

# Labor Hiring, Investment and Stock Return Predictability in the Cross Section\*

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## Abstract

We show that firms with lower labor hiring and investment rates have on average higher future stock returns in the cross-section of US publicly traded firms. The predictability holds even after controlling for other known stock return predictors, varies across firms' technologies and exhibits a clear trend over time. We propose a production-based asset pricing model with adjustment costs in both labor and capital inputs to explain the empirical findings. Labor adjustment costs make hiring decisions forward looking. Convex adjustment costs imply that the returns of firms that are investing or hiring relatively less fluctuate more closely with economic conditions. Thus the firms' labor hiring and investment rates predict stock returns in the data because these variables proxy for the firms' time-varying risk.

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# 1 Introduction

We study the relationship between firms' hiring and investment decisions and stock return predictability in the cross-section of US publicly traded firms. We show that firms with lower labor hiring rates and investment rates tend to have higher future stock returns. The predictability shows up in standard Fama-MacBeth cross sectional regressions and in portfolio sorts. A spread portfolio of stocks that goes long on firms with low investment and hiring rates and short on firms with high investment and hiring rates generates a significant value-weighted spread of 7.05% per annum. In standard asset pricing tests, we find that the unconditional CAPM is unable to explain the cross-sectional variation in the returns of nine double sorted investment and hiring rate portfolios. The Fama-French (1993) three factor model performs significantly better but it is unable to price the portfolio composed of firms with high investment and hiring rates, at least in equally-weighted portfolios.

Why does the hiring rate, in addition to the investment rate, predict stock returns? In this paper, we argue that in an economy with time-varying risk, the firm level hiring rate is negatively related to the firm's conditional beta. To establish this link, we propose a production-based asset pricing model that treats the firm's hiring decision as analogous to an investment decision. Our key assumption is the existence of adjustment costs in both labor and capital inputs, similar in spirit to q-theory models of investment and akin to Merz and Yashiv (2007).<sup>1</sup> Intuitively, and in contrast with the frictionless case, labor adjustment costs make hiring decisions forward looking and thus potentially informative about the firms' expectations about future economic conditions. This result is familiar from the standard q theory of investment. Here, investment is high when marginal q is high, and marginal q is high if expected future cash flows are high or risk-adjusted discount rates (expected stock returns) are low. This mechanism has been used to explain the well documented negative relationship between the firm's investment rate and expected stock returns.<sup>2</sup> We show that an analogous result holds for the relationship between the hiring rate and expected stock returns.

Theoretically, we show that the negative relationship between the firm's level of risk and the firm's investment and hiring rate arises endogenously in the production-based model due to convex adjustment costs in both capital and labor. The economic mechanism underlying

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<sup>1</sup>The idea that both labor and capital are costly to adjust is an old one. See, for example, on capital Lucas (1967) and on capital and labor, Nadiri and Rosen (1969). More recently, the search and matching models of Diamond (1982), Mortensen (1981), Pissarides (1985) and Yashiv (2001) emphasize the existence of frictions in the labor markets that prevent firms from costlessly adjust its labor stock.

<sup>2</sup>A partial list of empirical studies showing that investment and expected stock 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).

this relationship is analogous to the theoretical explanations of the value premium that emphasize the importance of frictions in the adjustment of capital inputs (e.g. Zhang, 2005), extended to a multi-factor inputs setting. In bad times, when most firms are trying to decrease production, the returns of the firms that are disinvesting or firing relatively more fluctuate more closely with aggregate shocks. If the recession deepens, the convexity of the adjustment cost function implies that it will be relatively more costly for these firms to further reduce their capital and labor stock. If economic conditions improve, these firms will benefit relatively more because of larger savings in total adjustment costs. In good times, when most firms are trying to increase production, an analogous mechanism applies. Taken together, this mechanism implies that, in the cross-section, firms that are investing or hiring relatively less have endogenously higher betas and thus have higher average stock returns in equilibrium as a compensation for their higher level of risk. The exact sensitivity of the firm's stock returns to aggregate shocks depends not only on how much the firm is investing but also on how much the firm is hiring. So both variables are needed in order to provide a complete characterization of the firm's conditional beta.

In the empirical section, we also show that the predictability of the investment and hiring rate for stock returns varies significantly over time. Using standard Fama-MacBeth cross sectional regressions, we find that the predictability of the hiring rate for stock returns has significantly increased over our sample period from 1965 to 2006, and is particularly strong after the late 1970's. Interestingly, we find the opposite pattern for the predictability of the investment rate for stock returns. Using the theoretical model, we show that these findings are consistent with the documented increase in the cost of adjusting labor. The change in the composition of the labor force from unskilled to skilled workers in the second half of the 20th century has made the worker screening, selection and hiring process more costly for employees.<sup>3</sup> Additionally, we show in the model that the increase in the cost of adjusting labor should be accompanied by an increase in the proportion of the firm's market value attributed to the value of labor inputs, consistent with the findings in Hall (2001).<sup>4</sup>

We also find that the stock return predictability of both the investment and the hiring rate for stock returns varies with the characteristics of the firm's technology as measured by the firm's capital intensity. Sensibly, the predictability content of the hiring rate is higher for labor intensive firms than for capital intensive firms and the exact opposite pattern is true for the investment rate. In the theoretical model, we show that the pattern of predictability across technologies can potentially be explained by a combination of differences in the relative magnitude of capital and labor adjustment costs across these technologies as

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<sup>3</sup>See, for example, Cappelli and Wilk (1997), Murnane and Levy (1996) and Acemoglu (2001).

<sup>4</sup>Hall (2001) finds that the increase in the firms' market value in the 90's can not be explained by a corresponding increase in the value of physical capital. The difference is attributed to an increase in the value of intangible capital, which in our setup also includes the value of labor inputs.

well as differences in the capital intensity parameter in a standard Cobb-Douglas production function.

As a test of our theoretical explanation for the relationship between hiring, investment and stock returns, we calibrate the production-based model developed here to match well known price and quantity US market data. We then show that a simulation of the model is able to qualitatively, and in some cases quantitatively, replicate the main empirical cross-sectional findings reasonably well with plausible parameter values. The model produces Fama-MacBeth regression slope coefficients that are negative for both the investment and hiring rates and with magnitudes that are close to the empirical estimates. The model also replicates the portfolio sort results and the asset pricing tests. The nine investment and hiring rates double sorted portfolios using simulated data exhibit average returns that are decreasing in both the investment and the hiring rate. The unconditional CAPM is rejected on these portfolios while the Fama-French (1993) three factor model performs significantly better. Finally, the model also does an overall reasonable job capturing the dynamic properties of the firm level investment and hiring rates observed in the data, although the correlation between these two variables is higher than in the data.

Finally, we also use the model as a laboratory to investigate the importance of labor adjustment costs for explaining the empirical findings. We confirm that labor adjustment costs are crucial to replicate the negative relation between the firm level hiring rate and future stock returns. When labor can be freely adjusted, the Fama-MacBeth regressions of future stock returns on investment and hiring rate using simulated data, produces slope coefficients for the hiring rate that are indistinguishable from zero. Similarly, the nine investment and hiring rates double sorted portfolios exhibit average returns that are non monotone across the hiring rate. This result is intuitive. Without labor adjustment costs, firms generate no rents from labor (all rents accrue to workers) and thus the market value of the firm only reflects the value of the capital inputs. In addition, because total adjustment costs only depend on the firm's investment rate, the firm's hiring rate does not provide additional information about the firm's level of risk, a result that is not supported by the data.

## 1.1 Related Literature

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 et al. (1998), and Santos and Veronesi (2006) 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.<sup>5</sup> 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.

The work in this paper is related to both the asset pricing, the labor demand and the investment literature. A large empirical literature on asset pricing explores the predictability of firm characteristics for stock returns in the cross-section of stock returns.<sup>6</sup> To this literature, our work adds the firm level hiring rate as a theoretically motivated stock return predictor, and it documents new facts regarding the well documented predictability of the investment rate for stock returns. Our approach is also closely related to the production and 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 as well as to the value premium.<sup>7</sup> 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.

A large literature on labor demand and investment investigates the importance of capital and labor adjustment costs to explain investment and hiring dynamics.<sup>8</sup> The estimated economic magnitude of adjustment costs is subject to some debate (we discuss this further in Section 4.1 below). For example, Shapiro (1986), shows that reasonably large estimates of labor adjustment costs are important to match investment and hiring dynamics (for non production workers, but not for production workers). Merz and Yashiv (2007) considers

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<sup>5</sup>References on the relationship between human capital and asset returns go as far back as Mayers (1972) and Fama and Schwert (1977).

<sup>6</sup>A partial list of papers documenting firm characteristics related to 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).

<sup>7</sup>Contributions in this area 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), Cooper, Gulen and Schill (2008), Gala (2005), Gomes, Yaron and Zhang (2006), Li, Livdan and Zhang (2008), Liu, Whited and Zhang (2008) and Gomes, Kogan and Yogo (2009).

<sup>8</sup>See, for example, on capital: Cooper and Haltiwanger (1997), Caballero, Engel and Haltiwanger (1995), Cooper, Haltiwanger and Power (1999) and Cooper and Haltiwanger (2003); on labor: Hamermesh (1989), Bertola and Bentolila (1990), Davis and Haltiwanger (1992), Caballero and Engel (1993), Caballero, Engel and Haltiwanger (1997), Cooper, Haltiwanger and Willis (2004); on joint estimation of capital and labor adjustment costs Shapiro (1986), Galeotti and Schiantarelli (1991), Hall (2004), Merz and Yashiv (2007) and Bloom (2008). Bond and Van Reenen (2007) provides a survey of the literature and Hamermesh (1993) reviews a set of direct estimates of the costs of adjusting labor.

the production decision problem of an aggregate representative firm and finds that adding labor adjustment costs substantially improves the fit of the model in matching the time series properties of aggregate stock market prices. Hall (2004) however, estimates both capital and labor adjustment costs to be negligible at the two-digit SIC industry level. All these studies focus on the direct estimation of the adjustment cost parameters, and thus the results are naturally subject to the quality of the input price and quantity data used, the econometric methodology and possible aggregation of data problems. Our work does not focus on the very important issue of estimation of the adjustment costs. Instead, we provide indirect evidence that rents arising from adjustment costs can be considerable, by showing that input adjustment costs generate stock return predictability at the firm level, which we confirm in the data.

The theoretical approach in this paper is most closely related to the work of Merz and Yashiv (2007) who builds upon earlier work of Cochrane (1991). Merz and Yashiv considers an aggregate representative firm in a setup in which, as in our model, the firm faces adjustment costs in both capital and labor and focus on the estimation of the production and adjustment cost function. We extend Merz and Yashiv setup to the firm level which allows us to use not only time-series data but also cross-sectional data, and we examine the implications of adjustment costs for firm level stock returns and stock return predictability. Our approach is also closely related to the work of Zhang (2005) and Li, Livdan and Zhang (2008) who investigate the ability of an investment q-theory model to explain several cross sectional asset pricing facts in a simulation economy.

The focus on labor markets and asset prices is also related to the theoretical work of Danthine and Donaldson (2002), who shows that operating leverage resulting from frictions in the determination of the wage rate magnifies the risk premium of equity returns at the aggregate level. We abstract from these frictions in our setup but note that frictions in the determination of the wage rate can potentially magnify even further the impact of labor adjustment costs on equity returns that we consider here. Finally, our work is also related in spirit to the work by Chen, Kacperczyk and Ortiz-Molina (2007) who document empirically that firms in more unionized industries tend to have higher (implied) expected stock returns. Their finding is consistent with the hypothesis that labor unions decrease firms' operating flexibility, which is a type of friction in the labor market that is generalized by the adjustment cost function considered in our equilibrium model.

The paper proceeds as follows. Section 2 presents the empirical facts in the data regarding the relationship between investment, hiring and stock return predictability. Section 3 presents a production-based asset pricing model that we use to understand the empirical evidence. Section 4 solves the model numerically and discusses its properties. Section 5 creates cross-sectional simulated data from the model and investigates if the model can

quantitatively and qualitatively replicate the empirical findings. Finally, Section 6 concludes. A separate appendix with additional results is posted on-line.

## 2 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 lagged 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 (see, for example, Fama and French (2008) for a discussion on the advantages and disadvantages of each approach). The two approaches allow us to cross-check the results and establish the robustness of the findings.

### 2.1 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. 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 beginning of the period capital stock ( $IK_t = I_t/K_{t-1}$ ), as in Xing (2008), Gala (2005) and Kaplan and Zingales (1997), and the hiring rate is given by the ratio of hiring to the beginning 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.<sup>9</sup> We winsorize the top 1% of the investment and hiring rate distribution to reduce the influence of outliers observed in our sample, which are likely to reflect mergers and acquisitions. Appendix A-1 provides a detailed description of the additional data used as well as the sample selection criteria.

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<sup>9</sup>Following Davis, Faberman and Haltiwanger (2006) we also computed the hiring rate as  $HN_t = H_t / (0.5(N_{t-1} + N_t))$ , which yields a measure that is symmetric about zero and bounded between -200 and 200 percent. The qualitative results are identical to the ones reported here.



## 2.2 Summary Statistics

### 2.2.1 Investment and Hiring Rates

Table 1 reports summary statistics of firm level (Panel A) and cross-sectional (Panel B) moments of the investment rate (IK) and the hiring rate (HN) data in our sample. For comparison, the table also reports the summary statistics of two other known stock return predictors, the book-to-market ratio and asset growth. In computing the summary statistics at the firm level, we require a firm to have at least 20 observations and we exclude micro caps firms in order to estimate these statistics with enough precision. Following Fama French (2008), micro cap firms are defined as stocks with a market capitalization below the bottom 20<sup>th</sup> percentile of the NYSE cross-sectional market size distribution. These firms are known to have characteristics with more extreme values and thus including these firms potentially distorts the average characteristic of a typical firm. Two important facts about the firm level statistics reported in Panel A are worth emphasizing. First, both the investment rate and, to a lesser degree, the hiring rate, are positively autocorrelated. The mean autocorrelation of the investment rate and hiring rate across firms is 0.45 and 0.11, respectively. Even though the autocorrelation of the hiring rate is small, the positive autocorrelation is consistent with the existence of convex adjustment costs at the firm level (this estimate is likely to be biased down due to probable measurement error as well as time aggregation problems in firm level data). Second, the mean correlation between the firm's investment and hiring rate is 0.32. To the extent that this relatively low correlation is not only due to measurement error in these variables, this low correlation suggests that investment and hiring decisions carry potentially different information about the firms' future stock returns. In turn, this fact provides support for the approach in this paper of jointly investigating the investment and hiring rate variables as stock return predictors.

[Insert Table 1 here]

The average values of the cross sectional moments (across time) of the selected variables reported in Table 1, Panel B, show that both the investment and hiring rates exhibit substantial cross sectional variation. This fact 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.

### 2.2.2 Other Variables

Table 2 , Panel A reports the summary statistics of selected variables used in our empirical work.

[Insert Table 2 here]

To investigate and characterize the predictability of the investment and the hiring rate across firms with different technologies, we group firms according to the firm's degree of capital intensity (which we justify below). Table 2, Panel B reports the summary statistics for all the firms in the sample as for the three groups of firms classified according to the firm's degree of 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 20<sup>th</sup> percentile of the LK cross sectional distribution in a given year; to be a capital and labor firm if the LK ratio is between the 20<sup>th</sup> and the 80<sup>th</sup> percentile; and to be labor intensive if the LK is on the top 20<sup>th</sup> percentile. We note that capital intensity classification could also be made based on the firm's labor share, as it is commonly done in practice. This approach is not feasible here, however, since the firm level wage bill data in COMPUSTAT is missing for approximately 90% of the firms on our sample. 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. Here, the average labor share in each group is computed using aggregate information available at the 2 digit Standard Industry Classification (SIC) level, as described in Appendix A-1.

## **2.3 Fama-MacBeth Cross-Sectional Regressions**

We run FMB cross-sectional regressions of monthly stock returns on lagged 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 rates for stock returns in the data, we discuss separately the results across: (1) all firms together (pooled sample) and (2) technology groups, as defined by the firm's capital intensity. 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 and potential changes of the relationships over time. We conclude this section by comparing the predictability of the investment and hiring rates for stock returns with that from a large set of other known stock return predictors.

### **2.3.1 Predictability in the Pooled Sample**

We consider three different empirical specifications of the FMB cross-sectional regressions. 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. The

full sample results in Table 3, Panel A show our main empirical result. Across all specifications, the regression produces negative and statistically significant average slopes associated with the investment and the 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, even controlling for the investment rate. On a separate web appendix, we show that the results are robust to the exclusion of micro cap firms from the sample, as suggested in Fama-French (2008).

[Insert Table 3 here]

Turning to the analysis of the return predictability over time, Table 3, Panel A also reports the FMB regression results for the sub-sample that goes from July 1965 to June 1985 and for the sub-sample that goes from July 1985 to June 2006. The investment and hiring rates are statistically significant predictors of returns in both periods. In addition, the pattern of the predictability of the hiring rate for stock returns over time is clear: the slope coefficients for the hiring rate are considerably 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. Figure 1 plots the time series of the investment and hiring rates Fama-MacBeth slope coefficients and the corresponding t-statistics. The predictability of the hiring rate increases significantly in the samples that start in the late 1970's. Interestingly, we observe a symmetric pattern for the investment rate. The investment rate loses its predictive power in the mid 1980's. We interpret these findings in the theoretical section.

[Insert Figure 1 here]

What is the economic significance of the marginal predictive power of the investment and hiring rate? And how much do we gain from combining the information of the investment and the hiring rates relative to using only the investment rate as in the previous literature? To examine this question, Table 4 reports the predicted and the realized average returns as well as the realized Sharpe ratio of spread (high minus low) portfolios formed using the predicted return values implied by the estimated FMB slope coefficients of Table 3, Panel A. We compute the spread portfolios for the FMB specifications that include the following return predictors: (1) only the investment rate, (2) only the hiring rate; and (3) both the investment and hiring rates. To create these spread portfolios we follow a procedure similar to Fama and French (2006) and, for each specification, we compute the predicted monthly

return on each individual stock at the end of each June by combining the current values of the explanatory variables with the average monthly regression slopes reported in Table 3, Panel A. We then allocate stocks to high and low expected return portfolios based on whether the predicted monthly stock return for the following year is above the 70<sup>th</sup> percentile or below the 30<sup>th</sup> percentile of the predicted return cross-sectional distribution for the year.

[Insert Table 4 here]

Interestingly, Table 4 shows that for both the predicted and the realized spread, the average spread is higher when both the investment and hiring rates are included than when these variables are used separately. In the full sample period, the realized annualized spread when both the investment and hiring rates are included is 7.14%, which is 1.44% higher than the realized spread when only the investment rate is used (spread of 5.70%) and 1.04% higher than the realized spread when only the hiring rate is used (spread of 6.10%). Thus, including the hiring rate, in addition to the investment rate, allow us to increase the portfolio spread by 1.44% and increase its Sharpe ratio from 0.6 to 0.79, which are significant values in economic terms. The benefit of using the hiring rate as a return predictor is particularly strong in the most recent sample period from July 1985 to June 2006. Here, including the hiring rate allows us to increase the portfolio spread by 2.63% and the Sharpe ratio of the portfolio from 0.55 to an impressive 0.91, relative to the spread portfolio in which only the information on the investment rate is included.

### 2.3.2 Predictability Across Technologies

In the previous section we pooled all firms 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. Firms differ in many dimensions however, which may make the previous assumption implausible. In this section, we investigate how the predictability of the investment and hiring rates vary with the firms' technology by grouping firms according to each firm's capital intensity.

The use of capital intensity as a proxy for a 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 vary with the firm's capital and labor intensity can be motivated by examining a limiting example. Consider a firm that uses (almost) only 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 uses (almost) only capital.

Table 3, Panel B, reports the results for the FMB cross-sectional regressions across firms grouped by capital intensity. The full sample results confirm the hypothesis that the predictive power of the hiring and the investment rates varies with the firms’ 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 firms, only the hiring rate has predictive power. The t-test for the difference in the slope coefficient for these firms (K minus L) 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 1985 to 2006.

The results in this section suggest that the sensitivity of the firms’ future returns to the investment and hiring rates varies across technologies. On a separate web appendix, we also investigate the predictability of the investment and hiring rates across industries with different labor union rates (a proxy for operational flexibility as in Chen, Kacperczyk and Ortiz-Molina, 2007) but found no systematic differences. In addition, we investigate the return predictability across seven 2-SIC digit code groups of industries, an alternative proxy for the firm’s technology. Consistent with the results reported here, we find that the predictability of the investment and hiring rate for stock returns also varies substantially across industries, and the predictability of the hiring rate is stronger in all industries in the more recent years.

### 2.3.3 Relationship With Other Stock Return Predictors

In this section we examine the marginal predictive power of the investment and hiring rate for stock returns after controlling for other firm level characteristics known to predict stock returns. Here, we follow Fama-French (2008) and control for size (market capitalization), book-to-market ratio, momentum, asset growth, net stock issues, positive accruals, and positive profitability.<sup>10</sup> These characteristics are the most relevant return predictors reported in Fama-French (2008), table IV, row “All but Micro”. We consider six empirical specifications which differ in the set of return predictors included. In addition to the investment and hiring rates, we consider size, book-to-market and momentum in all the specifications, since these

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<sup>10</sup>The choice of each firm level characteristic follows from the work of the following authors: size, Banz (1981); book-to-market, Rosenberg, Reid, and Lanstein (1985), Chan, Hamao, and Lakonishok (1991), and Fama and French (1992); momentum, Jegadeesh and Titman (1993); asset growth Cooper, Gulen and Schill (2008); net stock issues, Ikenberry, Lakonishok, and Vermaelen (1995), Loughran and Ritter (1995), Daniel and Titman (2006) and Pontiff and Woodgate (2006); accruals, Sloan (1996); profitability, Haugen and Baker (1996) and Cohen, Gompers, and Vuolteenaho (2002).

characteristics are the most common return predictors used in the empirical asset pricing literature. In specifications two to five we consider the other return predictors separately, and in the last specification we consider all the return predictors jointly. 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.

[Insert Table 5 here]

The first specification in Table 5 reports the full sample results when size, book-to-market ratio and momentum characteristics are added to the cross-sectional regressions. Interestingly, the investment and hiring rate slope maintains its predictive power for stock returns even in the presence of these strong return predictors. The average slopes associated with these characteristics have the same 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.

In the second specification in Table 5, the asset growth characteristic is included. Here, the hiring rate maintains its predictive power for returns, but the asset growth characteristic seems to drive out the investment rate factor. This suggests that the investment rate is capturing some information about stock returns that is partially contained in the asset growth factor. This is not surprising since capital is part of the assets of the firm. Comparing with the previously reported results in Table 3, 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 also expected since, as documented in Table 1, both the investment and hiring rates are significantly positively correlated with asset growth, both at firm level (Panel A) and in the cross-section (Panel B). 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 (2008).

In specifications three to five in Table 5, the net stock issues, positive accruals and positive profitability characteristics are included separately. Impressively, both the investment and the hiring rates maintain their sign and predictive power when each predictor variable is included, despite the decrease in the magnitude of the associated investment and hiring rate slope coefficients. Only when all return predictors are included together (last specification) the investment and hiring rates lose their marginal predictive power. This result is not surprising given the well documented joint predictive power for stock returns of these firm level characteristics. The estimated slope coefficients associated with these variables have 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.

## 2.4 Portfolio Approach

We now turn to a portfolio approach. We examine the realized average returns and 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 33<sup>th</sup> and 66<sup>th</sup> percentile) at the end of year  $t - 1$ . Then, each one of these three hiring portfolios are equally sorted into three portfolios based on their investment rate (cutoffs at the 33<sup>th</sup> and 66<sup>th</sup> 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 and to guarantee a reasonable number of firms in each portfolio, here we only study portfolios using the whole sample of firms and thus do not investigate the variation across groups of firms as in the FMB cross-sectional regressions.

[Insert Table 6 here]

Table 6 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 Patton and Timmermann (2008) monotonic relation test, strongly rejects the hypothesis that the average returns of these portfolios are all equal against the hypothesis that they are decreasing in both the investment and hiring rate, with a p-value of 1.3%.

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 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 asset growth (AG) is 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 traditional risk factors, we conduct standard time series asset pricing tests using the CAPM and the Fama-French (1993) three factor

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), and on the SMB (small minus big) and HML (high minus low) factors. Appendix A-1 explains the construction of these factors.

[Insert Table 7 here]

Table 7, Panel A reports the asset pricing test results for the CAPM and for the Fama French (1993) model using both equally-weighted and value-weighted portfolios. The CAPM is clearly rejected on both the equally-weighted and value-weighted portfolios by the GRS (Gibbons, Ross and Shanken, 1989) test with p-val of 0.00% and p-val of 5.03%, respectively. The reason for this rejection is that the unconditional CAPM market beta goes in the wrong direction. The portfolio of firms that hire more (similarly for investment) have a higher unconditional market beta than the portfolio of firms that hire less, which is not consistent with their lower average returns. In addition, the spread in the unconditional CAPM market beta across these portfolios is too small relative to the spread in realized 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 7 are better. The model is rejected on equally-weighted portfolios by the GRS test with p-val of 0.01%, but is not rejected on value-weighted portfolios with p-val of 37.1%.<sup>11</sup> As in the CAPM, the returns on the high-high equally-weighted portfolio represent a puzzle for the

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<sup>11</sup>We note 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 not reported here but are available upon request.



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.

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.

The portfolio level asset pricing results reported here are robust. We obtain qualitatively similar results even when the Carhart (1997) momentum factor is included in the Fama-French (1993) model, or 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).

### 3 A Production-Based Asset Pricing Model

We propose a production-based asset pricing model to understand the empirical evidence presented in the previous section. Producers make investment and hiring decisions in order to maximize the value of the firm. Optimal investment and hiring determines the firm's dividends and market value thus establishing an endogenous link between the firm's hiring and investment rate, and the firm's level of risk and expected stock return.

#### 3.1 Economic Environment

The economy is composed of a large number of firms that produce a homogeneous good. Firms are competitive and take as given the market-determined stochastic discount factor  $M_{t,t+1}$ , used to value the cash-flows arriving in period  $t + 1$ , as well as the stochastic wage rate  $W_{t+1}$ . 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, 2002, chapter 4.2).

### 3.1.1 Technology

We focus on the optimal production decision problem of one firm in the economy. The firm uses capital inputs  $k_t$ , and labor inputs  $l_t$  to produce output  $y_t$ , according to the technology

$$y_t = e^{x_t+z_t} k_t^{\alpha_k} n_t^{\alpha_n} \quad (1)$$

where  $0 < \alpha_k, \alpha_n$  and  $\alpha_k + \alpha_n \leq 1$ ,  $x_t$  is an aggregate productivity shock, and  $z_t$  is the firm's specific idiosyncratic productivity shock (we suppress any firm specific subscript to save on notation). The aggregate shock follows the process

$$x_{t+1} = \bar{x}(1 - \rho_x) + \rho_x x_t + \sigma_x \varepsilon_{t+1}^x, \quad (2)$$

where  $\varepsilon_{t+1}^x$  is an independently and identically distributed (i.i.d.) standard normal shock. The idiosyncratic productivity shock follows the process

$$z_{t+1} = \rho_z z_t + \sigma_z \varepsilon_{t+1}^z, \quad (3)$$

where  $\varepsilon_{t+1}^z$  is an i.i.d standard normal shock that is uncorrelated across all firms in the economy, and  $\varepsilon_{t+1}^x$  is independent of  $\varepsilon_{t+1}^z$  for each firm. 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 firm heterogeneity.

In every period  $t$ , the capital stock  $k_t$  depreciates at rate  $\delta_k$  and is increased (or decreased) by gross investment  $i_t$ . The law of motion of the capital stock is given by

$$k_{t+1} = (1 - \delta_k)k_t + i_t \quad 0 < \delta_k < 1. \quad (4)$$

Similarly, the firms' labor stock  $n_t$  depreciates at the quit rate  $\delta_n$ , the rate at which workers leave the firm for voluntary reasons. For tractability, the quit rate is assumed constant as in Shapiro (1986). The firm's labor stock is also increased (or decreased due to firing) by gross hires  $h_t$ . The law of motion of the labor stock is given by

$$n_{t+1} = (1 - \delta_n)n_t + h_t \quad 0 < \delta_n < 1. \quad (5)$$

We assume that both gross investment and gross hiring incur adjustment costs. Labor adjustment 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. Capital adjustment costs include planning and installation costs, learning the use of new equipment, or the fact that production is temporarily interrupted. Following Merz and Yashiv (2007), we specify these costs by an adjustment cost function  $g(i_t, h_t, k_t, n_t)$  that is homogeneous of degree one. The functional form for the adjustment cost function that we explore in this paper is

$$g(i_t, h_t, k_t, n_t) = \frac{c_k}{v_k} \left( \frac{i_t}{k_t} \right)^{v_k} k_t + \frac{c_n}{v_n} \left( \frac{h_t}{n_t} \right)^{v_n} n_t, \quad (6)$$

where  $c_k, c_n > 0$ ,  $v_k, v_n > 1$  are constants. When  $v_k = v_n = 2$ , this specification is the natural generalization of the quadratic investment adjustment cost function popular in the q theory of investment.

The functional form of the adjustment cost function in equation (6) is chosen both because of its tractability and because it captures the main feature which, as we argue below, is the most relevant to generate stock return predictability, namely that adjustment costs are increasing and convex in the investment and hiring rates.

### 3.1.2 Preferences

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

$$\log M_{t,t+1} = \log \beta + \gamma_t(x_t - x_{t+1}) \quad (7)$$

$$\gamma_t = \gamma_0 + \gamma_1(x_t - \bar{x}), \quad (8)$$

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 (7) 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 (2009). Following Zhang (2005), we assume in equation (8) that  $\gamma_t$  is time-varying and decreases in the demeaned aggregate productivity shock  $x_t - \bar{x}$  to capture the well documented countercyclical price of risk with  $\gamma_1 < 0$ . The precise economic mechanism driving the countercyclical price of risk is, e.g., time-varying risk aversion as in Campbell and Cochrane (1999) or time-varying economic uncertainty as in Bansal and Yaron (2004).

### 3.1.3 Capital and Labor Markets

Output is the numeraire and firms can transform one unit of output into one unit of the investment good. Equivalently, firms face a perfectly elastic supply of investment goods at the real price of one.

Similarly to investment goods, firm's face a perfectly elastic supply of labor at a given (stochastic) equilibrium real wage rate  $W_t$  (or labor cost per worker). The equilibrium real wage rate  $W_t$  is assumed to be an increasing function of the demeaned aggregate productivity shock

$$W_t = \lambda \exp(w(x_t - \bar{x})), \quad (9)$$

with  $\lambda > 0$  and  $0 < w < 1$ . In this specification,  $\lambda$  is a scaling factor and the constraint  $0 < w < 1$  allows us to capture the fact that the aggregate real wage rate is less volatile than aggregate productivity (output) as well as some, albeit very small, procyclicality of the real wage rate, as reported in Gomme and Greenwood (1995) and Merz and Yashiv (2007) in US data.<sup>12</sup>

## 3.2 Firm's Maximization Problem

All firms in the economy are assumed to be all-equity financed, so we define

$$d_t = y_t - W_t n_t - i_t - g(i_t, h_t, k_t, n_t), \quad (10)$$

to be the dividends distributed by the firm to the shareholders. The dividends consist of output  $y_t$ , less the wage bill  $W_t n_t$ , investment  $i_t$  and adjustment costs of investment and hiring summarized by the function  $g(i_t, h_t, k_t, n_t)$ . A negative dividend is considered as equity issuance.

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

$$V^{\text{cum}}(s_t) = \max_{i_{t+j}, h_{t+j}, j=0..∞} \left\{ \mathbb{E}_t \left[ \sum_{j=0}^{\infty} M_{t,t+j} d_{t+j} \right] \right\}, \quad (11)$$

subject to the capital and labor accumulation equations (4) and (5) for all dates  $t$ . The operator  $\mathbb{E}_t[\cdot]$  represents the expectation over all states of nature given all the information available at time  $t$ .

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<sup>12</sup>As reported in Gomme and Greenwood (1995) the international evidence on the procyclicality of the real wage rate is mixed, but is slightly procyclical in the US economy.

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

$$1 + g_{it} = \mathbb{E}_t [M_{t,t+1} (\alpha_k e^{x_t+z_t} k_t^{\alpha_k-1} n_t^{\alpha_n} + (1 - \delta_k) - g_{kt+1} + (1 - \delta_k)g_{it+1})] \quad (12)$$

$$g_{ht} = \mathbb{E}_t [M_{t,t+1} (\alpha_n e^{x_t+z_t} k_t^{\alpha_k} n_t^{\alpha_n-1} - W_{t+1} - g_{nt+1} + (1 - \delta_n)g_{ht+1})] \quad (13)$$

where we used the notation  $g_{it}$  to denote the first partial derivative of the function  $g$  with respect to the variable  $i$ . The first order conditions (12) and (13) establishes a link between the exogenous stochastic discount factor, the exogenous wage rate and the firm's 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.

### 3.2.1 Firm's Market Value, Risk and Expected Return

To simplify the notation, denote the marginal costs of investment and hiring as  $q_t^k$  and  $q_t^n$ , also known as the investment marginal  $q$  and the hiring marginal  $q$ . Using the adjustment cost functional form specified in equation (6), these costs are given by

$$q_t^k \equiv 1 + g_{it} = 1 + c_k \left( \frac{i_t}{k_t} \right)^{v_k-1} \quad (14)$$

$$q_t^n \equiv g_{ht} = c_n \left( \frac{h_t}{n_t} \right)^{v_n-1}, \quad (15)$$

which only depend on the investment and hiring rate.

To help in the interpretation of the results, we assume in this section that the production function specified in equation (1) has constant returns to scale. This assumption allows us to establish a link between the firm's market value, the firm's expected stock return and the firm's investment and hiring rates in closed form as stated in Proposition 1.

**Proposition 1** *When the firm's production and adjustment cost functions are both homogeneous of degree one, the ex dividend market value of the firm  $V_t^{ex}$  is given by*

$$V_t^{ex} = \underbrace{q_t^k k_{t+1}}_{\text{Market value of capital}} + \underbrace{q_t^n n_{t+1}}_{\text{Market value of labor}}, \quad (16)$$

and the firm's expected stock return is given by

$$\mathbb{E}_t [R_{t+1}^s] = \frac{\mathbb{E}_t [q_{t+1}^k k_{t+2} + q_{t+1}^n n_{t+2} + d_{t+1}]}{q_t^k k_{t+1} + q_t^n n_{t+1}} \quad (17)$$

where  $q_t^k \equiv 1 + c_k \left(\frac{i_t}{k_t}\right)^{v_k-1}$  and  $q_t^n \equiv c_n \left(\frac{h_t}{n_t}\right)^{v_n-1}$  are the marginal costs of investment and hiring respectively.

**Proof.** See Appendix A-2. The market value decomposition is simply an extension of Hayashi's (1981) result to a multi factor inputs setting (see Merz and Yashiv, 2007, and Galeotti and Schiantarelli, 1991, for a similar result). Equation (17) follows directly the definition of stock return  $R_{t+1}^s = (V_{t+1}^{\text{ex}} + d_{t+1})/V_t^{\text{ex}}$ . Since this equation holds ex post state by state, it also holds ex ante in expectation. ■

According to equation (16) in Proposition 1, the market value of the firm reflects the market value of both its capital and labor inputs when both inputs are subject to adjustment costs. Intuitively, the quasi-fixed nature of capital and labor allows firms to extract rents from these inputs and make operational profits. This result contrasts with that from standard q theory of investment with no labor adjustment costs, in which case the market value of the firm is equal to the value of the firm's capital stock. When labor is costlessly adjusted, labor receives its share in output and firms do not extract any rents from it. Note however that, in contrast to the value of the capital stock, when the firm faces labor adjustment costs the value of hired (installed) labor for the firm can be negative (if the wage rate is too high).

Equation (17) in Proposition 1 establishes a link between the firm's expected return and its investment and hiring rates. Thus firm characteristics can be interpreted as proxies for the firm's conditional beta, which provides theoretical support for the use of these firm characteristics in predictability regressions. To understand this link, we follow Cochrane (2002) and Chen and Zhang (2009) and re-write equation (17) in beta-pricing form:

$$\mathbb{E}_t [R_{t+1}^s] = R_t^f + \beta_t \lambda_{mt} \quad (18)$$

where  $R_t^f$  is the risk-free rate,  $\beta_t \equiv -\text{Cov}_t(R_{t+1}^s, M_{t,t+1})/\text{Var}(M_{t,t+1})$  is the amount of risk, and  $\lambda_{mt} \equiv \text{Var}(M_{t,t+1})/\mathbb{E}_t[M_{t,t+1}]$  is the price of risk is given. Combining equations (17) and (18) yields

$$\beta_t = \left( \frac{\mathbb{E}_t [q_{t+1}^k k_{t+2} + q_{t+1}^n n_{t+2} + d_{t+1}]}{q_t^k k_{t+1} + q_t^n n_{t+1}} - R_t^f \right) / \lambda_{mt} \quad (19)$$

where  $q_t^k \equiv 1 + c_k \left(\frac{i_t}{k_t}\right)^{v_k-1}$  and  $q_t^n \equiv c_n \left(\frac{h_t}{n_t}\right)^{v_n-1}$ . This equation trivially links the firm's conditional beta to firm characteristics, a result familiar to the investment-based asset pricing models of Cochrane (1991 and 1996), Liu, Whited and Zhang (2007) and Li, Livdan and Zhang (2008), for example.

## 4 Properties of the Model Solution

All the endogenous variables in the model, including the firm’s investment and hiring rates, risk and expected returns, are functions of the state variables. Because the functional forms are not available analytically, in this section we solve for these functions numerically and study their properties. In order to compute the model implied moments for asset prices and quantities, we proceed as follows. To neutralize the effect of initial conditions, we use the calibrated theoretical model to first simulate 3600 firms for 1000 years. We then take the end values of the cross-section of state variables from this simulation as the initial stationary distribution of the state variables in the economy. Using this stationary distribution, we create 1000 artificial panels, each of which has 3600 firms and 50 annual observations. Appendix A-3 provides a description of the solution algorithm and the numerical implementation of the model.

### 4.1 Calibration

The model is calibrated at annual frequency using the parameter values reported in Table 8. 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, including the aggregate and idiosyncratic productivity shocks, the wage rate and the stochastic discount factor.

[Insert Table 8 here]

The choice of the parameter values in the benchmark calibration is based on the parameter values reported in previous studies whenever possible. The additional free parameters are chosen to approximately match known aggregate asset pricing moments as well as key firm level moments reported in Table 1. In particular, we focus mainly on the first and second moments of the aggregate stock market and risk-free rate, and the first and second moments of the firm level investment and hiring rates and book-to-market ratio.

**Firm’s technology:** We set the output-capital elasticity parameter to  $\alpha_k = 0.31$  and the output-labor elasticity parameter to  $\alpha_n = 0.62$  in the Cobb-Douglas production function (1), which are close to the values reported in Gomes (2001). The capital depreciation rate  $\delta_k$  is set as 10% per annum as in Jermann (1998). The quit rate of labor is set at  $\delta_n = 20\%$  per annum. This estimate is based on the monthly quit rate reported by the Bureau of Labor Statistic JOLTS (Job Openings and Labor Turnover) data and by Davis, Faberman and Haltiwanger (2006) for the manufacturing sector.

The slope coefficients  $c_k$  and  $c_n$  in the adjustment cost function (6) determine the importance of the adjustment cost of each input. Empirical estimates of these parameters vary

substantially across studies and so they are difficult to calibrate. Estimates of  $c_k$  in the investment literature range from 20 in Summers (1980), to 2 in Whited (1993) to not significantly different from 0 in Hall (2004). Estimates related to  $c_n$  in Merz and Yashiv (2007), Shapiro (1986) (for nonproduction workers), Galeotti and Schiantarelli (1991) suggests that labor adjustment costs can be substantial while Hall (2004) and Shapiro (1986) (for production workers) finds them to be negligible (see also Hamermesh, 1993, and Hamermesh and Pfann, 1996, for a review of empirical studies on labor demand). The curvature parameters  $v_k$  and  $v_n$  in the adjustment cost function (6) controls the elasticity of the investment and hiring rate with respect to the investment and hiring marginal q, respectively. The literature also does not provide much guidance on the magnitude of these parameters. For tractability, the quadratic adjustment cost specification ( $v_k = v_n = 2$ ) has been often used in the literature, but some empirical evidence reviewed in Hamermesh and Pfann (1996) seems to reject this specification. Thus we set the adjustment cost parameters by calibrating the model to be consistent with the most recent estimates of labor and capital adjustment cost functions provided in Merz and Yashiv (2007) as well as with features of the US financial markets and firm level data reported in Table 1. In particular we look for parameters that are consistent with a 5 – 8% equity premium and annual firm level investment and hiring rate volatilities around 13% and 16% respectively. Through some experimentation, we set the slope parameter  $c_k = 1$  and  $c_n = 0.6$ , since Merz and Yashiv estimates  $c_k$  to be larger than  $c_n$ . In addition, we set the curvature parameters as  $v_k = 2.65$  and  $v_n = 2.40$ . We assess the reasonability of these parameter values below by investigating the implied magnitude of the total and marginal investment and hiring adjustment costs.

**Stochastic processes:** We set the persistence of aggregate productivity shock  $\rho_x = 0.98^4$  and conditional volatility  $\sigma_x = 0.007 \times 2$  as in King and Rebelo (1999). The long-run average level of aggregate productivity,  $\bar{x}$ , is a scaling variable. We set the average long-run capital in the economy at 1/4, which implies that the long-run average of aggregate productivity  $\bar{x} = -2.23$ . To calibrate the persistence  $\rho_z$  and the conditional volatility  $\sigma_z$  of the firm-specific productivity shock, 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 we set  $\rho_z = 0.78$ , and  $\sigma_z = 0.35$ , which implies an average annual volatility of individual stock returns of 24.4%, approximately the average of 25% reported by Campbell et al (2001) and 32% reported by Vuolteenaho (2001).

In the specification of the wage rate process in equation (9) we set  $w = 0.20$  and  $\lambda = 0.037$ . The parameter  $w$  controls the sensitivity of the the aggregate real wage rate to the aggregate productivity growth. This sensitivity is around 0.2 in the aggregate level data of Merz and Yashiv (2007). The parameter  $\lambda$  determines the average wage rate in the economy. We choose  $\lambda = 0.037$  to match the average firm level book-to-market ratio ratio.



Following Zhang (2005), we pin down the three parameters governing the stochastic discount factor,  $\beta$ ,  $\gamma_0$ , and  $\gamma_1$  to match three aggregate return moments: the average real interest rate, the volatility of the real interest rate, and the market equity premium. This procedure yields  $\beta = 0.94$ ,  $\gamma_0 = 28$ , and  $\gamma_1 = -300$ .

## 4.2 Evaluating the Benchmark Calibration

[Insert Table 9 here]

Table 9, Panel A, reports key moments of aggregate asset prices and measures of adjustment costs both in the real data and in the artificial data generated by the benchmark calibration of the theoretical model (case 1). The benchmark calibration does a reasonable job matching these key moments. By construction, the model quantitatively matches reasonably well the first two moments of the aggregate market return and risk free rate. The Sharpe ratio implied by the model is only slightly lower than in the data (0.33 vs 0.43). The magnitude of the adjustment costs in the model are also reasonable. The fraction of output that is lost due to capital and labor adjustment costs is around 6%. The marginal investment adjustment cost is \$2.23 per \$100 dollar invested and the marginal hiring adjustment cost is 1.7 the annual wage per worker.<sup>13</sup> These values are within some of the empirical estimates surveyed in Hamermesh and Pfann (1996), and discussed in Merz and Yashiv (2007).

The benchmark calibration of the model also does a reasonable job matching key firm level moments, in particular the second moment of the firm level investment and net hiring rate, and the first two moments of the book to market ratio, as reported in Table 9, Panel B (the means of the investment and hiring rates are pinned down by the capital depreciation rate and the quit rate). The implied correlation between the investment and the net hiring rate is higher than in the data, however. This result is expected for several reasons. First, both the investment and hiring rates are likely to be measured with error in the data and thus the empirical measure of correlation between these two variables is biased downwards (towards zero). In addition, the empirical correlation is subject to time aggregation problems because these variables are only observed at an annual frequency in the sample but are likely to be adjusted within the year, a feature that is absent from the model. Finally, in the interest of parsimony, we restricted the wage rate to be perfectly correlated with the aggregate productivity shock and assumed the quit rate to be constant. In the data however, the wage rate is not perfectly correlated with the aggregate productivity shock and the quit rate from

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<sup>13</sup>These values are evaluated at the steady-state of the investment and hiring rate, i.e.  $HN_t = \delta_n = 0.2$  and  $IK_t = \delta_k = 0.1$ . Given the adjustment cost functional form specified in equation (6) the marginal investment adjustment cost is  $MgI = c_k(IK_t)^{v_k-1}$  and the marginal hiring adjustment cost in terms of wages is  $MgH = c_n(HN_t)^{v_n-1}/\bar{W}$  where  $\bar{W}$  is the average wage rate in the model which is approximately equal to  $\lambda = 0.037$ .

labor is stochastic, and these properties are likely to affect primarily the firm’s hiring rate, thus helping to explain its observed relatively low correlation with the investment rate.

In addition to the benchmark case, we consider other alternative calibrations of the model, reported in Table 9, Panel A and Panel B (cases 2 to 5). We use these alternative calibrations to help us interpret the cross-sectional simulation results in Section 5.

### 4.3 Value Function, Policy Functions and Risk

Figure 3 plots the firm’s value function, policy functions (gross investment and net hiring rates) and risk obtained from the numerical solution of the benchmark calibration of the model. The firm level risk is measured by the firm’s conditional beta  $\beta_t$  which we infer in the model using equation (18). These functions depend on the four state variables, the capital stock  $k_t$ , the labor stock  $n_t$ , the aggregate productivity  $x_t$ , and the idiosyncratic productivity  $z_t$ . Because the focus of this paper is on cross-sectional heterogeneity, we fix the aggregate productivity at its long-run average,  $x_t = \bar{x}$  and we plot each function at two different values of the idiosyncratic productivity level  $z_t$  (high and low). The panels on the left, plot each function against  $k_t$ , with  $n_t$  and  $x_t$  fixed at their long-run average levels  $\bar{n}$  and  $\bar{x}$ . The panels on the right, plot each function against  $n_t$  and  $z_t$ , with  $k_t$  and  $x_t$  fixed at their long-run average level  $\bar{k}$  and  $\bar{x}$ . The x-axis variables are expressed as a proportion of the steady-state level of the corresponding variable. Thus a value of the capital stock of 0.5 (similarly for labor), corresponds to a capital stock that is half of the steady-state level of capital.

[Insert Figure 3 here]

The top two panels show that the firm’s market value is increasing in the firm’s productivity, capital stock and labor stock. The two panels in the middle show that gross investment and net hire are increasing in the firm’s productivity. Thus more profitable/high productivity firms invest and hire more than less profitable/low productivity firms. This result is consistent with the portfolio evidence reported in Table 6, as well as with the evidence documented in Fama and French (1995). Gross investment and net hire are also decreasing in the capital stock and labor stock, respectively. Thus small firms with less capital and labor, invest and hire more (and thus grow faster) than big firms with more capital and more labor. This result is consistent with the evidence provided by Evans (1987) and Hall (1987).

The last two panels in Figure 3 show that the firm’s risk is decreasing in the firm’s productivity and capital stock. This result is consistent with Zhang (2005), who shows that less profitable/low productivity firms are riskier than more profitable/high productivity

firms, and is also consistent with Li, Livdan and Zhang (2007) who show that small firms with less capital are more risky than big firms with more capital. The relationship between the firm's risk and the firm's labor stock is mostly flat, while there is a negative relationship between the firm's risk and the firm's capital stock. All else equal, a higher stock of capital or labor decreases the firm's *marginal* investment and hiring adjustment cost, making it less risky. Also, with decreasing returns to scale, a higher capital level also makes the firm less risky because the next period's value of capital is less sensitive to productivity shocks than the next period's output. Two other effects determine the relationship between labor and risk. First, a larger stock of labor makes a firm less risky. More labor makes the firm more productive per unit of capital and this in turn, implies that, net of depreciation, the firm's profits are less risky. Second, since firm has to pay workers the going wage regardless of the firm's productivity, a higher labor stock makes the firm more risky. These effects of the labor stock on the firm's risk mostly cancel out each other over the range of values plotted.

#### 4.4 Labor Hiring, Investment and Firm's Risk

The negative relationship between the firm's risk and the firm's investment and hiring rates, which is the empirical fact that we want to explain, is more difficult to investigate because the investment and hiring rates are not state variables of a firm's problem. Combining the information across panels in Figure 3 however, it is easy to infer that the model replicates the negative relationship observed in the data because of the positive relationship between the firm's productivity and the firm's investment and hiring rates (middle panels) and the negative relationship between the firm's productivity and firm's risk (bottom panels). In addition, these figures show that neither the investment rate or the hiring rate are sufficient statistics to characterize the firm's risk. Mechanically, this result follows from the fact that the model has multiple state variables. In economic terms, all else equal, the stock of capital and labor affects the slope of the marginal adjustment cost function, which in turn determines the ability of the firm to adjust investment and labor in response to shocks. This feature of the model helps to explain why, empirically, both the investment and hiring rate have marginal predictive power for expected stock return. We document this property of the model quantitatively in the next section.

The negative relationship between the firm's risk and the firm's investment and hiring rates is a direct consequence of the convexity of the adjustment cost function in both capital and labor inputs. For example, in bad times, when most firms are firing and desinvesting to decrease production, a bad aggregate shock in the economy will have a larger negative effect on the returns of the firms that are firing and desinvesting relatively more because convex adjustment costs makes it relatively more costly for these firms to further reduce their labor and capital stock. Likewise, a positive aggregate shock in the economy will have a higher

positive effect on these firms because of the relatively higher decrease in the adjustment costs as these firms scale back their desinvesting and firing plans. In good times, an analogous mechanism applies. Taken together, this mechanism implies that the returns of the firms that are hiring or investing relatively less fluctuate more closely with economic conditions (have higher betas) and thus these firms must offer higher average returns in equilibrium as a compensation for their higher level of risk.

## 5 Model Implications for the Cross-Section of Stock Returns

In this section, we investigate if the benchmark calibration of the model can qualitatively and quantitatively match the cross-sectional empirical facts reported in Section 2. We replicate the empirical procedures on the artificial data simulated by the model and report the cross-sample average results. In addition, to understand the variation in the predictability of the investment and the hiring rate for stock returns across technologies and over time, we consider alternative calibrations of the model. Finally, to investigate the importance of labor adjustment costs for matching the empirical evidence, we examine the results from a calibration of the model in which labor adjustment costs are set to zero.

The key cross-sectional asset pricing results on the simulated data for each calibration of the model are reported in the last three columns of Table 9, Panel B. The column FMB slope coefficients reports the average investment rate (IK) and hiring rate (HN) FMB slope coefficients across the 1000 simulations with the corresponding standard errors in parenthesis. The last column, portfolio spread, reports the average returns of a high minus low (spread) portfolio that goes long one dollar on a portfolio of firms with low investment and low hiring rates (bottom 33<sup>th</sup> percentile of the corresponding cross-sectional distribution) and short one dollar on the portfolio of firms with high investment and high hiring rates (top 33<sup>th</sup> percentile of the corresponding cross-sectional distribution).

### 5.1 Labor Hiring, Investment and Stock Return Predictability

#### 5.1.1 Fama-MacBeth Cross-Sectional Regressions

The model replicates well the negative slope of the investment rate and the hiring rate in the FMB cross-sectional regressions. As reported in Table 9, Panel B, the estimated average FMB investment and hiring rate slope coefficients in the benchmark calibration (case 1) are close to the empirical estimates. For the investment rate, the simulated average FMB slope is  $-0.82$  which is slightly higher (in absolute value) than the empirical slope of  $-0.45$ . For

the hiring rate the fit is better. The simulated average FMB slope is  $-0.59$  which is virtually identical to the empirical slope of  $-0.57$ . The histogram of the estimated FMB investment and hiring rate slope coefficients across the 1000 simulations of the model reported in Figure 4, Panel A, confirms that the FMB slope coefficients estimated in the data are well inside the distribution of the FMB slope coefficients generated by the model.

[Insert Figure 4 here]

### 5.1.2 Portfolio Approach

The benchmark calibration of the model also replicates reasonably well the portfolio results in terms of key portfolio characteristics, the failure of the unconditional CAPM and the better fit of the Fama French (1993) asset pricing model on the nine portfolios double sorted on investment and hiring rate. We replicate the construction of these portfolios on the simulated data following the procedure used in the real data, as described in Section 2.4. Here, we measure the firm’s market to book ratio as the ratio of the ex-dividend market value of the firm and the firm’s stock of physical capital, and the firm’s size is the ex-dividend market value of the firm. Table 10 reports the mean characteristics (averages across the simulated 1000 samples) of these 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, as reported in Table 6. The value-weighted and the equally-weighted average excess returns 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. The fit along the size and the labor to capital ratio characteristics is more modest, partially because the link between these characteristics and the investment and hiring rates is not monotone in the data.

[Insert Table 10 here]

In order to replicate the time series asset pricing tests, we follow Fama-French (1993) and construct the market excess return, the SMB and the HML factors using the simulated data. Table 11, Panel A reports the asset pricing test results for the CAPM and Table 11, Panel B reports the asset pricing test results for the Fama-French (1993) model. Here, we focus on the value-weighted portfolios since the results for the equally-weighted portfolios are qualitatively similar (the failures are even more pronounced on equally-weighted portfolios). The unconditional CAPM market betas of each portfolio goes in the theoretically right direction, i.e., the portfolio of firms with high investment or hiring rates has lower market betas, which is consistent with their lower average returns. Nevertheless, the unconditional CAPM is clearly rejected on these portfolios by the GRS test, with a p-val of 1.74%, because

the spread in the market betas is too small relative to the spread in the realized average excess returns. As a result, the model generates large and statistically significant alphas. The failure of the CAPM on these portfolios can also be seen in the plot of the pricing errors generated by the model, reported in the left panel of Figure 5. Because the spread in betas is too small, the relationship between the realized average excess returns and the predicted excess returns is too steep (vertical) relative to the 45° degree line along which all asset should lie.

[Insert Table 11 here]

[Insert Figure 5 here]

As in the real data, the Fama-French (1993) asset pricing model captures the cross-sectional variation in the returns of these portfolios better than the unconditional CAPM. Table 11 shows that the Fama-French model is (marginally) not rejected by the GRS test with a p-val of 11.03%. Consistent with the empirical results, the only difficulty of the model is in pricing the high-high portfolio (portfolio 33), but the economic magnitude of the pricing error on this portfolio is small (alpha of 0.96% per annum). 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 right panel of Figure 5, with most portfolios along the 45° degree line.

## 5.2 Predictability Across Technologies

In the data, the predictability of both the investment and the hiring rate for stock returns varies with the characteristics of the firm’s technology as measured by the firm’s capital intensity. Here, we consider two alternative calibrations of the theoretical model to investigate two potential (complementary) explanations of the predictability pattern in the data. The first explanation is based on differences in the parameters  $\alpha_k$  and  $\alpha_n$  in the production function (1). These parameters control the firm’s capital intensity and thus it is natural to investigate the impact of these parameters on the investment and hiring rate predictability. The second explanation is based on differences in the relative magnitude of the capital and labor adjustment costs parameters across firms, as captured by the slope parameters  $c_k$  and  $c_n$  in the adjustment cost function (6). The rationale for this explanation follows from the firm’s market value decomposition in Proposition 1, equation (16). These adjustment cost parameters have a first order effect on the firm’s investment and hiring marginal  $q$ ’s. As a result, and holding all else constant, inputs with higher adjustment cost represent a larger proportion of the firm’s market value (have higher shadow price) and thus, for a reasonable range of parameters, it is natural to expect a positive relation between the relative magni-

tude of the adjustment cost parameters  $c_i$  and the magnitude of the FMB slope coefficients of the corresponding input.

In order to examine the effect of the capital and labor intensity parameters  $\alpha_k$  and  $\alpha_n$  on the FMB investment and hiring rate slope coefficients in the stock return predictability regressions, we consider a calibration of the model in which  $\alpha_k = 0.13$  and  $\alpha_n = 0.8$  (Labor intensive economy - case 2) and a calibration of the model in which  $\alpha_k = 0.8$  and  $\alpha_n = 0.13$  (Capital intensive economy - case 3) (in the benchmark model these parameters are  $\alpha_k = 0.31$  and  $\alpha_n = 0.62$ ). Note that the degree of returns to scale is the same across all specifications (0.93). We then compare the estimated investment and hiring rate FMB slope coefficients across the alternative calibrations with those obtained in the benchmark calibration of the model.

As reported in Table 9, Panel B, the magnitudes of *both* the FMB investment *and* hiring rate slope coefficients in the labor intensive economy (case 2) are considerably larger (in absolute value) than in the benchmark calibration of the model (case 1), in contrast with the data. The results for the capital intensive economy (case 3) are consistent with the data. Here, in comparison with the benchmark model, the magnitudes of the FMB investment rate slope coefficient is higher than in the benchmark calibration ( $-0.96$  vs  $-0.82$ ), while the FMB hiring rate slope coefficients is considerably smaller ( $-0.25$  vs  $-0.59$ ). Taken together, the results from these two specifications suggest that differences in the capital intensity parameter across firms is only a partial explanation for the observed pattern of the FMB investment and hiring rate slope coefficients across technologies since it only explains the pattern across capital intensive firms.

Turning the analysis to the second explanation, we consider a calibration of the model in which the slope parameters of the adjustment cost function (6) are set to  $c_k = 0.2$  and  $c_n = 2$  (in the benchmark model these parameters are  $c_k = 1$  and  $c_n = 0.6$ ). We define this specification as the high relative labor adjustment cost economy (case 4), since labor is relatively more costly to adjust and capital relatively less costly to adjust in this calibration than in the benchmark calibration.

As reported in Table 9, Panel B (case 4), the decrease in the magnitude of the capital adjustment cost parameter generates a decrease in the magnitude (absolute value) of the investment rate FMB slope coefficients ( $-0.82$  in the benchmark case to  $-0.64$  in this case), and an increase in the absolute value of the hiring rate FMB slope coefficient ( $-0.59$  in the benchmark case to  $-0.96$  in this case). This result suggests that there is a strong positive link between the relative magnitude of the adjustment cost parameters  $c_i$  and the magnitude of the FMB slope coefficients of the corresponding input.

To help in the interpretation of the previous findings, we also compute the fraction of the

firm's value that is attributed to labor in each specification. This fraction is computed as

$$\% \text{ Labor Value} = \frac{q_t^n n_{t+1}}{q_t^n n_{t+1} + q_t^k k_{t+1}}, \quad (20)$$

which follows from equation (16), in Proposition 1. This value is just an approximation since it is based on the firm value decomposition for a constant returns to scale production technology. As reported in Table 9, Panel A (see column % Labor Value), in the labor intensive economy, the fraction of the firm's value that is attributed to labor is 49% (case 2), only 3% in the capital intensive economy (case 3) and 44% in the high labor relative adjustment cost economy (case 4). In the benchmark calibration (case 1), the fraction of the firm's value attributed to labor is 30%. This result suggests that, for the range of parameter values considered here, there is a positive relationship between the size of the labor intensity parameter  $\alpha_n$ , the labor adjustment cost slope parameter  $c_n$  and the fraction of the firm's value that is attributed to labor.

Taken together, the results in this section suggest that the investment rate is a less significant predictor of stock returns across labor intensive firms than in capital intensive firms because a relatively larger fraction of the market value of the labor intensive firms reflects the value of its labor inputs. This result follows not only because labor intensive firms use relatively more labor and less capital (high  $\alpha_n$ , low  $\alpha_k$ ), but also because capital inputs are likely to be more easily adjusted in labor intensive firms (low  $c_k$ ) and hence have a low shadow price (investment marginal  $q$ ). For capital intensive firms, the converse is true. Unfortunately, there is no direct empirical evidence, that we are aware of, on the relative importance of capital and labor adjustment costs across firms with different capital and labor intensities against which we can compare our results.

### 5.3 Predictability Over Time

In the data, the predictability of the hiring rate for stock returns has increased over time and the opposite pattern is observed for the investment rate, especially after the early 1980's (see Figure 1). The discussion and the results in the previous section for the high relative adjustment cost economy (case 4), suggests a possible explanation for this empirical fact. According to this explanation, the increase in the magnitude of the hiring rate FMB slope coefficient in the stock return predictability regressions reflects an increase in the relative magnitude of the labor adjustment cost slope coefficient  $c_n$  after the early 1980's, while a symmetric pattern has occurred for the slope coefficient  $c_k$  of capital adjustment costs.

Interestingly, the previous explanation is consistent with empirical evidence suggesting an increase in the cost of adjusting the labor force in recent decades. Hall (1987) estimates reduced form equations of the employment growth process at the firm level and finds that



labor adjustment costs rose in the 1970's and early 1980's. As discussed in Acemoglu (2001), the change in the composition of the labor force from unskilled to skilled workers in the second half of the 20th century has made the worker screening, selection and hiring process more costly for employees. Consistent with this view, Hamermesh and Pfann (1996) report results from micro studies that show that high skilled labor is more costly to adjust than low skilled labor. Cappelli and Wilk (1997) show that there has been a large change in the screening process of production workers in the 1970's and 1980's and Murnane and Levy (1996) report case study evidence of firms establishing lengthy selection processes in more recent years, consistent with higher labor adjustment costs.

Additionally, and as reported in Table 9, Panel A, an increase in the relative magnitude of labor adjustment costs leads to an increase in the average fraction of the firm's value that is attributed to labor from 30% (benchmark case 1) to about 44% (case 4) (see column % Labor Value), and thus a corresponding decrease in the fraction of the firm's value attributed to capital. The increase in the proportion of the firm's value attributed to labor is consistent with the findings in Hall (2001), who finds that the increase in the firms' market value in the 1990's cannot be completely explained by the increase in the value of the firms' stock of physical capital. The difference is attributed to an increase in the value of intangible capital, which in our setup also includes the value for the firm of its labor stock.

## 5.4 The 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 calibration of the model in which labor adjustment costs are set to zero ( $c_n = 0$ ). In addition, we allow labor to be instantaneously adjusted every period in response to the realization of the state of nature (i.e. labor is not chosen one period in advance as in the benchmark model). Naturally, in this case, the firm 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.

As reported in Table 9, Panel B, the estimated average FMB hiring rate slope coefficient in the model with no labor adjustment costs (case 5) is estimated to be exactly zero. As reported in histogram of the estimated FMB investment and hiring rate slope coefficients across the 1000 simulations of this model Figure 4, Panel B, right panel, this result holds in virtually all the simulated samples. The portfolio results confirm this finding. The nine investment and hiring rates double sorted portfolios using artificial data from the model with no labor adjustment costs exhibit average returns that are non monotone across the hiring rate (results not reported here for brevity but available upon request).

The result in this section is intuitive. Without labor adjustment costs, firms do not extract any rents from labor, and all the rents accrue to workers. As a result, the market

value of the firm only reflects the value of the capital inputs. At the same time, because total adjustment costs only depend on the firm's investment rate, hiring is not informative about the ability of the firm to adjust to aggregate shocks and thus about the firm's riskiness. This result however, is not supported by the data.

## 6 Conclusion

We find a negative relationship between the firm's hiring and investment rates and future stock returns in the cross-section of US publicly traded firms. We show that a production-based asset pricing model with adjustment costs in both labor and capital inputs can replicate the main empirical fact reasonably well with plausible parameter values. Taken together, our results provide indirect evidence for the importance of labor adjustment costs at the firm level, since the empirically documented stock return predictability of hiring shows up in the model only in the presence of labor adjustment costs.

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## A-1 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.

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,  $n$ . 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-year end in t-1 divided by assets per split-adjusted share at the fiscal-year end 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 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  $s_t = (k_t, n_t, x_t, z_t)$  where  $k_t$  is the firms current capital stock,  $n_t$  is the firms current labor stock,  $x_t$  is the current period aggregate productivity shock, and  $z_t$  is the current period firms' productivity shock. Let  $f(k_t, n_t) = k_t^{\alpha_k} n_t^{\alpha_n}$  so that

$y_t = \exp(x_t + z_t)f(k_t, n_t)$ . The first-order-conditions for  $i_t, h_t, k_{t+1}$ , and  $n_{t+1}$  are

$$q_t^k = 1 + g_{it} \quad (21)$$

$$q_t^n = g_{ht} \quad (22)$$

$$q_t^k = \mathbb{E}_t M_{t,t+1} [e^{x_{t+1}+z_{t+1}} f_k(k_{t+1}, n_{t+1}) - g_{kt+1} + (1 - \delta_k)q_{t+1}^k] \quad (23)$$

$$q_t^n = \mathbb{E}_t M_{t,t+1} [e^{x_{t+1}+z_{t+1}} f_n(k_{t+1}, n_{t+1}) - g_{nt+1} - W_{t+1} + (1 - \delta_n)q_{t+1}^n] \quad (24)$$

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

$$y_t = e^{x_t+z_t} f(k_t, n_t) = e^{x_t+z_t} f_k(k_t, n_t)k_t + e^{x_t+z_t} f_n(k_t, n_t)n_t \quad (25)$$

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

$$\lim_{j \rightarrow \infty} \mathbb{E}_t M_{t,t+j} q_{t+j}^k k_{t+j+1} = 0 \quad (26)$$

$$\lim_{j \rightarrow \infty} \mathbb{E}_t M_{t,t+j} q_{t+j}^n n_{t+j+1} = 0 \quad (27)$$

Firm's cum dividend market value is given by

$$V^{\text{cum}}(s_t) = V^{\text{ex}}(s_t) + d_t \quad (28)$$

With equation (10), we have

$$V^{\text{cum}}(s_t) = V^{\text{ex}}(s_t) + y_t - W_t n_t - i_t - g(i_t, k_t, h_t, n_t) \quad (29)$$

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

$$g(i_t, k_t, h_t, n_t) = g_{it}i_t + g_{kt}k_t + g_{ht}h_t + g_{nt}n_t \quad (30)$$

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

$$\begin{aligned} & V^{\text{cum}}(s_t) \\ &= \mathbb{E}_t \sum_{j=0}^{\infty} M_{t,t+j} \{ [e^{x_{t+j}+z_{t+j}} f(k_{t+j}, n_{t+j}) - i_{t+j} - W_{t+j}n_{t+j} - g(i_{t+j}, k_{t+j}, h_{t+j}, n_{t+j})] \\ & \quad - q_{t+j}^k [k_{t+j+1} - (1 - \delta_k)k_{t+j} - i_{t+j}] \\ & \quad - q_{t+j}^n [n_{t+j+1} - (1 - \delta_n)n_{t+j} - h_{t+j}] \} \end{aligned}$$

where  $q_t^k$  and  $q_t^n$  are the Lagrange multipliers associated with the constraints (4) and (5).

Recursively substituting equations (4), (5), (25), (21)-(24) and (30), we get

$$\begin{aligned}
V^{\text{cum}}(s_t) &= y_t - W_t n_t - g_{kt} k_t - g_{nt} n_t + q_t^k (1 - \delta_k) k_t + q_t^n (1 - \delta_n) n_t \\
&\quad - \lim_{j \rightarrow \infty} \mathbb{E}_t M_{t,t+j} q_{t+j}^k k_{t+j+1} - \lim_{j \rightarrow \infty} \mathbb{E}_t M_{t,t+j} q_{t+j}^n n_{t+j+1} \\
&= y_t - W_t n_t - g_{kt} k_t - g_{nt} n_t + q_t^k (1 - \delta_k) k_t + q_t^n (1 - \delta_n) n_t
\end{aligned}$$

The last equality follows transversality conditions (26) and (27). Together with equation (29), we have

$$\begin{aligned}
V^{\text{ex}}(s_t) + y_t - i_t - W_t n_t - g(i_t, k_t, h_t, n_t) \\
= y_t - W_t n_t - g_{kt} k_t - g_{nt} n_t + q_t^k (1 - \delta_k) k_t + q_t^n (1 - \delta_n) n_t
\end{aligned}$$

After re-arranging the previous equations using equations (21), (22) and (30), we get

$$V^{\text{ex}}(s_t) = q_t^k k_{t+1} + q_t^n n_{t+1} \quad (31)$$

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 use a multi-grid algorithm in which the maximum number of points is 200 in each dimension. In each iteration we specify a grid of points for capital and labor, respectively with upper bounds  $\bar{k}$  and  $\bar{n}$  that are large enough to be non-binding. 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  $i = 1, \dots, 200$  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  $\bar{k}$  and  $\bar{n}$ , given two pre-specified lower bounds  $\underline{k}$  and  $\underline{n}$ . The advantage of this recursive construction is that more grid points are assigned around  $\bar{k}$  and  $\bar{n}$ , where the value function has most of its curvature. To accelerate convergence in the presence of a discount factor close to 1, we use the Howard Improvement Algorithm with 20 same-policy repetitions per cycle.

The state variable  $x$  has continuous support in the theoretical model, but it has to be transformed into discrete state space for the numerical implementation. The popular method of Tauchen and Hussey (1991) does not work well when the persistence level is above 0.9.

Because both the aggregate and idiosyncratic productivity processes are highly persistent, we use the method described in Rouwenhorst (1995) for a quadrature of the Gaussian shocks. We use 5 grid points for the  $x$  process and 7 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 investment and hiring which do not lie directly on the grid points. Finally, we use a simple discrete, global search routine in maximizing the firm's problem.

Table 1  
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 twenty observations of firm level characteristics and excludes micro cap firms: it reports the mean, median, standard deviation (std), autocorrelation (AC1) and the 20<sup>th</sup>, 60<sup>th</sup> and 80<sup>th</sup> 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 20<sup>th</sup>, 60<sup>th</sup> and 80<sup>th</sup> 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.

Panel A: Mean across firms of firm level moments

	Mean	Median	std	AC1	Correlation		
					HN	BM	AG
IK	0.24	0.22	0.13	0.45	0.32	-0.08	0.42
HN	0.04	0.02	0.16	0.11	1.00	-0.14	0.50
BM	0.77	0.70	0.38	0.67	-0.14	1.00	-0.06
AG	0.08	0.08	0.14	0.16	0.50	-0.06	1.00

Panel B: Mean across time of cross-sectional moments

	Mean	Median	std	Correlation		
				HN	BM	AG
IK	0.32	0.23	0.33	0.38	-0.20	0.41
HN	0.09	0.03	0.30	1.00	-0.15	0.46
BM	0.97	0.78	0.88	-0.15	1.00	-0.19
AG	0.08	0.07	0.23	0.46	-0.19	1.00

Table 2  
Sample Summary Statistics

This table reports the mean values of selected variables across several groups of firms: the entire pooled sub-sample of COMPUSTAT firms (All Firms) and firms grouped by the firms' labor to capital ratio (LK). rVW and rEW are, respectively, the value-weighted and the equally-weighted annualized monthly excess 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, LS is the labor share (computed using two-SIC digit industry level data as described in Appendix A-1) and # FIRMS is the average number of firms in each group in each year. The data are annual (except returns) and the sample is July 1965 to June 2006.

	rVW	rEW	IK	HN	BM	SIZE	MOM	AG	YB	LK	LS	# FIRMS
All Firms	5.35	10.21	0.32	0.09	0.96	4.95	14.96	8.27	-0.15	10.95	0.65	1360
Capital Intensive	5.52	8.02	0.28	0.08	1.03	5.87	12.73	7.81	-0.66	0.81	0.53	272
Capital and Labor	5.25	10.69	0.31	0.08	0.94	4.98	15.04	8.37	-0.01	5.04	0.68	817
Labor Intensive	5.79	10.98	0.38	0.13	0.94	3.90	16.95	8.45	-0.07	39.01	0.70	270



Table 3

## 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. The left columns reports results for the whole sample period July 1965 to June 2006, the middle columns reports result for the sub-period from July 1965 to June 1985 and the right columns reports results for the sub-period from July 1985 to June 2006. Panel A reports results for a sample that includes all firms and Panel B reports results across capital intensity groups. 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). K minus L provides a t-test for the difference in the slope coefficients for capital intensive (K intensive) firms and labor intensive (L intensive) firms. The returns data is monthly, the accounting data is annual and the sample is from July 1965 to June 2006.

Specification	Full Sample 1965 to 2006				1965 to 1985		1985 to 2006	
	Int	IK	HN	$R^2$	IK	HN	IK	HN
Panel A: All Firms								
#1	1.55 [6.0]	-0.66 [-4.0]	-	0.6 -	-0.61 [-2.3]	-	-0.72 [-3.3]	-
#2	1.40 [5.01]	-	-0.77 [-5.8]	0.3 -	-	-0.58 [-2.9]	-	-0.96 [-5.6]
#3	1.53 [5.90]	-0.45 [-2.7]	-0.57 [-5.0]	0.7 -	-0.47 [-1.9]	-0.39 [-2.4]	-0.42 [-1.9]	-0.75 [-4.7]
Panel B: Capital Intensity Groups								
K Intensive	1.39 [5.82]	-0.65 [-2.66]	-0.18 [-0.92]	1.57 -	-0.49 [-1.25]	-0.12 [-0.37]	-0.81 [-2.70]	-0.24 [-1.02]
K and L	1.56 [6.02]	-0.51 [-2.79]	-0.57 [-3.97]	0.75 -	-0.60 [-2.43]	-0.33 [-1.66]	-0.43 [-1.59]	-0.80 [-3.98]
L Intensive	1.60 [4.81]	-0.26 [-1.57]	-0.90 [-4.66]	0.57 -	-0.36 [-1.40]	-0.84 [-2.52]	-0.16 [-0.78]	-0.96 [-4.72]
K minus L	-0.20 [-0.96]	-0.40 [-1.63]	0.72 [2.54]	1.00 -	-0.13 [-0.35]	0.72 [1.42]	-0.65 [-2.07]	0.72 [2.65]

Table 4  
Economic Significance of the FMB Slope Coefficients

This table reports the predicted (Pred.) and realized (Real.) average returns as well as the realized Sharpe ratio on spread (high minus low) portfolios formed using the predicted return values implied by the estimated FMB slope coefficients of Table 3, Panel A. The spread portfolios are computed for the FMB specifications that include the following return predictors: (1) only the investment rate (IK); (2) only the hiring rate (HN); and (3) both the investment and hiring rates (Both). The predicted monthly return on each individual stock at the end of each June is computed by combining the current values of the explanatory variables with the estimated average monthly regression slopes in each specification. Each stock is then allocated to high and low expected return portfolios based on whether their predicted monthly returns for the next year is above the 70<sup>th</sup> percentile or below the 30<sup>th</sup> percentile of the predicted return cross-sectional distribution for the year. The realized spread (Real. Spread) and the realized Sharpe ratio (Real. Sharpe) of the spread portfolio is then reported. The t-statistics in parenthesis are computed as in Newey-West with 4 lags. The data are monthly and the sample is July 1965 to June 2006.

Return Predictor	Full Sample 1965 to 2006			1965 to 1985			1985 to 2006		
	Pred. Spread	Real. Spread	Real. Sharpe	Pred. Spread	Real. Spread	Real. Sharpe	Pred. Spread	Real. Spread	Real. Sharpe
IK	4.43	5.70 [3.67]	0.60	3.13	4.78 [3.04]	0.81	5.92	6.57 [2.50]	0.55
HN	4.71	6.10 [4.78]	0.80	2.69	3.89 [2.43]	0.60	7.22	8.21 [4.27]	0.95
Both	5.76	7.14 [4.84]	0.79	3.68	4.92 [2.85]	0.71	8.18	9.20 [4.22]	0.91

Table 5  
Relationship With Other Stock Return Predictors

The table shows average slopes and their t-statistics (in parenthesis) from monthly Fama-MacBeth cross-section regressions to predict stock returns for six 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: an intercept (Int), 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 returns data is monthly, the accounting data is annual and the sample is from July 1965 to June 2006.

	Int	IK	HN	SIZE	BM	MOM	AG	NS	AcB <sup>+</sup>	YB <sup>+</sup>	R <sup>2</sup>
#1	1.28 [2.7]	-0.31 [-2.3]	-0.44 [-4.4]	-0.13 [-2.7]	0.20 [2.5]	0.79 [5.7]					3.8 -
#2	1.23 [2.60]	-0.22 [-1.46]	-0.28 [-3.22]	-0.12 [-2.56]	0.19 [2.47]	0.79 [5.73]	-0.58 [-3.02]				3.9 -
#3	1.32 [2.77]	-0.28 [-2.14]	-0.30 [-2.89]	-0.13 [-2.70]	0.19 [2.41]	0.77 [5.59]		-1.36 [-5.04]			4.0 -
#4	1.33 [2.76]	-0.30 [-2.25]	-0.42 [-4.07]	-0.14 [-2.80]	0.17 [2.15]	0.78 [5.68]			-0.29 [-2.00]		3.9 -
#5	1.26 [2.56]	-0.32 [-2.44]	-0.46 [-4.55]	-0.14 [-2.84]	0.23 [2.64]	0.77 [5.57]				0.83 [2.16]	4.0 -
#6	1.31 [2.72]	-0.10 [-0.71]	0.03 [0.31]	-0.13 [-2.81]	0.20 [2.23]	0.73 [5.35]	-1.01 [-4.74]	-1.84 [-6.59]	-0.24 [-1.54]	0.79 [2.08]	4.4 -

Table 6  
 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 33<sup>th</sup> and 66<sup>th</sup> percentile), and then, within each hiring rate bin, all firms are sorted on investment rate (cutoffs at the 33<sup>th</sup> and 66<sup>th</sup> percentile). Inv-L, M and Inv-H stands for the portfolio with low (L), medium (M) and high (H) cross sectional investment rates respectively, while Hire-Low, Hire-Med and Hire-High stand for the portfolio with low, medium and high cross sectional hiring rates respectively. rVW is the mean value-weighted excess return (in excess of the risk-free rate) and rEW 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 returns data is monthly, the accounting data is annual and the sample is from July 1965 to June 2006.

	Hire-Low			Hire-Med			Hire-High		
	Inv-L	M	Inv-H	Inv-L	M	Inv-H	Inv-L	M	Inv-H
rEW	13.30	12.91	12.42	12.03	10.66	9.68	10.46	7.29	3.6
rVW	8.37	7.35	5.42	7.90	7.29	3.36	6.94	4.40	1.32
HN	-0.14	-0.11	-0.11	0.03	0.03	0.04	0.29	0.3	0.45
IK	0.08	0.17	0.41	0.11	0.22	0.46	0.16	0.34	0.91
BM	1.45	1.15	1.00	1.15	0.88	0.79	0.95	0.72	0.58
SIZE	4.21	5.02	4.57	5.04	5.72	5.30	4.72	5.13	4.84
AG	-0.08	-0.01	0.03	0.02	0.07	0.11	0.11	0.18	0.30
YB	-0.31	-0.17	-0.27	0.02	-0.89	0.06	0.03	0.06	0.06
LK	9.14	7.47	10.75	7.37	7.73	14.96	12.71	13.4	14.62

Table 7  
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 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. Inv-L, M and Inv-H stands for the portfolio with low (L), medium (M) and high (H) cross sectional investment rates respectively, while Hire-Low, Hire-Med and Hire-High stand for the portfolio with low, medium and high cross sectional hiring rates respectively. The returns data is monthly, the accounting data is annual and the sample is from July 1965 to June 2006.

Panel A: CAPM Tests

Portfolios	equally-weighted Portfolios								
	Hire-Low			Hire-Med			Hire-High		
	Inv-L	M	Inv-H	Inv-L	M	Inv-H	Inv-L	M	Inv-H
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]							

Panel B: Fama-French Three Factor Model Tests

	equally-weighted Portfolios								
	Inv-L	M	Inv-H	Inv-L	M	Inv-H	Inv-L	M	Inv-H
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 8  
Parameter Values under Benchmark Calibration

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

Parameter	Value	Description
Technology		
$\alpha_k$	0.31	Elasticity of output with respect to capital
$\alpha_n$	0.62	Elasticity of output with respect to labor
$\delta_k$	0.10	Rate of depreciation for capital
$\delta_n$	0.20	Quit rate of labor
$v_k$	2.65	Curvature parameter in the adjustment cost function (investment)
$v_n$	2.40	Curvature parameter in the adjustment cost function (labor)
$c_k$	1	Slope parameter in capital adjustment cost
$c_n$	0.6	Slope parameter in labor adjustment cost
Stochastic Processes		
$\rho_x$	0.98 <sup>4</sup>	Persistence coefficient of aggregate productivity
$\sigma_x$	0.014	Conditional volatility of aggregate productivity
$\rho_z$	0.78	Persistence coefficient of firm-specific productivity
$\sigma_z$	0.35	Conditional volatility of firm-specific productivity
$\bar{x}$	-2.23	Long-run average of aggregate productivity
$\lambda$	0.037	Multiplicative coefficient on wage rate process
$w$	0.2	Sensitivity of the wage rate to aggregate productivity
$\beta$	0.94	Time-preference coefficient
$\gamma_0$	28	Constant price of risk
$\gamma_1$	-300	Time-varying price of risk

Table 9  
Data versus Model Implied Moments Across Several Calibrations

This table presents selected moments in the data and implied by the simulation of the model under alternative calibrations (cases one to four). The reported statistics are averages from 1000 samples of simulated data, each with 3600 firms and 50 annual observations, with the corresponding standard deviation across samples in parenthesis. Panel A reports moments of aggregate asset prices and measures of total and marginal investment and hiring adjustment costs. It reports the mean and the standard deviation, denoted by  $\sigma(\cdot)$ , of the market equity premium  $R_s^e$ , net real riskfree rate  $R_f$ , the Sharpe ratio on the aggregate stock market, the pseudo average percentage of the market value of the firm that is attributed to the value of its labor inputs (% Labor Value). Panel A also reports measures of adjustment costs. It reports the percentage of the firm's output that is lost due to labor adjustment costs (Adj Cost to Output- the figure for this variable in the data is from the evidence provided in Hamermesh and Pfann, 1996), the marginal investment adjustment cost, measured as the dollar amount that the firm loses in adjustment costs in a typical \$100 dollars of investment, and the marginal hiring adjustment cost, which measures the additional adjustment cost in terms of the yearly wage of a typical worker, that the firm pays to hire an additional worker. Panel B reports firm level moments and cross-sectional asset pricing results. It reports the mean and the standard deviation of the firm level investment rate (IK), net hiring rate (HN), book to market ratio (BM), the correlation between the investment rate and the hiring rate, the average investment and hiring rate FMB slope coefficients of the predictability regressions and the average portfolio spread, which is the average returns of a high minus low (spread) portfolio that goes long one dollar on a portfolio of firms with low investment and low hiring rates and short one dollar on the portfolio of firms with high investment and high hiring rates.

Panel A: Moments of Aggregate Asset Prices and Magnitude of the Adjustment Costs

Case	Aggregate Asset Prices						Adjustment Costs		
	Means		Std		Sharpe Ratio	% Labor Value	Adj Cost to Output	Marginal Investment	Marginal Hiring
	$R_s^e$	$R_f$	$\sigma(R_s^e)$	$\sigma(R_f)$				Adj Cost (per \$100)	Adj Cost (per Wage)
Data									
–	8.3	1.8	19.3	3	0.43	–	0.01 – 0.20	–	–
Benchmark calibration ( $c_n = 0.6, c_k = 1, \alpha_k = 0.31, \alpha_n = 0.62$ )									
1	6.76	0.97	21.24	3.69	0.33	0.30	0.06	\$2.23	1.70
	[21.24]	[3.69]	[6.14]	[2.39]	[0.12]	[0.01]	[0.01]		
Labor intensive economy ( $\alpha_k = 0.13, \alpha_n = 0.8$ )									
2	6.64	0.46	19.62	3.39	0.35	0.49	0.06	\$2.23	1.70
	[19.62]	[3.39]	[5.27]	[1.93]	[0.09]	[0.01]	[0.01]		
Capital intensive economy ( $\alpha_k = 0.8, \alpha_n = 0.13$ )									
3	6.41	0.1	15.52	3.18	0.32	0.03	0.07	\$2.23	1.70
	[20.25]	[3.46]	[4.98]	[1.97]	[0.14]	[0.00]	[0.01]		
High labor adjustment cost economy ( $c_k = .2, c_n = 2$ )									
4	4.66	2.33	15.52	3.18	0.32	0.44	0.025	\$0.44	5.53
	[15.52]	[3.18]	[4.98]	[1.97]	[0.14]	[0.02]	[0.00]		
No labor adjustment costs ( $c_n = 0, \delta_n = 1$ )									
5	4.96	1.66	19.74	4.13	0.27	0.00	0.03	\$2.23	0
	[19.74]	[4.13]	[6.88]	[1.76]	[0.15]	[0.00]	[0.00]		

Table 9 (cont)

Panel B: Firm Level Moments and Cross-Sectional Asset Pricing Results

Case	Firm Level						Cross-Section			
	Means			Std			Correl $\rho(\text{IK,HN})$	FMB Slope Coefficients		Portfolio Spread
	IK	HN	BM	$\sigma(\text{IK})$	$\sigma(\text{HN})$	$\sigma(\text{BM})$		IK	HN	
Data										
–	0.24	0.04	0.77	0.13	0.16	0.38	0.32	–0.45	–0.57	7.05
Benchmark calibration ( $c_n = 0.6, c_k = 1, \alpha_k = 0.31, \alpha_n = 0.62$ )										
1	0.15	0.05	0.64	0.12	0.13	0.33	0.61	–0.82	–0.59	6.01
	[0.02]	[0.02]	[0.10]	[0.01]	[0.01]	[0.12]	[0.02]	[0.42]	[0.17]	[1.22]
Labor intensive economy ( $\alpha_k = 0.13, \alpha_n = 0.8$ )										
2	0.11	0.01	0.52	0.11	0.12	0.39	0.60	–1.79	–1.13	8.72
	[0.02]	[0.03]	[0.08]	[0.01]	[0.01]	[0.11]	[0.01]	[0.82]	[0.26]	[2.39]
Capital intensive economy ( $\alpha_k = 0.8, \alpha_n = 0.13$ )										
3	0.16	0.06	0.90	0.17	0.16	0.49	0.60	–0.96	–0.25	3.37
	[0.02]	[0.02]	[0.16]	[0.01]	[0.01]	[0.19]	[0.04]	[0.62]	[0.08]	[0.91]
High labor adjustment cost economy ( $c_k = .2, c_n = 2$ )										
4	0.09	–0.01	0.62	0.12	0.07	0.26	0.46	–0.64	–0.96	4.09
	[0.02]	[0.02]	[0.07]	[0.02]	[0.00]	[0.08]	[0.01]	[0.31]	[0.31]	[0.73]
No labor adjustment costs ( $c_n = 0, \delta_n = 1$ )										
5	0.10	0.58	0.59	0.10	1.93	0.16	0.26	–1.43	–0.00	2.57
	[0.01]	[0.19]	[0.04]	[0.00]	[0.04]	[0.02]	[0.00]	[0.11]	[0.00]	[0.58]



Table 10  
Portfolio Characteristics of Nine Portfolios Double Sorted on Investment  
and Hiring Rates Based on Simulated Data

This table reports mean characteristics of selected variables of nine portfolios double sorted on investment and hiring rate constructed on data simulated by the benchmark calibration of the model. The nine portfolios are first sorted on net hiring rate (cutoffs at the 33<sup>th</sup> and 66<sup>th</sup> percentile), and then, within each hiring bin, all firms are sorted on gross investment rate (cutoffs at the 33<sup>th</sup> and 66<sup>th</sup> percentile). Inv-L, M and Inv-H stands for the portfolio with low (L), medium (M) and high (H) cross sectional investment rates respectively, while Hire-Low, Hire-Med and Hire-High stand for the portfolio with low, medium and high cross sectional hiring rates respectively. The table reports the mean on the following variables: rVW is the value-weighted excess return (in excess of the risk-free rate), rEW is the equally-weighted excess return, HN is the net hiring rate, IK is the gross investment rate, Size is market equity, BM is the ratio of book equity to market equity and LK is the labor to real capital ratio. The reported statistics are averages from 1000 samples of simulated data, each with 3600 firms and 50 annual observations.

	Hire-Low			Hire-Med			Hire-High		
	Inv-L	M	Inv-H	Inv-L	M	Inv-H	Inv-L	M	Inv-H
rEW	12.14	10.53	9.71	10.11	9.09	8.31	8.66	7.83	5.98
rVW	10.19	8.92	8.00	8.52	7.68	6.62	7.23	6.32	4.18
HN	-0.11	-0.08	-0.06	0.03	0.03	0.04	0.15	0.18	0.22
IK	0.02	0.05	0.13	0.05	0.11	0.24	0.10	0.21	0.38
BM	1.12	0.90	0.64	0.80	0.60	0.43	0.60	0.42	0.28
SIZE	0.60	0.63	0.81	0.78	0.92	1.16	1.15	1.40	1.89
LK	4.55	4.95	5.31	5.23	5.45	5.50	5.39	5.41	5.23

Table 11  
Time Series Asset Pricing Tests on Simulated Data

This table reports the CAPM (on Panel A) and the Fama-French (1993) (on Panel B) asset pricing test results on nine value-weighted double sorted investment and hiring rate portfolios based on data simulated by the benchmark calibration of the model. The table reports the intercept 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 1000 samples of simulated data, each with 3600 firms and 50 annual observations. Inv-L, M and Inv-H stands for the portfolio with low (L), medium (M) and high (H) cross sectional investment rates respectively, while Hire-Low, Hire-Med and Hire-High stand for the portfolio with low, medium and high cross sectional hiring rates respectively.

Panel A: CAPM Tests

Portfolios	Hire-Low			Hire-Med			Hire-High		
	Inv-L	M	Inv-H	Inv-L	M	Inv-H	Inv-L	M	Inv-H
Alpha	1.68	0.86	0.45	0.96	0.47	-0.06	0.49	-0.03	-1.56
Alpha t-stat	[3.23]	[2.39]	[1.30]	[2.53]	[1.52]	[-0.19]	[1.54]	[-0.08]	[-5.71]
Market Beta	1.25	1.19	1.11	1.11	1.06	0.98	0.99	0.94	0.85
GRS [p-val %]	5.08	[1.74]							

Panel B: Fama-French Three Factor Model Tests

Alpha	0.29	0.32	0.00	0.32	0.34	0.07	0.41	0.24	-0.96
Alpha t-stat	[0.73]	[0.72]	[0.10]	[0.76]	[0.88]	[0.31]	[1.04]	[0.73]	[-3.81]
Market Beta	1.01	1.05	1.00	1.01	1.01	0.99	1.01	0.99	0.97
SMB Beta	0.64	0.26	0.16	0.34	0.06	-0.12	0.10	-0.13	-0.29
HML Beta	0.36	0.25	0.20	0.14	0.10	0.01	-0.05	-0.09	-0.21
GRS [p-val %]	2.50	[11.03]							

Figure 1  
 Time Series of the Investment and Hiring Rates FMB Slope coefficient and t-statistic

The figure plots the time series of the FMB investment and hiring rate slope coefficient and the corresponding t-statistics obtained from Fama-MacBeth regressions computed on 15 year rolling windows. 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 returns data is monthly, the accounting data is annual and the sample is from July 1965 to June 2006.

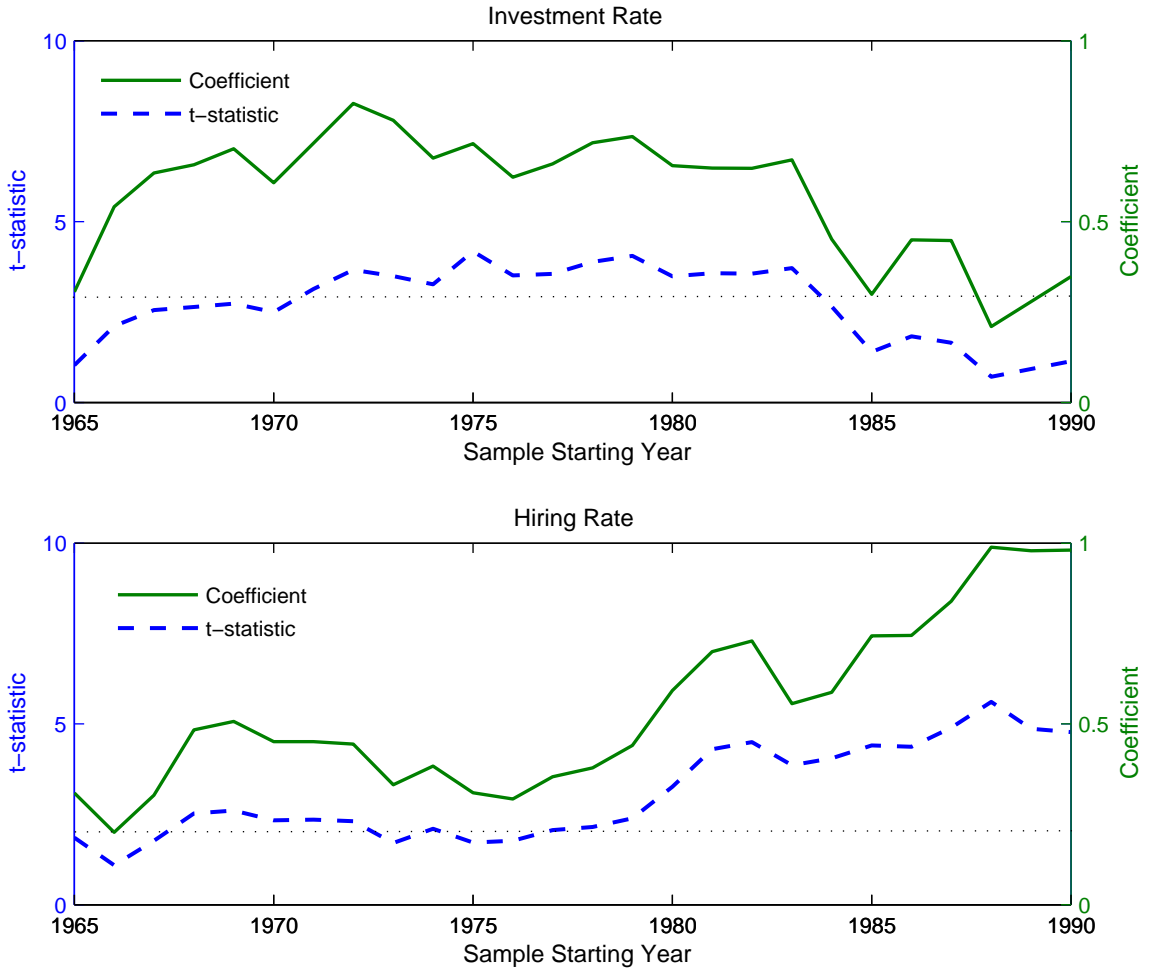


Figure 2  
 CAPM and Fama-French Pricing Errors of Nine Double Sorted Investment  
 and Hiring Rate Portfolios

The figure shows the plot of the realized annual excess returns of the nine value-weighted 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.

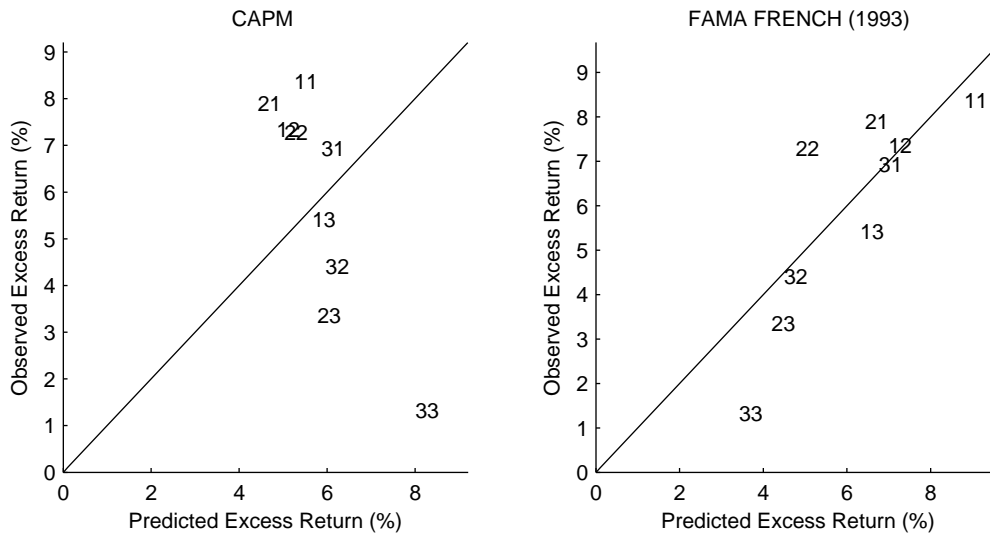


Figure 3  
Value Function, Policy Functions and Conditional Betas in the Benchmark Calibration

This figure plots the value function  $v(k, n, x, z)$ , the investment rate  $\frac{i}{k}(k, n, x, z)$ , the net hiring rate  $\frac{h}{n}(k, n, x, z)$  and the firm's 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, in the plots on the left we fix  $n = \bar{n}$  and  $x = \bar{x}$ , and plot the conditional beta against  $k$  and in the plots on the right we fix  $k = \bar{k}$  and  $x = \bar{x}$ , and plot the conditional beta against  $n$ . The two lines show the values at two different levels of firm level idiosyncratic productivity  $z$ . The x-axis are expressed in units of proportion value of the steady-state level of the corresponding variable. Thus a value of the capital stock of 1 (similarly for labor), corresponds to a capital stock that is equal to the average capital stock at the steady-state level, in which all stochastic variables are set at their unconditional mean level.

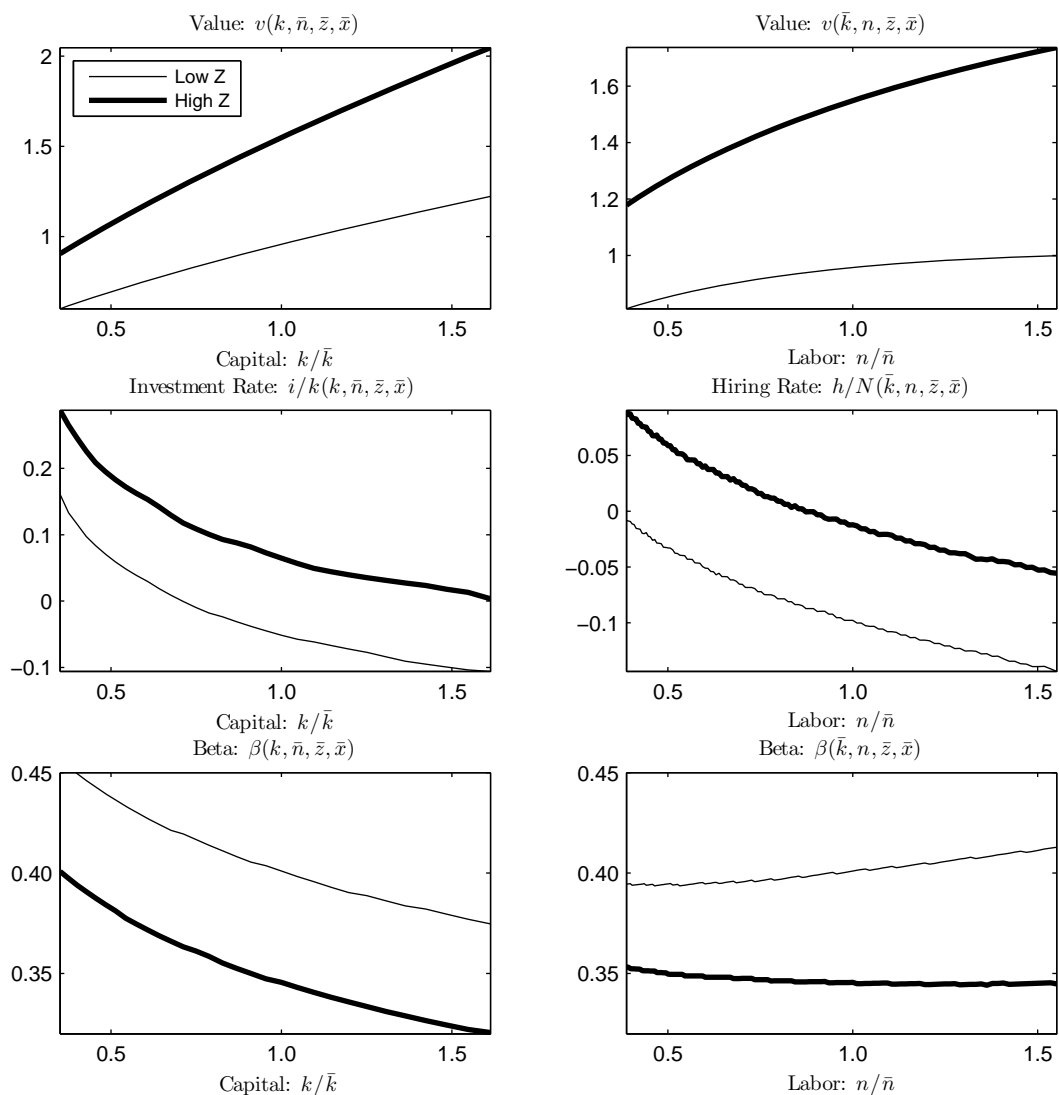
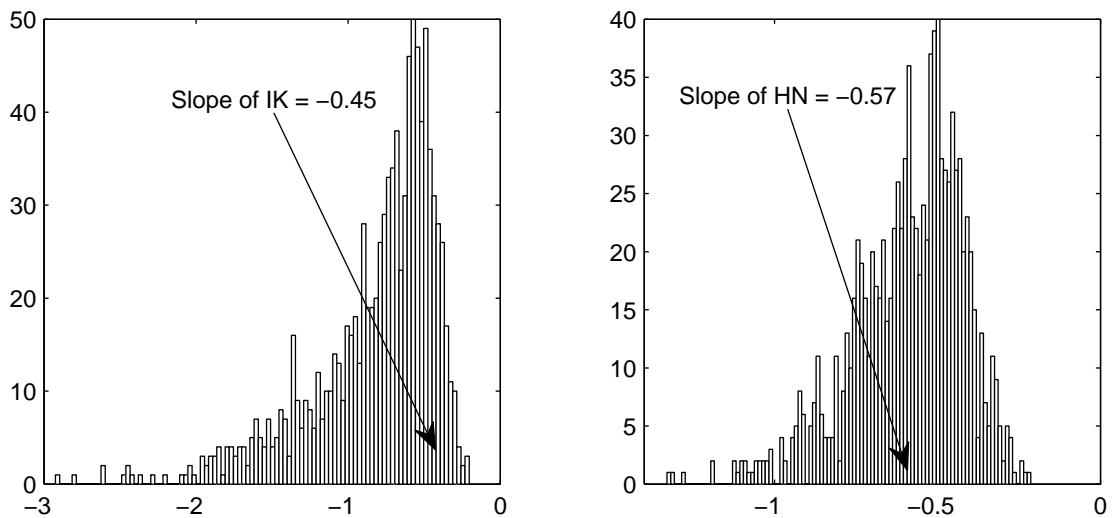


Figure 4  
 Histograms of the Investment and Hiring Rate Fama-MacBeth Slope  
 Coefficients on Simulated Data

The figure shows the histogram of the FMB investment rate (IK) slope coefficient on the left panels and the FMB hiring rate (HN) slope coefficient on the right panels across 1000 samples of simulated data, each with 3600 firms and 50 annual observations. Panel A reports the histograms in the benchmark calibrations of the model with adjustment costs in both capital and labor, and Panel B reports the histograms in the model with no labor adjustment costs. The arrow in each panel shows the estimated slope coefficient from the real data reported in Table 3.

Panel A: Benchmark Model



Panel B: No Labor Adjustment Costs Model

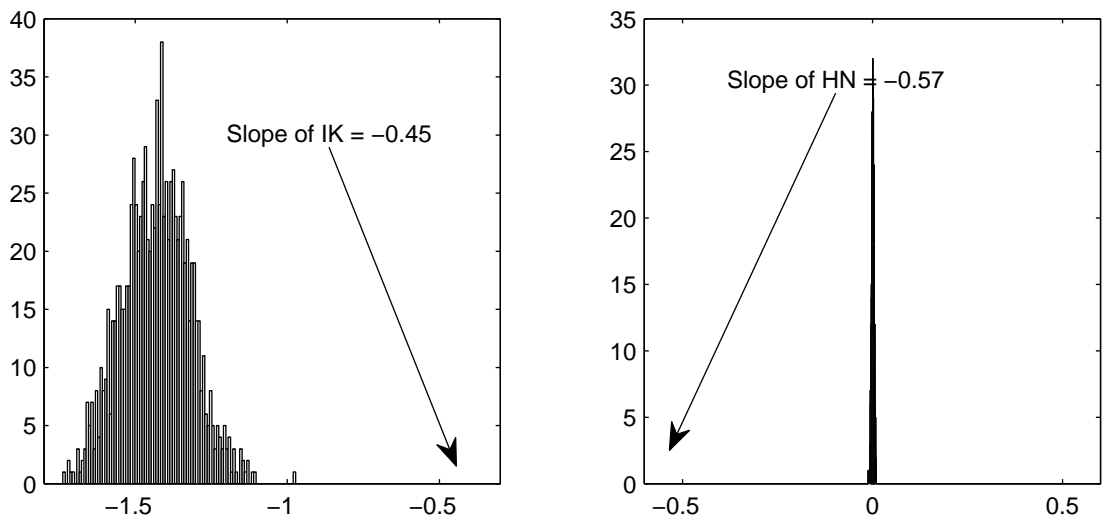


Figure 5  
 CAPM and Fama-French Pricing Errors of Nine Double Sorted Investment  
 and Hiring Rate Portfolios on Simulated Data

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 using the benchmark calibration of the model. 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 reported statistics are averages from 1000 samples of simulated data, each with 3600 firms and 50 annual observations.

