has a value weighted excess return of 8.37% (annually) in the data, whereas the portfolio composed of firms with high investment rates and high hiring rates has a value weighted excess return of only 1.32% (annually), a significant spread of 7.05%. We find that the unconditional CAPM is unable to explain the cross-sectional variation in the returns of these portfolios. The Fama-French (1993) three factors model is more successful at capturing the variation in returns of

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[2] References on human capital and asset returns go as far back as Mayers (1972) and Fama and Schwert (1977).

[3] A partial list of empirical studies showing that investment and average returns are negatively correlated includes: Cochrane (1991), Richardson and Sloan (2003), Titman, Wei, and Xie (2004), Anderson and Garcia-Feijoo (2006), Cooper, Gulen, and Schill (2007), Polk and Sapienza (2007), Xing (2007) and Fairfield, Whisenant, and Yohn (2003).

these portfolios but it is unable to price the portfolio composed of firms with high investment and hiring rates, at least in equally weighted portfolios. This portfolio represents a puzzle for the Fama French model: the returns on this portfolio are typical of a risky-value stock as measured by the portfolio high market and HML beta, but the average returns on this portfolio are too small, even taking into account its low SMB beta.

We calibrate the production-based model developed here to match well known US financial market data in order to understand the cross-sectional empirical facts and test our theoretical explanation for the relationship between hiring, investment and stock returns. We show that the model is able to qualitatively replicate the main empirical findings well. The model produces Fama-MacBeth regression slope coefficients that are negative for both the investment and hiring rates and with magnitudes that are very close to the empirical estimates. In addition, we show that the existence of labor adjustment costs is crucial to replicate the negative relation between hiring rates and future stock returns. A simulation of the model in which labor can be freely adjusted produces Fama-MacBeth slope coeffcients associated with the firm's hiring rate that are indistinguishable from zero.

The production-based model also replicates the portfolio sorts results found in the data. The simulated nine investment and hiring rates double sorted portfolios exhibit returns that are decreasing in both the investment and hiring rates. The sorting procedure also generates the negative relationship between the book-to-market ratio and the investment and hiring rates observed in the real data. In addition, the model replicates the rejection of the CAPM on these portfolios. As in the real data, this rejection follows from the fact that the spread in the unconditional CAPM market beta across these portfolios is too small relative to the spread in the average excess returns. The Fama-French (1993) performs sgnificantly better than the CAPM but is also rejected in the simulated data. The rejection is mainly driven by the difficulty of the model in pricing some portfolios, in particular the high hiring-high investment portfolio, similarly to what is observed in the real data.

The production-based model can also be used to interpret other known facts in the empirical asset pricing literature such as the value premium.[4] In our model, value firms hire and invest less than growth firms, which implies that the expected returns on hiring and investment are higher for value firms. Hence, value firms earn higher expected stock returns than growth firms do. The economic mechanism underlying the value premium in our model is similar to that in Zhang (2005) and Liu, Whited and Zhang (2008) who study the value premium by exploring the one-to-one mapping between the market-to-book ratio and the marginal q of investment (a function of the investment rate). In our model, the assumption of adjustment costs to labor implies that the market-to-book ratio depends on both the marginal q of investment and the marginal q of hiring (a function of the hiring rate). Thus our model predicts that labor hire, in addition to investment, plays an important role in explaining the value premium.

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[4]A partial list of studies exploring why book-to-market ratio positively forecasts average stock returns includes Berk, Green and Naik (1999), Carlson, Fisher and Giammarino (2004), Kogan (2004), Zhang (2005), Cooper (2006), and Liu, Whited and Zhang (2008).

Related Literature: Our empirical work is related to a large empirical literature on the cross-section of stock returns that explore the predictability of firm characteristics for stock returns.[5] Our theoretical work is related to the production/investment-based asset pricing literature that emerged from the q-theory of investment. This literature establishes an explicit link between the investment rate and stock returns.[6] In most of this literature however, labor is either not explicitly modeled or does not play any role in explaining stock returns because it can be costlessly adjusted. Therefore our work sheds new light on the economic determinants of the covariations of hiring, investment and stock returns in the cross-section.

The production-based model proposed here is related to the work by Merz and Yashiv (2007) who consider an aggregate firm in a setup in which, as in our model, firms' face adjustment costs in both capital and labor. They find that adding labor adjustment costs substantially improves the fit of the model in matching the time series properties of aggregate stock market prices. We extend Merz and Yashiv to the firm level which allows us to study the cross-section of stock returns. In addition, we focus on stock return predictability, an issue not considered in Merz and Yashiv. Finally, we evaluate the model using stock market return data and by examining the properties of the model in a simulation economy calibrated to match well known US financial market data, whereas Merz and Yashiv focus on the empirical estimation of the production and adjustment cost functions.

Our theoretical work is also related to the work by Danthine and Donaldson (2002) who show that operating leverage resulting from frictions in the determination of the wage rate magnifies the risk premium of equity returns. Danthine and Donaldson model cannot be directly used to interpret the relationship between hiring rates and stock returns however, because the equlibrium model has full employment. Thus at the aggregate level, the hiring rate simply reflects changes in the size of the population. We note however that frictions in the determination of the wage rate can potentially magnify the impact of labor adjustment costs on equity returns. For tractability and to emphasize the role of labor adjustment costs for our results, we don't explore this interesting additional channel in the current version of the model..

Finally, our focus on the predictability of the hiring rate, a labor market variable, is also related in spirit to the work by Chen, Kacperczyk and Ortiz-Molina (2007) (CKOM hereafter) who document that firms in more unionized industries have higher stock returns on average. CKOM argue that their findings are consistent with the hypothesis that labor unions decrease firms' operating flexibility, which is in fact a type of friction in the labor market that is generalized by the adjustment cost function considered in our equilibrium model. In addition, most of the analysis in CKOM is based on the expected stock returns implied by the Fama-French (1993) model and thus

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[5] A partial list of papers documenting accounting variables, financial variables and corporate events that forecast average stock returns include Banz (1981), Basu (1983), Rosenberg, Reid, and Lanstein (1985), Fama and French (1992), Bhandari (1988), Jegadeesh and Titman (1993), Ikenberry, Lakonishok, and Vermaelen (1995), Loughran and Ritter (1995), Chan, Jegadeesh, and Lakonishok (1996), and Piotroski (2000).

[6] An incomplete list of contributions include: Cochrane (1991), Cochrane (1996), Berk, Green and Naik (1999), Kogan (2001, 2004), Gomes, Kogan and Zhang(2003), Carlson, Fisher and Giammarino (2004), Zhang (2005), Gala (2006), Gomes, Yaron and Zhang (2006), Belo (2008), Li, Livdan and Zhang (2008) and Liu, Whited and Zhang (2008).

the predictability of the labor unionization rates for the cross sectional returns is directly related to differences in the Fama-French factor loadings. In contrast, we look at realized stock returns and we find that the cross-sectional differences in the average returns across portfolios sorted on investment and hiring rates are not completely explained by the Fama-French (1993) factors. Finally, the labor union data used in CKOM is only available at the industry level whereas the hiring rate that we use here is available at the firm level. Thus our focus on the hiring rate allows us to capture firm level information about operational flexibility that is missed by labor union industry data.

The paper proceeds as follows. Section I presents the empirical facts in the data regarding the relationship between investment, hiring and stock returns. Section II presents the theoretical model that we use to understand the empirical evidence. Section III reports the quantitative findings form a simulation of the model. Section IV concludes.

I   The Empirical Link Between Labor Hiring, Investment and Stock Return Predictability

We follow two complementary empirical methodologies to examine the relationship between the firm level investment and hiring rates and stock return predictability in the data. The first approach consists of running standard Fama and MacBeth (1973) (henceforth FMB) cross sectional regressions of firm level returns on firm level characteristics that include the firm level investment and hiring rates as explanatory variables. The second approach consists of constructing portfolios sorted on firm level investment and hiring rates. We follow these two approaches because of the well known advantages and disadvantages of each approach, as discussed extensively in Fama and French (2008), for example. Thus the two approaches allows us to cross-check the results.

A   Data

Monthly stock returns are from the Center for Research in Security Prices (CRSP) and accounting information is from the CRSP/COMPUSTAT Merged Annual Industrial Files. The sample is from July 1965 to June 2006. We exclude from the sample any firm-year observation with missing data or for which total assets, the gross capital stock, or total employees are either zero or negative. In addition, as standard, we omit firms whose primary SIC classification is between 4900 and 4999 (regulated firms) or between 6000 and 6999 (financial firms). Following Vuolteenaho (2002) and Xing (2008), we require a firm to have a December fiscal-year end in order to align the accounting data across firms. Since most firms have a December fiscal-year end, this selection requirement does not bias the representativeness of the sample. Following Fama and French (1993), we also require that each firm must have at least two years of data to be included in the sample. Finally, following Titman, Wei and Xie (2004), we exclude firms with total net sales below US $10 million to exclude firms in their early stage of development. This last requirement has a very small impact on the overall set of results.

6

The two key variables for the empirical work are the firm level investment and hiring rate. We construct these variables as follows. Firm level capital investment (I_t) is given by COMPUSTAT data item 128 (Capital Expenditures). The capital stock (K_t) is given by the data item 8 (Property, Plant and Equipment). The number of employees or stock of labor (N_t) is given by data item 29 (Employees). Net hiring (H_t) is given by the change in the stock of labor in year t from year t-1 ($H_t = N_t - N_{t-1}$). The investment rate is given by the ratio of investment to beggining of the period capital stock ($IK_t = I_t/K_{t-1}$) (as in Xing (2008) and Kaplan and Zingales (1997)) and the hiring rate is given by the ratio of hiring to the beggining of the period stock of labor ($HN_t = H_t/N_{t-1}$). Thus our hiring rate is effectively the net growth rate of the labor stock of the firm. We winsorize the top 1% of the investment and hiring rate distribution to reduce the influence of a small number of large outliers observed in our sample. Appendix A-1 provides a detailed description of the additional data used.

B   Summary Statistics

B.1   Investment and Hiring Rates

Table I reports detailed firm level and cross-sectional summary statistics of the investment and hiring rate data in our sample. For comparison, the table also reports the summary statistics of book-to-market ratio and asset growth variables, which are two known stock return predictors. Panel A reports the mean values across firm level moments of these variables. In computing these statistics, we require a firm to have at least 10 observations in order to estimate these statistics with enough precision at the firm level. Two important facts about the statistics reported in Panel A are worth emphasizing. First, the hiring rate and, to a less degree, the investment rate, have relatively low autocorrelations. The mean across firms autocorrelation of the hiring rate is 0.06, which is lower than the mean autocorrelation of 0.30 of the investment rate and much lower than the mean autocorrelation of 0.52 of the book-to-market ratio. The relatively low autocorrelation of the hiring rate and the investment rate is an important fact in the data since it is well known that variables with an high autocorrelation often generate spurious evidence of predictability (see Ferson, Sarkissian and Simin (2003) for a detailed discussion on this issue). Second, the mean correlation between the firm's investment and hiring rate is 0.33. This relatively low correlation suggests that investment and hiring decisions carry potentially different information about the firms' prospects, and hence about firm's future returns. In turn, this fact provides support for the approach in this paper of jointly considering the role of the investment and hiring rate variables as stock return predictors. Finally, in unreported results, we also compute the average correlation between the firm level hiring rate and the aggregate unemployment rate and find it to be low (-0.13). Since Boyd, Hu and Jagannathan (2005) have shown that unemployment news are related to the stock market, this low correlation suggests that firm level hiring rate is potentially capturing independent information about the firms' prospects that is not contained in the aggregate unemployment rate.

[Insert Table I here]

Table I, Panel B reports the average values (across time) of cross sectional moments of the investment and hiring rates as well as the book-to-market ratio and asset growth. Importantly, both the investment and hiring rate exhibit substantial cross sectional variation which suggests that a large fraction of the information content of both the investment and hiring rates is firm specific. In turn, this fact provides support for the use of the firm level investment and hiring rate characteristics as opposed to an aggregate labor market factor. In addition, the cross-sectional moments (in addition to the firm level moments) show that the correlation between the firm level hiring or investment rate and the firm level asset growth is high (0.46 and 0.41 respectively). This fact suggests that it is important to control for the asset growth effect in the empirical tests in order to establish a marginal predictive power for returns of the investment and hiring rate.

B.2 Other Variables

Table II reports the summary statistics of selected variables used in our empirical work. It reports mean values for monthly returns (RET), investment rate (IK), hiring rate (HN), book to market (BM), (log) market capitalization (SIZE), momentum (MOM), net assets growth (AG), profitability (YB), labor to real capital ratio (LK) and labor share (LS). In Panel A, we separately reports the summary statistics for all the firms in our sample as well as for a sub-sample of firms that excludes micro cap firms (All Firms but Micro). Following Fama French (2008), micro caps are defined as stocks with a market capitalization bellow the bottom 20th percentile of the NYSE cross-sectional market size distribution. Naturally, the average returns of the All Firms but Micro subsample are lower than the average returns for the full sample of firms, reflecting the well documented higher average returns of micro caps. In unreported results, we also examine the representativeness of our sample by comparing the summary statistics of our sub-sample of COMPUSTAT firms with the summary statistics of all firms in COMPUSTAT firms and we conclude that the summary statistics of the two samples are very similar. This suggests that our sub-sample of firms is representative of the universe of all COMPUSTAT firms (results available upon request).

[Insert Table II here]

To investigate and characterize the predictability of the investment and the hiring rate across firms with different technologies, we group firms according to two distinct firm level technology related characteristics (which we justify below): capital intensity and industry classification. Table II, Panel B reports the summary statistics for three groups of firms classified according to firm's capital intensity, which we proxy by the firm's labor to capital ratio (LK). We consider a firm to be capital intensive if it has a LK ratio below the 20th percentile of the LK cross sectional distribution in a given year. Similarly, the capital and labor group is composed of firms that have a LK ratio between the 20th and the 80th percentile of the LK cross sectional distribution. Finally, we consider a firm to be labor intensive if it has a LK ratio on the top 20th percentile of the LK cross-sectional distribution. In terms of average characteristics, capital intensive firms in our sample tend to have lower returns, lower investment and hiring rates, are bigger than labor firms, have slightly

higher book-to-market ratios, are less profitable and have lower labor shares.[7] We note that the classification could also be made based on the firm's capital and labor shares to more accurately reflect the value of the inputs and hence their importance in the production of the firm's output. This approach is not feasible in practice, however. Due to missing firm level wage bill data in COMPUSTAT for a significant number of firms, the labor share can only be computed for 10% of the firms on our sample.

Table II, Panel C reports the summary statistics for five groups of firms classified according to the firm's industry standard industry code (SIC) and using the five industry classification available in Prof. Kenneth French's website. We focus on a small number of industries in order to guarantee a large number of firms in each industry, as required to run the Fama-MacBeth cross sectional regressions with sufficient precision. The five industries that we consider are: (1) Consumer, which includes consumer durables goods (cars, tvs, furniture and household appliances), consumer nondurables (food, tobacco, textiles, apparel, leather and toys), wholesale, retail, and some services (laundries and repair shops); (2) Manufacturing (machinery, trucks, planes, office furniture, paper and commercial printing), energy (oil, gas, and coal extraction, chemicals and allied products) and utilities; (3) High-Tech, which include business equipment (computers, software and electronic equipment), telephone and television transmission; (4) Healthcare, medical equipment and drugs; and (5) all other firms (Other).

C Fama-MacBeth Cross-Sectional Regressions

In this section we run FMB regressions of monthly stock returns on firm level hiring and investment rates and report the time series averages of each cross-sectional regression loading along with its time-series t-statistic (computed as in Newey-West with 4 lags). In order to better characterize the predictive power of the hiring and the investment rate for stock returns in the data, we discuss separetely our results across the following groups of firms: (1) all firms together (pooled sample) versus all firms excluding micro cap stocks; and (2) technology groups, measured by the firm's capital intensity and the firm's industry classification. In all the analysis, we run FMB regressions across the full sample period and across two sub-periods of equal size in order to examine the stability of the relationships over time. We conclude this section by comparing the predictability power of the investment and hiring rate with that from a large set of other known return predictors of stock returns.

C.1   Predictability in the Pooled Sample and Excluding Micro Caps

In Table III, we report results the FMB regressions for a sample that includes all firms in the sample (left panels) and for a sample that includes all firms excluding micro caps (right panels). The separate analysis of a sample of firms that excludes micro caps is motivated by the fact that FMB regression results can be largely dominated by micro caps, because these firms are plentiful

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[7]The summary statistics for the labor share date is not based on firm level data but it is computed using aggregate information available at the 2 digit Standard Industry Classification (SIC) level as discussed in Appendix A-1.

and tend to have more extreme values of the explanatory variables and more extreme returns (see discussion in Fama and French (2008)). In each FMB regression we consider five different empirical specifications, which differ in the explanatory variables considered. In the first two specifications, we use either the investment rate or the hiring rate separately as explanatory variables and in the third specification we include both variables together. In the fourth specification, we add other well known return predictors (also known as anomalies) to examine if the investment and the hiring rates have additional marginal ability to predict stock returns in the presence of these known anomalies. Here, we focus on the size (market capitalization), book-to-market ratio and the momentum anomalies.[8] In section C.3 we consider other return anomalies. As in Fama-French (2008) we omit the inclusion of the market beta since the market beta for individual stocks is not precisely measured in the data.

The full sample results in Table III, Panel A for the sample that includes all firms (left panel) shows that both investment and hiring rates predict future returns across all specifications. The regression produces negative average slopes associated with investment and hiring rates. These results confirm the well documented negative relationship between high current investment rates and low future stock returns and reveal the novel fact that high current hiring rates also predicts low future returns. Examining the results in Table III in more detail, the results also show that the predictive power of investment and hiring rates is economically significant. For example, when the investment rates and hiring rates are considered separately, a one standard deviation increase in the investment rate and hiring rate (see values reported in Table I, Panel A) is associated with a decrease of 1.74% and 2.03% respectively in the firm's annualized future returns. The average slope associated with the size, book-to-market and momentum characteristics produces the standard signs documented in the literature. Here, high values of size are associated with low future returns, whereas high values of book-to-market and momentum are associated with high future returns.

[Insert Table III here]

Turning to the analysis of the stability of the results over time, Table III, Panel B reports the FMB regression results for the sub-sample that goes from July 1965 to June 1985 and Table III, Panel C reports the FMB regression results for the sub-sample that goes from July 1985 to June 2006. Comparing the results both across the sample that includes all firms and the sample that excluded micro firms, the pattern for the hiring rate predictability is clear: the slope coefficients for the hiring rate are higher (in absolute value) and more statistically significant across all specifications in the later sub-sample period than in the initial sub-sample period.

To examine in detail the change over time in the predictive content of the firm level investment and hiring rate for stock returns, we run Fama-MacBeth regressions on rolling 15 year window samples and control for size, book-to-market and momentum. Figure 1 plots the time series of the

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[8] The use of the size characteristics follows from the work of Banz (1981). The use of the book-to-market characteristic follows from the work of Rosenberg, Reid, and Lanstein (1985), Chan, Hamao, and Lakonishok (1991), and Fama and French (1992). The use of the momentum characteristics follows from the work by Jegadeesh and Titman (1993).

corresponding investment and hiring rate Fama-MacBeth slope t-statistic. The hiring rate becomes a statistically significant predictor of stock returns in the late 70's. Interestingly, we observe a symmetric pattern for the investment rate. The investment rate looses is predictive power in the mid 80's. We interpret these findings in the theoretical model below.

[Insert Figure 1 here]

C.2 Predictability Across Technologies

In the previous section we pooled firms with different technologies together in the FMB regressions. Implicit in this procedure is the assumption that the investment and the hiring rate have the same predictive power for stock returns across firms. But firms differ in many dimensions which may make the previous assumption implausible. One fundamental characteristic that distinguishes firms is the type of technology used in the production of its output. In this section, we investigate how the predictability of the investment and hiring rates varies with the firm's technology by grouping firms according to two technology related characteristics: (1) firm's capital intensity; or (2) firm's industry classification.

The use of the first characteristic, capital intensity, as a proxy for the firm's technology is natural since labor and capital are inputs with different characteristics and the capital intensity provides information about the relative importance of each input in the firm's production process. The hypothesis that the predictive power of the hiring and investment varies with the firm's capital and labor intensity can be motivated by examining a limiting example. Consider a firm that (almost) only uses labor to produce output. Naturally, in this case, the firm's investment rate provides little information about the firms prospects' and thus its predictive content for stock returns should be negligible; only the hiring rate should be informative about the firm's future returns. Analogously, the hiring rate should have no predictive power for a firm that (almost) only uses capital. The use of the second characteristic, firm's industry classification, as a proxy for the firm's technology is also natural. Technologies vary on dimensions other than just capital and labor intensity, and thus grouping firms based on capital and labor intensity might not necessarily create technologically affine groups of firms. For example, capital and labor are non-homogeneous inputs across technologies. Some technologies require highly skilled labor to operate (e.g. pharmaceuticals) whereas other technologies can accommodate a large proportion of low-skilled workers (e.g. construction). Likewise, the embodied technological progress in capital is also likely to vary across technologies. These differences suggest that the information content of investment and hiring rates may vary across industries and these differences might be captured by grouping firms at the industry level.

Table IV reports the results for the FMB cross-sectional regressions across firms grouped by capital intensity. The full sample results presented in Panel A confirm the hypothesis that the predictive power of the hiring and the investment rates varies with the firm's capital and labor intensity. In both cases, the slope coefficients are negative but the magnitude and the statistical significance of the coefficient varies across each type of firm. As conjectured, only the investment rate has predictive power for stock returns within capital intensive firms whereas for labor intensive

11

firms, only the hiring rate has predictive power. The t-test for the difference in the slope coefficient for these firms (G1 minus G3) confirm statistically that the difference in the slope coefficient across the capital intensive and the labor intensive group of firms is statistically significant, especially in the more recent sample period (Panel C).

[Insert Table IV here]

Turning to the analysis of the stock return predictability across industries, Table V reports the full sample FMB cross-sectional regression results across five industries. In computing these regressions, we require that each industry specific cross-section has at least 15 firms in order to estimate the industry specific slope coefficients with sufficient precision. As before, the regression produces negative average slopes for the hiring and investment rates across all industries. More interestingly, the results show some variation in the predictive power of hiring and investment rates across industries. Focusing on the full sample period results in Panel A, the investment rate is a significant predictor of returns in the manufacturing and high-tech sectors, whereas the hiring rate is significant return predictor in the consumer, manufacturing and high-tech sectors. Consistent with the analysis in the previous section, the predictability of the hiring rate is particularly strong in the more recent sample period in which the hiring rate is a statistically significant predictors of returns in all the industries considered (at the 10% level in the health-care sector). Taken together, the results in this section suggest that the sensitivity of the firm's future returns to the investment and hiring rates varies across technologies.

[Insert Table V here]

C.3   Relationship With Other Anomalies

In this section we examine if the investment and hiring rate maintain its predictive power after controlling for a broader set of stock return predictors. In choosing the set of return predictors, we follow Fama-French (2008). In addition to the standard size, book-to-market and momentum characteristics, we examine asset growth, net stock issues, positive accruals, and positive profitability.[9] These additional anomaly variables are the statistically significant predictors of returns reported in Fama-French (2008), table IV, row "All but Micro". We consider five empirical specifications which differ in the set of return predictors included. We consider size, book-to-market and momentum in all specifications and in specifications one to four we consider one the previous additional anomaly variables separately. Finally, in the last specification we consider all anomaly variables together.

The first specification in Table VI, Panel A reports the full sample results when the asset growth characteristics is included. The slope coefficient associated with asset growth is negative and statistically significant as in Fama-French (2008) and in the original Cooper, Gulen and Schill

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[9]The use of the asset growth characteristic follows from the work of Cooper, Gulen and Schill (2008). The use of the net stock issues characteristic follows from the work of Ikenberry, Lakonishok, and Vermaelen (1995), Loughran and Ritter (1995), Daniel and Titman (2006) and Pontiff and Woodgate (2006). The use of the accruals characteristics folows from the work initiated by Sloan (1996). Finally, the use of the profitability characteristic follows from the work of Haugen and Baker (1996) and Cohen, Gompers, and Vuolteenaho (2002).

(2008). Comparing with the previously reported results in Table III, Panel A, we note that the presence of the asset growth variable decreases the slope coefficient associated with investment and hiring in half. This is expected since, as documented in Table I, both the investment and hiring rate are significantly correlated with asset growth. Interesting however, the hiring rate is still a significant predictor of returns after controlling for asset growth. But the asset growth characteristic seems to drive out the investment rate factor.

[Insert Table VI here]

Specifications two to four in Table VI, Panel A report the full sample results when the net stock issues, positive accruals and positive profitability are included separately. The estimated slope coefficients associated with these variables produces the sign previously documented in the literature. High net stock issues and accruals are associated with low future returns, whereas high values of profitability are associated with high future returns. Impressively, both the investment and the hiring rate maintain its predictive power when each anomaly variable is included, despite the decrease in the magnitude of the associated investment and hiring rate slope coefficients. Only when all anomalies variables are included together (last specification) the investment and hiring rate loose their marginal predictive power. This result is not surprising given the well decomunented predictive power for stock returns of all these anomaly variables.

D   Portfolio Approach

We now turn to a portfolio approach to investigate the predictive content of the investment and the hiring rate for stock returns. We examine the characteristics of nine portfolios double sorted on hiring and investment rates. In constructing these portfolios, we follow Fama and French (1993). In each June of year t, we first sort the universe of common stocks into three portfolios based on the firm's hiring rate (cutoffs at the 33th and 66th percentile) at the end of year t-1. Then, each one of these three hiring portfolios are then equally sorted into three portfolios based on their investment rate (cutoffs at the 33th and 66th percentile) at the end of year $t-1$. Once the portfolios are formed, their value and equally weighted returns are tracked from July of year t to June of year t+1. The procedure is repeated in June of year t+1. For tractability, we only study portfolios using the whole sample of firms and do not investigate the variation across groups of firms as we did in the previous section.

[Insert Table VII here]

Table VII reports mean characteristics for each portfolio. Except for returns, all characteristics are measured at the time of the portfolio formation. Consistent with the results from the FMB regressions, the value weighted and the equally weighted average excess returns are decreasing in both the investment and hiring rates. The sorting procedure generates an impressive spread in the average excess returns of these portfolios. For example, the low investment rate-low hiring rate portfolio (low-low) has a value weighted excess return of 8.37% in the data whereas the high

13

investment rate-high hiring rate portfolio (high-high) has a value weighted excess return of only 1.32% (a difference of 7.05% per year). This difference is even more impressive for equally weighted returns (9.7% per year). The characteristics of these portfolios also reveal that the book-to-market ratio (BM) is significantly negatively correlated with the average investment and hiring rates of these portfolios whereas and Asset Growth (AG) are positively correlated with the average investment and hiring rates. These variables have been found to be strong predictors of future returns by previous research (see, for example, the summary provided in Fama and French, 2008) and thus the large spread in the returns of these portfolios is consistent with these previous findings.

In order to investigate if the spread in the average returns across these portfolios reflects a compensation for risk (at least as measured by standard risk factors), we conduct time series asset pricing tests using the CAPM and the Fama French (1993) model as the benchmark asset pricing models. In testing the CAPM, we run time series regressions of the excess returns of these portfolios on the market excess return portfolio while in testing the Fama-French three factor model we run time series regressions of the excess returns of these portfolios on the market excess return portfolio (Market), the SMB and the HML factors. We then examine the alphas (intercepts) of these regressions which are a measure of abnormal return. If the spread in the average returns of these portfolios is indeed a compensation for risk, then the alpha of these portfolios should be jointly zero. We test this prediction by the Gibbons, Ross and Shanken (Gibbons, Ross and Shanken ,1989) GRS test of the hypothesis that the alphas are jointly zero.

[Insert Table VIII here]

Table VIII, Panel A reports the asset pricing test results for the CAPM and for the Fama French (1993) model using both equally weighted and the value weighted portfolios and for the whole sample period. The CAPM is clearly rejected on both the equally weighted and value weighted portfolios by the GRS test (p-val of 0.00% and p-val of 5.03% respectively). The reason for this rejection follows from the fact that the spread in the unconditional CAPM market beta across these portfolios is too small relative to the spread in the average excess returns. Thus the model generates large statistically significant alphas for some portfolios, especially for the high-high portfolio. The returns on this portfolio clearly represent a puzzle for the CAPM. This portfolio behaves as a risky stock as measured by its high market beta but the realized average returns on this portfolio are very small. The poor fit of the CAPM on these portfolios can also be seen in the top panel in Figure 2, which plots the realized versus the predicted excess returns implied by the estimation of the CAPM on these portfolios. The straight line in each panel is the 45° line, along which all the assets should lie. The deviations from this line are the alphas (pricing errors). As a result of the low spread in betas, most portfolios lie along a vertical line and the high-high portfolio (portfolio 33 in the picture) is a clear outlier.

[Insert Figure 2 here]

The test results for the Fama French (1993) asset pricing model presented in Table VIII are better. The model is rejected in equally weighted portfolios by the GRS test (p-val of 0.01%) but

it's not rejected on value weighted portfolio (p-val of 37.1%).[10]As in the CAPM, the returns on the high-high equally weighted portfolio represent a puzzle for the Fama French model. This portfolio behaves as a risky-value stock as measured by its high market and HML beta but the realized average returns on this portfolio are too small even considering its low (negative) SMB beta. The relative better fit of the Fama French model on these portfolios and the difficulty in pricing the high-high portfolio (portfolio 33) can also be seen in the plot of the pricing errors from this model presented in the right panel of Figure 2. In this picture, most portfolios lie along the 45° degree line and the high-high portfolio is again an outlier. These results are robust. We obtain qualitatively similar conclusions when the Carhart (1997) momentum factor is included, when we examine an asset pricing model that includes a factor mimicking portfolio of the aggregate unemployment rate (following the evidence presented in Boyd, Hu and Jagannathan (2005)), the aggregate labor income growth factor (following the evidence presented in Jagannathan and Wang (1996)), or when the returns of these portfolios are measured net of the return on a matching portfolio formed on size and book-to-market equity (the portfolio adjusted average returns are similar to the intercepts on the three Fama-French factors time series regressions).

Taken together, the unconditional asset pricing test results presented in this section are consistent with the hypothesis that the firm betas are time varying. The unconditional CAPM beta is unable to capture the variation in the returns on these portfolios. The Fama French model is more successful at capturing the variation in the returns across these portfolios, but the model still leaves the returns on the high-high portfolio as a puzzle to be explained.

II   The Theoretical Link Between Hiring, Investment and Stock Returns

In this section we propose a production-based asset pricing model that links the firm's hiring and investment rates to the firm's stock return. The purpose of the model is to provide a theoretical justification for the use of the investment and hiring rate as predictors of stock returns and to understand the economic driving forces that underlie the empirical evidence presented in the previous section. We show that the firm's hiring and investment rate are proxies for the firm's conditional beta. As a test of the story proposed by our model, in section III we provide a simulation of the model and verify that the model can replicate the empirical facts well.

A   Model

We consider an economy composed of a large number of firms that produce an homogeneous good. Here, we consider the production decision problem of one firm in this economy. This firm uses capital k_t and labor n_t to produce output y_t and is subject to adjustment costs when changing

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[10]We not that the non rejection of the Fama-French model on value weighted portfolios is not robust across periods. In a sub-sample from 1975 to 2006, the Fama-French model is rejected on both equally weighted and value weighted portfolios. In this sub-sample, the misspricing of the high-high portfolio is even more pronounced than in the full sample (alpha of the high-high portfolios is statistically significant). Results are available upon request.

these inputs along the lines of Merz and Yashiv (2007). The firm is competitive and takes as given the market-determined stochastic discount factor M_{t+1} used to value the cash-flows arriving in period $t+1$, the stochastic wage rate W_{t+1} and the stochastic firm level productivity $e^{x_t+z_t}$, where x_t is an aggregate shock and z_t is a firm specific shock.[11] These stochastic variables are assumed to be correlated but we postpone the specification of the stochastic processes of these variables to the simulation of the model section (section III) since the exact specification does not play a direct role on the results in this section.

Define the vector of state variables as $s_t = (k_t, n_t, W_t, M_t, x_t, z_t)$ and let $V^{\text{cum}}(s_t)$ be the cum dividend contingent claim value of the firm in period t. The firm makes investment i_t and hiring h_t decisions in order to maximize the cum dividend present value of the firm by solving the problem

$$V^{\text{cum}}(s_t) = \max_{i_{t+j}, h_{t+j}, j=1..\infty} \mathbb{E}_t \left[\sum_{j=0}^{\infty} M_{t,t+j+1} d_{t+j} \right] \tag{1}$$

subject to the constraints,

$$d_t = y_t - W_t n_t - i_t - g(i_t, h_t, k_t, n_t) - f \tag{2}$$

$$y_t = e^{x_t+z_t} f(k_t, n_t) \tag{3}$$

$$n_{t+1} = (1 - \delta_k) n_t + h_t \tag{4}$$

$$k_{t+1} = (1 - \delta_n) k_t + i_t \tag{5}$$

$$k_0, n_0 \text{ given}$$

for all dates t and where we use $\mathbb{E}_t[.]$ to represent the expectation over all states of nature given all the information available at time t. We focus on an all-equity financed firm and therefore we model the dividends d_t in (2) as consisting of output y_t, less the wage bill $W_t n_t$, investment i_t, adjustment costs of investment and hiring which are summarized by the function $g(i_t, h_t, k_t, n_t)$, and a fixed cost of production f. A negative dividend is considered as equity issuance. Total output is given by (3) where $f(k_t, n_t)$ is a standard production function that is increasing and concave in both arguments. The law of motion for the capital and labor stock in (5) and (4) has a standard form except that the stock of labor is assumed to decline at an exogenous separation or 'attrition' rate of δ_n, as in Shapiro (1984). The capital stock is assumed to depreciate at a rate of δ_k. As in Merz and Yashiv (2007), the adjustment cost function $g(i_t, h_t, k_t, n_t)$ is homogeneous of degree one in its arguments and is increasing and convex in the investment and hiring rate and decreasing and convex in the capital and labor stock.

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[11]The existence of a strictly positive stochastic discount factor is guaranteed by a well-known existence theorem if there are no arbitrage opportunities in the market (see for example, Cochrane (2001), chapter 4.2).

A.1 Decomposition of Firm's Market Value and Stock Return

The first order conditions for the firms' maximization problem are given by

$$1 + g_{it} = \mathbb{E}_t \left[M_{t,t+1} \left(y_{kt+1} + (1 - \delta_k) - g_{kt+1} + (1 - \delta_k) g_{it+1} \right) \right] \qquad (6)$$

$$g_{ht} = \mathbb{E}_t \left[M_{t,t+1} \left(y_{nt+1} - W_{t+1} - g_{nt+1} + (1 - \delta_n) g_{ht+1} \right) \right] \qquad (7)$$

where we use the notation g_{it} to denote the first partial derivative of the function g with respect to the variable i, and similarly for the other variables. The first order conditions (6) and (7) establishes a link between the exogenous stochastic discount factor, the exogenous wage rate and the firms' investment and hiring decisions. The left hand sides of these equations are the marginal cost of investment and the marginal cost of hiring, respectively. The right sides of these equations are the risk adjusted discounted marginal benefit of investment and hiring, respectively. At the optimum, the firm chooses a level of investment and hiring such that the marginal costs and the marginal benefits are equalized.

To simplify the notation, define q_t^k and q_t^n as the marginal costs of investment and hiring (the investment marginal q and the hiring marginal q), respectively:

$$q_t^k \equiv 1 + g_{it} \qquad (8)$$

$$q_t^n \equiv g_{ht} \qquad (9)$$

To facilitate the exposition, we will assume for now that the production function $f(.)$ has constant returns to scale (CRS) and we set the fixed costs of production to zero. Even though we will assume decreasing returns to scale and positive fixed costs of production in the simulation section of the model, these additional assumptions allows us to establish a link between the firm's value, the firm's stock return and the firm's investment and hiring rates in closed form. Following Merz and Yashiv (2007), we show in Proposition 1 that in this setup, the market value of the firm reflects the market value of the two inputs (capital and labor) used in the production of the firm's output. This result is simply an extension of Hayashi's (1981) result to a multi factor inputs setting.

Proposition 1 (Merz and Yashiv (2007), Hayashi (1981)) *When the firm's production and adjustment cost functions are both homogeneous of degree one (constant returns to scale) and fixed costs of production are zero, the ex dividend market value of the firm V_t^{ex} equals the sum of the market value of capital and market value of labor*

$$V_t^{ex} = \underbrace{q_t^k k_{t+1}}_{Market\ value\ of\ capital} + \underbrace{q_t^n n_{t+1}}_{Market\ value\ of\ labor},$$

where $q_t^k \equiv 1 + g_{it}$ and $q_t^n \equiv g_{ht}$ are the marginal costs of investment and hiring respectively.

Proof. See A-2. ∎

Intuitively, Proposition 1 states that the factor inputs are valued at their replacement costs, which in our setup are given by the marginal cost of investment and hiring (q_t^k and q_t^n). Because of the existence of labor adjustment costs, the marginal cost of hiring is typically non-zero, and thus a component of the market value of the firm is attributed to labor. This result is in sharp contrast with the results from standard q theory with no adjustment costs in labor ($q_t^n \equiv 0$), in which the market value of the firm only reflects the value of the firms' stock of capital.

The decomposition of the market value of the firm can be extended to establish a link between between the firm's stock return and the firm's investment and hiring rates, as stated in Proposition 2. To make the link more transparent, we proceed by specifying a functional form for the adjustment cost function. The results in this section hold for any homogeneous of degree one production and adjustment cost function. The functional form for adjustment costs function that we explore in this paper is

$$g(i_t, h_t, k_t, n_t) = \frac{c_i}{2} \left(\frac{i_t}{k_t}\right)^2 k_t + \frac{c_h}{2} \left(\frac{h_t}{n_t}\right)^2 n_t \tag{10}$$

where c_i and c_h are constants. This specification is the natural generalization of the quadratic investment adjustment cost specification popular in the q-theory of investment literature.[12]

Proposition 2 *When the firm's production and adjustment cost functions are both homogeneous of degree one (constant returns to scale) and fixed costs of production are zero, the firm's stock return is given by*

$$R_{t+1}^s = \frac{q_{t+1}^k k_{t+2} + q_{t+1}^n n_{t+2} + d_{t+1}}{(1 + c_i \frac{i_t}{k_t})k_{t+1} + c_h \frac{h_t}{n_t} n_{t+1}} \tag{11}$$

where $q_t^k \equiv 1 + c_i \frac{i_t}{k_t}$ and $q_t^n \equiv c_h \frac{h_t}{n_t}$ are the marginal costs of investment and hiring respectively. The expected stock market return can then be expressed as

$$\mathbb{E}_t \left[R_{t+1}^s \right] = \frac{\mathbb{E}_t \left[q_{t+1}^k k_{t+2} + q_{t+1}^n n_{t+2} + d_{t+1} \right]}{(1 + c_i \frac{i_t}{k_t})k_{t+1} + c_h \frac{h_t}{n_t} n_{t+1}} \tag{12}$$

Proof. Equation (11) follows directly from the defintion of stock return $R_{t+1}^s = \frac{V_{t+1}^{\text{ex}} + d_{t+1}}{V_t^{\text{ex}}}$ and from Proposition 1, $V_t^{\text{ex}} = q_t^k k_{t+1} + q_t^n n_{t+1}$. To go from (11) to (12) we use the fact that (11) holds ex post state by state and thus it also holds ex ante in expectation. ∎

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[12]This specification differs from Merz and Yashiv (2007) who allow adjustment costs to hiring and investment to interact in order to capture the idea that simultaneous hiring and investment is less costly than sequential hiring and investment of the same magnitude because simultaneous action by the firm is less disruptive to production than sequential action. For tractability, we omit the interaction term from our exposition since, for reasonable calibrations, the interaction term does not change the qualitative implications of the model for the link between stock return predictability and the firm investment and hiring rates that we explore in this paper.

A.2 The Link Between the Firm's Investment Rate, Hiring Rate and Conditional Beta

Proposition 2 shows that characteristics are sufficient statistics for expected returns since the marginal costs of investment and hiring as well as the firms' dividends are a function of firm characteristics only. This interesting result is familiar from the investment-based asset pricing models of Cochrane (1991 and 1996), Liu, Whited and Zhang (2007) and Li, Livdan and Zhang (2008) for example. To understand the link between characteristics, firm beta and expected stock returns, we follow Cochrane (2005, p.14-16) and Chen and Zhang (2007) and re-write equation (12) in beta-pricing form:

$$\mathbb{E}_t\left[R^s_{t+1}\right] = R^f_t + \beta_t \lambda_{mt} \tag{13}$$

where $q^k_t \equiv 1 + c_i \frac{i_t}{k_t}$, $q^n_t \equiv c_h \frac{h_t}{n_t}$, R^f_t is the risk-free rate, $\beta_t \equiv -\text{Cov}_t\left(R^s_{t+1}, M_{t+1}\right)/\text{Var}(M_{t+1})$ is the amount of risk, and the price of risk is given by $\lambda_{mt} \equiv \text{Var}(M_{t+1})/\mathbb{E}_t\left[M_{t+1}\right]$. Combining equations (12) and (13) yields

$$\beta_t = \left(\frac{\mathbb{E}_t\left[q^k_{t+1}k_{t+2} + q^n_{t+1}n_{t+2} + d_{t+1}\right]}{(1 + c_i \frac{i_t}{k_t})k_{t+1} + c_h \frac{h_t}{n_t}n_{t+1}} - R^f_t\right)/\lambda_{mt} \tag{14}$$

which trivially links the firm's conditional beta to firm characteristics. This result shows that a characteristic-based interpretation and a risk-based interpretation of expected returns are in fact the two sides of the same coin, as discussed extensively in Liu, Whited and Zhang (2007) and Chen and Zhang (2007), for example. In particular, characteristics can be seen as proxies for the firm's conditional beta (a risk-based explanation). In empirical work however, characteristics-based models are likely to outperform covariance-based models. As discussed in Chen and Zhang (2007), this observation follows naturally from the fact that in a world with time varying betas, characteristics are more precisely measured than covariances, an observation that Gomes, Kogan and Zhang (2003) confirm in simulated data. Thus the use of firm level characteristics such as the investment and the hiring rate is supported theoretically by the fact that these characteristics are proxies for firm's time varying conditional beta.

III Model Predictions from a Simulation Economy

The firm's stock return decomposition established in Propositon 2 can be used to understand the driving forces behind expected stock returns. By providing a link between firm level investment, hiring and stock returns, Proposition 2 allows us to to interpret the facts in the data. The analysis of this relationship is complicated however, because the investment and hiring rate are endogenous variables in the model. Thus a simple differentiation analysis of the firm's equilibrium stock return decomposition (12) with respect to the investment and hiring rate is not an appropriate procedure to evaluate the model implied relationship between stock returns and investment and hiring rates. To address this question, we create artificial data by simulating the theoretical model and investigate

the quantitative implications concerning the cross section of returns. We simulate 100 samples, each with 3600 firms and 50 annual observations. The empirical procedure on each artificial sample is implemented and the cross-simulation results are reported. We also replicate the portfolio approach by constructing nine double-sorted portfolios sorted on investment and hiring rate and examine if the model can replicate the failures of the CAPM and the better fit of the Fama French (1993) model. Appendix A-3 provides a detailed description of the solution algorithm and the numerical implementation of the model.

A   Stochastic Processes and Functional Forms

Production requires two inputs, capital, k, and labor, l, and is subject to both an aggregate shock, x, and an idiosyncratic shock, z. The aggregate productivity shock has a stationary and monotone Markov transition function, denoted by $Q_x(x_{t+1}|x_t)$, and follows the following process:

$$x_{t+1} = \bar{x}(1 - \rho_x) + \rho_x x_t + \sigma_x \varepsilon_{t+1}^x, \tag{15}$$

where ε_{t+1}^x is an IID standard normal shock. The idiosyncratic productivity shocks, denoted by $z_{j,t}$, are uncorrelated across firms, which we index by j, and have a common stationary and monotone Markov transition function, denoted by $Q_z(z_{j,t+1}|z_{j,t})$, and follows the following process:

$$z_{j,t+1} = \rho_z z_{j,t} + \sigma_z \varepsilon_{j,t+1}^z, \tag{16}$$

where $\varepsilon_{j,t+1}^z$ is an IID standard normal shock and $\varepsilon_{j,t+1}^z$ and $\varepsilon_{i,t+1}^z$ for any pair (i, j) with $i \neq j$. Moreover, ε_{t+1}^x is independent of $\varepsilon_{j,t+1}^z$ for all j. In the model, the aggregate productivity shock is the driving force of economic fluctuations and systematic risk, and the idiosyncratic productivity shock is the driving force of the cross-sectional heterogeneity of firms.

The production function is decreasing returns to scale:

$$y_t = e^{x_t + z_{j,t}} k_t^{\alpha_k} n_t^{\alpha_n}, \tag{17}$$

where y_t is output.

Following Berk, Green and Naik (1999) and Zhang (2005), we directly specify the pricing kernel without explicitly modeling the consumer's problem. The pricing kernel is given by

$$\log M_{t,t+1} = \log \beta + \gamma_t(x_t - x_{t+1}) \tag{18}$$

$$\gamma_t = \gamma_0 + \gamma_1(x_t - \bar{x}), \tag{19}$$

where $M_{t,t+1}$ denotes the stochastic discount factor from time t to $t+1$. The parameters $\{\beta, \gamma_0, \gamma_1\}$ are constants satisfying $1 > \beta > 0$, $\gamma_0 > 0$ and $\gamma_1 < 0$.

Equation (18) can be motivated as a reduced-form representation of the intertemporal marginal rate of substitution for a fictitious representative consumer or the equilibrium marginal rate of transformation as in Cochrane (1993) and Belo (2008). Following Zhang (2005), we assume in

20

equation (19) that γ_t is time varying and decreases in the demeaned aggregate productivity shock $x_t - \bar{x}$ to capture the countercyclical price of risk with $\gamma_1 < 0$.[13]

The equilibrium wage rate W_t is assumed to be an increasing function of the aggregate shock x_t

$$W_t = w \exp(x_t). \tag{20}$$

with $w > 0$.

B Calibration

We calibrate parameters at annual frequency based on existing empirical evidence as well as by matching known aggregate asset pricing facts. Table IX presents these parameters. The first set of parameters specifies the technology of the firm. The second set of parameters describes the exogenous stochastic processes that the firm faces. The first three parameters are relatively uncontroversial and we set them according to exiting empirical estimates. We set the capital intensity parameter to $\alpha_k = 0.3$ and the labor intensity parameter to $\alpha_n = 0.65$ in the Cobb-Douglas production function (17), which are close to the labor share parameters specified in Gomes(2001) for a CRS technology. The capital depreciation δ_k to be 10% a year as in Jermann (1998), and the labor force attrition to be 32% equivalent to Merz and Yashiv's (2007) 8% quarterly separation rate and consistent with the estimate of labor flows in Burgess Lane and Stevens (2000). We set the persistence of aggregate productivity shock $\rho_x = 0.95^4$ and conditional volatility $\sigma_x = 0.007 \times 2$, which corresponds to the quarterly estimates in Cooley and Prescott (1995). The long-run average level of aggregate productivity, $\bar{x}$, is a scaling variable. Following Zhang (2005), we set the average long-run capital in the economy at one, which implies that the long-run average of aggregate productivity $\bar{x} = -1.93$. To calibrate persistence ρ_z and conditional volatility σ_z of firm-specific productivity, we follow Gomes (2001) and Zhang (2005) and restrict these two parameters using their implications on the degree of dispersion in the cross-sectional distribution of firms' stock return volatilities. Thus $\rho_z = 0.70$, and $\sigma_z = 0.30$, which implies an average annual volatility of individual stock returns of 24.4%, approximately the average of 25% reported by Campbell at al (2001) and 32% reported by Vuolteenaho (2001).

Following Zhang (2005), we pin down the three parameters governing the stochastic discount factor, β, γ_0, and γ_1 to match three aggregate return moments: the average real interest rate, the volatility of the real interest rate, and the average annual Sharpe ratio. This procedure yields $\beta = 0.94$, $\gamma_0 = 28$, and $\gamma_1 = -300$, which generate an average annual real interest rate of 1.20%, an annual volatility of real interest rate of 5.8%, an average annual Sharpe ratio of the model is 0.33.

The rest of the parameters are not so straightforward to choose. In particular, the cost of adjustment parameters are very controversial. Estimates in the investment literature range from 20 in Summers (1980), to 2 in Whited (1993) to not significantly different from 0 in Hall (2001). The

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[13]The precise economic mechanism driving the countercyclical price of risk is, e.g., time-varying risk aversion as in Campbell and Cochrane (1999).

costs of adjusting labor are also controversial. Most of the literature assumes they are insignificant, while direct estimates suggests they can be substantial (Hamermesh (1993) and Merz and Yashiv (2007)). We therefore set the adjustment cost parameters by calibrating the model to be consistent with recent estimates of labor and capital adjustment cost functions (Merz and Yashiv (2007)) and with features of the US financial markets. In particular we look for parameters that are consistent with a 5-8% equity premium. Specifically, we set the parameter $c_k = 4$ which in the middle of the range of emprical estimates, and we set $c_n = 0.8$ since Merz and Yashiv estimated that c_k is about four to six times bigger than c_n.We estimate the parameter w in the wage process W_t to be 0.20. In order to gurrentee that firms market value of equity is increasing in labor in the state space, we set $w = 0.15$. And the fixed cost of production is set at $f = 0.03$ by matching the average book-to-maket ratio.

Table X reports the unconditional moments of well known moments from the simulated and the real data. The model matches quantitatively the mean and volatility of the risk free rate, the risk-premium and the average gross investment and net hiring rates in the data. The sharpe ratio implied by the model is slightly higher than the Sharpe ratio in the data and the average book to market is slighlty lower. The major difficulty of the model is in replicating the volatility of the investment and hiring rates which are too low in the model. In addition, the model generates a correlation between then investment and hiring rate that is too high relative to the correlation in the data.

C   Properties of the Model Solutions

C.1   The Value Function and Policy Functions

Using the numerical solution to the benchmark model, we plot and discuss the value and policy functions as functions of the underlying state variables. Because there are four state variables (capital stock k_t, labor stock n_t, the aggregate productivity shock x_t, and idiosyncratic productivity shock z_t), and the focus of the paper is the cross-sectional variations, we fix the aggregate productivity shock at its long-run average, $x_t = \bar{x}$. Figure 3, Panels A and C plot the variables against k_t and z_t, with n_t and x_t fixed at their long-run average levels $\bar{n}$ and $\bar{x}$. Panels B and D in Figure 3 plot the variables against n_t and z_t, with k_t and x_t fixed at their long-run average level $\bar{k}$ and $\bar{x}$. Each one of these panels has a set of curves corresponding to different values of z_t, and the arrow in each panel indicates the direction along which z_t increases.

[Insert Figure 3 here]

In Panels A and B in Figure 3, the firm's *cum*-dividend market value of equity is increasing in the firm-specific productivity, the capital stock and the labor stock. In Figure 3, Panels C and D, the optimal investment and hire are increasing in the firm-specific productivity. This indicates that the more profitable firms with higher firm-specific productivity invest and hire more than less profitable firms with lower firm-specific productivity. This finding is consistent with the evidence

documented by Fama and French (1995). In Figure 3, Panels C and D, the optimal investment rates and hire rates are decreasing in capital stocks and labor stock, respectively. Small firms with less capital invest and hire more and grow faster than big firms with more capital and more labor. That prediction is consistent with the evidence provided by Evans (1987) and Hall (1987).

C.2 Fundamental Determinants of Risk

We find that risk, measured as β_t from equation (14), is decreasing in the three firm-specific state variables: the capital stock, the labor stock and the firm-specific productivity. Using the benchmark parametrization, Panels E and F of Figure 3 plot β_t against physical capital, k_t, and labor stock, n_t, and firm-specific productivity, z_t, with the aggregate productivity fixed at its long-run averages, $x_t = \bar{x}$. Doing so allows us to focus on the cross-sectional variation of risk. Panels E and F plot β_t in four curves, each of which corresponds to one value of firm-specific productivity, z_t. The arrow in the panels indicates the direction along which z_t increases. Small firms with less capital and less labor are more risky than big firms with more capital and more labor. That is consistent with Li, Livdan and Zhang (2007). Consistent with Zhang (2005), less profitable firms are riskier than more profitable firms

D Can the Model Replicate the Empirical Findings?

D.1 Stock Return Predictability and Hiring and Investment Rates

The main empirical fact established in this paper is that the current hiring rate, in addition to the current investment rate, is negatively correlated with future stock returns. The model can replicate the negative slope of the FMB coefficients remarkably well. Figure 4, Panels A and B plot the histogram of the estimated FMB slope coefficients associated with the investment rate and the hiring rate respectively, and Figure 4 Panel C plot the joint histogram of the investment and hiring rate slope coefficients. As the figures shows, the empirical FMB slope coefficients are well inside the distribution of the FMB slope coefficients generated by the model. The estimated average slopes in the simulated model are thus close to the empirical estimates. For the investment rate, the simulated average FMB slope is -0.85 which is slighlty higher than the empirical slope of -0.45. For the hiring rate the fit is better. The simulated average FMB slope is -0.56 which is virtually identical to the empirical slope of -0.57.

[Insert Figure 4 here]

D.2 Stock Return Predictability Across Firms With Different Technologies

In the data, future stock returns of capital intensive firms are more sensitive to variations in the investment rate than to variations in the hiring rate and the opposite was true for labor intensive firms. In addition, there is substantial variation in the predictive power of the investment and hiring rate across industries. We use the model to explore two potential explanations for this pattern. The first explanation is based on differences in the labor intensity parameter in the production function

across firms. The second explanation is based on differences in the magnitude of the capital and labor adjustment costs parameters across firms.

To examine the impact of differences in the labor intensity parameter on the FMB investment and hiring rate slope coefficients in our simulation economy, we solve the model with a labor intensity parameter of $\alpha = 0.4$ and $\alpha = 0.2$ (in the benchmark case the labor intensity parameter is $\alpha = 0.65$). For each labor intensity parameter we simulate an identical sequence of aggregate and firm specific productivity shocks in order to produce artificial firm level time series of investment, hiring, and stock returns that are comparable across specifications. We do not find systematic differences in the model implied FMB slope coefficients relative to the benchmark model across these different specifications in our current results (results not reported here but available upon request). Thus the difference in the labor intensity parameter per se (at least for the intermediate cases of the labor intensity parameter considered here) does not seem to be sufficient to generate the pattern of the FMB slope coefficients across capital intensity firms nor across industries that is observed in the data. This result is consistent with the findings in Xing (2008) who finds that expected changes in the marginal product of capital do not generate enough predictability in the cross section. Here, the labor intensity parameter is basically changing the expected marginal product of labor and capital, and we confirm that changes in these variables do not generate enough cross sectional predictability as well. Thus this analysis suggest that changes in the cash flow process do not seem to be the driving force in the cross sectional predictability.

To examine the impact of the adjustment cost parameters on the FMB investment and hiring rate slope coefficients in our simulation economy, we switch the capital and labor adjustment costs parameters relative to the benchmark calibration. Thus we consider $c_i = 0.8$ and $c_h = 4$ (in the benchmark case these parameters are $c_i = 4$ and $c_h = 0.8$). The results are reported in Figure 5, Panel A, which we refer to the high relative labor adjustment cost specification. Clearly, the decrease in the magnitude of the capital adjustment cost parameter leads to a decrease in the investment rate FMB slope coefficients (-0.85 in the benchmark case to -0.12 in this case). Similarly, the increase in the magnitude of the labor adjustment cost parameter leads to an increase in the hiring rate FMB slope coefficient (-0.56 in the benchmark case to -0.7 in this case.).

[Insert Figure 5 here]

The previous findings allows us to interpret the pattern of stock return predictability across technologies presented in Tables V and IV as resulting from differences in the magnitude of the capital and labor adjustment costs across firms. From this perspective, this analysis suggests that the hiring rate is not a significant predictor of stock return across capital intensive firms because labor adjustment costs are small in magnitude for these firms (the converse is true for labor intensive firms). Focusing on the full sample period results, the lack of predictive power of the investment rate (but the high predictive power of hiring) in the consumer goods sector suggests that capital adjustment costs are considerably smaller in magnitude (or non existent) relative to labor adjustment costs in this industry. In addition, the lack of predictive power of both the hiring rate and the investment rate in the health care and other sectors suggests that capital and labor

adjustment costs are small in these industries (at least in the initial sample period from 1965 to 1985).

D.3   Stock Return Predictability Over Time

In the data, the FMB slope coefficient associated with the hiring rate increases over time and the converse is true for the FMB slope coefficient associated with the investment rate, especially after the early 80's (see Figure 1). The discussion in the previous section suggests that this fact may be the result of changes in the capital and labor adjustment costs over time. From this perspective, the increase in the FMB slope coefficient associated with the hiring rate suggest that labor adjustment costs have increased after the early 80's, while a symmetric pattern has occured for capital adjustment costs.

D.4   Importance of Labor Adjustment Costs

In order to examine the importance of labor adjustment costs for generating stock return predictability from the firm's hiring rate, we simulate a version of the model in which labor adjustment costs are set to zero and labor is instantaneously adjusted every period (and not one period in advance as in the benchmark model) in response to the realization of the state of nature. Naturally, in this case, the fim hires labor until the marginal product of labor equals the wage rate. This is the standard neoclassical model and thus it constitutes a natural benchmark. Figure 5, Panel B, shows that the model with no adjustment costs in labor generates a FMB slope coefficient associated with the firm's hiring rate that is indistinguishable from zero. Thus we conclude that labor adjustment costs are essencial to replicate the empirical finding that both the investment and hiring rates are negatively associated with future stock returns.

[Insert Figure 5 here]

D.5   Portfolio Characteristics and Asset Pricing Tests

In this section we replicate the portfolio approach using the simulated data and we examine if the model can replicate the failure of the CAPM observed in the data as well as the relative better fit of the Fama French (1993) model. We construct the nine double sorted portfolios as in the real data (see Section D). Table XI reports the mean characteristics of the nine double sorted on investment and hiring rate portfolios. The portfolio procedure generates a pattern of average excess returns that is qualitatively similar to the pattern of average excess returns in the data (see Table VII). The value weighted and the equally weighted average excess returns are in general decreasing in both the investment and hiring rates. The sorting procedure also generates the negative relationship between the book-to-market ratio and the investment and hiring rates observed in the real data.

[Insert Table XI here]

In order to replicate the time series asset pricing tests using the CAPM and the Fama French three factor model, we construct the market excess return, the SMB and the HML factors in our simulated data. We then replicate the asset pricing tests of the empirical section on this simulated data. Table XII, Panel A reports the asset pricing test results for the CAPM and Table XII, Panel B reports the asset pricing test results for the Fama French (1993) model. The unconditional CAPM is clearly rejected on these portfolios by the GRS test (p-val of 0.00% in both equally-weighted and value-weighted portfolios). As in the real data, this rejection follows from the fact that the spread in the unconditional CAPM market beta across these portfolios is too small relative to the spread in the average excess returns. Thus the model generates large statistically significant alphas. The poor fit of the CAPM on these portfolios can also be seen in the plot of the pricing errors from this model presented in the left panel of Figure 6. As a result of the low spread in betas, most portfolios lie along a vertical line.

[Insert Table XII here]

The test results for the Fama French (1993) asset pricing model presented in Table XII are better, as in the real data. The model is rejected in the simulated data by the GRS test however (p-val of 0.00% in equally-weighted portfolios and 5.45% on value-weighted portfolios). This rejection is driven by the fact that the Fama-French model has some difficulties in pricing some portfolios, including the high-high portfolio that the model fails to correctly price in the real data. The relative better fit of the Fama French model on these portfolios can also be seen in the plot of the pricing errors from this model presented in the left panel of Figure 6. In this figure, there is a clear relationship between the predicted and the realized returns of these portfolios

[Insert Figure 6 here]

IV   Conclusion

We study empirically and theoretically the relationship between investment and hiring decisions and stock returns in a production-based asset pricing model with adjustment costs in both capital and labor. We find that hiring predicts stock returns in the cross-section of US publicly traded firms after controlling for other well documented return predictors such as investment, size, book-to-market, momentum, net stock issues, accruals, asset growth and profitability. A calibration of the model on US financial market data qualitatively replicates the cross-sectional facts observed in the data.

Although the evidence in this paper is consistent with a rational model with frictions in the adjustment of capital and labor, it of course does not rule out alternative explanations. For example, one can argue that the negative relationship between current hiring rate and stock returns is a result of systematic misspricing due to inefficient markets, in the spirit of Polk and Sapienza (2006) or Titman, Wei and Xie (2004). Studying alternative explanations for the empirical finding in this paper is an interesting topic for future research.

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APPENDIX

A-1   Data

Following Fama and French (1993), we define book value of equity as the COMPUSTAT book value of common equity (data item 60) plus balance-sheet deferred taxes (data item 74) and investment tax credits (data item 208), minus the book value of preferred stock. Depending on availability, we use the redemption (data item 56), liquidation (data item 10), or par value (data item 130) of preferred stock. When data item 60 is not available, the liquidation value of common equity (data item 235) is used. COMPUSTAT data item 128 is used for capital investment, i; the net book value of property, plant, and equipment (data item 8) is used for the capital, k; employees (data item 29) is used for labor stock, n. The monthly seasonal adjusted unemployment rate is from the Bureau of Labor Statistics (BLS) with a series ID of LNS14000000. We follow Hou and Robinson (2006) and Fama-French (2008) in defining the main variables that we use in our analysis:

LK: Labor-to-capital ratio, employees (31) in year t divides property, plant & equipment (8) in year t.

BM: Book-to-market equity, the ratio of the book value of equity to the market value of equity. Market equity is price times shares outstanding at the end of December of t, from CRSP.

SIZE: the price times shares outstanding at the end of June of year t, from CRSP.

Lev: leverage, book liabilities (total assets (6) minus book value of equity) in year t divides market value of firm (size plus total assets (6) minus book value of equity).

AG: Asset growth, the natural log of the ratio of assets per split-adjusted share at the fiscal yearend in t-1 divided by assets per split-adjusted share at the fiscal yearend in t-1. This is equivalent to the natural log of the ratio of gross assets at t-1 (6) divided by gross assets at t-1 minus net stock issues from t-1 to t.

YB: Profitability, equity income (income before extraordinary (18), minus dividends on preferred (19), if available, plus income statement deferred taxes (50), if available) in t divided by book equity for t.

The data for the three Fama-French factors (SMB, HML and Market excess returns), the six Fama-French factors and the risk-free rate is from Prof. Kenneth French's webpage. The three factors are: (i) the Market excess return on a value-weighted portfolio of NYSE, AMEX, and Nasdaq stocks minus the T-bill rate; (ii) SMB which is the return on the Small-minus-Big portfolio; and (iii) HML, which is the return on the High-minus-Low portfolio. The SMB and HML portfolios are based on the six Fama-French benchmark portfolios sorted by size (breakpoint at the median) and book-to-market equity (breakpoints at the 30th and 70th percentiles). The SMB return is the difference in average returns between three small and three big stock portfolios. The HML return

is the difference in average returns between two high and two low book-to-market portfolios. See Fama and French, 1993, "Common Risk Factors in the Returns on Stocks and Bonds," Journal of Financial Economics, for a complete description of these factor returns.

Labor share share data is from the Bureau of Economic Analysis (BEA) website, GDP-by-Industry accounts. The industry level data is available at the two digit Standard Industry Classification (SIC) code. Labor share is measured as the ratio of the total compensation to employees to the gross value added. Firm level labor shares are computed by matching the first two digits of the firm specific CRSP SIC code to the corresponding two-digit SIC code labor share data.

A-2   Proof of Proposition 1

Define the vector of state variables as $s_t = (k_t, n_t, W_t, x_t)$ where x_t is the current period firms' productivity shock, k_t is the firms current capital stock, n_t is the firms current labor stock and W_t is the current wage rate. The first-order-conditions for i_t, h_t, k_{t+1}, and n_{t+1} are

$$q_t^k = 1 + g_{it} \tag{1}$$

$$q_t^n = g_{ht} \tag{2}$$

$$q_t^k = \mathbb{E}_t M_{t,t+1}[e^{x_{t+1}+z_{t+1}} f_k(k_{t+1}, n_{t+1}) - g_{kt+1} + (1 - \delta_k)q_{t+1}^k] \tag{3}$$

$$q_t^n = \mathbb{E}_t M_{t,t+1}[e^{x_{t+1}+z_{t+1}} f_n(k_{t+1}, n_{t+1}) - g_{nt+1} - W_{t+1} + (1 - \delta_n)q_{t+1}^n] \tag{4}$$

Production function is constant-return-to-scale, so

$$e^{x_t+z_t} f(k_t, n_t) = e^{x_t+z_t} f_k(k_t, n_t)k_t + e^{x_t+z_t} f_n(k_t, n_t)n_t \tag{5}$$

Transversality conditions for k_{t+1+j} and n_{t+1+j} are

$$\lim_{j \to \infty} \mathbb{E}_t M_{t,t+j} q_{t+j}^k k_{t+j+1} = 0 \tag{6}$$

$$\lim_{j \to \infty} \mathbb{E}_t M_{t,t+j} q_{t+j}^n n_{u,t+j+1} = 0 \tag{7}$$

Firm's cum dividend market value is given by

$$V^{\mathrm{cum}}(s_t) = V_t^{\mathrm{ex}}(s_t) + d_t \tag{8}$$

With equation (2), we have

$$V^{\mathrm{cum}}(s_t) = V_t^{\mathrm{ex}}(s_t) + y_t - W_t n_t - i_t - g(i_t, k_t, h_t, n_t) \tag{9}$$

Since $g(i_t, k_t, h_t, n_t)$ is constant returns to scale in (i_t, k_t, h_t, n_t), we have

$$g(i_t, k_t, h_t, n_t) = g_{it} i_t + g_{kt} k_t + g_{ht} h_t + g_{nt} n_t \tag{10}$$

We can write the write the Lagrangian of the firms' maximization problem as

$$V^{\text{cum}}(s_t)$$

$$= \mathbb{E}_t \sum_{j=0}^{\infty} M_{t,t+j}\{[e^{x_{t+j}+z_{t+j}}f(k_{t+j}, n_{t+j}) - i_{t+j} - W_{t+j}n_{t+j} - g(i_{t+j}, k_{t+j}, h_{t+j}, n_{t+j})]$$

$$- q_{t+j}^k[k_{t+j+1} - (1-\delta_k)k_{t+j} - i_{t+j}]$$

$$- q_{t+j}^n[n_{t+j+1} - (1-\delta_n)n_{t+j} - h_{t+j}]\}$$

where q_t^k and q_t^n are the Lagrange multipliers associated with the constraints (5) and (4). Recursively substituting equations (5), (4), (5), (1)-(4) and (10), we get

$$V^{\text{cum}}(s_t)$$

$$= y_t - W_t n_t - g_{kt} k_t - g_{nt} n_t + q_t^k(1-\delta_k)k_t + q_t^n(1-\delta_n)n_t$$

$$- \lim_{j\to\infty} \mathbb{E}_t M_{t,t+j} q_{t+j}^k k_{t+j+1} - \lim_{j\to\infty} \mathbb{E}_t M_{t,t+j} q_{t+j}^n n_{t+j+1}$$

$$= y_t - W_t n_t - g_{kt} k_t - g_{nt} n_t + q_t^k(1-\delta_k)k_t + q_t^n(1-\delta_n)n_t$$

The last equality follows transversality conditions (6) and (7). Together with equation (9), we have

$$V_t^{\text{ex}}(s_t) + y_t - i_t - W_t n_t - g(i_t, k_t, h_t, n_t)$$

$$= y_t - W_t n_t - g_{kt} k_t - g_{nt} n_t + q_t^k(1-\delta_k)k_t + q_t^n(1-\delta_n)n_t$$

After re-arranging the previous equations using equations (1), (2) and (10), we get

$$V_t^{ex}(s_t) = q_t^k k_{t+1} + q_t^n n_{t+1} \tag{11}$$

Q.E.D.

A-3 Numerical Algorithm and Calibration

To solve the model numerically, we use the value function iteration procedure to solve the firm's maximization problem. The value function and the optimal decision rule are solved on a grid in a discrete state space. We specify a grid with 200 points each for the capital and labor, respectively with upper bounds $\bar{k}$, $\bar{n}$ (large enough to be nonbinding at all times). The grids for capital and labor stocks are constructed recursively, following McGrattan (1999), that is, $k_i = k_{i-1} + c_{k1} \exp(c_{k2}(i - 2))$, where i=1,...,200 is the index of grids points and c_{k1} and c_{k2} are two constants chosen to provide the desired number of grid points and two upper bounds $\bar{k}$, $\bar{n}$, given two pre-specified lower bounds $\underline{k}$, $\underline{n}$. The advantage of this recursive construction is that more grid points are assigned around $\bar{k}$, $\bar{n}$, where the value function has most of its curvature.

The state variable x is defined on continuous state space, which has to be transformed into

discrete state space. Because both aggregate and idiosyncratic productivity processes are highly persistent, we use the method described in Rouwenhorst (1995). The method of Tauchen and Hussey (1991) does not work well when persistence level is above 0.9. We use 5 grid points for the x process and 5 grid points for the z process. In all cases the results are robust to finer grids as well. Once the discrete state space is available, the conditional expectation can be carried out simply as a matrix multiplication. Linear interpolation is used extensively to obtain optimal investments which do not lie directly on the grid points. Finally, we use a simple discrete, global search routine in maximizing problems.

Table I
Summary Statistics of the Firm Level Investment and Hiring Rate

This table reports summary statistics of firm level investment rate (IK) and hiring rate (HN) as well the firm level book-to-market (BM) and the firm level asset growth rate (AG) for comparison. Panel A reports mean value across firms with at least ten observations of firm level characteristics: it reports the mean, median, standard deviation (std), autocorrelation (AC1) and the 20th, 60th and 80th percentile of the distribution of the firm level investment rate, hiring rate, book-to-market and asset growth as well as their correlations. Panel B reports mean values across time of the cross-sectional moments. It reports the cross-sectional mean, cross-sectional median, cross-sectional standard deviation (std), and the 20th, 60th and 80th percentile of the cross-sectional distribution of the firm level investment rate, hiring rate, book-to-market and asset growth as well as their correlations. The data are annual and the sample is July 1965 to June 2006.

					Percentile			Correlation		
	Mean	Median	std	AC1	20%	60%	80%	HN	BM	AG

Panel A: Mean across firms of firm level moments

	Mean	Median	std	AC1	20%	60%	80%	HN	BM	AG
IK	0.30	0.25	0.22	0.30	0.14	0.29	0.43	0.33	−0.17	0.44
HN	0.07	0.04	0.22	0.06	−0.07	0.08	0.19	1.00	−0.19	0.48
BM	0.98	0.87	0.54	0.52	0.56	0.99	1.35	−0.19	1.00	−0.16
AG	0.08	0.07	0.18	0.12	−0.04	0.11	0.20	0.48	−0.16	1.00

Panel B: Mean over time of cross-sectional moments

	Mean	Median	std		20%	60%	80%	HN	BM	AG
IK	0.32	0.23	0.33	−	0.12	0.27	0.43	0.38	−0.20	0.41
HN	0.09	0.03	0.30	−	−0.06	0.06	0.18	1.00	−0.15	0.46
BM	0.97	0.78	0.88	−	0.41	0.92	1.34	−0.15	1.00	−0.19
AG	0.08	0.07	0.23	−	−0.04	0.10	0.19	0.46	−0.19	1.00

Table II

Sample Summary Statistics

This table reports the mean values mean of selected variables across several groups of firms. Panel A reports values for our pooled sub-sample of COMPUSTAT firms as well as the descriptive statistics across all firms in our sample but excluding micro cap firms (All but Micro), which are defined as stocks with a market capitalization bellow the bottom 20th percentile of the NYSE cross-sectional market size distribution. Panel B reports values for firms grouped by the firms' labor to capital ratio (LK). Panel C reports values across firms grouped by industry classification. Mean Ret is the monthly average return in percentage, IK is investment rate measured as the capital expenditure scaled by the previous period capital stock, HN is the hiring rate measured as the net change in the employees scaled by the previous period number of employees, SIZE is the log of CRSP price times shares outstanding, BM is the ratio of book equity to market equity, MOM is momentum computed as the cumulative return from month j-12 to j-2 (updated monthly), AG is asset growth obtained as the change in the natural log of assets per split-adjusted share from t-2 to t-1, YB is a measure of profitability given by equity income in t-1 divided by book equity in t-1, LK is the labor to capital ratio measured as the ratio of the number of employees to the real stock of capital and LS is the labor share. The data are annual and the sample is July 1965 to June 2006.

	RET	IK	HN	BM	SIZE	MOM	AG	YB	LK	LS
					Panel A: Pooled Group					
All Firms	1.37	0.34	0.10	0.96	5.01	15.69	7.74	−0.27	10.59	0.64
All Firms but Micro	1.15	0.32	0.11	0.72	6.57	17.82	11.19	0.05	7.84	0.63
					Panel B: Capital Intensity Groups					
Capital Intensive	1.18	0.29	0.08	1.02	5.98	13.37	7.44	−1.04	0.69	0.51
Capital and Labor	1.42	0.33	0.09	0.94	5.04	15.99	7.87	−0.06	4.61	0.67
Labor Intensive	1.40	0.41	0.13	0.95	3.94	17.07	7.79	−0.15	38.55	0.69
					Panel C: Industry Groups					
Consumer	1.22	0.31	0.08	1.09	4.69	13.81	8.26	−0.01	10.71	0.64
Manufacturing	1.30	0.25	0.05	1.03	5.23	14.28	6.70	0.03	4.26	0.63
High-Tech	1.57	0.48	0.14	0.70	5.08	18.81	7.00	−1.22	7.91	0.64
Health	1.66	0.41	0.16	0.55	5.60	20.34	11.27	−0.21	7.52	0.68
Other	1.36	0.34	0.11	1.14	4.67	15.38	8.40	−0.13	26.75	0.65

Table III
Fama-MacBeth Cross-Sectional Regressions of Firm Level Monthly Returns

The table shows average slopes and their t-statistics from monthly cross-section regressions to predict stock returns for five empirical specifications which differ in the set of return predictos included and across two samples which differ in the set of firms included. The results in the left columns are obtained from a sample that includes All Firms and the results in the right columns are obtained from a sample that includes All Firms excluding Micro Cap firms (All Firms but Micro). Micro caps firms are defined as stocks with a market capitalization bellow the bottom 20th percentile of the NYSE cross-sectional market size distribution. The variables used to predict returns for July of t to June of t+1 are: the investment rate (IK), the hiring rate (HN), the natural log of market cap in June of t (Size, in millions), the natural log of the ratio of book equity for the last fiscal year end in t-1 divided by market equity in December of t-1 (BM), and momentum (Mom) for month j which is computed as the cumulative return from month j-12 to j-2. Panel A reports results for the whole sample period, Panel B reports result for the period July 1965 to June 1985 and Panel C reports results for the period July 1985 to June 2006. Int is the average regression intercept and the average regression R^2 is adjusted for degrees of freedom. The t-statistics (in parenthesis) for the average regression slopes use the time-series standard deviations of the monthly slopes (computed as in Newey-West with 4 lags). The data are monthly and the sample is July 1965 to June 2006.

| Panel A: Full Sample July 1965 to June 2006 | | | | | | | | | | | | | |
| All Firms | | | | | | | All Firms but Micro | | | | | | |
Int	IK	HN	SIZE	BM	MOM	R^2	Int	IK	HN	SIZE	BM	MOM	R^2
1.55	−0.66	−	−	−	−	0.6	1.33	−0.55	−	−	−	−	1.3
[6.0]	[−4.0]	−	−	−	−	−	[6.1]	[−2.5]	−	−	−	−	−
1.40	−	−0.77	−	−	−	0.3	1.22	−	−0.56	−	−	−	0.7
[5.01]	−	[−5.8]	−	−	−	−	[5.1]	−	[−3.2]	−	−	−	−
1.53	−0.45	−0.57	−	−	−	0.7	1.32	−0.38	−0.33	−	−	−	1.4
[5.90]	[−2.7]	[−5.0]	−	−	−	−	[5.9]	[−1.8]	[−2.6]	−	−	−	−
1.28	−0.31	−0.44	−0.13	0.20	0.79	3.8	0.83	−0.28	−0.26	−0.08	0.15	0.84	5.4
[2.7]	[−2.3]	[−4.4]	[−2.7]	[2.5]	[5.7]	−	[1.6]	[−1.6]	[−2.3]	[−2.0]	[1.9]	[4.4]	−
Panel B: July 1965 to June 1985													
1.53	−0.61	−	−	−	−	0.5	1.30	−0.53	−	−	−	−	0.9
[3.9]	[−2.3]	−	−	−	−	−	[3.8]	[−1.6]	−	−	−	−	−
1.37	−	−0.58	−	−	−	0.3	1.17	−	−0.46	−	−	−	0.5
[3.3]	−	[−2.9]	−	−	−	−	[3.2]	−	[−1.8]	−	−	−	−
1.51	−0.47	−0.39	−	−	−	0.6	1.29	−0.42	−0.24	−	−	−	1.1
[3.8]	[−1.9]	[−2.4]	−	−	−	−	[3.8]	[−1.7]	[−1.2]	−	−	−	−
1.17	−0.30	−0.23	−0.16	0.19	0.93	4.9	0.94	−0.25	−0.10	−0.16	0.18	1.07	6.0
[1.7]	[−1.6]	[−1.7]	[−2.5]	[1.7]	[4.1]	−	[1.2]	[−1.0]	[−0.5]	[−2.4]	[1.5]	[3.8]	−
Panel C: July 1985 to June 2006													
1.57	−0.72	−	−	−	−	0.6	1.36	−0.56	−	−	−	−	1.6
[4.6]	[−3.3]	−	−	−	−	−	[4.7]	[−1.9]	−	−	−	−	−
1.43	−	−0.96	−	−	−	0.3	1.26	−	−0.65	−	−	−	0.9
[3.9]	−	[−5.6]	−	−	−	−	[4.1]	−	[−2.8]	−	−	−	−
1.55	−0.42	−0.75	−	−	−	0.8	1.34	−0.35	−0.43	−	−	−	1.8
[4.6]	[−1.9]	[−4.7]	−	−	−	−	[4.7]	[−1.2]	[−2.7]	−	−	−	−
1.37	−0.31	−0.64	−0.10	0.20	0.67	2.8	0.73	−0.31	−0.42	−0.02	0.12	0.62	4.7
[2.1]	[−1.8]	[−4.6]	[−1.4]	[1.8]	[4.2]	−	[1.0]	[−1.4]	[−2.9]	[−0.30]	[1.20]	[2.5]	−

Table IV
Fama-MacBeth Cross-Sectional Regressions of Firm Level Monthly Returns Across Firms
With Different Capital and Labor Intensities

The table shows average slopes and their t-statistics (in parenthesis) from monthly cross-section regressions to predict stock returns across three groups of firms, created based on the firms' labor to capital ratio (LK). G1: Capital Intensive is composed of firms with a LK ratio below the 20th percentile of the cross-sectional LK distribution in a given year; G2: Capital and Labor is composed of firms that use both capital and labor and consists of firms that have a LK ratio between the 20th and the 80th percentile of the cross-sectional LK distribution; G3: Labor Intensive, is composed of firms that have a LK ratio on the top 20th percentile of the cross-sectional LK distribution. G1 minus G3 provides a t-test for the difference in the slope coefficients for G1: Capital Intensive and G3: Labor Intensive. The variables used to predict returns for July of year t to June of year t+1 are and the firm level investment rate (IK) and the firm level hiring rate (HN). Int is the average regression intercept. R^2 is the average cross-sectional R^2 regression adjusted for degrees of freedom. The t-statistics for the average regression slopes use the time-series standard deviations of the monthly slopes (computed as in Newey-West with 4 lags). The data are monthly and the sample is July 1965 to June 2006.

	Int	IK	HN	R^2
Panel A: Full Sample July 1965 to June 2006				
G1: Capital Intensive	1.39	−0.65	−0.18	1.57
	[5.82]	[−2.66]	[−0.92]	−
G2: Capital and Labor	1.56	−0.51	−0.57	0.75
	[6.02]	[−2.79]	[−3.97]	−
G3: Labor Intensive	1.60	−0.26	−0.90	0.57
	[4.81]	[−1.57]	[−4.66]	−
G1 minus G3	−0.20	−0.40	0.72	1.00
	[−0.96]	[−1.63]	[2.54]	−
Panel B: Sub-Sample July 1965 to June 1985				
G1: Capital Intensive	1.37	−0.49	−0.12	1.83
	[3.79]	[−1.25]	[−0.37]	−
G2: Capital and Labor	1.51	−0.60	−0.33	0.61
	[3.93]	[−2.43]	[−1.66]	−
G3: Labor Intensive	1.71	−0.36	−0.84	0.60
	[3.38]	[−1.40]	[−2.52]	−
G1 minus G3	−0.33	−0.13	0.72	1.22
	[−1.22]	[−0.35]	[1.42]	−
Panel C: Sub-Sample July 1985 to June 2006				
G1: Capital Intensive	1.41	−0.81	−0.24	1.32
	[4.49]	[−2.70]	[−1.02]	−
G2: Capital and Labor	1.61	−0.43	−0.80	0.89
	[4.60]	[−1.59]	[−3.98]	−
G3: Labor Intensive	1.49	−0.16	−0.96	0.53
	[3.44]	[−0.78]	[−4.72]	−
G1 minus G3	−0.08	−0.65	0.72	0.79
	[−0.24]	[−2.07]	[2.65]	−

Table V
Fama-MacBeth Cross-Sectional Regressions of Firm Level Monthly Returns Across Industries

The table shows average slopes and their t-statistics (in parenthesis) from monthly cross-section regressions to predict stock returns across five industries. The variables used to predict returns for July of t to June of t+1 are the firm level investment rate (IK) and the firm level hiring rate (HN). Int is the average regression intercept. R^2 is the average cross-sectional R^2 regression adjusted for degrees of freedom. The t-statistics for the average regression slopes use the time-series standard deviations of the monthly slopes (computed as in Newey-West with 4 lags). In the computation of the average slope coefficients, only cross-sectional regressions with at least 15 firms in a given industry are considered. The data are monthly and the sample is July 1965 to June 2006.

	Int	IK	HN	R^2
Panel A: Full Sample July 1965 to June 2006				
Consumer	1.41	−0.33	−0.44	0.80
	[5.27]	[−1.50]	[−2.31]	−
Manufacturing	1.45	−0.64	−0.35	0.79
	[5.95]	[−2.94]	[−2.23]	−
High-Tech	1.87	−0.74	−0.88	1.30
	[5.23]	[−2.94]	[−3.71]	−
Health	1.95	−0.94	−0.13	2.29
	[6.14]	[−1.56]	[−0.24]	−
Other	1.44	−0.22	−0.51	1.10
	[5.14]	[−1.01]	[−1.55]	−
Panel B: Sub-Sample July 1965 to June 1985				
Consumer	1.54	−0.28	−0.40	0.84
	[3.64]	[−0.77]	[−1.33]	−
Manufacturing	1.43	−0.64	−0.19	0.90
	[3.81]	[−1.96]	[−0.80]	−
High-Tech	1.84	−1.05	−0.81	1.67
	[3.70]	[−2.32]	[−2.01]	−
Health	1.76	−1.13	0.36	3.74
	[4.11]	[−0.95]	[0.37]	−
Other	1.52	0.07	−0.46	1.44
	[3.51]	[0.20]	[−0.73]	−
Panel C: Sub-Sample July 1985 to June 2006				
Consumer	1.30	−0.37	−0.47	0.75
	[3.87]	[−1.50]	[−2.03]	−
Manufacturing	1.48	−0.65	−0.50	0.68
	[4.68]	[−2.21]	[−2.51]	−
High-Tech	1.90	−0.45	−0.95	0.94
	[3.71]	[−1.94]	[−3.66]	−
Health	2.14	−0.75	−0.59	0.92
	[4.57]	[−2.87]	[−1.75]	−
Other	1.36	−0.51	−0.56	0.78
	[3.79]	[−2.10]	[−2.31]	−

Table VI
Fama-MacBeth Cross-Sectional Regressions of Firm Level Monthly Returns Across Several Anomalies

The table shows average slopes and their t-statistics (in parenthesis) from monthly cross-section regressions to predict stock returns for five empirical specifications. Each specification contains a different set of return predictors. The variables used to predict returns for July of t to June of t+1 are: the investment rate (IK), the hiring rate (HN), the natural log of market cap in June of t (Size, in millions), the natural log of the ratio of book equity for the last fiscal year end in t-1 divided by market equity in December of t-1 (BM), net stock issues (NS) computed as the change in the natural log of split-adjusted shares outstanding from the fiscal year end in t-2 to t-1, positive accruals (AcB) which is measured as the change in operating working capital per split-adjusted share from t-2 to t-1 divided by book equity per split-adjusted share in t-1 if the change is positive and zero otherwise, momentum (Mom) for month j which is computed as the cumulative return from month j-12 to j-2, growth in assets (AG) given by the change in the natural log of assets per split-adjusted share from t-2 to t-1, and positive profitability (YB$^+$) given by equity income in t-1 divided by book equity in t-1 if it is positive and zero otherwise. Int is the average regression intercept and the average regression R^2 is adjusted for degrees of freedom. The t-statistics (in parenthesis) for the average regression slopes use the time-series standard deviations of the monthly slopes (computed as in Newey-West with 4 lags). The data are monthly and the sample is July 1965 to June 2006.

Int	IK	HN	SIZE	BM	MOM	AG	NS	AcB$^+$	YB$^+$	R^2
1.23	−0.22	−0.28	−0.12	0.19	0.79	−0.58	–	–	–	3.94
[2.60]	[−1.46]	[−3.22]	[−2.56]	[2.47]	[5.73]	[−3.02]	–	–	–	–
1.32	−0.28	−0.30	−0.13	0.19	0.77	–	−1.36	–	–	3.95
[2.77]	[−2.14]	[−2.89]	[−2.70]	[2.41]	[5.59]	–	[−5.04]	–	–	–
1.33	−0.30	−0.42	−0.14	0.17	0.78	–	–	−0.29	–	3.92
[2.76]	[−2.25]	[−4.07]	[−2.80]	[2.15]	[5.68]	–	–	[−2.00]	–	–
1.26	−0.32	−0.46	−0.14	0.23	0.77	–	–	–	0.83	3.96
[2.56]	[−2.44]	[−4.55]	[−2.84]	[2.64]	[5.57]	–	–	–	[2.16]	–
1.31	−0.10	0.03	−0.13	0.20	0.73	−1.01	−1.84	−0.24	0.79	4.36
[2.72]	[−0.71]	[0.31]	[−2.81]	[2.23]	[5.35]	[−4.74]	[−6.59]	[−1.54]	[2.08]	–

Table VII
Portfolio Characteristics of Nine Portfolios Double Sorted on Investment and Hiring Rates

This table reports average characteristics of selected variables of nine portfolios double sorted on investment and hiring rate. All characteristics (except returns) are measured at the time of the portfolio formation. The nine portfolios are first sorted on the hiring rate (cutoffs at the 33th and 66th percentile), and then, within each hiring rate bin, all firms are sorted on investment rate (cutoffs at the 33th and 66th percentile). ExRet VW is the mean value weighted excess return (in excess of the risk-free rate) and ExRet EW is the mean equally weighted excess return. The remaining values report means of the following variables: HN is the hiring rate, IK is the investment rate, Size is (log) market equity, BM is the ratio of book equity to market equity, AG is the assets growth, YB is the firm profitability and LK is the labor to real capital ratio. The data are monthly and the sample is July 1965 to June 2006.

| Portfolio | | ExRet | ExRet | | | | | | | |
Hire	Inv.	VW	EW	HN	IK	BM	SIZE	AG	YB	LK
Low	Low	8.37	13.30	−0.14	0.08	1.45	4.21	−0.08	−0.31	9.14
Low	Mid	7.35	12.91	−0.11	0.17	1.15	5.02	−0.01	−0.17	7.47
Low	High	5.42	12.42	−0.11	0.41	1.00	4.57	0.03	−0.27	10.75
Mid	Low	7.90	12.03	0.03	0.11	1.15	5.04	0.02	0.02	7.37
Mid	Mid	7.29	10.66	0.03	0.22	0.88	5.72	0.07	−0.89	7.73
Mid	High	3.36	9.68	0.04	0.46	0.79	5.30	0.11	0.06	14.96
High	Low	6.94	10.46	0.29	0.16	0.95	4.72	0.11	0.03	12.71
High	Mid	4.40	7.29	0.30	0.34	0.72	5.13	0.18	0.06	13.40
High	High	1.32	3.60	0.45	0.91	0.58	4.84	0.30	0.06	14.62

Table VIII
Time Series Asset Pricing Tests

This table reports the CAPM and the Fama-French (1993) asset pricing test results on nine equally weighted and nine value weighted double sorted investment and hiring rate portfolios. The table reports the annualized average value weighted and equally weighted excess returns (in excess of the risk free rate), the intercept (annualized alpha) of a time series regression of the portfolio excess returns on the market excess return (if CAPM) or the Market, SMB and HML factors (if Fama–French three factor model (1993)), the corresponding t-statistics with Newey-West standard errors in parenthesis, the factor betas, and the GRS (Gibbons, Ross and Shanken (1989)) test of the hypothesis that the alphas are jointly zero with the corresponding p-value (in percentage) in parenthesis. The data are monthly and the sample is July 1965 to June 2006.

	Full Sample 1965 to 2006								
Portfolios	Hire-Low			Hire-Med			Hire-High		
	Inv-L	M	Inv-H	Inv-L	M	Inv-H	Inv-L	M	Inv-H
ExRet EW	13.30	12.91	12.42	12.03	10.66	9.68	10.46	7.29	3.6
ExRet VW	8.37	7.35	5.42	7.90	7.29	3.36	6.94	4.40	1.32
CAPM Tests									
Equally Weighted Portfolios									
Alpha	7.50	7.17	5.86	6.70	5.20	3.42	4.25	0.64	−4.4
Alpha t-stat	[3.32]	[3.76]	[2.67]	[4.01]	[3.83]	[2.07]	[2.3]	[0.4]	[−1.88]
Market Beta	1.07	1.06	1.21	0.99	1.01	1.16	1.15	1.23	1.48
GRS [p-val %]	7.07	[0.00]							
Value Weighted Portfolios									
Alpha	3.12	2.5	−0.24	3.48	2.26	−2.42	1.06	−1.57	−6.69
Alpha t-stat	[1.80]	[1.80]	[−0.2]	[3.11]	[2.52]	[−1.78]	[0.96]	[−1.41]	[−2.54]
Market Beta	0.97	0.9	1.04	0.82	0.93	1.07	1.08	1.10	1.48
GRS [p-val %]	1.90	[5.03]							
Fama-French Three Factor Model Tests									
Equally Weighted Portfolios									
Alpha	1.93	2.65	2.14	2.08	1.95	1.08	0.19	−1.59	−4.76
Alpha t-stat	[1.41]	[2.49]	[1.56]	[2.27]	[2.45]	[1.04]	[0.19]	[−1.6]	[−3.13]
Market Beta	1.02	1.02	1.07	0.97	0.99	1.03	1.06	1.09	1.18
SMB Beta	0.53	0.43	0.25	0.47	0.32	0.12	0.33	0.1	−0.26
HML Beta	0.90	0.72	0.93	0.64	0.5	0.7	0.82	0.73	1.0
GRS [p-val %]	3.99	[0.01]							
Value Weighted Portfolios									
Alpha	−0.43	0.36	−0.9	1.47	2.51	−0.84	0.18	−0.1	−2.1
Alpha t-stat	[−0.28]	[0.3]	[−0.69]	[1.50]	[3.01]	[−0.64]	[0.15]	[−0.08]	[−0.98]
Market Beta	1.09	1.03	1.08	0.93	0.99	1.02	1.09	1.05	1.22
SMB Beta	0.49	0.36	0.1	0.33	0.03	−0.21	0.1	−0.2	−0.74
HML Beta	0.07	−0.16	−0.01	−0.11	−0.23	−0.06	0.09	−0.03	0.24
GRS [p-val %]	1.09	[37.1]							

Table IX
Parameter Values under Benchmark Calibration

This table presents the calibrated parameter values of the benchmark model.

Notations	Values	Descriptions
α_k	0.30	Share of capital in output production
α_n	0.65	Share of labor in output production
δ_k	0.10	Rate of depreciation for capital
δ_n	0.32	Rate of separation for labor
f	0.03	Fixed cost of production
c_k	4.00	Adjustment costs parameter for capital
c_n	0.80	Adjustment costs parameter for labor
ρ_x	0.95^4	Persistence coefficient of aggregate productivity
σ_x	0.014	Conditional volatility of aggregate productivity
ρ_z	0.70	Persistence coefficient of firm-specific productivity
σ_z	0.30	Conditional volatility of firm-specific productivity
β	0.94	Time-preference coefficient
γ_0	28	Constant price of risk
γ_1	-300	Time-varying price of risk
$\bar{x}$	-1.94	Long-run average of aggregate productivity
w	0.15	Coefficient of wage rate

Table X

Data versus Model Implied Selected Moments under the Benchmark Calibration

This table presents the selected moments in the data and implied by the model under the benchmark calibration.

Moment	Data	Model
Average Risk Free Rate	0.018	0.012
Risk Free Rate Volatility	0.030	0.058
Sharpe Ratio	0.430	0.326
Average IK	0.220	0.107
Average HN	0.020	-0.022
Volatility of IK	0.170	0.043
Volatility of HN	0.190	0.061
Correlation (IK, HN)	0.330	0.611
Average Book-to-Market	0.660	0.453

Table XI
Portfolio Characteristics of Nine Portfolios Double Sorted on Investment and Hiring Rates Based on Simulated Data

This table reports mean and median characteristics of selected variables of nine value weighted portfolios double sorted on investment and hiring rate constructed on data simulated by the model under the benchmark calibration. The nine value weighted portfolios are first sorted on net investment rate (cutoffs at the 33th and 66th percentile), and then, within each investment bin, all firms are sorted on gross hiring rate (cutoffs at the 33th and 66th percentile). Ret VW is the mean value weighted excess return (in excess of the risk-free rate) and Ret EW is the mean equally weighted excess return. The remaining values report medians of the following variables: HN is the hiring rate, IK is the investment rate, Size is market equity, BM is the ratio of book equity to market equity, Lev. is leverage, AG is the gross assets growth, YB is the firm profitability and LK is the labor to real capital ratio. The reported statistics are averages from 100 samples of simulated data, each with 3600 firms and 50 annual observations.

| Portfolio | | ExRet | ExRet | | | | | |
Hire	Inv.	VW	EW	HN	IK	BM	SIZE	LK
Low	Low	6.91	6.63	−0.10	0.01	0.51	0.19	4.44
Low	Mid	6.40	6.10	−0.08	0.04	0.45	0.21	4.48
Low	High	5.78	5.54	−0.08	0.07	0.40	0.26	4.53
Mid	Low	6.32	5.99	−0.04	0.04	0.45	0.21	4.55
Mid	Mid	6.21	5.93	−0.04	0.07	0.40	0.27	4.62
Mid	High	5.53	5.11	−0.03	0.10	0.35	0.28	4.69
High	Low	6.12	5.89	0.02	0.06	0.40	0.25	4.92
High	Mid	5.34	5.16	0.03	0.10	0.35	0.28	4.97
High	High	4.06	3.57	0.05	0.13	0.29	0.35	5.22

Table XII
Time Series Asset Pricing Tests on Simulated Data

This table reports the CAPM and the Fama-French (1993) asset pricing test results on nine equally weighted and nine value weighted double sorted investment and hiring rate portfolios based on simulated data. The table reports the annualized average value weighted an equally weithted excess returns (in excess of the risk free rate), the intercept (annualized alpha) of a time series regression of the portfolio excess returns on the market excess return (if CAPM) or the Market, SMB and HML factors (if Fama–French three factor model (1993)), the corresponding t-statistics with Newey-West standard errors in parenthesis, the factor betas, and the GRS (Gibbons, Ross and Shanken (1989)) test of the hypothesis that the alphas are jointly zero with the corresponding p-value (in percentage) in parenthesis. The reported statistics are averages from 100 samples of simulated data, each with 3600 firms and 50 annual observations.

	Simulated Data								
Portfolios	Hire-Low			Hire-Med			Hire-High		
	Inv-L	M	Inv-H	Inv-L	M	Inv-H	Inv-L	M	Inv-H
ExRet EW	6.63	6.10	5.54	5.99	5.93	5.11	5.89	5.16	3.57
ExRet VW	6.91	6.40	5.78	6.32	6.21	5.53	6.12	5.34	4.06
	CAPM Tests								
	Equally Weighted Portfolios								
Alpha	0.74	0.48	0.06	0.36	0.56	−0.25	0.47	−0.13	−1.37
Alpha t-stat	[5.65]	[3.76]	[0.42]	[2.38]	[4.57]	[−1.66]	[4.45]	[−0.98]	[−11.34]
Market Beta	1.09	1.04	1.02	1.05	0.99	0.99	1.01	0.98	0.92
GRS [p-val %]	9.60	[0.00]							
	Value Weighted Portfolios								
Alpha	0.87	0.57	0.17	0.42	0.61	−0.04	0.56	−0.09	−1.06
Alpha t-stat	[6.80]	[5.37]	[1.41]	[2.46]	[3.75]	[−0.28]	[6.47]	[−0.69]	[−9.78]
Market Beta	1.12	1.08	1.04	1.09	1.04	1.03	1.03	1.01	0.95
GRS [p-val %]	8.42	[0.00]							
	Fama-French Three Factor Model Tests								
	Equally Weighted Portfolios								
Alpha	−0.20	0.30	0.21	−0.23	0.32	−0.22	0.44	0.16	−0.62
Alpha t-stat	[−0.80]	[1.24]	[1.49]	[−2.53]	[2.79]	[−1.37]	[2.55]	[1.10]	[−3.80]
Market Beta	0.96	1.02	1.04	0.98	0.98	0.98	1.00	1.03	1.00
SMB Beta	0.62	0.13	−0.09	0.43	0.20	−0.07	0.01	−0.18	−0.52
HML Beta	0.60	0.07	−0.16	0.22	0.03	0.18	0.07	−0.25	−0.35
GRS [p-val %]	2.97	[0.90]							
	Value Weighted Portfolios								
Alpha	−0.07	0.26	0.34	−0.35	0.09	−0.29	0.34	0.12	−0.42
Alpha t-stat	[−0.29]	[1.51]	[2.42]	[−2.71]	[0.66]	[−1.75]	[2.33]	[0.95]	[−2.72]
Market Beta	0.98	1.03	1.06	1.00	0.97	0.96	0.99	1.03	1.02
SMB Beta	0.59	0.19	−0.12	0.54	0.35	0.09	0.12	−0.15	−0.46
HML Beta	0.69	0.24	−0.07	0.39	0.30	0.46	0.22	−0.07	−0.27
GRS [p-val %]	2.10	[5.45]							

Figure 1
Time Series of the Investment Hiring Rate FMB Slope Coefficient and T-statistic

The figure plots the time series of the FMB investment and hiring rate slope coefficient and corresponding t-statistics obtained from Fama-MacBeth regressions computed on 15 year rolling windows and including size, book-to-market and momentum as control variables. The t-statistics for the average regression slopes uses the time-series standard deviations of the monthly slopes (computed as in Newey-West with 4 lags). The reported year corresponds to the initial year of the 15 year window. The data are monthly and the sample is July 1965 to June 2006.
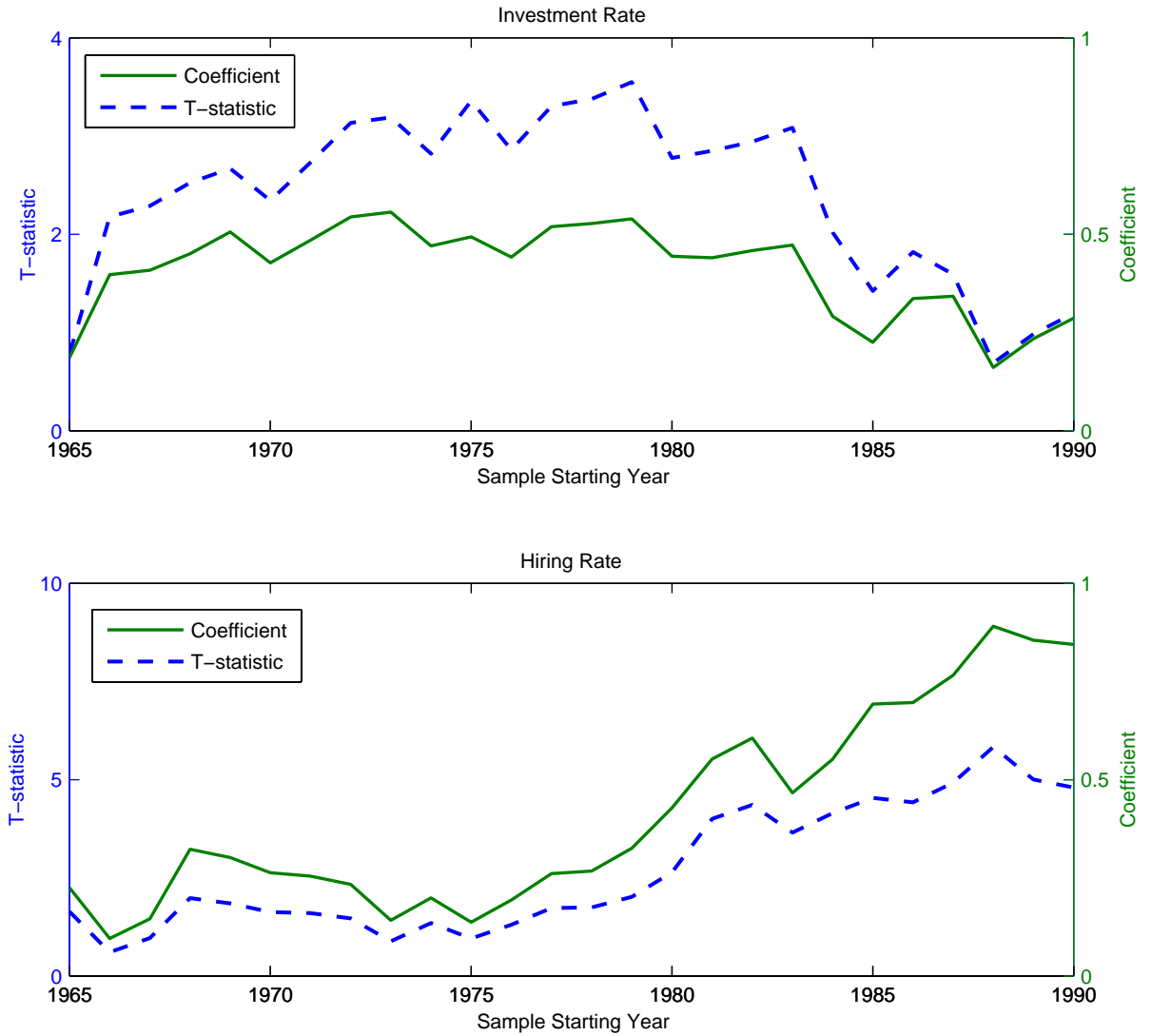
Figure 2

CAPM and Fama-French Implied Excess Returns versus Realized Returns of Nine Double Sorted Investment and Hiring Rate Portfolios

The figure shows the plot of the realized annual excess returns of the nine equally weighted (EW) and value weighted (VW) double sorted investment and hiring rate portfolios against the predicted annual excess returns implied by the CAPM and the Fama-French (1993) three factor model . Each portfolio is represented by two digits. The first digit corresponds to the hiring rate bin which goes from 1 (low hiring rate) to 3 (high hiring rate) and the second digit corresponds to the investment rate bin which goes from 1 (low investment rate) to 3 (high investment rate). The data are monthly and the sample is July 1965 to June 2006.
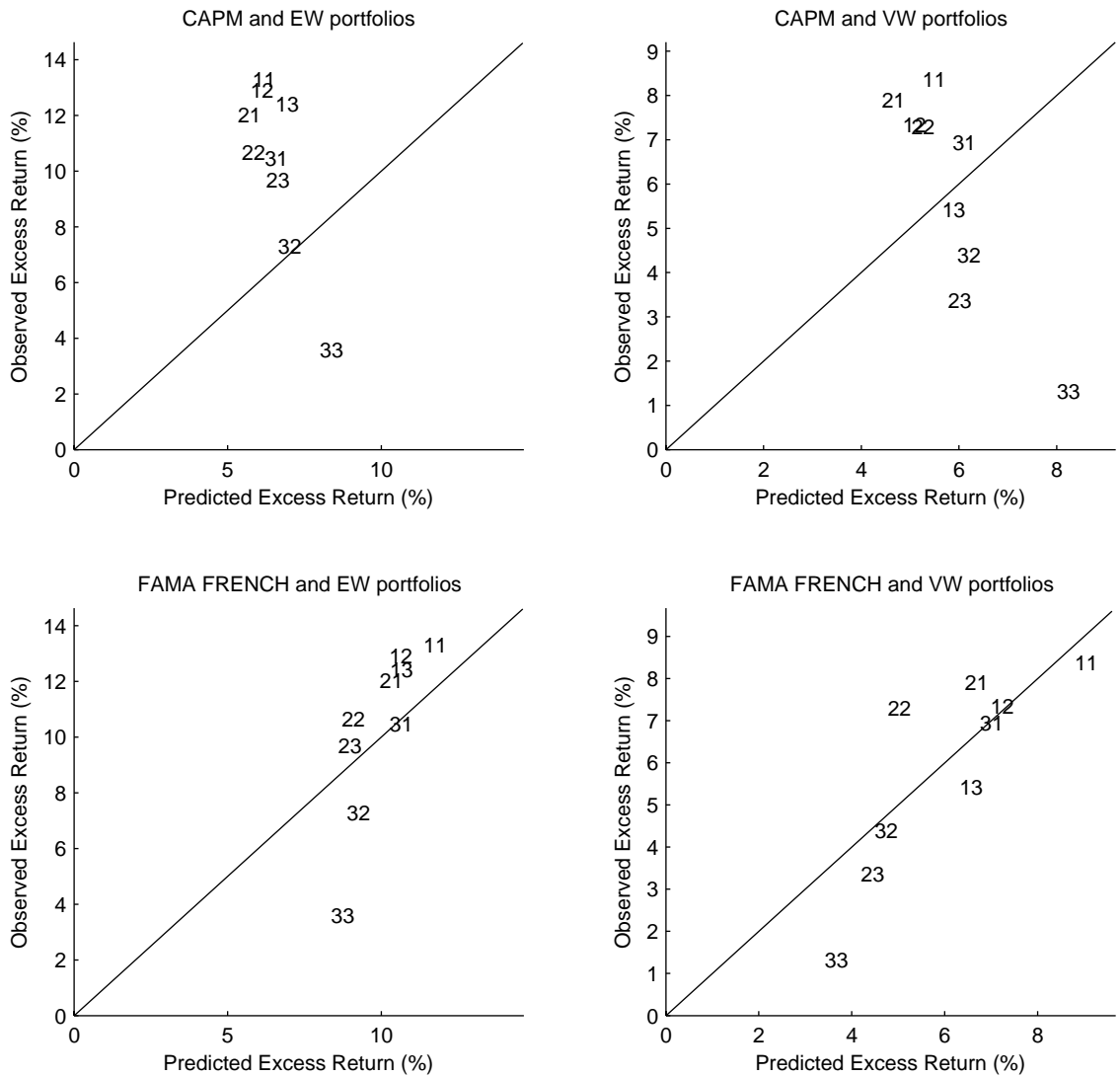
Figure 3

Value Function, Policy Functions and Conditional Beta in the Theoretical Model

This figure plots the value function $v(k, n, x, z)$, the investment-to-capital ratio $\frac{i}{k}(k, n, x, z)$, the hire-to-labor ratio $\frac{h}{n}(k, n, x, z)$ and the conditional beta $\beta(k, n, x, z)$ as functions of two endogenous state variable k and n, and two exogenous state variable x (aggregate productivity shock) and z.(firm-specific productivity shock) Because there are four state variables, we fix $n = \bar{n}$ and $x = \bar{x}$, and plot the value and policy functions against k in Panels A, C and E respectively. The arrows indicate the direction along which z increases. In panels B, D and F, we fix $k = \bar{k}$ and $x = \bar{x}$, and plot the value and and policy functions against n, respectively.

Panel A: $v(k, \bar{n}, \bar{x}, z)$ Panel B: $v(\bar{k}, n, \bar{x}, z)$

Panel C: $\frac{i}{k}(k, \bar{n}, \bar{x}, z)$ Panel D: $\frac{h}{n}(\bar{k}, n, \bar{x}, z)$

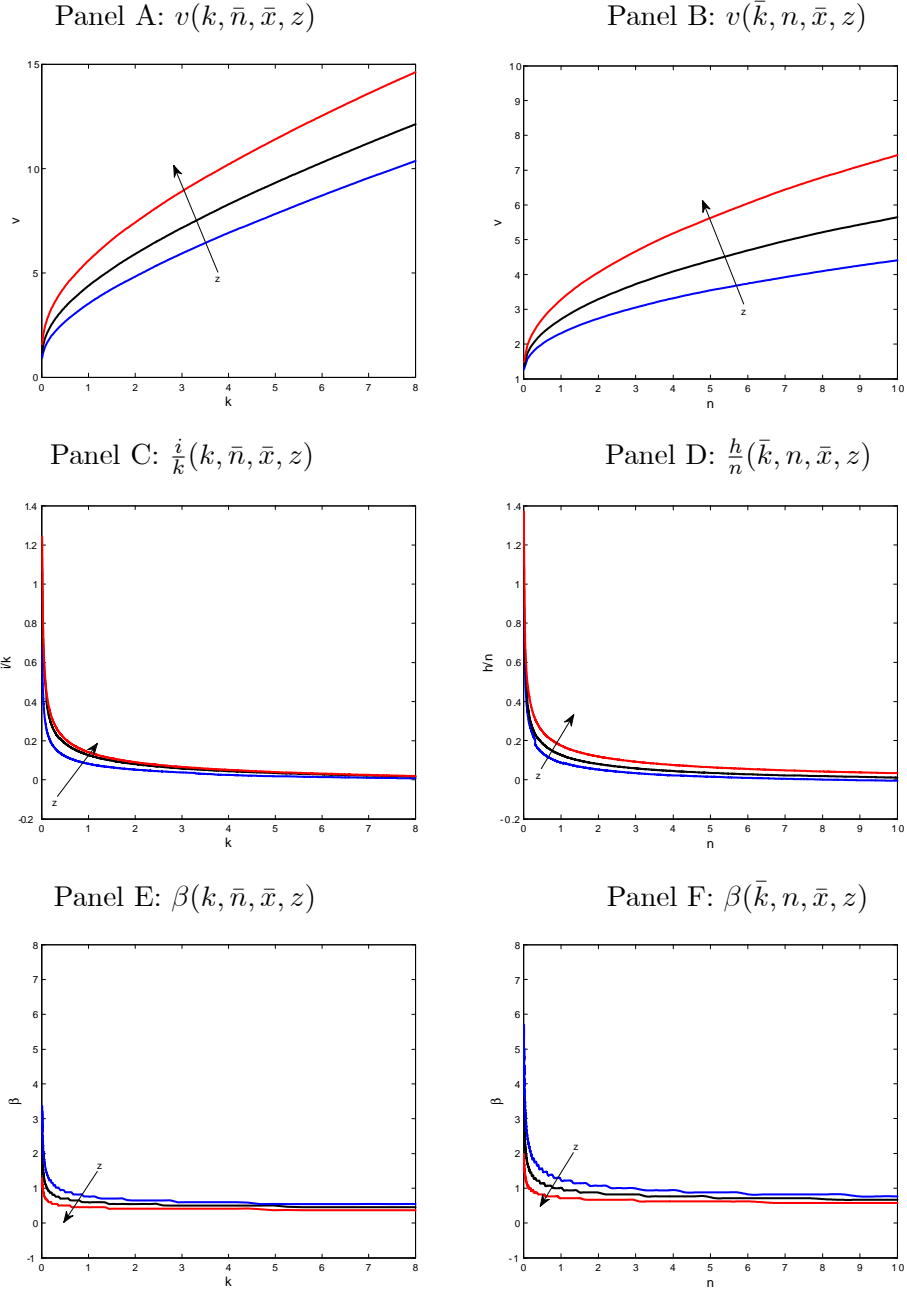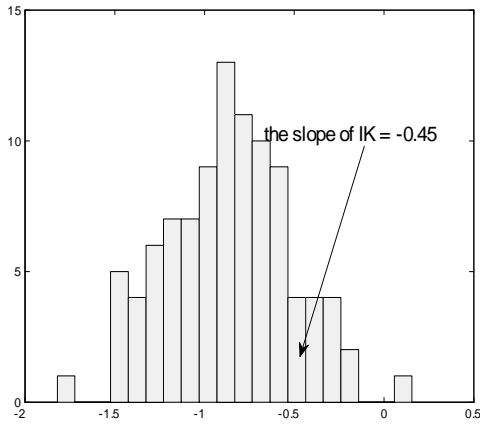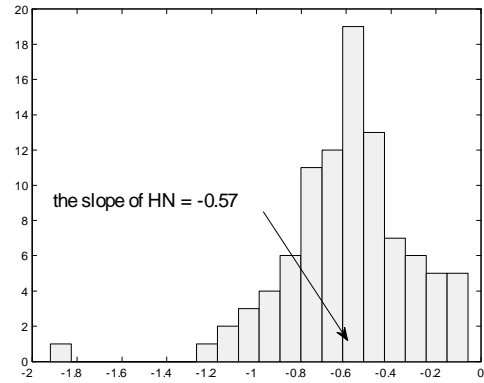Panel E: $\beta(k, \bar{n}, \bar{x}, z)$ Panel F: $\beta(\bar{k}, n, \bar{x}, z)$

Figure 4
Histograms of the Investment and Hiring Rate Fama-MacBeth Slope Coefficients on Simulated Data: Benchmark Model

The figure shows the histogram of the FMB slope coefficient across 100 samples of simulated data, each with 3600 firms and 50 annual observations in the benchmark model with adjustment costs in both capital and labor ($c_i = 4$ and $c_h = 0.8$). Panel A and Panel B plot the one way histogram of the invesment rate and the hiring rate FMB slope coefficient respectively. Panel C plots the two-way histogram of both the investment and hiring rate FMB slope coefficients. The arrow in each panel shows the estimated slope coefficient from the real data reported in Table III.

Panel A: The IK slope   Panel B: The HN slope
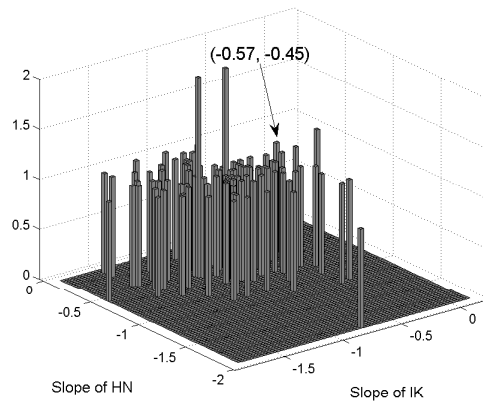

Panel C: The IK and HN slope

50

Figure 5
Histograms of the Investment and Hiring Rate Fama-MacBeth Slope Coefficients on Simulated Data: Alternative Parameterizations

The figure shows the histogram of the investment and hiring rate FMB slope coefficient across 100 samples of simulated data, each with 3600 firms and 50 annual observations in two alternative parameterization. Panel A plots the histogram of the investment rate and the hiring rate FMB slope coefficients in a version of the model with higher labor adjustment costs and lower capital adjustment costs relative to the benchmark case ($c_i = 0.8$ and $c_h = 4$). Panel B plots the histogram of the investment rate and the hiring rate FMB slope coefficients in a version of the model with no labor adjustment costs. The arrow in each panel shows the estimated slope coefficient from the real data reported in Table III.

Panel A: High Relative Labor Adjustment Cost Specification

IK slope   HN slope
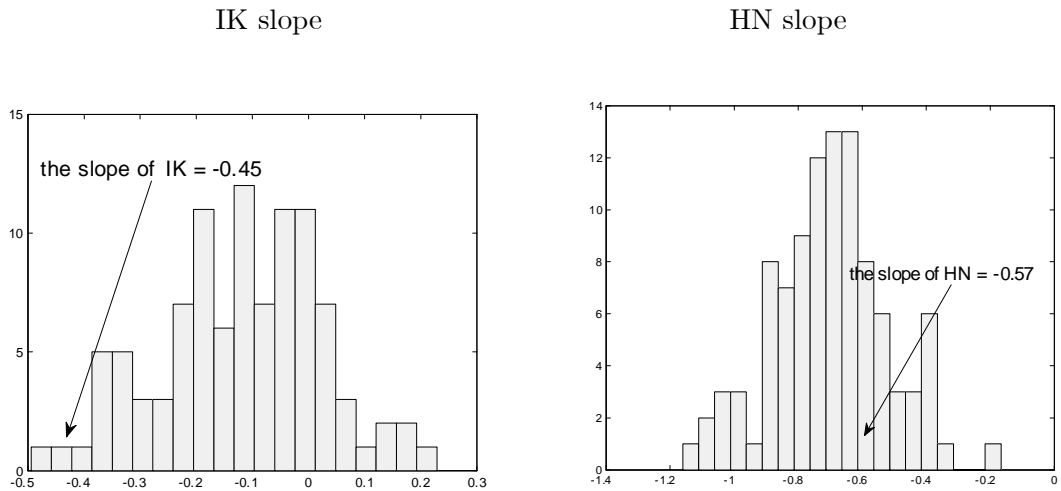
Panel B: No Labor Adjustment Cost Specification

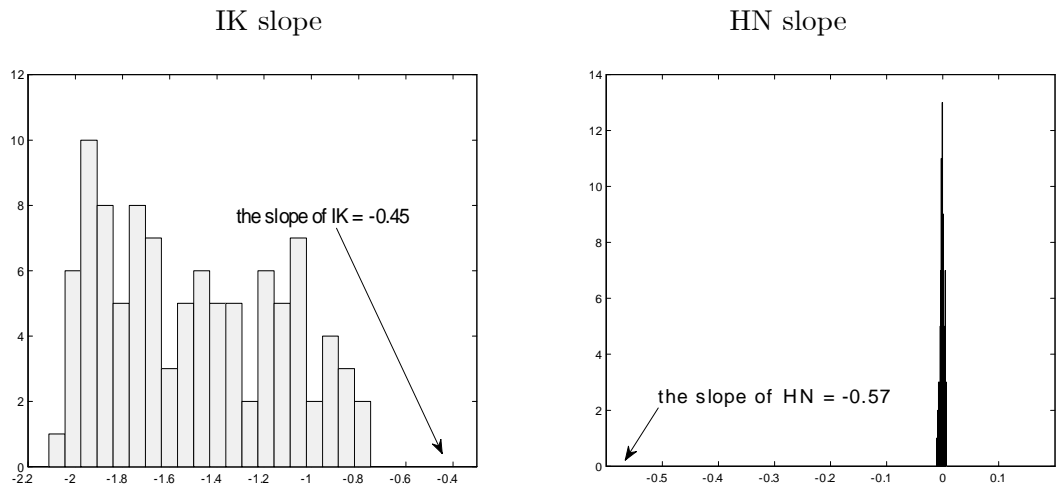IK slope   HN slope

Figure 6
CAPM and Fama-French Implied Excess Returns versus Realized Returns of Nine Double Sorted Investment and Hiring Rate Portfolios on Simulated Data

The figure shows the plot of the realized excess returns of the double sorted investment and hiring rate portfolios against the predicted excess returns (annualized and in percentage) implied by the CAPM (left panel) and the Fama-French (1993) three factor model (right panel) on simulated data. Each portfolio is represented by two digits. The first digit corresponds to the investment rate bin which goes from 1 (low investment rate) to 3 (high investment rate) and the second digit corresponds to the hiring rate bin which goes from 1 (low hiring rate) to 3 (high hiring rate). Portfolios with the digit 4 correspond to spread (low minus high) portfolios. The data are monthly and the sample is July 1965 to June 2006.The data is obtained from simulations of 1000 firms over 250 periods, out of which the first 50 are eliminated.