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HUMAN CAPITAL AND CAPITAL MARKET EQUILIBRIUM*

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This paper finds that extending popular two-parameter models of capital market equilibrium to allow for the existence of non-marketable human capital does not provide better empirical descriptions of the expected return–risk relationship for marketable securities than those that come out of the simpler models. This conclusion arises from the fact that relationships between the return on human capital and the returns on various marketable assets are weak, so that the model that includes human capital leads to estimates of risk for marketable assets indistinguishable from those of the simpler models.

David Mayers (1972, 1973) extends the two-parameter model of capital market equilibrium of Sharpe (1964), Lintner (1965), Black (1972), and others to include nonmarketable assets such as human capital. The purpose of this paper is to determine whether, as an empirical matter, the Mayers model improves on the description of the pricing of marketable assets provided by the Sharpe-Lintner-Black (SLB) model.

1. The competing theories

In the Sharpe–Lintner model, capital market equilibrium is characterized by the following relationship between the expected return on any asset and its risk,

$$E(\tilde{R}_{jt}) = R_{ft}+[E(\tilde{R}_{Mt})-R_{ft}]\beta_j. \tag{1}$$

Tildes (˜) are used to denote random variables; R_{ft} is the interest rate on risk-free loans undertaken at time $t-1$ for repayment at time t; $E(\tilde{R}_{jt})$ is the expected return on asset j from $t-1$ to t, with the return defined as dividend plus capital

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gain divided by the price at $t-1$; $E(\tilde{R}_{Mt})$ is the expected return on the market portfolio M, defined as the portfolio of all assets in the market, with each weighted by the ratio of the total market value of all its outstanding units to the total market value of all assets at $t-1$; and

$$\beta_j = \text{cov}\,(\tilde{R}_{jt}, \tilde{R}_{Mt})/\sigma^2(\tilde{R}_{Mt}) \tag{2}$$

is the risk of asset j in the market portfolio M measured relative to the risk of M. In Black's model, there are no risk-free assets, and R_{ft} in (1) is replaced by $E(\tilde{R}_{zt})$, the expected return on any asset or portfolio z whose return is uncorrelated with the return on M.[1]

In the SLB model, investors are risk-averse and they know the parameters of the assumed multivariate normal distribution of market values of assets at time t. Moreover, the capital market is perfect in the sense that investors are price-takers, any information is costlessly available to everybody, all assets are infinitely divisible, and any assets can be bought or sold without transactions costs. Keeping all of the other assumptions, Mayers (1972, 1973) extends the SLB model by dropping the assumption that all assets are perfectly marketable. In his world, some assets are completely non-marketable, and assets are either perfectly marketable or non-marketable.

In Mayers' adaptation of the Sharpe–Lintner model, a market equilibrium at $t-1$ is characterized by the expected return–risk relationship,

$$E(\tilde{R}_{jt}) = R_{ft} + [E(\tilde{R}_{Mt}) - R_{ft}]\beta_j^*. \tag{3}$$

The variables are as defined in (1) except that M is now explicitly identified as the market portfolio of marketable assets, eq. (3) only applies to marketable assets, and the risk measure β_j^* is

$$\beta_j^* = \frac{V_{M,\,t-1}\,\text{cov}\,(\tilde{R}_{jt}, \tilde{R}_{Mt}) + \text{cov}\,(\tilde{R}_{jt}, \tilde{H}_t)}{V_{M,\,t-1}\sigma^2(\tilde{R}_{Mt}) + \text{cov}\,(\tilde{R}_{Mt}, \tilde{H}_t)} \tag{4}$$

$$= \frac{\beta_j\,[1 + (\text{cov}\,(\tilde{R}_{jt}, \tilde{H}_t))/(V_{M,\,t-1}\,\text{cov}\,(\tilde{R}_{jt}, \tilde{R}_{Mt}))]}{[1 + (\text{cov}\,(\tilde{R}_{Mt}, \tilde{H}_t))/(V_{M,\,t-1}\sigma^2(\tilde{R}_{Mt}))]}. \tag{5}$$

In the equations, $V_{M,\,t-1}$ is the total market value of all marketable assets at time $t-1$, $\tilde{H}_t$ is the total payoff (income) at t on all non-marketable assets, and β_j is defined by (2). If there are no risk-free assets, then Mayers' version of the Black model requires substituting $E(\tilde{R}_{zt})$ for R_{ft} in (3).

[1]A detailed presentation of two-parameter theory is in Fama and Miller (1972). Jensen (1972) describes the historical development of the model and gives a useful survey of empirical results. Fama (1976) gives an elementary discussion of theory and tests.

In brief, in the Sharpe–Lintner–Black model, there are only marketable assets; and the risk of asset j, its β_j, is determined by the covariance of the return on the asset with the return on the market. In the Mayers model, there are both marketable and non-marketable assets; and the risk of any marketable asset j, its β_j^*, depends both on the covariance of its return with the return on all marketable assets and on the covariance of its return with the *payoff on all non-marketable assets.*

In eqs. (4) and (5), returns on marketable assets appear as rates of return at t on market values at $t-1$. In contrast, the return on non-marketable assets appears as the payoff or income on these assets at t. This difference between the way returns are measured is a consequence of difference between marketable and non-marketable assets. Whereas the payoff on a marketable asset includes both dividend and capital gain, the concept of a capital gain has no meaning for an asset which is completely non-marketable. Such an asset has no market value (price) at $t-1$ or t, and its return at t is just the income it produces at t.

Since the interpretation of the risk-free rate R_{ft} and the premium per unit of risk $[E(\tilde{R}_{Mt})-R_{ft}]$ is the same in eq. (3) as in (1), the only difference between the expected return–risk equations of the SLB and Mayers models is in the measure of the risk of a marketable asset. Thus one way to test whether the Mayers model improves on the description of the pricing of marketable assets is to estimate the differences $\beta_j^*-\beta_j$ between the Mayers and SLB risk measures for different classes of marketable assets.

Taking non-marketable assets to be synonymous with human capital, we estimate $\beta_j^*-\beta_j$ for portfolios of New York Stock Exchange (NYSE) common stocks and for portfolios of U.S. Treasury Bills and bonds. We find that the differences between the Mayers and SLB risk measures are small, at best. We attribute this finding to the fact that the relationships between the payoff to human capital and the returns on bonds and stocks are 'weak', so that any existence of non-marketable human capital does not have important effects on risk for these two important classes of marketable assets. We conclude that for bonds and common stocks, the extensions of two-parameter theory provided by the Mayers model are not of much consequence for describing the relationship between expected return and risk.

2. The data

2.1. *Definitions and descriptions*

The total payoff on human capital, henceforth called income, is defined as wage and salary disbursements plus the proprietors' income portion of seasonally adjusted personal income, as computed by the U.S. Department of Commerce and reported in the *Survey of Current Business.* Monthly data for the 1953–72 period are used. Different definitions of income were also tried (e.g., in one case net transfer payments were included and in another total personal income was used), with results similar to those reported below.

The empirical task of the paper is to compare estimates of β_j and β_j^* of (2) and (5) for different marketable assets j. Estimates of β_j and β_j^* require time series of (i) the total value of marketable assets, (ii) the return on the market portfolio of marketable assets, and (iii) returns for different classes of marketable assets. Our proxy for the market portfolio is a value-weighted portfolio of NYSE stocks and U.S. government debt, and these securities also comprise the total value of marketable assets. Portfolios of subsets of NYSE stocks and subsets of government bonds provide the different classes of marketable assets for comparing estimates of β_j and β_j^*.

In more detail, data on the end of month total market values of NYSE stocks were obtained from the Research Department of the NYSE, and Myron Scholes provided the monthly returns R_{St} on a value-weighted portfolio of NYSE stocks. Quarterly data on the face value of government debt for five intervals of term to maturity (less than one year, one to five years, five to ten years, ten to twenty years, and more than twenty years), obtained from the National Bureau of Economic Research Time Series Databank, are used to approximate the monthly market values of these classes of government bonds. The face values for a given quarter are applied to each month in the quarter. Indices of monthly returns on portfolios of government bonds, segregated by term to maturity, are available in Bildersee (1974). We aggregate his data into five portfolios corresponding to the term to maturity intervals in the data on the face value of government debt. For lack of the appropriate value weights, in forming any one of these five portfolios, equal weights are applied to the returns on the component Bildersee portfolios. The five resulting portfolio returns, along with the face value data, are used to approximate the monthly returns R_{Bt} on a value-weighted portfolio of government debt. This bond portfolio B is combined with the value-weighted portfolio of NYSE stocks S to obtain the proxy for the value-weighted market portfolio M.

Estimates of β_j and β_j^* of (2) and (5) are eventually compared for two major classes of marketable assets: portfolios of NYSE common stocks and portfolios of government bonds. In one set of common stock portfolios, obtained from Myron Scholes, the portfolios are formed according to ranked estimates of the risk measure β_j of (2). Another set of common stock portfolios includes industry portfolios formed according to SEC Industrial Classification by James MacBeth (1974). The government debt portfolios are the five component portfolios used to construct B, the value-weighted portfolio of government debt. The bond portfolios allow us to test for differences between the Mayers risk measure β_j^* and the SLB measure β_j as a function of term to maturity, while the common stock portfolios are concerned with differences as a function of industry and risk level.

In the two-parameter portfolio model which is the foundation of both the

Mayers and SLB models, people invest in order eventually to consume. They evaluate investment payoffs in units of consumption goods and services. This implies that variables should be measured in 'real' rather than nominal units. All of the results below are reported for both real and nominal versions of the variables, where the real variables are the nominal variables deflated by the U.S. Consumer Price Index (CPI).

The reported tests are for the 1953–72 period, but tests have also been carried out on data that go back to 1929. The data on most of the variables are of higher quality in the later period than in the earlier period. For example, in the 1930's and early 1940's there is substantial interpolation of components of monthly personal income from annual data, and the sample that the Department of Commerce uses to estimate monthly aggregate personal income increases in size and coverage through time. In the 1940's and on up to the Treasury–Federal Reserve Accord of 1951, interest rates on short-term government bonds were pegged by the Fed, and such short-term bonds are a large component of government debt. Finally, Fama (1975) describes an upgrading of the CPI in January 1953 that makes the Index a more accurate measure of month-to-month price movements. Thus, at least for the tests on the real versions of the variables, 1953 is a natural breaking point. The tests on data for earlier periods, however, lead to the same conclusions as the results for 1953–72.

2.2. *Summary statistics and some statistical issues*

To get good estimates of β_j^* of (5) for different classes of marketable assets, there are some statistical problems, centering on the appropriate way to measure income, that must be solved.

Estimates of the two covariances, cov $(\tilde{R}_{jt}, \tilde{H}_t)$ and cov $(\tilde{R}_{Mt}, \tilde{H}_t)$, that appear in β_j^* of (5), must be based on time series of the variables. In the Mayers model, $\tilde{H}_t$ is the aggregate income received at t by the labor force employed from $t-1$. To get appropriate measures of the covariances of income with returns, one must first abstract from any variation through time in aggregate income that just reflects changes in the size of the labor force. We solve this problem by using income per capita of the labor force to measure the variation through time in the payoff to a unit of human capital. The measure of the labor force (L_t) is the seasonally adjusted total civilian labor force collected by the Bureau of the Census of the Department of Commerce.

To estimate covariances between income and returns from time series data, one assumes that the bivariate distributions of the income and return variables are stationary through time, which implies that the marginal distributions of the variables are stationary. The distribution of per capita income is not stationary; income has an upward trend, and the autocorrelations of per capita income, H_t/L_t, shown in table 1, are close to one for many lags.

The standard cure for this type of mean non-stationarity is to work with a differenced form of the variable. Table 1 shows the autocorrelations of the percent change in per capita income,

$$h_t = \frac{H_t(L_{t-1}/L_t)}{H_{t-1}} - 1, \tag{6}$$

for the 1953–72 period. The autocorrelations of h_t are rather close to zero, and their behavior in general is quite consistent with stationarity.

Table 1 also shows autocorrelations for the monthly return R_{St} on the value-weighted portfolio of NYSE common stocks, the return R_{Bt} on the value-weighted portfolio of government bonds, the return R_{Mt} on the value-weighted market portfolio of S and B, and the returns on the five subportfolios of government bonds. Consistent with the assumption of stationarity, the autocorrelations of R_{St} and R_{Mt} are close to zero. The returns on the various common stock portfolios that are later used to make comparisons of β_j^* and β_j behave like R_{St}, so autocorrelations for these portfolios are not shown.

Since their return behavior is somewhat more interesting, detailed results for the returns on the five subportfolios of the bond portfolio B are shown in table 1. Note first that the autocorrelations of the nominal returns on B are large and of similar magnitude for different lags, which suggests non-stationarity, whereas the autocorrelations of the real returns are close to zero, which is consistent with stationarity. From the results for the subportfolios of B, one can see that this difference between the behavior of real and nominal bond returns is due primarily to the shortest-term bond portfolio (bills and bonds with less than one year to maturity). The results are consistent with those of Fama (1975) who argues that expected real returns on Treasury Bills are approximately constant during the post-1952 period, while expected nominal returns vary with the expected inflation rate, which follows a non-stationary process close to a random walk. In any case, since we feel that the results for real versions of the variables are most relevant, we do not worry too much about the apparent non-stationarity of nominal returns on short-term bonds.

Table 1 also shows the means and standard deviations of h_t and the portfolio returns. In terms of variability, the behavior of h_t is similar to that of the return on the government bond portfolio that covers 1–5 year maturities. The standard deviation of h_t is much smaller than those of the returns on the long-term bond and common stock portfolios. The most extreme comparison is with the common stock portfolio S whose returns have standard deviation about six times as large as the standard deviation of h_t. Thus, the percent changes in per capita income are much less variable through time than the returns on most of the portfolios of marketable assets.

Finally, there are many questions that can be raised about both the data and the tests. For example, using per capita income, or the percent change therein, adjusts for changes in the size of the labor force, but we are left with any prob-

Table 1
Autocorrelations of monthly variables, 1953–72.[a]

	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	ρ_7	ρ_8	ρ_9	ρ_{10}	ρ_{11}	ρ_{12}	$s(\rho_1)$	$\bar{x}$	s
Nominal															
H_t/L_t	0.99	0.97	0.96	0.95	0.93	0.92	0.91	0.90	0.88	0.87	0.86	0.84	0.06	5382	1366
h_t	0.06	0.13	−0.02	0.12	0.08	0.08	0.03	−0.04	−0.04	−0.04	0.04	−0.11	0.06	0.0034	0.0060
R_{St}	0.11	0.01	0.01	0.14	0.05	−0.01	−0.13	−0.12	0.06	−0.15	0.03	0.00	0.06	0.0101	0.0367
R_{Mt}	0.15	0.01	0.02	0.13	0.08	−0.00	−0.13	−0.16	0.08	−0.12	0.06	0.01	0.06	0.0071	0.0242
R_{Bt}	0.24	0.21	0.12	0.23	0.11	0.11	0.09	0.12	0.19	0.10	0.18	0.17	0.06	0.0029	0.0059
Real															
H_t/L_t	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.88	0.87	0.06	5576	653
h_t	0.12	0.15	0.00	0.09	0.03	0.08	0.03	−0.03	−0.03	−0.04	0.01	−0.11	0.06	0.0014	0.0061
R_{St}	0.13	0.02	0.03	0.14	0.07	−0.01	−0.13	−0.11	0.07	−0.14	0.03	0.01	0.06	0.0082	0.0370
R_{Mt}	0.14	−0.00	0.01	0.12	0.07	−0.01	−0.15	−0.17	0.07	−0.13	0.06	−0.00	0.06	0.0052	0.0245
R_{Bt}	0.10	0.07	−0.03	0.08	−0.05	−0.04	−0.08	−0.04	0.05	−0.05	0.05	0.03	0.06	0.0010	0.0062
Government bond portfolios by term to maturity															
Nominal															
1. Less than 1 year	0.71	0.67	0.65	0.59	0.59	0.57	0.49	0.52	0.57	0.53	0.52	0.52	0.06	0.0030	0.0015
2. 1–5 years	0.19	0.08	0.06	0.05	−0.01	−0.00	−0.08	−0.05	0.08	−0.03	0.06	0.02	0.06	0.0032	0.0071
3. 5–10 years	0.03	−0.03	0.01	0.15	−0.10	−0.03	−0.04	−0.04	0.11	−0.08	−0.02	0.04	0.06	0.0031	0.0121
4. 10–20 years	−0.06	−0.01	−0.13	0.21	−0.01	−0.02	−0.05	−0.03	0.07	−0.06	0.04	−0.04	0.06	0.0024	0.0182
5. More than 20 years	−0.05	0.03	−0.14	0.19	−0.03	−0.02	−0.07	−0.00	0.07	−0.09	0.04	−0.02	0.06	0.0022	0.0190
Real															
1. Less than 1 year	0.12	0.13	−0.03	−0.07	−0.00	−0.08	−0.09	0.02	0.06	0.10	0.05	0.17	0.06	0.0010	0.0021
2. 1–5 years	0.18	0.09	0.03	0.00	−0.04	−0.02	−0.10	−0.06	0.06	−0.02	0.05	0.03	0.06	0.0012	0.0073
3. 5–10 years	0.02	−0.02	0.00	0.12	−0.11	−0.03	−0.06	−0.04	0.10	−0.08	−0.03	0.05	0.06	0.0011	0.0122
4. 10–20 years	−0.06	0.00	−0.14	0.20	−0.01	−0.02	−0.04	−0.03	0.06	−0.06	0.04	−0.03	0.06	0.0005	0.0183
5. More than 20 years	−0.05	0.05	−0.13	0.19	−0.02	−0.01	−0.06	0.00	0.08	−0.08	0.05	−0.01	0.06	0.0003	0.0191

[a] ρ_τ is the autocorrelation for lag τ; $s(\rho_1)$ is the standard error of the first-order autocorrelation; $\bar{x}$ and s are the sample mean and standard deviation of the monthly values of the variable.

lems created by the fact that the quality of a unit of labor, as measured, for example, by years of schooling, increases through time. Moreover, there is the more fundamental question about whether human capital is a non-marketable asset. These and other problems are discussed in the concluding section of the paper, where, with the empirical results in hand, the arguments can be made most easily.

2.3. Restatement of the Mayers risk measure

To work with the percent change in per capita income $\tilde{h}_t$, the parameters $\text{cov}(\tilde{R}_{Mt}, \tilde{H}_t)$ and $\text{cov}(\tilde{R}_{jt}, \tilde{H}_t)$ in (5) must be restated in terms of $\tilde{h}_t$. Interpret H_{t-1} and $\tilde{H}_t$ as aggregate income earned at $t-1$ and t by L_{t-1}, the total labor force at $t-1$. Looking forward from $t-1$, which is the perspective of eqs. (1) to (5),

$$\tilde{H}_t = H_{t-1}(1+\tilde{h}_t),$$

and (5) can be rewritten as

$$\beta_j^* = \beta_j \frac{[1+(H_{t-1}/V_{M,\,t-1})(\text{cov}(\tilde{R}_{jt}, \tilde{h}_t))/(\text{cov}(\tilde{R}_{jt}, \tilde{R}_{Mt}))]}{[1+(H_{t-1}/V_{M,\,t-1})(\text{cov}(\tilde{R}_{Mt}, \tilde{h}_t))/(\sigma^2(\tilde{R}_{Mt}))]}. \tag{7}$$

Our presumption is that the parameters (covariances and variances) of the distributions of $\tilde{R}_{jt}$, $\tilde{R}_{Mt}$ and $\tilde{h}_t$ that appear in (2) and (7) are stationary through time, so that it is appropriate to estimate β_j and β_j^* from time series of $\tilde{R}_{jt}$, $\tilde{R}_{Mt}$, and $\tilde{h}_t$. Comparisons of the estimates of β_j and β_j^* then answer the question of whether non-marketable human capital has an appreciable effect on the risks of marketable assets. We first present the comparisons and then interpret the results.

First, however, a common characteristic of the risk measures β_j and β_j^* should be noted. Let x_{jM} be the weight of asset j in the market portfolio M,

$$x_{jM} = \frac{\text{Total value at } t-1 \text{ of all units of marketable asset } j}{\text{Total value at } t-1 \text{ of all marketable assets}}.$$

If we multiply β_j of (2) by x_{jM} and then sum over all assets j, we get the familiar result that the weighted average of the SLB risk measures β_j is one. If we multiply β_j^* of (4) by x_{jM} and sum over j, we get the same result; the weighted average of the Mayers risk measures β_j^* across all marketable assets j is also one. Thus in comparing estimates of β_j^* and β_j for different classes of assets, we must keep in mind that if there are systematic differences of a given sign between β_j^* and β_j for some classes of assets, they must be balanced by systematic differences of the opposite sign for other assets.

3. Comparisons of the risk measures: monthly data

Table 2 shows comparisons of estimates of β_j^* and β_j for two portfolios, the value-weighted portfolio S of NYSE stocks and the value-weighted portfolio B of government debt. The SLB risk estimates $\hat{\beta}_j$ are the slope coefficients from 'market model' regressions of R_{St} and R_{Bt} on R_{Mt}, where M is the value-weighted market portfolio of S and B. The estimates $\hat{\beta}_j^*$ of the Mayers risk measure use the market model estimates for β_j and the standard formulas for sample co-variances and variances for the remaining parameters in (7). The ratio $H_{t-1}/V_{M,\,t-1}$ in (7) is estimated as the average of the monthly values of this ratio for the indicated period.[2] Table 2 gives, in parentheses, the sample standard errors of the SLB risk estimates. We see no easy way to get comparable measures of the reliability of the Mayers risk estimates. This does not seem to be a problem, however, since the evidence in table 2, and in results to be presented later, leads so uniformly to the same conclusion.

The question posed for table 2 is whether there are important differences between the Mayers and SLB risk measures for NYSE common stocks and government bonds when considered as two general classes of marketable assets. The clear-cut answer seems to be 'no'. Only two of twelve differences $\hat{\beta}_j^* - \hat{\beta}_j$ in table 2 are as large as 0.01 in absolute value. There are substantial shifts from the 1953–62 period to the 1963–72 period in the levels of the risk measures for the bond and stock portfolios ($\hat{\beta}_B$ rises and $\hat{\beta}_S$ falls), but the differences $\hat{\beta}_j^* - \hat{\beta}_j$ are always small.

Although we can infer that the values of $\beta_j^* - \beta_j$ are close to zero for NYSE stocks and government bonds when considered as general classes of assets, there may be subclasses of stocks and bonds for which there are important differences between the two risk measures. Table 3 shows comparisons of $\hat{\beta}_j^*$ and $\hat{\beta}_j$ for the five portfolios of government bonds formed according to term maturity. Table 4 shows comparisons of $\hat{\beta}_j^*$ and $\hat{\beta}_j$ for the five portfolios of NYSE stocks formed on the basis of ranked estimates of the SLB risk measure $\hat{\beta}_j$ for individual stocks, and for the six portfolios of NYSE stocks formed according to industry.

To put the differences $\hat{\beta}_j^* - \hat{\beta}_j$ in tables 3 and 4 into perspective, the average monthly nominal return on the market portfolio M for the 1953–72 period is 0.0071, or about seven-tenths of one percent per month, and the average nominal return on a one-month Treasury Bill is 0.0027. Taking the difference between these two numbers as the sample estimate of the average value of $E(\tilde{R}_{Mt}) - R_{ft}$ in (3), the average risk premium per unit of β_j^* for this period is 0.0044 per month. Thus if one incorrectly uses β_j instead of β_j^* to measure the risk of asset j, and if $\beta_j^* - \beta_j$ is, say, 0.05, one understates the expected return on security j by only two one-hundredths of one percent per month.

[2]The ratio of income H_t to V_{Mt}, the combined value of government debt and NYSE stocks, averages about 0.85 for 1953–54, drops to about 0.73 in the 1955–58 period, and thereafter is fairly stable in the vicinity of 0.65.

Table 2

Comparisons of SLB and Mayers risk estimates: monthly data for common stock and government bond portfolios.[a]

	Nominal			Real				
Portfolio	$\hat{\beta}_J$	$\hat{\beta}_J^*$	$\hat{\beta}_J^*-\hat{\beta}_J$	$\hat{\beta}_J$	$\hat{\beta}_J^*$	$\hat{\beta}_J^*-\hat{\beta}_J$	Nominal s_{Jh}/s_{JM}	Real s_{Jh}/s_{JM}
1/53–12/72								
Common stocks (*S*)	1.496 (0.017)	1.497	0.001	1.489 (0.017)	1.505	0.016	0.029	0.045
Government debt (*B*)	0.046 (0.016)	0.046	0.000	0.063 (0.016)	0.062	−0.001	−0.083	0.010
1/53–12/62								
Common stocks (*S*)	1.740 (0.027)	1.746	0.006	1.730 (0.027)	1.732	0.002	0.036	0.047
Government debt (*B*)	−0.020 (0.026)	−0.031	−0.011	−0.005 (0.027)	−0.009	−0.004	0.784	1.110
1/63–12/72								
Common stocks (*S*)	1.365 (0.009)	1.365	0.000	1.359 (0.009)	1.359	0.000	0.026	0.044
Government debt (*B*)	0.082 (0.019)	0.081	−0.001	0.099 (0.019)	0.099	0.000	0.008	0.040

[a] s_{Jh}/s_{JM} is the estimate of $\text{cov}(\tilde{R}_{Jt}, \tilde{h}_t)/\text{cov}(\tilde{R}_{Jt}, \tilde{R}_{Mt})$ in (7). The implications of the observed estimates of the covariance ratio are discussed later.

The absolute differences between the Mayers and SLB risk estimates in tables 3 and 4 are generally smaller than 0.05. For the bond portfolios of table 3, only three of thirty values of $\hat{\beta}_j^* - \hat{\beta}_j$ are as large as 0.02 in absolute value. For the common stock portfolios of table 4, only nine of forty-two $\hat{\beta}_j^* - \hat{\beta}_j$ are as large as 0.03 in absolute value. Moreover, the larger $\hat{\beta}_j^* - \hat{\beta}_j$ are generally for the portfolios whose $\hat{\beta}_j$ have the largest standard errors. The larger differences are also usually observed in subperiods. And for given portfolios, the differences between the Mayers and SLB risk estimates seem to change signs randomly from one subperiod to the next. We conclude that the deviations of the estimates $\hat{\beta}_j^* - \hat{\beta}_j$ from zero are probably attributable to sampling error.

4. Results for annual data

One can question the validity of tests of the Mayers model based on monthly data. For example, in seasonally adjusting the income series, interesting variation in income may also be 'smoothed away'. To allay suspicions that false conclusions are drawn from faulty monthly data, the tests are replicated on annual data. The marketable assets are the same common stock and bond portfolios as in the monthly data. As in the monthly data, some background evidence is first examined, and then comparisons of estimates of β_j^* and β_j are presented.

4.1. Stationarity of the annual variables

Table 5 shows autocorrelations of the annual versions of the percent change in income per capita h_t and the returns on (i) the value-weighted portfolio S of NYSE stocks, (ii) the value-weighted portfolio B of government bonds, and (iii) the value-weighted market portfolio M of S and B. The autocorrelations for the usual bond and stock subportfolios, which we do not bother to show, are similar to those for the corresponding aggregates. None of the autocorrelations are systematically large relative to their standard errors, so that the behavior of the annual versions of h_t, R_{St}, R_{Bt} and R_{Mt} is consistent with stationarity. Thus as in the monthly data, (7) seems to be the appropriate version of β_j^* for estimating the Mayers risk measure from time series data.

4.2. Comparisons of the Mayers and SLB risk estimates

Table 6 compares estimates of β_j^* and β_j first for the value-weighted bond and stock portfolios B and S, and then for the usual subportfolios of bonds and common stocks. The time periods are the post-1952 periods of data availability for each portfolio, the market portfolio M is the value-weighted combination of B and S, and the estimates $\hat{\beta}_j^*$ and $\hat{\beta}_j$ are computed as in tables 2 to 4, except that annual data are used.

Table 3

Comparisons of SLB and Mayers risk estimates: monthly data for government bond portfolios by term to maturity.

	Nominal			Real			Nominal	Real
Maturity	$\hat{\beta}_j$	$\hat{\beta}_j^*$	$\hat{\beta}_j^* - \hat{\beta}_j$	$\hat{\beta}_j$	$\hat{\beta}_j^*$	$\hat{\beta}_j^* - \hat{\beta}_j$	s_{jh}/s_{jM}	s_{jh}/s_{jM}
1/53–12/72								
Less than 1 year	0.001 (0.004)	0.002	0.001	0.018 (0.005)	0.020	0.002	0.617	0.220
1–5 years	0.070 (0.018)	0.067	−0.003	0.086 (0.018)	0.085	−0.001	−0.032	0.025
5–10 years	0.117 (0.031)	0.111	−0.006	0.132 (0.031)	0.128	−0.004	−0.044	0.004
10–20 years	0.151 (0.048)	0.138	−0.013	0.167 (0.047)	0.157	−0.010	−0.103	−0.047
More than 20 years	0.159 (0.050)	0.142	−0.017	0.174 (0.049)	0.160	−0.014	−0.136	−0.080

1/53–12/62								
Less than 1 year	−0.006 (0.005)	−0.007	−0.001	0.008 (0.010)	0.014	0.006	0.199	1.033
1–5 years	−0.005 (0.028)	−0.015	−0.010	0.008 (0.029)	0.004	−0.004	2.804	−0.712
5–10 years	−0.030 (0.045)	−0.048	−0.018	−0.015 (0.045)	−0.025	−0.010	0.872	1.068
10–20 years	−0.056 (0.067)	−0.080	−0.024	−0.037 (0.067)	−0.052	−0.015	0.650	0.609
More than 20 years	−0.048 (0.071)	−0.086	−0.038	−0.030 (0.071)	−0.058	−0.028	1.150	1.407
1/63–12/72								
Less than 1 year	0.005 (0.005)	0.004	−0.001	0.024 (0.006)	0.024	0.000	−0.089	0.073
1–5 years	0.110 (0.024)	0.110	0.000	0.127 (0.024)	0.128	0.001	0.023	0.050
5–10 years	0.196 (0.043)	0.196	0.000	0.211 (0.042)	0.211	0.000	0.021	0.044
10–20 years	0.263 (0.066)	0.256	−0.007	0.276 (0.065)	0.268	−0.008	−0.019	0.001
More than 20 years	0.271 (0.069)	0.264	−0.007	0.283 (0.068)	0.275	−0.008	−0.014	0.004

Table 4

Comparisons of SLB and Mayers risk estimates: monthly data for common stock portfolios.

Portfolio	Nominal $\hat{\beta}_j$	Nominal $\hat{\beta}_j^*$	Nominal $\hat{\beta}_j^*-\hat{\beta}_j$	Real $\hat{\beta}_j$	Real $\hat{\beta}_j^*$	Real $\hat{\beta}_j^*-\hat{\beta}_j$	Nominal s_{jh}/s_{jM}	Real s_{jh}/s_{jM}
Part A: Industry portfolios								
1/53–6/68								
Utilities	1.044 (0.064)	1.017	−0.027	1.044 (0.064)	1.018	−0.026	−0.019	−0.002
Food	1.405 (0.060)	1.390	−0.015	1.399 (0.059)	1.384	−0.015	0.004	0.019
Petroleum	1.618 (0.080)	1.620	0.002	1.595 (0.079)	1.587	−0.008	0.021	0.028
Chemicals	1.917 (0.052)	1.924	0.007	1.905 (0.051)	1.912	0.007	0.024	0.041
Transportation equipment	1.905 (0.083)	1.933	0.028	1.899 (0.082)	1.930	0.031	0.041	0.059
Primary metals	2.187 (0.089)	2.234	0.047	2.170 (0.088)	2.214	0.044	0.051	0.065
Part B: Portfolios formed according to SLB risk level								
1/53–6/70								
1.	1.169 (0.038)	1.163	−0.006	1.172 (0.037)	1.146	−0.026	0.010	0.038
2.	1.426 (0.031)	1.426	0.000	1.423 (0.029)	1.399	−0.024	0.019	0.043
3.	1.651 (0.036)	1.656	0.005	1.641 (0.035)	1.619	−0.022	0.024	0.047
4.	1.887 (0.048)	1.908	0.021	1.876 (0.047)	1.866	−0.010	0.024	0.049
5.	2.291 (0.071)	2.316	0.025	2.275 (0.068)	2.263	−0.012	0.036	0.059

1/53–12/62								
1.	1.180 (0.050)	1.172	−0.008	1.179 (0.050)	1.184	0.005	0.021	0.037
2.	1.546 (0.045)	1.555	0.009	1.544 (0.044)	1.536	−0.008	0.039	0.054
3.	1.757 (0.052)	1.775	0.018	1.751 (0.052)	1.750	−0.001	0.047	0.058
4.	2.002 (0.066)	2.049	0.047	1.993 (0.065)	2.018	0.025	0.047	0.061
5.	2.406 (0.101)	2.463	0.057	2.401 (0.099)	2.431	0.030	0.064	0.081
1/63–6/70								
1.	1.155 (0.057)	1.153	−0.002	1.156 (0.056)	1.134	−0.022	0.010	0.040
2.	1.327 (0.037)	1.324	−0.003	1.322 (0.035)	1.296	−0.026	0.008	0.038
3.	1.570 (0.048)	1.565	−0.005	1.562 (0.046)	1.532	−0.030	0.008	0.039
4.	1.799 (0.072)	1.798	−0.001	1.790 (0.068)	1.755	−0.035	0.008	0.042
5.	2.207 (0.101)	2.206	−0.001	2.194 (0.096)	2.156	−0.038	0.013	0.046

Table 5

Autocorrelations of annual variables, 1953–72.[a]

	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	$s(\rho_1)$	$\bar{x}$	s
Nominal									
h_t	0.21	0.01	0.25	0.22	0.04	0.13	0.22	0.0409	0.0236
R_{St}	−0.29	−0.28	0.07	0.23	−0.12	−0.05	0.22	0.1336	0.1856
R_{Mt}	−0.35	−0.25	0.04	0.23	−0.11	0.01	0.22	0.0898	0.1012
R_{Bt}	−0.22	−0.02	0.25	0.10	−0.03	0.04	0.22	0.0354	0.0295
Real									
h_t	−0.08	−0.18	0.13	−0.12	−0.19	0.10	0.22	0.0169	0.0196
R_{St}	−0.23	−0.27	0.08	0.23	−0.11	−0.03	0.22	0.1090	0.1910
R_{Mt}	−0.33	−0.27	0.03	0.24	−0.10	−0.03	0.22	0.0655	0.1063
R_{Bt}	−0.10	−0.07	0.26	−0.15	−0.33	−0.07	0.22	0.0116	0.0265

[a] ρ_τ is the autocorrelation for lag τ; $s(\rho_1)$ is the standard error of the first-order autocorrelation; $\bar{x}$ and s are the sample mean and standard deviation of the annual values of the variable.

To get some perspective on the numbers in table 6, note that for the 1953–72 period the average annual nominal return on the market portfolio M is 8.98 percent, while the average annual nominal return on the portfolio of government bonds with one year or less to maturity is 3.63 percent. If we take the difference between these numbers as an estimate of the average value of $E(\tilde{R}_{Mt})-R_{ft}$, the average risk premium per unit of β_j^* in (3) for the 1953–72 period is 5.35 percent per year. Thus, if one incorrectly uses β_j instead of β_j^* to measure the risk of asset j, and if $\beta_j^*-\beta_j$ is, say, 0.05, one understates the expected return on security j by only about one-quarter of one percent per year.

Only one of thirty-six estimates $\hat{\beta}_j^*-\hat{\beta}_j$ in table 6 is as large as 0.05 in absolute value. In the results for real versions of the variables, only three estimates $\hat{\beta}_j^*-\hat{\beta}_j$ are as large as 0.03 in absolute value. The deviations of $\hat{\beta}_j^*-\hat{\beta}_j$ from zero seem generally larger when the nominal versions of the variables are used, but they are still always small in terms of what they imply about differences in average risk premiums. Finally, because of the smaller sample sizes, risk estimates from annual data are less reliable than those from monthly data, and more dispersion is to be expected in the differences $\hat{\beta}_j^*-\hat{\beta}_j$ computed from annual data. This leads us to conclude that the observed differences $\hat{\beta}_j^*-\hat{\beta}_j$ in table 6, which are small in any case, can probably be attributed to sampling error.

In sum, annual data, like monthly data, do not produce evidence of important differences between the Mayers and SLB risk measures β_j^* and β_j for portfolios of government bonds and NYSE common stocks. Thus at least for these securities the extension of two-parameter theory provided by the Mayers model seems to be of no consequence for empirical description of the relationship between expected return and risk.

5. Interpretation of the results: The relationships between income and the returns on marketable assets

Eqs. (4), (5) and (7) indicate that the key to differences between the Mayers and SLB risk measures β_j^* and β_j is in the relationships between the payoffs on human capital and the returns on marketable assets. We now argue that the major reason estimates of $\beta_j^*-\beta_j$ for portfolios of government bonds and NYSE common stocks differ little from zero is that the relationships between $\tilde{h}_t$ and the returns on these assets are 'weak'.

5.1. The market portfolio

Since $\operatorname{cov}(\tilde{R}_{Mt}, \tilde{h}_t)/\sigma^2(\tilde{R}_{Mt})$ appears in the denominator of (7) for all assets j, the value of this ratio is of special interest. But

$$\beta_h = \operatorname{cov}(\tilde{R}_{Mt}, \tilde{h}_t)/\sigma^2(\tilde{R}_{Mt}) \tag{8}$$

is just the slope coefficient in the 'market model' regression of $\tilde{h}_t$ on $\tilde{R}_{Mt}$. Esti-

Table 6

Comparisons of SLB and Mayers risk estimates: annual data for post-1952 periods.

Portfolio	Nominal			Real			Nominal	Real
	$\hat{\beta}_j$	$\hat{\beta}_j^*$	$\hat{\beta}_j^* - \hat{\beta}_j$	$\hat{\beta}_j$	$\hat{\beta}_j^*$	$\hat{\beta}_j^* - \hat{\beta}_j$	s_{jh}/s_{jM}	s_{jh}/s_{jM}
Part A: Government bonds and common stocks								
1953–72								
Common stocks (S)	1.773 (0.111)	1.820	0.047	1.749 (0.097)	1.757	0.008	−0.139	−0.052
Government debt (B)	−0.090 (0.066)	−0.100	−0.010	−0.017 (0.059)	−0.025	−0.008	−0.025	0.545
Part B: Government bonds by term to maturity								
1953–72								
Less than 1 year	−0.057 (0.035)	−0.051	0.006	0.010 (0.017)	0.011	0.001	−0.301	−0.005
1–5 years	−0.074 (0.084)	−0.086	−0.012	−0.005 (0.079)	−0.015	−0.010	0.051	3.063
5–10 years	−0.126 (0.112)	−0.149	−0.023	−0.052 (0.101)	−0.068	−0.016	0.062	0.373
10–20 years	−0.129 (0.161)	−0.167	−0.038	−0.044 (0.156)	−0.061	−0.017	0.214	0.515
More than 20 years	−0.144 (0.161)	−0.192	−0.048	−0.044 (0.157)	−0.061	−0.017	0.263	0.491

	Part C: Industry common stock portfolios							
1953–67								
Utilities	0.870 (0.249)	0.804	−0.066	0.915 (0.237)	0.884	−0.031	−0.249	−0.149
Food	1.808 (0.201)	1.806	−0.002	1.725 (0.203)	1.691	−0.034	−0.151	−0.128
Petroleum	1.688 (0.267)	1.704	0.016	1.657 (0.256)	1.663	0.006	−0.137	−0.096
Chemicals	2.215 (0.165)	2.197	−0.018	2.146 (0.166)	2.119	−0.027	−0.159	−0.118
Transportation equipment	2.656 (0.255)	2.691	0.035	2.549 (0.256)	2.560	0.011	−0.131	−0.095
Primary metals	2.807 (0.362)	2.841	0.034	2.733 (0.344)	2.765	0.032	−0.133	−0.086
	Part D: Portfolios formed according to SLB risk level							
1953–69								
1.	1.423 (0.117)	1.397	−0.026	1.408 (0.106)	1.398	−0.010	−0.143	−0.061
2.	1.860 (0.131)	1.817	−0.043	1.816 (0.120)	1.787	−0.029	−0.148	−0.074
3.	2.123 (0.114)	2.108	−0.015	2.048 (0.112)	2.033	−0.015	−0.129	−0.063
4.	2.453 (0.201)	2.427	−0.026	2.358 (0.191)	2.336	−0.022	−0.132	−0.065
5.	3.043 (0.271)	3.022	−0.021	2.908 (0.259)	2.889	−0.019	−0.126	−0.062

mates of this regression for both monthly and annual data are summarized in table 7.

For the monthly data, the estimates $\hat{\beta}_h$ are always positive, and, at least for the longer periods, they are generally large relative to their standard errors. In terms of proportion of variance explained, however, the relationships between h_t and R_{Mt} are 'weak'. For the monthly regressions of h_t on R_{Mt} in table 7, the largest coefficient of determination is 0.068, and this is twice the size of the next largest. Thus, very little of the month to month variation in per capita income is explained by relationships between h_t and the return on the market.

Moreover, although from a statistical viewpoint the market model regressions of h_t on R_{Mt} produce identifiable positive relationships, it is the size of β_h, and more particularly the deviation of $(H_{t-1}/V_{M,t-1})\beta_h$ from zero that determines how the denominator of (7) deviates from one. In the monthly data, the largest value of $\hat{\beta}_h$ is 0.045. The ratio $H_{t-1}/V_{M,\,t-1}$ is always less than one, and the average value of this ratio for the 1953–72 period is 0.68. Thus, for our purposes, the measured relationships between h_t and R_{Mt} are also weak in the sense that they imply that the denominator of (7) is close to one.

The regressions of h_t on R_{Mt} for the annual versions of the variables are interesting. In the nominal regression, $\hat{\beta}_h$ is large relative to its standard error, but the relationship between nominal h_t and nominal R_{Mt} is negative, whereas in the monthly data the relationships are always positive. Another feature of the annual results, which again does not show up in the monthly data, is that the estimate $\hat{\beta}_h$ is closer to zero for the real than for the nominal versions of the variables. In the nominal regression $\hat{\beta}_h = -0.111$, which is more than two standard errors from zero, but in the real regression $\hat{\beta}_h = -0.038$ which is less than one standard error from zero. Likewise the coefficient of the determination drops from 0.23 in the nominal regression to 0.04 when the real versions of the variables are used.

The behavior of $\hat{\beta}_h$ in the annual data can be traced to the fact that during the 1953–72 period, human capital provided somewhat of a hedge against inflation; that is, nominal h_t tended to deviate from its mean in the same direction as the inflation rate, whereas the return on the market portfolio M, and more specifically the common stock component of M, tended to move perversely with the inflation rate. For the 1953–72 period, the correlation between nominal h_t and the annual inflation rate is 0.57, whereas the correlation between nominal R_{Mt} and the inflation rate is -0.37. This negative correlation is, however, due entirely to the nominal return R_{St} on the common stock component of M which has a correlation of about -0.45 with the inflation rate.[3] The correlation between the inflation rate and the nominal return R_{Bt} on the bond component of

[3]The negative correlation between nominal R_{St} and the inflation rate is apparently a post-1952 phenomenon. In annual data for the 1929–52 period the correlation is positive, but small (0.13). On the other hand, the always substantial positive correlation between nominal h_t and the inflation rate is even higher in the annual data for the 1929–52 period (0.77) than in the 1953–72 period (0.57).

Table 7

'Market model' regressions: $h_t = \hat{\alpha}_h + \hat{\beta}_h R_{Mt} + \hat{\varepsilon}_t$.

Period	Nominal					Real				
	$\hat{\alpha}_h$	$\hat{\beta}_h$	$s(\hat{\varepsilon})$	Coeff. of det.	Durbin–Watson	$\hat{\alpha}_h$	$\hat{\beta}_h$	$s(\hat{\varepsilon})$	Coeff. of det.	Durbin–Watson
Part A: Monthly data										
1953–72	0.0032 (0.0004)	0.0284 (0.0160)	0.0060	0.013	1.86	0.0012 (0.0004)	0.0445 (0.0160)	0.0061	0.032	1.78
1953–62	0.0022 (0.0007)	0.0310 (0.0316)	0.0070	0.008	1.86	0.0010 (0.0007)	0.0452 (0.0323)	0.0072	0.016	1.95
1963–72	0.0042 (0.0004)	0.0261 (0.0152)	0.0046	0.024	2.04	0.0014 (0.0004)	0.0444 (0.0152)	0.0046	0.068	1.86
Part B: Annual data										
1953–72	0.051 (0.006)	−0.111 (0.048)	0.021	0.228	1.57	0.019 (0.005)	−0.038 (0.042)	0.020	0.043	1.73

M is 0.41. The opposite correlations of nominal h_t and R_{Mt} with the inflation rate combine with a weak relationship between the real versions of h_t and R_{Mt} to produce a negative relationship in the nominal regressions of h_t on R_{Mt}.

In any case, in the more relevant results for the real versions of the variables, the value of $\hat{\beta}_h$ in the annual data is close to zero. Moreover, although large relative to its standard error, the value of $\hat{\beta}_h$ in the nominal regression seems to have the wrong sign (negative); and in absolute terms, the value $\hat{\beta}_h = -0.111$ does not seem impressively non-zero. Thus, as in the tests on monthly data, the measured relationship between the annual versions of h_t and R_{Mt} is weak in the sense that it implies that the denominator of (7) is close to one.

5.2. The common stock and bond portfolios

A weak relationship between income and the return on the market does not in itself imply that the Mayers risk measure β_j^* is the same as the SLB risk measure β_j for every marketable asset j. Inspection of (7) indicates that non-zero values of $\operatorname{cov}(\tilde{R}_{jt}, \tilde{h}_t)/\operatorname{cov}(\tilde{R}_{jt}, \tilde{R}_{Mt})$ produce differences between β_j^* and β_j for individual securities even when $\beta_h = \operatorname{cov}(\tilde{R}_{Mt}, \tilde{h}_t)/\sigma^2(\tilde{R}_{Mt}) = 0$. On the other hand, even if β_h were substantially different from zero, this would not in itself imply differences between β_j^* and β_j for individual securities. Nonzero values of $\beta_j^* - \beta_j$ require that the values of $\operatorname{cov}(\tilde{R}_{jt}, \tilde{h}_t)/\operatorname{cov}(\tilde{R}_{jt}, \tilde{R}_{Mt})$ differ across assets. If the covariance ratio is the same for all assets, then it is necessarily equal to β_h, and $\beta_j^* = \beta_j$ for all j.

Estimates of $\operatorname{cov}(\tilde{R}_{jt}, \tilde{h}_t)/\operatorname{cov}(\tilde{R}_{jt}, \tilde{R}_{Mt})$, labeled s_{jh}/s_{jM}, for the various portfolios of government bonds and NYSE stocks appear in tables 2, 3, 4, and 6. A few comments on the estimates suffice. In the monthly data of tables 2 and 4, the values of s_{jh}/s_{jM} for different common stock portfolios and different time periods are all close to zero. The relationships between income and the returns on common stocks, as measured by the covariance s_{jh}, are always weak relative to the relationships between stock returns and the return on the market, as measured by s_{jM}. Thus for stocks the bracketed terms in the numerator and denominator of (7) are both close to one in the monthly data, which explains why estimates of $\beta_j^* - \beta_j$ for common stock portfolios are close to zero.

Similar comments apply to the estimates s_{jh}/s_{jM} obtained for the common stock portfolios from annual data. There is, however, one new wrinkle. In the annual data the nominal regression of h_t on R_{Mt} yields $\hat{\beta}_h = -0.111$. For the common stock portfolios in table 6, negative values of s_{jh}/s_{jM} are likewise observed in the results for the nominal versions of the variables, but the ratios s_{jh}/s_{jM} are similar in value to $\hat{\beta}_h$, which explains why the differences $\hat{\beta}_j^* - \hat{\beta}_j$ are small. Thus when we focus on the strongest observed relationship between income and the market, the relationships between income and the returns on different classes of common stocks do not differ enough to produce substantial differences between the Mayers and SLB risk measures.

For the bond portfolios in tables 2, 3 and 6, the values of s_{jh}/s_{jM} are in some cases large (greater than one or two). However, the large values of s_{jh}/s_{jM} always occur when the values of $\hat{\beta}_j = s_{jM}/s^2(R_M)$ for the relevant bond portfolios are close to zero. From (7) we can then see that when a large value of s_{jh}/s_{jM} is observed for a bond portfolio, there is, in percentage terms, a large difference between the Mayers and SLB risk estimates, but the difference is trivial in absolute terms and in terms of the implied over- or under-estimate of the security's expected return. For example, the largest observed value of s_{jh}/s_{jM} is 3.063 for the annual real returns on the portfolio of bonds with 1–5 years to maturity in table 6. However, the large value of the covariance ratio reflects a small value of s_{jM} [in this case, $\hat{\beta}_j = s_{jM}/s^2(R_M) = -0.005$] rather than a large value of s_{jh}, that is, a strong relationship between the portfolio's return and changes in per capita income. As a result, for this portfolio the difference $\hat{\beta}_j^* - \hat{\beta}_j = -0.010$ is large relative to $\hat{\beta}_j$. But such a small difference in risk measures implies a trivial difference in the estimates of $E(\tilde{R}_j)$ obtained from the Mayers and SLB risk measures.

We emphasize that inferences about the empirical relevance of the Mayers model are appropriately based on the differences between estimates of the Mayers and SLB risk measures. For the bond portfolios as well as for the common stock portfolios, these differences are always small.

5.3. *Some supporting regressions*

For the purpose of determining why estimates of $\beta_j^* - \beta_j$ are close to zero, estimates and comparisons of the ratios cov $(\tilde{R}_{jt}, \tilde{h}_t)$/cov $(\tilde{R}_{jt}, \tilde{R}_{Mt})$ and $\beta_h =$ cov $(\tilde{R}_{Mt}, \tilde{h}_t)/\sigma^2(\tilde{R}_{Mt})$ in (7) provide the direct evidence that the relationships between income and the returns on marketable assets are weak. But the regressions of h_t on R_{St} and on the returns on the bond portfolios, shown in table 8, put this result in more familiar terms.

In the monthly data, the regressions of h_t on R_{St}, the return on the value-weighted portfolio of NYSE stocks, yield slope coefficients that are positive and large relative to their standard errors, but small in absolute terms. Thus the point estimate is that a 100 percent return on S is on average associated with less than a 2 percent increase in income per capita. Moreover the relationships between h_t and R_{St} are 'weak' in the sense that the coefficients of determination (0.01 in the nominal and 0.03 in the real regression) imply proportions of variance explained that are close to zero. Results for the various subportfolios of common stocks, which are not shown, are similar. In the monthly data, the regressions of h_t on the returns on the various bond portfolios likewise produce coefficients of determination that are close to zero, but for the bond portfolios the slope coefficients in the regressions are also generally less than one standard error from zero.

In the annual data, we observe the negative relationship between nominal

Table 8

Regressions of h_t on portfolio returns, 1953–72: $h_t = \hat{a}_h + \hat{\beta}_h R_{jt} + \hat{\varepsilon}_t$.

Portfolio	Nominal $\hat{a}_h$	Nominal $\hat{\beta}_h$	Nominal $s(\hat{\varepsilon})$	Nominal Coeff. of det.	Nominal Durbin–Watson	Real $\hat{a}_h$	Real $\hat{\beta}_h$	Real $s(\hat{\varepsilon})$	Real Coeff. of det.	Real Durbin–Watson
Part A: Monthly data										
Common stocks (S)	0.0032	0.0189	0.0060	0.013	1.86	0.0012	0.0293	0.0061	0.031	1.79
	(0.0004)	(0.0105)				(0.0004)	(0.0106)			
Government debt (B)	0.0036	−0.0640	0.0060	0.004	1.91	0.0014	0.0096	0.0062	0.000	1.74
	(0.0004)	(0.0654)				(0.0004)	(0.0643)			
Subportfolios of B										
1. Less than 1 year	0.0027	0.2171	0.0060	0.003	1.87	0.0009	0.5637	0.0060	0.037	1.77
	(0.0008)	(0.2521)				(0.0004)	(0.1878)			
2. 1–5 years	0.0035	−0.0261	0.0060	0.001	1.90	0.0014	0.0243	0.0062	0.001	1.73
	(0.0004)	(0.0550)				(0.0004)	(0.0547)			
3. 5–10 years	0.0034	−0.0208	0.0060	0.002	1.90	0.0014	0.0023	0.0062	0.000	1.75
	(0.0004)	(0.0321)				(0.0004)	(0.0325)			
4. 10–20 years	0.0034	−0.0275	0.0060	0.007	1.92	0.0015	−0.0141	0.0061	0.002	1.77
	(0.0004)	(0.0213)				(0.0004)	(0.0218)			
5. More than 20 years	0.0035	−0.0348	0.0060	0.012	1.94	0.0015	−0.0229	0.0061	0.005	1.78
	(0.0004)	(0.0203)				(0.0004)	(0.0207)			

				Part B: Annual data						
Common stocks (R_{St})	0.0507 (0.0055)	−0.0733 (0.0245)	0.0198	0.332	1.71	0.0200 (0.0050)	−0.0283 (0.0232)	0.0193	0.076	1.69
All government debt (R_{Bt})	0.0400 (0.0086)	0.0259 (0.1882)	0.0242	0.001	1.79	0.0187 (0.0048)	−0.1509 (0.1702)	0.0197	0.042	1.86
Subportfolios of B										
1. Less than 1 year	0.0167 (0.0121)	0.6649 (0.3054)	0.0216	0.208	2.16	0.0170 (0.0087)	−0.0095 (0.5946)	0.0201	0.000	1.91
2. 1–5 years	0.0420 (0.0080)	−0.0288 (0.1521)	0.0242	0.002	1.75	0.0191 (0.0048)	−0.1466 (0.1334)	0.0194	0.063	1.89
3. 5–10 years	0.0421 (0.0069)	−0.0328 (0.1124)	0.0242	0.005	1.75	0.0183 (0.0046)	−0.1044 (0.0971)	0.0195	0.060	1.91
4. 10–20 years	0.0425 (0.0058)	−0.0566 (0.0777)	0.0239	0.029	1.78	0.0172 (0.0044)	−0.0529 (0.0653)	0.0197	0.035	1.89
5. More than 20 years	0.0430 (0.0057)	−0.0771 (0.0764)	0.0236	0.054	1.82	0.0171 (0.0044)	−0.0477 (0.0635)	0.0198	0.030	1.87

h_t and nominal R_{St} which we earlier argued primarily reflects the fact that in the 1953–72 period, nominal h_t is positively correlated with the inflation rate, while the nominal returns on stocks are negatively correlated with the inflation rate. The relationship between h_t and R_{St} disappears when the real versions of the variables are used. In the annual regressions of h_t on the returns on the various bond portfolios, the slope coefficients are generally small relative to their standard errors, and the coefficients of determination are close to zero. The exception is the noticeable positive relationship between nominal h_t and the nominal return on the shortest-term bond portfolio, which reflects the fact that this portfolio, like human capital, provides somewhat of a hedge against the annual inflation rate. Thus, the correlation between the annual nominal return on the shortest-term bond portfolio and the annual inflation rate is 0.89, and the correlation between the inflation rate and the annual percent change in per capita income is 0.57. The relationship between h_t and the return on the portfolio of shortest-term government debt disappears when the real versions of the variables are used.

6. Conclusions and qualifications

For portfolios of NYSE common stocks and U.S. Treasury Bills and bonds, the relationships between returns and aggregate payoffs to the economy's human capital are insufficient to produce important differences $\beta_j^* - \beta_j$ between the Mayers and Sharpe–Lintner–Black risk measures. Since the expected return–risk relationships of the Mayers and SLB models differ only in what is taken to be the relevant measure of the risk of an asset, we conclude that for NYSE common stocks and government bonds, it is unnecessary to take account of the effects of human capital on the market equilibrium relationships between expected return and risk.

There are, however, problems in our procedures and thus legitimate questions that can be raised about the conclusions. We consider some of these now.

6.1. The weights in the market portfolio

The government bond portfolios can also be interpreted as proxies for portfolios of default-free corporate debt with comparable terms to maturity. From this viewpoint, it is inappropriate to weight the government bond portfolios by their own values when forming the market portfolio M. Given that real returns on both bonds and common stocks are virtually unrelated to $\tilde{h}_t$, however, the results that we report would change little with changes in the weights applied to bonds and stocks in M.

Other types of marketable assets are, however, omitted from the tests. Some of these, like corporate bonds and preferred stocks, have default-risk and can be viewed as combinations of default-free debt and equity, the instruments on which the current tests are based. Including them in the tests probably would not materially change the results. On the other hand, there is one type of marketable asset, privately held real estate, including a large fraction of the agricultural sector, that looms large in the total value of marketable assets, and is omitted entirely from the tests. The conclusions of this paper cannot be applied to real estate, and it is possible that the conclusions themselves would change if real estate were included in the tests. The same criticism applies, however, to all empirical work to date on the expected return–risk relationships of two-parameter models.

6.2. Measuring the return on human capital

There are many legitimate quarrels with the way we measure the return to human capital. For example, we use gross income per capita as the measure of the payoff to a unit of human capital when net income, that is, gross income less the maintenance costs that must be incurred to keep a unit of human capital in working order, is probably more appropriate. Our implicit assumption is that such maintenance costs are not highly related to the returns on marketable assets so that net income, like gross income, is likely to be more or less unrelated to the returns on marketable assets.

Another legitimate criticism is that working with per capita income corrects for changes in aggregate income that result from changes in the size of the labor force but it leaves any problems created by changes through time in the quality of the labor force. Computations by the Bureau of Labor Statistics (1973) indicate that the quality of the labor force, as measured by 'median school years completed', increased during the 1953–72 period, but slowly and smoothly. Thus it seems reasonable to presume that the effects of quality change show up primarily in the mean rate of change of per capita income $\tilde{h}_t$, and that the variation through time of $\tilde{h}_t$, which is what is critical in the tests, is relatively free of the effects of quality changes.

Nevertheless, the rigor of the paper would be improved if all appropriate adjustments of aggregate income were made. What the reader must judge is whether such adjustments, if they were possible, would change the basic result: that the relationships between income and the returns on bonds and common stocks are so weak that for these assets any differences between the Mayers and Sharpe–Lintner–Black risk measures are trivial. We suspect that the result is robust with respect to different definitions of income.

6.3. Human capital as a marketable asset

Prohibitions against slavery may not be sufficient to justify the assumption that human capital is non-marketable. For example, athletic contracts and book publishing contracts involving bonuses or advances for future services can be regarded as partial sales of human capital. The same is true of borrowing with future income as the specific collateral. The Mayers model is quite clear on this point. The model allows unrestricted shortselling of marketable assets, whether riskless or risky, but one cannot borrow specifically against future income. Such borrowing is in fact possible, although the amount that can be borrowed is usually less than one or two years income. Likewise, bonuses and other advances that amount to partial sales of human capital are not typical of the way payments are made to human capital. The extent to which human capital is marketable, then, is an open question.

One way to sidestep the question is to say that the goal is to test the Mayers model, and since the model does not seem to improve on the SLB description of the expected return–risk relationship for marketable assets, questions about its logical foundations are moot. We prefer to try a more ambitious and perhaps tenuous tack. Suppose human capital is completely marketable. Do the results of this paper permit inferences about the errors that arise in studies of expected return–risk relationships for marketable assets that overlook the possible effects of marketable human capital on such relationships?

Mayers himself, in his 1972 paper, points the way to the answer to this question. He notes that his model for non-marketable assets is similar to a 'missing assets' model where all assets are marketable, but, through oversight or lack of data, the researcher omits some assets in studying the relationship between expected return and risk. In the missing assets model, the relationship between expected return and risk for included assets is (3), and β_j^* in (3) is as given in (7) except that M is now the market portfolio of 'included' assets, $\tilde{h}_t$ is the return (dividend plus capital gain divided by price at $t-1$) on the missing assets, H_{t-1} is the total market value of the missing assets at $t-1$, and $V_{M,\,t-1}$ is the total market value of the included assets.

If the omitted marketable assets are taken to be human capital, the major problem in applying the missing assets model is that since explicit market values of human capital are not available, the rate of return $\tilde{h}_t$ on human capital cannot be computed directly. We must improvise. Thus, consistent with the autocorrelations of H_t/L_t and h_t in tables 1 and 5, suppose we assume that per capita income follows a random walk, perhaps a multiplicative random walk and perhaps with deterministic drift. Suppose also that the SLB risk of human capital is constant through time and that the expected return–risk relationships of the SLB model are constant through time. Under these conditions the discount rate applied to expected future incomes to get the market value of human capital is constant through time, and the market value of human capital is proportional to and thus perfectly correlated with income. It follows that the percent change in per capita income (our h_t) is also the percent capital gain return on human capital.

The finding that the percent change in per capita income is unrelated to the returns on government bonds and NYSE common stocks can now be used to infer that in the missing assets model, as in the nonmarketable assets model,

$\beta_j^* - \beta_j$ is close to zero for bonds and common stocks so that one need not take account of human capital in describing the relationship between the expected returns on these securities and their risks. Moreover, the fact that in the missing assets model the percent change in per capita income corresponds only to the capital gain portion of the percent return on human capital is unimportant. In the present scenario, income and the market value of human capital are perfectly correlated. If the capital gain return on human capital is unrelated to the returns on marketable assets, so is the 'dividend' return.

We feel, then, that the empirical findings of this paper should be some comfort to researchers who have studied expected return–risk relationships without considering any possible effects of human capital, and that this is irrespective of whether one considers human capital as marketable or non-marketable.

6.4. Some final considerations

Like the SLB model, the Mayers model for non-marketable assets is a one-period model. Fama (1970) and Merton (1973) discuss the conditions under which the expected return–risk relationships of the SLB model apply period-by-period in a multiperiod world. The Mayers model can be transformed into a multiperiod model for portfolio selection and capital market equilibrium much in the way described by Fama and Merton for the SLB model. We shall not go into the details. Suffice it to say that the conditions required for the period-by-period validity of the expected return–risk relationship obtained in the one-period version of the Mayers model are stronger than those required in the SLB model. For example, a sufficient condition on the opportunity set if the SLB model is to apply period-by-period is that the joint distribution of security returns remains the same through time. In the Mayers model for non-marketable assets, one must in addition assume either that the payoffs (current, past and future) on non-marketable assets are unrelated to the returns on marketable assets or that the distributions of investors' per capita incomes are constant or change deterministically through time.

Inconsistent with this last condition, both the monthly and the annual data for the 1953–72 period indicate that income per capita is a non-stationary process close to a random walk. With such a process, every change in income per capita is expected to be permanent; and, if it is possible, investors have an incentive to use any correlation between income and the returns on marketable assets to hedge against unanticipated permanent changes in income. One can then use Merton's (1973) analysis to show that the premium (or discount) that the market assigns to that part of an asset's risk that reflects its quality as a hedge against unexpected changes in income need not be the same as the premium per unit of its SLB portfolio risk. The difference between the two sources of risk arises from the fact that since human capital is non-marketable, an unexpected change in income leads to a permanent shift in the split of the investor's resources between marketable and non-marketable assets, whereas the investor can always rebalance his portfolio of marketable assets to undo shifts in his holdings of these assets due to randomness in their returns.

One could say, then, that from the viewpoint of the Mayers model itself, it is somewhat fortuitous that the returns on marketable assets, or at least on those examined in this paper, seem to be unrelated to income. Moreover, we have checked for lead and lag relationships between income and the return on common stocks and government bonds, and they are, if anything, weaker than the contemporaneous relationships. But these are precisely the conditions in which the Mayers model reduces to the SLB model and so provides no new insights on the expected return–risk relationships for marketable assets.

We have, however, been too hard on the Mayers model. His model of market equilibrium derives from a portfolio model in which holdings of specific marketable assets by an investor are in part determined by the relationships between the returns on these assets and the payoffs on the specific non-marketable assets held by the investor. Interpreting non-marketable assets as human capital, aggregate income may be more or less unrelated to the returns on marketable assets, but there may be occupational subgroups for which the relationships are non-trivial. Thus it is possible that the Mayers model may help to describe differences in portfolio holdings among occupational groups that cannot be explained with SLB type models, even though, at the aggregate level, the Mayers model does not seem to improve on the description of the equilibrium relationship between expected return and risk for marketable assets that is obtained from the SLB model.

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