Is Education as Good as Gold?

A Portfolio Analysis of Human Capital Investment

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Abstract. Is there underinvestment in education? One way to answer this question is to compare the expected returns to education to the returns of assets of comparable risk. This paper examines two human capital asset pricing models which integrate the ideas of the CAPM with unique features of human capital investments and labor markets. Both models argue that the human capital return premium should be largely determined by its systematic risk. Combining our theoretical results with existing empirical results indicates that the return to education is greater than that of assets of like riskiness, implying underinvestment.

1. Introduction

Education is an investment with a high return. In fact, the mean return on education is similar to that of equity, and far greater than the return to bonds or gold. The high returns to assets such as equity are justified by their high risk. In the risk dimension, equity is a poor asset, but bonds are safe, and assets like insurance contracts and gold are good since their return is high when the marginal value of wealth is high. Can risk explain the high return to human capital investments? Unfortunately, there has been little analysis, theoretical or empirical, focussing on the risk properties of educational investments. We want to ask where education fits in this spectrum: should its returns be heavily discounted like equity, or are its risk properties more like bonds, insurance, or gold?

We use two simple models of risky human capital investment to address these questions. We highlight the unique features of educational investment and labor

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markets. It has been long recognized that a portfolio approach to education is important. Early discussions of educational investments compared the return to education to safe assets and argued that there was underinvestment in education because education had a much higher return than bonds; see Glick and Miller (1956), and Morgan and David (1963). This approach was criticized in Becker(1976), who asserted that

> "an investment in college education is subject to considerable risk, and is obviously extremely illiquid. Consequently, the gain from education should be compared with that on investments with equally large risk and illiquidity."

Becker then examines the social return to college education, argues that it ranges[1] between "8 and 11 per cent," notes that business investment has a return of "between 8 and 12 percent", and concludes that the "rates of return on business capital and college education seem, therefore, to fall within the same range." Despite the large body of work done since, Becker's assertions are still good rough estimates of the rates of return on physical and human capital[2]; see Psacharapoulos (1994) for an international review of the evidence. We make no contribution to these empirical issues. Instead we develop theoretical models which tell us how to compare human capital with other investments.

Becker's question is an important one to which we apply modern portfolio ideas. There are actually two underinvestment questions. The first issue is whether individuals are making efficient decisions given the risks and returns they face; call this the *private underinvestment question*. The second issue is whether there are some social policies that can improve on the competitive equilibrium; call this the *social underinvestment question*. The two issues are distinct. It may be that individuals are rational in limiting their educational investments because of personal risks, but that there are social policies that could ameliorate these risks and produce a superior allocation. We shall examine both underinvestment issues as we present two models of risky human capital investment.

[1] Our concept of social return is the before-tax return on all inputs to investment. In the case of education, it includes all expenditures on education.

[2] There are reasons to believe that this is a low range of estimates for the return to education. For example, these estimates typically ignore in-kind compensation such as health and dental insurance, free parking, and other employee benefits. A reasonable conjecture is that education increases the chances of working for a firm offering good benefits. Other sources of bias are nonpecuniary aspects of a job. For example, education increases the chance that one spends summer workdays in an air-conditioned environment and winter workdays in a heated environment. College-educated workers generally have more flexibility in how they perform their work. Any serious discussion of the underinvestment issue should include these benefits. Since our analysis appears to find underinvestment, including these elements would only strengthen our conclusions.

CAPM analysis teaches us that an asset's value depends on its expected return and the covariance of its return with some aggregate collection of all assets. The question we ask in this paper is where does human capital fit in the universe of assets. We cannot apply the simplest arguments from finance since human capital investment is not like portfolio investment. The risks are often individualistic and human capital is an illiquid asset. We develop a human capital asset pricing model (HCAPM) that incorporates two critical factors. First, the total riskiness of human capital investment is not proportional to the size of the investment, and an individual cannot diversify his human capital investments. For example, one cannot partly invest in a high school education and partly in a college education. We generalize the basic portfolio investment model and show that the correct pricing of risk for human capital investment in the HCAPM augments the familiar CAPM analysis with an extra term representing the marginal impact of education on the covariance of returns with the market. These aspects of human capital returns cannot explain much of the return to educational investments since labor income is not strongly tied to asset market returns, and education tends to reduce an individual's exposure to aggregate risk. For example, the analysis in Davis and Willen (1999) indicates that there is little systematic risk in labor income for all levels of educational investment. Rubinstein and Tsiddon (2000) show that some college graduates actually experience absolute wage gains during recessions. The high return to human capital cannot be explained in terms of covariance, or marginal covariance, with aggregate economic performance.

The second fact incorporated in our analysis is that human capital investments often bring idiosyncratic, undiversifiable risk. Before we can value the riskiness of education, we need to understand why some labor income risk is not diversifiable. We examine two approaches. We first take the conventional, but *ad hoc*, approach of assuming the presence of idiosyncratic, undiversifiable risk in labor income. This approach to labor income risk was taken in Eaton and Rosen (1980) and Hamilton (1987). They showed that an optimal policy uses taxes and lump-sum transfers to create insurance. The implications are clear: an individual would treat human capital risk as costly, but the social price is zero and social policies such as income taxation can be used to produce Pareto improvements. This model can be used to explain why individuals do not invest more in human capital, indicating that there is no private underinvestment. However, it implies that there is social underinvestment since there are simple Pareto-improving policies that will bring the mean return on human capital closer to the mean return on safe assets. In this paper, we reexamine these issues in a model where there are risky financial assets as well as risky human capital. We present numerical examples to show that the implications for tax policy are quantitatively significant.

Some of these ideas have been examined in earlier studies, but none combine all the essential features. Levhari and Weiss (1974) study a model with risky and illiquid human capital but with only a safe financial asset. They show that illiquidity implies the critical distinction between marginal and average riskiness. Williams (1978) examines a mean-variance model with investment in human capital and risky financial assets. For reasons of tractability, Williams made linearity assumptions that make human capital look just like financial assets. Both Levhari and Weiss, and Williams include undiversifiable risk in human capital investments, but neither models the reason for undiversifiable risk nor interactions with labor supply. Bodie et al. (1992) examines how elastic labor supply affects demand for financial assets, but ignores human capital investment. Our model incorporates the nonlinearities and illiquidity of Levhari and Weiss, the risky financial assets of Williams, and the endogenous labor supply of Bodie et al.

Some will argue that the welfare economics of the *ad hoc* model are rigged, and that we should explicitly model why the individual risk is undiversifiable. This paper examines a second model where moral hazard endogenously generates idiosyncratic risk in labor income as an outcome of an optimal contract. Since the idiosyncratic risk arises for incentive compatibility reasons, the allocation cannot be improved by simple tax and subsidy policies which face the same incentive constraints. The result is that competitive equilibrium is efficient. However, the Beckerian view of no underinvestment cannot take comfort in the moral hazard model. This model implies that individuals will invest in human capital up to the point where its expected return equals the expected return of assets with similar systematic risk alone. Therefore, the presence of undiversifiable risk adds nothing to the equilibrium risk premium. The result arises for a simple reason: the risk necessary to impose incentive compatibility is effectively a fixed cost and so has no effect on the marginal risk of human capital investment. Therefore, since there is little systematic risk in human capital investments, the mean return on human capital investments should be closer to the safe rate of return than to the mean return on equity, a prediction which is contradicted by the data.

Our two models of idiosyncratic, undiversifiable risk indicate that the efficient investment view is difficult to support. One can either choose a model that can rationalize the high observed returns to educational investment but implies the desirability of significant tax policy intervention, or a model in which educational investment is efficient in equilibrium but cannot explain the significant premium in the return of human capital over assets of similar systematic risk.

These observations indicate that the riskiness of human capital does not justify its large expected return. This implies that there is a "human capital risk premium puzzle." This is a puzzle beyond the normal equity premium puzzle. The equity premium puzzle says that it is hard to explain the absolute level of the equity premium. The puzzle here is that the premium on human capital returns seems not only large in absolute terms but also large relative to the equity premium.

Section 2 lays out a basic model of human capital investment and uses it to solve a simple optimal tax problem. We extend previous models by adding other risky assets, and use some numerical examples to examine the quantitative importance of the optimal Pareto-improving taxation. Section 3 develops a model where moral hazard in an optimal labor contract produces some idiosyncratic risk, showing that there is no reason for subsidizing education in that model but that the equilibrium risk premium for idiosyncratic risk is small, possibly negative. Section 4 discusses alternative interpretations of the results, arguing that there are no easy answers. Section 5 concludes.

2. Human Capital Investment and Exogenous Riskiness

We first consider a simple generalization of the CAPM model that incorporates features of idiosyncratic risk and illiquidity unique to human capital investments. This section considers the case where the human capital risks are fixed exogenously.

2.1. Purely Idiosyncratic Risk. We first present the Levhari-Weiss model, where the only financial asset is a safe bond but human capital investment is illiquid and has nonlinear returns. In particular, we do not allow an individual to trade away his human capital risk or to invest in other individuals' human capital.

We examine a two-period model. Investment decisions are made in the first period and all consumption occurs in the second period. We assume that human capital investment, h, produces an income of $f(h)+\Sigma(h)Y$, where $E\{Y\}=0$. This expression essentially separates the return into the mean component, $f(h)$, and its risky component, $\Sigma(h)Y$. We will assume that total utility equals $u(c)+V(h)$ where $u(c)$ is utility over consumption and $V(h)$ is the utility from h. We assume that $u(c)$ is increasing and concave, but we assume that V is either increasing or decreasing in h; this allows V to represent both nonpecuniary costs of education as well as nonpecuniary benefits.

The individual's problem becomes

$$\begin{array}{ll} \max\limits_{s,h} & E\left\{u\left(f(h)+\Sigma(h)Y+sR\right)\right\}+V(h) \\ \text{s.t.} & s+h=W \end{array} \tag{1}$$

where W is the initial endowment of wealth and s is savings in financial assets that have a safe return R. The result is a pure portfolio problem since all income is consumed in the second period. The first-order condition can be written as

$$f'(h)-R+\frac{V'(h)}{E\left\{u'\left(c\right)\right\}}=\Sigma'(h)\frac{-Cov(u'\left(c\right),Y)}{E\left\{u'\left(c\right)\right\}}\equiv\Sigma'(h)\beta \tag{2}$$

where β is the "price of risk" and $\Sigma'(h)$ is the marginal risk of investment in h. The price of risk β contains the critical covariance of returns with the marginal utility of consumption. Investment in h will continue until (2) holds.

To understand (2), we consider some simple examples. If $f(h) = \mu h$, and $V(h) = 0$, and $\Sigma(h) = \sigma h$ then

$$\mu - R = \sigma\beta \tag{3}$$

which is the conventional consumption beta relation from finance expressing the excess return, $\mu - R$, in terms of the price of risk. This case where both the mean return and the risk is proportional to the investment expenditure h is the case of normal portfolio investment. However, such proportionality is not expected of human capital investment. First of all, there is no reason to suspect a linear relation between $f(h)$ and h in the case of education. This leads to only minor adjustments in our analysis, replacing μ with $f'(h)$.

Second, and more important for our purposes, there is no reason to suspect that $\Sigma(h)$ is proportional to h. Suppose $\Sigma(h) = h\sigma(h)$, where $\sigma(h)$ is the average variance per unit of human capital investment. In the financial asset case, $\sigma(h)$ is constant and (3) holds. The average variance $\sigma(h)$ will probably not be constant since each level of h corresponds to a different asset, not just more of a fixed asset. For example, a college education of 16 years is not the same as two grade school educations. Different levels of education are likely to be fundamentally different in terms of the return structure since they are related to different skills and different product markets. However, an individual cannot diversify across different levels of h. This produces a kind of illiquidity and lack of diversification.

Therefore, we must consider a more general forms for $\Sigma(h)$. Suppose $\Sigma(h) = h\sigma(h)$ and $V(h) = 0$; then equation (2) reduces to

$$f'(h) - R = \sigma(h)\beta + h\sigma'(h)\beta \tag{4}$$

This expression shows that nondiversifiability of human capital adds a new term, $h\sigma'(h)$. The risk premium term in the HCAPM expression, equation (4), has two pieces: the $\sigma(h)$ term that is the conventional CAPM term, plus the new term $h\sigma'(h)$ which reflects the marginal change in per unit variance. Not only is human capital risky on average, $\sigma(h)$, but there is marginal average riskiness which arises here but is absent in (3). The intuition is that an additional dollar invested in human capital produces some new risks, but it may reduce the riskiness of the sunk investment.

Another instructive example is $\Sigma(h) = f(h)\sigma(h)$ and $V(h) = 0$. In this case, equation (2) reduces to

$$f'(h) - R = \sigma(h)f'(h)\beta + f(h)\sigma'(h)\beta$$

In this case $\sigma(h)$ is the ratio of variance to mean income. If σ' is negative, the extra marginal risk term reduces the cost of risk.

Our human capital investment return function $f(h) + \Sigma(h)Y$ is not general. It assumes that Y does not depend on h, and that human capital investment affects only the mean and variance of the returns. It may be that human capital investment also affects other moments of the return, such as skewness or kurtosis. Suppose, for example, that education did not affect mean or variance but shifted the returns so that "downside" risk was reduced but that the upper tail become longer. Under some utility functions, this would be desirable even though it did not affect conventional notions of riskiness. To model this, assume that the return to education equals $f(h)+\Xi(h)$ where $\Xi(h)$ is a family of zero mean random variables. Then (2) becomes

$$f'(h) - R + \frac{V'(h)}{E\{u'(c)\}} = \frac{-E\{u'(c)\,\Xi'(h)\}}{E\{u'(c)\}}$$

where the risk premium now becomes the covariance between the marginal utility of income and the marginal random variable $\Xi'(h)$. We will not develop this generalization any further since the simpler formulation is a better vehicle for expositing the basic points. However, any quantitatively serious analysis of these issues will need to consider moments other than mean and variance.

We will ignore the nonpecuniary returns term $V(h)$ after this point. We have no direct measure of nonpecuniary benefits and costs and the extensions to nonzero $V(h)$ functions are obvious. We will follow the usual practice and focus on the pecuniary aspects of educational investments.

2.2. Systematic and Idiosyncratic Risk. We now extend this to the case where an individual can invest in stocks, and human capital contains both idiosyncratic and systematic risk. We assume that wage income is $f(h)+\Sigma(h)Y+\Psi(h)(Z-\mu)$ where Z is the return on risky financial investments and $\mu = E\{Z\}$. Z is the systematic source of risk and Y is idiosyncratic. The portfolio problem is

$$\max_{s,h,e} \quad E\{u(f(h)+\Sigma(h)Y+\Psi(h)(Z-\mu)+sR+eZ)\} \quad \text{s.t.} \quad s+h+e=W \tag{5}$$

where s is bond purchases, h is human capital investment, and e is investment in risky equity. If we fix $s = W - e - h$, the first-order condition for h is

$$0 = E\{u'(c)(f'(h) - R + \Sigma'(h)Y + \Psi'(h)(Z-\mu))\} \tag{6}$$

and the first-order condition for e is

$$0 = E\{u'(c)(Z-R)\} \tag{7}$$

The first-order conditions together imply

$$\begin{aligned} f'(h) - R &= \Psi'(h)\frac{-Cov(u'(c), Z)}{E\{u'(c)\}} + \Sigma'(h)\frac{-Cov(u'(c), Y)}{E\{u'(c)\}} \\ \mu - R &= -\frac{Cov(u'(c), Z)}{E\{u'(c)\}} \end{aligned}$$

To get a clearer picture, consider the special case $\Sigma(h) = h\sigma_Y(h)$ and $\Psi(h) = h\sigma_Z(h)$. Then the first-order conditions imply that the risk premium for human capital equals

$$\begin{aligned} f'(h) - R &= (\sigma_Z(h) + h\sigma_Z'(h))(\mu - R) \\ &\quad + (\sigma_Y(h) + h\sigma_Y'(h)) \frac{-Cov(u'(c), Y)}{E\{u'(c)\}} \end{aligned} \tag{8}$$

Equation (8) decomposes the required return into two basic risk factors, one for each source of risk. The first term is the conventional term associated with the systematic risk component and the second component represents the cost of the idiosyncratic risk. Each of these terms are further divided into an average σ component and a marginal σ term.

2.3. Ex Post Elastic Labor Supply. We next allow an ex post elastic labor supply. We want our simple model to approximate dynamic models of labor supply and investment choice. Therefore, we assume that individuals know their wages and asset returns before they make their labor supply decisions. This may not be true within a short period of time, but over time labor supply certainly can respond to changes in wages and to the performance of the worker's investments. We also want the labor supply to approximate retirement decisions. Even though hours may not vary much for a person while he works, retirement decisions may be affected by wage earnings and portfolio performance. Therefore, we assume labor supply decisions are made after wages and portfolio uncertainty is resolved and the elasticity of labor supply includes both changes in hours and number of working years.

We illustrate the first-order conditions for the case with no systematic risk, but the generalization is straightforward (albeit messy) when there is systematic risk. The agent's problem becomes

$$\max_{s,h,L_Y} \quad E\{u((f(h) + \Sigma(h)Y)L_Y + sR, L_Y)\}$$
$$\text{s.t.} \quad s + h = W$$

where s is savings, h is human capital investment, and L_Y is the ex post labor supply in state Y, chosen after wages, $f(h) + \Sigma(h)Y$, are known. The first-order condition for h (with $s = W - h$) is

$$0 = E\{u_c(c, L_Y)((f'(h) + \Sigma'(h)Y)L_Y - R)\}$$

which implies the risk premium expression

$$E\{(f'(h) + \Sigma'(h)Y)L_Y\} - R = -\Sigma'(h)\frac{Cov(u_c, (f'(h) + \Sigma'(h)Y)L_Y)}{E\{u_c(c, L_Y)\}}$$

This premium expression relates the excess of marginal earnings over the safe return, $E\left\{\left(f'(h)+\Sigma'(h)Y\right)L\right\}-R$, to the marginal risk, $\Sigma'(h)$, and the covariance between marginal utility and marginal earnings.

2.4. Optimal Tax Policy Examples. We next investigate optimal tax policy in this model. We will allow three tax instruments: a tax on labor income, τ (with full expensing of human capital investments), a lump-sum transfer (or tax), T, and a subsidy, ψ, on human capital investment. Our objective is to examine the efficiency of equilibrium allocations and the magnitude of any efficiency-enhancing tax intervention. If decisions are efficient, then no subsidy is desired, and any revenue needed for government expenditures are raised with a lump-sum tax.

We assume each agent has a utility function

$$u(c,\ell)=\frac{c^{1-\gamma}}{1-\gamma}-B\frac{\ell^{1+1/\eta}}{1+1/\eta}$$

where γ is the coefficient of relative risk aversion and η is the elasticity of labor supply. This is a simple two-period model, but we want to use it to approximate richer dynamic life-cycle problems. Therefore, η represents both the sensitivity of labor supply during working years as well as the sensitivity of retirement to wages and wealth. Therefore, we will examine nontrivial values for η. We assume

$$f(h)=\frac{h^{\alpha}}{\alpha}\left(1+Y\right)$$

We choose B so that $\ell=h=1$ if there were no wage uncertainty, i.e., $Y=0$. We assume that Y takes on two values: σ_Y and $-\sigma_Y$. We also assume that there is no initial wealth since that would just introduce income effects and not affect the critical marginal conditions. Each individual can have positive consumption because $f'(0)=\infty$.

Computing the optimal tax policy is a difficult problem, as is any incentive problem. We proceed in a conservative fashion. We allow the tax rates to be some multiple of .02 up to .96, and allow the human capital investment subsidy to be a multiple of .002. For any choice of (τ,ψ) we compute the lump-sum transfer T which produces revenue with market value zero. Since there are risky assets, we compute the market value of revenues, not the expected value of revenue. The perspective is that of a small, open economy where factor prices are fixed. For the sake of simplicity, we assume a safe asset with return of 0; that is, a one dollar investment yields one dollar for sure.

Our first table examines the case with no equity investment. Table 1 displays τ^* and ψ^*, the optimal choices of τ and ψ, for various values of γ, η, and σ_Y. It also displays the expected return to human capital investment with no taxes, r_0, and under the optimal policy, r^*.

Table 1: Optimal Tax Policy: Only idiosyncratic wage risk

		$\sigma_Y = .1$				$\sigma_Y = .2$			
γ	η	τ^*	ψ^*	$1+r^*$	$1+r_0$	τ^*	ψ^*	$1+r^*$	$1+r_0$
1.1	1.00	0.020	0.008	1.004	1.012	0.100	0.038	1.004	1.049
1.1	0.40	0.040	0.010	1.003	1.013	0.160	0.039	1.002	1.055
1.1	0.10	0.140	0.012	1.000	1.015	0.340	0.029	0.999	1.062
1.1	0.04	0.240	0.009	1.001	1.016	0.480	0.018	0.999	1.065
1.1	0.00	0.960	0.000	0.999	1.016	0.960	0.000	1.003	1.067
10.0	1.00	0.040	0.004	1.009	1.012	0.140	0.008	1.039	1.050
10.0	0.40	0.100	0.006	1.005	1.011	0.340	0.020	1.018	1.047
10.0	0.10	0.420	0.023	0.992	1.032	0.700	0.031	0.997	1.111
10.0	0.04	0.620	0.015	1.000	1.055	0.800	0.018	1.007	1.163
10.0	0.00	0.960	0.001	0.999	1.097	0.960	0.000	0.999	1.246

Table 1 contains numerous examples of our model. The results are similar to those in Eaton and Rosen (1980), and Hamilton (1987). Those studies showed that tax policy may be able to improve on the equilibrium allocation, but did not indicate the quantitative significance of those interventions. They also neglected interactions with aggregate risk. Table 1 shows that very significant tax policy interventions are justified by the presence of idiosyncratic risk. When labor supply is elastic, the optimal tax policy imposes a small tax rate because labor taxation reduces labor supply. As the labor supply elasticity falls, the optimal tax rate rises until it is essentially 100% for the case of zero labor supply elasticity.

The subsidies reported in Table 1 may appear small, but recall that a subsidy of .01 implies that every dollar of human capital investment produces a one cent subsidy in each following period of time. If the return to human capital is 4%, then a .01 subsidy equals a fourth of the marginal market return to human capital.

The optimal human capital investment subsidy is substantial in almost all cases, but not monotonically related to labor supply elasticity. When labor supply is elastic, no intervention is desired, but none is needed because of the insurance aspect of an elastic labor supply. This insurance effect induces individuals to invest in h until the expected return falls to a low level, so there is little need to further increase h. As elasticity decreases, there is more consumption risk, and a higher tax on labor income. As labor income tax increases, it reduces labor supply and human capital investment. The optimal subsidy increases in order to offset these effects. The optimal subsidy falls back to zero when labor supply is inelastic since the high labor income tax has little impact on labor supply

Human capital returns in Table 1 rise as the idiosyncratic risk, σ_Y, increases. Since this risk has no social cost, the optimal tax policy offsets this by an increase in labor taxation, lump sum rebates, and the subsidy to human capital formation.

Tables 2 and 3 examine cases where there is a risky asset similar to equity. Both tables assume that the risky asset has a mean return of 6% and standard deviation of 20%, corresponding roughly to annual returns for U. S. equities. We allow the possibility that human capital is correlated with equities. More precisely, we assume

$$f(h) = \frac{h^{\alpha}}{\alpha}(1 + Y + \rho Z)$$

where Z, the systematic shock, takes on two values: .20 and -.20. The parameter ρ models the correlation between human capital risk and the risk of financial investments.

Table 2 examines cases where human capital risk is purely idiosyncratic and there is a risky financial asset. The results in Table 2 are less supportive of tax interventions. The policy of no distortionary taxes is optimal when labor supply is relatively elastic. Significant tax policy interventions are desirable only for low values of labor supply elasticity and high values of risk aversion.

Table 2: Optimal Tax Policy: $\pi = 0.06$, $\sigma_Z = .2$, $\rho = 0.0$

		$\sigma_Y = .1$				$\sigma_Y = .2$			
γ	η	τ^*	ψ^*	$1+r^*$	$1+r_0$	τ^*	ψ^*	$1+r^*$	$1+r_0$
1.1	1.00	0.000	0.000	0.929	0.929	0.000	0.000	0.964	0.964
1.1	0.40	0.000	0.000	0.978	0.978	0.000	0.000	1.020	1.020
1.1	0.10	0.000	0.000	1.007	1.007	0.260	0.023	1.010	1.056
1.1	0.04	0.160	0.006	1.004	1.013	0.460	0.017	1.003	1.065
1.1	0.00	0.960	0.000	1.000	1.017	0.960	0.000	1.002	1.070
10.0	1.00	0.000	0.001	0.927	0.929	0.000	0.000	0.960	0.960
10.0	0.40	0.000	0.000	0.978	0.978	0.000	0.000	1.020	1.020
10.0	0.10	0.220	0.007	1.015	1.023	0.680	0.020	1.035	1.101
10.0	0.04	0.580	0.014	1.005	1.051	0.780	0.023	0.995	1.159
10.0	0.00	0.960	0.000	1.006	1.097	0.960	0.001	0.999	1.246

Many of the results for r_0 and r^* correspond to standard intuitions. Expected human capital return without tax intervention, r_0, is high when there is substantial idiosyncratic risk of human capital returns. In some cases, the expected return to human capital exceeds the return to financial assets, but in those cases the optimal tax policy substantially reduces the expected return close to the social cost.

The results for r_0 and r^* are interesting when labor supply is elastic, as when $\eta = 1$. In fact, the expected return on human capital is less than the safe return in both the zero tax and optimal tax cases. This is somewhat surprising since human capital has zero systematic risk. The reason is that when equity returns are low, labor supply increases. Labor supply responses provide a kind of insurance against bad returns for financial assets. Bodie and Samuelson (1992) examined this phenomenon in the context of portfolio choice in the presence of risky labor income, arguing that an elastic labor supply makes one more willing to invest in risky financial assets. Here, the presence of elastic labor supply makes investment in human capital more attractive since the extra human capital enhances the insurance aspect of flexible labor supply. When labor supply is less elastic, the zero-tax choice for human capital implies a high expected return, but the optimal tax policy often pushes the expected return below the safe return through a reduction in the variance in returns and (sometimes) through a subsidy.

Table 3 repeats Table 2 except that human capital has some systematic risk. Specifically, we set $\rho = .5$. The cases in Table 3 indicate a strong case for substantial tax intervention that brings the mean return on human capital down to and often below the premium justified by its systematic component.

Table 3: Optimal Tax Policy: $\pi = 0.06$, $\sigma_Z = .2$, $\rho = 0.5$

		$\sigma_Y = .1$				$\sigma_Y = .2$			
γ	η	τ^*	ψ^*	$1+r^*$	$1+r_0$	τ^*	ψ^*	$1+r^*$	$1+r_0$
1.1	1.00	0.000	0.000	1.003	1.003	0.000	0.000	1.047	1.047
1.1	0.40	0.080	0.020	1.006	1.029	0.200	0.040	1.018	1.077
1.1	0.10	0.380	0.035	0.980	1.044	0.480	0.040	0.986	1.099
1.1	0.04	0.600	0.024	0.975	1.048	0.660	0.026	0.975	1.104
1.1	0.00	0.960	0.002	0.980	1.050	0.960	0.002	0.982	1.108
10.0	1.00	0.000	0.000	1.025	1.025	0.000	0.000	1.043	1.043
10.0	0.40	0.260	0.007	1.021	1.023	0.440	0.030	1.015	1.078
10.0	0.10	0.600	0.029	0.984	1.062	0.740	0.037	0.980	1.149
10.0	0.04	0.740	0.023	0.970	1.090	0.840	0.021	0.978	1.206
10.0	0.00	0.960	0.002	0.985	1.135	0.960	0.003	0.978	1.295

Tables 1, 2, and 3 assume that there is no revenue needed to finance government expenditures. The results in Tables 1, 2, and 3 often implies substantial lump-sum transfers. Other computations showed that if revenues were needed to finance government expenditures, they would be financed by a reduction in the lump-sum transfers, with little change in the optimal values of τ and ψ.

The results in Tables 1, 2, and 3 examine a wide range of parameter values and appears to give little general guidance. However, the cases with substantial taxes and subsidies are more supported by empirical evidence. The cases where no tax intervention is justified are also the cases where the labor supply elasticity is high and where the zero tax mean return to human capital investment is low. Since we observe high mean returns to human capital, the most relevant rows are those with a high value for $1 + r_0$, and those are the rows with high human capital subsidies.

Conclusion 1. *In the model of exogenous idiosyncratic human capital risk, if the observed premium on human capital substantially exceeds the price of its systematic component, then the optimal tax policy reduces the human capital premium to nearly its systematic component.*

The results in Tables 1, 2, and 3 indicate that social underinvestment in education is a common outcome of competitive equilibrium, and that the optimal tax policy is often a substantial deviation from pure lump sum taxation. The critical feature is that there are no assets the individual can use to hedge his labor income risk, even though his labor income risk is not correlated with aggregate income. If individual income and human capital investment is measured by the tax authority, then a subsidy to human capital investment is often appropriate. This indicates that the desirability of a subsidy for h arises for efficiency reasons, not because of redistributive objectives nor to internalize externalities.

3. HUMAN CAPITAL INVESTMENT AND MORAL HAZARD

The exogenous idiosyncratic risk model permitted human capital investment to depend on both systematic risk, Z, and idiosyncratic risk, Y. This is unsatisfactory since we did not model the nature of the idiosyncratic risk, and the exogenous approach raises an important question. If income has an exogenous idiosyncratic component, then why doesn't a private contract arise that eliminates this risk? The optimal tax exercise assumes that income is observable, a reasonable assumption since there are many actors, including employers and the IRS, who have a strong interest in the correct reporting of an worker's wage income. The optimal tax exercise shows that a strongly progressive tax policy is often optimal, but does not explain why a private actor could not also provide the same insurance using the available individual-specific wage data. Furthermore, analyses that proceed in the *ad hoc* fashion in the exogenous idiosyncratic risk model presume that the nature of the idiosyncratic risk is not independent of the worker's actions and that this may affect the results. We shall see that this is a dangerous presumption.

To answer these questions, this section develops a model that fully models the nature of the idiosyncratic risk. More specifically, we examine a model where idiosyncratic risk arises from moral hazard considerations, and where an optimal contract is written between the worker and the firm. This may not be the most reasonable explanation of idiosyncratic risk, but it is the one that we explore here to demonstrate the importance of endogenizing the idiosyncratic component of risk.

We also examine a model with moral hazard because it is sometimes said that moral hazard is a motivation for the idiosyncratic risk in the exogenous idiosyncratic risk model. For example, in discussing their model with exogenous idiosyncratic risk, Eaton and Rosen (1980) say that ".. the risk associated with investment in human capital is typically neither insurable nor diversifiable. In many cases the market does not provide insurance against the vagaries of wage rates. Problems of moral hazard associated with insurance in general are especially pervasive in the insurance of human capital." We agree that moral hazard is an important problem, but the analysis below shows that a model with moral hazard may not be well approximated by the basic exogenous idiosyncratic risk model.

3.1. Moral Hazard and a Safe Asset. We first consider the case where the only alternative investment is a safe asset with return R. We take a simple optimal contract point of view where the only function of the employer is to absorb idiosyncratic risk. We also assume that human capital investment h is observable to the employer as well as savings s[3]. Let p be the probability that a worker's output will be $f(h)$; output will be zero otherwise. We assume that the worker chooses p and experiences disutility $v(p)$. We also assume that there is free entry of firms that drives expected profits to zero[4].

The employer pays wages which depend on the observed output. Let the wage be w_1 when output is high and w_2 otherwise. A worker who has accumulated human capital h and has savings s and faces the wage policy (w_1, w_2) will solve the problem

$$\max_p E\left\{u(w+sR)\right\} - v(p)$$

which implies the first-order condition for p

$$u(c_1) - u(c_2) - v'(p) = 0 \tag{9}$$

Equation (9) represents the incentives for effort produced by the wage policy (w_1, w_2).

The competitive equilibrium labor contract contingent on h and s will choose p, and state-contingent wages so as to maximize the worker's expected utility subject to the constraint that his expected wage equals his expected output, and that the

[3] This last observability assumption is a strong and somewhat unreasonable one, but standard in the contracting literature. If individual savings are not observable (or contractible) but social savings are observable to the government then tax policy can be used to improve on the competitive allocation. See Arnott and Stiglitz (1990) for a treatment of these issues. We assume observability here since doing otherwise would take our focus away from human capital formation issues, and would probably not affect the results concerning these issues.

[4] The model is a general equilibrium model since the firms have no costs and do nothing other than pool idiosyncratic risks, and since there are no other agents other than the workers modelled here.

choices of p and the state-contingent wages are incentive compatible. The individual with initial wealth W will choose h and s to maximize his expected utility subject to the (h, s)-contingent labor contract. The final allocation combining these two steps solves the combined problem

$$\begin{array}{lll} \max\limits_{w_1, w_2, s, h, p} & & E\{u(w+sR)\} - v(p) \\ & \text{s.t.} & pf(h) - E\{w\} = 0 \\ & & u(c_1) - u(c_2) - v'(p) = 0 \\ & & W - s - h = 0 \end{array} \tag{10}$$

The Lagrangian is

$$\begin{aligned} \mathcal{L} &= E\{u(w+sR)\} - v(p) + \lambda\left(pf(h) - E\{w\}\right) \\ &\quad + \theta\left(u(c_1) - u(c_2) - v'(p)\right) + \phi\left(W - s - h\right) \end{aligned}$$

and the first-order conditions are

$$\begin{array}{lll} \mathcal{L}_{w_1} & = 0 = & pu'(c_1) - \lambda p + \theta u'(c_1) \\ \mathcal{L}_{w_2} & = 0 = & (1-p)u'(c_2) - \lambda(1-p) - \theta u'(c_2) \\ \mathcal{L}_s & = 0 = & E\{u'(c)R\} + \theta(u'(c_1) - u'(c_2))R - \phi \\ \mathcal{L}_h & = 0 = & \lambda pf'(h) - \phi \end{array} \tag{11}$$

Evaluating $\mathcal{L}_{w_1} + \mathcal{L}_{w_2} = 0$ implies

$$\lambda = E\{u'(c)\} + \theta\left(u'(c_1) - u'(c_2)\right)$$

$\mathcal{L}_s = 0$ implies that $\phi = \lambda R$. When combined with the $\mathcal{L}_h = 0$ condition, we have

$$pf'(h) = R$$

The final equation says that h is chosen so as to equate the safe rate with the expected marginal product, with no allowance for any risk premium associated with the idiosyncratic risk.

This result may seem odd but there is a simple Envelope Theorem intuition. The moral hazard problem implies that there needs to be a gap between utility in the high output state and utility in the low output state. That gap is like a fixed cost necessary to provide proper incentives. If p does not change as h increases, it is a fixed cost and marginal changes in h will not affect this fixed risk in utility. Therefore, there is no marginal impact on riskiness and no marginal risk premium. The analysis shows that this continues to hold even when p is allowed to vary as h increases.

3.2. Safe and Risky Assets with Ex Post Effort Choice. We next generalize our moral hazard model to the case where there are two alternative financial investment: the safe asset with return R, and a risky asset with return Z and mean return μ. Z now is also the source of aggregate risk. The timing is as follows: first, the worker makes education, savings, and equity investment choices; then Z is realized; then labor contracts are written contingent on private choices and Z; then p is chosen; and, finally, the output is realized and wages paid. Since there are no agents in the economy other than the workers, free entry by firms implies that profits will be zero in each Z state. The final equilibrium allocation will solve the problem

$$\begin{array}{lrl} \max\limits_{w_{Z,1}, w_{Z,2}, s, h, e, p_Z} & & E\{u(w_Z + sR + eZ)\} - E\{v(p_Z)\} \\ & \text{s.t.} & p_Z f(h, Z) - E\{w_Z|Z\} = 0, \ \forall Z \\ & & u(c_{Z,1}) - u(c_{Z,2}) - v'(p_Z) = 0, \ \forall Z \\ & & W - h - s - e = 0 \end{array} \tag{12}$$

where $w_{Z,1}, w_{Z,2}, p_Z$ are the Z-contingent wage structure and effort supply, and $c_{Z,i}$ is consumption in aggregate state Z and individual state i. Since effort is chosen after Z is realized, there is a separate incentive compatibility condition for each worker in each Z state.

The Lagrangian for (12) is

$$\begin{aligned} \mathcal{L} &= E\{u(w_Z + sR + eZ)\} - E\{v(p_Z)\} + \sum_Z \lambda_Z \left(p_Z f(h, Z) - E\{w_Z|Z\}\right) \\ &\quad + \sum_Z \theta_Z \left(u(c_{Z,1}) - u(c_{Z,2}) - v'(p_Z)\right) + \phi\left(W - s - h\right) \end{aligned}$$

and the first-order conditions are

$$\begin{array}{lll} \mathcal{L}_{w_{Z,1}} & = 0 = & p_Z u'(c_{Z,1}) - \lambda_Z p_Z + \theta_Z u'(c_{Z,1}), \ \forall Z \\ \mathcal{L}_{w_{Z,2}} & = 0 = & (1 - p_Z) u'(c_{Z,2}) - \lambda_Z (1 - p_Z) - \theta_Z u'(c_{Z,2}), \ \forall Z \\ \mathcal{L}_s & = 0 = & E\{u'(c_Z) R + \theta_Z (u'(c_{Z,1}) - u'(c_{Z,2})) R\} - \phi \\ \mathcal{L}_h & = 0 = & E\{\lambda_Z p_Z f'(h, Z)\} - \phi \\ \mathcal{L}_e & = 0 = & E\{u'(c_Z) Z + \theta_Z (u'(c_{Z,1}) - u'(c_{Z,2})) Z\} - \phi \end{array}$$

Evaluating $\mathcal{L}_{w_{Z,1}} + \mathcal{L}_{w_{Z,2}} = 0$ for each Z implies that the shadow price of wealth satisfies

$$\lambda_Z = E\{u'(c)|Z\} + \theta_Z \left(u'(c_{Z,1}) - u'(c_{Z,2})\right) \tag{13}$$

The shadow price of wealth in equation (13) includes a term, $\theta_Z \left(u'(c_{Z,1}) - u'(c_{Z,2})\right)$, expressing the interaction between wealth and incentives.

The first-order conditions $\mathcal{L}_s = \mathcal{L}_e = 0$ imply that the excess return for equity satisfies

$$\mu - R = -\frac{Cov\left(\lambda_Z, Z\right)}{E\{\lambda_Z\}}. \tag{14}$$

Note that (14) looks like the classic consumption CAPM equation except that the marginal utility of consumption has been replaced by the shadow price of wealth, λ_Z. We see that the idiosyncratic risk arising from moral hazard does have an impact on the problem, but it enters all investment decisions, not just human capital investment.

When we combine the $\mathcal{L}_h = 0$ and $\mathcal{L}_s = 0$ conditions, we find

$$0 = E\left\{\lambda_Z \left(p_Z f'(h, Z) - R\right)\right\}$$

Suppose that we can decompose f into its deterministic and systematic components

$$f(h, Z) = f_m(h) + f_Z(h)\left(Z - \mu\right) \tag{15}$$

The term $f_Z(h)$ is the covariance of the output process (conditional on effort) with the aggregate risk, Z. Individuals still experience idiosyncratic risk in consumption because their wages are tied to individual output. The decomposition in (15) implies

$$\begin{aligned}
0 &= E\left\{\lambda_Z \left(p_Z (f'_m(h) + f'_Z(h)\left(Z - \mu\right)) - R\right)\right\} \\
&= E\left\{\lambda_Z p_Z f'_m(h) - \lambda_Z R + \lambda_Z p_Z f'_Z(h)\left(Z - \mu\right))\right\} \\
&= E\left\{\lambda_Z \left(p_Z f'_m(h) - R\right))\right\} + E\left\{\lambda_Z p_Z f'_Z(h)\left(Z - \mu\right)\right\} \\
&= f'_m(h) E\left\{\lambda_Z p_Z\right\} - E\left\{\lambda_Z\right\} R + f'_Z(h) E\left\{p_Z \lambda_Z \left(Z - \mu\right)\right\} \\
&= f'_m(h)\left(Cov(\lambda_Z, p_Z) + E\left\{\lambda_Z\right\} E\left\{p_Z\right\}\right) - E\left\{\lambda_Z\right\} R + f'_Z(h) E\left\{p_Z \lambda_Z \left(Z - \mu\right)\right\}
\end{aligned}$$

The $E\left\{p_Z \lambda_Z \left(Z - \mu\right)\right\}$ term can be decomposed into

$$\begin{aligned}
E\left\{p_Z \lambda_Z \left(Z - \mu\right))\right\} &= E\left\{\left(p_Z - E\left\{p_Z\right\}\right) \lambda_Z \left(Z - \mu\right)\right\} + E\left\{p_Z\right\} E\left\{\lambda_Z \left(Z - \mu\right)\right\} \\
&= Cov\left(p_Z, \lambda_Z \left(Z - \mu\right)\right) + E\left\{p_Z\right\} Cov\left(\lambda_Z, Z\right)
\end{aligned}$$

When we combine these conditions, we arrive at Theorem 2.

Theorem 2. *Assume $f(h, Z) = f_m(h) + f_Z(h)Z$ in the moral hazard model with optimal contracting. Then the risk premium for human capital, $E\left\{p_Z\right\} f'_m(h) - R$, satisfies*

$$\begin{aligned}
E\left\{p_Z\right\} f'_m(h) - R &= E\left\{p_Z\right\} f'_Z(h)\left(\mu - R\right) \\
&\quad - E\left\{p_Z\right\} f'_m(h) \frac{Cov(\lambda_Z, p_Z)}{E\left\{p_Z\right\} E\left\{\lambda_Z\right\}} \\
&\quad - f'_Z(h) \frac{Cov\left(p_Z, \lambda_Z \left(Z - \mu\right)\right)}{E\left\{\lambda_Z\right\}}
\end{aligned} \tag{16}$$

Theorem 2 decomposes the human capital premium into three terms. The first term, $E\{p_Z\}\, f'_Z(h)\,(\mu - R)$, is the conventional risk premium since $\mu - R$ is the price of risk and $E\{p_Z\}\, f'_Z(h)$ is the increase in risk when h is increased but p_Z is unchanged.

The second term in the risk premium expression has an insurance character. $Cov(\lambda_Z, p_Z)/\left(E\{p_Z\}\, E\{\lambda_Z\}\right)$ is the correlation of the marginal value of wealth with the level of effort. One expects this will be positive since then the worker works harder when the marginal value of wealth is higher. This reflects the flexibility of labor supply and the tendency to increase effort when income is more valuable. The expected marginal value of human capital is $E\{p_Z\}\, f'_m(h)$. The product of these two terms represents the insurance value of extra human capital investment when changes in h do not affect the systematic riskiness of labor income. If λ_Z and p_Z are positively correlated, the insurance component of human capital investment reduces the risk premium for human capital investment.

The third term represents the residual where effort changes in response to aggregate income risk and changes in h also affect the systematic risk of human capital investment. There is no immediately obvious intuition as to its sign, but one suspects that its magnitude is not large since it is the product of fluctuations in effort and the marginal riskiness of human capital investment, both of which are likely to be small.

Theorem 2 shows that the essence of Theorem 1 holds when we introduce systematic risk of a fairly general nature. The risk premium for human capital depends on systematic components of risk, not on idiosyncratic risk. In fact, the moral hazard formulation brings in factors, such as effort responsiveness to aggregate shocks, which reduce the risk premium. This contrasts with the tendency of idiosyncratic risk to increase the risk premium in the ad hoc exogenous idiosyncratic risk model.

Theorem 2 makes a variety of separability assumptions but the model is a natural benchmark. At the least, it shows that any risk premium arising from idiosyncratic risk must rely on nonseparable features of tastes and technology which would be difficult to estimate.

3.3. Tax Policy and the Moral Hazard Model. Theorems 1 and 2 show that idiosyncratic risk cannot explain the high observed premium on human capital risk if labor markets deal efficiently with moral hazard. The tax policy implications are immediate. Since the labor contract is optimal in the moral hazard model, there is no gain from any pooling beyond that implicit in the optimal contract. Tax policy cannot improve on the competitive equilibrium, since the optimal tax problem (with zero revenue needs) is identical to the problem solved by the competitive equilibrium.

This also shows that moral hazard cannot be used to justify the idiosyncratic risk model above. This would be particularly misleading when we examine tax policy. In a world with optimal contracts, there will be idiosyncratic risk and it would be tempting to analyze it using the stochastic structure in (5). That approach implicitly assumes that the idiosyncratic risk, $\Sigma(h)Y$, is invariant to government policy. However, the idiosyncratic risk in before-tax wages would not be invariant to policy in a world with optimal contracting. If one were to apply the tax policies recommended in Tables 1, 2, and 3, the labor supply would be substantially affected and/or private contracts would be adjusted to neutralize the tax policy.

4. The Human Capital Premium Puzzle

We have investigated two models of human capital accumulation with both idiosyncratic and aggregate risk. Both indicate that empirically plausible specifications of risk cannot justify a large expected excess return of human capital investment, $f'(h) - R$. The exogenous idiosyncratic risk model suggests that it may be large in a competitive equilibrium because the idiosyncratic risk causes individuals to reduce their human capital investments. However, the human capital risk premium would not remain large if appropriate tax-subsidy policies were put in place. The moral hazard model with endogenous idiosyncratic wage risk suggests that the human capital risk premium should not be large even without policy interventions since optimal contracting in the labor market will reduce idiosyncratic to the minimum necessary to provide the proper incentives for effort. The two models have some common features. For example, both imply that human capital investments will have an insurance feature if labor (or effort) supply is elastic. This insurance feature increases demand for human capital and reduces the final premium. The presence of aggregate risk may even reduce the human capital risk premium relative to the deterministic case. Both models lead us to ask what could justify the large observed excess return for education.

There are many possible explanations, but none have strong empirical support. Significant capital market failures may prevent individuals from financing educational investment and reduce educational attainment below its efficient level. However, Cameron and Heckman (1999) argue against that possibility since short-term credit constraints on students do not explain educational attainment once family factors are considered.

An alternative explanation would appeal to unobservable costs. Our initial analysis allowed utility to depend directly on educational attainment. If the utility costs of educational attainment were large, then equation (2) implies that $f'(h) - R$ would equal the financial terms plus $(-V'(h))/E\{u'(c)\}$, the monetary value of the marginal disutility of education. The human capital investment demand equations in the moral hazard model would be modified in the same way by unobservable utility costs. We largely ignored such costs, as did Becker when he posed the underinvestment question. The objective here is to ask the question "Is there underinvestment?", not to assume that educational investment is efficient and use that to identify nonpecuniary costs of educational investment. Since there is no way to directly measure unobservables, it is difficult to rule out this "ignorance-is-bliss" explanation. However, many would find it implausible for the marginal disutility to be large enough to explain the premium.[5].

There has been some effort to identify the marginal utility costs (or benefits) of education, but the results do not help explain the human capital premium. Heckman et al. (1999) find a mixed set of results. They divide people into four ability quartiles and find that $V'(h)$ is significantly negative for the lowest quartile individuals, about zero for the second quartile and significantly positive for the third quartile. This cannot explain the puzzle; in fact it deepens it. Since $V'(h)$ is positive for individuals in the third quartile, $f'(h)$ should be significantly less than R for them, not greater. This is particularly relevant since the third quartile contains many marginal college students, the group which should be most influential in determining the equilibrium return to education[6].

The issue of underinvestment bears on many important policy and empirical issues. Many macroeconomists assume that there is underinvestment in education. For example, Romer (1990), Lucas (1988), and Mankiw (1997) argue that externalities in human capital accumulation are important in explaining economic growth. However, Heckman and Klenow (1997) argue that there is little empirical support for this assumption. The Heckman and Klenow analysis revolves around mean returns to human capital investments, and measures differences between social and private returns to education. They argue that current subsidies to education are justified only if the social return exceeds private returns by 30%, and that there is no reason to increase them.

Comparing our analysis with that in Heckman and Klenow and similar work shows how important it is to include risk in the analysis. It is natural to look for externalities to justify educational subsidies if one ignores risk factors. Since general human capital externalities are not likely to be large[7], it is not surprising that they cannot justify

[5] Introspection indicates that this argument gets the sign wrong. Consider, for example, calculus courses. The benefits of going to calculus class include not only future higher wages but also the aesthetic experience of watching beautiful mathematical ideas unfold in the lecture and the pleasure of using these ideas to solve homework problems. Therefore, the measured pecuniary returns should be less than the returns to comparable financial assets.

[6] Heckman et al. (1999) find that $V'(h)$ was significantly negative for the highest ability quartile. This is puzzling since one would think that these individuals would have the lowest utility costs of going to college. However, this empirical result would arise if expectational errors were correlated with ability. Suppose high ability individuals thought that the financial returns to college for them was equal to the financial returns for the *average* college student. Then, they would be underestimating their true financial return and some may choose not to go to college. The Heckman et al. analysis assumed perfect foresight and so would attribute this decision to a large negative utility shock.

[7] There are two kinds of externalities which are clearly present but they do not justify general

educational subsidies. We see that the picture is far less clear when we consider the risk classification of human capital as well as its mean return.

Tax reform discussions also need to know if there is underinvestment in education. For example, so-called "consumption" tax advocates propose tax reforms that treat educational investment as consumption. This would bias investment against human capital in favor of physical capital investments. If there is rough efficiency in the allocation between human and physical capital investments, then this redistribution of income would have little efficiency cost. However, if there is underinvestment in education despite the deductibility of state and local taxes that finance education, then this redistributive feature of consumption tax reforms would aggravate underinvestment and likely have substantial efficiency costs.

5. CONCLUSION

This paper formulates two models of risky human capital investment, and finds that the conventional approaches to portfolio analysis need to be modified in order to integrate human and physical capital investments. First, the conventional covariance formulation of the price of risk needs to be augmented by a marginal covariance term because of the nondiversifiability of human capital. Second, we also show that idiosyncratic risk should be ignored in equilibrium pricing to the extent that it arises from moral hazard considerations in an optimal incentive contract. The results indicate that a rational individual employed under perfect contracting conditions and possessing perfect access to capital markets would invest in human capital to the point where its mean return equals the mean return to portfolio assets with the same market covariance plus the marginal covariance, and would ignore idiosyncratic risk. We have argued that it is difficult to explain the excess return of human capital investment.

Our two models indicate that it is difficult to explain observed returns to education without also concluding that equilibrium is inefficient and that substantial tax policy interventions are necessary. If one takes the idiosyncratic view of human capital risk, then highly progressive tax policies are often appropriate. If one believes that idiosyncratic risk arises from asymmetric information which is efficiently handled in private negotiations, then there is no role for tax policies, but this model implies that only systematic risk can contribute to the equilibrium premium for human capital returns.

The two models we examined above were quite simple. First, the dynamics were

subsidies. First, education may reduce criminal activity by some low ability individuals. Second, education will produce the scientists who will invent new goods and technology, and cure diseases. However, both arguments cover only individuals at the two tails of the ability distribution, a small fraction of the population. Smaller, more targeted programs would be more efficient responses to these externalities.

trivial. One important difference between financial and human capital investments is that one can alter financial investments in response to new information and evolving life-cycle objectives, whereas education and training are difficult to adjust. Second, we have ignored the role of governments in providing human capital investments. We have tacitly assumed a Tiebout approach to education provision whereby the provision of local publicly provided goods is equivalent to private provision. While this is a reasonable benchmark, it is probably not an accurate model of education policy. Any optimal Federal tax policy analysis should include a richer model of local and state education policies.

The models we examined here were simple and generalizations are desirable. However, they clearly demonstrate that analyses of human capital investments and related tax policy issues need to consider the individual and social risks.

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