Internet Appendix: Labor Income, Relative Wealth Concerns, and the Cross-section of Stock Returns

This Appendix includes some results that, although not essential to understand the main arguments of the paper, provides complementary material and further support to the evidence presented in the body of the paper. The Appendix has three main parts, and two figures referenced in the paper. In Appendix A, we summarize the optimal portfolio choice problem of an agent with either endogenous or exogenous keeping up with the Joneses preferences. For a detailed derivation, we refer the reader to Gómez, Priestley and Zapatero (2009). In Appendix B we present the portfolio tests of the country level analysis. This is a robustness test. We also perform portfolio tests at the divisional level, but these are less likely to be biased by the sorting procedure, therefore we leave them in the body of the paper. In Appendix C we derive a linear approximation to the stochastic discount factor (SDF) implied by our model. We then apply the SDF to the estimation of the prices of risk by the General Method of Moments (GMM).

Appendix A

0.1 Exogenous keeping up with the Joneses preferences

In this subsection we analyze the implications of a version of the keeping up with the Joneses preferences of Abel (1990) and Galí (1994). In particular, in the economy we consider investors are endowed with an utility function[1]

$$u(c, C) = \frac{c^{(1-\alpha)}}{1-\alpha} C^{\gamma\alpha}, \tag{1}$$

where c denotes the investor's consumption of the single consumption good, the economy's numeraire; C is the division average or per capita consumption; $\alpha > 0$ is the (constant) relative risk-aversion coefficient and $1 > \gamma \geq 0$ is the "Joneses parameter."

Here, workers represent agents endowed with non-tradable income. For instance, their human capital, that will materialize into wage income, or entrepreneurial income. Call w_k^0 the initial aggregate endowment of non-financial wealth for workers in division k; w_k denotes the final ($t = 1$) random value of their non-tradable income. Workers face incomplete markets because they cannot trade their human capital (due to moral hazard issues) and have no access to financial markets; therefore, they cannot hedge their income risk.

Since each investor takes C as exogenous and common, the typical aggregation property of the CRRA utility functions allows us to replace all the investors in a given division by a representative investor with utility function (1) endowed with the aggregated investors income without affecting the equilibrium prices. At time $t = 0$ each representative investor is endowed with a share of the local firm (unit value by assumption); hence, $c^0 = 1$ in all divisions.

We can write the problem's first order condition as a function of the investor's consumption and the workers relative wealth, w/c:

$$E\left(r\, c^{-\alpha(1-\gamma)}(1 + w/c)^{\alpha\gamma}\right) = 0. \tag{2}$$

[1] To simplify the notation, we drop the division subindex k for the moment (thus, all variables to be introduced next apply to investors in any division).

Notice that, in the absence of keeping up with the Joneses behavior ($\gamma = 0$), the previous condition reduces to $E\left(r\, c^{-\alpha}\right) = 0$, the standard CRRA Euler equation.

Condition (2) allows us to solve for the representative investor's optimal portfolio. Since financial markets are complete, there exists a mimicking portfolio X^w that maps the workers relative income onto the investment opportunity set such that $w/c = w^0(R + r'X^w)$. Following Galí (1994), given w^0 and X^w, for small values of $E(r)$, the optimal portfolio of the representative investor of division k can be approximated as a function of α, γ and the risk adjusted risk premia $\Omega^{-1}E(r)$:

$$x_k^* = \frac{\theta_k \gamma_k}{1-\gamma_k} X_k^w + \frac{1}{\alpha_k(1-\gamma_k)} \Omega^{-1} E(r), \tag{3}$$

with $\theta_k = \frac{w_k^0}{1+w_k^0}$, the workers initial wealth as a proportion of the division's total wealth (investor's plus non-diversifiable wealth).

Notice that even if there is a friction ($\theta_k > 0$) that prevents full risk-diversification for a set of agents (the workers), investors will hold well diversified portfolios unless they exhibit some degree of keeping up with the Joneses behavior ($\gamma_k > 0$). Thus, it is important to emphasize that investors' portfolios will be locally biased if and only if *both* keeping up with the Joneses behavior and a market friction exist.

0.2 Endogenous keeping up with the Joneses preferences

In this section, we discuss the endogenous keeping up with the Joneses preferences presented in DeMarzo, Kaniel and Kremer (2004). In this specification agents consume two types of goods: c, which has the interpretation of a global good, and w_k, a local good, like housing services. Utility over consumption for these two goods is given by:

$$u(c, w) = \frac{1}{1-\alpha}(c^{1-\alpha} + \delta w^{1-\alpha}).$$

The parameter $\delta > 0$ specifies the relative importance of the local good. All consumption takes place at the end of the period. At time $t = 0$, investors are endowed with shares of the firm that produces the global good. Call c_k^0 the aggregate value of those shares at the beginning of the period for agents in division k. For simplicity, let $c_k^0 = 1$ in all divisions.

Workers in each division will receive a fixed number $\bar{w}_k$ of units of the local good at time $t = 1$. In equilibrium, the relative price of the local good in terms of the global good at $t = 1$ is given by $p_k = \delta \left(\frac{c_k}{\bar{w}_k}\right)^{\alpha}$. As it would be expected, the scarcer the (fixed) local good endowment relative to the (stochastic) global good consumption, the higher the relative price of the former. The investor's hedging demand for this risk will trigger the endogenous keeping up with the Joneses behavior in this model. Financial markets are complete.

If workers can not diversify their endowment risk (due, for instance, to short-selling constraints and moral hazard), Proposition 2 in DeMarzo, Kaniel and Kremer (2004) shows that the representative investor's marginal utility is given by:

$$u_c(c, p) = c^{-\alpha} \left(1 + \delta^{1/\alpha} p^{1-1/\alpha}\right)^{\alpha}. \tag{4}$$

Let $p^0 = \delta \left(\frac{c^0}{\bar{w}}\right)^{\alpha}$ denote the relative price at $t = 0$ of one unit of the non-diversifiable, local good endowment of workers at time $t = 1$. Recall that we normalized the initial investor's shares endowment $c^0 = 1$. Hence, $p^0 = \delta \bar{w}^{-\alpha}$. The present value of the workers endowment is therefore $\bar{w}^0 = \delta \bar{w}^{1-\alpha}$.

In this model, the relative wealth at $t = 0$ of the workers in division k as a proportion of the total division wealth is given by $\theta_k = \frac{\bar{w}_k^0}{1+\bar{w}_k^0}$. Call $\bar{w}_k p_k / \bar{w}_k^0$ the return on the workers wealth (in units of the global good) over the period. Like in the exogenous preferences specification, under complete (financial) markets, there exists a portfolio X_k^w such that $\frac{\bar{w}_k p_k}{\bar{w}_k^0} = R + r' X_k^w$.

After these definitions, we can write the approximate function for division k investor's optimal portfolio as follows:

$$x_k^* = \frac{\theta_k (\alpha_k - 1)}{\alpha_k} X_k^w + \frac{1}{\alpha_k} \Omega^{-1} E(r). \tag{5}$$

Notice that, in this model, the optimal portfolio for the logarithmic investor ($\alpha = 1$) coincides with the benchmark, well diversified portfolio $\Omega^{-1} E(r)$. No relative wealth concern arises even in the presence of local, non-diversifiable wealth. Only for $\alpha > 1$ should we observe a local bias in portfolio holdings.

Appendix B

0.1 Country Level Portfolios

We complement here the results of Section 4 in the paper. In that section we test the implications of the model using individual stocks. In addition, it is standard in empirical asset pricing tests to use portfolios of stocks as test assets in order to reduce the errors in variables problem that plagues the two-step Fama and MacBeth (1973) estimation methodology. Furthermore, it is common to use factor mimicking portfolios to proxy risk factors in order to be able to interpret the estimated prices of risk in terms of returns (risk premia). Furthermore, model performance that focuses on pricing errors is easier to undertake with the use of well diversified portfolios.

We construct a factor mimicking (FM) portfolio for the orthogonal state labor income risk as follows. For each stock i, we use the slope coefficient on the orthogonal labor factor $\hat{\beta}_i^F$ estimated in equation (6) in the paper until the fourth quarter of 1964, to rank stocks in 1965. Next, we form three equally weighted portfolios according to the size of the coefficient. We then add one year of quarterly data. We re-estimate the coefficient, rank the stocks, sort them into three portfolios and compute their quarterly returns in 1966. We continue adding one year and re-estimating the coefficients until we have thirty-six quarterly observations in the time-series regressions. At this point, we start rolling the data one year at a time: adding on a new year and taking off the first year. We continue this process until the end of the sample.

The above procedure results in three portfolios, from the first quarter of 1965 to the final quarter of 2011, formed in year t based on the estimated coefficient on orthogonal labor income estimated until year $t-1$. The returns of the factor mimicking portfolio are computed as the returns of the portfolio (P1) formed by the stocks with the highest one third of coefficient estimates minus the returns on the portfolio (P3) formed by the stocks with the lowest one third of coefficient estimates. We represent by r_t^{FM} the return of the state factor mimicking portfolio at t.

As test assets, we consider the Fama and French twenty-five size and book to market portfolios that have become standard in asset pricing tests due to their large spread in returns. In addition, we form test portfolios based on the sorted orthogonal betas from individual stocks estimated in equation (6) in the paper. The reason for this is that Daniel and Titman (2011) and Lewellen, Nagel, and Shanken (2010) note that testing asset pricing models using portfolios formed on firm characteristics, such as size and book to market, can lead to spurious conclusions about the usefulness of a proposed factor. This is because the factor structure of the portfolios is so strong that any proposed factor that is only weakly correlated with size or book-to-market will appear to price the test assets. That is, testing a new proposed factor on test assets sorted only by size and book-to-market is likely to have very low power. In order to alleviate this concern, we follow the recommendations in Daniel and Titman (2011) and Lewellen, Nagel, and Shanken (2010) and sort stocks by lagged loadings on our proposed factor. We use these beta-sorted portfolios together with the twenty-five Fama and French portfolios sorted by size and book-to-market in the cross-sectional tests of our model.

To generate the beta-sorted test portfolios we repeat the procedure discussed above and construct ten and twenty equally weighted portfolios.[2] We calculate excess returns on all the test portfolios by subtracting the one month T-bill rate from the actual returns.

Panel A of Table 1 in this Appendix shows the average return spread between the portfolio containing the stocks with the highest orthogonal betas (P1) and the portfolio containing the stocks with the lowest orthogonal betas (P3, P10 and P20, respectively). Notice that, consistent with the model's prediction, portfolios with a higher orthogonal beta carry a lower return relative to portfolios with lower orthogonal beta. This difference is economically significant and above 1% per quarter. We test whether the difference between both portfolios is different from zero. In the first two cases (P1-P3 and P1-P10) we strongly reject that the difference is zero. In the third case (P1-P20) we can only reject it marginally, however it should be noted that the size of the spread on the P1-P20 portfolio is larger than the spread on the P1-P3 portfolio. The lower level of statistical significance could be due to the smaller number of stocks in the 20 portfolios.

Panel B of Table 1 presents the average excess return on each of the twenty beta-sorted portfolios and the correlation coefficient between each portfolio and the factor mimicking portfolio.[3] Notice that as we move from top to bottom in the table, the average return on the portfolios increases while the correlation decreases. That is, portfolios more correlated with the factor mimicking portfolio offer a better hedging against deviations from the Joneses consumption (including non-diversifiable wealth) and trade at a higher price (lower expected return). Using the full sample, the coefficient $\hat{\beta}_p^{FM}$ is obtained by regressing the return on each of the portfolios against the return on the factor mimicking portfolio and the market excess return:

$$r_{p,t} = \alpha_p + \beta_p^{FM} r_t^{FM} + \beta_p^{erm} r_{erm,t} + u_{p,t}. \tag{1}$$

[2]All the results presented in the paper are generally robust to the use of market capitalization weighted portfolios.

[3]When examining portfolios, we use excess returns in order to test whether the models' pricing errors are equal to zero.

where $r_{p,t}$ is the excess return on portfolio p, r_t^{FM} is the return on the factor mimicking portfolio, $r_{erm,t}$ is the excess return on the aggregate stock market portfolio, and $u_{p,t}$ is the residual. All but the three top betas are strongly statistically significant. The spread in returns and betas indicates that orthogonal local labor income is closely related to stock returns. It is worth mentioning that if the distributions of betas and the prices of risk are different across divisions, the estimates of α_p from regression (1) cannot be interpreted as KEEPM pricing errors even if the KEEPM model is true. The fact that the spread in average returns in panel B of Table 1 is not monotonic suggests so.[4] Furthermore, nine of the estimate of α_p are statistically significant although the patterns is the alpha have no clear relation to the portfolios sorting. In order to address the concern that the distribution of betas and prices of risk could be different across divisions, we will repeat the time series and cross-section tests at the divisional level in section 5 in the paper.

We now turn to analyzing the cross-sectional performance of the KEEPM. As test assets, we use the excess returns on the twenty beta-sorted portfolios plus the Fama and French twenty-five size and book to market portfolios.[5] The cross sectional regressions regress excess returns in each quarter on the portfolio betas on the factor mimicking portfolio based on the orthogonal state labor income return, $\hat{\beta}_p^{FM}$, and the stock market return, $\hat{\beta}_p^{erm}$, estimated in (1):

$$r_p = \lambda_t^0 + \lambda_t^{FM} \hat{\beta}_p^{FM} + \lambda_t^{erm} \hat{\beta}_p^{erm} + \xi_p. \tag{2}$$

The results from this cross-sectional regression are reported in Panel A of Table 2 in this Appendix. The quarterly price of risk on the orthogonal factor mimicking portfolio is negative, economically important at -0.88% per quarter, and statistically significant. The adjusted R^2, $\overline{R}^2$, is 66% indicating a good measure of fit.[6] Notice that the intercept, which should be zero, is positive and statistically significant, which indicates that the model is not correctly specified. As noted above, one potential reason for this that we explore later is that we restrict the price of risk on the orthogonal labor income risk to be the same across all stocks irrespective of where the stocks come from.

[4] We thank the referee for this comment.

[5] All cross-sectional results are qualitatively analogous when the prices of risk are estimated with respect to the one-year lagged betas.

[6] Following Jagannathan and Wang (1996) and Lettau and Ludvigson (2001b), we calculate R^2 as $\left[Var_c(\overline{r}_p) - Var_c(\overline{\xi}_p)\right] / Var_c(\overline{r}_p)$, where Var_c is the cross-sectional variance, $\overline{r}_p$ is the average return and $\overline{\xi}_p$ is the average residual. $\overline{R}^2$ is the adjusted R^2.

For comparison, the second row of Panel A reports the price of risk, λ^{erm}, and the average $\overline{R}^2$ from the cross-sectional regression of the CAPM. As in previous tests of the unconditional CAPM, the estimated price of risk is statistically not different from zero and the $\overline{R}^2$ is only 8%. The third row of Panel A presents the results from the three-factor Fama and French model. The prices of risk associated with size, λ^{smb}, and book-to-market, λ^{hml}, are positive and statistically different from zero. The average $\overline{R}^2$ is 73% and similar to the value from the KEEPM.

In order to assess whether there is any additional explanatory power in the size and book-to market risk factors relative to that of the KEEPM, in the fourth row of Panel A, we estimate the KEEPM whilst including the *smb* and *hml* risk factors in (2):

$$r_p = \lambda_t^0 + \lambda_t^{FM}\hat{\beta}_p^{FM} + \lambda_t^{erm}\hat{\beta}_p^{erm} + \lambda_t^{smb}\hat{\beta}_p^{smb} + \lambda_t^{hml}\hat{\beta}_p^{hml} + \xi_p. \tag{3}$$

The price of risk on the orthogonal factor mimicking portfolio is -0.896, virtually identical to the original value reported in the first row, and also statistically significant. The estimated price of risk on the book-to-market factor remains positive and significant, although the size risk premium is smaller and only marginally significant and the $\overline{R}^2$ is 75%. We interpret these findings as evidence that the model's prediction of a negative price of risk on the Joneses risk-hedging factor remains robust to the inclusion of other risk factors known for their ability to explain the cross-section of the US stock returns. In light of the results in the fourth row of Panel A, we conclude that the orthogonal labor income factor commands a price of risk not explained by the size and book-to-market risk premia. Appendix C shows that these results are robust, and even stronger, when estimated by GMM.

To provide a more formal test of the performance of the KEEPM relative to the CAPM and the three-factor Fama and French model, Panel B presents the square root of the squared pricing errors for each test portfolio and each model. We define the pricing error of a given portfolio as the difference between the actual portfolio return and the expected return according to the cross-sectional model. Overall, the size of the pricing errors of the KEEPM are small relative to the portfolio returns in Panel B of Table 1. In particular, the average pricing error is 0.287, about ten times smaller than the average portfolio return. The pricing errors from the CAPM, as expected, are large relative to those of the other models, with an average value of 0.483. A comparison of the pricing errors of the KEEPM with those of the three-factor Fama and French model reveals that they are of similar magnitude (the average value is 0.241) and smaller in eight out of the twenty-five Fama and French portfolios (Panel

B.1) and eleven out of the twenty beta-sorted portfolios (Panel B.2). When we add the size and book-to-market risk factors to the KEEPM in the last column, the average pricing error decreases to 0.222 and the pricing errors are smaller than those from the three-factor model for eleven of the Fama and French portfolios and thirteen of the beta-sorted portfolios.

Panel B.3 includes the average cross-sectional pricing errors from each model for the forty-five portfolios of panels B.1 and B.2. We also test whether the pricing errors are jointly zero.[7] Except for the three-factor Fama and French model, the test rejects the hypothesis that the pricing errors are jointly zero, although it should be emphasized that the pricing errors are economically small and very similar in size for the KEEPM and the Fama-French three factor model and actually smaller for the model that incorporates all four factors.

The evidence presented so far shows strong support at the country level for the main prediction of the model: a negative and significant price of risk on the orthogonal state labor income return factor. In the time-series, the test portfolios' betas with respect to the orthogonal factor mimicking portfolio are strongly significant in most cases and give a reasonable and statistically significant spread in returns. In the cross-sectional tests, the KEEPM performs well both in its own right and in comparison with the three-factor Fama and French model, and the orthogonal factor mimicking portfolio is shown to be robust to the inclusion of the size and book-to-market risk factors.

[7] This is a Chi-sq test given as $\widehat{\alpha}' cov(\widehat{\alpha})^{-1}\widehat{\alpha}$, where $\widehat{\alpha}$ is the vector of average pricing errors across the forty-five portfolios and cov is the covariance matrix of the pricing errors. p-values in brackets.

Appendix C

0.1 A linear approximation to the Stochastic Discount Factor (SDF)

We will derive this approximation both for the endogenous and the exogenous case. Like in the derivation of the optimal portfolio, the only difference will lay on the interpretation of the deep parameters.

Let us start with the exogenous Joneses specification. The investor's (first order condition) optimal consumption choice is given in equation (2). This condition holds for any asset i and any division k. The first-order approximation to the marginal's utility is given by $u_c(c_k, w_k/c_k) \approx u_c(c_k^0, w_k^0/c_k^0) + u_{c,c}(c_k^0, w_k^0/c_k^0)(c_k - c_k^0) + u_{c,w/c}(c_k^0, w_k^0/c_k^0)(w_k/c_k - w_k^0/c_k^0) = u_c(1, w_k^0)\left[1 - \alpha(1-\gamma)(r'x_k^* + R - 1) + \theta_k\, \alpha\gamma(r'X_k^w + R - 1)\right].$

Replacing the later expression in (2) we obtain the following condition:

$$E\left(r_i\ \left[\tau_k - (r'x_k^* + R - 1) + \theta_k b_k(r'X_k^w + R - 1)\right]\right) = 0, \tag{1}$$

where $\tau_k = \frac{1}{\alpha_k(1-\gamma_k)}$ and $b_k = \frac{\gamma_k}{1-\gamma_k}$. We multiply (1) by ω_k, the proportion of country market capitalization in division k and add up across all divisions:

$$E\left(r_i\ \left[H^{-1} - (r_M + R - 1) + \sum_k \omega_k\theta_k b_k(r_k^w + R - 1)\right]\right) = 0, \tag{2}$$

where $H^{-1} = \sum_k \omega_k\tau_k$ is the aggregate risk aversion coefficient. We have used the market clearing condition $\sum_k \omega_k x_k^* = x_M$ and the definitions $r_M = r'x_M$ and $r_k^w = r'X_k^w$. After regressing the workers non-diversifiable income onto the country market portfolio return – equation (2) in the paper– we can write $r_k^w = \beta_k r_M + r_k^F$. We replace the later expression in the Euler equation. Moreover, we assume that $E(r_i)(R-1) \approx 0$ for small values of $E(r_i)$ and the (net) risk-free rate, $R - 1$. This results into the following Euler equation:

(3) $$E\left(r_{i,t}\left[H^{-1}-(1-\sum_{k=1}^{K}\omega_k\theta_k b_k\beta_k)r_M+\sum_{k=1}^{K}\omega_k\theta_k b_k r_k^F\right]\right)=0.$$

We turn now to the endogenous Joneses specification. The investor's optimal consumption choice is given in equation (4). This expression can be linearly approximated as follows: $u_c(c_k,p_k)\approx u_c(c_k^0,p_k^0)+u_{c,c}(c_k^0,p_k^0)(c_k-c_k^0)+u_{c,p}(c_k^0,p_k^0)(p_k-p_k^0)$.

Replacing the values of c_k^0, p_k^0, and c_k in the later expression we obtain the following:

$$u_c(c_k,p_k)\approx u_c(1,\delta_k\bar{w}_k^{-\alpha_k})\left[1-\alpha_k(r'x_k^*+R-1)+\theta_k\left(\alpha_k-1\right)\left(\frac{\bar{w}_k p_k}{\bar{w}_k^0}-1\right)\right].$$

We replace the later expression in (4). Given that $\frac{\bar{w}_k p_k}{\bar{w}_k^0}=R+r_k'^w$, we obtain condition (1) with $\tau_k=\frac{1}{\alpha_k}$ and $b_k=\frac{\alpha_k-1}{\alpha_k}$. Following the same procedure as in the exogenous case we arrive at equation (2) and finally equation (3).

Equation (3) implies an approximate linear expression to the stochastic discount factor:

(4) $$m\approx c_0+c_M r_M+\sum_{k=1}^{K}c_k r_k^F,$$

where $c_0=H^{-1}$, $c_M=\sum_{k=1}^{K}\omega_k\theta_k b_k\beta_k-1$ and $c_k=\omega_k\theta_k b_k$. We define $\boldsymbol{c}\equiv(c_M,c_1,...,c_k,...,c_K)$ as the vector of coefficients; recall that $\boldsymbol{r^F}=(r_M,r_1^F,...,r_k^F,...,r_K^F)$ denotes the vector of factor returns. Hence, we can write the stochastic discount factor is a more compact way as $m\approx c_0+\boldsymbol{c}\boldsymbol{r^F}$.

Define the forecast error at time t for the parameter vector $\boldsymbol{c}$ as $\mathbf{v}_t(\boldsymbol{c})\equiv r_t(c_0+\boldsymbol{c}\boldsymbol{r^F})$, such that, according to the equilibrium orthogonality condition (3), its unconditional expectation $E(\mathbf{v}_t(\boldsymbol{c}))=0$. Define the sample mean of the forecast errors over the T observations as:

$$\mu_T(\boldsymbol{c})\equiv\frac{1}{T}\sum_{t=1}^{T}\mathbf{v}_t(\boldsymbol{c}).$$

The GMM methodology estimates the parameter vector $\boldsymbol{c}$ that minimizes

$$\widehat{\boldsymbol{c}} = \arg\min_{c}(\mu_T'(\boldsymbol{c})\boldsymbol{\Sigma}\mu_T(\boldsymbol{c})),$$

where $\boldsymbol{\Sigma}$ is a positive definite weighting matrix. Under GMM this weighting matrix is the inverse of a consistent estimator of the spectral density matrix of $\mathbf{v}_t$ at frequency zero, defined as $\mathbf{S} = \sum_{j=-\infty}^{\infty} E[\mathbf{v}_t\mathbf{v}_{t-j}'] = T \cdot \text{var}(\mu_T)$. Hansen (1982) shows that it is optimal to use the inverse of a consistent estimator of $\mathbf{S}$ as the weighting matrix, since the estimated parameter vector has the lowest variance asymptotically. When $\boldsymbol{\Sigma}$ is the optimal weighting matrix $\mathbf{S}^{-1}$, the asymptotic standard errors are given by $\text{var}(\widehat{\boldsymbol{c}}) = \frac{1}{T}(\mathbf{D}_T'\mathbf{S}^{-1}\mathbf{D}_T)^{-1}$, where $\mathbf{D}_T = \frac{\partial\mu_T(\boldsymbol{C})}{\partial\boldsymbol{C}'}$.

0.2 GMM Estimation of the Prices of Risk

In this subsection, we approach the estimation of prices of risk implied by the KEEPM model in sections 0.1 in this Appendix and 5.2 in the paper using the GMM procedure described above. This allows for any heteroscdasticity in the residuals to be controlled for, a potential weakness of the OLS based Fama-MacBeth methodology. Whilst it is possible to use GLS in the Fama-MacBeth methodology, there are well know problems associated with the GLS method in cross sectional regressions. In particular, in finite samples the covariance matrix could be poorly estimated (see Cochrane (2005)). In order to capture possible heteroscedasticity in the residuals, we have decided to estimate the prices of risk using one-step GMM which provides robust standard errors. This approach is based on the derivation of an approximate linear stochastic discount factor (SDF) in Appendix C.1 based on the model equilibrium condition for the prices of risk (4).

Equation (2) in section 0.1 shows the Fama-MacBeth cross-section regression that we used to estimate the orthogonal price of risk on the factor mimicking portfolio (common across all portfolios), λ^{FM}, and the market price of risk, λ^{erm}. We now use the approximate Euler equation (3) and the implied stochastic discount factor, m, in (4) to estimate the corresponding loadings and prices of risk using the GMM approach. In particular, for each portfolio p, the orthogonality condition is given by:

$$r_p \left(c_0 + c_{erm}r_{erm} + c_{FM}r^{FM}\right) = 0, \tag{5}$$

where r^{FM} represents the return on the (orthogonal) labor risk factor-mimicking portfolio, common across all divisions; c_{FM} is the corresponding factor loading in the SDF. We also follow Cochrane (2005), who notes that, given a stochastic discount factor m, a risk factor vector $\boldsymbol{r^F}$, and factor risk premia vector $\boldsymbol{\lambda}$, $E(m\boldsymbol{r^F} - \boldsymbol{r^F} + \boldsymbol{\lambda}) = 0$. This results into two additional orthogonality conditions:

$$\begin{aligned}
\left(c_0 + c_{erm} r_{erm} + c_{FM} r^{FM}\right) r_{erm} - r_{erm} + \lambda^{erm} &= 0, \\
\left(c_0 + c_{erm} r_{erm} + c_{FM} r^{FM}\right) r^{FM} - r^{FM} + \lambda^{FM} &= 0,
\end{aligned} \tag{6}$$

which we can incorporate into the moment conditions given by (5) to produce efficient estimates of the SDF loadings (c_0, c_{erm}, and c_{FM}), the prices of risk λ^{erm} and λ^{FM}, and their associated standard errors (see Li, Vassalou and Xing (2006)). As testing portfolios we use the 20 state beta-sorted portfolios from Table 1 Panel B of this Appendix plus the twenty-five Fama-French portfolios sorted first by size from smaller to larger and sorted then within each quintile by book-to-market from lower to higher. The system involves $N = 20 + 25 + 2 = 47$ orthogonality conditions to estimate $L = 5$ parameters.

In Table 3 of this Appendix, the KEEPM Model (second row) is supported by the data, with a sizeable quarterly premium (-2.045) significant at almost the 1% level. The corresponding coefficient in the pricing kernel, c_{FM}, is also significant at the 1% level. Looking at the KEEPM model extended with the Fama and French factors (bottom row), all the estimated prices of risk are very similar to those reported in Table 3 Panel A with a quarterly premium on the orthogonal labor risk factor equal to -0.936, significant at the 5% level.

We estimate next the prices of risk from the KEEPM model per division. Table 4 of the Appendix presents the coefficients and prices of risk estimated in each division using the orthogonality conditions in (5) and (6). When comparing these estimates and their statistical significance with those in Table 4 in the paper, obtained using the Fama-MacBeth methodology, we find, with the exception of MA and EN which have a larger estimates, very similar results in terms of the size and the extent of the statistical significance of the estimate prices of risk.

Summarizing, the results regarding the statistical significance of the estimated prices of risk are robust to two different estimation techniques, the traditional Fama-MacBeth cross sectional regressions (reported in tables 2 of the Appendix and 4 of the paper) and the GMM technique (reported in tables 3 and 4 of the Appendix) which is robust to heteroscedacticity.

References

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[2] Li, Q. Vassalou, M., and Y. Xing, 2006, Sector Investment Growth Rates and the Cross-Section of Equity Returns, Journal of Business 79, 1637–1665.