The Human Capital Premium Puzzle

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Abstract

This paper studies the dynamic relationship between consumption and human capital investments. We find that the riskiness of human capital investments alone cannot possibly justify the return premium that is observed on human capital assets relative to the return on the riskless asset. Using a stochastic discount factor methodology, we then study the extent to which different frictions in human capital markets such as short-sale constraints and irreversibility, borrowing and solvency constraints, and psychic costs of investment help to explain the size of the risk-adjusted premium. We find that some of these frictions allow the models to satisfy the basic restrictions that human capital returns impose on the variability of the intertemporal marginal rate of substitution under feasible preferences parameters. This is particularly the case for short-sale and irreversibility constraints, and for preference specifications that include various non-separabilities in consumption. We also find that frictions in human capital markets are quite different across demographic groups, decreasing with education, age, and experience. On average the size of frictions for the different demographic groups is from 4 to 14 times greater than in financial markets.

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1 Introduction

Every individual holds human capital assets. These assets represent the most important component of the wealth portfolio for the vast majority of individuals. Different authors have estimated that human capital wealth may account for more than 90 percent of all wealth (not just GNP) of the United States and other developed nations, and that the value of human capital is at least four times the value of stocks, bonds, housing, and all other assets.[1] Beginning with the seminal work of Becker (1964), there has been an enormous amount of energy devoted to the analysis of human capital during the last four decades. The result has been the accumulation of an impressive amount of evidence testifying to the importance of human capital to the structure and evolution of earnings, employment, occupation, fertility, aggregate wealth, and economic growth.[2] Interestingly enough, despite its importance, we know relatively little about the *properties* of human capital returns and about the determinants of the human capital *premium*. In fact, the relationship between human capital investment choices and consumption choices that is so important for a large class of models and areas in the labor economics literature, has received virtually no attention in the literature. Moreover, the theory of asset valuation, which studies the relationship among consumption, investment, and asset returns and that represents an integral part of modern intertemporal asset pricing and macroeconomics, has essentially ignored human capital in the analysis of utility-based intertemporal investment models. Theoretical and empirical analyses in the asset pricing literature have focused *exclusively* on the analysis of financial assets.[3] As a result, although it is the main capital asset that individuals hold and a critical determinant of consumption and all other behavior, little is known about human capital returns and their relationship with consumption.

This paper provides a first empirical examination of the *size* and *determinants* of the *human capital premium* by studying the dynamic relationship between human capital investments and consumption choices. More precisely, it studies the extent to which the riskiness, illiquidity, credit constraints, psychic costs, and other frictions that are intuitively associated with human capital markets may be responsible for

[1]Jorgenson and Fraumeni (1993), Becker (1993), and Rosen (1993).

[2]See Becker (1964, 1993), Rosen (1987), and other references therein.

[3]This may seem justified, at least in part, because information on these assets allows us to study a number of questions of interest and because data on these assets are readily available. As a result, we have rich evidence about the properties of financial returns, and the models that can (and cannot) reconcile data on consumption and financial asset returns. See Cochrane (2001) and Campbell (2000, 2003) for reviews of this literature.

the return premium received by human capital investments, above and beyond the return on a riskless, liquid asset.

We follow the methodology developed in the consumption-based asset pricing literature during the 1990s. This methodology, which will be described below, is appropriate because a common implication of all human capital investment models is that the equilibrium price of future payoffs (wages and non-monetary returns) can be represented as the expectation of the product of the payoff and the intertemporal marginal rate of substitution (IMRS) of an individual (Becker (1993), MaCurdy (1978, 1999)). The general modelling approach taken in an extensive human capital literature is to *restrict* the IMRS to be a specific parametric function of the observed data and then estimate the resulting equilibrium relationship assuming that the function is consistent with the observed data.[4] This was also the general approach followed in the financial asset pricing literature before the introduction of the non-parametric methodology by Hansen and Jagannathan (1991)—and extended by He and Modest (1995), Luttmer (1996), and others to the case in which asset markets are subject to frictions. Their basic idea is to impose as little structure as possible, that is to extract information about the IMRS from data on asset returns *without* restricting the analysis to any specific parametric family of models. As a result, restrictions on the mean and standard deviation of the IMRS can be readily derived from the equilibrium conditions and from data on human capital returns in models in which human capital markets are either frictionless or subject to frictions such as short-sale constraints, liquidity and borrowing constraints, psychic costs, and others. For a given specification of preferences, the implications for the relative risk aversion coefficient and other preference parameters can then be derived from data on consumption so that the models meet the minimum volatility restrictions imposed by the return data on the IMRS.

As an anticipation of some of the main results, we find that the data imply the existence of a sizeable human capital premium "puzzle" in frictionless models. This puzzle arises because the comovements of consumption and human capital returns are not enough to justify the premium on human capital assets over the riskless asset (which we will find it to range from 6 to 17 percent for the different education levels we consider) under plausible preference parameters. In other words, because the correlation between consumption growth and human capital returns is relatively low, human capital assets are not perceived as very risky and should not require a large risk

[4]See, for instance, Carneiro and Heckman (2002) and other references therein.

premium. In consequence, the coefficients of relative risk aversion that are necessary to explain the size of the human capital premium are implausibly high (e.g., from 30 to 60 across the different demographic groups for CRRA utility). Interestingly, we also find that the extent of this "puzzle" is quite different for different demographic groups and education levels. In particular, the risk-adjusted human capital premium is notably greater for females than for males, for blacks than for whites, and for less educated than for more educated individuals.

Although to the best of our knowledge there is no previous empirical characterization in the literature of the finding that the risk-adjusted premium is too high, this may perhaps be not too surprising given the nature of human capital assets. Human capital is illiquid, largely irreversible, acts as poor collateral, and is difficult to diversify. Clearly, these and other characteristics may play an important role in explaining the size of the premium.

Why is then the human capital premium so high? How can the size of the premium be explained? Is the premium mostly determined by the illiquidity of the asset, by the impossibility of borrowing against it, by the psychic costs of investments, or by other frictions? We then attempt to understand the extent to which different market frictions may be relevant for explaining the premium on human capital. The results we find show that market frictions can greatly help reconciling movements in human capital returns and consumption for the different demographic groups. For instance, we find that the fact that human capital assets are illiquid and subject to short-sale constraints may account for up to two thirds of the risk-adjusted premium. Weaker frictions such as borrowing and solvency constraints (that is, restrictions to borrow against human capital assets to finance current and future consumption and investments) may be responsible for one third to up to one half of the risk-adjusted premium. Across demographic groups, we systematically find that greater frictions are needed for explaining the premium for females than for males, for blacks than for whites, and for less educated than for more educated individuals.

We also implement the analysis for various specifications of preferences: CRRA utility, preferences with habit persistence in consumption, Abel's (1990) "catching-up-with-the-Joneses" preferences, and Epstein-Zin recursive preferences. Not surprisingly, the size of the risk-adjusted premium decreases when incorporating time- and state-nonseparabilities in consumption, although it still remains sizable. Interestingly, the premium is lowest for Epstein-Zin recursive preferences.

Lastly, it is worth noting that all of our empirical findings appear to be robust to different forms of approximating human capital returns, and that the *relative* intensity of the determinants of the size of the premium is also quite robust across the different preference specifications considered in the analysis.

2 Related Literature

Although the study of the dynamic relationship between human capital and consumption has not been addressed previously in the literature, the importance placed on the basic ideas underlying the analysis in this paper have already been stressed in the literature.

First, the key insight that human capital assets are the main determinants of consumption has been emphasized by various authors such as Becker (1997):

> "Human capital is estimated to be three to four times the value of stocks, bonds, housing and other assets. For *most* employees, human capital and housing are *the only important* wealth, since stocks and bonds are concentrated in the portfolio of the rich and in pension assets of retired persons ... Human capital's dominant position in the aggregate wealth implies that even large changes in the market value of stocks and other financial assets will not greatly affect the [consumption and] behavior of most people *unless* the value of their human capital also changes ... Human capital is largely unaffected by the market's gyrations" (italics added).

Thus, human capital, as a main driving force behind consumption and other choices can be expected to be intimately related to individual and aggregate behavior.

Second, even though human capital is formally considered as an asset in the labor economics and human capital literature, no research has studied the properties of human capital investment returns and their relationship to consumption choices. Consequently, we do not know which models and preference specifications may allow us to reconcile the joint behavior of consumption and human capital investments. Further, we have little evidence about the extent of the relevant frictions in human capital markets, the extent to which these frictions require a premium in the rate of return obtained from investments, and the extent to which they may be different across different individuals and education levels. In fact, the current methodology does not seem appropriate to examine these questions. Interestingly, the need to bring the basic insights and methodologies of modern asset pricing to bear on these issues was already emphasized by Becker (1975, p. 2) who, referring to his own influential book, says: "There is a more serious *error* in my discussion of the riskiness of investments in education [in Becker (1964)]. I ignored the then developing literature on optimal portfolios, and did not derive my measure of marginal risk—the variance in the rate of return—from an analysis of utility maximization" (italics added). This error seems to have gone largely unnoticed in the literature.

Lastly, there is some recent work in the labor economics literature, as the papers in this issue and their references show, as well as in the financial asset pricing literature, that is worth mentioning. In the labor economics literature, the risk properties of the human capital investment returns were first studied in Palacios-Huerta (1995, 2003a).[5] This paper extends those analyses by studying under what conditions we can understand the relationship between human capital returns and consumption data. Although unrelated to this paper in terms of the methodology and/or the questions that they study, there are some recent papers of interest. Rubinstein and Tsiddon (1999), for instance, studies the behavior of wages over the business cycle, while Pistaferri (2003) studies wage risk and life-cycle labor supply. With respect to frictions in education markets, Cameron and Taber (2004) study the relationship between borrowing constraints and the returns to schooling, while Carneiro and Heckman (2002) focus on credit constraints. They find evidence that these constraints have little impact on college enrollments and returns. This is consistent with our findings to the extent that after short-sale and irreversibility constraints are accounted for, we find that borrowing and solvency constraints do not explain much of the premium.

Finally, the finance literature has recently experienced substantial progress on various issues using human capital data, in particular in the study of the relationship between labor income and financial asset returns.[6]

[5] Christiansen, Joensen and Nielsen (2006) implement the mean-variance spanning tests in Palacios-Huerta (2003a) for different professions and job categories in Danish micro data. Relatedly, Nielsen and Vissing-Jørgensen (2006) and Saks and Shore (2005) study the impact of wage risk on educational and occupational choices.

[6] See, for instance, Jagannathan and Wang (1996), Julliard (2004a), Lettau and Ludvigson (2001), Lustig and Van Nieuwerburgh (2006), Palacios-Huerta (2003b), Santos and Veronesi (2006) and other references therein. For the role of human capital in the context of the internacional diversification puzzle, see Julliard (2002, 2004b) and Palacios-Huerta (2001).

3 Equilibrium Conditions in Human Capital Markets and the Intertemporal MRS

The typical optimization problem of the consumer-investor in the classical human capital framework consists of maximizing his expected lifetime discounted utility $\sum_{i=0}^{\infty} \beta^{t+i} E_t u(c_{t+i})$, by choosing consumption and investments in human capital and possibly other assets, where $u(.)$ is a well-behaved utility function, $E_t[.]$ denotes the expectation conditional on information at time t, $\beta > 0$ represents the rate of time preference, and c_t is consumption at date t (Becker (1993), MaCurdy (1978, 1999)).[7] Let $R^i_{t+1} = 1 + r^i_{t+1}$ denote the real return of asset i from date t to date $t+1$, R_{t+1} an n-dimensional vector of returns, and R^f_{t+1} the real return earned by the riskless asset from t to $t+1$.

3.1 Equilibrium Conditions

3.1.1 Frictionless Human Capital Markets

We begin the analysis by examining the extent to which the riskiness of human capital investments *alone* may explain the size of the human capital premium. Hence, we first study whether or not the human capital premium is excessively high after accounting for the riskiness of the investment but assuming no irreversibility, illiquidity, borrowing constraints or any other frictions. As is well known, the equilibrium conditions in markets with no frictions can be written as:

$$\begin{aligned} E_t[m_{t+1} R_{t+1}] &= \mathbf{1}, \\ E_t[m_{t+1} R^f_{t+1}] &= 1, \end{aligned}$$

where m_{t+1} is the IMRS and $\mathbf{1}$ is an n-dimensional vector of 1s. The simple but far from trivial question is to find suitable models for m_{t+1} given data on R_{t+1} and R^f_{t+1}. For instance, for a constant relative risk aversion utility function $u(c_t) = \frac{1}{1-\gamma} c_t^{1-\gamma}$, we have $m_{t+1} = \beta \frac{u'(c_{t+1})}{u'(c_t)} = \beta \left(\triangle c_{t+1}\right)^{-\gamma}$. Hence, assuming that consumption and returns are jointly log-normal, we obtain:

$$E_t R^i_{t+1} = \gamma E_t(\triangle c_{t+1}) + \beta - (1/2)\gamma(\gamma+1) var_t(\triangle c_{t+1}) + \gamma \cdot cov_t(R^i_{t+1}, \triangle c_{t+1}).$$

Therefore, the difference between returns on asset i and on asset j is:

$$E_t(R^i_{t+1} - R^j_{t+1}) = \gamma \cdot corr(R^i_{t+1} - R^j_{t+1}, \triangle c_{t+1}) \cdot \sigma_t(\triangle c_{t+1}) \cdot \sigma_t(R^i_{t+1} - R^j_{t+1}).$$

[7] We will also consider the choice of leisure in an extension of the empirical analysis. The results of this extension are briefly discussed in subsection 5.3.

Hansen and Jagannathan (1991) show that for given $E_t(m_{t+1}) = v = 1/R^f_{t+1}$ the variable $m^v = R'_v\ \beta_v = R'_v[E_t(R_v R'_v)]^{-1}\mathbf{1}$, with $R'_v = [R' \quad \frac{1}{v}]$, $\beta_v = [\beta \quad \eta]'$, has the same mean as the true m_{t+1} and has the minimum variance among all the possible variables that satisfy $E_t[m_{t+1}R_{t+1}] = \mathbf{1}$. Thus, this variable can be used to set minimum volatility bounds on the IMRS. All the models for m_{t+1} in this frictionless case must then meet these minimum volatility bounds.[8]

No assumption other than the law of one price (human capital assets with the same payoffs have the same price) will be imposed in the empirical analysis. In particular, lack of arbitrage opportunities in human capital markets is not assumed. The reason is that human capital investments are difficult to diversify and human capital assets cannot be sold. As a result it may be difficult, to say the least, to exploit any arbitrage opportunities that may arise in human capital markets. Assuming lack of arbitrage opportunities would require adding a positivity restriction on m_{t+1}.

3.1.2 Frictions in Human Capital Markets

If riskiness alone were not sufficient to explain the full size of the human capital premium, it would then be relevant to examine the extent to which frictions in human capital markets require a premium. Human capital is largely illiquid. It acts as poor collateral and it is difficult, if not impossible, to borrow against it. Ex post appropriation is clearly a problem. Although active insurance markets exist for hedging some of the risks in human capital investments (e.g., life insurance, unemployment insurance, disability and medical insurance), diversifying investments in human capital is also difficult and often impossible—except perhaps through marriage and through investments in other family members' human capital for altruistic reasons. It then seems reasonable to expect that some of these frictions will be relevant for explaining part of the size of the risk-adjusted premium.

We will study the equilibrium conditions that result when human capital assets are subject to short-sale constraints, borrowing constraints, solvency constraints, and transaction costs in utility-based models. These conditions have already been obtained in the literature by He and Modest (1996) and Luttmer (1996, 1999). They can be summarized as follows:

[8]This variable m^v can be evaluated from the vector of asset returns, as long as $E_t(R_v R'_v)$ is non-singular. In addition, all admissible m's must obey $\sigma(m) \geq \beta'_v \Sigma \beta_v$, where Σ is the covariance matrix of the asset returns, and $\frac{\sigma(m)}{E(m)} \geq \frac{|E(R^e)|}{\sigma(R^e)}$, where R^e is the difference between any two returns (see Hansen and Jagannathan, 1991).

A. Short-Sale Constraints. Human capital assets are illiquid and largely irreversible. Clearly, they cannot be sold and they may not be reduced except for depreciation. Formally, let A be the subset of all assets owned by the individual that cannot be sold short. Then, the equilibrium conditions are:

$$\begin{aligned} E_t[m_{t+1}R^i_{t+1}] &\leq 1, i \in A, \\ E_t[m_{t+1}R^i_{t+1}] &= 1, i \notin A. \end{aligned}$$

B. Borrowing Constraints and Solvency Constraints. Human capital is poor collateral and cannot be expropriated in case of default. Moreover, courts are not reliable enforcers of indentured-servitude type of contracts. When consumer-investors cannot borrow against their human capital and, therefore, cannot consume or invest more than their current non-human wealth, the first-order conditions are:

$$\begin{aligned} E_t[m_{t+1}(R^i_{t+1} - R^j_{t+1})] &= 0, \forall i, j, \\ E_t[m_{t+1}R^i_{t+1}] &\leq 1, \forall i. \end{aligned}$$

Solvency constraints are similar to borrowing constraints but they put restrictions on *future* non-human wealth; that is, non-human wealth next period cannot be below some predetermined level (see Luttmer (1992, 1996)). The first-order conditions in this case are:

$$E_t \beta \frac{u'(c_{t+1}) + \varphi_{t+1}}{u'(c_t)} R^i_{t+1} = 1, \ \forall i,$$

for some Lagrange multiplier $\varphi_{t+1} \geq 0$ on next period wealth.

With regard to these constraints, various authors have noted that the market value of mortgage loans, consumer credit and bank loans to the household sector represent about 80 percent of GNP, and that "since these can be viewed as borrowing against future income, it does not appear inappropriate to view human capital like any other form of capital, cash flows which are traded through issuance of financial assets" (Jagannathan and Wang, 1996, p. 13). Whether or not this view is correct, the extent to which borrowing and solvency constraints are binding, and hence relevant for explaining the size of the human capital premium, remains an open empirical question.

C. Transaction Costs. It is difficult to conceptualize transaction costs in human capital markets. They may encompass, for instance, various costs associated with the constraints described above, may include the psychic costs of investment, and others. He and Modest (1995) show that if these costs are proportional to the amount invested, then:

$$\frac{1-\mu_i}{1+\mu_i} \leq E_t\left[\beta \frac{u'(c_{t+1})}{u'(c_t)} R^i_{t+1}\right] \leq \frac{1+\mu_i}{1-\mu_i},$$

where μ_i denotes the proportional cost for asset i. The first of these two inequalities does not apply if human capital assets cannot be sold short. The second applies to positive investments and may be interpreted, for instance, as the extent and frequency with which individuals are at a corner and cannot invest in additional human capital. Luttmer (1999) offers a related specification for fixed, rather than proportional, transaction costs.

It is also generally argued that the psychic costs of education can be substantial, especially for the marginal individual (Lazear, 1977). The Euler equations take a simple form in the specific case of psychic costs of investments when human capital assets cannot be sold. Let $k^{e,e+1}_{t+1}$ denote the marginal psychic costs for an individual with e units of human capital (say, e years of education) who invests from t to $t+1$ in one additional unit, and let $R^{e,e+1}_{t+1}$ denote the expected gross rate of return obtained from the investment. The expected rate of return net of psychic costs of investment is $R^{e,e+1}_{t+1}\left(1-k^{e,e+1}_{t+1}\right)$. Thus, the equilibrium conditions can be written as:

$$E_t\left[\beta \frac{u'(c_{t+1})}{u'(c_t)}\left[R^{e,e+1}_{t+1}\left(1-k^{e,e+1}_{t+1}\right)\right]\right] = 1.$$

D. Multiple Frictions. Obviously, various frictions may operate simultaneously in human capital markets. In this case, the corresponding sets of constraints described above must be combined to get the relevant first-order conditions for human capital returns in equilibrium. In the presence of short-sale, borrowing and solvency constraints in human capital markets, and under the assumption that the time-series sequences if the growth rates of consumption and returns are jointly stationary and ergodic, the equilibrium equations can be written in unconditional form as:

$$E_t[m_{t+1}R_{t+1}] = \lambda,\ \lambda^L \leq \lambda \leq \lambda^U,$$

where λ^L and λ^U are n-dimensional vectors whose elements are restricted by the equilibrium relationships previously described. For transaction costs and psychic costs the restrictions can be rewritten in unconditional form as:

$$E_t[m_{t+1}R_{t+1}] = \lambda; \lambda \in \Lambda = \left\{\lambda : \lambda_i^{L^*} \leq \lambda_i \leq \lambda_i^{U^*}; \lambda_{ij}^{L^*} \leq \frac{\lambda_i}{\lambda_j} \leq \lambda_{ij}^{U^*}\right\},$$

where $\lambda_i^{L^*}$, $\lambda_i^{U^*}$, $\lambda_{ij}^{L^*}$, and $\lambda_{ij}^{U^*}$ are the constant bounds previously derived. The feasible region for the mean and standard deviation of the IMRS, Ω_λ, is obtained as the lowest possible bound for the standard deviation of the IMRS for a given riskless asset $E_t(m_{t+1}) = v = 1/R_{t+1}^f$. This bound is found by choosing λ to minimize:

$$\sigma(m_v) = \left[(\lambda - vE[R_{t+1}])' \, \Sigma^{-1} \, (\lambda - vE[R_{t+1}])\right]^{1/2},$$

where Σ is the covariance matrix of R_{t+1}. Therefore, the set of *lowest* volatility bounds that must be kept by any admissible model for m_{t+1} is:

$$\bigcup_\lambda \Omega_\lambda.$$

3.2 The IMRS for Different Preference Specifications

In addition to time- and state-separable constant relative risk aversion (CRRA) preferences, we will consider three additional specifications of preferences featuring different forms of non-separabilities in consumption previously studied in the intertemporal utility-based literature:

A. CRRA Utility. This function can be specified as:

$$u(c_t) = \frac{1}{1-\gamma} c_t^{1-\gamma},$$

where γ represents the coefficient of relative risk aversion. The IMRS is:

$$m_{t+1} = \beta \left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}.$$

B. Habit Persistence in Consumption. Following Constantinides (1990) and Ferson and Constantinides (1991), and as Kocherlakota (1996) suggests, habit persistence in consumption can be captured by a function:

$$u(c_t) = \frac{(c_t - \theta c_{t-1})^{1-\gamma} - 1}{1-\gamma},$$

where $\theta > 0$ and $\gamma > 0$. Each period's utility is a decreasing function of last period's consumption and, therefore, the marginal utility in period t is an increasing function of consumption in period $t-1$.[9] The IMRS in this case is:

$$m_{t+1}=\beta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\frac{\left(1-\theta\frac{c_t}{c_{t+1}}\right)^{-\gamma}-\beta\theta E_{t+1}\left[\left(\frac{c_{t+2}}{c_{t+1}}-\theta\right)^{-\gamma}\right]}{\left(1-\theta\frac{c_{t-1}}{c_t}\right)^{-\gamma}-\beta\theta E_t\left[\left(\frac{c_{t+1}}{c_t}-\theta\right)^{-\gamma}\right]}.$$

C. "Catching Up with the Joneses" Preferences. Abel (1990) presents a model of habit persistence in which utility at period t is a function of consumption at time t relative to the average level of aggregate per capita consumption at time $t-1$, and the individual does not take into account the consumption "externality" that is present under habit persistence.[10] The associated IMRS can be written as:

$$m_{t+1}=\beta\left(\frac{c_{t+1}}{c_t}\right)^{-\gamma}\frac{\left(\frac{1-\theta c_t}{c_{t+1}}\right)^{-\gamma}}{\left(\frac{1-\theta c_{t-1}}{c_t}\right)^{-\gamma}}.$$

The coefficient of relative risk aversion in this case is equal to $\gamma/\left(1-\overline{x}\right)$.

D. Recursive Utility. Epstein and Zin (1989, 1991) generalize the standard formulation of preferences by assuming that the period t utility received by a consumer from a stream of consumption is described recursively by:

$$u(c_t)=\left[(1-\beta)\,c_t^{1-\sigma^{-1}}+\beta\left(E_t u(c_{t+1})^{1-\gamma}\right)^{\frac{1-\sigma^{-1}}{1-\gamma}}\right]^{\frac{1}{1-\sigma^{-1}}}.$$

Thus, utility today is a constant elasticity function of current consumption and expected future utility, where γ governs the degree of risk aversion and σ the elasticity of intertemporal substitution. The IMRS in this case is:

$$m_{t+1}=\beta^{\frac{1-\gamma}{1-\sigma^{-1}}}\left(\frac{c_{t+1}}{c_t}\right)^{-\frac{1-\gamma}{\sigma-1}}R_{m,t+1}^{\frac{\sigma^{-1}-\gamma}{1-\sigma^{-1}}},$$

where $R_{m,t+1}$ is the gross return on the market portfolio. In the empirical analysis, it will be approximated by a convex combination of the human capital return of each demographic group weighted by 0.85 and the value-weighted NYSE return with a weight 0.15.[11]

[9] Assuming that log consumption is a random walk with drift: $\log c_{t+1}=g+\log c_t+\varepsilon_{t+1}$, the coefficient of relative risk aversion (RRA) is equal to $RRA=\frac{\gamma}{\varphi}$, with $\varphi=1-\overline{x}\frac{e^{-\gamma g}-\beta\gamma}{e^{-\gamma g}-\beta\theta}$ and $\overline{x}=\theta e^{-g}$. Constantinides (1990) and Ferson and Constantinides (1991) propose a slightly more general process for the habit component. However, this specification is general enough for the purposes of our analysis.

[10] Empirical tests have also been implemented for $u(c_t)=\sum_{s=0}^{\infty}\beta^s c_t^{1-\alpha}C_t^{\gamma}C_{t-1}^{\delta}$, where C_t is the average level of per capita consumption, for different choices of γ and δ. This specification includes the analysis of Gali (1994) when $\gamma\neq 0$.

[11] Thus, $R_{m,t+1}$ will be different across demographic groups. The results that will be reported

4 Human Capital Returns and Data Sources

The measurement of human capital returns has been the subject of keen interest in the labor economics literature. Card (2001) offers a thorough review of progress in this area. There are a number of approaches to estimate the returns to schooling. Interestingly, the basic results we obtain are quite similar across the different measures of human capital returns that we consider. We follow the labor literature and, as education accounts for much of the improvement in population quality, per-period human capital rates of return will be calculated as the returns to education for individuals characterized by their sex, race, and experience.

4.1 Measures of Human Capital Returns

1. The first measure we consider is the one previously studied in Palacios-Huerta (2003a). The idea is to capture the per-period marginal rate of return that is obtained from having one additional "unit" of human capital over one period. This measure is important since it is directly associated with the growth rate in marginal utility that characterizes the equilibrium conditions. The basic idea is the following. An individual at time t with $e-1$ units of human capital (say, years of education) is deciding his current consumption and whether to attend school or gain one more year of experience either this period (t) or next period ($t+1$). If he decides to attend school this period and work next period, he will earn nothing at t and an expected real payoff of $w_{e,t+1}$ at $t+1$ with e years of education. If instead he decides to attend school next period and work today, he will earn a real payoff of $w_{e-1,t}$ today and nothing next period. Under these circumstances, the one-period human capital return is:

$$R^h_{e,t+1} = \frac{w_{e,t+1}}{w_{e-1,t}}.$$

Intuitively, this ratio is the marginal payoff of the last unit of human capital (education) over one period. This measure has the property of taking into account both the "gains" that arise from owning a stock of $e-1$ units of human capital at t, as well as the skill premium that is obtained from increasing the stock of human

turn out to be not very sensitive to the consideration of an aggregate index of human capital returns common to all individuals, or to variations in the weight on the human capital return between 0.7 and 0.9. The evidence presented in Becker (1993), Jorgenson and Fraumeni (1989), and Rosen (1989) suggests that human capital's share in the wealth of the U.S. is in fact between these values.

capital. The reason is that it can be decomposed as:

$$R^h_{e,t+1} = \frac{w_{e-1,t+1}}{w_{e-1,t}} \frac{w_{e,t+1}}{w_{e-1,t+1}} = r^{e-1}_{t,t+1} \cdot r^{t+1}_{e-1,e}.$$

The first term, $r^{e-1}_{t,t+1}$, captures the gains obtained from the initial stock of human capital for one period. These gains are, on average, around 2 percent per year in the U.S. labor market, and are typically ignored or, at best, indirectly approximated in other human capital measures (see Becker, 1993). The second term, $r^{t+1}_{e-1,e}$, is the skill premium obtained by owning one more unit of human capital. It captures the relative extra wages that derive from having one more unit of education at a given time. As a result, $R^h_{e,t+1}$ captures the relative difference between marginal productivities of human capitals $e-1$ and e over one period of time, which is precisely the measure of returns that is related to the growth rate in marginal utilities that characterizes the equilibrium conditions.[12]

This measure also provides a natural interpretation for frictions in human capital markets. If we define $w_{t,e} = w_{t,e-1} + d_{t,e}$, then the implicit equilibrium relationship $w_{t,e-1}u'(c_t) = E_t\beta u'(c_{t+1})w_{t+1,e}$ yields the typical present value expression: $w_{t,e-1}u'(c_t) = E_t \sum_{j=1}^{\infty} \beta^j u'(c_{t+j})d_{t+j,e}$, and $\lim_{j\to\infty} \beta^j u'(c_{t+j})w_{t+j,e} = 0$. This expression indicates that utils provided by net real wages today (t) with education $e-1$, are equal to the expected discounted sum of utils provided by the extra wages $d_{t+j,e}$ (wages with education e minus wages with education $e-1$) that one more unit of education will provide for the rest of life. This means that frictions such as transaction costs are to be interpreted as the costs of trading claims on the present discounted value of all future *additional* wages $\{d_{t+j,e} : j = 1, ..., \infty\}$ that are obtained from the marginal additional investment in human capital.[13]

The empirical tests to be implemented using this measure will also be implemented (a) including tuition fees, in addition to foregone earnings, in the cost of education, (b) accounting for ability and selectivity biases in the measurement of wages, (c)

[12] This measure can also be interpreted as the gross income less the maintenance costs that must be incurred to keep a unit of human capital in working order: a "rental" rate (see Becker (1971)). Note that $R^h_{e,t+1}$ does not exclusively apply to young individuals who invest early in their lives in education and other forms of human capital. This rental rate of return may be interpreted as the premium necessary to "transfer" any individual, regardless of age, from his current life-cycle wage profile (that of someone with $e-1$ units of human capital) from date t to $t+1$ to that associated with one more unit of human capital. In other words, $R^h_{e,t+1}$ is the premium that someone at $t+1$ obtains *ceteris paribus* relative to t from having one more unit of human capital over that one period.

[13] These individual returns can then be aggregated in a value-weighted fashion within each demographic group (sex, race, and experience), according to the relative share of each individual observation within that particular group.

using various conditioning instruments, and (d) accounting for unemployment probabilities. Although $R^h_{e,t+1}$ does not include evolving perceptions about future wages and revisions in expected future labor income, the results are similar for alternative measures that account for these effects such as the next two that we consider.

2. The second measure we study is that developed in Buchinsky and Leslie's (1997) finite-horizon dynamic optimization model with endogenous labor supply. As in the case of $R^h_{e,t+1}$, individuals decide in each period their current consumption and whether to attend school or gain a year of work experience. They use a quantile regression approach to compute human capital returns. The novel feature of their model is the inclusion of evolving perceptions about future wages.[14]

3. The third measure we study comes from Campbell (1996), who suggests the following approximation. Let r^j_t denote the logarithm of R^j_t. If the conditional expected return on financial wealth F equals the conditional expected return on human capital wealth h, then given that $r^h_t \approx R^h_t - 1$ and $r^F_t \approx R^F_t - 1$, the log-linear approximation of Campbell and Shiller (1988) and Campbell (1991) implies:

$$r^h_{t+1} = E_t r^h_{t+1} + (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \triangle w_{t+1+j} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r^F_{t+1+j}.$$

This means that increases in expected future labor income cause a positive return on human capital (r^h), whereas increases in expected future financial asset returns (r^F) cause a negative return because the labor income stream is discounted at a higher rate. Other authors have used some components of this measure.[15]

4. Finally, the last measure we study follows the classic Becker-Mincer approach which provides a powerful conceptual framework around which much of the research in this area has been organized. We estimate a log wage regression where the set of regressors include education, experience, dummies for sex, race, nine geographical dummies, standard metropolitan statistical area dummy, individual and family non-earned income, marital status dummy, and dummies for children. Ability and selectivity biases in the measurement of wages will also be accounted for.

[14] The Bellman equation for their problem implies that if there are sufficiently many agents with given wage prospects and if there were no frictions, then it would be possible for each individual to invest any desired amount in human capital assets with those payoffs. The reason is that in equilibrium prices adjust so that the aggregate demand is non-negative and no larger than the supply of individuals of that type. I thank Moshe Buchinsky for this insight.

[15] For instance, Shiller (1993) discounts aggregate income at a constant rate, that is, he assumes $(E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r^F_{t+1+j} = 0$. Jagannathan and Wang (1996) and Baxter and Jermann (1997), in addition, assume that labor income growth is unforecastable: $(E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \triangle w_{t+1+j} = 0$ for $j > 0$. Therefore, they work only with the first term: the growth rate in labor income.

4.2 Data Sources

Wages. The wage data come from the March supplements of the Current Population Survey (CPS) and from the Bureau of Labor Statistics during the period 1964-2003. Individual observations are grouped according to gender (male, female), ethnicity (white, black, other), educational attainment (less than high school, high school, some college, college, more than college), and years of experience (1–5, 6–15, more than 15), which are defined in the usual way as the min $\{age - years\ of\ schooling - 7, age - 17\}$. Given the characteristics of the consumption data with which human capital returns will be matched, most of the estimates that will be presented consider 16 demographic groups: sex (male, female), race (white, black), education (high school degree or less, college degree or more) and experience (15 years or less, more than 15).

Further details of how the wage data are treated are the following. The 1992 changes in the "educational attainment" question in the CPS are reconciled with the previous questions following the procedure suggested by Jaeger (1997). The variable "numbers of weeks worked" is reported in seven categories prior to the 1976 survey. Only those in the top category are considered full-time workers.[16] A relevant issue arose after changes in the sampling frame and coverage were introduced in 1976. As shown by Juhn, Murphy and Pierce (1993) these changes affect mainly the top and bottom ten percent of the *wage* distribution. In our case, after controlling for education and experience, and because returns take the form of wage ratios, these changes do not appear to introduce any observable changes in the *return* distribution and thus in the analysis. Lastly, the tests are also implemented including tuition fees, in addition to foregone earnings, in the cost of education in the measure $R^h_{e,t+1}$. The data come from the State of Washington Higher Education Coordinating Board which collected data on resident undergraduate tuition and required fees from a nationwide sample of colleges and universities for the years 1972–1992. (Tuition costs for the years 1993–1998 are extrapolated by linearly regressing the real cost of education in year t on a constant, the real cost in year $t-1$, the year t, and year squared t^2).

Financial Returns. The return on the U.S. Treasury Bill is chosen as the return on the riskless asset. Data on the T-Bill and on the value-weighted NYSE, which are used to approximate $R_{m,t+1}$ in the recursive formulation of preferences, are obtained from the Center for Research in Security Prices (CRSP). These data will also be useful for determining the set of admissible IMRSs implied by human capital *and*

[16] Following the imputation method suggested by Buchinsky (1994) for all categories does not change the properties of the return series.

financial assets for stockholders in one extension of the analysis.

Consumption. Monthly, quarterly, and yearly consumption data are obtained from the Consumption Expenditure Survey (CEX) for the period 1980(1) to 2003(4). The CEX collects detailed data on the consumption expenditures of roughly 5,000 households per quarter in the United States. The survey attempts to account for an estimated 95% of all quarterly expenditures on consumption made by the subject households. The interviews are conducted every three months. When interviewed, households are asked to report consumption for the previous three months separately. Consumer units are dropped from the sample after four quarters. That is, in any quarter, one-fourth of the sample is replaced by new entrants. Also, the CEX provides a detailed weighting scheme allowing extrapolation to the general U.S. population of the survey data. Aggregation across demographic groups adheres as closely as possible to the National Income and Product Account definitions of consumption aggregates. The consumption measure used is nondurables and services. Extreme outliers (the top and bottom two percent of consumption growth rates) are dropped. Real, seasonally adjusted per capita consumption data are calculated by deflating the series with the CPIs for the appropriate consumption series using the X-11 program and dividing by the size of each household.

5 Empirical Evidence

Table 1 reports the basic features of human capital returns.

[Table 1 Here]

A first characteristic of the data is that the mean human capital returns $R^h_{e,t+1}$ for the different demographic groups are broadly similar to those typically found in the literature (e.g., Card (2001)). However, the variability is slightly greater.[17] For the purposes of the analysis, this means that the Sharpe ratios associated with this measure, $E(R^s_{t+1})/\sigma(R^s_{t+1})$ with $R^s_{t+1} = R^h_{e,t+1} - R^f_{t+1}$, are lower than for other human capital measures. As a result, the size of the risk-adjusted premium may be slightly

[17] Given the important changes that have occurred in the structure of wages since the late 1970s and early 1980s, and the important changes in education and skill premiums that have been widely documented in the labor economics literature during this period, it is no surprise to observe that $R^h_{e,t+1}$ has similar means but slightly greater variability, especially for blacks and females. One reason for this is that in the measure $R^h_{e,t+1} = \frac{w_{e,t+1}}{w_{e-1,t}}$ for given e, $e-1$ is the immediately preceding education level. See Katz and Murphy (1992), Murphy and Welch (1992), and other references therein.

lower as well and, hence, it will be easier to satisfy the minimum variance bounds on the IMRS, $\frac{\sigma(m)}{E(m)} \geq \frac{|E(R^s)|}{\sigma(R^s)}$. This means that, if anaythin, the size of the human capital premium associated with $R^h_{e,t+1}$ may be considered as a *lower bound,* relative to the one that may be obtained for other measures.

Section 5.1 examines whether the size of the human capital premium may be explained by the riskiness of the investment *alone* for time- and state-separable preferences. Section 5.2 examines the role of frictions across the different preference specifications for explaining the size of the risk-adjusted premium. Section 5.3 reports the evidence from a number of additional estimations with other return measures that evaluate the robustness of the results. Lastly, Section 5.4 introduces financial assets and computes the set of admissible IMRSs for households that hold both human capital and financial assets, and also at the aggregate level.

5.1 The Human Capital Premium: A Puzzle

Tables 2 and 3 report the results of two different studies that evaluate whether consumption and human capital returns data can be reconciled under plausible preference parameters. Using a benchmark CRRA specification of utility, these studies account *only* for the riskiness of investments in human capital.

In Table 2 we first calibrate the equilibrium conditions using the information on consumption and human capital returns, and the *actual* empirical correlation between consumption growth and returns. In Table 3, we compute the minimum coefficients of RRA that allow the IMRS to satisfy the *weakest* variance bounds on the IMRS implied by human capital returns. These bounds are obtained using the highest possible absolute value for the correlation between consumption growth and human capital returns, which is of course 1, rather than the actual observed correlation (Hansen and Jagannathan, 1991). The main result in both cases is rather conclusive.

RESULT 1. *The Human Capital Premium Puzzle: The size of the human capital premium cannot be explained by riskiness alone. Under time- and state-separable utility, the minimum coefficients of RRA that are necessary to reconcile movements in consumption and human capital returns in frictionless economies are implausible.*

Consider the typical calibration in frictionless models (e.g., Vissing-Jørgensen (1997), Mankiw-Zeldes (1991)). If consumption growth and human capital returns are jointly log-normal conditional on information at time t, then log-linearizing the

Euler equations as in Hansen and Singleton (1983), assuming constant conditional variances and covariances, and using the law of iterated expectations, the coefficient of RRA can be calibrated as:

$$RRA = \frac{E\left(\ln R^h_{e,t+1} - \ln R^f_{t+1}\right) + \frac{1}{2}V \ln R^h_{e,t+1}}{cov\left(\ln R^h_{e,t+1}, E\ln\left(\frac{c_{t+1}}{c_t}\right)\right)}.$$

The results of this calibration show that the risk-adjusted human capital premium is very high. Table 2 shows that γ ranges from 38.6 to 66.4 across the different demographic groups.

[Table 2 Here]

This means that risk alone can explain very little of the human capital premium. A reason is that the correlation of human capital returns with consumption growth is low for all demographic groups. Thus, human capital assets are not very risky and, consequently, they should not require a big risk premium. The large premium over the riskless asset would then only arise for an implausibly high coefficient of relative risk aversion. It may also be noted that the Sharpe ratios $|E(R^s)|/\sigma(R^s)$ are very different across demographic groups. For more educated individuals the Sharpe ratio is between 1.15 and 1.40, whereas for those with only a high school education it ranges from 0.58 to 0.88. Females tend to have greater variability of consumption growth with a lower correlation with human capital returns. Blacks tend to have greater Sharpe ratios than whites, and females greater than males.[18]

Interestingly, a human capital premium "puzzle" is also obtained when we compute the lowest coefficients of RRA that are necessary for the IMRS to satisfy the minimum restrictions on its volatility. These estimates are collected in Table 3.

[Table 3 Here]

In this case, the coefficients range from 21.4 to 41.1 for the different groups. Clearly, these estimates are lower than in the previous calibration since the minimum volatility bounds on m are computed for $\left|corr(R^h_{e,t+1}, m_{t+1})\right| = 1$, and hence

[18]Different calibrations with annual, quarterly, and monthly CEX data have also been implemented. The results are qualitatively similar to the ones presented in this table. Compared to the usual calibration for the index of financial returns, the correlation of consumption growth with human capital returns is low but greater than the correlation with financial returns. The volatility of consumption growth at individual levels is also greater than at the aggregate level, and the Sharpe ratios $|E(R^s)|/\sigma(R^s)$ for human capital returns are also greater than for financial returns.

represent weaker restrictions than when using the actual observed correlations. Figure 1 shows, as an example, the graphical representation for one case. It shows the Hansen-Jagannathan restrictions imposed on the IMRS for one specific demographic group, and the mean and std. deviation of the IMRS for various values of the RRA coefficient for this group. Confidence intervals for the point estimates of the bounds were computed using Monte Carlo techniques. The confidence intervals on the minimum γ that satisfies the volatility bounds on m shown in the table correspond to the minimum γ that satisfy the 95% point estimate of the bounds.

[Figure 1 here]

A second noteworthy finding is concerned with the pattern of the size of the human capital premium across demographic groups:

RESULT 2. *The extent of the risk-adjusted human capital premium is greater for blacks than for whites, for females than for males, for those with at most a high school degree than for college graduates, and for individuals with less experience (1-15 years) than for those more experienced (>15 years).*

At the two extremes, the risk-adjusted human capital premium is *greatest* for black females with at most a high school education and low experience, while it is *lowest* for white males with a college degree and high experience. Comparing black males and white females across education and experience, the coefficients of RRA are generally greater for white females than for black males, with the exception of college graduates with more than 15 years of experience.[19] These findings may also help provide some initial intuition for the differences to be expected in the magnitudes of the *frictions* that may be necessary to reconcile human capital returns and consumption data for the different demographic groups that will be examined in the next section.

Summing up, we interpret the results as establishing that the size of the risk-adjusted human capital premium is implausibly large in frictionless models. How then can this premium be explained? What frictions in human capital markets may

[19]Note that these results are not at all apparent from the basic comparison of the Hansen-Jagannathan bounds without using consumption data in Palacios-Huerta (2003a). Although the variance bounds on the IMRS implied by the human capital returns of college graduates are more stringent than those implied by the human capital returns of individuals without a college degree, the minimum coefficient of RRA necessary to meet the bounds is smaller. The reason is the relative greater variability of the IMRS of college graduates. Also, although the volatility bounds on the IMRS become slightly sharper with experience, the variability of the IMRS also increases with experience. This increase is relatively greater, which causes the size of the risk-adjusted premium to decrease slightly.

help explain its size? Is the premium different for other specifications of preferences? We study these questions next.

5.2 Understanding the Size of the Risk-Adjusted Human Capital Premium

5.2.1 Frictions for Time- and State-Separable Utility

Table 4 reports the minimum coefficients of relative risk aversion that are necessary to meet the volatility bounds on the IMRS maintaining the CRRA specification of utility and allowing for different frictions in human capital markets. In this sense, it is directly comparable to Table 3.[20] He and Modest (1995) and Luttmer (1996) report a number of figures that show the general shape of the IMRS bounds associated with borrowing, solvency, and short-sale constraints. In order to conserve space, they are not shown here, except in one example to be discussed below.

[Table 4 Here]

As expected, the size of the coefficient of RRA necessary for the IMRS to meet the minimum volatility hurdle is lower in models with frictions. For Borrowing Constraints the coefficient across the different demographic groups is on average about .55–.60 times the one found under no frictions. For females the coefficient is reduced slightly more than for males. The relative reduction is also greater for whites than for blacks. Solvency Constraints have a slightly greater explanatory power than borrowing constraints: the coefficient of RRA is always lower than for borrowing constraints, and on average about half of that in the frictionless case. These results are consistent with the idea that the restrictions that consumers cannot borrow against their human capital (their consumption and investments cannot be below current or future non-human wealth) may help a great deal to explain the risk-adjusted premium.

Interestingly, the restriction that human capital holdings are subject to Short-sale constraints decreases the minimum coefficients of RRA, on average, to about one third of those obtained in the frictionless case. The range of γ is 4.7 to 13.2 for males, 5.9 to 19.2 for females, 4.7 to 13.2 for whites, 8.8 to 19.2 for blacks, 4.7 to 12.7 for college graduates and 6.7 to 19.2 for high school graduates. Figure 2a shows

[20] In Tables 4 and 5 the confidence intervals on the coefficient of RRA obtained from the confidence intervals for the point estimates of the bounds are omitted for clarity. They are typically at most about $\pm 10\%$ the estimates reported in these tables, and are available upon request. The reported estimates are those that allow the IMRS to satisfy the average point estimate of the bounds.

the restrictions imposed on the IMRS in the case of proportional transaction costs and Figure 2b in the case of short-sale, solvency and borrowing constraints for white male college graduates and 1-15 years of experience.

[Figures 2a-2b here]

Clearly, these coefficients are still too large to be conclusively regarded as plausible, especially if we consider that these values allow the IMRS to satisfy just the weakest possible restrictions on its volatility.[21] Yet, the main result is that these natural frictions greatly help reduce the size of the premium left to be explained, to almost plausible levels in some cases. Hence:

RESULT 3. *The restriction that human capital holdings are subject to short-sale constraints may explain up to two thirds of the risk-adjusted premium, whereas an inability to borrow against human capital assets, either to consume and invest now more that one's current non-human wealth (borrowing constraints) or to consume and invest more at a future date (solvency constraints) may explain about half of the risk-adjusted premium.*[22]

These results indicate that these frictions may be binding often enough in equilibrium so that they *do increase* the required rate of return on human capital investments. Also, these frictions appear to become less important in *absolute* terms with age, experience, and education. This suggests that younger and less educated individuals would benefit more than older and more educated individuals from access to some forms of credit and borrowing against human capital. Another interpretation is that if mortgage loans, consumer credit and bank loans to the household sector are viewed as borrowing against future income, then it may not appear to be entirely inappropriate to view "human capital like any other form of capital, cash flows which are treated through issuance of financial assets" (Jagannathan and Wang (1996)) for older and more educated individuals, but it would be rather inappropriate to interpret it this way for younger and less educated households.

The analysis, more generally, indicates that frictions do *have to* be present in any meaningful utility-based intertemporal model that considers human capital at the

[21] When these three classes of frictions are assumed simultaneously, the minimum coefficients of RRA become only slightly lower than those found for short-sale constraints alone. The reason for these weak gains is that short-sale constraints are much stronger than both borrowing and solvency constraints (see, for instance, He and Modest (1995)).

[22] We use the term "explain" to refer to the relative decrease observed in the size of the minimum coefficient of RRA that is necessary to satisfy the volatility bounds on the IMRS.

levels of aggregation studied in this paper (or greater). The results also indicate the *relative* extent across demographic groups to which these frictions are important in their human capital markets.

An alternative assessment of the relative extent of frictions across individuals can also be established in a different, indirect way. Assume that all individuals are characterized by the same basic coefficient of relative risk aversion, say $\gamma = 2$.[23] What then are the minimum proportional transaction costs (assuming no other frictions) for which the IMRS satisfies the minimum volatility bounds implied by human capital returns? The last column in Table 4 answers this question. The only purpose of this back-of-the-envelope exercise is to study in a different way the *relative* extent across individuals using some general "index" of frictions.[24] Not surprisingly, the results are consistent with those obtained from short-sale, borrowing and solvency constraints: greater costs would be needed for females than for males, for blacks than for whites, and for less educated than for more educated individuals.[25] Figure 2a above shows the restrictions imposed on the IMRS for various proportional transaction costs in the case of white males with a college education and 1-15 years of experience.

This exercise was not only chosen for its simple intuition, but also because the results can be readily compared with those of previous studies in the financial asset pricing literature. Using the same equilibrium conditions and same CRRA utility specification, proportional transaction costs that are about 1%–2% allow the IMRS with $\gamma \leq 2$ to satisfy the restrictions imposed by financial asset return data (e.g., He and Modest (1995) and Luttmer (1996)). Table 4 indicates that, for human capital returns, proportional costs that range from 8% to 14% across demographic groups impose the *same* restrictions on the IMRS as financial assets. This indicates that frictions in human capital markets may be somewhere from 4 to 14 times greater than in financial markets.

[23] Fixing the level of this coefficient at other reasonable values would serve the same purpose.

[24] As discussed earlier, it is difficult to conceptualize the nature of these costs, though they could definitely include the psychic costs associated with investments in human capital and many others. See Becker (1964, 1993) for a discussion of frictions and transaction costs in human capital markets.

[25] The restrictions on the IMRS implied by the human capital returns of high school graduates are identical to those implied by the human capital returns of college graduates if, assuming no differences in other costs or frictions, the marginal psychic costs for the representative high school graduate are on average 2.1 percent greater than the marginal psychic cost for the representative college graduate.

5.2.2 The Size of the Risk-Adjusted Premium for other Preference Specifications

The extent and determinants of the human capital premium are examined in Table 5 for specifications of preferences that include different forms of time- and state-nonseparabilities in consumption. As is well known, introducing these non-separabilities induces greater volatility in the IMRS for given attitudes towards risk and, hence, decreases the extent to which a give risk-adjusted premium may be considered puzzling.

A. Frictionless Case. The Epstein-Zin (EZ) recursive specification of utility clearly dominates the other specifications in terms of a much lower coefficient of RRA that is necessary to explain the size of the premium.[26] The main general finding is that the extent of the risk-adjusted human capital premium is greatest for CRRA utility and smallest for EZ recursive utility. Habit persistence in consumption and "catching-up-with-the-Joneses" preferences induce lower coefficients than CRRA utility (from one third to one half lower), but are around two times those that are induced by EZ recursive utility.

Unlike the results obtained in frictionless models of financial asset markets, we see that it is *not* possible to reconcile the movements of human capital and consumption under plausible preference parameters in *any* of these specifications of preferences. Even for EZ preferences the coefficients of RRA are somewhat high, ranging from 5.8 to 12. The confidence intervals (not reported in the tables) at these two extremes are [5.2, 6.3] and [10.6, 13.1] respectively.

Frictions, therefore, clearly appear to be necessary for the IMRS to satisfy even the weakest volatility restrictions implied by human capital returns. Lastly, the pattern concerning the *relative* size of the minimum coefficients of RRA across demographic groups is very similar within each of these preference specifications.

B. Market Frictions. In models with frictions, the coefficients are substantially reduced in some cases. Not surprisingly, the general pattern across the different specifications of preferences is the same as in the frictionless case: CRRA utility induces greater minimum coefficients of RRA than "catching-up-with-the-Joneses"

[26] These preferences also appear to perform better than preferences with exogenous habit persistence in consumption and than catching-up-with-the-Joneses preferences for financial returns data (see Epstein and Zin (1991) and Kocherlakota (1996)). Note that, in our case, human capital returns are part of the market portfolio, whereas in the empirical implementations considered in the financial asset pricing literature human capital assets have never been considered as part of the market return.

preferences, while these in turn induce greater coefficients than preferences with habit persistence in consumption, and these in turn induce greater coefficients than those associated with EZ's recursive utility. We report only the results for short-sale and borrowing constraints. The coefficients are lowest for EZ preferences, ranging from 3.5 to 7 for borrowing constraints and from 1.4 to 5.7 for short-sale constraints.[27] As obtained in the frictionless case, the coefficients are greater for blacks than for whites, for females than for males, for those without a college degree than for college graduates, and for less experienced individuals than for more experienced ones. Some of these coefficients may be considered plausible, in particular the ones corresponding to white males with a college degree and short-sale constraints (for instance, for EZ preferences, the region of admissible IMRS is met for coefficients of RRA below 2 for this demographic group).

While these coefficients are plausible, we should bear in mind that the minimum volatility bounds on the IMRS represent the weakest possible restrictions implied by returns. Hence, these estimates do represent a lower bound on the extent of frictions and coefficients of relative risk aversion. The results may be summarized as follows:

RESULT 4. *Introducing time- and state-nonseparabilities in consumption, especially through an EZ recursive utility formulation, helps reconciling consumption with the size of the human capital premium. The extent to which frictions are necessary to reconcile human capital and consumption data, varies across demographic groups, decreasing with age, experience, and education. The patterns concerning the relative explanatory power of each friction across demographic groups are extremely similar within the different preference specifications.*

5.2.3 The Human Capital Premium at the Aggregate Level

The previous analyses have examined the extent of the human capital premium and its determinants at the level of sex, race, education, and experience characteristics. We do not claim generality of these results beyond these levels of disaggregation. Clearly, the same approach should be followed at further disaggregated levels such as occupation, industry, and others. Yet, the levels of aggregation studied here are often the levels at which a wide range of research areas, topics and issues in the labor economics and macroeconomics literatures are studied.

[27] The confidence intervals on these coefficients are again typically less than $\pm 10\%$ times the point estimates reported in the tables.

Given our data, we may also study the relationship between human capital returns and consumption data at the *aggregate* level. The results are collected in Table 6.

[Table 6 Here]

The estimates indicate that in frictionless models the minimum coefficient of RRA is always too high to be plausible. The coefficient ranges from 18.3 for EZ recursive utility to 52.8 for CRRA utility. Introducing borrowing, solvency, and short-sale constraints lowers these coefficients, but they still are generally implausible. Short-sale constraints in all assets (human capital and the T-bill) induce the lowest coefficients, especially for EZ's recursive utility. They range from 4.7 to 17.9 with these frictions. For solvency constraints, the range goes from 7.5 to 22.0, and for borrowing constraints from 8.2 to 28.9. The two reasons for these results are, on one hand, the lower variability of human capital returns at the aggregate level than at disaggregated levels (the greater Sharpe ratio induces stricter variance bounds) and, on the other, the lower variability of consumption growth at the aggregate level than at the individual level (the IMRS is thus less volatile for given preference parameters). As a result, it is harder to explain the size of the risk-adjusted human capital premium at the aggregate level.

5.3 Extensions and Robustness of the Results

The patterns of the main results, namely the large size of the risk-adjusted human capital premium and the relative explanatory power of the different frictions and preferences across the different demographic groups are maintained in a number of extensions that we have examined. We briefly mention the results.

5.3.1 Alternative Measures of Human Capital Returns and Tuition Costs

Table 7 reports the minimum coefficients of RRA that are necessary for the IMRS to satisfy the volatility bounds implied by the measures of human capital returns suggested by Campbell (1996), Buchinsky and Leslie (1997), and following the Becker-Mincer approach in frictionless models. The Campbell measure induces minimum coefficients of RRA that are about 1.5 times (or 50%) greater for white males, and 1.5 to 2 times (or 50 to 100%) greater for black males, than those found for $R^h_{e,t+1}$. The coefficients are even relatively greater for females. These findings are consistent across preference specifications and demographic characteristics. More importantly, however, the patterns of the results across individuals and preferences are very similar to those obtained for $R^h_{e,t+1}$. Similar patterns are also found using the Buchinsky-Leslie measure. For these measures the coefficients of RRA are about 1.2 to 1.3 times greater than those obtained for $R^h_{e,t+1}$.[28] With regard to the Becker-Mincer measures the results are similar to those obtained for the Campbell measure, if anything the estimates tend to be slightly lower.[29]

The greater size of the premium for these measures may not be very surprising. As indicated earlier, $R^h_{e,t+1}$ exhibits similar means and slightly greater variability than other measures. Consequently, it is characterized by lower Sharpe ratios and thus lower risk-adjusted human capital premiums. The results, therefore, support the robustness of the findings obtained for $R^h_{e,t+1}$: the "excessively large" size of the risk-adjusted premium in frictionless economies, which is even larger for these three alternative measures, and the relative explanatory power of the different frictions across demographic groups.

Lastly, tuition costs were also included, in addition to foregone earnings, in $R^h_{e,t+1}$ for the period 1972-2003. In this case, the risk-adjusted premium tends to decrease slightly across the different frictions and specifications of preferences, but this decrease is often statistically insignificant. The observed patterns of results are still similar.

5.3.2 Conditioning Information, Ability and Selectivity Biases, and Unemployment Probabilities

Conditioning instruments were also used to construct "scaled returns." In particular, a vector of ones, the vector of lagged human capital returns and the vector of lagged consumption growth were used as instruments z_t to condition on the information available to consumers. In equilibrium $E_t m_{t+1} \left(R_{t+1} \otimes z_{t+1} \right) = \lambda \otimes z_{t+1}$, with $\lambda^L \leq \lambda \leq \lambda^U$ and $\lambda \in \Lambda$ as described in section 2.1 for the different frictions. Volatility bounds on the IMRS become slightly sharper in these cases and, consequently, consumption and human capital returns are reconciled under only slightly greater coefficients of RRA than those for the unconditional bounds.

The tests were also conducted accounting for selectivity bias and ability bias in the measurement of human capital returns. The results remained essentially unchanged

[28] As indicated earlier, confidence intervals on the coefficient of RRA are typically about $\pm 10\%$ the estimates reported in these tables, and are available upon request.

[29] The results for models with frictions (not reported), for these three measures also show patterns basically identical to those of the frictionless case. In addition, the *relative* explanatory power of short-sale, borrowing and solvency constraints are extremely similar to those found under $R^h_{e,t+1}$. When frictions are considered the coefficients of RRA are never below 10. The smallest coefficients correspond to EZ recursive utility in the presence of short-sale constraints.

across demographic groups. This is largely due to the fact that the basic features of the return series do not change much and that the size of the risk-adjusted premium is always quite large. Likewise, the main features of the results remain unchanged for the different demographic groups when we account for unemployment probabilities in the measurement of human capital returns, even though these probabilities appear to be especially relevant for low education levels (see Altonji, 1993).[30]

5.3.3 Leisure

When leisure is included in a time-separable fashion in any of the specifications of preferences that we considered, the IMRS tends to have a greater mean but a lower volatility than when only consumption is considered. The reason is that the time series of leisure is quite flat for each and every demographic group and also at the aggregate level. As a result, there are no substantial differences in the results. Basically, returns covary little with leisure and, hence, the size of the human capital premium tends to be slightly larger. Unless individuals are extremely averse to leisure risk, greater coefficients of RRA to consumption risk are necessary to satisfy the bounds on the IMRS.

5.3.4 Human Capital Returns *and* Financial Returns

The percentage of stockholding households has notably increased during recent years in the U.S. During the 1970s and 1980s, for instance, it was about 15-20 percent. In the early 1990s, survey data report that about one third of households held some equity. The Survey of Consumer Finances (SCF), the CEX survey, the NYSE-Stockownership Survey and others report that about 50 percent of American households hold stocks in this period (directly or indirectly). However, the proportion of wealth in the form of equity held by stockholders is typically low. For instance, in 1998 it is estimated that fewer than 15 percent of households hold more than 10,000 dollars in equity.[31]

Given the low extent of participation in stock markets during the last three decades, it seems apparent that the returns of risky financial assets *alone* should not be used to infer the set of feasible IMRS at the aggregate level and for the

[30] All these results are available upon request but omitted for clarity of the exposition.

[31] This is the case for the four measures of stock ownership considered in the literature: (1) = direct holdings of equities; (2) = (1) + equity and balanced mutual funds; (3) = (2) + stocks in IRAs + stocks in trusts; (4) = (3) + stocks in defined contribution pension plans (see, for instance, Blume and Zeldes (1994)).

majority of households in the U.S. during this period as is typically done in the consumption-based finance literature. Conversely, given that all households are human capital holders, human capital returns may well be very valuable for inferring the set of admissible IMRSs.

There is one demographic group, however, for which the information contained in *both* human capital and equity returns is relevant to infer their set of admissible IMRSs. The data in the SCF, CEX, and other surveys reveal that households whose heads are white, male, with at least a college education and 40 years of age (about 15 years of work experience) are much more likely than any other demographic group to be considered a "stockholder" during the last few decades. We next examine the implications that *both* human capital returns and equity returns impose on the volatility of their IMRS for this demographic group. In addition, we also examine the same implications at the aggregate level using aggregate human capital return data.

The restrictions implied by the value-weighted index of equity returns *alone* are well known in the literature (see, for instance, Hansen and Jagannathan (1991), He and Modest (1995), Luttmer (1996)). They are much less stringent than those implied by the human capital returns of this demographic group and by aggregate human capital returns (Palacios-Huerta, 2003a). When combining both classes of returns, the restrictions imposed on the volatility of the IMRS are more stringent than the ones implied by each asset separately but, interestingly enough, not statistically different from those implied by human capital returns alone.[32]

This result indicates that for given specification of preferences, both the frictions on human capital markets obtained in the previous sections *jointly* with the frictions on financial markets suggested in the literature (e.g., Luttmer 1996) are in fact necessary for reconciling consumption data with human capital *and* equity return data under plausible preference parameters both for this demographic group and at the aggregate level.

[32]We used the tests developed in De Santis (1993) for the comparison of bounds on the IMRS when a given set of returns is increased by considering one additional asset or a set of assets. This result was also obtained in Palacios-Huerta (2003a) for a shorter period of time and similar demographic groups.

6 Concluding Remarks

As the most important asset individuals and modern economies possess, human capital is an essential ingredient in a large class of utility-based intertemporal models and in a number of areas in economics. The study characterizes the dynamic relationship between human capital returns and consumption, and studies the extent and determinants of the human capital premium.

Under time- and state-separable preferences, we find an intuitive but heretofore unrecognized relationship between human capital and consumption data: the riskiness of human capital investments *alone* is not enough to justify the premium on human capital assets over the riskless asset under plausible preference parameters. Frictions in human capital markets for different preference specifications are then studied in an attempt to help explain the size of the risk-adjusted premium. We find that some combinations of these frictions and preferences do greatly help explaining the size of this premium. The extent of frictions is quite different across demographic groups, decreasing with education, age, and experience, and about 4 to 14 times greater than in financial markets.

We have also evaluated the robustness of the results. While, of course, there is variation in point estimates, the pattern of the empirical findings seem robust to the use of different measures of human capital returns, conditioning instruments, tuition, ability and selectivity biases, and the consideration of unemployment probabilities. The patterns concerning (1) the large size of the risk-adjusted premium on human capital, (2) the relative explanatory power of the different frictions, and (3) the differences in the effects of market frictions across demographic groups, are the main findings worth emphasizing.

Notwithstanding the stability of these patterns, other preference specifications and other frictions may be examined by further study. The analysis may also be readily extended to consider other demographic characteristics such as occupation, industry, family circumstances, and others. Clearly, however, at *any* level of aggregation, some idiosyncratic risk will be left out of the calculations. This is commonly done in financial research in the analysis of the properties of indexes of financial returns. However, unlike financial asset returns which yield the same return to all individuals, human capital returns vary across individuals. Interestingly, Judd's (2000) theoretical analysis shows how when idiosyncratic risk is endogenous the risk premium for human capital depends on systematic components of risk, *not* on idiosyncratic risk. In the analysis we control for sex, race, education, and experience levels. It is conceivable that other sources of heterogeneity and individual-level uncertainty may not induce substantially different results if they mostly introduce idiosyncratic risk. This, however, remains an open empirical question for further research.

The analysis also has implications for the financial asset pricing literature as human capital is an important component of the individual's investment portfolio and one of the assets that determines the structure of the IMRS. This asset holds important information on the full set of frictions experienced by individuals, and is important to understand how savings are invested in financial assets, human capital, and consumer durables (MaCurdy, 1999). The role of frictions in human capital markets and the differences in frictions across demographic groups may also be valuable to help explain the puzzling departure from full consumption insurance reported in the literature (e.g., Attanasio and Davis (1996), and Meguir and Weber (1996)).

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TABLE 1

DESCRIPTIVE STATISTICS for REAL HUMAN CAPITAL RETURNS 1964-2003

	MALES		FEMALES	
	WHITES	BLACKS	WHITES	BLACKS
EDUCATION-EXPERIENCE	Mean (St.dev.)	Mean (St.dev.)	Mean (St.dev.)	Mean (St.dev.)
EDUCATION: Some High School				
Experience: 1-5	5.8 (6.2)	3.2 (7.3)	2.9 (5.6)	3.6 (10.2)
6-15	5.5 (4.8)	2.1 (8.1)	2.3 (4.6)	3.0 (10.0)
>15	5.4 (5.3)	3.0 (8.5)	4.6 (6.2)	2.7 (9.6)
EDUCATION: High School				
Experience: 1-5	13.4 (9.8)	21.3 (16.3)	18.7 (9.2)	20.4 (13.7)
6-15	8.2 (5.7)	15.5 (11.3)	13.8 (10.1)	22.9 (14.3)
>15	5.0 (7.5)	12.0 (8.6)	7.3 (6.8)	12.1 (10.2)
EDUCATION: Some College				
Experience: 1-5	6.0 (6.0)	14.8 (9.9)	11.1 (4.8)	10.3 (14.0)
6-15	7.2 (5.5)	9.5 (8.3)	10.9 (5.0)	8.3 (12.2)
>15	7.2 (4.3)	8.6 (8.2)	10.1 (7.4)	9.0 (11.5)
EDUCATION: College				
Experience: 1-5	14.1 (11.0)	17.7 (10.0)	16.5 (8.3)	11.2 (8.0)
6-15	8.8 (7.5)	11.5 (9.2)	14.3 (10.3)	13.5 (9.5)
>15	10.1 (9.0)	13.5 (12.2)	9.1 (8.6)	6.0 (9.7)
EDUCATION: More than College				
Experience: 1-5	10.3 (4.8)	11.9 (10.4)	12.2 (6.5)	14.1 (8.8)
6-15	10.0 (5.1)	10.2 (8.5)	10.4 (9.3)	20.3 (11.0)
>15	8.6 (8.2)	7.0 (12.2)	11.0 (8.8)	18.4 (12.5)
AGGREGATE HUMAN CAPITAL	10.8 (5.2)			

TABLE 2

CALIBRATION OF THE COEFFICIENT OF RELATIVE RISK AVERSION (γ)
FOR REAL HUMAN CAPITAL RETURNS AND REAL T-BILL RETURNS 1980(1)-2003(4)

DEMOGRAPHIC GROUP		Sharpe ratio	$\sigma(\Delta C_{t+1})$	corr $(\Delta C_{t+1}, R_{e,+1})$	γ
MALES					
WHITES. High School or less					
Experience:	1-15	0.66	0.026	0.40	63.4
	>15	0.73	0.024	0.57	53.3
College or More					
Experience:	1-15	1.20	0.051	0.55	42.7
	>15	1.15	0.062	0.48	38.6
BLACKS. High School or less					
Experience:	1-15	0.69	0.020	0.61	56.5
	>15	0.88	0.027	0.69	47.2
College or More					
Experience:	1-15	1.27	0.067	0.38	49.8
	>15	1.22	0.071	0.33	52.0
FEMALES					
WHITES. High School or less					
Experience:	1-15	0.58	0.033	0.27	65.0
	>15	0.68	0.026	0.38	68.8
College or More					
Experience:	1-15	1.40	0.052	0.44	61.1
	>15	1.37	0.058	0.38	62.1
BLACKS. High School or less					
Experience:	1-15	0.72	0.037	0.36	54.0
	>15	0.88	0.041	0.43	50.0
College or More					
Experience:	1-15	1.59	0.057	0.42	66.4
	>15	1.52	0.056	0.40	67.8

Notes: $\gamma = [E[\ln(R_{e,t+1}) - \ln(R_{f,t+1})] + 0.5V(\ln(R_{e,t+1}))] / [\mathrm{cov}(\ln((R_{e,t+1}), \ln(C_{t+1}) - \ln(C_t))]$ with $R_{e,t+1} = w_{e,t+1}/w_{e-1,t}$. CEX quarterly and monthly data are not seasonally adjusted. Seasonal adjustment with 4 and 12 seasonal dummies gives similar results.

TABLE 3

MINIMUM COEFFICIENT OF RELATIVE RISK AVERSION
NECESSARY TO SATISFY THE VARIANCE BOUNDS ON IMRS FOR
REAL HUMAN CAPITAL RETURNS WITH CRRA UTILITY

		MALES	FEMALES
WHITES			
High School or less			
Experience:	1-15	26.1	34.1
		[24.3, 28.4]	[32.2, 37.3]
	>15	24.6	30.0
		[22.4, 26.8]	[28.0, 32.6]
College or more			
Experience:	1-15	23.5	29.2
		[21.8, 25.6]	[27.5, 31.2]
	>15	21.4	22.2
		[19.0, 23.3]	[20.9, 24.0]
BLACKS			
High School or less			
Experience:	1-15	31.8	41.1
		[30.0, 34.2]	[39.0, 45.1]
	>15	28.3	37.0
		[26.3, 30.3]	[34.8, 39.3]
College or more			
Experience:	1-15	27.9	32.8
		[25.9, 30.1]	[30.1, 36.0]
	>15	25.2	27.0
		[23.1, 26.0]	[25.7, 29.3]

Note: Confidence intervals in brackets.

TABLE 4

MINIMUM COEFFICIENT OF RELATIVE RISK AVERSION NECESSARY TO SATISFY THE VARIANCE BOUNDS ON IMRS FOR REAL HUMAN CAPITAL RETURNS WITH CRRA UTILITY

DEMOGRAPHIC GROUPS	No Frictions	FRICTIONS: CONSTRAINTS Short-Sale	Borrowing	Solvency	Transaction costs at $\gamma = 2$
MALES					
WHITES. *High School or less*					
Experience: 1-15	26.1	9.4	17.3	14.8	9.2%
>15	24.6	7.5	12.9	11.0	8.7%
College or more					
Experience: 1-15	23.5	6.0	14.6	12.7	8.4%
>15	21.4	4.7	12.0	10.3	8.0%
BLACKS. *High School or less*					
Experience: 1-15	31.8	13.2	21.3	19.0	11.7%
>15	28.3	11.7	17.1	16.0	10.3%
College or more					
Experience: 1-15	27.9	9.9	18.7	16.6	9.6%
>15	25.2	8.8	15.0	14.5	9.0%
FEMALES					
WHITES. *High School or less*					
Experience: 1-15	34.1	10.3	18.9	16.4	13.3%
>15	30.0	6.7	14.2	12.7	11.1%
College or more					
Experience: 1-15	29.2	9.8	18.8	15.1	10.8%
>15	22.2	5.9	13.1	11.2	8.3%
BLACKS. *High School or less*					
Experience: 1-15	41.1	19.2	26.5	24.4	14.1%
>15	37.0	16.3	22.6	20.7	13.7%
College or more					
Experience: 1-15	32.8	12.7	20.1	16.6	12.0%
>15	27.9	9.0	12.1	10.8	9.9%

Notes: The column "Transaction costs at $\gamma = 2$" indicates the *proportional* transaction costs that are needed for the IMRS with $\gamma = 2$ to coincide with the minimum variance bounds. Short-sale constraints are imposed on all assets (human capital and T-bill).

TABLE 5 -MINIMUM COEFFICIENT OF RELATIVE RISK AVERSION NECESSARY TO SATISFY THE VARIANCE BOUNDS ON THE IMRS FOR REAL HUMAN CAPITAL RETURNS WITH HABIT PERSISTENCE, "CATHING-UP-WITH-THE-JONESES," AND EPSTEIN-ZIN PREFERENCES UNDER NO FRICTIONS, AND FOR SHORT-SALE AND BORROWING CONSTRAINTS

	HABIT PERSITANCE			CATCHING-UP-WITH-THE-JONESES			EPSTEIN-ZIN		
DEMOGRAPHIC GROUPS	No Frictions	Short-Sale	Borrowing	No Frictions	Short-Sale	Borrowing	No Frictions	Short-Sale	Borrowing
MALES									
WHITES. High School or less									
Experience: 1-15	16.1	6.3	11.3	13.6	4.9	8.8	6.9	2.5	4.4
>15	15.0	4.9	8.4	12.6	4.0	6.8	6.8	2.0	3.5
College or more									
Experience: 1-15	14.2	3.9	9.7	11.9	3.1	7.7	6.8	1.8	3.8
>15	12.9	3.1	7.8	10.5	2.6	6.4	5.8	1.4	3.6
BLACKS. High School or less									
Experience: 1-15	20.3	8.7	14.0	16.0	6.8	11.2	9.0	3.6	6.0
>15	17.8	6.0	11.3	14.8	6.0	8.8	8.3	3.0	4.8
College or more									
Experience: 1-15	18.0	6.5	12.2	14.2	5.2	9.6	8.0	2.6	5.7
>15	16.5	5.8	10.0	13.0	4.6	7.9	7.0	2.2	4.4
FEMALES									
WHITES. High School or less									
Experience: 1-15	22.8	6.7	13.4	17.6	5.3	9.7	9.2	3.0	4.8
>15	19.5	4.4	9.5	15.5	3.9	7.5	6.5	2.0	3.7
College or more									
Experience: 1-15	19.1	6.5	12.3	15.0	5.0	9.6	7.5	2.6	4.9
>15	14.5	3.7	8.3	11.9	3.8	6.9	6.0	1.5	3.4
BLACKS. High School or less									
Experience: 1-15	26.4	12.1	17.6	21.6	10.2	14.1	12.0	5.7	7.0
>15	26.5	10.9	14.9	19.6	9.6	14.0	10.1	4.7	6.0
College or more									
Experience: 1-15	21.6	8.2	13.0	16.6	6.8	10.8	8.5	4.0	5.6
>15	16.9	5.7	8.2	14.3	4.9	7.0	7.3	2.3	3.7

Notes: Short-sale constraints are imposed on all assets (human capital and T-bill). For Epstein-Zin preferences the gross return on the market portfolio is approximated by a convex combination of the value-weighted human capital return, weighted by 0.85, and the value-weighted NYSE return weighted by 0.15.

TABLE 6

MINIMUM COEFFICIENT OF RELATIVE RISK AVERSION
NECESSARY TO SATISFY THE VARIANCE BOUNDS ON IMRS
FOR AGGREGATE REAL HUMAN CAPITAL RETURNS

	PREFERENCES SPECIFICATIONS			
	CRRA	Habit persistence	"Catching-up with-the-Joneses"	Epstein-Zin Utility
NO FRICTIONS.................	52.8 [45.3, 59.3]	32.5 [30.2, 35.9]	30.7 [27.1, 33.0]	18.3 [16.7, 20.0]
FRICTIONS:				
Short-Sale Constraints.....	17.9 [16.2, 18.5]	14.6 [13.2, 16.1]	10.4 [9.7, 11.5]	4.7 [4.3, 5.1]
Borrowing Constraints....	28.9 [26.5, 31.5]	20.7 [18.3, 22.6]	16.8 [15.3, 18.2]	8.2 [7.7, 9.0]
Solvency Constraints.......	22.0 [19.9, 24.1]	17.0 [15.5, 18.6]	14.0 [12.7, 15.3]	7.5 [6.7, 8.0]

Notes: For Epstein-Zin recursive utility specification the gross return on the market portfolio is approximated by a Convex combination of the value-weighted human capital return, weighted by 0.85, and the value-weighted NYSE return, weighted by 0.15. Short-sale constraints are on all assets (human capital and the T-Bill). Confidence intervals in brackets.

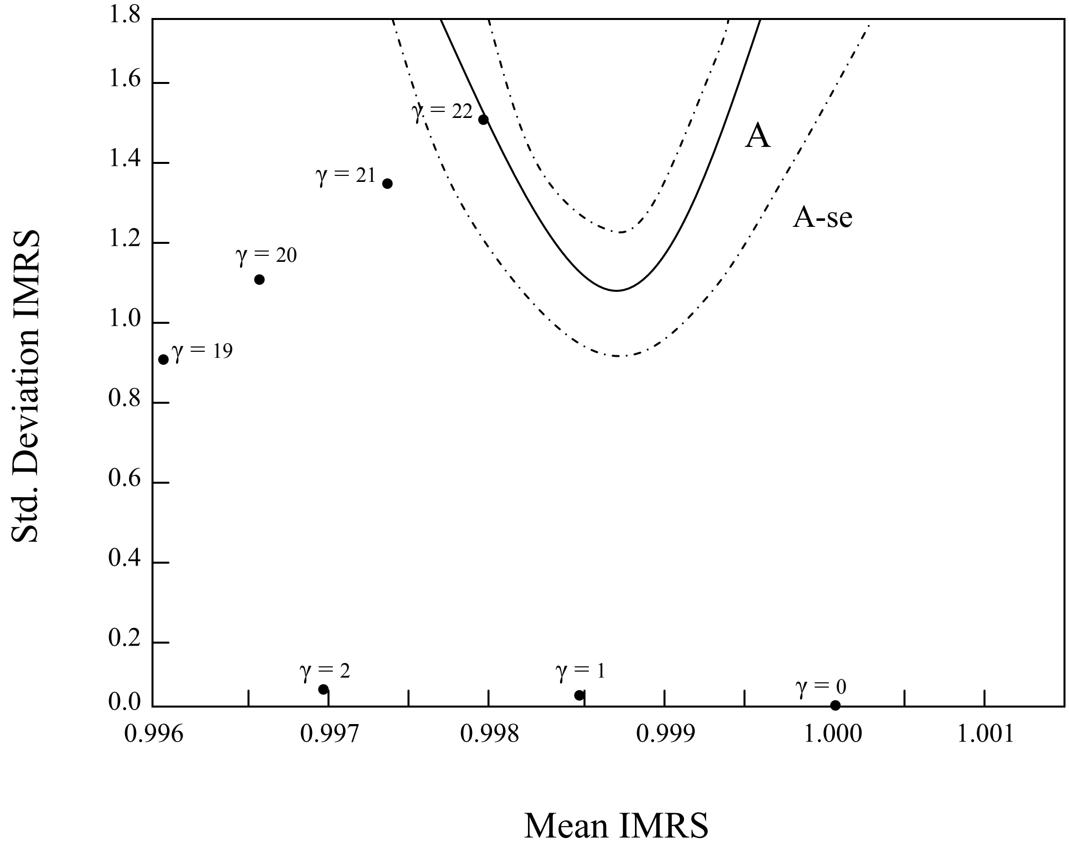
TABLE 7

MINIMUM COEFFICIENT OF RELATIVE RISK AVERSION
NECESSARY TO SATISFY THE VARIANCE BOUNDS ON IMRS FOR CAMPBELL (C), BUCHINSKY-LESLIE (BL) AND BECKER-MINCER (BM) MEASURES OF REAL HUMAN CAPITAL RETURNS IN FRICTIONLESS MODELS

	Preferences Specifications											
	CRRA			Habit persistence			"Catching-up-with-the-Joneses"			Epstein-Zin Utility		
Demographic characteristics	C	BL	BM	C	BL	BM	C	BL	BM	C	BL	BM
MALES												
WHITES. High School or less												
Experience: 1-15	40.2	33.5	41.0	25.1	20.0	27.5	22.3	17.7	23.5	12.4	10.3	14.0
>15	36.3	29.5	36.0	23.9	19.1	24.6	18.2	14.2	16.3	10.5	9.1	10.5
College or more												
Experience: 1-15	35.0	28.2	36.3	22.5	17.7	22.2	17.9	14.1	20.2	11.8	9.6	12.4
>15	30.7	27.9	29.5	19.3	15.1	19.0	15.0	11.8	17.1	9.9	8.9	9.3
BLACKS. High School or less												
Experience: 1-15	50.6	38.0	52.2	35.4	29.0	37.7	29.1	23.2	32.0	18.0	15.1	17.1
>15	37.8	32.3	39.7	30.2	25.3	32.1	26.8	20.2	27.9	14.1	11.7	15.2
College or more												
Experience: 1-15	36.8	31.0	40.2	29.4	24.4	31.2	28.7	22.0	31.8	15.7	13.4	16.0
>15	36.2	28.0	35.0	26.5	20.0	27.6	26.6	20.4	27.5	14.8	12.6	15.9
FEMALES												
WHITES. High School or less												
Experience: 1-15	56.0	42.1	55.9	37.9	28.4	40.3	28.4	23.8	29.4	16.9	13.3	17.5
>15	48.8	37.8	50.8	32.7	24.2	34.8	23.7	22.7	24.6	14.3	10.0	15.6
College or more												
Experience: 1-15	49.0	39.4	51.3	33.1	25.2	36.5	23.2	16.2	20.2	15.6	12.2	16.2
>15	35.6	28.5	34.6	26.8	20.1	29.4	19.9	14.6	18.3	12.8	9.6	12.8
BLACKS. High School or less												
Experience: 1-15	73.5	62.3	70.5	45.2	34.2	48.9	40.2	31.3	38.7	20.7	18.6	19.7
>15	61.6	48.6	56.9	40.1	33.3	42.0	40.0	28.4	35.1	18.3	16.8	17.4
College or more												
Experience: 1-15	50.9	41.7	48.4	33.3	27.0	36.2	27.1	22.5	30.0	15.3	12.4	16.3
>15	39.5	33.2	40.1	26.4	22.2	30.1	22.3	18.1	25.0	14.0	10.2	12.1

Notes: For Epstein-Zin recursive utility specification the gross return on the market portfolio is approximated by a convex combination of the value-weighted human capital return, weighted by 0.85, and the value-weighted NYSE return, weighted by 0.15. Short-sale constraints are on all assets (human capital and the T-bill).

FIGURE 1
Hansen-Jagannathan Bounds for
White Males with a College Education



Note: The restrictions on the admissible set of IMRSs (A) are those imposed by the human capital returns of white males with a college education and 1-15 years of experience in a frictionless model. Standard errors (se) on the bounds are computed using Monte Carlo simulations and are based on Newey-West with one year of lags. The mean and standard deviation of the IMRS for CRRA utility for this demographic group is shown for various values of the coefficient of relative risk aversion γ(•).

FIGURE 2

Restrictions on the IMRS imposed by the Human Capital Returns of White Male with a College Education under Different Frictions

Fig. 2A. Proportional Transaction Costs A: 0%, B: 3%, C: 5%, D: 8.4%.

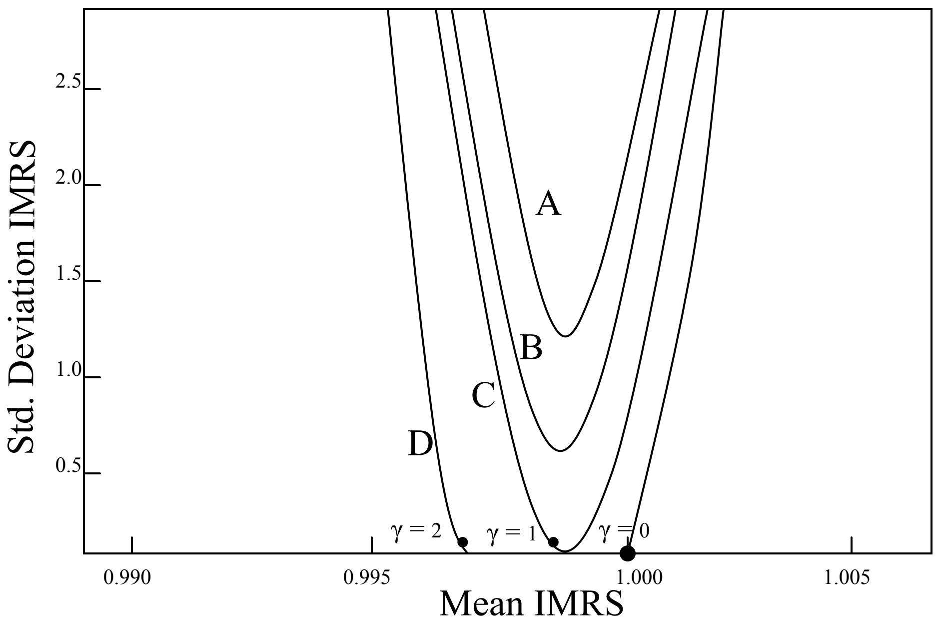
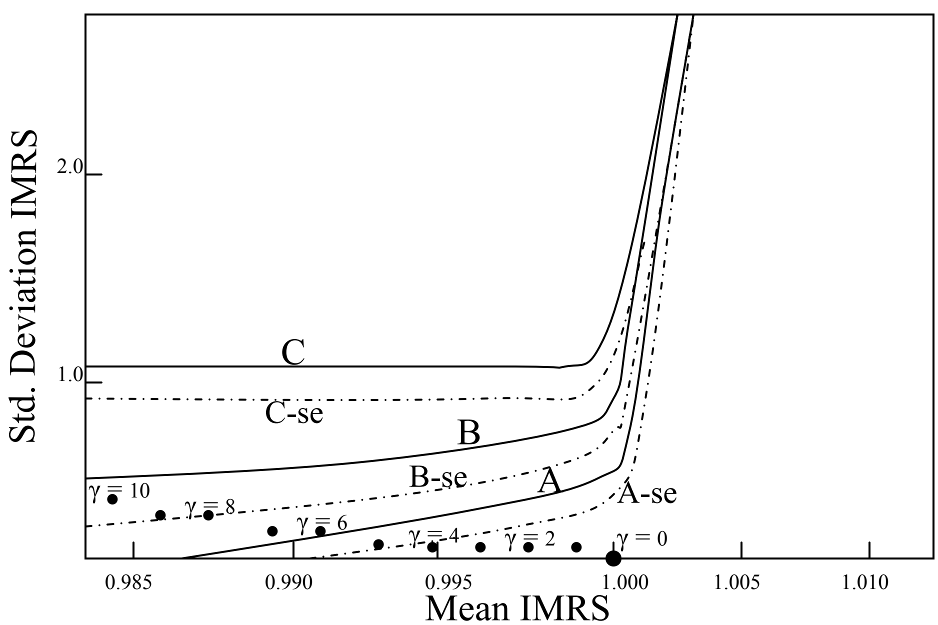


Fig. 2B. Short-Sale (A), Solvency (B), and Borrowing (C) Constraints



Note: Standard errors (se) on the bounds are computed using Monte Carlo simulations and are based on Newey-West with one year of lags. The mean and standard deviation of the IMRS for CRRA utility is shown for various values of ♑ (•).