Human Capital and Popular Investment Advice

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Abstract

Popular investment advice recommends that the stock/bond and stock/wealth ratios should rise with investor risk tolerance and investment horizon respectively, prescriptions that are difficult to reconcile with standard models of portfolio choice. Canner et al (1997) point out that the first piece of advice can potentially be explained by human capital considerations, but only by exacerbating the puzzle surrounding the second piece of advice. However, we show that human capital *can* simultaneously justify both pieces of advice, so long as the correlation between human capital returns and stockmarket returns lies within a range that depends on market and investor-specific parameters. Historical data comfortably satisfy this requirement for the average investor.

1. Introduction

One of the cornerstones of modern portfolio theory is the two-fund separation theorem. This seminal result, originally due to Tobin (1958), states that the composition of the optimal portfolio of risky assets depends solely on the stochastic structure of market returns and is independent of investor-specific characteristics such as risk tolerance. However, Canner et al (1997) find that popular investment advice recommends that less risk-tolerant investors hold a higher ratio of bonds to stocks, a phenomenon they refer to as the asset allocation puzzle. As they point out, this is perplexing not only because the advice differs from that implied by theory, but also because it is more complicated than theory.

For many investors, human capital is a significant part of their overall portfolio, but it plays no role in the one-period mean-variance model that gives rise to the two-fund separation theorem. Extending the model to incorporate human capital can potentially resolve the asset allocation puzzle. Suppose that returns to human capital are perfectly correlated with those on stocks. Then human capital and stocks are perfect substitutes, so the separation theorem implies that the ratio

$$\frac{\text{BONDS}}{\text{HUMAN CAPITAL + STOCKS}}$$

is independent of investor risk tolerance. An increase in risk tolerance increases both the numerator and denominator of this ratio in the same proportion. But at any point in time, the quantity of human capital is non-tradable and thus fixed, so the quantity of stocks must rise proportionately more than the quantity of bonds. That is, the ratio of stocks to bonds is greater for more risk-tolerant investors, just as popular advice recommends.

However, Canner et al (1997) reject this explanation on two grounds. First, human capital and stocks are unlikely to be perfect substitutes for many investors. Second, if human capital returns *are* strongly correlated with stock returns, then it becomes difficult to reconcile theory with another popular piece of investment advice: that young investors with long investment horizons should hold more of their wealth in stocks than older investors.[1] In general, young investors have more human capital than their older counterparts, so a high positive correlation between stocks and human capital implies that young investors optimally allocate *less* of their wealth to stocks, thereby contradicting the standard advice. By contrast, if human capital is uncorrelated with stocks, and thus a close substitute for cash, then younger investors should indeed hold a higher proportion of their wealth in stocks, just as popular advice dictates. But then the advice that more risk-tolerant investors hold a higher ratio of stocks to bonds cannot be explained.

Thus, human capital considerations seem unable to resolve the asset allocation puzzle without simultaneously creating another equally-perplexing puzzle. On the one hand, the strong correlation between human capital returns and stock returns required to justify the asset allocation advice creates an investment horizon puzzle. On the other hand, the weak correlation between human capital returns and stock returns required to justify the investment horizon advice cannot explain the asset allocation puzzle. More succinctly, it seems impossible for the human capital of any investor to be simultaneously risky (a close substitute for stocks) and riskless (a close substitute for cash).[2]

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[1] See, for example, the Vanguard Group advice quoted in Ameriks and Zeldes (2001).

[2] Of course, one could assume that the investment horizon advice is justified by other considerations, but this is hard to sustain; Jagannathan and Kocherlakota (1996), for example, argue that human capital

In this paper, we subject this pessimistic conclusion to further scrutiny. Specifically, we ask two questions. First, despite the misgivings outlined above, is it *theoretically* possible for human capital considerations to reconcile the simple mean-variance model with popular advice on asset allocation *and* investment horizon. Second, if a theoretical explanation of the two puzzles does exist, is it *empirically* plausible? That is, given the ubiquitous nature of these two pieces of investment advice, do the conditions required for a solution to exist in theory seem likely to also exist in practice?

For the first question, we use a simple extension of the Campbell and Viceira (2002) log-linear version of the mean-variance model, and show that human capital factors *can* justify popular advice about both the asset allocation and investment horizon decisions so long as the correlation between stock and human capital returns falls within some range defined by market and investor-specific parameters. To address the second question, we use historical data to estimate these parameters and find that, at least for the various data sets we employ, the stock-human capital correlation falls comfortably within the allowed range.

Previous research has identified other possible solutions for the asset allocation puzzle. Elton and Gruber (2000) argue that theory and popular advice can be reconciled by introducing various constraints into the mean-variance model, while Brennan and Xia (2000) and Campbell and Viceira (2001) show that time-varying expected returns can justify the advice for an infinitely-lived investor. None of these, however, considers the relevance of their analysis for investment horizon considerations. Other authors, such as Bodie et al (1992), Jagannathan and Kocherlakota (1996), and Viceira (2001), show that human capital considerations can justify the popular investment horizon advice, but do not discuss the asset allocation puzzle. As far as we are aware, our analysis is the first to consider whether or not recognition of non-tradable human capital can *simultaneously* justify *both* pieces of investment advice within the mean-variance model.[3]

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considerations represent the only convincing explanation for the view that the stock/wealth ratio should rise with investment horizon.

3 Gomes and Michaelides (2002) calibrate a multi-period model with non-mean-variance preferences and a fixed market entry cost and find optimal behavior that is broadly consistent with both pieces of investment advice. However, their primary focus is on other matters, so they do not explore the source of these results.

2. Optimal asset allocation in the presence of non-tradable human capital

An investor has some initial endowment of financial wealth $\bar{W} > 0$ which is used to construct a portfolio that generates the random rate of return R_p. One period later, the investor consumes (i) the portfolio's liquidation value $\bar{W}(1+R_p)$ plus (ii) labor income L earned over the period.

At the beginning of the period, the investor chooses the portfolio that maximizes the expected utility of terminal wealth $W = \{\bar{W}(1+R_p) + L\}$. This decision is determined by the power utility function

$$U(W) = \frac{W^{1-\gamma}}{1 - \gamma} \qquad (1)$$

where $\gamma > 0$ is the coefficient of relative risk aversion.

In Campbell and Viceira (2002), the investor's portfolio decision consists of choosing the optimal combination of two assets, one of which is riskless while the other is risky. To address the asset allocation puzzle of Canner et al (1997), we require two risky assets, so we extend the Campbell and Viceira model to a three-asset setting. Asset f, which we call cash, is riskless and offers the rate of return R_f over the period. Asset s, which we call stocks, is risky with random rate of return R_s. Asset b, which we call bonds, is also risky and has random rate of return R_b. We assume that $(1+R_s)$, $(1+R_b)$, and labor income L are lognormal random variables.

The portfolio shares allocated to assets s and b are α_s and α_b respectively. Thus, the investor chooses these portfolio shares to maximize the expected value of (1) subject to the budget constraint

$$W = L + \bar{W}(1+R_p) \qquad (2)$$

The details of the solution to this problem are straightforward, but tedious, so we relegate them to an appendix. There we show that the optimal asset allocations are

$$\alpha_s = \frac{1}{\Delta}\left[\frac{1}{\rho\gamma}\{\sigma_b^2\,\mu_s - \sigma_{sb}\,\mu_b\} + (1 - \frac{1}{\rho})\{\sigma_b^2\,\sigma_{ls}) - \sigma_{sb}\,\sigma_{lb}\}\right] \qquad (3a)$$

$$\alpha_b = \frac{1}{\Delta}\left[\frac{1}{\rho\gamma}\{\sigma_s^2\,\mu_b - \sigma_{sb}\,\mu_s\} + (1 - \frac{1}{\rho})\{\sigma_s^2\,\sigma_{lb} - \sigma_{sb}\,\sigma_{ls}\}\right] \qquad (3b)$$

where, for i = s, b, $r_i = \ln(1+R_i)$, $\sigma_i^2 = \mathrm{var}(r_i)$, $\sigma_{sb} = \mathrm{cov}(r_s, r_b)$, $\sigma_{li} = \mathrm{cov}(l, r_i)$, $\Delta = \{\sigma_s^2\,\sigma_b^2 - (\sigma_{sb})^2\}$ is the determinant of the variance-covariance matrix, $\mu_i = \{E[r_i] - r_f + \sigma_i^2/2\}$ is the logarithmic risk premium for asset i, and $\rho \in [0, 1)$ is a constant that is defined in the Appendix.

Note that without labor income, the second terms in the square brackets in (3a) and (3b) both equal zero, so the ratio α_s/α_b is independent of investor risk attitudes γ, i.e., the two-fund separation theorem applies. With labor income, however, this independence disappears. In the next section, we determine whether this can change the model's implications in a way that is consistent with popular investment advice.

3. Risk aversion, investment horizon, and optimal asset choice

We first determine the effect of risk aversion γ on the ratio $\alpha \equiv \alpha_s/\alpha_b$. According to the two-fund separation theorem, α and γ are independent, but popular advice, as documented in Canner et al (1997), recommends that less risk-tolerant investors hold a lower ratio of stocks to bonds. That is, $\partial\alpha/\partial\gamma$ should be negative.

In our model, the sign of $\partial\alpha/\partial\gamma$ is determined by the sign of (see Appendix)

$$\mu_s\,\sigma_{lb} - \mu_b\,\sigma_{ls} \qquad (4)$$

Letting $c_{li} = \sigma_{li}/\sigma_l\sigma_i$ denote the linear correlation coefficient for asset i returns and human capital, (4) is negative if and only if

$$c_{ls} > \underline{H} \qquad (5)$$

where $\underline{H} = (\mu_s/\mu_b)(\sigma_b/\sigma_s)c_{lb}$.[4] Thus, more risk-tolerant investors should indeed hold a higher proportion of stocks, so long as their labor income is more strongly correlated with stock returns, the required extent of which is determined by the relative size of the stock and bond Sharpe ratios. This condition reflects the tradeoff between the two determinants of asset demand: the ability to hedge human capital returns and the risk-return tradeoff as measured by the Sharpe ratio. If equation (5) is satisfied, the hedging capabilities of the bond are sufficient to offset the risk-return properties of the stock, so an investor who wishes to reduce his risk exposure holds less of both stocks and bonds, but reduces stock holdings by more since he must continue to hold his non-tradable human capital.

This result is a simple extension of the Canner et al (1997) argument that human capital considerations can justify popular asset allocation advice if stocks and human capital are perfect substitutes. It shows that human capital need only be *relatively* more "stock-like" than "bond-like", thereby negating Canner et al's concern that perfect substitutability is unlikely to be the case for most investors. What remains unresolved is whether this weaker condition can also overcome Canner et al's other objection: that relatively "stock-like" human capital is inconsistent with popular advice on the relationship between investment horizon and optimal stock holdings. This advice is neatly summarized by Malkiel (1996):

> "... the longer the time period over which you can hold on to your investments, the greater should be the share of common stocks in your portfolio."

However, if human capital is strongly correlated with the stockmarket, then the holding of "stock-like" assets automatically increases with the investment horizon, thereby implying that the share of traded stocks should be *smaller* the longer the time period over which the portfolio can be held. If human capital considerations *are* to be a plausible explanation for the asset allocation puzzle, then the required condition (5) should not rule out the recommended relationship between stock holdings and investment horizon, i.e., the required high correlation between stock market returns and labor income should not be so high as to imply that investors with a long time horizon should hold a *lower* share of common stocks in their portfolios.

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[4] To avoid unnecessary complications associated with negative numbers, we anticipate our subsequent empirical findings and assume $\mu_b > 0$.

To address this issue, we use the parameter $1/\rho$ as a proxy for the length of investment horizon. This can be justified by noting that ρ, as defined in the Appendix, is decreasing in the ratio of human capital wealth to financial wealth. Young investors, with long investment horizons and long working lives, have high human capital but low financial wealth, so they have lower ρ than do older investors with shorter investment horizons.

Differentiating (3a) with respect to $(1/\rho)$ yields

$$\frac{\partial \alpha_s}{\partial (1/\rho)} = \frac{1}{\gamma} (\sigma_b^2 \mu_s - \sigma_{sb} \mu_b) - (\sigma_b^2 \sigma_{ls} - \sigma_{sb} \sigma_{lb})$$

To justify popular advice, this expression must be positive. This occurs if and only if

$$c_{ls} < \bar{H} \tag{6}$$

where $\bar{H} = (1/\gamma\sigma_l\sigma_s)(\mu_s - (c_{sb}\sigma_s/\sigma_b)\mu_b) + c_{sb}c_{lb}$. Thus, as previously argued by Bodie et al (1992) and Jagannathan and Kocherlatoka (1996), long-horizon investors should indeed allocate a greater proportion of their wealth to stocks so long as the correlation between stock returns and labor income is not too high. The condition appearing in (6) gives concrete expression to what is meant by "not too high". If (6) is satisfied, then stocks are a good hedge for non-tradable human capital, so a young investor with a long investment horizon puts more into stocks than an older investor with a shorter horizon, just as popular advice recommends.

Of course, what we are primarily interested in is whether the joint distribution of labor income and stock and bond returns can justify popular advice on both asset allocation and investment horizon; that is, whether (5) and (6) can simultaneously hold. This occurs if and only if

$$\underline{H} < c_{ls} < \bar{H} \tag{7}$$

That is, so long as the correlation between stock returns and labor income falls within a certain range, investors should allocate less of their wealth to stocks as their investment horizon shortens *and* they should adjust their bond/stock ratios downwards in response to any increase in tolerance for risk.

From inspection of $\underline{H}$ and $\overline{H}$, it is clear that (7) cannot automatically be ruled out. That is, there are combinations of parameters for which (7) is satisfied, so it *is* theoretically possible for human capital considerations to reconcile the simple mean-variance model with popular advice on asset allocation in a way that does not conflict with other popular advice on the relationship between stock holdings and the investment horizon. It remains to determine whether such a possibility is empirically plausible; that is, whether the parameter combinations satisfying (7) are likely to exist in practice. We turn to this task in the next section.

4. Empirical estimates of c_{ls}, $\underline{H}$, and $\overline{H}$

To determine whether our model's justification of popular advice is plausible, we use historical data to estimate c_{ls}, $\underline{H}$, and $\overline{H}$, and evaluate these in the context of (7). If (7) holds, then this is consistent with the view that popular investment advice implicitly incorporates human capital considerations; if (7) does not hold, then this suggests that popular investment advice cannot be justified by human capital considerations, at least not in the way envisaged by our model.

To obtain some simple baseline estimates, we use US market returns data from Ibbotson Associates and per-capita income data from the US Department of Commerce's Bureau of Economic Analysis (BEA) for the period 1931-99.[5] Ibbotson Associates report price index data for long-term government bonds, intermediate-term government bonds, and corporate bonds, so we calculate $\underline{H}$ and $\overline{H}$ for each bond type; for stock returns, we use the large company index.

We fit these data to a one-lag vector autoregression model and use the resulting estimates to calculate the values of $\underline{H}$ and $\overline{H}$. The results of this procedure appear in Table 1.

[Insert Table 1 about here]

5 The BEA data are available from http://www.bea.doc.gov/.

Even for high levels of risk aversion, (7) is comfortably satisfied, regardless of the type of bond. The labor-stock correlation is 0.48, but the highest estimate of $\underline{H}$ is 0.13 while the smallest estimate of $\overline{H}$ (for $\gamma = 10$) is 0.8.

Although these results are consistent with the view that popular investment advice can be justified by human capital considerations, they are based on data from a single country for a recent time period and for the labor income of a 'representative' investor. Given the ubiquitous nature of the investment advice, it seems prudent to recalculate our model's parameters using other data sets. For countries other than the US, we hope to use the long-term market returns data compiled by Dimson et al (2002), but these are currently unavailable to us. In the meantime, we consider labour income distributions other than those implied by aggregate earnings by drawing on the work of Campbell et al (2001). They estimate labor income distribution parameters for three groups categorized by educational attainment - no high school qualification, high school graduation, and college degree - for the period between 1970 and 1999. For each of these groups, we report our calculations of the parameters in (7) in panel B of Table 1.[6] As can be seen, the labor-stock correlation falls between $\underline{H}$ and $\overline{H}$ for each educational group, although it is fairly close to $\overline{H}$ for less risk-tolerant individuals in two of these groups.

4. Concluding Remarks

Can human capital considerations resolve the asset allocation puzzle of Canner et al (1997)? Those authors are doubtful, primarily because the strong correlation between stock returns and labor income gains that would be required also implies that investors with a long investment horizon should allocate less of their financial wealth to stocks, exactly the opposite of popular investment advice. However, once non-tradable human capital is explicitly modelled, the optimal stock-bond ratio depends not only on the correlations of these assets with labor income, but also on the simple risk-return tradeoffs offered by these assets. As a result, the correlation

6 Campbell et al (2001) do not report labor-bond correlations, so we estimate these by assuming that they bear the same relationship to their labor-stock correlations as do their counterparts estimated from Ibbotson and BEA data. That is, corresponding to each of Campbell et al's labor-stock correlation estimates c_{ls}^{C}, we calculate the labor-bond correlation c_{lb}^{C} as $(c_{lb}^{IB}/c_{ls}^{IB})c_{ls}^{C}$, where the correlation terms inside the brackets are those obtained from the Ibbotson Associates and BEA data for the same period. For this purpose, we use the intermediate government bonds price index.

between stock returns and labor income gains required to resolve the asset allocation puzzle does not, after all, have to be all that high, leaving open the possibility that it can be sufficiently low to also justify the investment horizon advice.

The principal contributions of this paper have been, first, to confirm the theoretical validity of the above logic, and second, to verify that it is consistent with historical data. Thus, human capital considerations may yet be the primary explanation of the asset allocation puzzle. Of course, we cannot definitively claim that such considerations are *the* explanation, since other observed features of portfolio construction in practice are not easily explained by our model. Nevertheless, our analysis suggests that human capital issues are likely to be an integral part of a future "super-model" that successfully resolves all of these puzzles.

Appendix

Proof of (3)

Maximizing the expected value of (1) subject to (2) yields the first-order conditions

$$E[(R_i - R_f)\, W^{-\gamma}] = 0 \qquad\qquad i = s, b$$

which can be re-written as

$$\ln\, E[(1+R_i)\, W^{-\gamma}] = (1+R_f)\, \ln\, E[W^{-\gamma}] \qquad i = s, b \qquad\qquad (A\text{-}1)$$

To make this problem analytically tractable, we follow the procedure outlined by Campbell and Viceira (2001, 2002). First, a Taylor expansion of the logarithmic form of (2) gives

$$w \approx k + \rho(\overline{w} + r_p) + (1-\rho)l \qquad\qquad (A\text{-}2)$$

where $r_p = \ln(1+R_p)$, $l = \ln L$, $\overline{w} = \ln \overline{W}$, and

$$\rho = \frac{\exp(\overline{w} + E[r_p - l])}{1 + \exp(\overline{w} + E[r_p - l])} < 1$$

$$k = \ln\,(1 + \exp(\overline{w} + E[r_p - l])) - \rho(\overline{w} + E[r_p - l])$$

Second, a Taylor expansion of $\ln(1+R_p)$ yields

$$r_p \approx r_f + \alpha_s(r_s - r_f) + \alpha_b(r_b - r_f) + \frac{1}{2}\,[\alpha_s(1-\alpha_s)\sigma_s^2 + \alpha_b(1-\alpha_b)\sigma_b^2 - 2\alpha_s\alpha_b\sigma_{sb}] \qquad (A\text{-}3)$$

where $r_i = \ln(1+R_i)$, $\sigma_i^2 = \mathrm{var}(r_i)$, and $\sigma_{sb} = \mathrm{cov}(r_s, r_b)$.

As r_s and r_b are jointly normal, (A-3) implies that r_p also has a normal distribution. Then, since l is also normal, (A-2) implies that w is normal as well. Thus, both terms inside the expectations operator in (A-1) are lognormally distributed. Using the standard properties of a lognormal random variable, we obtain

$$\ln E[(1+R_i)\, W^{-\gamma}] \;=\; E[r_i - \gamma w] + \frac{1}{2}\,\mathrm{var}(r_i - \gamma w) \qquad i = s, b$$

$$(1+R_f) \ln E[W^{-\gamma}] \;=\; r_f - \gamma E[w] + \frac{1}{2}\,\mathrm{var}(-\gamma w)$$

Substituting these back into (A-1) yields

$$E[r_i] - r_f + \frac{\sigma_i^2}{2} \;=\; \gamma\, \mathrm{cov}(r_i, w)$$

$$= \gamma\, \mathrm{cov}(r_i, \rho r_p + (1-\rho) l) \qquad \text{by (A-2)}$$

$$= \gamma\rho\, \mathrm{cov}(r_i, \alpha_s r_s + \alpha_b r_b) \;+\; \gamma(1-\rho)\, \mathrm{cov}(r_i, l) \quad \text{by (A-3)}$$

which is a system of two linear equations in the two unknowns α_s and α_b. Solving this system produces (3). ||

Proof of (4)

From (3), we can write

$$\alpha \;=\; \frac{(g_s/\gamma) + h_s}{(g_b/\gamma) + h_b}$$

where

$$g_s = \frac{\sigma_b^2\, \mu_s - \sigma_{sb}\, \mu_b}{\rho}$$

$$g_b = \frac{\sigma_s^2\, \mu_b - \sigma_{sb}\, \mu_s}{\rho}$$

$$h_s = (1 - \frac{1}{\rho})\{\sigma_b^2\, \sigma_{ls} - \sigma_{sb}\, \sigma_{lb}\}$$

$$h_b = (1 - \frac{1}{\rho})\{\sigma_s^2\, \sigma_{lb} - \sigma_{sb}\, \sigma_{ls}\}$$

Then

$$\frac{\partial \alpha}{\partial \gamma} = \frac{g_b h_s - g_s h_b}{(g_b + g h_b)^2}$$

where

$$g_b h_s - g_s h_b = \frac{1}{\rho}\left(1 - \frac{1}{\rho}\right) \Delta \left(\mu_b \sigma_{ls} - \mu_s \sigma_{lb}\right)$$

Since $1 - 1/\rho < 0$ and $\Delta > 0$, $(g_b h_s - g_s h_b)$ has the sign of $(\mu_s \sigma_{lb} - \mu_b \sigma_{ls})$. ||

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Table 1

Baseline estimates of c_{ls}, $\underline{H}$, and $\overline{H}$

Popular investment advice on (i) stock/bond allocation and risk tolerance and (ii) stock allocation and investment horizon can both be justified if and only if $\underline{H} < c_{ls} < \overline{H}$, where c_{ls} is the linear correlation between labor income and stock returns, and $\underline{H}$ and $\overline{H}$ are constants that depend on market and investor-specific parameters. In panel A, we use market returns data of Ibbotson Associates for the period 1931-99 and combine these with labor income data from the Department of Commerce's Bureau of Economic Analysis. In panel B, we use parameter estimates implied by the work Campbell et al (2001) which is based on data from the Panel Study of Income Dynamics for the period 1970-99. γ is the coefficient of relative risk aversion.

	c_{ls}	$\underline{H}$		$\overline{H}$	
			$\gamma=2$	$\gamma=5$	$\gamma=10$
Panel A: Ibbotson Associates data (1931-99)					
Long-term government bonds	0.48	0.13	4.4	1.8	0.9
Intermediate-term government bonds	0.48	0.10	4.9	2.0	1.0
Corporate bonds	0.48	0.08	4.0	1.6	0.8
Panel B: Campbell et al data (1970-99)					
No High School	0.33	0.13	1.6	0.66	0.36
High School	0.37	0.15	2.6	1.1	0.41
College	0.52	0.21	3.2	1.3	0.72