Future Labor Income Growth and the Cross Section of Equity Returns

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JEL classification: G12; G14.

Keywords: Revisions in expectation of future labor income growth, Fama-French factors, Economic tracking portfolio, Intertemporal CAPM.

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Abstract

This paper studies an equilibrium relation between future labor income growth and expected asset returns. We propose revisions in expectation of future labor income growth as a macroeconomic state variable and suggest a three-factor model including a factor related to this variable, along with the consumption growth factor and the market factor. The proposed future labor income growth factor is positively associated with the Fama-French factors and subsumes their explanatory power in explaining the cross-section of stock returns. These results provide an economic explanation for the roles of the Fama-French factors: they might be compensation for higher exposure to the risk related to changes in the value of human capital. We also compare the performance of the proposed three-factor model with other competing models and find that the proposed model specification explains better in various aspects than any of the competing asset pricing models considered.

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1. Introduction

It is a stylized empirical fact in the literature that small stocks and value stocks have high average returns than big stocks and growth stocks. The Capital Asset Pricing Model (CAPM) of Sharpe (1964) and Linter (1965) encounters difficulty in accounting for these well-established empirical regularities (Fama and French, 1992). In response to this difficulty, Fama and French (1993, 1995, 1996) (FF hereafter) propose a three-factor model that includes a factor related to size (SMB) and a factor related to book-to-market (HML), together with the market factor. These authors empirically demonstrate that their model can largely explain a cross-sectional pattern of average stock returns of portfolios sorted by size and book-to-market ratio.

Nonetheless, the Fama-French model is often criticized because its factors lack theoretical justification. Furthermore, the factors and the test portfolios share the same characteristics. These factors results in frequent debate over the interpretation of the success of the Fama-French factors. Fama and French argue that SMB and HML might mimic state variables of special hedging concern to investors. However, they have not identified which state variables SMB and HML could proxy for. Specifically, Fama and French (1992, p.450) suggest a path to find out economic meaning of their factors by stating “examining relations between the returns on these portfolios and economic variables that measure variations in business conditions might help expose the nature of the economic risks captured by size and book-to-market equity”

Several studies have examined a link between the FF factors and macroeconomic variables and business cycle fluctuations. Recently, Liew and Vassalou (2000) show that HML and SMB retain the ability to predict future economic growth. Vassalou (2003) argues that changes in the investment opportunity set are summarized by changes in future GDP growth, and HML and SML appear to contain mainly news related to future GDP growth. Petkova (2006) shows that shocks to the aggregate macroeconomic variables such as dividend yield, term spread, default spread, and one-month Treasury bill yield, which describe investment opportunity sets, fully replace the explanatory power of HML and SMB in the cross-section of average returns.

In this paper, we propose revisions in expectation of future labor income growth as such a macroeconomic state variable that is closely related to macroeconomic conditions and business cycle fluctuations and may imply the nature of the economic risk captured by size and book-to-market equity. We then suggest a three-factor model that includes a factor related to this variable, along with the consumption growth factor and the market factor. We examine whether revisions in expectation of future labor income growth capture the pricing abilities of the Fama-French factors in explaining the size and book-to-market effects. In order to obtain the risk factor that captures revisions in future labor income growth, which is unobservable, we adopt the economic tracking portfolio approach introduced by Lamont (2001). Economic tracking portfolios are designed to capture unexpected returns that are maximally correlated with unexpected components (or news) of a target macroeconomic variable (discounted sum of future labor income growth in this study).

The reasons we choose revisions in expectation of future labor income growth as a source of risk and a state variable of investors' hedging concerns are as follows: First, since investors fear to have low stock returns in bad times when expectation of future labor income (or return on human capital) is changed to be low, stocks having positive correlation with news about future labor income would demand high risk premium. Second, expected changes in future labor income growth should have information about changes in the market value of human capital (Shiller, 1993). Therefore, revisions in expectation of future labor income growth capture a relevant state variable and source of risk. In addition, shocks to human capital are aggregate risks that affect the total wealth of a representative agent (Campbell, 1996; Jagannathan and Wang, 1996). Third, unexpected changes (or innovations) in labor income cause changes in consumers' expenditure that can affect firms' revenues and cash flows. This induces changes in the investment opportunity set for investors. Thus, investors would demand a greater risk premium for assets whose cash flows are more sensitive to innovations in labor income. We use future labor income rather than current labor income because investors react more preemptively to news about innovations in future labor income than to news about current labor income.

We find that our proposed three-factor specification explains relatively well the cross-section of average returns for size and book-to-market sorted portfolios, and performs better than the competing asset pricing models considered: the Fama and French (1993) model, the CAPM, the Jagannathan and Wang (1996) human capital CAPM, the consumption CAPM, the Epstein-Zin (1991) model, the Lettau-Ludvigson (2001) model, and the Vassalou (2003) model. Furthermore, the risk factor related with revisions in expectation of future labor income growth is positively associated with the Fama-French factors SMB and HML, and subsumes the explanatory power of these Fama-French factors in explaining the cross-section of stock returns. Specifically, this future labor income growth factor reduces the risk premium of SMB and HML more than 50%, making them no longer significant. Since the results could be sensitive to the specification used for constructing the tracking portfolio, we perform robustness tests using various alternative specifications for constructing the tracking portfolio. However, the overall results are qualitatively the same.

The reason for the positive association between the Fama-French factors and the labor income risk could be the asymmetry of employment across the firms. In recession, employment in small and value firms, of which cash flows are uncertain and earnings are persistently low (Chan and Chen (1991); Fama and French (1995)), is more vulnerable than that in big and growth firms. Since small and value firms have high risk exposure to the SMB and HML, a negative shock to SMB and HML may imply a negative shock to the value of human capital. Rational investors, who have hedging concern to the state variable associated with human capital, have an incentive to avoid stocks of small and value firms. As a result, small and value firms are riskier than big and growth firms in recession when the price of risk associated with labor income is high.

The rest of the paper is organized as follows. Section 2 explains the theoretical background of our three-factor model, Section 3 explains empirical methodology and data, Section 4 presents the empirical results, and Section 5 performs various robustness tests. Section 6 concludes.

2. Theoretical Background

Since time-varying expectation of future labor income in the economy should capture movements in a relevant state variable such as the level of human capital, it is likely to have an influence on equilibrium asset returns. To see this formally, consider a representative agent whose utility is assumed to take the recursive form of Epstein and Zin (1989, 1991)

$$U_t = \left\{(1-\delta)C_t^{\frac{\psi-1}{\psi}} + \delta\left[E_t\left(U_{t+1}^{1-\gamma}\right)\right]^{\frac{1}{\theta}}\right\}^{\frac{\psi}{\psi-1}}, \tag{1}$$

where C_t is the consumption level at time t, $\theta \equiv (1-\gamma)/\left(1-\frac{1}{\psi}\right)$, $\gamma > 0$ is the relative risk aversion coefficient, $\psi > 0$ denotes the elasticity of intertemporal substitution (EIS), and $0 < \delta < 1$ is the time discount factor. When $\theta = 1$, this reduces to the standard model of time-separable power utility model.

The intertemporal budget constraint for a representative agent can be written as

$$W_{t+1} = R_{w,t+1}(W_t - C_t), \tag{2}$$

where W_{t+1} is the representative agent's total wealth, and $R_{w,t+1}$ is the return on W_{t+1}. The representative agent's total wealth includes human capital as well as financial assets. From equations (1) and (2), an Euler equation for asset *i* is obtained:

$$E_t \left\{ \delta^{\theta} \left(\frac{C_{t+1}}{C_t} \right)^{-\frac{\theta}{\psi}} \left(\frac{1}{R_{w,t+1}} \right)^{1-\theta} R_{i,t+1} \right\} = 1. \tag{3}$$

Thus, the log stochastic discount factor or pricing kernel is equal to

$$m_{t+1} = \theta \log\delta - \frac{\theta}{\psi} \Delta c_{t+1} - (1-\theta) r_{w,t+1}, \tag{4}$$

where $\Delta c_{t+1} \equiv log\left(\frac{C_{t+1}}{C_t}\right)$ and $r_{w,t+1} \equiv \log\left(R_{w,t+1}\right)$ denote the log consumption growth and log return on total wealth, respectively.

When investors' total wealth consists of financial wealth and human capital, the aggregate return on total wealth can be expressed as

$$R_{w,t+1} = (1-v) R_{a,t+1} + v\, R_{h,t+1}, \tag{5}$$

where v is the ratio of human capital wealth to total wealth, $R_{a,t+1}$ is the return on financial wealth, and $R_{h,t+1}$ is the return on human capital. Campbell (1996) shows that equation (5) can be approximated as the log or continuously compounded return:

$$r_{w,t+1} \approx (1-v) r_{a,t+1} + v\, r_{h,t+1}, \tag{6}$$

where $r_{t+1} = \log(1 + R_{t+1})$.

In fact, labor income (Y_{t+1}) can be thought of as the dividend on human capital (H_{t+1}) [Campbell (1996), Jagannathan and Wang (1996)]. Thus, return on human capital ($R_{y,t+1}$) can be defined as

$$R_{\mathrm{y},t+1} = \frac{H_{t+1} + Y_{t+1}}{H_t}. \tag{7}$$

If we follow the log-linear approximation of Campbell and Shiller (1988) under the assumption of the constant discount rate on human capital following Shiller (1993), the log human capital (h_t) can be expressed as a function of the discounted sum of future labor income growth (y_t)

$$h_t = h + y_t + E_t \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}\,, \tag{8}$$

where h is a constant of no interest. This tells us that the expected discounted value of labor income is an important determination of human capital wealth. Thus, expectation of future labor income growth should have important information about a state variable associated with human capital.

The log return on human capital ($r_{h,t+1}$) can be written by a linear combination of future log labor income growth:

$$r_{h,t+1} = r + (E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}\,, \tag{9}$$

where r is a constant of no interest. That is, the return on human capital is determined by revision in expectation of future labor income growth. The last term on the right hand side of equation (9) measures the contribution of news about future labor income growth to the state variable h_t, and therefore captures the expected long run wealth effect of labor income shocks.

Substituting equation (9) into (6) yields

$$r_{w,t+1} = rv + (1-v)r_{a,t+1} + v(E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}\,. \tag{10}$$

Then, equation (10) is substituted into equation (4) to obtain

$$m_{t+1} = k - \frac{\theta}{\psi}\Delta c_{t+1} - (1-\theta)(1-v)r_{a,t+1} - (1-\theta)v(E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}\,. \tag{11}$$

Equation (11) indicates that the (log) stochastic discount factor depends on news about future long horizon labor income growth which is the last term on the right-hand. Therefore, innovation to the expected present discounted value of labor income should appear as additional risk factor along with current consumption growth and current return on the financial wealth.

For the cross-section of asset returns, the following expected return-covariance representation needs to hold in the equilibrium:

$$E\left(r_{i,t+1} - r_{f,t+1}\right) + \frac{\sigma_i^2}{2} = -\mathrm{Cov}\left(m_{t+1}, r_{i,t+1}\right), \tag{12}$$

where $\sigma_i^2/2$ is a Jensen Inequality adjustment arising from the lognormal model, and the left hand side of equation (12) is the relevant measure for risk premium for asset i. Substituting the pricing kernel equation of (11) into equation (12), we see that the expected risk premium for any asset *i* is determined by three covariances. That is,

$$E(r_{i,t+1} - r_{f,t+1}) + \frac{\sigma_i^2}{2} = \frac{\theta}{\psi}\sigma_{ic} + (1-\theta)(1-\nu)\sigma_{ia} + (1-\theta)\nu\, \sigma_{ih}, \qquad (13)$$

where $\sigma_{ic} \equiv \text{Cov}(r_{i,t+1},\ \Delta c_{t+1})$, $\sigma_{ia} \equiv \text{Cov}(r_{i,t+1},\ r_{a,t+1})$, and $\sigma_{ih} \equiv \text{Cov}\left[r_{i,t+1}, (E_{t+1} - E_t)\sum_{j=0}^{\infty}\rho^j \Delta y_{t+1+j}\right]$ represents the covariances of stock *i*'s return with the current consumption growth (Δc_{t+1}), current return on financial wealth $(r_{a,t+1})$, and revision in the expectation of long-run labor income growth $\left((E_{t+1} - E_t)\sum_{j=0}^{\infty}\rho^j \Delta y_{t+1+j}\right)$, respectively.

Given that most asset pricing models are estimated and evaluated in a form of expected return-beta representation, we can restate equation (13) in terms of betas as

$$E(r_{i,t+1} - r_{f,t+1}) + \frac{\sigma_i^2}{2} = \lambda_c\beta_{ic} + \lambda_a\beta_{ia} + \lambda_h\beta_{ih}, \qquad (14)$$

where $\lambda_c \equiv \frac{\theta}{\psi}\sigma_c^2$, $\lambda_a \equiv (1-\theta)(1-\nu)\sigma_a^2$, and $\lambda_h \equiv (1-\theta)\nu\sigma_h^2$ are the prices of risk for the three risk factors. Following Campbell and Vuolteenaho (2004), if we use simple expected returns, $\mathrm{E}(\mathrm{R}_{\mathrm{i,t+1}} - \mathrm{R}_{\mathrm{f,t+1}})$, instead of log returns, $\mathrm{E}(\mathrm{r}_{\mathrm{i,t+1}} - \mathrm{r}_{\mathrm{f,t+1}})$, equation (14) becomes

$$E(R_{i,t+1} - R_{f,t+1}) \approx \lambda_c\beta_{ic} + \lambda_a\beta_{ia} + \lambda_h\beta_{ih}, \qquad (15)$$

where R indicates holding period return. Equation (15) is a three-factor model we suggest in this paper. The third component in equation (15), β_{ih}, indicates the factor reflecting revision in expectation of future labor income growth. It is worth to note that since the covariance terms in the above equations are separately figured, it is consistent with the theoretical derivation to estimate betas in equation (15) in separate univariate regression models.[1]

1 This paper is different from Campbell (1996) in that consumption is not substituted out using the intertemporal budget constraint combined with the assumption of homoskedasticity for both asset returns and consumption growth. Since the model implied consumption innovations, which are determined by news about current returns and by news about future expected returns on the market portfolio, are

3. Empirical Methodology and Data

3.1 Construction of the Economic Tracking Portfolio

In the three-factor model specification of equation (14), the first two risk factors (the current consumption growth and the current return on financial assets) are empirically well specified in the literature and so easily obtained. However, the third risk factor (revisions in the expectation of labor income growth) is not. In order to obtain the risk factor that captures revisions in expectation of future labor income growth, we adopt the economic tracking portfolio approach, which was introduced by Lamont (2001). Economic tracking portfolios are designed to capture unexpected returns that are maximally correlated with unexpected components (or news) of a target macroeconomic variable (discounted sum of future labor income growth in this study). The first assumption in this approach is that one can always write a projection equation of news on unexpected returns. That is,

$$(E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} = a\,\tilde{R}_{t,t+1} + \eta_{t+1}, \tag{14}$$

where $\tilde{R}_{t,t+1}$ is a vector of unexpected returns on the base assets, which are actual return minus expected return [= $R_{t,t+1} - E_t(R_{t,t+1})$], and η_{t+1} is the component of revisions or news that is orthogonal to unexpected returns.

The realization of long-run labor income growth, $\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}$, can be rewritten as

$$\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} = E_{t+1}\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} + e_{t+1}$$

completely different from those in the data [Lustig and Van Nieuwerburgh (2008)], we avoid this possible model misspecification error. More importantly, the main purpose of this paper is to investigate the relation between Fama-French factors and the state variable associated with the human capital. Our model is also different from Jagannathan and Wang (1996). They assume that labor income growth is unpredictable. As a result, labor income growth over the following quarter becomes a risk factor. As documented in Campbell (1996) and our results, however, labor income growth is predictable in the data.

$$= E_t \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} + (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} + e_{t+1}. \tag{15}$$

We also assume that expected returns on the base assets are linear functions of Z_t, a vector of control variables known at time t:

$$E_t(R_{t,t+1}) = b\, Z_t. \tag{16}$$

And, we define the projection equation of lagged expectations of long-run labor income growth on the lagged control variables as

$$E_t \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} = f\, Z_t + \zeta_t. \tag{17}$$

Combining equations (14)-(17) yields the following representation:

$$\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j} = cR_{t,t+1} + dZ_t + \varepsilon_{t+1}, \tag{18}$$

where c and d are the regression coefficient vectors to be estimated, $\varepsilon_{t+1} = \eta_{t+1} + e_{t+1} + \zeta_t$, Δy_{t+1+j} is the labor income growth between *t+j* and *t+1+j*, and $\rho = 0.95^{1/4}$.[2] Since the terms beyond a certain lead, S, on the left-hand side of equation (18) can be ignored,[3] equation (18) can be approximately rewritten as

$$\sum_{j=0}^{S} \rho^j \Delta y_{t+1+j} \cong cR_{t,t+1} + dZ_t + \varepsilon_{t+1}. \tag{19}$$

In fact, we considered several possible upper limits in the sum, and find no significant difference in the results beyond 11 quarters. Thus, we set S=12. We use quarterly data in estimating the regression model (19). Note that by including control variables in the right hand side of the regression, we can capture only innovation component of future labor income. This

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[2] Following literature, we set to ρ be 5 % per annum, implying $\rho = 0.95^{1/4}$ quarterly. We also allow ρ to take different values between $0.9^{1/4}$ and 1, and find no significant difference in results.

[3] Due to the limited time-series observation of labor income series, we cannot continue the sum $\sum_{j=0}^{S} \rho^j \Delta y_{t+1+j}$ to the upper limit of infinity. However, it is likely that labor income growth very far out in the future will not matter substantially in estimating $\mathrm{Cov}\left[r_{i,t+1}, (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}\right]$, because they are unlikely correlated with the current period returns.

is the critical difference between economic tracking portfolio and factor mimicking portfolio of Breeden, Gibbons, and Litzenberger (1989).[4]

Returns on the tracking portfolio, which tracks innovations in long-run labor income growth, are computed by multiplying actual returns on the base assets by the regression coefficient, $\hat{c}$, estimated from equation (19). That is,

$$LIG_{t,t+1} = \hat{c}\, R_{t,t+1}. \tag{20}$$

According to the frequency of the base assets' returns, monthly or quarterly returns of the economic tracking portfolio are generated. The resulting economic tracking portfolio is the minimum variance combination of assets that is maximally correlated with long-run labor income growth. We use the *zero-investment* returns for the base assets, so that there is no restriction imposed on portfolio weights, c. Estimation of the tracking portfolios through equation (20) imposes no particular model of asset prices or equilibrium conditions. The only assumption used in deriving equation (19) is that information on changes in expectations about a future economic variable is reflected in asset returns, and these asset returns are a function of the lagged control variables. This assumption is justified if financial markets are efficient enough to reflect information on changes in expectations about future economic conditions.

Note that the use of the economic tracking portfolio is necessary for this study. The risk factor our theoretical model implies is *revision* in expectation of long-run labor income growth, $(\mathrm{E}_{t+1} - \mathrm{E}_t)\sum_{j=0}^{\infty} \rho^j \Delta y_{t+1+j}$, rather than expectation or actual future labor income growth. But innovation in future labor income growth is unobservable. The construction of the economic tracking portfolio enables us to capture such unobservable components from the asset returns, which is likely to contain information about the economic variable.[5]

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[4] Another difference is that the dependent variable of equation (19) is the realized *future* economic variable, while the dependent variable in the estimation of the factor mimicking portfolio is the *contemporaneous* economic variable. Thus, the economic tracking portfolios are designed to capture information about future economic conditions.

[5] Alternatively, one can use vector autoregressive (VAR) approach to extract news about future labor income growth as in Campbell (1996). However, the economic tracing portfolio approach has a potential

3.2 Testing Methodologies for the Pricing Ability of the Risk Factors

In order to examine whether revisions in future labor income growth is priced in stock returns, we employ two estimation methods: the Fama and MacBeth (1973) two-pass methodology and the SDF approach implemented by the GMM estimation.

A. The Fama-MacBeth Method

All test assets' returns in excess of the riskless return are cross-sectionally regressed on their factor loadings estimates. That is, for a given time *t*,

$$r_{i,t} = \lambda_{0t} + \lambda_t' \hat{\beta}_i + e_{i,t} \tag{21}$$

where $r_{i,t}$ is the excess return on asset *i*; $\hat{\beta}_i$ is the $(K \times 1)$ factor loadings vector of asset *i* which are estimated in the first-pass intertemporal regression; $e_{i,t}$ is the error term; and λ_t is a $(K \times 1)$ parameter vector of the risk premia to be estimated at time t.[6] The ultimate estimate of the risk premium for each risk factor is the time-series average of the month-by-month estimates of λ's, and its statistical significance is determined by the standard error of the time-series average. In the second pass cross-sectional regression (CSR), a well-known problem, so called the errors-in-variables (EIV) problem, arises due to the use of the estimated factor loadings as regressors. Shanken (1992) suggests a remedy in computing the standard errors of the estimated λ adjusting for the overstated precision of the standard Fama-MacBeth standard error caused by

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advantage over the VAR procedure. As the VAR system estimates factor loadings through a specific dynamic model of all the variables in the system, it can bring about a potential source of model misspecification. As Lamont (2001) argues, however, the tracking portfolio approach obtains data directly from the regression of the future economic variable on equity returns, without specifying a complete description of the data-generating process.

[6] Note that when returns on the tracking portfolio are included in the first-pass time-series regression model as one of the factors, this is a generated regressor. Pagan (1984) argues that if the generated regressor represents the unexpected component of a certain variable, the standard errors of the OLS coefficients' estimates are still correct.

the errors-in-variables problem, while Kim (1995) provides a direct correction for the estimated value itself. This paper reports Shanken's adjusted *t*-statistics as well as Fama and MacBeth's unadjusted *t*-statistics.

To judge the overall fit of each asset pricing model in the CSR, we adopt the cross-sectional R^2 measure employed by Jagannathan and Wang (1996) and Lettau and Ludvigson (2001) as a summary statistic. This measure is defined as

$$R^2 = \frac{\mathrm{Var}(\bar{r}) - \mathrm{Var}(\bar{e})}{\mathrm{Var}(\bar{r})}, \tag{22}$$

where $\mathrm{Var}(\bar{r})$ is the cross-sectional variance of the average returns and $\mathrm{Var}(\bar{e})$ is the cross-sectional variance of the residual average returns.

B. The Stochastic Discount Factor Approach

It is well known that when there is no arbitrage, there exists a positive stochastic discount factor (SDF) (or pricing kernel) m_{t+1} such that

$$E_t[m_{t+1}R_{t+1}] = 1_n, \tag{23}$$

where R_{t+1} is a $(n \times 1)$ vector of gross returns; 1_n is a $(n \times 1)$ vector of ones; and *n* is the number of the test assets. Since all asset pricing models under consideration are linear factor pricing models, the pricing kernel can be represented as a linear combination of those *K* factors. That is,

$$m_{t+1} = b_0 + b_1^{'} f_{t+1}, \tag{24}$$

where f_{t+1} is a $(K \times 1)$ vector of factors; b_0 is an intercept; and b_1 is a $(K \times 1)$ coefficient vector. b_0 and b_1 are called the SDF loadings.

When it becomes necessary to simultaneously estimate the tracking portfolios (i.e., estimating coefficients *c* and *d* in equation (19)) and the coefficients in the SDF (i.e., b_0 and b_1 equation (24)), the orthogonality condition of equation (15) is stacked at the moment condition of the asset pricing model of equation (23) such that

$$\mathrm{g}(\theta) = \begin{pmatrix} \mathrm{E}[\eta_{t,t+4} \otimes \mathrm{z}_t] \\ E_t[m_{t+1}R_{t+1} - 1_n] \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \tag{25}$$

where $\theta = (b_0, b_1, c, d)$ represents the parameters to be estimated, and $\mathrm{z_t} = [\mathrm{B}_{t-1,t} : \mathrm{Z}_{t-2,t-1}]$ is a vector of the explanatory variables in equation (19). However, when risk factor f_{t+1} is already determined, it is natural to estimate only the coefficients in the SDF, and thus only the moment condition of the asset pricing model of equation (23) is used such that

$$\mathrm{g}(\theta) = (E[m_{t+1}R_{t+1} - 1_n]) = (0), \tag{26}$$

where $\theta = (b_0, b_1)$. Parameters θ are chosen by minimizing the quadratic form

$$J_T = g(\theta)' W g(\theta), \tag{27}$$

where W is a weighting matrix that defines the metric used to make g close to zero. Since our competing models already have the determined risk factors, the estimation of the pricing ability of these competing models can be accomplished by Hansen's (1982) GMM method using equation (26). In order to make a fair comparison, the pricing ability of our alternative model is also estimated in the same way as the competing models.

Two weighting matrices are used to minimize the quadratic equation of equation (27). The first is the asymptotically optimal weighing matrix which is adopted to compute Hansen's *J*-statistic on the overidentifying restrictions of the models. The second is the Hansen and Jagannathan (1997) weighing matrix, $E[RR']^{-1}$, which is the inverse of the second moments of asset returns. Its main advantage is that it is invariant across competing asset pricing models. In order to compare the performance of pricing ability across models, therefore, we use this weighting matrix in computing the Hansen-Jagannathan distance (HJ-distance). The HJ-distance can be interpreted as the maximum pricing error for the set of assets mispriced by the model [Campbell and Cochrane (2000)].

According to Cochrane (1996), the risk premia, λ, can be estimated in the SDF approach as follows

$$\lambda = -r_f \, Cov(f, f') \, b_1, \tag{28}$$

where r_f is the riskless return; f is a $(\mathrm{K} \times 1)$ vector of the factors; and b_1 is a $(K \times 1)$ coefficient vector in the pricing kernel of equation (23).

3.3 Data

For test assets, we use the 25 Fama and French size and book-to-market sorted portfolios, since these portfolios are one of the most commonly used test set in the literature due to their large cross-section dispersion in expected returns. These test assets and the three Fama-French factors are taken from Kenneth French's web site.[7] For labor income data, we use seasonally adjusted real per capita labor income from the second quarter of 1963 to the fourth quarter of 2007. The quarterly real per capital labor income data are taken from the National Income and Product Accounts (NIPA) Table 7.1 available from the Bureau of Economic Analysis. We make the standard "end-of-period" timing assumption that labor income during quarter t occurs at the end of the quarter.

We use labor income data from the second quarter of 1963 to the fourth quarter of 2007. The sample period of asset returns is accordingly determined by the availability of labor income data. Since we allow up six years in computing future labor income growth (i.e., S=16 quarters in equation (19)), the actual test period is from the third quarter of 1963 to the fourth quarter of 2001.

According to Breeden, Gibbons, and Litzenberger (1989), the same tests assets should be used to construct tracking portfolios as a set of base assets.[8] However, when the 25 Fama-French portfolios are used as a set of base assets, we have difficulties in the estimation since

[7] We are grateful to Kenneth French for making the data available on his website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

[8] Asset pricing implications are the same only when the base assets are the same as test assets. We can prove this argument using a simple algebra. Mathematically, $E(mR) = 1$ is equivalent to $E[proj(m|R)R]=1$, where m denotes the stochastic discount factor, and R is the test assets.

there are many parameters relative to a limited time-series observations. In order to obtain reliable estimation, therefore, we need to choose a parsimonious set which can proxy for the test assets. These considerations lead us to choose a small growth (average of the two smallest size, two lowest book-to-market from the 25 Fama-French portfolios), a small value (average of the two smallest size, two highest book-to-market stocks), a large growth (average of the two largest size, two lowest book-to-market stocks), and a large value (average of the two largest size, two highest book-to-market stocks) portfolio as the base assets. Malloy, Moskowitz, and Vissing-Jorgensen (2008) also used the same base assets. In fact, these portfolios turn out to be informative about expectation of future labor income growth, as will be shown later.

The construction of the tracking portfolios requires the control variables in order to capture unexpected components of base assets' returns. Control variables should have the ability to predict future equity returns. Thus, we include the three-month T-bill yield (RF) and the term spread (TERM) as control variables; these variables are known for their predictive power (e.g., Fama (1981); Fama and French (1989)). TERM is the difference between the yields on a ten-year and a one-year government bond. All the bond yields data are from the FRED® database of the Federal Reserve Bank of St. Louis.

4. Empirical Results

4.1 Predictability of the Base Assets for Future Labor Income Growth

One of necessary conditions in selecting base assets is that base assets should reflect revisions in future labor income growth. It is important, therefore, to examine whether the chosen base assets are actually able to predict future labor income growth. In order to do so, we regress long-run discounted labor income growth rates from quarter $t+1$ to $t+1+S$ (i.e., $\sum_{j=0}^{S} \rho^j \Delta y_{t+1+j}$ in equation (19)) on contemporaneous returns of the four base assets and the control variables as in equation (19).

In order to determine a reasonable value for *S* which provides reliable and stable estimated value of the regression coefficients on the base assets' returns, we estimate the regression model of equation (19) for *S* = 1, 2, 4, 8, 12, 16, 20, and 24 quarters. Table 1 reports the estimation results of the regression coefficients for each value of *S*. The estimated coefficients on the base assets' returns are unstable and changing when *S* changes from 1 quarter to 12 quarters. In contrast, the estimated coefficients are stable in magnitude and statistical significance after *S* = 12 quarters.[9] Therefore, we use 12-quarter discounted future labor income growth rates to estimate returns on the tracking portfolio. For the robustness check, we also have tried the longer horizons such as *S* = 16, 20, and 24 quarters. However, the overall test results are qualitatively the same, which are reported and discussed in Section 5.

After estimating the regression coefficients of equation (19), returns on the tracking portfolio are obtained by multiplying the estimated regression coefficients by returns on the base assets as in equation (20). We regard these returns as a risk factor associated with revisions in expectation of future labor income growth and denote it as LIG. Table 2 reports the summary statistics of the five risk factors considered: excess market returns (MKT), log consumption growth rate (CONS), LIG, and Fama and French's SMB and HML. The average of LIG is 0.31% per quarter and statistically different from zero (t = 5.78). Note that since LIG factor is in the form of portfolio excess return, its average is interpreted as its risk premium. The correlation coefficients of LIG with SMB and HML are 0.36 and 0.30, respectively. This indicates that our proposed risk factor, LIG, share information with the Fama-French factors.

4.2 Asset Pricing Test Results

A. The Pattern of the Factor Loadings on the Tracking Portfolios

[9] Small growth portfolio significantly negatively predicts future labor income growth, while small value portfolio significantly positively predicts future labor income growth.

It is widely accepted in the literature that firm size and book-to-market are important forces in explaining stock returns. If a given factor is a determinant of average returns, then the loading associated with that factor should have a systematic pattern across firm sizes and book-to-market ratios. In this context, we examine whether there is a systematic pattern in the loading with the factor associated with revisions in expectation about future labor income growth (LIG) across firm sizes and book-to-market ratios. Note that cross-sectional regression tests in this section are performed using quarterly returns since quarterly consumption growth rates are used.

Table 3 shows the estimation results of the time series univariate regression model of each of the 25 Fama and French size/BM-sorted portfolios on each of the five factors. The factor loadings associated with revisions in expectation of future labor income growth (β_{LIG}) are all significantly estimated. More importantly, the estimated factor loadings show a systematic pattern across both firm size and book-to-market. That is, β_{LIG} monotonically decreases with firm size within each book-to-market quintile and increases with book-to-market within each firm size quintile. Thus, this is indirect evidence that the long-run labor income growth factor is related to both firm size and book-to-market. This is an interesting result, since we find that each of the Fama and French factors is related only to its own corresponding characteristic, that is, SMB is related only to firm size, and HML is related only to book-to-market.[10]

One necessary condition for a factor loading to have satisfactory explanatory power for cross-sectional variations in average returns is for it to have sufficient cross-sectional spread in the factor loading. In this sense, the future labor income growth factor satisfies this necessary condition, since the magnitude of the cross-sectional spread in β_{FLIG} is greater than that in the other factor loadings under consideration. For example, the cross-sectional spread in β_{LIG} is between 5.65 and 13.58 while the cross-sectional spreads in β_{SMB} and β_{HML} are between -0.28

[10] More specifically, as designed, the factor loadings on SMB (β_{SMB}) show a monotonic decreasing pattern across firm size but almost no pattern across book-to-market. Meanwhile, the factor loadings on HML (β_{HML}) show a monotonic increasing pattern across book-to-market but almost no pattern across firm size.

and 1.59 and between -0.42 and 1.02, respectively. Moreover, the smallest and largest values of β_{LIG} are occurred at the lower-left and upper-right corners of the table where the smallest and largest average returns are occurred, respectively. However, the smallest and largest values of β_{SMB} and β_{HML} are not occurred at these corners.

B. Results of Cross-Sectional Regression Tests

In the time-series tests, we have preliminarily observed a positive cross-sectional association between the factor loadings on the future labor income growth factor (β_{LIG}) and average returns. In order to formally examine whether the risk associated with revisions in expectation of future labor income growth is priced, we perform cross-sectional regression tests.

Table 4 reports the CSR estimation results of the Fama and French three-factor model (in Panel A), our alternative three-factor model (in Panel B), a one-factor model including LIG only (in Panel C), a five-factor model including all the five factors (in Panel D), and a three-factor model including LIG, SMB, and HML (in Panel E), within Fama and MacBeth's (1973) methodology framework. Test portfolios are the 25 Fama and French size and book-to-market sorted portfolios, and betas are estimated in the first-pass univariate time-series regression models over the whole test period from 1963:Q3 through 2001:Q4.[11]

Panel A of Table 4 shows that the Fama and French three-factor model shows a significant explanatory power. The adjusted R2 is 0.74 and the risk premium estimate of HML is positively significant, while that of SMB is insignificant. Panel B shows that our alternative model also has a significant explanatory power. The consumption growth beta and the market beta are not significant, but the future labor income growth beta is statistically positively significant. The risk premium of LIG is estimated as 0.30 percent (with t-statistic of 3.72). This

[11] It is worth to note that since the covariances or betas in the derivation of our three-factor model are separately considered, the use of univariate betas in asset pricing tests is consistent with the theoretical derivation. It is important, however, to note that our results remain quantitatively the same even when betas are jointly estimated in multivariate regressions.

estimated risk premium is very close to the magnitude of the observed average of LIG (0.31 percent from Table 2). Moreover, the intercept estimate of our alternative model is not statistically significant. The intercept estimate is 0.17 percent, with t-statistic of 0.18. Our alternative model performs slightly better than the Fama and French three-factor model in terms of adjusted R^2. The adjusted R^2 of our alternative model is 0.81. This is somewhat surprising when we recall that SMB and HML are constructed with the same characteristics as the test portfolios. When the revisions in expectation of future labor income risk factor alone is included in the model (in Panel C), the adjusted R2 is 0.76. This indicates that LIG contributes most of the explanatory power of our alternative three-factor model.

In order to examine whether there is an incremental explanatory power of SMB and HML when they are added into our three-factor model, we estimate a five-factor model including all five factor loadings (in Panel D) and a three-factor model including SMB, HML, and LIG only (in Panel E). The CSR results show that only the coefficient estimate on β_{LIG} is significant and has an economically consistent sign; it is 0.30 percent (with t-statistic of 3.08) in the five-factor model. However, the coefficient estimates on β_{SMB} and β_{HML} are all insignificant. Moreover, the statistical significance of HML disappears, when LIG is in the model. These results are also confirmed when we estimate a three-factor model including SMB, HML, and LIG (in Panel E). These results imply that SMB and HML have no incremental explanatory power for the cross-section of average returns when the future labor income growth factor is included in the model. It could be argued, therefore, that revisions in expectation of future labor income growth absorb the pricing effect of SMB and HML.[12] One noteworthy thing is that the magnitude of the risk premium of LIG is very stable across the estimated models.

C. GMM Estimation Results

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[12] As a robustness test, we run the CRS with beta estimates of orthogonalized factors to examine whether the corresponding factor is marginally useful in pricing assets, given the presence of other factors. We find that only the coefficient of orthogonalized factor associated with labor income risk is significant.

Along with the Fama-MacBeth CSR tests, we also evaluate the performance of our alternative models using the SDF approach implemented through the GMM estimation. Table 5 reports the GMM estimation results using the optimal weighting matrix, which are generally consistent with the CSR results. The GMM estimation results for the Fama and French three-factor model (in Panel A) show that SMB and HML are significantly priced. Their SDF loadings and risk premia are statistically significant, and the p-values of the Wald (b) tests are less than a significance level of one percent. Note that the Wald (b) test examines whether the coefficients in the pricing kernel, b, or the SDF loadings are jointly zero. Rejecting the null hypothesis of $b = 0$ implies that the factors jointly have important implication of the SDF and have marginal explanatory power for pricing the test portfolios.

For our three-factor model (in Panel B), the SDF loading on LIG is statistically significant (with t-statistic of -5.23), implying that revisions in expectation of future labor income growth are important in explaining stock returns. The risk premium on LIG (λ_{LIG}) is statistically significant; it is 0.20 percent with t-statistic of 3.52.[13] The p-value of the Wald (b) test for our three-factor model is less than 0.01, rejecting the null hypothesis of $b = 0$. Panel C shows the GMM estimation results of the five-factor model. When LIG is included in the model, the significance of the SDF loadings on SMB and HML disappears, and the SDF loading on LIG only is significant. Moreover, the risk premium on LIG is still significant. In the five-factor model, the risk premium on HML is also significant. However, when the identity matrix or Hansen and Jagannathan (1997) weighing matrix is used in the GMM estimation instead of the optimal weighting matrix, the risk premium on HML is not significant, while the risk premium on LIG is still significant. These results are consistent with the CSR results.

To compare the performance of the asset pricing models, we compute the HJ-distance which translates into the maximum pricing error generated by each of the models. In terms of

[13] We also estimate our alternative model by simultaneously estimating the tracking portfolios and the coefficients in the SDF through Hansen′s (1982) GMM method using equation (25). However, the results are similar. These results are available upon request.

the HJ-distance, our model performs better in explaining the cross section of returns than the Fama and French model. The values of the HJ-distance are 0.58 and 0.63 for our alternative model and the Fama-French model, respectively. These results are consistent with the CSR tests in which the adjusted R^2 of our alternative model is higher than the Fama-French model. Nonetheless, the HJ-distance test for the null hypothesis that the squared pricing errors are statistically different from zero rejects both our model (p-value = 0.04) and Fama-French model (p-value = 0.00) at a significance level of five percent, implying that any of the models considered does not correctly price the test assets.

4.3 Relations between the Fama-French Factors and the Future Labor Income Growth Factor

The previous CSR testing results show that our alternative model performs better than the Fama and French three-factor model, and our proposed factor, the future labor income growth factor, subsumes the explanatory power of the Fama-French factors in explaining the cross-section of stock returns. In order to more directly examine whether the future labor income growth factor, LIG, shares important pricing information with the Fama and French factors, we run the following time-series regression equations:

$$SMB_t = \alpha_{SMB} + \delta_{SMB} LIG_t + \varepsilon_t \tag{29}$$

$$HML_t = \alpha_{HML} + \delta_{HML} LIG_t + \varepsilon_t \tag{30}$$

Table 6 reports the coefficient estimates of the above time series regression models along with the corresponding t-statistics corrected for heteroskedasticity and autocorrelation. The coefficients on LIG in equations (29) and (30), δ_{SMB}, and δ_{HML}, are all positive and statistically significant at a one percent level. That is, the risk factor reflecting revisions in expectation of future labor income growth covary positively with SMB and HML. When we regress LIG on the Fama-French factors, the coefficients on SMB and HML are also both positive and statistically significant.

The intercept of the above equation indicates the amount of the remaining risk premium after excluding the common portion with LIG from each factor's total risk premium. The intercept estimates of the above two models, $\hat{\alpha}_{\text{SMB}}$ and $\hat{\alpha}_{\text{HML}}$, are all insignificant. Moreover, the intercept estimates are much small in magnitude compared with the magnitude of their total risk premium. That is, $\hat{\alpha}_{\text{SMB}}$ and $\hat{\alpha}_{\text{HML}}$ are -0.31 percent and 0.48 percent, respectively, while the total risk premiums of SMB and HML (in Table 2) are 0.688 percent and 1.332 percent, respectively. These results suggest that the substantial amount of the Fama and French factors are overlapped with LIG.

In order to more thoroughly examine the relationship between the Fama and French factors and the future labor income growth factor, we investigate the time-series movements of the risk premiums of these according to business cycles. The risk premium associated with the combined Fama and French factors is obtained as follows: First, each of the 25 Fama and French portfolios is regressed on MKT, SMB, and HML. Second, we compute the average of the 25 Fama and French portfolios' estimated corresponding factor loadings multiplied by SMB and HML (that is, $\hat{\beta}_{i,SMB}SMB_t + \hat{\beta}_{i,HML}HML_t$); this is regarded as the combined risk premium for the Fama and French factors. Figure 1 plots the time series movement of these two risk premia, and shows a quite positive association between the risk premia. Especially, in bad state of the economy, both risk premia are higher, and they covary more closely than in good state of the economy. Specifically, the correlation coefficients over the whole, contraction, and expansion periods are 0.49, 0.58, and 0.46, respectively. It is interesting that the correlation between the two risk premia is higher in a contracting period than in an expanding period. Note that we use the NBER definition of the business cycle, and the shaded bar in Figure 1 indicates the contraction period.[14]

[14] We also obtain the similar results when we use the different definition of business condition. As in Petkova and Zhang (2005), we define a time period as 'peak' if the expected risk premium of the period is below the bottom 10%, and as 'trough' if the expected risk premium of the period is above the top 10% among the whole periods. The expected risk premium is obtained as the fitted value of the y-variable

In fact, a positive relationship between LIG and the Fama-French factors is economically plausible. When good states of the economy are expected, small capitalization stocks and value stocks with high financial leverage might be able to better prosper than big capitalization stocks and growth stocks. As a result, during good (bad) times in terms of business conditions, when the future labor income growth rate is expected to be high (low), returns on small stocks and high book-to-market stocks would be relatively higher (lower) than those of big stocks and low book-to-market stocks. Thus, returns on SMB and HML are positively associated with shocks to the level of human capital. We interpret these results as suggesting that small firms and value stocks are more sensitive to shocks to the state of the human capital. That is, small stocks and value stocks are indeed fundamentally riskier than big stocks and growth stocks.

Another possible interpretation for the positive association between news about future labor income growth and the Fama-French factors is asymmetric employment across the firms. In recessions, employment in small and value firms, typically weak firms with persistently low earning and high cash flow uncertainty (Chan and Chen (1991); Fama and French (1995)), is more likely to contract than in big and growth firms. Thus, a negative shock to SMB and HML more likely implies a negative shock to the value of human capital. Rational investors, who have hedging concern to their future labor income, have an incentive to avoid the stocks of small and value firms. As a result, small and value firms are riskier than big and growth firms in recessions when the price of risk associated with labor income is high. Indeed, our results echo the view of Fama and French (1996, p. 77): “Why is relative distress a state variable of special hedging concern to investors? One possible explanation is linked to human capital, an important asset for most investors.”

4.4 Comparison with Competing Asset Pricing Models

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from the regression of the market excess return on the lagged TERM, DEF, and the risk-free return.

In order to examine how well our three-factor model performs in explaining the cross-section of stock returns, we also estimate several competing models by using the CSR and GMM estimations. Table 7 reports the CSR and GMM estimation results of six competing models: the CAPM (in Panel B), the Jagannathan and Wang (1996) human capital CAPM (in Panel C), the consumption CAPM (in Panel D), the Epstein-Zin (1991) model (in Panel E), the Lettau-Ludvigson (2001) model (in Panel F), and the Vassalou (2003) model (in Panel G). The results of our three-factor model from Tables 4 and 5 are repeated in Panel A. The human capital CAPM is considered to compare the pricing ability of the factors related to *current* labor income growth and to innovations to *future* labor income growth. The Lettau-Ludvigson model is considered because it uses macroeconomic variables similar to ours and is known to have an almost equal ability in explaining the cross-section of average stocks returns as the Fama and French three-factor model.

The overall results of Table 7 show that our three-factor model performs better than any other competing model. The HJ-distance of our three-factor model is 0.58, which is the smallest among those of all competing models. Note that the HJ distance measures (maximum) pricing errors. The values of the HJ-distance are 0.68, 0.65, 0.68, 0.68, 0.67, and 0.63, respectively, for the CAPM, the human capital CAPM, the consumption CAPM, the Epstein-Zin model, the Lettau-Ludvigson model, and the Vassalou model. Recall that the HJ distance of the Fama-French model is 0.63. The intercept estimate of our three-factor model is insignificant. However, the intercept estimates of the competing models are all quite significant.

The Wald (SMB&HML) statistic is used to test whether the Fama-French factors SMB and HML are marginally useful in pricing assets, given the presence of other factors, when these two factors are added into the model. The p-value of the Wald (SMB&HML) test for our three-factor model is 0.31, which means that when our three factors, especially LIG, are included in the model, the SDF loading estimates of SMB and HML turn out insignificant and their marginal explanatory power for the cross-sectional of stock returns is limited. Except for the

Vassalou model, however, the Wald (SMB&HML) test for the competing models indicates that there is still a room for SMB and HML in explaining the cross-sectional of stock returns. Put differently, the factors of the competing models, except for Vassalou's (2003) GDP growth rate factor, do not successfully explain the portion of the cross-section of average returns that SMB and HML do.

5. Robustness Checks

This section provides a battery of robustness tests. These tests verify that our conclusions regarding future labor income growth risk are not driven by different estimation methods, alternative base assets, control variables, labor income data, and alternative horizon over which labor income growth computed for constructing the economic tracking portfolio, and different frequency.

The above-mentioned estimation results for LIG could be sensitive to how to construct the tracking portfolio. Recall that for constructing the tracking portfolios, we have used the following specifications; FF's four portfolios (small growth, small value, large growth, and large value portfolios) as base assets, quarterly labor income data, RF and TERM as control variables, long-run discounted labor income growth rates up to 12 quarters, and quarterly returns on the tracking portfolios.

It would be necessary, therefore, to perform a robustness test using various alternative specifications for constructing the tracking portfolios. Table 8 shows both CSR and GMM estimation results of our three-factor model in various alternative specifications.[15] We consider six different specifications: ten industry portfolios as base assets (in Panel A),[16] monthly labor

[15] Since the consumption data is available in quarterly frequency, the two-factor model (MKT and LIG) without CONS is estimated (in Panel F) when returns on the tracking portfolio is given.

[16] Returns on these industry portfolios are obtained from Kenneth French's web site. We are grateful to Kenneth French for making the data available on his website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

income data (in Panel B), DEF (difference between the yields on Moody's Baa and Aaa corporate bonds yields) and DIV (dividend yield of CRSP value-weighted portfolio)as control variables (in Panel C), long-run discounted labor income growth rates up to 4 years (or 12 quarters) and up to Five years (in Panels D and F, respectively), and monthly returns on the tracking portfolios (in Panel F).

The overall results are similar to those of the original specification for constructing the tracking portfolios. That is, in any specifications considered, the risk premium estimate on LIG is positive and statistically strongly significant. The HJ distance of each specification is also similar. The *p*-value of Wald (SMB&HML) test is 0.27, which means that when SMB and HML are added into the three-factor model, the coefficients on SMB and HML in the pricing kernel are not different from zero. That is, their marginal explanatory power for the cross-sectional of average returns is insignificant. These results are consistent with Panel D of Table 4.

6. Conclusions

This paper proposes revisions in expectation of future labor income growth as a macroeconomic state variable that is closely related to macroeconomic conditions and business cycle fluctuations and may imply the nature of the economic risk captured by size and book-to-market equity. We then suggest a three-factor model that includes a factor related to this variable, along with the consumption growth factor and the market factor. We examine whether this future labor income growth factor captures the pricing abilities of the Fama-French factors in explaining the size and book-to-market effects. In order to obtain the risk factor that captures revisions in future labor income growth, which is unobservable, we adopt the economic tracking portfolio approach introduced.

The CSR and GMM estimation results show that our three-factor model performs at least as much as the Fama and French model in explaining the cross-section of average returns of 25 size and book-to-market sorted test portfolios. In particular, our future labor income growth factor is consistently significantly priced in various model specifications. When the Fama and French factors are added into our three-factor model, they are no longer significant. This means that the future labor income growth factor is positively associated with the Fama-French factors and subsumes the explanatory power of these Fama-French factors in explaining the cross-section of stock returns. We interpret this positive association between the Fama-French factors and the future labor income growth factor as suggesting that small firms and value stocks are more sensitive to shocks to the state of future labor income growth. Thus, our empirical results provide an economic explanation for the roles of the Fama-French factors in explaining equity returns: they might be compensation for higher exposure to the risk related to revisions in expectation of long-run future labor income growth. Since the results in this paper could be sensitive to the specification used for constructing the tracking portfolio, we perform robustness tests using various alternative specifications for constructing the tracking portfolio. However, the overall results are qualitatively the same. We also compare the performance of our three-factor model with other competing models in explaining the cross-section of average returns. We find that our proposed three-factor specification explains better in various aspects than any of the competing asset pricing models considered.

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Table 1
Predictability of Future Labor Income Growth by the Base Assets

The table reports the forecasting regression results for the following regression specification:

$$\sum_{j=0}^{S} \rho^{j} \Delta y_{t+1+j} = a + cB_{t-1,t} + dZ_{t-2,t-1} + \eta_{t,t+S},$$

where $\sum_{j=0}^{S} \rho^{j} \Delta y_{t+1+j}$ is the discounted sum of labor income growth rate over the following S quarters, $B_{t-1,t}$ is the quarterly excess returns (over the T-bill rate) of a small growth (average of the two smallest size, two lowest book-to-market from the 25 Fama-French portfolios), a small value (average of the two smallest size, two highest book-to-market stocks), a large growth (average of the two largest size, two lowest book-to-market stocks), and a large value (average of the two largest size, two highest book-to-market stocks) portfolio, and $Z_{t-2,t-1}$ is the lagged control variables containing the difference between the yields of a ten-year and a one-year government bond (TERM), and the 3-month T-bill yield (RF). The *t*-statistics are reported in parentheses and are corrected for serial correlation up to three lags and White's (1980) heteroskedasticity using the Newey-West (1987) estimator. R-squares are reported. The sample period is from 1963:Q3 to 2007:Q4.

	S =	1	2	4	8	12	16	20	24
Base Assets	Small Growth	-0.02	-0.04	-0.04	-0.10	-0.12	-0.11	-0.08	-0.11
		(-0.71)	(-1.32)	(-0.92)	(-1.97)	(-2.14)	(-1.93)	(-1.38)	(-1.76)
	Small Value	0.03	0.06	0.09	0.14	0.17	0.19	0.19	0.24
		(1.07)	(1.55)	(1.55)	(1.90)	(2.04)	(2.20)	(2.04)	(2.57)
	Large Growth	0.02	0.04	0.05	0.10	0.08	0.09	0.06	0.08
		(0.88)	(0.95)	(1.15)	(1.59)	(1.05)	(1.09)	(0.67)	(0.87)
	Large Value	-0.03	-0.04	-0.09	-0.11	-0.06	-0.14	-0.15	-0.19
		(-1.04)	(-0.92)	(-1.63)	(-1.22)	(-0.63)	(-1.20)	(-1.26)	(-1.60)
Control Variables	Constant	0.89	1.82	3.41	5.85	7.80	10.02	12.55	14.99
		(3.26)	(3.77)	(4.20)	(4.19)	(4.90)	(5.71)	(6.88)	(7.42)
	TERM	0.02	-0.02	-0.02	-0.32	-0.83	-1.18	-1.43	-1.59
		(0.15)	(-0.09)	(-0.07)	(-0.83)	(-1.91)	(-2.58)	(-3.11)	(-3.23)
	RF	-0.06	-0.12	-0.19	-0.23	-0.20	-0.22	-0.33	-0.47
		(-1.58)	(-1.85)	(-1.87)	(-1.22)	(-0.89)	(-0.94)	(-1.33)	(-1.67)
	R^2	0.05	0.07	0.10	0.07	0.09	0.11	0.15	0.19

Table 2
Descriptive Statistics

The table reports the mean, standard deviation, t-statistic, and first-order autocorrelation of log consumption growth rate (CONS), excess market return (MKT), factor reflecting revisions in expectation of future labor income growth (LIG), Fama-French factors related to size (SMB) and book-to-market (HML). It also reports the correlation among these variables. All data are quarterly observations. If portfolios' returns are given as monthly, these are compounded to convert into quarterly returns. The sample period is from 1963:Q3 to 2007:Q4.

Factors	CONS	MKT	LIG	SMB	HML
			Mean		
	0.566	1.338	0.307	0.688	1.332
			Standard Deviation		
	0.450	8.572	0.659	5.987	6.028
			t-statistic		
	15.613	1.938	5.784	1.425	2.743
			Autocorrelation		
	0.418	0.020	0.013	-0.022	0.141
			Correlation Coefficient		
CONS		0.17	0.11	0.12	-0.03
MKT			0.51	0.49	-0.49
LIG				0.36	0.30
SMB					-0.19
HML					

Table 3
Factor Loading Estimates of the Risk Factors

This table reports the estimate results of the time-series univariate regression of returns on the Fama-French 25 size and book-to-market sorted portfolios on each of the five risk factors: excess market returns (MKT), log consumption growth rate (CONS), revisions in expectation of future labor income growth (LIG), and Fama and French's SMB and HML. *T*-statistics are corrected for autocorrelation and heteroskedasticity using the Newey-West (1987) estimator with three lags. The sample period is from 1963:Q3 to 2007:Q4.

	Low	2	3	4	High	Low	2	3	4	High
	$\beta_{\Delta c}$ (CONS)					$t(\beta_{\Delta c})$				
Small	6.72	6.52	4.83	4.90	5.44	2.24	2.55	2.09	2.25	2.30
2	4.75	3.94	4.14	3.63	4.60	1.76	1.78	2.14	1.89	2.27
3	3.85	3.63	3.56	3.22	3.79	1.52	1.78	1.99	1.66	2.09
4	3.67	3.45	2.60	2.93	3.80	1.52	1.84	1.44	1.71	1.87
Large	3.27	1.93	2.98	2.07	3.02	1.77	1.23	2.10	1.41	2.24
	β_M (MKT)					$t(\beta_M)$				
Small	1.66	1.40	1.23	1.15	1.19	19.86	19.21	16.33	15.63	14.56
2	1.57	1.29	1.15	1.05	1.08	21.51	19.46	17.30	15.54	13.06
3	1.47	1.18	1.01	0.95	0.98	23.86	23.43	15.13	14.15	11.49
4	1.34	1.10	0.96	0.93	0.98	23.54	18.72	17.56	16.71	12.66
Large	1.03	0.91	0.76	0.75	0.75	40.42	23.36	17.76	15.28	13.63
	β_{LIG} (LIG)					$t(\beta_{LIG})$				
Small	8.96	9.97	11.21	11.71	13.58	2.99	3.97	6.01	7.34	7.73
2	8.15	9.83	10.34	11.80	12.95	3.44	5.37	6.58	10.52	9.67
3	7.46	9.55	10.04	10.33	11.46	3.17	6.24	10.10	9.46	9.40
4	6.19	9.11	9.27	9.27	9.55	2.67	7.64	8.09	8.28	7.09
Large	5.65	6.83	6.15	7.37	7.71	3.42	5.81	6.50	9.04	9.18
	β_{SMB} (SMB)					$t(\beta_{SMB})$				
Small	2.32	2.05	1.79	1.69	1.81	18.46	20.53	17.54	18.21	16.03
2	1.91	1.68	1.43	1.32	1.44	14.84	16.10	14.02	13.07	12.80
3	1.59	1.30	1.14	1.03	1.24	12.20	13.00	10.96	8.84	10.41
4	1.21	1.03	0.88	0.86	1.06	9.72	8.79	8.53	8.59	8.60
Large	0.51	0.48	0.38	0.43	0.52	4.65	4.94	4.16	4.14	5.12
	β_{HML} (HML)					$t(\beta_{HML})$				
Small	-1.40	-0.84	-0.56	-0.40	-0.21	-6.51	-4.39	-3.26	-2.41	-1.10
2	-1.37	-0.75	-0.46	-0.22	-0.10	-7.61	-4.17	-2.80	-1.39	-0.60
3	-1.37	-0.66	-0.31	-0.11	-0.01	-8.49	-4.21	-1.96	-0.71	-0.06
4	-1.30	-0.57	-0.30	-0.18	-0.09	-8.87	-3.20	-2.04	-1.33	-0.55
Large	-0.98	-0.56	-0.33	-0.08	-0.01	-8.84	-4.01	-2.65	-0.63	-0.08

Table 4
Cross-Sectional Regression Estimation Results

The table reports the time-series averages (in percent per quarter) of the regression coefficient estimates of the cross-sectional regression model:

$$r_{i,t} = \lambda_{0t} + \lambda_t' \hat{\beta}_i + e_{i,t},$$

where $r_{i,t}$ is the return of portfolio i in excess of the riskless return, and $\hat{\beta}$ is the factor loadings estimated in the first-pass univariate time-series regression model using quarterly returns over the whole sample period. The test portfolios are Fama-French's (1993) 25 portfolios independently sorted by size and book-to-market. CONS is the log consumption growth rate, MKT is the market return in excess of the riskless rate of return, SMB and HML are Fama and French's (1993) factors related to firm size and book-to-market, and LIG is the factor reflecting revisions in expectation of future labor income growth. "*t*-value" is computed by using the uncorrected Fama-MacBeth standard errors. "Shanken-t" is computed by using Shanken's (1992) correction for the errors-in-variables bias. The adjusted R^2 is computed by using Jagannathan and Wang's (1996). The sample period is from 1963:Q3 to 2007:Q4.

	Panel A: The Fama-French Three-Factor Model						
	Constant	MKT	SMB	HML			Adj. R^2
Estimate	1.05	1.17	0.64	1.87			0.74
t-value	0.69	0.43	0.66	2.03			
Shanken-t	0.63	0.40	0.64	1.99			
	Panel B: Our Alternative Three-Factor Model						
	Constant	CONS	MKT	LRLIG			Adj. R^2
Estimate	0.17	0.05	-0.93	0.30			0.81
t-value	0.18	0.31	-0.85	3.72			
Shanken-t	0.15	0.27	-0.84	3.69			
	Panel C: A One-Factor Model						
	Constant	LRLIG					Adj. R^2
Estimate	-0.69	0.31					0.76
t-value	-0.75	3.34					
Shanken-t	-0.68	3.13					
	Panel D: A Five-Factor Model						
	Constant	CONS	MKT	LRLIG	SMB	HML	Adj. R^2
Estimate	0.26	0.04	-1.00	0.30	0.05	0.00	0.79
t-value	0.19	0.30	-0.37	3.08	0.06	0.00	
Shanken-t	0.13	0.22	-0.30	4.31	0.05	0.00	
	Panel E: A Three-Factor Model						
	Constant	LRLIG	SMB	HML			Adj. R^2
Estimate	-0.15	0.28	-0.07	0.38			0.81
t-value	-0.19	2.93	-0.11	0.62			
Shanken-t	-0.17	2.92	-0.11	0.65			

Table 5
GMM Estimation Results

This table reports the GMM estimation results by using Fama and French's (1993) 25 size and book-to-market sorted portfolios. CONS is the log consumption growth rate, MKT is the market return in excess of the riskless rate of return, SMB and HML are Fama and French's (1993) factors related to firm size and book-to-market, and LIG is the factor reflecting revisions in expectation of future long-run labor income growth. All data are quarterly observations. If portfolios' returns are given as monthly, these are compounded to convert into quarterly returns. The Wald (b) test is a joint significance test of the factor loadings in the pricing kernel. The SDF loadings and the test statistics for Wald (b) are computed through the GMM estimation that uses the optimal weighting matrix. The HJ-distance is the Hansen-Jagannathan (1997) distance measure, and its p-value is obtained from 10,000 simulations. The sample period is from 1963:Q3 to 2007:Q4.

Panel A: The Fama-French Three-Factor Model								
	Constant	MKT	SMB	HML				Wald (b)
Factor Loadings	1.10	-0.01	-0.03	-0.05			Test Statistic	18.77
t-value	21.91	-0.60	-1.49	-2.83			p-value	0.00
								HJ-distance
Risk Premium		0.48	1.01	1.15			Test Statistic	0.63
t-value		0.50	2.49	2.63			p-value	0.00
Panel B: The Alternative Three-Factor Model								
	Constant	CONS	MKT	LIG				Wald (b)
Factor Loadings	0.91	0.41	0.03	-0.65			Test Statistic	29.40
t-value	3.95	0.98	2.52	-5.23			p-value	0.00
								HJ-distance
Risk Premium		-0.08	-0.29	0.20			Test Statistic	0.58
t-value		-0.91	-0.37	3.52			p-value	0.04
Panel C: A Five-Factor Model								
	Constant	CONS	MKT	LIG	SMB	HML		Wald (b)
Factor Loadings	0.91	0.38	0.04	-0.65	-0.01	0.01	Test Statistic	30.11
t-value	3.91	0.90	1.63	-3.59	-0.68	0.30	p-value	0.00
								HJ-distance
Risk Premium		-0.08	-0.66	0.18	0.41	1.49	Test Statistic	0.56
t-value		-0.87	-0.67	2.62	0.80	3.62	p-value	0.03

Table 6
Pricing the Fama-French Factors

The table reports the estimation results of time-series regressions of each Fama-French factors on the factor reflecting revisions in expectation of future labor income growth (LIG). *T*-statistics are reported below the coefficient estimates and are corrected for autocorrelation and heteroskedasticity using the Newey-West (1987b) estimator with three lags. All data are quarterly observations. If portfolios' returns are given as monthly, these are compounded to convert into quarterly returns. The sample period is from 1963:Q3 to 2007:Q4.

Panel A: $SMB_t = \alpha_{SMB} + \delta_{SMB} LIG_t + \varepsilon_t$			
	α_{SMB}	δ_{SMB}	Adj. R^2
estimate	-0.31	3.24	0.12
t-value	-0.54	4.27	
Panel B: $HML_t = \alpha_{HML} + \delta_{HML} LIG_t + \varepsilon_t$			
	α_{HML}	δ_{HML}	Adj. R^2
estimate	0.48	2.78	0.09
t-value	0.85	2.94	
Panel C: $LIG_t = \alpha_{LIG} + \delta_{LIG} SMB_t + \varepsilon_t$			
	α_{LIG}	δ_{LIG}	Adj. R^2
estimate	0.28	0.04	0.12
t-value	5.40	4.04	
Panel D: $LIG_t = \alpha_{LIG} + \delta_{LIG} HML_t + \varepsilon_t$			
	α_{LIG}	δ_{LIG}	Adj. R^2
estimate	0.26	0.03	0.09
t-value	5.59	2.97	

Table 7
Comparison of Competing Asset Pricing Models

This table reports the CSR estimation results (in the upper part) and the GMM estimation results (in the lower part) of the competing models. CONS is the log consumption growth rate, MKT is the market return in excess of the riskless rate of return, SMB and HML are Fama and French's (1993) factors related to firm size and book-to-market, LIG is the factor reflecting revisions in expectation of future labor income growth, LI is the log of (present) labor income growth rate, and CAY is the consumption-wealth ratio created by Lettau and Ludvigson (2001). All data are quarterly observations. If portfolios' returns are given as monthly, these are compounded to convert into quarterly returns. The risk premiums associated with factors are estimated using Fama-MacBeth method. The adjusted R^2 is computed by using Jagannathan and Wang (1996). The Wald (b) test is a joint significance test of the factor loadings in the pricing kernel. The HJ-distance is the Hansen-Jagannathan (1997) distance measure, and its p-value is obtained from 10,000 simulations. The J-test is Hansen's (1982) test on the overidentifying restrictions of the model. The Wald (SMB&HML) statistic tests whether SMB and HML contain an incremental ability in pricing the test assets. The test statistics for Wald (b), HJ-distance, J test, and Wald (SMB&HML) are computed through the GMM estimation. The sample period is from 1963:Q3 to 2007:Q4.

Panel A: The Alternative Model					
	Constant	CONS	MKT	LIG	Adj. R^2
Risk Premium	0.17	0.05	-0.93	0.30	0.81
t-value	0.18	0.31	-0.85	3.72	
Shanken-t	0.15	0.27	-0.84	3.69	
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	29.40	0.58	37.74	2.31	
p-value	0.00	0.04	0.01	0.31	

Panel B: The CAPM					
	Constant	MKT			Adj. R^2
Risk Premium	2.71	-0.48			-0.02
t-value	2.96	-0.42			
Shanken-t	2.95	-0.42			
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	8.93	0.68	89.95	7.43	
p-value	0.00	0.00	0.00	0.02	

Panel C: The Jagannathan-Wang Model					
	Constant	MKT	LI		Adj. R^2
Risk Premium	3.20	-1.14	-1.12		0.24
t-value	3.32	-0.99	-3.38		
Shanken-t	2.13	-0.72	-2.20		
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	13.48	0.65	59.46	5.02	
p-value	0.00	0.01	0.00	0.08	

Table 7 (Continued)

Panel D: The Consumption CAPM

	Constant	CONS			Adj. R^2
Risk Premium	1.58	0.15			0.02
t-value	2.40	0.72			
Shanken-t	2.28	0.68			
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	0.05	0.68	115.86	8.22	
p-value	0.82	0.00	0.00	0.02	

Panel E: The Epstein-Zin Model

	Constant	CONS	MKT		Adj. R^2
Risk Premium	2.84	0.54	-2.49		0.29
t-value	3.10	2.65	-2.05		
Shanken-t	1.89	1.63	-1.41		
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	12.85	0.68	91.09	7.49	
p-value	0.00	0.00	0.00	0.02	

Panel F: The Lettau-Ludvigson Model

	Constant	CAY	CONS	CAY*CONS	Adj. R^2
Risk Premium	3.35	-0.02	0.05	0.01	0.54
t-value	3.17	-2.54	0.21	2.64	
Shanken-t	1.17	-0.96	0.08	1.01	
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	11.10	0.67	98.16	7.37	
p-value	0.01	0.01	0.00	0.03	

Panel G: The Vassalou Model

	Constant	MKT	GDPG		Adj. R^2
Risk Premium	1.93	-11.02	0.71		0.72
t-value	2.08	-3.40	3.30		
Shanken-t	0.26	-0.57	0.53		
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	22.49	0.63	67.68	2.22	
p-value	0.00	0.01	0.00	0.33	

Table 8
Cross-Sectional Regression and GMM Estimation Results of the Three-factor Model

The table reports the CSR estimation results (in the upper part) and the GMM estimation results (in the lower part) of our three-factor model. In Panel A, ten industry portfolios are used as alternative base assets in estimating LIG. In Panel B, *monthly* labor income (obtained from NIPA table 2.6) rather than quarterly labor income data is used in estimating LIG. In Panel C, DEF (the difference between the yields of a long-term corporate Baa bond and a long term corporate Aaa bond) and DIV (dividend yield) are used as alternative control variables in estimating LIG. In Panel D, monthly LIG is used in the cross-sectional regression. In Panel E, long-run labor income growth from quarter *t* to *t+16* is used in estimating LIG. In Panel F, long-run labor income growth from quarter *t* to *t+20* is used in estimating LIG. The risk premiums associated with factors are estimated using Fama-MacBeth method. The adjusted R^2 is computed by using Jagannathan and Wang (1996). The Wald (b) test is a joint significance test of the factor loadings in the pricing kernel. The HJ-distance is the Hansen-Jagannathan (1997) distance measure. The *J*-test is Hansen's (1982) test on the overidentifying restrictions of the model. The Wald (SMB&HML) statistic tests whether SMB and HML contain an incremental ability in pricing the test assets. The test statistics for Wald (b), HJ-distance, J test, and Wald (SMB&HML) are computed through the GMM estimation. The sample period is from 1963:Q3 to 2007:Q4.

Panel A: Ten Industry Portfolio as Alternative Base Assets					
	Constant	CONS	MKT	LIG	Adj. R^2
Risk Premium	2.29	-0.04	-5.58	1.09	0.67
t-value	2.58	-0.30	-3.22	3.83	
Shanken-t	1.23	-0.15	-1.69	1.89	
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	8.24	0.62	77.93	2.62	
p-value	0.04	0.01	0.00	0.27	
Panel B: Monthly Labor Income					
	Constant	CONS	MKT	LIG	Adj. R^2
Risk Premium	0.88	-0.08	1.01	0.14	0.81
t-value	0.96	-0.53	0.86	3.61	
Shanken-t	0.88	-0.49	0.82	3.53	
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	24.25	0.59	39.70	3.11	
p-value	0.00	0.02	0.01	0.21	

Table 8 (Continued)

Panel C: DEF and DIV as Alternative Control Variable

	Constant	CONS	MKT	LIG	Adj. R^2
Risk Premium	0.93	-0.04	-1.01	0.20	0.81
t-value	1.02	-0.29	-0.92	3.63	
Shanken-t	0.90	-0.26	-0.92	3.77	
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	28.17	0.58	38.04	2.02	
p-value	0.00	0.03	0.01	0.36	

Panel D: Four Years

	Constant	CONS	MKT	LIG	Adj. R^2
Risk Premium	1.86	0.02	-2.13	0.28	0.76
t-value	2.10	0.12	-1.81	3.82	
Shanken-t	1.73	0.10	-1.67	3.63	
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	40.93	0.57	34.48	0.78	
p-value	0.00	0.07	0.03	0.68	

Panel E: Five Years

	Constant	CONS	MKT	LIG	Adj. R^2
Risk Premium	3.09	-0.11	-2.53	0.26	0.75
t-value	3.31	-0.80	-2.08	3.67	
Shanken-t	2.74	-0.67	-1.88	3.51	
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	40.97	0.58	34.42	0.17	
p-value	0.00	0.06	0.03	0.92	

Panel F: Monthly Frequency Estimation

	Constant	MKT	LIG		Adj. R^2
Risk Premium	-0.23	-0.21	0.12		0.73
t-value	-0.44	-0.44	4.23		
Shanken-t	-0.39	-0.42	4.13		
Tests:	Wald (b)	HJ-distance	*J*-test	Wald (SMB&HML)	
statistic	33.86	0.30	30.93	5.06	
p-value	0.00	0.07	0.10	0.08	

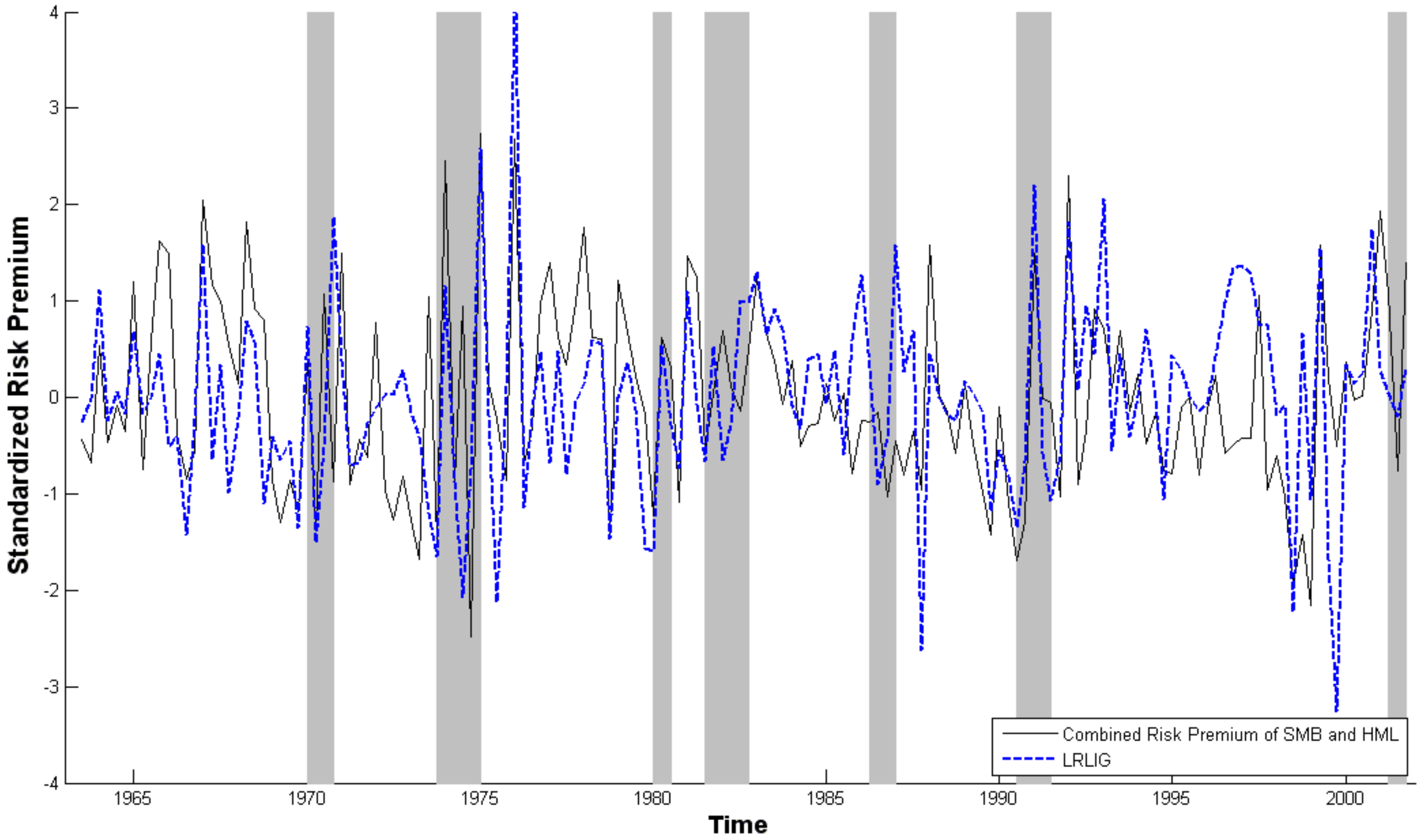

Figure 1 Risk Premium Associated with the Fama-French Factors and the Long-Run Labor Income Growth Factor

The figure is a time-series plot of the risk premium associated with revisions in expectation of future long-run labor income growth (LIG) (dotted line) and the Fama-French factors (solid line). The risk premium associated with the combined Fama-French factors is obtained as follows: Each of the Fama and French 25 portfolios is regressed on MKT, SMB, and HML. Then, we compute the average of Fama and French 25 portfolios' estimated corresponding factor loadings times SMB and HML (that is, $\hat{\beta}_{i,SMB} SMB_t + \hat{\beta}_{i,HML} HML_t$), which is regarded as the combined risk premium for the Fama and French factors. Both series are normalized to standard deviations of unity. The shaded regions indicate the recession periods defined by NBER.