EMPIRICAL STUDIES OF PORTFOLIO CHOICE AND ASSET PRICES

Björn Lagerwall

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Empirical Studies of Portfolio Choice and Asset Prices
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EMPIRICAL STUDIES OF PORTFOLIO CHOICE AND ASSET PRICES

Björn Lagerwall

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EFI, The Economic Research Institute
To Lisa and Gustav
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Stockholm, April 2004

Björn Lagerwall
Introduction and Summary

Portfolio choice and asset prices are two closely related topics of economics and finance. From an empirical point of view, they also constitute some of the most puzzling evidence. In post-war yearly data from the United States, the premium from investing in a broad stock market index as compared to a short treasury bill has on average been about eight percent. According to standard consumption-based economic theory, this is far too high. The equity premium puzzle is one of the great empirical failures of rational expectation economics, and it represents the asset pricing perspective of the equity risk premium.

When deciding to allocate savings in a portfolio of bonds and stocks, the equity premium is of fundamental importance. Data from the United States reveal that less than 50 percent of the population own stocks, which is puzzling given the eight percent risk premium on stocks. What keeps a majority of the population out of such an attractive market? A second feature of data on households’ portfolios is the high degree of heterogeneity in asset allocation. How can households act on the same information in such different ways? One proposed explanation to the equity premium puzzle is that the consumption model holds for households owning stocks. However, this does not explain why the rest of the households stay out of the stock market. Hence, portfolio choice and asset pricing can be seen as different sides of the same coin.

This thesis contains empirical studies of portfolio choice and asset prices. The first two chapters explore the consequences of incorporating labor supply into models traditionally only focusing on consumption. Do possibilities of varying labor supply, and thus hedging stock market risk, help explain the stock ownership patterns of households? This is the topic of the first chapter. Can the risk premium on stocks be better understood when taking labor supply into account? This question is what the second chapter tries to answer. If labor income moves with the stock market, an attempt should be made to hedge this with a lower share of stocks in the portfolio, but do households act according to this rule? This is what the third chapter investigates.

Chapter one, Labor Supply Flexibility and Portfolio Choice: Evidence from the PSID, examines the relationship between labor supply flexibility and portfolio choice. Theoretical articles have shown that, ceteris paribus, the optimal portfolio share of risky assets (stocks) increases with labor supply flexibility, due to increased possibilities of
hedging financial risk by adjusting the labor supply. Using PSID household data, this hypothesis is tested using a direct measure of labor supply flexibility from survey questions. The results indicate that the total portfolio share is increased by labor supply flexibility. When separated, most of this effect seems to come from the increased probability of stock ownership due to flexible labor, rather than an increased portfolio share among stockholders.

Chapter two, *Can Leisure Explain the Equity Premium Puzzle? An Empirical Investigation*, investigates the asset pricing properties of non-separable utility functions with consumption and leisure. The parameter restrictions needed to match the historical equity premium are explored using US data on consumption, hours and returns. Empirically, it is shown that to match the equity premium with a low level of risk aversion, consumption and leisure need to be strong complements, i.e. have a very low substitution elasticity.

Chapter three, *Income Risk and Stockholdings: Evidence from Swedish Microdata*, examines the relationship between income risk and portfolio choice. It empirically investigates whether the stock market risk (the covariation with the stock market) in labor income is reflected by an offsetting lower share of stocks in financial portfolios, an effect that has been shown to exist in theoretical articles. Swedish microdata from HINK on households' income and wealth are used for this purpose. In repeated cross-sections, households are divided into "portfolio cohorts" corresponding to percentiles of the share of stocks in financial assets. Income risk, i.e. the regression beta of (log) income growth on aggregate stock returns, is compared for the different groups. As predicted by theory, the results provide some support for a negative relationship between income risk and the share of stocks.
Chapter 1
Labor Supply Flexibility and Portfolio Choice: Evidence from the PSID*

Björn Lagerwall**

Abstract

This paper examines the relationship between labor supply flexibility and portfolio choice. Theoretical articles have shown that, ceteris paribus, the optimal portfolio share of risky assets (stocks) increases with labor supply flexibility, due to increased possibilities of hedging financial risk by adjusting the labor supply. Using PSID household data, this hypothesis is tested using a direct measure of labor supply flexibility from survey questions. The results indicate that the total portfolio share is increased by labor supply flexibility. When separated, most of this effect seems to come from the increased probability of stock ownership due to flexible labor, rather than an increased portfolio share among stockholders.

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1 Introduction

This paper is one of the first empirical tests of the relationship between labor supply flexibility and portfolio choice. The intuition for why labor supply should increase the willingness to invest in risky assets is simple: great control over labor supply makes it possible to compensate value losses in financial assets by increasing the labor supply. Bodie et al (1992) showed theoretically that the greater is labor supply flexibility, the higher should the share of stocks in the investor's portfolio be. Chan and Viceira (2000) is another example of a theoretical article confirming the results of Bodie et al (1992), but generalizing to an incomplete markets environment with nontradeable labor income.

Bodie et al (1992) offer suggestions of how to empirically test the predictions of their model. Given a suitable measure of flexibility, the authors claim that a positive correlation would be expected between holdings of risky assets and labor flexibility in a cross-section of households. The problem in applying this suggested test is that few data sets simultaneously offer good descriptions of households' labor flexibility and asset holdings.

Benitez-Silva (2003) has explicitly tested the relation between labor supply flexibility and portfolio choice. The data used in that essay, the Health and Retirement Study (US), mainly consist of elderly people. This constitutes a potential problem, since according to theoretical essays by e.g. Bodie et al (1992) and Chan and Viceira (2000), the effect is stronger for younger individuals. One characteristic of Benitez-Silva's investigation is that survey answers were used as measures of labor supply flexibility. Three waves of the survey (1992-1997) were used. The respondents were asked about their opportunity to increase/decrease their working hours. The answers (yes/no) regarding increases were then used as a dummy variable in a cross-sectional analysis. Further, a more implicit measure of flexibility was used, namely a dummy indicating if the respondent had an additional job, but according

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1 The authors suggest that jobs with great flexibility in labor supply are those offering opportunities for working additional hours, taking additional jobs, or delaying retirement. Another more indirect measure that is suggested is family status, in the sense that households with many potential workers enjoy greater labor flexibility. Out of these suggested flexibility measures, opportunities for working additional hours appear to be most natural as a hedging devise.

2 Arguably, this is the only important measure of hedging.
to the author, this may be an inappropriate measure. The analysis concluded that
the amount of risky assets (not portfolio share) was significantly increased by the
ability to increase the working hours, but not by holding an additional job.

This paper examines labor supply flexibility from survey answers of the Panel Study
of Income Dynamics (PSID). The 1984 survey was the last containing questions
about the respondents’ possibilities to vary their labor supply. In particular, the
respondents were asked if they could have worked more on their job if they wanted
to. This makes the study comparable to that of Benitez-Silva (2003). However,
all age groups are included in the PSID data set, which is a great advantage since,
as mentioned above, labor supply flexibility is particularly important for younger
households. Further, it is quite common to use the PSID in empirical studies of
consumption, portfolio choice and also asset pricing; see e.g. Mankiw and Zeldes

The paper is organized as follows. Section 2 briefly surveys modern theory and
empirical studies of portfolio choice. Section 3 provides a theoretical background of
both a standard portfolio choice model and a model with labor supply flexibility.
Section 4 describes the data set, while section 5 describes the empirical strategy.
Section 6 provides the results and section 7 concludes.

2 A Brief Survey of Portfolio Theory and Empirical Studies

2.1 Classic Portfolio Theory

Modern portfolio theory with multi-period utility-maximizing individuals was intro-
duced by Merton (1969) and Samuelson (1969). Two striking results came out of
these essays. First, assuming i.i.d. returns and constant relative risk aversion util-

3 This could actually be a measure of lack of flexibility due to increased bounds on hours because
of the multiple jobs.

4 They were also asked if they could have worked less, but this is arguably not interesting as a
hedging devise.

5 Mossin (1968) is another early contribution to this literature.
ity, the optimal share of risky assets is constant and independent of the investment horizon. Second, the optimal share of risky assets is also independent of the wealth level. At least the first of these results was striking and at odds with common advice from the finance industry, where younger people are advised to hold more stocks than older people. One further implicit assumption in these classical theories of portfolio choice is that there is no labor income or other non-tradable assets and hence, markets are complete. It is important that to generate other predictions than those of the classical models, deviations from one or more of the underlying assumptions are needed. The most common deviations have been the introduction of (possibly non-tradable) labor income, and non-i.i.d. returns.

2.2 Early Empirical Studies

Early empirical studies of portfolio choice were mainly tests of utility functions. For example, a common question was whether risk aversion increased or decreased with wealth. Friend and Blume (1975) concluded that constant relative risk aversion was supported by their cross-sectional household data from the Federal Reserve Board, since the portfolio shares were fairly constant over different levels of wealth. Furthermore, estimated risk aversion coefficients based on portfolio choice were plausible. In 1975, Journal of Finance devoted an issue to studies of household portfolio choices. Once more, the focus was mainly on inferring preferences (increasing, constant or decreasing relative risk aversion) and, in addition, the degree of diversification. One conclusion was that, according to Blume and Friend (1975) households tended to hold poorly diversified portfolios.

2.3 A Solved Problem?

After the 1970s, portfolio choice was not a frontier field of finance. Heaton and Lucas (2000) argue that this was due to the fact that the early empirical tests of portfolio choice models on household data (e.g. Friend and Blume, 1975) offered
support for the predictions of theory. For this reason, the problem of portfolio choice was considered to be solved, and there was little research in this area during the next decade. Campbell and Viceira (2001) also conclude that for a long time, portfolio choice was "a rather quiet backwater of finance."

Some exceptions to this development are the papers by King and Leape (1984, 1987) dealing with the wealth- and life-cycle effects of portfolio choice. In their first paper, King and Leape (1984) supported the earlier findings that households hold incomplete portfolios. It was also shown that the portfolio choices of households changed with wealth. The data used were Survey of Consumer Financial Decisions by SRI international. Using the same data set, King and Leape (1987) found support for a life-cycle effect on portfolio choice: age was an important determinant of household portfolios in the empirical investigation, which was partly a rejection of the models of Merton-Samuelson where life-cycle effects are absent. Hence, as compared to earlier research of Friend and Blume (1975), the results differed considerably, possibly because of the more complete and novel data set used. However, the papers by King and Leape (1984, 1987) did not receive much attention at the time (they were not published), which meant that these rejections never spurred a new interest in portfolio choice.

2.4 New Problems - Renewed Interest

An interest in portfolio choice has emerged during the 1990s and onwards for several reasons. First, researchers have become more interested in models with various deviations from the neoclassical consumption model from which the Merton-Samuelson models were derived, including incomplete markets. Second, and in my view the single most important factor, is the development of the consumption-based capital asset pricing model (CCAPM) in the late 1970s and early 1980s (see Lucas, 1978, Breeden, 1979 and Grossman and Shiller, 1981, 1982). The many empirical tests

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6 Cochrane (2001) offers an explanation for this conclusion. In the model estimated by Friend and Blume (1975), consumption is assumed to be perfectly correlated with wealth. Hence, consumption variance equals stock return variance for an investor holding the market portfolio. In practice, consumption standard deviation is only about one tenth of that of stock returns. Hence, much higher risk aversion is needed when taking this into account. However, the link between consumption volatility, stock returns and risk aversion was not noticed until the consumption based CAPM was developed; see more on this issue below.
of that model have generated the "equity premium puzzle" (Mehra and Prescott, 1985) and an increased interest in asset pricing. Researches have become aware of the striking connection between asset pricing and portfolio choice. An important proposed solution to the puzzle by Mankiw and Zeldes (1991) provided a link between portfolio choice and asset pricing. It also confirmed that many households had incomplete portfolios. Third, there has been an increased availability of microdata on portfolio choice in the US and elsewhere. For instance, the Survey of Consumer Finances (SCF) provided detailed information on household's portfolios; it has been issued triennially since 1983. Further, the Panel Study of Income Dynamics (PSID) has also been used, but to a lesser degree. In 1984, the regular information was supplemented with information about portfolios for the first time in the PSID.

One important conclusion from the papers by e.g. Mankiw and Zeldes (1991) is that few households own stocks. This is in contrast with the classical Merton-Samuelson theory, according to which all households should hold at least a small amount of stocks. This has become known as the stockholding puzzle. It can be viewed as the microeconomic version of the equity premium puzzle: given the sizable risk premium on stocks, it is strange that so few household exploit this by investing in them. Halliasos and Bertaut (1995) and Bertaut (1998) use the Survey of Consumer Finances (SCF) to examine the question of why so few households hold stocks. A plausible explanation proposed by the authors was that information costs prevent many households from entering the stock market. Hence, education increased the probability of stock ownership in the empirical investigation.

2.5 New Portfolio Theory

As mentioned above, to derive different predictions than in the classical models of portfolio choice, deviations from one of the core assumptions or more must be added. In recent years, the most common of these have been to consider non-i.i.d. returns and labor income and incomplete markets. Some of this research is reviewed below.

2.5.1 Non-i.i.d. Returns

In the classical model, returns are assumed to be i.i.d. In the late 1980s, documental evidence began to appear of expected stock returns both being predictable
by dividend-price (d/p) ratios (Fama and French, 1988a) and being mean-reverting (Fama and French, 1988b, Poterba and Summers, 1988), which has immediate consequences for optimal portfolio choice. If stock returns are mean reverting, they are effectively less risky over long horizons. Moreover, if the expected returns are predictable by d/p ratios, this may also cause the portfolio choice to change.

Incorporating these elements of expected returns into models of portfolio choice has been one of the most active areas of theoretical portfolio modelling in the last years. Some well-known studies are those of Campbell and Viceira (1999), Brandt (1999) and Barberis (1999). For an excellent survey of this new theory, and its relation to standard modelling, see Cochrane (1999).

Barberis (1999) documents clear mean reversion in expected stock returns. When incorporating this in a theoretical model of portfolio choice, it is shown that stocks are safer for a long horizon and hence, the optimal allocation to stocks is indeed increasing with the investment horizon.

Brandt (1999) incorporates return predictability into a portfolio choice model. It is shown that due to predictability by d/p ratios, the optimal allocation to stocks involves strong elements of market-timing. Thus, changes in d/p ratios involve correspondingly large changes in the stock ratio during the investment horizon.

Campbell and Viceira (1999) confirm the results of Brandt (1999) and show that when returns are time-varying and predictable by d/p ratios, the optimal portfolio rule involves aggressive market timing. A further result is that given the assumed characteristics of stock returns, high returns drive down d/p ratios which signal lower future returns. Hence, as compared to a short-term bill, usually considered as the risk-free asset, stocks offer a good hedge against changing investment opportunities by reducing the reinvestment risk in the very long run. For risk averse investors with long horizons, this hedging demand is found to be large.

To conclude, mean reversion and predictability in stock returns have three different effects on optimal stock allocation. First, given mean reversion, stocks are safer in the long than in the short run, inducing the allocation to stocks to increase with the horizon. Second, the predictability of returns by d/p ratios implies that for a given horizon, the allocation to stocks should change with d/p ratios. Third, mean reversion in stock returns means high returns when the expected future returns, i.e. investment opportunities, are low. Hence, the amount of stocks demanded is higher,
due to hedging from changing investment opportunities.

All the results referred to above concern simulations of theoretical models. The theories are quite complex, which makes them hard to test with household data. However, Ameriks and Zeldes (2001) investigate how household asset allocation varies with age, using both pooled data from the SCF and panel data on individuals from the TIAA-CREF data base. The authors report substantial non-stockownership: more than half the households in the 1998 SCF hold no stocks, either directly or indirectly. Further, there is considerable heterogeneity in the asset allocation across households. Turning to age effects, when disregarding cohort effects (data of birth) but considering time effects (data of observation), the authors find that stock ownership displays a hump-shape with respect to age: increasing in youth and declining with retirement. However, given stock ownership, the share of stocks in financial assets is fairly constant over the life cycle. Considering cohort effects, but not time effects, the equity share increases with age. When following the same individuals over time, there is a clear indication of very inactive portfolio policies. Nearly half the households made no active changes in their portfolio composition over the nine-year sample period. In sum, the empirical results of Ameriks and Zeldes (2001) offer clear evidence against households following any type of the market timing strategies referred to above. Further, equity shares tend to increase with age rather than the opposite, which is optimal given the mean reversion.

2.5.2 Labor Income and Incomplete Markets

One addition to the traditional model is background risk, i.e. some risks that could vary between households, and could not be traded. In this respect, labor income is particularly important. An early theoretical paper showing the effects of labor income risk on portfolio choice is Bodie, Merton and Samuelson (1992). In a continuous time model, they show that the riskier is human capital expressed as wage correlation with stock returns, the lower should the share of stocks in the investor’s portfolio be. The more recent article by Viceira (2001) has a more quantitative approach; in a standard model of consumption and portfolio choice with retirement, labor income is allowed to co-vary positively with stock returns.\footnote{This covariation only affects investors in the labor market, since labor income is zero after retirement.}
for the optimal share of stocks now includes a negative hedging component: the regression beta of stock returns and labor income growth. Viceira’s calibrations of the model show that this hedging demand can be large.

Empirical studies of portfolio choice from the 1990s and onwards have mostly been tests of the new generation of theoretical models with more factors affecting portfolio choice. Some authors have tried to empirically measure the aforementioned effect, i.e. whether portfolio choice is affected by income risk. Guiso, Jappelli and Terlizzese (1996) study the effects of income risk on the portfolio choice of a cross-section of Italian households. They find some evidence of the riskiness of the portfolio being negatively related to the riskiness of income. Heaton and Lucas (2000) use a panel data set of tax payers (“tax model”) to see if the second moments of wage and business income can affect households' shares of stocks. The standard deviation of labor income (wage plus business income) has a negative but insignificant effect on the share of stocks, while the covariance of labor income with stock returns has a significant negative effect on the share of stocks. Lagerwall (2004) provides a more thorough description of the empirical studies of income risk and portfolio choice.

In a theoretical model of income risk and portfolio choice like that of Viceira (2001), labor supply is exogenously fixed, which means that the variation in labor income solely stems from the wage process. Another view is to model labor supply as endogenously chosen by the investor, who thus has a utility function with both labor/leisure and consumption. In this way, the investor’s labor income can be controlled by adjusting labor supply, leading to more aggressive portfolio policies with increased labor supply flexibility. Theoretical research along these lines, for example Bodie et al (1992) and Chan and Viceira (2000), is referred to in the introduction.

2.6 Concluding Remarks

The book by Guiso et. al. (2002) presents recent empirical studies of portfolio choice from Europe and the US. The focus is quite general and both ownership and portfolio shares are examined. The patterns from the US study (Bertaut and Starr-McCluer, 2002) are fairly robust internationally. First, stockholdings and shares of stocks are increasing in wealth, where the latter effect is not consistent with constant relative
risk aversion. Second, age has a significant effect on the probability of stock ownership, which is also evidence against the standard model. Third, educated households tend to hold riskier portfolios, which is consistent with information barriers to stock ownership. Fourth, stockholding has increased during the 1990s, both to the extent that a greater proportion of households hold stocks and that stockholders have larger stock shares. Fifth, households tend to have safe and simple portfolios. However, studying the rich in isolation, Carrol (2002) finds that, compared to the rest of the population, the rich both tend to have riskier portfolios and be much more involved in entrepreneurship. This might seem like a contradictory observation. If entrepreneurship is to be considered as riskier than regular jobs, which is quite likely, why do these households also hold more stocks? One potential explanation is that entrepreneurs possibly have greater labor supply flexibility, which ceteris paribus leads to more stock holdings. Hence, understanding the properties of labor supply flexibility among households can also shed light on previous puzzling observations of portfolio choice.

3 Theoretical background

3.1 Standard Portfolio Choice Model

Here, I review a dynamic portfolio choice model to show the essence of the problem. A continuous-time analogue is the classical model of Merton (1969), while this discrete-time derivation follows Campbell and Viceira (2001). The investor maximizes a standard CRRA utility function subject to a budget constraint:

$$\max_{c_t} E_t \left( \sum_{s=0}^{\infty} \beta^s \frac{C_{t+s}^{1-\gamma}}{1 - \gamma} \right)$$

s.t. $W_{t+1} = R_{t+1}^p (W_t - C_t)$

$$R_{t+1}^p = \alpha_t (R_{t+1} - R_f) + R_f,$$  \hspace{1cm} (1)

where $W$ is wealth and $C$ is consumption. The return on the portfolio, $R_{t+1}^p$, is a function of the allocation between a risky asset (stock) with return $R_{t+1}$ and a safe

8The second feature is not too surprising, considering the sky-rocketing stock prices during the 1990s.
asset (bond) with return $R^f$. The allocation of total wealth to the risky asset is $\alpha_t$. The Euler equation for optimal consumption is

$$1 = \beta E_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} R_{t+1}^p \right]. \quad (3)$$

Assuming joint lognormality of consumption and returns, we can derive the risk-premium equation (Consumption CAPM):

$$E_t r_{t+1} - r^f = \gamma \text{cov} (r_{t+1}, \Delta c_t), \quad (4)$$

where lower-case letters are logs. Divide through the budget constraint (equation 1) by $W_t$:

$$\frac{W_{t+1}}{W_t} = R_{t+1}^p \left( 1 - \frac{C_t}{W_t} \right).$$

Taking logs of this equation yields

$$w_{t+1} - w_t = r_{t+1}^p + \ln \left[ 1 + e^{c_t - W_t} \right].$$

The expression $\ln \left[ 1 + e^{c_t - W_t} \right]$ is nonlinear in $c_t - w_t$; a first-order Taylor approximation around the mean $E(c_t - w_t) = c - w$ yields

$$\Delta w_{t+1} \approx r_{t+1}^p + k + \rho (c_t - w_t), \quad (5)$$

where $k$ and $\rho = \frac{e^{c_t - w_t}}{1 - e^{c_t - w_t}}$ are constants. Similarly, the portfolio return (equation 2) can be log-linearized. Divide through by $R^f$:

$$\frac{R_{t+1}^p}{R^f} = \alpha_t \left( \frac{R_{t+1}}{R^f} - 1 \right) + 1.$$ 

Take logs of both sides according to

$$r_{t+1}^p - r^f = \ln \left[ \alpha \left( e^{r_{t+1} - r^f} - 1 \right) + 1 \right].$$

A first-order Taylor approximation of $\ln \left[ \alpha \left( e^{r_{t+1} - r^f} - 1 \right) + 1 \right]$ around $r_{t+1} - r^f = 0$ yields

$$r_{t+1}^p - r^f \approx \alpha_t (r_{t+1} - r^f)$$

$$\Rightarrow r_{t+1}^p \approx \alpha_t (r_{t+1} - r^f) + r^f. \quad (6)$$

This can be simplified by assuming consumption to be a constant fraction $b$ of wealth: $\frac{C_t}{W_t} = b$, which means that in logs, we have

$$c_t = b + w_t,$$
and taking first differences means that log consumption moves one-for-one with log wealth:

$$\Delta c_{t+1} = \Delta w_{t+1}. \quad (7)$$

The assumption that consumption is a constant fraction of wealth is satisfied under two conditions. First, if returns are i.i.d. and utility is CRRA, the scale independence of utility together with constant investments opportunities make consumption a constant fraction of wealth. Second, even with time-varying investment opportunities, if we have log utility (the limit of $\gamma = 1$), consumption is once more a constant fraction of wealth since the income- and substitution effects from changing investment opportunities cancel. Throughout the theoretical derivation, I assume that returns are i.i.d. and utility CRRA.

Substituting $\Delta w_{t+1} = \Delta c_{t+1}$ into the risk premium equation (4) yields

$$E_t r_{t+1} - r^f = \gamma \text{cov} (r_{t+1}, \Delta w_{t+1}).$$

We can substitute the approximate expression for $\Delta w_{t+1}$ (equation 5) according to

$$E_t r_{t+1} - r^f = \gamma \text{cov} \left( r_{t+1}, k + \rho (c_t - w_t) + r_{t+1}^p \right) = \gamma \text{cov} (r_{t+1}, r_{t+1}^p).$$

Finally, substitute the expression for the approximate portfolio return $r_{t+1}^p$ (equation 6), which means that

$$E_t r_{t+1} - r^f = \gamma \text{cov} \left\{ r_{t+1}, \alpha_t \left( r_{t+1} - r^f \right) + r^f \right\} = \gamma \alpha \sigma^2_{r_{t+1}}.$$

The demand for the risky asset is entirely driven by the first two moments of excess stock returns and risk aversion:

$$\alpha = \frac{1}{\gamma} \frac{E_t r_{t+1} - r^f}{\sigma^2_{r_{t+1}}}, \quad (8)$$

which is the standard portfolio choice solution of Merton (1969).
3.2 Portfolio Choice with Endogenous Labor Supply

One particularly simple specification of the portfolio problem with leisure in the utility function is to have separability of leisure and consumption. As will be shown, leisure does not enter the Euler equation for consumption. This model is inspired by the models of Campbell and Viceira (2001) and Chan and Viceira (2002), but it is simplified with a constant real wage and absent retirement. The following maximization problem applies:

\[
\max_{\alpha_t} E_t \sum_{s=0}^{\infty} \beta^s \left[ \frac{C_{t+s}^{1-\gamma}}{1-\gamma} + \theta \frac{(1 - N_{t+s})^{1-\lambda}}{1-\lambda} \right]
\]

s.t. \( W_{t+1} = R^p_{t+1} (W_t + N_t - C_t) \) (9)

\( R^p_{t+1} = \alpha_t (R_{t+1} - R^f) + R^f \). (10)

Consumption is both due to accumulated wealth \( W_t \) and labor income (real wage times labor supply \( N_t \)) where, for simplicity, I have normalized the real wage to one. Hence, labor income is solely dependent on labor supply \( N_t \). Otherwise, the model is similar to the standard one.

The Euler equation for optimal consumption is exactly the same as before, due to the separability in utility between leisure and consumption:

\[
\beta E_t R^p_{t+1} \left[ \frac{C_{t+1}}{C_t} \right]^{-\gamma} = 1,
\]

where, as previously, this could be approximated in log-form, assuming lognormality:

\[
E_t r_{t+1} - r^f = \gamma \text{cov} (r_{t+1}, \Delta c_{t+1}).
\]

Divide through the budget constraint (equation 9) by \( W_t \) according to

\[
\frac{W_{t+1}}{W_t} = R^p_{t+1} \left( 1 + \frac{N_t}{W_t} - \frac{C_t}{W_t} \right).
\]

Taking logs yields

\[
w_{t+1} - w_t = r^p_{t+1} + \ln \left[ 1 + e^{(n_t - w_t)} - e^{(c_t - w_t)} \right].
\]

A first-order Taylor approximation of \( \ln \left[ 1 + e^{(n_t - w_t)} - e^{(c_t - w_t)} \right] \) around the means \( E(n_t - w_t) = n - w \) and \( E(c_t - w_t) = c - w \) gives an approximate budget constraint of the form
\[
\Delta w_{t+1} \approx \phi + \rho_n (n_t - w_t) + \rho_c (c_t - w_t) + r^p_{t+1},
\]
where \(\rho_n = \frac{e^{(n-w)}}{1+e^{(n-w)}-e^{c-w}}\), \(\rho_c = \frac{e^{(c-w)}}{1+e^{(n-w)}-e^{(c-w)}}\) and \(\phi\) is another constant.

A first-order Taylor approximation of the log portfolio return is exactly the same as in the last section, i.e.
\[
r^p_{t+1} \approx \alpha_t (r_{t+1} - r^f) + r^f.
\]
The first-order condition for labor and consumption together is
\[
\theta (1 - N_t)^{-\lambda} = C_t^{-\gamma},
\]
i.e. that the marginal utility of consumption times the real wage (which is equal to one) should equal the marginal utility of leisure. Taking logs of both sides of equation (14) gives
\[
\ln \theta - \lambda \ln (1 - e^{nt}) = -\gamma c_t.
\]
The expression \(\ln (1 - e^{nt})\) can be approximated with first-order Taylor expansion around \(E(n_t) = n\), according to
\[
\ln \theta - \lambda ((1 - e^n) - \rho_n n_t, ) = -\gamma c_t,
\]
where \(\rho_n = \frac{e^n}{1-e^n}\). Hence, log labor supply is
\[
n_t \approx k - \frac{1}{\lambda \rho_n} \gamma c_t,
\]
where \(k\) is a constant. In first differences, we have that
\[
\Delta n_{t+1} \approx -\frac{1}{\lambda \rho_n} \gamma \Delta c_{t+1},
\]
where \(\frac{1}{\lambda \rho_n}\) is the elasticity of log labor supply. If \(\frac{1}{\lambda \rho_n}\) is zero, labor supply is obviously constant. As before, assume consumption to be a constant fraction of total wealth, which is now equal to financial wealth plus labor income\(^9\) which, in turn, is identical to labor supply \(N_t\). Hence, we have that
\[
\frac{C_t}{W_t + N_t} = b
\]
\(^9\)This is a simplification, since more realistically, it is the expected present value of all future realizations of labor income that enters total wealth.
\[ C_t = b \left( W_t + N_t \right). \]

Now, divide through this expression by \( N_t \), i.e.

\[ \frac{C_t}{N_t} = b \left( \frac{W_t}{N_t} + \frac{1}{N_t} \right). \]

Taking logs means that

\[ c_t - n_t = \ln b + \ln \left[ e^{w_t-n_t} + 1 \right]. \]

A first-order Taylor approximation of \( \ln \left[ e^{w_t-n_t} + 1 \right] \) around \( E(w_t-n_t) = w - n \) means that

\[ c_t - n_t \approx k + \rho_w (w_t - n_t), \]

where \( \rho_w = \frac{e^{w-n}}{e^{w-n} + 1} < 1 \) and \( k \) is another constant. Solving for \( c_t \), we thus have that

\[ c_t \approx k + \rho_w w_t + (1 - \rho_w) n_t, \]

where \( \rho_w \) and \( (1 - \rho_w) \) are the respective log consumption elasticities of log wealth and log labor income which, by definition, are both lower than one. In first differences,

\[ \Delta c_{t+1} \approx \rho_w \Delta w_{t+1} + (1 - \rho_w) \Delta n_{t+1}. \quad (16) \]

We can substitute the expression for \( \Delta n_{t+1} \) above (equation 15) into the consumption equation (16):

\[ \Delta c_{t+1} \approx \rho_w \Delta w_{t+1} + (1 - \rho_w) \left( \frac{1}{\lambda \rho_n} \gamma \Delta c_{t+1} \right). \]

This can be solved for consumption as a function of wealth, i.e.

\[ \Delta c_{t+1} \approx \frac{\rho_w}{1 + (1 - \rho_w) \frac{1}{\lambda \rho_n} \gamma} \Delta w_{t+1}. \quad (17) \]

Expression (17) can now be inserted into the Euler equation (11), resulting in the following:

\[ E_t r_{t+1} - r^f = \gamma \text{cov} \left( r_{t+1}, \frac{\rho_w}{1 + (1 - \rho_w) \frac{1}{\lambda \rho_n} \gamma} \Delta w_{t+1} \right) = \]

\[ = \frac{\gamma \rho_w}{1 + (1 - \rho_w) \frac{1}{\lambda \rho_n} \gamma} \text{cov} (r_{t+1}, \Delta w_{t+1}). \quad (18) \]
Using the expression for $\Delta w_{t+1}$ (equation 12), we have the wealth covariance

$$\text{cov} (r_{t+1}, \Delta w_{t+1}) = \alpha \sigma^2.$$ 

Hence, equation (18) reduces to

$$E_t r_{t+1} - r^f = \frac{\gamma \rho_w}{1 + (1 - \rho_w) \frac{1}{\lambda \rho_n}} \alpha \sigma.$$ 

We can solve for optimal $\alpha$ as before, and the solution is

$$\alpha = \frac{E_t r_{t+1} - r^f}{\sigma^2} \frac{1}{\gamma \rho_w} = \frac{1}{\gamma \rho_w} \left[ \frac{1}{\rho_w} + \frac{1 - \rho_w}{\rho_w} \frac{1}{\lambda \rho_n} \right]. \quad (19)$$

The Sharpe ratio is multiplied by two terms in the parenthesis. The first is very similar to the ordinary portfolio expression (8): the inverse of risk aversion times the wealth elasticity of consumption. The second term in the parenthesis increases the demand for risky assets as compared to this base case: the higher is labor elasticity $\lambda \rho_n$, the more risky assets are demanded. Hence, it can be seen from the expression (19) that the optimal portfolio share of stocks is increasing in labor-supply flexibility.

## 4 Empirical Strategy

In the theoretical model described above, the portfolio choice decision is only how large a fraction to invest in the risky and risk-free asset, respectively. In reality, only a fraction of households hold risky assets, i.e. stocks of any form. Basically, there are two different ways of empirically estimating portfolio choices. First, one may want to capture the total portfolio share including non-stockholders and second, one may want to separate this effect into ownership and portfolio shares of stockholders. I will describe these strategies below.

### 4.1 Total effect: Tobit Regression

The decision not to hold stocks can be seen as a portfolio choice of zero risky assets. Hence, throwing away non-stockholders may remove information on portfolio choice.
Instead of concentrating on ownership or portfolio share conditional on ownership, both might be estimated at the same time. The Tobit model, first proposed by Tobin (1958), is a simple way of doing this. The same specification is assumed to be valid for both the entry decision and the portfolio share decision.

4.2 Separated Ownership and Portfolio Effects: Two-step Regression

Since only a share of households own stocks, it is common to estimate a regression trying to explain ownership; see e.g. Bertaut and Haliassos (1995). In this case, a probit model is estimated. However, this only explains the decision to own stocks, not the portfolio share described by the classic model (reviewed in section 2). It could be considered as a rough approximation, seeing the portfolio choice as "stocks" or "no stocks." Another strategy is to concentrate on stockholders only, since they are the only ones who really make a choice on the share of stocks in the portfolio. Among stockholders, there is an attempt to explain differences in the share of stocks in financial assets. This is a direct empirical test of the classical portfolio theory. However, the inference now concerns the stockholding part of the population, not the population as a whole, since there is a potential selection bias.

The two-step approach pioneered by Heckman (1976, 1979), commonly referred to as Heckit, may be used if one wants to model the decision to hold stocks separately from the portfolio decision. In this case, a probit is first estimated to explain ownership, including variables that are absent in the portfolio specification. Second, the information in the entry equation is used as an additional explanatory variable in the portfolio decision.\textsuperscript{10} It should be known that according to the classical theory, this is simply not true. The decision is continuous, and the portfolio decision is the only relevant decision.

\textsuperscript{10}This is done in the form of an "inverse Mills ratio" from the first regression that is used in the second.
5 Data Description and Summary Statistics

In the Panel Study of Income Dynamics (PSID), the 1984 survey was the first to include questions of wealth and its components. The usual background data were collected together with this information. For an overview of the PSID data set, see Brown et al (1996). This data set was used by Mankiw and Zeldes (1991) in a well-known study of the consumption of stockholders and nonstockholders. Interestingly, the 1984 survey was the last containing questions about the respondents' possibilities to vary their labor supply. In particular, the respondents were asked if they could have worked more on their job if they had wanted to.\(^{11}\)

In using this data set, I delete top-coded variables and extreme values. Further, for obvious reasons, only people working are included in the study. The total financial assets must be at least 100$ to exclude incidental holdings. The same limit is also set for stock ownership, i.e. a person with less than 100$ in stockholdings is treated as a nonstockholder. Totally, 2364 households are left for the empirical analysis. Table 1 shows some characteristics of financial asset ownership, both for the whole sample and respondents with flexible labor, i.e. those having answered that they can increase their working time.

Starting with the full sample, the fraction of households that are stockholders is around 26%, a figure similar to Mankiw and Zeldes (1991). The share of stocks in stockholders' portfolios is 46% on average, whereas it is only 12% when including nonstockholders (0.26 x 0.46). Around 43% of the households reported flexible labor. For the sample of households with flexible labor, the fraction of stockholders is larger than that of nonflexible-labor households (0.30 vs 0.23). However, the portfolio share of stocks for stockholders is somewhat lower for flexible-labor households (0.43 vs 0.48). The total share of stocks including nonstockholders is slightly higher for the flexible-labor group (0.13 vs 0.11).

Table 2 presents descriptive statistics for nonstockholders and different degrees of stock ownership. A number of control variables are added. Some characteristics of the results can be seen. First, considering stockholders vs nonstockholders, the mean

\(^{11}\)They were also asked if they could have worked less but arguably, this is not interesting as a hedging devise.
age, the fraction with a college degree, the mean wage, and the mean total financial assets are all higher for stockholders than nonstockholders. Further, in accordance with the results in Table 1, a higher proportion of stockholders reported flexible labor as compared to nonstockholders (50% vs 40%). For stockholders, quartiles 1 to 4 referring to the stock share in total financial assets are displayed. There is no indication of any systematic relationships between the control variables and the degree of stock ownership, conditioned on being a stockholder. This is also true for labor supply flexibility.

To conclude, the descriptive statistics hint at some regularities in the differences between stockholders and nonstockholders. Among other things, stockholders on average seem to be more flexible than nonstockholders as concerns labor. For stockholders, the portfolio share does not seem positively related to labor supply flexibility. However, according to Table 1, if nonstockholders are included, households reporting flexible labor on average have a higher portfolio share of stocks. I report the econometric results below.

6 Results

6.1 Total effect: Tobit Regression

Table 3 shows a tobit regression for all households, including nonstockholders. The dependent variable is the share of stocks, but this is zero for all nonstockholders, which is taken into account. Intuitively, a tobit can be seen as a product of an OLS and probit regression, in the sense that it tries to explain the probability of stock ownership times the portfolio share, a kind of an expected share of stocks. Thus, this model is useful in studying the pattern in the descriptive statistics that flexible labor seems to raise the TOTAL share of stocks, i.e. probability times share. The table both shows a standard tobit with censoring at 0 and a tobit with censoring both at 0 and 1, since some households only have stocks in the financial assets.

The signs of the control variables are as expected, and the coefficients are mainly significant. Labor supply flexibility also has the expected sign, and the significance is quite high (2-tailed $p$-value of around 0.11)
6.2 Separated Ownership and Portfolio Effects: Two-step Regression

The first part of this strategy is to see whether labor supply flexibility raises the probability of stock ownership. For this purpose, a probit regression is run, including a number of control variables. Except labor supply flexibility, the variables included are common in this setting; see e.g. Guiso et al (2002). Table 4 reports the results of a probit regression. The estimated coefficients in a probit do not equal the marginal effects on the probability; I have reported these effects as $dF/dx$, in addition to the coefficients.

All coefficients on the control variables have the expected signs, but age squared and total financial assets are not statistically significant. Education and marriage seem to be the quantitatively most important control variables. Turning to labor supply flexibility, the coefficient has the predicted sign and is also statistically significant, which confirms the results from the descriptive statistics. Quantitatively, flexible labor increases the probability of stock ownership by about 4%.

If a regression explaining the share of stocks in financial assets on the sample of stockholders were to be estimated, it is implicitly assumed that stockholders could be analyzed separately from nonstockholders. Hence, there is no self-selection into stock ownership. However, there may be factors affecting stock ownership, possibly unobservables, that could also be important in explaining the share of stocks. The Heckman (1976, 1979) two-step estimator makes it possible to analyze this econometrically. A probit to explain stock ownership is estimated on the whole sample, in the same way as previously. Information from this estimation, the inverse Mills ratio, is then used in a second OLS regression to determine the stock share of the sample of stockholders. If the coefficient on the Mills ratio (or ultimately the correlation between residuals, $\rho$) is significant in the second regression, there is an indication of selection bias.

Table 5 reports the results of such a regression. To begin with, the same explanatory variables are used in both equations.\footnote{This makes it somewhat harder to estimate the model due to problems of collinearity. Ideally, some additional variables in the selection equation would be desired, an issue which will be addressed below.}

The model is estimated with the more
efficient maximum-likelihood, instead of the standard two-step method, which also makes it possible to directly estimate $\rho$. Table 5 confirms the view that ownership is much easier to explain than portfolio shares for stockholders. The results of the first step in the Heckman model are almost identical to those of the probit model estimated earlier. The results of the second-step equation are similar to the separate OLS on stockholders, which is also reported in the table for comparison. A notable difference is that labor supply flexibility has a higher $p$-value in the second-step equation, as compared to OLS. Interestingly, the estimated $\rho$ parameter is not significant, thereby indicating that there is no selection bias. Hence, the equations do not have any common residual relation, and the OLS and the probit could be estimated separately.

One restrictive assumption of the Tobit model is that the same variables, and their effects, govern both the probability of stock ownership and the portfolio share, given ownership. It is possible that some variables are important for the probability of ownership, but not for the optimal share. Education and wealth seem important in determining the probabilities of ownership, but may be irrelevant for the optimal share, given ownership. In Table 6, I have estimated a model where education, wage and total financial assets are included in the selection equation (a probit) and not in the second equation. The first equation is thus identical to the probit estimated earlier, but the second step is a smaller specification with four variables.

The results are similar to the specification in Table 5. The stock-share equation has low explanatory power and the results from the ownership equation are once more almost identical to the earlier probit. Further, the second equation on portfolio shares shows none of the control variables to be significant. Once again, labor supply flexibility seems to have a negative effect on the portfolio share, and the coefficient is now significant at 10% in the Heckman model. In Table 7, a further specification of the two-step model is presented, with similar results.

To sum up, the results indicate the probability of stock ownership to be increased by labor supply flexibility. The stock share in the portfolio of stockholders is hard to explain in the regression framework, but labor supply flexibility seems negatively related to the stock share, given ownership. The total portfolio share including nonstockholders, estimated with Tobit, seems positively related to labor supply flexibility, in accordance with theory. Different specifications of Heckman selection

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models confirm the results from the probit and OLS regressions and no selection bias was found.

7 Conclusions

This is one of the first empirical studies of the relationship between labor supply flexibility and portfolio choice. Benitez-Silva, 2003, has found some support for a positive effect of labor supply flexibility on the amount of risky assets held by households in the US. This confirms the result from earlier theoretical models of portfolio choice with endogenous labor supply, e.g. Bodie et al. (1992).

The results in this paper indicate that the probability of stock ownership is increased by labor supply flexibility. The stock share in the portfolio of stockholders is hard to explain in the regression framework, but labor supply flexibility seems negatively related to the stock share, given ownership. The total portfolio share including nonstockholders, estimated with Tobit, seems positively related to labor supply flexibility, in accordance with theory. Different specifications of Heckman selection models confirm the results from the probit and OLS regressions and no selection bias was shown.
References


### Table 1. Descriptive statistics

<table>
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<th>No flexible labor</th>
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<td>N</td>
<td>Mean</td>
<td>N</td>
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<tr>
<td>Total financial assets, dollars</td>
<td>2364</td>
<td>19945</td>
<td>1013</td>
</tr>
<tr>
<td>Stockholdings, dollars</td>
<td>2364</td>
<td>5149</td>
<td>1013</td>
</tr>
<tr>
<td>Fraction stockholders</td>
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<td>1013</td>
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<tr>
<td>Stock ratio including nonstockholders</td>
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<td>Stock ratio, stockholders</td>
<td>615</td>
<td>0.46</td>
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### Table 2. Descriptive statistics: mean values for different degrees of stock ownership

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<tr>
<td>N</td>
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<td>615</td>
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<td>Stock ratio</td>
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<td>0.46</td>
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<td>Age</td>
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<tr>
<td>Married*</td>
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<tr>
<td>Labor supply flexibility*</td>
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*Dummy variable that is one for the described character and zero otherwise.
### Table 3. Tobit on stock share, censoring at 0 (Tobit 1) and censoring at 0 and 1 (Tobit 2).

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<thead>
<tr>
<th></th>
<th>Tobit 1 Coef.</th>
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<td>0.110</td>
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Number of obs
2364
2364
LR chi2(8)
319.11
315.21
Prob > chi2
0.000
0.000
Pseudo R2
0.110
0.107
left-censored observations at 0
1749
1749
uncensored observations
615
593
right-censored observations at 1
22
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<tr>
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<th>Coef.</th>
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<th>p-value</th>
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<td>2.44</td>
<td>0.015</td>
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<tr>
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Observed probability 0.2602
Predicted probability at means 0.2326

Number of obs 2364
LR chi2(8) 382.55
Prob > chi2 0.000
Pseudo R2 0.141

*dF/dx is for a discrete change of dummy variable from 0 to 1. Otherwise, it is an increase from means of indep. variables. Inference refers to coefficients.
Table 5. Heckit on ownership and stock share, and sub-sample OLS on stock-share.

<table>
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<tr>
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### Table 6. Heckit on ownership and stock share, and sub-sample OLS on stock share.

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<th></th>
<th>Heckit Coef.</th>
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<th>OLS Coef.</th>
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Table 7. Heckit on ownership and stock share, and sub-sample OLS on stock-share.

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<tr>
<th>Stock share</th>
<th>Heckit Coef.</th>
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<th>p-value</th>
<th>OLS Coef.</th>
<th>t-ratio</th>
<th>p-value</th>
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Adj R-squared

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<th>p-value</th>
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<td>AGE</td>
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<td>LABOR SUPPLY FLEXIBILITY</td>
<td>0.1394</td>
<td>2.32</td>
<td>0.020</td>
</tr>
</tbody>
</table>

Rho
| Lambda | 0.0625 | 0.43 | 0.664 |
| Number of obs | 2364 |
| Censored obs | 1749 |
| Uncensored obs | 615 |
| Wald chi2(5) | 9.65 |
| Prob > chi2 | 0.086 |
Chapter 2
Can Leisure Explain the Equity Premium Puzzle?  
An Empirical Investigation*

Björn Lagerwall**

Abstract

This paper investigates the asset pricing properties of non-separable utility functions with consumption and leisure. The parameter restrictions needed to match the historical equity premium are explored using US data on consumption, hours and returns. Empirically, it is shown that to match the equity premium with a low level of risk aversion, consumption and leisure need to be strong complements, i.e. have a very low substitution elasticity.

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*I thank Martin Flodén, Lars Ljungqvist and Paul Söderlind for valuable comments. The paper has also benefited from discussions with participants in the macroeconomics workshop at the Stockholm School of Economics. Financial support from Jan Wallander’s and Tom Hedelius’ Foundation is gratefully acknowledged.

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1 Introduction

The high level of the historical equity premium has been hard to understand using standard consumption models. Mehra and Prescott (1985) called this problem the "Equity Premium Puzzle." Using constant relative risk aversion (CRRA) utility, very high risk aversion is needed to match the high equity premium with the low volatility of consumption growth. Several explanations to the puzzle have been proposed; for good surveys, see Mehra and Prescott (2003), Cochrane (1997, 2001), Campbell (1999) and Kocherlakota (1996).

One common feature of the proposed explanations to the equity premium puzzle is that they are refinements of the consumption model in various ways, e.g. habit persistence. Labor supply is almost always omitted, since risk aversion and intertemporal substitution of consumption are considered to be crucial in understanding the puzzle.

In business cycle and labor supply research, utility functions with both consumption and leisure/labor are used. A key ingredient in this line of research is the intertemporal substitution in labor supply, i.e. how labor supply reacts to changes in economic incentives, e.g. wages and interest rates and this is viewed as a fundamental issue in understanding economic fluctuations. The debate in real business cycle research is to a great extent linked to the degree of intertemporal substitution in labor supply and has stimulated a large amount of research in empirical labor economics trying to document this degree of substitution.

There has been little research in exploring the asset pricing properties of consumption-leisure utility specifications. For example, in the survey by Mehra and Prescott (2003), adding leisure in the utility function is not mentioned as a proposed solution to the equity premium puzzle. In his finance textbook, Cochrane (2001) briefly (less than half a page) analyzes leisure when discussing extensions of the consumption model to explain the puzzle. Clearly, this route has not been explored to any great extent, but there are some exceptions.

Lettau (2003) derives asset prices in a theoretical real business cycle model with consumption and leisure. The utility function considered is separable in the two arguments and hence, there is only an indirect effect of flexible labor on the equity

\[ \text{I provide a survey of the puzzle in section 2.} \]
premium (it is zero in a partial equilibrium). Among other things, it is investigated how the introduction of flexible labor affects risk premia. In calibrations, the resulting equity premium is somewhat higher since labor supply responds to technology shocks, thereby increasing consumption volatility. However, this effect is small. Overall, the derived asset pricing results in this general equilibrium production economy are puzzling, and the return of long-term bonds often exceeds that of equity. Lettau's conclusion is that RBC-type asset pricing models cannot at all account for the observed level of equity premia.

Basak (1999) develops a theoretical general equilibrium model with non-separable consumption and leisure to derive equity premium equations in continuous time. Under certain conditions, he shows that consumption-leisure utility can generate different equity premia than the standard consumption model. Some interesting results are presented. With Cobb-Douglas utility and multiple technology shocks, labor is non-stochastic. Furthermore, consumption and stock market volatility are equated, which is entirely contradictory to empirics. The equity premium is the same as in the baseline consumption model. Basak concludes that this commonly used specification must be modified to account for the observed features of the data.

Once more allowing for multiple shocks, but generalizing utility to constant elasticity of substitution (CES) utility, Basak finds that deviations from the predictions in the standard consumption model emerge. The crucial element is the comovement between consumption and leisure, and their complementarity in the utility function. First, if leisure and consumption move in opposite directions (as observed in the data), the equity premium is increased by complementarity between leisure and consumption in the utility function. Second, if leisure and consumption move in the same direction, substitutability between consumption and leisure in the utility function increases the equity premium. Since the model is set in general equilibrium, the comovement between leisure and consumption is, in turn, determined by the intratemporal substitution between consumption and leisure. If this elasticity is less than unity, they comove, whereas an elasticity less than unity implies movements in opposite directions. However, no empirics is carried out.

2The exact effect of a technology shock on labor supply depends on the difference between the firm's output elasticity of the marginal product of labor and the consumer's consumption-leisure elasticity of substitution. With a Cobb-Douglas utility and production function, both these quantities equal unity, and labor supply is deterministic.
The goal of this paper is to empirically investigate if the equity premium can be better understood with consumption-leisure utility. A partial equilibrium model is investigated, with consumption and leisure in different specifications. The intratemporal substitution between consumption and leisure is shown to play a major role. To match the observed equity premium and given the fact that leisure and consumption move in opposite directions, two features are required: first, complementarity between consumption and leisure and second, a low level of intratemporal substitution between these arguments.

Thus, in sum, relative risk aversion and intertemporal substitution in consumption are emphasized in empirical tests of consumption-based asset pricing models, whereas intertemporal substitution in labor/leisure is a central part in a considerable part of business cycle and labor supply research. The success of an asset pricing model with consumption and leisure crucially depends on their intratemporal substitution.

In partial equilibrium models with consumption-leisure utility, non-separability between the two is necessary to obtain a risk premium equation with both leisure and consumption. If the utility function is separable, the marginal utility of consumption only depends on consumption and the prediction of the equity premium is the same as in consumption models.

This paper investigates the asset pricing properties of two different non-separable utility specifications with consumption and leisure. Both belong to the constant elasticity of substitution (CES) class of utility. The first specification is the restriction leading to the important special case of Cobb-Douglas (C-D), and the second is a utility without these restrictions, which I simply denote CES. The parameter restrictions needed to match the historical equity premium are explored using US quarterly data on consumption, hours and returns.

The paper proceeds as follows. Section 2 briefly surveys the research on the equity premium puzzle, and Section 3 provides a theoretical background of consumption-based asset pricing and the extension with leisure. Section 4 discusses the non-separable utility functions with consumption and leisure to be used. Section 5 presents the empirical strategy, while section 6 describes the data set and provides some summary statistics. Section 7 displays the results and finally, section 8 concludes.
2 A Survey of the Equity Premium Puzzle and Proposed Solutions

2.1 The Consumption-Based Capital Asset Pricing Model

The consumption-based capital asset pricing model (CCAPM) was developed in a series of papers in the late 1970s and early 1980s. Lucas (1978) derived a pure exchange model where asset prices were shown to depend on the marginal utilities of consumption in different periods, and Breeden (1979) derived asset returns depending on covariances with consumption growth. Further developments of the model were made by Grossman and Shiller (1981, 1982) with constant relative risk aversion (CRRA) utility. The fundamental aspect of the model is that the intertemporal first-order condition for optimal consumption, or the Euler equation, is taken as the basis for asset prices, which makes this kind of model extremely general and intuitively appealing. Furthermore, whereas the traditional capital asset pricing model takes the excess return on the stock market as given, the consumption-based model holds for all assets, including a broad stock market index, usually applied as a proxy for the market portfolio.

2.2 The Equity Premium Puzzle

Unfortunately, early empirical investigations of the CCAPM almost immediately rejected the model’s predictions. Grossman and Shiller (1981) concluded that the implied coefficient of relative risk aversion seemed implausibly high when estimating the model on US data. Hansen and Singleton (1983) rejected the model in an econometric specification. In a seminal paper, Mehra and Prescott (1985) used a variant of Lucas’ (1978) model with CRRA utility. With US yearly data from 1890 to 1979, the authors calibrated the parameters so that the model matched the observed moments of consumption growth in the data. Setting the relative risk aversion to 10, i.e. the maximum value considered by Mehra and Prescott, the predicted equity premium was 0.4%. In the data, it was more than 6%! This was called the "Equity Premium Puzzle" and has received an enormous amount of attention.

The driving force behind Mehra and Prescott’s results can be illustrated using the...
derivations of the CCAPM by Grossman and Shiller (1982). Under lognormality assumptions and CRRA utility, the log-equity premium is the product of the CRRA coefficient and the covariance between consumption growth and the equity premium. Empirically, this covariance is extremely low and a very high level of risk aversion is needed to match the observed equity premium.³ Hansen and Jaganathan (1991) illustrated the puzzle in yet another way, emphasizing smoothness of consumption as the main problem of the model. Mankiw and Zeldes (1991) showed that an even higher risk aversion was needed to explain the postwar US equity premium.

To conclude, the essence of the equity premium puzzle is the following. According to the CCAPM, consumption risk, i.e. the covariance between consumption growth and excess return, is the risk of importance. This risk is far too small to justify the observed level of the equity premium, unless an extremely high risk aversion is imposed. Introspection and experiments have shown this not to be reasonable.⁴ One obvious solution to the puzzle is to set the risk aversion coefficient at a very high value, notwithstanding if it is reasonable. However, this leads to a counterfactual very high real interest rate. Weil (1989) dubbed this the "riskfree rate puzzle," but it was already emphasized by Mehra and Prescott (1985).

Several resolutions to the equity premium puzzle have been suggested. Below, I review the main ideas behind these. I have divided the explanations into empirical explanations, focusing on data problems and other shortcomings of the empirical investigations leading to the puzzle, and theoretical explanations, trying to modify the theory of the CCAPM to better match the data, taking as given that the statement of the puzzle is correct.

2.3 Empirical explanations

The empirical explanations can basically be divided into two lines of reasoning: bias in the observed equity premium due to Peso problems and survival, and bias in observed consumption due to non-stockownership of the majority of households.

³In U.S. data, the covariance is usually measured to be around 0.2%, or even lower. To yield an equity premium of 6%, we hence need an implied risk aversion of 6/0.2 = 30
⁴The following is an example from Mankiw and Zeldes (1991): a relative risk aversion of 30 means that the certainty equivalence of a 50-50 bet of 50,000 $ and 100,000$ is approximately 51,000$!
The first line of empirical explanations to the equity premium puzzle takes the observed equity premium as the critical point. Is there really an equity premium of the size mentioned? This line of explanations can be divided into two basic parts: Peso problems and survival bias. In short, Peso problems imply that the ex-ante returns of the CCAPM model are downward biased. By allowing for higher ex-ante risk, the observed premia can be matched by high expected returns. The survival bias literature does the opposite: the observed equity premium is claimed to be upward biased, due to rare lucky circumstances.

The second line of empirical explanations takes into account that far from all households hold stocks. An implicit consequence of the CCAPM is that given a risk premium on stocks, all households should have at least some stocks in their portfolios. Hence, the model should hold better for the stockholding part of the population.

2.3.1 Peso problems

The Peso problem literature has its origins in the studies of exchange rates. It is theoretically reasonable that in a market where agents have rational expectations, the forward exchange rate should be a very good predictor of the realized future spot rate. However, in many empirical studies, the future change in the spot rate is not only erroneously predicted by the forward rate, but the sign is also wrong! One explanation for this is the Peso problem: the forward rate included (non-negligible) probabilities for events that never occurred. Naturally, events never occurring are not present in the data.

The Peso problem has also been used to explain the equity premium puzzle. Rietz (1988) develops a theoretical model with a small probability of a disastrous crash in the economy. He shows that this risk can have an upward effect on the equity premium. As an example, imagine that a crash occurs with a yearly probability of e.g. 1%. Then, the crash only materializes every 100 years and hence, the data set needs to be very long for it to be included with certainty. According to the model, a 1% risk of a 25% decline in consumption could solve the puzzle with a risk aversion below 10. Mehra and Prescott (2003) have two objections to this explanation. First,

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5The term originates from Milton Friedman's comment on the Mexican Peso in the early 1970s. Rogoff (1980) is an early empirical study of the phenomenon.
as yet, a 25% decline in consumption has not occurred in any year, and the data set over US consumption and asset returns becomes quite long to fit with the story. Second, and more importantly, real interest rates should move inversely with the probability of the catastrophe. However, the data do not show real interest rate movements of this kind around events like World War II and the Cuba crisis.

Danthine and Donaldson (1999) take this one step further and develop a model where the crash never occurs, but agents have beliefs that it might and take this into account. This leads to even stronger results, and when calibrated, the authors claim that the model matches the historical level of the US equity premium. Though the model can generate a high equity premium with modest risk aversion, its belief formation in some sense represents a deviation from the rational expectations paradigm. Hence, it is questionable whether the explanation is plausible.6

2.3.2 Survival bias

The survival bias approach takes into account that when observing the equity premium puzzle, mostly US data are used. However, this could be a bad measure of the international stock market as a whole. In comparison with other countries, the US looks very much like a success-story with no war-sufferings close to those of Germany and Japan, for example. A hundred years ago, Argentina had about the same prospects for economic development as the US. However, things did not turn out as well for Argentina. In this case, the ex-post US stock returns seem conditioned on the most favorable outcomes and thus, there could be survival bias, as claimed by e.g. Brown, Goetzmann, and Ross (1995). Studies actually show that other stock markets than the US have shown a poorer performance. Hence, there is some validity in the survival bias critique, but not enough to explain the whole problem. Even in other countries in the world, such as Germany and Japan, the equity premium has been substantial during the 1900s. An excellent survey of stock markets during the 1900s is found in Goetzmann and Jorion (1997).

I will describe behavioral explanations to the puzzle in section 2.5 below.
2.3.3 Stockholders and Nonstockholders

The difference between stock- and nonstockholder consumers is investigated by Mankiw and Zeldes (1991). They use data from the Panel Study of Income Dynamics (PSID) 1970 to 1984. To begin with, it is reported that by 1984, 28% of the sample households hold some kind of stocks. The hypothesis of the paper is that the CCAPM is better matched by the part of the population holding stocks and thus, their consumption should be more correlated with stock returns.\(^7\)

Using the estimated equity premium for the 1948-88 period, the following parameters are estimated in the sample: \(\gamma = 100\) for all consumers, \(\gamma = 262\) for nonstockholders and \(\gamma = 32\) for stockholders. Hence, a much lower risk aversion is needed for stockholders to match the historical equity premium. Mankiw and Zeldes conclude that this only partially solves the puzzle; \(\gamma = 32\) is still far too high. However, they also mention in their paper that if also imposing the three times as large consumption correlation of the stockholders in the Mehra-Prescott 1890-1979 sample, the calibrated risk-aversion is only six.

To conclude, if the results provided by Mankiw and Zeldes in the sample 1970-84 were also to hold for the whole period 1890-1979, there is a potential explanation for a large part of the equity premium puzzle.

The promising results of Mankiw and Zeldes have led other researchers to investigate this issue with new data sets. It has been confirmed that distinguishing between stockholders and non-stockholders is one of the most promising explanations to the equity premium puzzle. Attanasio et al (2002) use U.K. data to examine asset holdings and consumption volatility. For the group of households that are "likely" stockholders' (stock ownership can only be indirectly determined via probit estimations), the consumption CAPM is not rejected. Vising-Jörgensen (2002) shows both theoretically and empirically, using US microdata from the Survey of Consumer Finances (SCF), that limited participation in the stock market has the potential of resolving the equity premium puzzle.

\(^7\)Mankiw and Zeldes use data on food consumption, which is the only consumption measure available in the PSID.
2.4 Theoretical explanations

The theoretical explanations take the observed ex-post equity premium as the "true" one. Hence, the goal of this approach is to develop theoretical models that can generate an equity premium of the size measured empirically. Usually, the test is to insert reasonable values of parameters and calibrate the model. If the observed equity premium is higher than in the standard CCAPM, then a step towards explaining the equity premium puzzle has been taken. There are several different ways of changing the standard CCAPM model. Broadly spoken, they could be divided into the following categories: 1) changing the preferences, and thus the utility function, of consumers. 2) allowing for market frictions, 3) introducing heterogeneity among agents, and 4) behavioral models and deviations from rational expectations. Combinations of these approaches have also been investigated.

2.4.1 Changing the utility function

The dominating type of models changing the utility function is variants of habit persistence. These models introduce non-separability over time. It is also possible to have non-separability over states. In the standard model, there is independence both across time and states: the utility in one state/time combination is independent of that in another.

**Habit persistence** The intuition behind habit persistence utility is that people become accustomed to a specific level of consumption. It is the consumption level relative to this habit that is of importance, not the absolute level. Habit can be divided into two parts: internal and external. Internal habit has a natural interpretation, which can be considered as the consumer's standard of living. The idea is that the same amount of consumption gives different utility, depending on the habit level. External habit is that people compare their consumption, not to their own level, but to the average level in the economy. For this reason, these utility functions are called "catching up with the Joneses", referring to everyone's comparison of his own consumption to that of the "average person." Habit persistence models have been presented by Constantinides (1990), Abel (1990) and Campbell and Cochrane (1999), among others.
A key feature of habit models is that the relative risk aversion is no longer constant. Instead, people become more risk averse the closer is their consumption to the habit, which emphasizes the fact that when reaching the threshold level of wealth, the consumer becomes very cautious and thus, borrowing is shunned. This is the large advantage of this model, since it provides a solution to the risk-free rate puzzle. The main drawback of this class of models is that a very high degree of risk aversion is still needed to generate a high equity premium. A further drawback is that habit preferences have proven troublesome in other contexts, like macroeconomic models of fiscal policy and consumption dynamics; see Ljungqvist and Uhlig (2000) and Lettau and Uhlig (2002).

Recursive Preferences Epstein and Zin (1989, 1991) and Weil (1989) have emphasized recursive preferences with nonseparability across states. An important feature of CRRA utility is that the coefficient of relative risk aversion, which influences the equity premium, is the inverse of the intertemporal elasticity of substitution, which influences the risk-free rate. Hence, a high risk aversion means a strong desire to smooth consumption. With recursive utility, the two parameters can be independently determined, i.e. both risk aversion and substitution elasticity can be high at the same time. Thus, this model can solve the risk-free rate puzzle. However, the problem is that much empirical evidence hints at low intertemporal substitution (see e.g. Campbell, 1999, and Mehra and Prescott, 2003) and hence, not many people consider these preferences to be a plausible solution to the equity premium puzzle.

2.4.2 Market frictions and Market Incompleteness

A basic assumption behind the standard model is the absence of market frictions, and that markets are complete. An early study of transaction costs and asset prices is that of Constantinides (1986), which investigates the impact of transaction costs in a consumption/portfolio choice model. He concludes that the liquidity premium resulting from transaction costs is small, since consumers react to the transaction cost by reducing the volume and frequency of trade, and utility is insensitive to deviations from optimal portfolio policies. One conclusion is that transaction costs can hardly account for the differences in returns for small and large company stocks. However, and most importantly, no relation to the aggregate equity premium or
Mehra and Prescott’s (1985) puzzling results is mentioned, since the results are not modelled in the CCAPM framework.\textsuperscript{8}

Aiyagari (1993) describes a model containing incomplete markets and transaction costs. In this model, agents face uninsurable idiosyncratic risk. Furthermore, markets are incomplete in the sense that agents cannot buy claims against their labor income; hence they must trade assets to self-insure against income risk, which increases the demand for assets, thereby driving down the risk-free return. In Aiyagari’s model, there are transaction costs for stocks and not for the risk-free asset, which makes transaction costs important in equilibrium. Hence, this induces a liquidity premium for stocks, which drives up the equity premium, while the risk-free rate is still low. However, Campbell (1999) points out a weakness of this argument. If stocks have a liquidity premium, so will long-term bonds. In the empirical literature, small return premia are reported for bonds over bills, which indicates that liquidity plays a limited role in explaining return differences.

### 2.4.3 Heterogeneous consumers

There are several ways of introducing heterogeneity among consumers. Arguably, the most successful attempt has been provided by Constantinides and Duffie (1996). In their model, consumers face idiosyncratic income risk. The authors point out a potential failure of the standard model: the equity risk premium is zero if consumption growth is constant, since then, it has no covariance with returns. Now, if consumption growth is constant, there might still be variation (and thus covariance with returns) in the cross-sectional variance in consumption growth. Hence, there could be an equity premium even when aggregate consumption growth is constant. If the cross-sectional variance increases in economic downturns, the estimated risk aversion is higher than the true one. Thus, we can generate the same equity premium as before, but with lower risk aversion. Under these specific assumptions, the model provides a potential explanation of the puzzle. Heaton and Lucas (1996) calibrate a model of this type with data from PSID, and their results show that the model only offers a partial solution to the puzzle.

\textsuperscript{8}The equity premium puzzle was not as well known at this point in time either.
2.5 Behavioral Models and Deviations from Rational Expectations

One of the latest areas of research on the equity premium puzzle is models where agents fail to have rational expectations, an example of which is Cechetti, Lam and Mark (1999). The basic result is that if investors have "distorted beliefs", i.e. overpessimism in expansions and excessive optimism in recessions, a higher equity premium is generated. Note that this explanation is very similar in spirit to the Peso problem approach, where investors could also be regarded as irrational, since the crash never occurs in the observed sample.

The "prospect theory" proposed by Kahneman and Tversky (1979) incorporates experimental results from psychology. It has become increasingly common to apply these theories in finance, known as "behavioral finance." It has also been used trying to explain the equity premium puzzle. Benartzi and Thaler (1995) claim some success in explaining the puzzle with myopic loss aversion preferences according to the "prospect theory." Barberis et al (1999) also examine this kind of utility in an asset pricing setting, and their results are promising. However, the "behavioral finance" modeling of preferences yet remains to be established in other disciplines of economics and remains quite controversial.

3 Theoretical Background

3.1 Standard Consumption Model

The consumption-based CAPM (Breeden, 1979, Grossman and Shiller, 1981, 1982, among others) is the standard asset pricing model in macroeconomics and finance. In that model, the starting point is the consumer’s optimization problem, i.e.

\[
\max_{c_t} E_t \sum_{s=0}^{\infty} \beta^s U(C_{t+s})
\]

s.t. \( W_{t+1} = R_{t+1} (W_t - C_t) \),
where $C$ is consumption, $W$ wealth and $R$ the gross investment return. The Euler equation for optimal consumption is

$$1 = \beta E_t \frac{U_c(C_{t+1})}{U_c(C_t)} R_{t+1}. \quad (1)$$

It can easily be shown that for the excess return (risky asset minus bond return), the following must hold:

$$E_t \frac{U_c(C_{t+1})}{U_c(C_t)} R^e_{t+1} = 0. \quad (2)$$

Usually, the constant relative risk aversion utility function $U(C) = \frac{C^{1-\gamma}}{1-\gamma}$ is assumed. Then, the excess return equation becomes

$$E_t \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} R^e_{t+1} = 0.$$

Below, I will go through the asset pricing implications of a model with consumption and labor.

### 3.2 Asset Pricing with Non-Separable Consumption-Leisure Utility

In business cycle and labor supply research, it is natural to add leisure to consumption in the utility function. This typically means the following optimization program of choosing consumption ($C$) and leisure ($L$), resulting in a model of type

$$\max_{C_t, L_t} E_t \sum_{s=0}^{\infty} \beta^s U(C_{t+s}, L_{t+s})$$

$$s.t. \quad W_{t+1} = R_{t+1} (W_t + N_t Y_t - C_t)$$

$$T_t = N_t + L_t.$$

Leisure is defined as a time endowment ($T$) minus labor input ($N$), i.e. $L = T - N$. Consumption is both due to accumulated wealth ($W_t$) and labor income $N_t Y_t$ (labor supply times wage). If the utility function is non-separable in consumption and leisure, the Euler equation for optimal consumption now also involves leisure:

$$\beta E_t R_{t+1} \frac{U_c(C_{t+1}, L_{t+1})}{U_c(C_t, L_t)} = 1. \quad (3)$$
In analogy with the above consumption model, the risk premium equation must satisfy
\[ E_t R_{t+1}^e \frac{U_c(C_{t+1}; L_{t+1})}{U_c(C_t, L_t)} = 0. \]  

### 3.3 Stochastic Discount Factor Methodology

The asset pricing problem can be presented in terms of the stochastic discount factor (SDF), as is common in finance textbooks. The basic asset pricing that must hold for all assets is

\[ E m R = 1, \]

where \( m \) is the SDF. For excess returns, we have that

\[ E m R^e = 0. \]  

In an economic setting, the SDF equals the marginal rate of substitution; hence for the consumption model, we have that

\[ m_{t+1} = \frac{U_c(C_{t+1})}{U_c(C_t)}. \]  

Specifically, for the constant relative risk aversion utility function \( U(C) = \frac{C^{1-\gamma}}{1-\gamma} \), the SDF is

\[ m_{t+1} = \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma}. \]

Similarly, for a model with non-separable consumption-leisure utility, we have that marginal utility is dependent on both consumption and leisure and hence, the SDF is

\[ m_{t+1} = \frac{U_c(C_{t+1}; L_{t+1})}{U_c(C_t, L_t)}. \]

The SDF methodology presents a very general framework for evaluating asset pricing models. Starting from equation (5) above, the excess return formula can be rewritten in the following way:

\[ E m R^e = 0 \]

\[ \Rightarrow E m R^e + cov(m, R^e) = 0 \]
\[ E^{Re} = \frac{-\text{cov}(m, R^e)}{Em} \]
\[ \Rightarrow E^{Re} = -\rho(m, R^e) \frac{\sigma(m) \sigma(R^e)}{Em}, \]

where \( \rho \) is the correlation coefficient. Since \( |\rho| < 1 \), we have the following bounds:

\[ \frac{|E^{Re}|}{\sigma(R^e)} \leq \frac{\sigma(m)}{Em}. \]

These are the well-known Hansen-Jagannathan (1991) bounds on the SDF. The volatility/mean ratio of the SDF must be at least as large as the (absolute) Sharpe ratio of the excess return.

### 4 Non-separable Utility Functions with Consumption and Leisure

#### 4.1 Data and Utility Functions: Which One Will Work?

It is empirically well documented that consumption and leisure are negatively correlated; see e.g. Mankiw et al (1985). The basic problem with the consumption model is the low volatility of the SDF. Hence, adding leisure to that model will only be helpful if it increases that particular volatility. Given the negative correlation in the data, a natural requirement of a consumption-leisure utility is that the marginal utility of consumption is increasing in leisure, or formally

\[ U_{C,L} > 0, \]

since marginal utility is decreasing in consumption for a concave utility function. Hence, with this property, leisure and consumption reinforce each other and the SDF is more volatile. Which utility function satisfies this property? I compare the Cobb-Douglas utility with the more general CES utility function.

#### 4.2 Case 1: Cobb-Douglas

The most common non-separable utility function with consumption and leisure is the Cobb-Douglas utility
where $\gamma > 0$ and $\theta \in (0, 1)$. Consumption and leisure enter multiplicatively. $\theta$ may be interpreted as the weight on consumption, and $\gamma$ is the risk aversion coefficient of the composite good $[C^\theta L^{1-\theta}]$. A value of around 0.3 is common for $\theta$ in the literature, and $\gamma$ is often given the same values as the CRRA in the standard utility function with consumption only, i.e. a value between 0 and 10.

Marginal utility of consumption includes both consumption and hours according to

$$U_C = \theta C^{\theta(1-\gamma)-1} L^{(1-\gamma)(1-\theta)},$$

implying that

$$m_t = \frac{U_C(C_{t+1}, L_{t+1})}{U_C(C_t, L_t)} = \left[\frac{C_{t+1}}{C_t}\right]^{\theta(1-\gamma)-1} \left[\frac{L_{t+1}}{L_t}\right]^{(1-\gamma)(1-\theta)}.$$

Now, we have that

$$U_{C,L} = \frac{\partial (U_C)}{\partial (L)} = \theta(1-\theta)(1-\gamma)C^{\theta(1-\gamma)-1} L^{(1-\gamma)(1-\theta)-1}.$$

Since $\theta \in (0, 1), \theta(1-\theta) > 0$, the sign of the cross-derivative is determined by the sign of the factor $(1-\gamma)$. Hence, for every $\gamma > 1$, $U_{C,L} < 0$ and consumption and leisure are substitutes. Note also that if $\gamma < 1$, consumption and leisure are complements but then, risk aversion is very low. Lettau (2003) briefly notes that this utility function may have even worse asset pricing implications than the standard CRRA utility with only consumption. The argument is that consumption and labor input $(N)$ are positively correlated in the data, which means that consumption and leisure $(L)$ are negatively correlated. Therefore, if $\gamma > 1$, both exponents in the above expression for $U_C$ are negative, and the volatility of the SDF is reduced. However, no empirics is carried out. I will do the calculations below, to see exactly how the above conjecture matches the facts.

4.3 Case 2: CES utility

The CES utility function is defined as

$$U = \frac{1}{1-\gamma} \left[\eta C^{1-\alpha} + (1-\eta)L^{1-\alpha}\right]^{\frac{1-\gamma}{\gamma-2}},$$
where $\gamma, \alpha > 0$ and $\eta \in (0, 1)$. These parameters have a natural interpretation: $1/\alpha$ is the consumption-leisure elasticity of substitution while $\gamma$ and $1/\gamma$ are the coefficients of relative risk aversion and the elasticity of intertemporal substitution, respectively, both referring to the composite good $[\eta C^{1-\alpha} + (1 - \eta) L^{1-\alpha}]^{1-\alpha}$. $\eta$ is the weight on consumption in the utility.

There are some important special cases of this utility function. In the limit $\alpha = 1$, it converges to the Cobb-Douglas utility described above,

$$U = \frac{1}{1 - \gamma} [C^{\eta} L^{1-\eta}]^{1-\gamma}.$$

If $\gamma = \alpha$, there is an additively separable utility function, and $U_C$ only depends on consumption. The same values for $\gamma$ are considered as reasonable as in the Cobb-Douglas and CRRA-consumption model, i.e. between 0 and 10. In the Cobb-Douglas case ($\alpha = 1$), it is often reasonable to have $\eta = 0.3$, or at least between 0.2 and 0.4. Hence, these should also be the reasonable values in the CES, as mentioned in the literature; see e.g. Auerbach et al (1983) and Turnovski (2002). The substitution elasticity between consumption and leisure ($1/\alpha$) has not been subject to much study. Auerbach et al (1983) conclude that a wide range of values seem plausible, and that the low measures of substitution elasticity of leisure in the literature hint at a low value also for $1/\alpha$ (below 1). Turnovski (2002) reports that he was unable to find any direct estimates of $1/\alpha$, but also concludes that the reported low intertemporal leisure elasticities may also imply a low value of $1/\alpha$.

In the general case, there is the following expression for marginal utility of consumption:

$$U_C = [\eta C^{1-\alpha} + (1 - \eta) L^{1-\alpha}]^{\alpha-1} (1-\alpha) C^{-\alpha}.$$ 

Thus, the SDF is

$$m_{t+1} = \frac{U_C(C_{t+1}, L_{t+1})}{U_C(C_t, L_t)} = \left[ \frac{\eta C_{t+1}^{1-\alpha} + (1 - \eta) L_{t+1}^{1-\alpha}}{\eta C_t^{1-\alpha} + (1 - \eta) L_t^{1-\alpha}} \right]^{\alpha-1} \left[ \frac{C_{t+1}}{C_t} \right].$$

Further, we have that

$$U_{C,L} = \partial (U_C) / \partial (L) = \eta (1 - \eta) (\alpha - \gamma) [\eta C^{1-\alpha} + (1 - \eta) L^{1-\alpha}]^{\alpha-3} C^{-\alpha} (L)^{-\alpha}.$$

Since $\eta \in (0, 1)$, $\eta (1 - \eta) > 0$, which means that the sign of the cross derivative is determined by the sign of $(\alpha - \gamma)$. The only restriction is that both $\alpha$ and $\gamma$ are
greater than zero, so there is nothing to prevent this derivative from having either sign. Consumption and leisure could be both complements ($\alpha > \gamma$) and substitutes ($\alpha < \gamma$) with CES utility. Given the negative correlation between consumption and leisure in the data, complementarity is a desirable feature since it increases the volatility of the SDF as compared to the C-D model. Further, with CES utility, risk aversion can be high at the same time (as long as $\alpha > \gamma$), thereby further increasing the SDF volatility.

To conclude, a feature of the CES utility function is much improved flexibility as compared to the C-D utility function. Specifically, consumption and leisure could be complements in the utility function, acting in the direction resolving the equity premium puzzle. Below, I empirically investigate the necessary parameter values of both the C-D and the CES utility to match the equity premium.

5 Empirical Strategy

5.1 Euler equation

The first strategy is to directly test the basic asset pricing relation

$$E_t m_{t+1} R_{t+1}^e = 0.$$  

Taking unconditional expectations of this expression leads to the following empirically testable equation:

$$E m_{t+1} R_{t+1}^e = 0. \quad (8)$$

The null hypothesis is that the population mean $\mu_e = E m_{t+1} R_{t+1}^e$ is zero. Now, if the number of observations is $T$, the sample mean and the standard deviation are

$$\hat{\mu}_e = \frac{1}{T} \sum_{t=0}^{T} m_{t+1} R_{t+1}^e$$  

$$\hat{\sigma}_e = \sqrt{\frac{1}{(T - 1)} \sum_{t=0}^{T} \left[ m_{t+1} R_{t+1}^e - \hat{\mu}_e \right]^2}. \quad (10)$$

9In a theoretical general equilibrium model in continuous time, Basak (1999) reaches a similar conclusion.
Then, the quantity \( t = \frac{\hat{\mu}_e}{\hat{\sigma}_e/\sqrt{T}} \) is approximately \( \sim N(0,1) \), provided that there is a large number of i.i.d. observations. For small values of \( t \), the null hypothesis of the population mean being zero cannot be rejected. Kocherlakota (1996) shows how this can be used for a CRRA consumption model, for which the testable equation is

\[
E \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} R_{t+1} = 0.
\]

Using data on real per capita consumption growth in addition to data on stock and bond returns, he derives the sample mean \( \hat{\mu}_e \) and the standard deviation \( \hat{\sigma}_e \) to obtain a value of \( t \). This is done for different values of the coefficient of relative risk aversion, \( \gamma \). If the significance level is set to 0.05, \( t = 2 \) is the approximate critical value of a two-sided test. In his calculation, Kocherlakota shows that \( \gamma = 7 \) is needed to obtain a \( t \)-value of less than 2, i.e. a population mean not significantly different from zero. The data set used was Mehra and Prescott’s original yearly series from 1890 to 1979.

I will use this method in investigating the different consumption-leisure utility functions. The basic equation that will be tested is the same,

\[
E m_{t+1} R_{t+1}^e = 0,
\]

but the SDF will differ for the C-D and the CES utility. I will set the significance level at 0.05, meaning that 1.96 is the critical value of \( t \).

5.2 Volatility bounds

The second empirical investigation will be a test of the volatility bounds of Hansen and Jagannathan (1991), i.e.

\[
\frac{|ER^e|}{\sigma(R^e)} \leq \frac{\sigma(m)}{Em}.
\]  

(11)

For both C-D and CES utility, I will compute the sample mean and standard deviation of the SDF according to

\[
\hat{E}(m) = \frac{1}{T} \sum_{t=0}^{T} m_{t+1}
\]  

(12)
\[ \hat{\sigma}(m) = \sqrt{\frac{1}{(T-1)} \sum_{t=0}^{T} [m_{t+1} - \hat{\mu}]^2}. \]  

To empirically test equation (11), the parameter values needed for the ratio \( \hat{\sigma}(m)/\hat{E}(m) \) to exceed the sample Sharpe ratio are examined. Cochrane and Hansen (1992) describe this strategy in detail for consumption models.

6 Data Description and Summary Statistics

In the empirical investigation, I use US quarterly data from 1964 to 2002. Consumption, aggregate hours and interest rates are from the FRED data base, and the returns are from Robert Shiller's home page. Consumption is real (deflated by CPI) per capita (adult population) nondurables and services. The hours series is per capita (adult population) aggregate hours of the non-farm sector. The time endowment \( T \) used to compute leisure \( T - N \) is set to 112 hours per week, which follows standard convention; see e.g. Mankiw, Rotemberg and Summers (1985). The three-month t-bill is used as the risk-free rate. S&P 500 prices and dividends are used as the equity return. All raw data are monthly observations transformed into quarterly data. For the consumption and hours series, the quarterly values are averages of the monthly values of each quarter. The quarterly equity premium is the stock index return between the first months of two quarters (e.g. January to April for Q1-Q2) minus the t-bill rate in the first month (e.g. the January rate for Q1-Q2). The total sample length is 1964Q1-2002Q2, meaning 154 observations.

Table 1 gives some summary statistics of consumption, leisure and the equity premium. Consumption growth has about the same volatility as hours growth, but more volatility than leisure growth (the figures are quarterly). The equity premium has about ten times the volatility of consumption and hours growth, but less than four times the average of consumption growth. The Sharpe ratio (average divided by standard deviation) of the equity premium is about 0.19.

Hours and consumption growth are positively correlated (the opposite for leisure growth), while consumption growth, as described earlier, is positively correlated with the equity premium. Hours and leisure growth have a positive and a negative
correlation with the equity premium, respectively.

7 Results

Below, I will show the results of the empirical strategy described above. For comparison, I will start by examining a standard CRRA consumption model.

7.1 Standard Consumption Model

In the standard CRRA consumption model, we have that

\[ m_{t+1} = \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma}. \]

I begin with a test of equation (8), where I use the formulas in equations (9) and (10) to compute the t-value.

Table 2 below lists the sample value of t and the associated p-value for different \( \gamma \). As expected, the t-value is decreasing in \( \gamma \). Since the significance level is 0.05, a t-value below 1.96 is needed not to reject the null hypothesis. This is only achieved for \( \gamma = 16 \) or higher, which is a verification of the Equity premium puzzle.

I proceed to test equation (11). The sample Sharpe ratio of the excess return is 0.19, which means that the volatility-mean ratio of the SDF must be at least that large. Table 3 below shows sample values of \( E(m) \) (equation 12) and \( \sigma(m) \) (equation 13) for different values of \( \gamma \).

The ratio is increasing in \( \gamma \), and only for \( \gamma = 30 \) or higher does it exceed the sample Sharpe ratio, which is another way of demonstrating the equity premium puzzle. The different critical \( \gamma \) compared to the t-test stems from two sources. First, the volatility test implies a correlation of 1 between the SDF and the equity premium, not assumed in the t-test, which points toward a lower critical \( \gamma \) in the volatility test. Second, the t-test implies that the model only holds within a 95% confidence

\[ \text{It can be noted that with } \gamma = 30, \text{ we also have that } E(m) = 0.91, \text{ which should equal the inverse of the risk-free rate and hence, should be closer to one. This is the risk-free rate puzzle, which will not be addressed in this paper.} \]
interval, which points toward a lower critical \( \gamma \) in the t-test. Hence, the latter effect dominates in the consumption model.

The volatility test can also be illustrated in a diagram with \( E(m) \) and \( \sigma(m) \) on the x and y axis, respectively. SDFs above a line with slope 0.19 satisfy the volatility bound. Figure 1 illustrates different mean-standard deviation pairs for increments in \( \gamma \) of 5, starting at the bottom-right with \( \gamma = 0 \). Only for \( \gamma = 30 \) is the volatility above the line. This diagram and the results are similar to those of Cochrane and Hansen (1992).

7.2 Cobb-Douglas utility

With C-D utility, the SDF is:

\[
m_{t+1} = \left[ \frac{C_{t+1}}{C_t} \right]^{\theta(1-\gamma)-1} \left[ \frac{L_{t+1}}{L_t} \right]^{(1-\gamma)(1-\theta)}
\]

I begin by testing equation (8) in a way similar to the consumption case above. The sample mean and standard deviations according to equations (9) and (10) are computed to obtain t-values.

Table 4 shows the smallest integer value of \( \gamma \) for the sample t-value to fall below the critical \( t = 1.96 \), for all values of \( \theta \) from 0.1 to 1, which reduces to the standard consumption CRRA model. Table 4 shows the Cobb-Douglas utility function to indeed have severely worse asset pricing implications than the standard consumption model. In fact, the critical \( \gamma \) is decreasing in \( \theta \) and is smallest for \( \theta = 1 \). If the aim is for \( \theta \) to be around 0.3, the model implies very high risk aversion to match the equity premium.

In sum, the test indicates that the equity premium puzzle is severely worsened for Cobb-Douglas utility as compared to standard CRRA consumption utility.

The next empirical investigation is to see which parameter values are needed for equation (11) to hold with the C-D SDF. In Table 5, I compute the smallest integer value of \( \gamma \) needed for the sample \( \sigma(m)/E(m) \) ratio to exceed the sample Sharpe ratio of 0.19. This is done for values of \( \theta \) from 0.1 to 1 (standard consumption CRRA). The pattern is very similar to that of the t-test. Critical values of \( \gamma \) decrease in \( \theta \) with the lowest value for the consumption model (\( \theta = 1 \)). Extremely high values of
\( \gamma \) are needed, if \( \theta \) is desired to be below 0.5.

### 7.3 CES utility

For the CES utility, we have the following SDF:

\[
\begin{align*}
    m_{t+1} &= \left[ \frac{C_{t+1}^{1-\alpha} + \eta L_{t+1}^{1-\alpha}}{C_t^{1-\alpha} + \eta L_t^{1-\alpha}} \right]^{\frac{\gamma-1}{\alpha-1}} \left[ \frac{c_{t+1}}{c_t} \right]^{-\alpha}.
\end{align*}
\]

I start with a test of equation (8). The sample mean and standard deviations according to equations (9) and (10) are computed to obtain t-values. Table 6 displays the results: for given values of \( \alpha \) and \( \eta \), the lowest integer value of \( \gamma \) to make the sample t-value fall below 1.96 is shown.\(^{11}\)

The results have some characteristics. For a low \( \eta \), the critical \( \gamma \) is extremely sensitive to shifts in \( \alpha \). This sensitivity decreases for higher \( \eta \). Hence, for values of \( \eta \) between 0.2 and 0.4, which are often considered to be reasonable, there is great sensitivity in the critical \( \gamma \). With \( \alpha = 15 \), the critical \( \gamma \) is the same as \( \alpha \), since the utility is separable in consumption if \( \alpha = \gamma \), and for the consumption model the critical \( \gamma \) is 15. For \( \alpha < 15 \), the critical \( \gamma \) is higher than in the consumption model, while it is lower for \( \alpha > 15 \).\(^{12}\)

The next empirical investigation is to see which parameter values are needed for the inequality in equation (11) to hold with the CES utility SDF. This test is done in Table 7. The table works in the same way as Table 6: for given values of \( \alpha \) and for \( \eta \) between 0.1 and 0.9, the lowest integer value of \( \gamma \) needed to make the sample value of \( \sigma(m)/E(m) \) (using the formulas in equations 12 and 13) exceed the sample Sharpe ratio (0.19) is shown.

The results are similar to those of the t-test. For values of \( \eta \) between 0.2 and 0.4, the critical \( \gamma \) is quite sensitive to shifts in \( \alpha \). For \( \alpha = 30 \), the critical \( \gamma \) is always about the same as \( \alpha \), since the utility is close to separable in consumption if \( \alpha \approx \gamma \).

\(^{11}\)There is an explicit assumption in these parameter variations. If it is assumed that \( C/L = 1 \) in steady state, \( \alpha \) can be varied, independently of \( \eta \). Therefore, I have scaled consumption by a constant so that for the sample average, we have that \( C/L = 1 \).

\(^{12}\)For low values of \( \eta \), very high values of \( \alpha \) imply that the model is accepted even for practical risk neutrality, i.e. \( \gamma \approx 0 \). ("0" should be read as "very close to 0" in the table, because \( \gamma > 0 \) in the model).
and for the consumption model, the critical $\gamma$ is about 30. With $\alpha < 30$, the critical $\gamma$ is higher than in the consumption model, while it is lower for $\alpha > 30$.\(^{13}\)

### 7.3.1 Discussion and Summary of the Results

The empirical results show some basic patterns.

The C-D utility function has even worse asset pricing implications than the standard consumption model in the sense of a higher CRRA ($\gamma$) being needed to match the equity premium. The intuition is that for every $\gamma > 1$, consumption and leisure are substitutes. Hence, they offset each other and a higher risk aversion is needed to generate SDF volatility.

The CES utility function can improve the standard consumption model. The intuition is that for every $\alpha > \gamma$, consumption and leisure are complements, thereby having a low substitution elasticity. Hence, a lower $\gamma$ is needed to match the equity premium since consumption and leisure reinforce each other and the SDF is more volatile. The greater is the complementarity between consumption and leisure ($\alpha - \gamma$), the lower is the necessary risk aversion ($\gamma$). To sum up, the results indicate that CES utility has the potential of matching the equity premium with a low risk aversion, provided that there is a very low substitution elasticity between consumption and leisure.

**Reasonable Values of Consumption-Leisure Elasticities** While the scarce reports of substitution elasticity ($1/\alpha$) in the literature indicate that it should be low, the results here indicate that to match a high equity premium, it should be very low. For example, in the t-test, a value below $1/15 \approx 0.07$ is needed in order to improve the C-D and consumption model, and to get reasonable risk aversion ($<10$) we need $1/30 \approx 0.03$. However, unlike the case of risk aversion ($\gamma$), where a great deal of research has been done to establish reasonable values, this remains to be done with consumption-leisure substitution elasticities ($1/\alpha$). The evidence in this paper indicates a very low value.

\(^{13}\)The same notion as for the t-test applies here. For low values of $\eta$, very high values of $\alpha$ imply that the model is accepted even for practical risk neutrality, i.e. $\gamma \approx 0$. ("0" should be read as "very close to 0" in the table, because $\gamma > 0$ in the model).
8 Conclusion

This paper investigates the asset pricing properties of non-separable utility functions with consumption and leisure. Two different utility functions of the constant elasticity of substitution (CES) family are discussed, namely the more restrictive Cobb-Douglas and a general CES utility. The parameter restrictions needed to match the historical equity premium are explored using US data on consumption, hours and returns. Empirically, it is shown that the feature of the C-D utility that consumption and leisure are substitutes for every risk aversion over unity, is important. This makes the asset pricing properties worse than for the CRRA consumption model, since leisure smooths consumption fluctuations, thus making the SDF less volatile than with consumption only. However, CES utility can match the equity premium with a low level of risk aversion by making consumption and leisure strong complements, i.e. having a very low substitution elasticity. The intuition is that with a sufficiently strong complementarity between leisure and consumption, movements in consumption are reinforced by movements in leisure. Hence, the SDF becomes more volatile than with consumption only.

The core of the Equity Premium Puzzle is that a large risk aversion is needed to match the high level of the equity premium. A high risk aversion coefficient, like 30, is ruled out because it implies implausible certainty equivalence values in bets on wealth, e.g. "paying 49,000 $ is equally preferred to a 50-50 chance of losing 50,000 $". This paper has shown that a low consumption-leisure substitution is needed to match the level of the equity premium in a consumption-leisure model. It is not as instantly clear what the reasonable values of consumption-leisure elasticities might be. Therefore, it would be interesting to study this in more detail in order to generate examples like the one with relative risk aversion in consumption. This might be done in the form of experiments.

One implication of the results in this paper is that the success of an asset pricing model with consumption and leisure crucially depends on the intratemporal substitution between consumption and leisure. An interesting topic for future research is to take this insight to a general equilibrium model, and study the effects of varying this parameter on other aspects of macroeconomics. In the literature on economic growth and business cycles, the Cobb-Douglas utility function has dominated. One reason for this is that a unitary consumption-leisure elasticity generates
balanced growth. However, this paper has shown that it does not generate a plausible equity premium. Therefore, it would be interesting to study the effects of low consumption-leisure elasticities in business-cycle and growth models, which would reveal if generating a high equity premium is compatible with other aspects of general equilibrium.
References


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Table 1. Summary statistics.

<table>
<thead>
<tr>
<th>Moments</th>
<th>hours growth</th>
<th>leisure growth</th>
<th>cons growth</th>
<th>eq premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>average (percent)</td>
<td>0.08</td>
<td>-0.02</td>
<td>0.39</td>
<td>1.33</td>
</tr>
<tr>
<td>standard deviation (percent)</td>
<td>0.73</td>
<td>0.15</td>
<td>0.71</td>
<td>6.89</td>
</tr>
</tbody>
</table>

Correlations

- hours growth, eq premium: 0.09
- leisure growth, eq premium: -0.09
- cons growth, eq premium: 0.37
- hours growth, cons growth: 0.40
- leisure growth, cons growth: -0.41

Table 2. Consumption model: Euler equation t-test of $H_0 : E^{t+1} R_{t+1}^e = 0$.

<table>
<thead>
<tr>
<th>$\gamma$</th>
<th>t-value</th>
<th>p-value</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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<td>0.02</td>
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<td>5</td>
<td>2.26</td>
<td>0.02</td>
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<tr>
<td>10</td>
<td>2.11</td>
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</tr>
<tr>
<td>16</td>
<td>1.96</td>
<td>0.05</td>
</tr>
<tr>
<td>20</td>
<td>1.80</td>
<td>0.07</td>
</tr>
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</table>

Table 3. Consumption model: sample SDF volatility-mean ratio ($\tilde{\sigma}(m)/\tilde{E}(m)$) and Sharpe ratio ($\hat{E}(R^e)/\tilde{\sigma}(R^e)$).

<table>
<thead>
<tr>
<th>$\gamma$</th>
<th>$\tilde{E}(m)$</th>
<th>$\tilde{\sigma}(m)$</th>
<th>$\tilde{\sigma}(m)/\tilde{E}(m)$</th>
<th>$\hat{E}(R^e)/\tilde{\sigma}(R^e)$</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.19</td>
</tr>
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<td>0.91</td>
<td>0.18</td>
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<td>35</td>
<td>0.89</td>
<td>0.21</td>
<td>0.23</td>
<td>0.19</td>
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</table>
Table 4. Cobb-Douglas model: Critical $\gamma$, i.e. lowest $\gamma$ not rejecting $Em_{t+1}R^e_{t+1} = 0$.  

<table>
<thead>
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<tr>
<td>1</td>
<td>16</td>
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</table>

Table 5. Cobb-Douglas model: Critical $\gamma$, i.e. lowest $\gamma$ for which $\hat{a}(m)/\hat{E}(m) > \hat{E}(R^e)/\hat{a}(R^e)$. 

<table>
<thead>
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<th>$\theta$</th>
<th>Critical $\gamma$</th>
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</table>

Table 6. CES model: Critical $\gamma$, i.e. lowest $\gamma$ not rejecting $Em_{t+1}R^e_{t+1} = 0$. 

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>$\eta$</th>
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<td>40</td>
<td>0.8</td>
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<td>45</td>
<td>0.9</td>
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Table 7. CES model: Critical $\gamma$, i.e. lowest $\gamma$ for which $\hat{\sigma}(m)/\hat{E}(m) > \hat{E}(R^e)/\hat{\sigma}(R^e)$.

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>$\eta$ 0.1</th>
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Figure 1. Graphical illustration of Table 2. The triangles show combinations of $\hat{E}(m)$ and $\hat{\sigma}(m)$ for different values of $\gamma$, and the line shows the volatility bound for which $\hat{\sigma}(m)/\hat{E}(m) = \hat{E}(R^e)/\hat{\sigma}(R^e) = 0.19$. 
Chapter 3
Income Risk and Stockholdings: Evidence from Swedish Microdata*

Björn Lagerwall**

Abstract

This paper examines the relationship between income risk and portfolio choice. It empirically investigates whether the stock market risk (the covariation with the stock market) in labor income is reflected by an offsetting lower share of stocks in financial portfolios, an effect that has been shown to exist in theoretical articles. Swedish microdata from HINK on households' income and wealth are used for this purpose. In repeated cross-sections, households are divided into "portfolio cohorts" corresponding to percentiles of the share of stocks in financial assets. Income risk, i.e. the regression beta of (log) income growth on aggregate stock returns, is compared for the different groups. As predicted by theory, the results provide some support for a negative relationship between income risk and the share of stocks.

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1 Introduction

This paper examines the relation between portfolio choice and income risk. Labor income growth can be considered as the return on human capital, which is a non-tradable asset. If labor income growth covaries positively (negatively) with stock returns, this constitutes a risk (hedge) factor, and there is no possibility of directly insuring against this covariation. However, the stock market offers opportunities: the risk (hedge) can be compensated for by decreasing (increasing) the share of stocks in the portfolio of financial assets. Hence, stock market risk in labor income decreases the optimal amount of risk in financial assets.

The paper is organized as follows. The remainder of this section gives a theoretical and empirical background to the study. Section two describes the data set used. Section three presents the empirical strategy, while section four provides the results. Section five concludes.

1.1 Theoretical Background

An early theoretical paper showing the effects of labor income risk on portfolio choice is Bodie, Merton and Samuelson (1992). In a continuous time model, they show that the riskier is human capital expressed as wage correlation with stock returns, the lower should the share of stocks in the investor’s portfolio be. The more recent article by Viceira (2001) has a more quantitative approach; in a standard model of consumption and portfolio choice with retirement, labor income is allowed to covary positively with stock returns. The expression for the optimal share of stocks now includes a negative hedging component: the regression beta of stock returns and labor income growth. Viceira’s calibrations of the model show that this hedging demand can be large. Heaton and Lucas (2000a) also use calibrations of a theoretical model. Their results indicate that changes in the riskiness of income can generate significant offsetting effects on the predicted stock proportions in their model. Thus, there is a clear theoretical link between income risk and portfolio choice, a basic effect which is shown below. To clarify, a standard portfolio choice

\footnote{This covariation only affects investors in the labor market, since labor income is zero after retirement.}
model is first derived.

1.1.1 Standard Portfolio Choice Model

Here, I review a dynamic portfolio choice model to show the essence of the problem. A continuous-time analogue is the classical model of Merton (1969), while this discrete-time derivation follows Campbell and Viceira (2001). The investor maximizes a standard CRRA utility function subject to a budget constraint:

\[
\max_{c_t} E_t \sum_{s=0}^{\infty} \beta^s \frac{C_{t+s}^{1-\gamma}}{1-\gamma}
\]

s.t. \( W_{t+1} = R^p_{t+1} (W_t - C_t) \)
\( R^p_{t+1} = \alpha_t (R_{t+1} - R^f) + R^f, \)

where \( W \) is wealth and \( C \) is consumption. The return on the portfolio, \( R^p_{t+1} \), is a function of the allocation between a risky asset (stock) with return \( R_{t+1} \) and a safe asset (bond) with return \( R^f \). The allocation of total wealth to the risky asset is \( \alpha_t \).

The Euler equation for optimal consumption is

\[
1 = \beta E_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} R^p_{t+1} \right].
\]

If assuming joint lognormality of consumption and returns, we can derive the risk-premium equation (Consumption CAPM):

\[
E_t[r_{t+1} - r^f] = \gamma \text{cov}(r_{t+1}, \Delta c_{t+1}),
\]

where lower case letters are logs. Divide through the budget constraint (equation 1) by \( W_t \):

\[
\frac{W_{t+1}}{W_t} = R^p_{t+1} \left( 1 - \frac{C_t}{W_t} \right).
\]

Taking logs of this equation yields

\[
w_{t+1} - w_t = r^p_{t+1} + \ln \left[ 1 + e^{c_t - w_t} \right].
\]

The expression \( \ln [1 + e^{c_t - w_t}] \) is nonlinear in \( c_t - w_t \); a first-order Taylor approximation around the mean \( E(c_t - w_t) = c - w \) yields

\[
\Delta w_{t+1} \approx r^p_{t+1} + k + \rho (c_t - w_t),
\]

where \( k \) is the risk premium, and \( \rho \) is the correlation coefficient between consumption and returns.
where $k$ and $\rho = \frac{e^w}{1 - e^w}$ are constants. Similarly, the portfolio return (equation 2) can be log-linearized. Divide through by $R^f$:

$$\frac{R_{t+1}^p}{R^f} = \alpha_t \left( \frac{R_{t+1}^f}{R^f} - 1 \right) + 1.$$ 

Take logs of both sides according to 

$$r_{t+1}^p - r^f = \ln \left[ \alpha \left( e^{r_{t+1}^f - r^f} - 1 \right) + 1 \right].$$ 

A first-order Taylor approximation of $\ln \left[ \alpha \left( e^{r_{t+1}^f - r^f} - 1 \right) + 1 \right]$ around $r_{t+1}^f - r^f = 0$ yields

$$r_{t+1}^p - r^f \approx \alpha_t \left( r_{t+1}^f - r^f \right)$$

$$\Rightarrow r_{t+1}^p \approx \alpha_t \left( r_{t+1}^f - r^f \right) + r^f. \quad (6)$$

This can be simplified by assuming consumption to be a constant fraction $b$ of wealth: $\frac{c_t}{W_t} = b$, which means that in logs, we have

$$c_t = b + w_t,$$

and taking first differences means that log consumption moves one-for-one with log wealth:

$$\Delta c_{t+1} = \Delta w_{t+1}. \quad (7)$$

The assumption of consumption being a constant fraction of wealth is satisfied under two conditions. First, if returns are i.i.d. and utility is CRRA, the scale independence of utility together with constant investments opportunities make consumption a constant fraction of wealth. Second, even with time-varying investment opportunities, if we have log utility (the limit of $\gamma = 1$), consumption is once more a constant fraction of wealth since the income- and substitution effects of changing investment opportunities cancel. Throughout the theoretical derivation, I assume returns to be i.i.d. and utility CRRA.

Substituting $\Delta w_{t+1} = \Delta c_{t+1}$ into the risk premium equation (4) yields

$$E_t r_{t+1} - r^f = \gamma \text{cov} \left( r_{t+1}, \Delta w_{t+1} \right).$$

We can substitute the approximate expression for $\Delta w_{t+1}$ (equation 5) according to

$$E_t r_{t+1} - r^f = \gamma \text{cov} \left( r_{t+1}, k + \rho (c_t - w_t) + r_{t+1}^p \right) =$$
Finally substitute the expression for the approximate portfolio return \( r_{t+1}^p \) (equation 6), which means that

\[
E_t r_{t+1} - r^f = \gamma \text{cov} \{r_{t+1}, \alpha_t (r_{t+1} - r^f) + r^f\} = \gamma \alpha \sigma_{r_{t+1}}^2.
\]

The demand for the risky asset is entirely driven by the first two moments of excess stock returns and risk aversion:

\[
\alpha = \frac{1}{\gamma} \frac{E_t r_{t+1} - r^f}{\sigma_{r_{t+1}}^2},
\]

which is the standard portfolio choice solution of Merton (1969).

1.1.2 Portfolio Choice with Income Risk

The above model can be seen as including perfectly tradable labor income, which is thus embedded in the financial assets, \( W \). Non-tradable labor income is introduced in that model. The model derived here builds on Viceira (2001), but is simplified to highlight the empirical content. In an otherwise standard model, labor income now enters the consumer's budget constraint:

\[
s.t. \quad W_{t+1} = R_{t+1}^p (W_t + Y_t - C_t)
\]

where

\[
R_{t+1}^p = \alpha_t (R_{t+1} - R_f) + R_f.
\]

Consumption is both due to accumulated wealth \( W_t \) and labor income \( Y_t \). The Euler equation is the same as before, as is the risk premium equation assuming log-normality, i.e.

\[
E_t r_{t+1} - r^f = \gamma \text{cov} \{r_{t+1}, \Delta c_{t+1}\}.
\]

Divide through the budget constraint (equation 9) by \( W_t \) according to

\[
\frac{W_{t+1}}{W_t} = R_{t+1}^p \left(1 + \frac{Y_t}{W_t} - \frac{C_t}{W_t}\right).
\]
Taking logs means that
\[ w_{t+1} - w_t = r_{t+1}^P + \ln \left( 1 + e^{(y_t-w_t)} - e^{(c_t-w_t)} \right). \]

A first-order Taylor approximation of \( \ln \left[ 1 + e^{(y_t-w_t)} - e^{(c_t-w_t)} \right] \) around the means \( E(y_t-w_t) = y - w \) and \( E(c_t-w_t) = c - w \) yields
\[ \Delta w_{t+1} = \phi + \rho_y (y_t - w_t) + \rho_c (c_t - w_t) + r_{t+1}^P, \quad (12) \]
where \( \rho_y = \frac{e^{(y-w)}}{1+e^{(y-w)}-e^{(c-w)}} \) and \( \rho_c = \frac{e^{(c-w)}}{1+e^{(y-w)}-e^{(c-w)}} \) and \( \phi \) is a constant. A first-order Taylor approximation of the log portfolio return (equation 10) is exactly the same as in the last section:
\[ r_{t+1}^P \approx \alpha_t \left( r_{t+1} - r^f \right) + r^f. \quad (13) \]

As before, assume consumption to be a constant fraction of total wealth, which is now equal to financial wealth plus labor income,\(^2\) i.e.
\[ \frac{C_t}{W_t + Y_t} = b \]
\[ \Rightarrow C_t = b (W_t + Y_t). \]

Now, divide through by \( Y_t \) according to
\[ \frac{C_t}{Y_t} = b \left( \frac{W_t}{Y_t} + 1 \right). \]

Taking logs of this expression gives
\[ c_t - y_t = \ln b + \ln \left[ e^{w_t-y_t} + 1 \right]. \]

A first-order Taylor approximation of \( \ln \left[ e^{w_t-y_t} + 1 \right] \) around \( E(w_t - y_t) = w - y \) gives the following approximation:
\[ c_t - y_t \approx k + \rho_w (w_t - y_t), \]
where \( \rho_w = \frac{e^{w-y}}{e^{w-y}+1} < 1 \) and \( k \) is another constant. Solving for \( c_t \), we thus have that
\[ c_t \approx k + \rho_w w_t + (1 - \rho_w) y_t, \]

\(^2\)This is a simplification, since more realistically, it is the expected present value of all future realizations of labor income that enters total wealth.

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where \( \rho_w \) and \( 1 - \rho_w \) are the respective log consumption elasticities of log wealth and log labor income which, by definition, are both lower than one. In first differences, we have that

\[
\Delta c_{t+1} \approx \rho_w \Delta w_{t+1} + (1 - \rho_w) \Delta y_{t+1}.
\]  \((14)\)

Expression (14) can now be inserted into the Euler equation (11), resulting in the following:

\[
E_t r_{t+1} - r_f = \gamma \text{cov}(r_{t+1}, \rho_w \Delta w_{t+1} + (1 - \rho_w) \Delta y_{t+1}).
\]  \((15)\)

Using the expression for \( \Delta w_{t+1} \) above (equation 11), we have the wealth covariance

\[
\text{cov}(r_{t+1}, \Delta w_{t+1}) = \text{cov}(r_{t+1}, \Delta w_{t+1}^P) = \alpha \sigma^2.
\]

Hence, equation (15) simplifies to

\[
E_t r_{t+1} - r_f = \gamma [\rho_w \alpha \sigma^2 + (1 - \rho_w) \text{cov}(r_{t+1}, \Delta y_{t+1})],
\]

which can be solved for optimal \( \alpha \) as before:

\[
\alpha = \frac{E_t r_{t+1} - r_f - \gamma (1 - \rho_w) \text{cov}(r_{t+1}, \Delta y_{t+1})}{\gamma \rho_w \sigma^2} = \frac{E_t r_{t+1} - r_f}{\sigma^2 \gamma \rho_w} - \frac{(1 - \rho_w) \text{cov}(r_{t+1}, \Delta y_{t+1})}{\rho_w \sigma^2}.
\]  \((16)\)

The optimal stock share is negatively related to the covariance between labor income growth and stock returns and thus, stock market risk in labor income reduces the optimal portfolio share of stocks. Note that equation (16) can be written as

\[
\alpha = \frac{E_t r_{t+1} - r_f}{\sigma^2 \gamma \rho_w} - \frac{(1 - \rho_w) \text{cov}(r_{t+1}, \Delta y_{t+1})}{\rho_w \sigma^2} \beta_{\Delta y_{t+1}, r_{t+1}}.
\]  \((17)\)

The share of stocks is thus negatively related to the regression beta of labor income growth and stock returns.\(^3\) If labor income is uncorrelated with stock returns, we naturally have the standard solution referred to above (equation 8), but scaled by \( \frac{1}{\rho_w} \).

The empirically testable hypothesis from equation (17) is that the portfolio share of stocks is negatively related to income risk, as measured by \( \beta_{\Delta y_{t+1}, r_{t+1}} \).

\(^3\)i.e. in the regression \( \Delta y_{t+1} = \alpha + \beta r_{t+1} + \varepsilon \), we have \( \beta = \frac{\text{cov}(r_{t+1}, \Delta y_{t+1})}{\text{var}(r_{t+1})} \)
1.2 Empirical Background

Some authors have tried to measure empirically whether portfolio choice is affected by income risk. Guiso, Jappelli and Terlizzese (1996) study the effects of income risk in isolation (without correlation effects) on the portfolio choice of a cross-section of Italian households. They find some evidence of the riskiness of the portfolio being negatively related to the riskiness of income. However, these authors use a subjective measure of income riskiness (based on survey answers). Heaton and Lucas (2000b) use a panel data set of tax payers ("tax model") to see if the second moments of wage and business income can affect households' shares of stocks. The standard deviation of labor income (wage plus business income) has a negative but insignificant effect on the share of stocks. The covariance of labor income with stock returns has a significant negative effect on the share of stocks, though $R^2$ is just around 3% in the regression. The method used has certain features worth considering. Assets are imperfectly measured in this database; they must be estimated on the basis of dividend and interest income and capital gains. Further, the length of the time series when estimating the second moments of income varies between individuals (3 to 11 years).

An additional recent study is Vissing-Jørgensen (2002). She investigates first and second moments of non-financial income and portfolio choice using PSID (Panel Study of Income Dynamics). There is some evidence of a mean and standard deviation effect on the share of stocks. As predicted, the conditional mean of non-financial income (as a share of financial wealth) has a significant positive effect, and volatility a significant negative effect on stock holdings. The author finds no evidence of a correlation effect. This study has some limitations, however. First, only asset holdings for 1989 (with 1984 holdings as the explanatory variable) are used. Second, and more important, only four observations of income innovations (1989-1992) are used when calculating moments.

There is also some empirical evidence using repeated cross-sectional data sets. Davis

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4This is defined as all taxable income plus transfers minus all capital income, which makes it approximately equal to labor income.

5The more valuable is human capital, the more you can invest in stocks to keep the desired portfolio mix, provided that human capital is virtually risk-free. Hence, the effect depends on the covariance of incomes with stock returns. This mean effect is not illustrated in the stylized model in this section, however.
and Willen (2000a) construct synthetic panels of the Current Population Survey (CPS) 1965-94 for different cohorts of age, sex and education. Then, they measure the correlation of labor income shocks with stock returns for each group. The estimated correlations vary from -0.25 (least educated men) to over 0.25 (college educated women). For both men and women, the correlation appears to increase with education and thus, there appears to be great heterogeneity in income risk between different groups. The authors then solve a life-cycle model, incorporating the income characteristics of the cohorts. They find that hedging demand from income risk is an important determinant of portfolio choice. However, in a related article (Davis and Willen 2000b), the same authors test the covariance effect, or regression beta, where they also use CPS (1968-94). Here, they find no statistical significance when regressing income innovations on aggregate stock returns for different occupational groups.

To conclude, the empirical evidence on income risk and portfolio choice is mixed, and much research remains to be done in this area.

In this paper, I use Swedish cross sectional data on income and assets (HINK, i.e. Household Income Database) for the period 1981-91. The great advantage of this data set is that it is possible to obtain both income growth and assets for every year, which makes it unique compared to those used in previous studies, e.g. PSID and Survey of Consumer Finances (SCF), which contain detailed asset information for two or three non-consecutive years only. The method in this paper can be compared to those used by Davis and Willen (2000a, b). In accordance with these studies, synthetic cohorts are constructed from repeated cross-sections. However, instead of using demographics and occupation as grounds for the cohorts, I use the households' portfolio characteristics. I construct synthetic "portfolio cohorts", consisting of groups with different shares of stocks in their financial assets, according to percentiles for every year in the period, except 1987. The regression beta of labor income growth on stock returns is calculated and compared for different percentiles of portfolio shares. If hedging income risk is important when forming portfolios, then income risk, i.e. the regression beta, should be lower (possibly negative) for the top than the bottom percentiles.

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6I also use 1980 income data.

7No asset data were available in the Current Population Survey used by Davis and Willen.
2 The Data

HINK is a random sample of around 10 000 Swedish households for every year since 1980 supplied by Statistics Sweden. Detailed information on income, demographics and assets is provided, using a combination of registers and interviews. For a specific year, income is the money earned during that year, and assets are measured at the end of the year. Half of the sample households are replaced every year. Hence, income and assets for two consecutive years can be calculated for about 5 000 people each year. As concerns financial assets, there is information about stock holdings for all years 1981-91, except 1986-87. Thus, it is possible to link income growth and assets for all years in this period, except one.\(^8\)

For this investigation, I only use people gainfully employed in both years. Further, the financial assets must be non-zero. Then, I merge income and assets for all individuals in 1981-91 (except 1987). I link the assets of the previous year to the income of the two previous years, e.g. assets in 1981 to income in 1980-81. There are some exceptions, however. In 1986, the 1985 assets were linked to the income in 1985-86 (stock holdings were missing in 1986). Second, 1990 assets were linked to income in 1990-91 to facilitate the comparison between years.\(^9\) Between 2800 and 3400 households now remain in each pair of years, as illustrated in Table 1, which forms the basis for the empirical investigation described below.

3 Empirical Strategy

3.1 Selection Criteria

There are 10 years of income pairs and assets. From these data sets, I select households owning positive amounts of listed stocks. As appears from Table 1, these range from about 500 to 1200 (18-35 % of the sample), thereby reflecting the increased degree of stock ownership. Then, I calculate the share of stocks in the total financial

\(^8\)Income growth in 1985-86 can be linked to assets in 1985 and income growth in 1987-88 to assets in 1988.

\(^9\)Some definitions of assets were changed in 1991.
assets. I do not consider real assets in this study.

In Table 2 below, I show percentiles of the ratio of stocks to the total financial assets among the households owning stocks in the different years. These figures are used as guidelines to divide the stock-holding sample of households into different "portfolio cohorts", which represent groups of households with different stock shares in financial assets.

3.2 Synthetic Cohorts of Stockholders

In the HINK data set, there are asset data and income growth rates available for a series of 10 years, but there is no panel aspect of the income growth rates so that each household can be traced. For this reason, one must resort to synthetic cohorts to obtain a time series dimension. In the study by Davis and Willen (2000a) described earlier, this technique is used, and they base the cohorts on background information like education, age and sex. For example, the correlation of income growth with stock returns for the synthetic group "college educated men" is examined. In this paper, on the other hand, since data on asset holdings are available, I exploit this by using the share of stocks in financial assets, according to percentiles, as the basis for synthetic cohorts. The goal of this technique is to trace the income risk of groups of stockholders which differ with respect to their portfolio share of stocks. These synthetic cohorts are formed in the same way every year, and thus represent the same group of stockholders, e.g. top 10%. Then, the income growth of these cohorts are calculated for all 10 years, and the income risk can be examined. I will do this both by comparing two different groups of stockholders, and by comparing several groups in a cross-sectional framework. These strategies are described below.

These mainly consist of bank deposits, bonds, listed stocks, cash, tax favored savings accounts, and tax favored mutual funds. Tax favored mutual funds could be included, since they consist of stocks. However, in some years, tax favored savings and mutual funds are not separated (1988-90). This opens up for alternative definitions of "stocks": to include tax-favored mutual funds when separately described, and to choose tax-favored mutual funds plus savings for the other years or for all years. For these reasons, I stick to the "plain" stock definition.
3.3 Test One: Comparisons between Two Groups

The first test involves a comparison of top and bottom groups of stock owners. I choose two different splits for stock proportions. First, I select the "large-share-of-stocks group" as those with more than the 90th percentile's stockholdings of each year. Then, I compare this group with the bottom 10%. As seen from Table 2, this implies roughly above 75% and below 2% of stocks, respectively, i.e. a considerable difference. Similarly, two groups consist of the top and bottom 50%, respectively, implying approximately above and below 20% of stocks. The last split allows for larger samples but less difference in portfolio shares over the years. The splitting strategy according to percentiles has two major advantages. First, I keep the share of stocks over different years fairly constant and second, I compare groups of equal size every year. For the respective groups, I first compute the mean income for each year. The real mean income is obtained using the Consumer Price Index. Then, the regression beta and its components\(^{11}\) of (log) real labor income growth with (log) real stock returns are computed and compared. For both splits, my hypothesis is that the labor income regression beta is lower for the group with the higher stock share: there is compensation for income risk in financial portfolios.

3.4 Test two: Cross-sectional Comparisons

The second test is a division of each year's sample into all ten deciles, with respect to stock share. Then, I calculate the regression beta of income on stock returns, as in the above test. Thus, we have ten groups with two characteristics each: stock share and income risk. As a third step, I estimate the yearly average of labor income and total financial assets, which serve as control variables. Finally, I run a cross-sectional regression with the yearly average of stock shares as the dependent variable. The regression beta of income and stock returns, plus the yearly average of the two other variables, are the independent variables. There are ten observations in this cross-section, corresponding to each decile of stock shares. The advantage of this strategy is that other factors than income risk that may determine the share of stocks in portfolios of households are controlled for. The hypothesis is a negative relation between labor income beta and stock share.

\[^{11}\text{Note that } \beta_{\Delta y, r} = \text{cov}(\Delta y, r) / \text{var}(r) = \rho_{\Delta y, r} \sigma_r \sigma_{\Delta y} / \sigma_r^2.\]
4 Results

4.1 Comparison of Two Groups

4.1.1 Split One: Top 10% vs Bottom 10% Stockholders

For each year, I have selected the top and bottom 10% groups, according to the limits in Table 2. Table 3 below shows the mean proportion of stocks for every year, together with the yearly average (1981-91) of those mean proportions. For the 90th percentile, the yearly average stock proportion is as high as 88%, while the 10th percentile only has 1% in stocks as its yearly average.\(^{12}\)

For the two groups, I then calculate the mean labor income for every pair of years. For these mean income observations, the log real growth rate \((\Delta y_{t+1})\) is obtained. The results are shown in Table 4, where I have calculated the yearly mean, the standard deviation, the correlation with stock returns\(^{13}\), and the regression beta\(^{14}\). As is apparent, the numbers are in accordance with theory. For the 90th percentile, income growth is negatively correlated with stock returns, indicating a hedging demand for stocks. Similarly, the 10th percentile income growth is positively correlated with stock returns, indicating hedging away stocks because of income risk. The difference in correlation might seem somewhat low (-0.420 vs 0.121) to justify the large difference in the stock share in financial assets (88% vs 1%). However, in calibrations of a theoretical model, Heaton & Lucas (2000a) show that letting the correlation between income growth and stock returns vary between -0.1 and 0.2, optimal portfolio shares could differ by up to 20 percentage points just because of this effect. Even larger effects are shown when the volatility of income growth is also varied.

The total hedging component, beta, is clearly different for the two groups, (-0.117 vs 0.021) and higher for the 10th percentile, as predicted by theory. Further, mean wage growth is higher for the 90% group, thereby indicating a higher return on

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\(^{12}\)Not shown in the table, the yearly average of real financial assets is not extremely different for the two groups; they differ by around 110 000 SEK (425 000 vs 315 000).

\(^{13}\)This is "Affärsvärldens generalindex" 1981-1991, measured as the log real growth rate. The Consumer Price Index is used as a deflator before taking logs of growth rates.

\(^{14}\)This is the estimated beta of a regression of income growth on stock returns, i.e. the covariance of wage growth and stock returns divided by the variance of stock returns.
human capital.

4.1.2 Statistical Significance: Split One

To test if the difference in the total hedging component, beta, is statistically significant, I use the same method as Mankiw and Zeldes (1991).\textsuperscript{15} First, the difference in income growth between the two groups is regressed on stock returns. The resulting beta is the same as the difference between the betas presented above. Further, if the regression beta in the nested regression is statistically different from zero, this means that the betas are statistically significantly different from each other. To sum up, I run the following regression:

\[ \Delta y_{(90\%)} - \Delta y_{(10\%)} = \alpha + \beta r + \varepsilon. \]

The hypothesis to be supported is that \( \beta < 0 \). The results from the regression are shown in Table 5. \( R^2 \) is quite high and, more important, the estimated beta is negative (which has already been established) and significant at the 10\% level. The quantitative prediction is that an increase in stock returns by 0.10 decreases the wage growth difference by 1.4 percentage points.

To conclude, this first test indicates that income risk differs between these two groups. As hypothesized, this difference is negative.

4.1.3 Split Two: Top 50\% vs Bottom 50\% Stockholders

I have now selected the top and bottom halves of the samples for each year, according to Table 2. Table 6 displays the mean proportion of stocks in 1981-91 for the top and bottom 50\% stockholders. The yearly average proportion of stocks is 50\% for the top group and 8\% for the bottom group. Thus, the difference in portfolio shares is not as large as in the first split, but it is still substantial.\textsuperscript{16}

The different patterns of income growth are shown in Table 7. The correlation (-0.059 vs 0.015) and beta coefficients (-0.005 vs 0.001) are still as expected; lower

\textsuperscript{15}They use it to test if the covariance of stockholders' and nonstockholders' consumption growth with stock returns was statistically significantly different.

\textsuperscript{16}The difference in mean real financial assets is not large for this split: 287 000 vs 231 000.
for the top 50% than for the bottom 50%.\textsuperscript{17} Hence, the results are qualitatively the same as in the first split, but the difference is smaller.

### 4.1.4 Statistical significance: Split Two

To test the significance of the beta difference, I run the same regression as in the last section. This means the following specification:

\[ \Delta y_{\text{Top 50\%}} - \Delta y_{\text{Bottom 50\%}} = \alpha + \beta r + \varepsilon. \]

As before, $\beta < 0$ should be accepted. The results are shown in Table 8. The estimated beta is (naturally) of the right sign, but quite small. It is also clear that the difference is no longer statistically significant. $R^2$ is practically zero, and the beta is not even significant at the 40% level. The quantitative prediction is that an increase in stock returns by 0.10 only decreases the wage growth difference by 0.2 percentage points (as compared to 1.4 percentage points), and the relation is thus weaker.

To conclude, test two provides qualitative indications of an income risk difference between the groups, but without statistical significance.\textsuperscript{18}

### 4.2 Cross-sectional Regression for all Deciles

The final strategy is to divide the sample each year into all ten deciles, according to the portfolio shares of stocks. For each decile, I repeat the above calculation of income risk. Further, I include financial assets and income, for which the mean is computed each year. The next step is to calculate the yearly average of stock share, the mean income and financial assets for each decile. The characteristics of

\textsuperscript{17}Further, mean wage growth is higher for the top than the bottom group, thereby indicating higher return on human capital for the top group.

\textsuperscript{18}In addition to the comparison between different groups of stockholders, I have also tried regressing income growth on stock returns for all households including nonstockholders. For the whole sample, the beta on stock returns was slightly negative and insignificant. The correlation and standard deviations were similar to those reported for the aggregate real wage in the U.S. by Heaton & Lucas (2000b). Comparing stockholders and nonstockholders, there was no significant difference in beta between the two groups.
all deciles are shown in Table 9. A cross-sectional regression can be performed on the columns of Table 9, with mean percentage stocks (stockratio) as the dependent variable. The independent variables are income risk (betainc) plus, as control variables, mean of real income (meaninc) and real financial assets (fina). Thus, there is a regression with ten observations. Controlling for other factors, we can explore if there is a relation between income risk and the share of stocks. When running the regression, I scale income and financial assets down by dividing by 100 000, which gives quantitatively meaningful coefficient estimates. The three specifications to be estimated are:

\[
\begin{align*}
\text{Stockratio}_i &= \alpha_1 + \alpha_2 \beta_{g,r,i} + \varepsilon_i \\
\text{Stockratio}_i &= \alpha_1 + \alpha_2 \beta_{g,r,i} + \alpha_3 \text{fina}_i + \varepsilon_i \\
\text{Stockratio}_i &= \alpha_1 + \alpha_2 \beta_{g,r,i} + \alpha_3 \text{fina}_i + \alpha_4 \text{meaninc}_i + \varepsilon_i
\end{align*}
\]

The basic hypothesis in this regression is a negative relation between stock proportion and income risk, as measured by beta. Thus, I test if \( \alpha_2 < 0 \).

### 4.2.1 Specification one

As a first exercise, I only use the regression beta on stock returns (betainc) as the explanatory variable, which corresponds to equation (18) above. The results are found in Table 10. It is apparent that \( R^2 \) is reasonably high. Further, the slope coefficient \( \alpha_2 \) has the right sign, and the \( p \)-value is below 0.10. Hence, there is an indication of a negative relation between income risk and stock holdings, according to the prediction of the theory. The quantitative predictions of the model are the following. With zero income risk, the estimated stock ratio is 23%. An increase in income risk (beta) by 0.01 reduces the share of stocks by 3.1 percentage points.

### 4.2.2 Specification Two

When running a regression and controlling for other factors, the small number of observations must be taken into account. This limits the number of explanatory
variables to be included in a single regression, and one must stick to those most likely to be important. As a first step, I add mean financial assets, a very common factor used when explaining stock ownership in cross-sections; see e.g. Heaton and Lucas (2000b). Thus, the specification is as in equation (19) above. As before, we expect $\alpha_2 < 0$. Concerning financial assets, the expected sign is not obvious. According to the theory described above, the size of the assets to be allocated should be of no importance for the division into stocks. However, results from previous studies (Guiso, Japelli and Terlizzese 1996, Heaton and Lucas 2000b) indicate a positive sign, i.e. richer people have (relatively) more stocks. Hence, we should also expect $\alpha_3 > 0$. The regression results are shown in Table 11. $R^2$ is now higher, and the signs of the parameter estimates are as expected. Income risk (betainc) is still negative ($\hat{\alpha}_2 < 0$), and mean financial assets (fina) are positive ($\hat{\alpha}_3 > 0$). However, the income risk parameter is insignificant, although the financial assets parameter has a p-value below 0.05. There is a negative intercept; according to the prediction of the model, some income hedge or financial assets are needed to get a positive stock ratio. From the equation, it is also predicted that an increase in income risk by 0.01 yields a 0.6 percentage point reduction in stock share. An increase in financial assets by 10 000 yields an estimated increase in stock share by 2.44 percentage points.

### 4.2.3 Specification Three

Third, I choose the mean of financial assets and the mean level of labor income as additional variables, which corresponds to equation (20) above. Regarding the first two terms, I expect, as before, that $\alpha_2 < 0$ and $\alpha_3 > 0$. In previous studies (e.g. Vissing-Jørgensen 2002), income levels have been found to be positively related to stock shares in portfolios. This is intuitively appealing, since higher income means more "buffer" for other risks from for example stock market fluctuations. Income could also be seen as a measure of human capital value. With this interpretation, the more human capital, the higher is the stock ratio, which reflects that better informed people are more willing to hold stocks. This leads to an expected positive sign of the income parameter; i.e. my hypothesis is that $\alpha_4 > 0$. The regression result is shown in Table 12. $R^2$ is quite high, and the signs are as expected. Income risk still has a negative sign ($\hat{\alpha}_2 < 0$), and financial assets have a positive sign ($\hat{\alpha}_3 > 0$). Further, mean income has a positive sign; $\hat{\alpha}_4 > 0$. All explanatory variables are significant at the five percent level, except income risk (betainc) which is significant at 10%.
more, the intercept is negative, thereby indicating some barrier to stock owning. An increase in income risk by 0.01 now yields a predicted reduction in the stock ratio of 3.7 percentage points. An increase in the financial assets by 10 000 increases the predicted stock share by 3.5 percentage points. Further, an increase in income by 1 000 means an estimated 3.5 percentage point increase in the stock ratio.

The cross-sectional analysis produces results analogous to the first exercise in section 4.1. There appears to be a negative relationship between income risk and stockholdings; however, the statistical significance varies between different specifications. In addition, income and financial wealth seem to have a positive and significant effect on stock holdings, which is in accordance with intuition and the results of other empirical studies (e.g. Guiso, Japelli and Terlizzese 1996).

5 Conclusion

This paper has examined the relationship between income risk and the share of stocks in household portfolios. Theoretical articles have shown that a higher income risk yields a lower share of stocks. The evidence in this article offers some support for this hypothesis. Using Swedish household data from 1980-91, I examine the income risk for stockholders with different shares of stocks in financial assets, according to percentiles. First, the top and bottom 10% and the top and bottom 50% were compared. The income risk appeared to be higher for groups with less stocks, but only the top-bottom 10% split offered acceptable statistical significance.

As a second test, I divided the sample into all ten deciles, corresponding to the share of stocks. Then, I ran a cross-sectional regression across these deciles, which had the advantage of allowing the inclusion of other control variables. All specifications showed results that were qualitatively similar to the first exercise on income risk, while the statistical significance was mixed. As expected, financial assets and income had positively significant effects on the share of stocks.

The results in this study are similar in spirit to most previous empirical studies: there seems to be a negative relation between income risk and stock share in household portfolios, although the statistical significance varies with the econometric specifications.
References


### Table 1. Number of observations, total and stockholders.

<table>
<thead>
<tr>
<th>Year</th>
<th>n total</th>
<th>n stockholders</th>
<th>% stockholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>2948</td>
<td>684</td>
<td>23%</td>
</tr>
<tr>
<td>1982</td>
<td>2869</td>
<td>504</td>
<td>18%</td>
</tr>
<tr>
<td>1983</td>
<td>2974</td>
<td>511</td>
<td>17%</td>
</tr>
<tr>
<td>1984</td>
<td>2762</td>
<td>581</td>
<td>21%</td>
</tr>
<tr>
<td>1985</td>
<td>2861</td>
<td>571</td>
<td>20%</td>
</tr>
<tr>
<td>1986</td>
<td>2839</td>
<td>591</td>
<td>21%</td>
</tr>
<tr>
<td>1988</td>
<td>3309</td>
<td>587</td>
<td>18%</td>
</tr>
<tr>
<td>1989</td>
<td>3374</td>
<td>709</td>
<td>21%</td>
</tr>
<tr>
<td>1990</td>
<td>3432</td>
<td>1188</td>
<td>35%</td>
</tr>
<tr>
<td>1991</td>
<td>3246</td>
<td>1102</td>
<td>34%</td>
</tr>
<tr>
<td></td>
<td>Yearly Average</td>
<td>3061</td>
<td>703</td>
</tr>
</tbody>
</table>

### Table 2. Limits for the 1st and 10th decile, plus quartiles 1-3, for the share of stocks.

<table>
<thead>
<tr>
<th>Percentiles of stock proportion</th>
<th>Year</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1981</td>
<td>0.02</td>
<td>0.07</td>
<td>0.19</td>
<td>0.48</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>1982</td>
<td>0.03</td>
<td>0.08</td>
<td>0.21</td>
<td>0.50</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>1983</td>
<td>0.04</td>
<td>0.10</td>
<td>0.25</td>
<td>0.59</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>1984</td>
<td>0.02</td>
<td>0.08</td>
<td>0.22</td>
<td>0.47</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>1985</td>
<td>0.03</td>
<td>0.09</td>
<td>0.28</td>
<td>0.55</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>1986</td>
<td>0.04</td>
<td>0.11</td>
<td>0.28</td>
<td>0.53</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>1988</td>
<td>0.02</td>
<td>0.05</td>
<td>0.17</td>
<td>0.44</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>1989</td>
<td>0.02</td>
<td>0.05</td>
<td>0.14</td>
<td>0.36</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>0.01</td>
<td>0.03</td>
<td>0.10</td>
<td>0.29</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>1991</td>
<td>0.01</td>
<td>0.03</td>
<td>0.09</td>
<td>0.27</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>Yearly Average</td>
<td>0.02</td>
<td>0.07</td>
<td>0.19</td>
<td>0.45</td>
<td>0.73</td>
</tr>
</tbody>
</table>
### Table 3. Mean share of stocks, 10th and 1st decile.

<table>
<thead>
<tr>
<th>Year</th>
<th>90th percentile pr stocks</th>
<th>10th percentile pr stocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>0.94</td>
<td>0.01</td>
</tr>
<tr>
<td>1982</td>
<td>0.90</td>
<td>0.01</td>
</tr>
<tr>
<td>1983</td>
<td>0.96</td>
<td>0.02</td>
</tr>
<tr>
<td>1984</td>
<td>0.87</td>
<td>0.01</td>
</tr>
<tr>
<td>1985</td>
<td>0.93</td>
<td>0.02</td>
</tr>
<tr>
<td>1986</td>
<td>0.88</td>
<td>0.02</td>
</tr>
<tr>
<td>1988</td>
<td>0.89</td>
<td>0.01</td>
</tr>
<tr>
<td>1989</td>
<td>0.79</td>
<td>0.01</td>
</tr>
<tr>
<td>1990</td>
<td>0.82</td>
<td>0.00</td>
</tr>
<tr>
<td>1991</td>
<td>0.79</td>
<td>0.00</td>
</tr>
<tr>
<td>Yearly Average</td>
<td>0.88</td>
<td>0.01</td>
</tr>
</tbody>
</table>

### Table 4. Log growth rate of mean real income, 10th and 1st decile.

<table>
<thead>
<tr>
<th>Year</th>
<th>( \Delta y ) (90%)</th>
<th>( \Delta y ) (10%)</th>
<th>( r )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>0.035</td>
<td>-0.029</td>
<td>0.363</td>
</tr>
<tr>
<td>1982</td>
<td>-0.018</td>
<td>-0.071</td>
<td>0.209</td>
</tr>
<tr>
<td>1983</td>
<td>0.011</td>
<td>-0.073</td>
<td>0.417</td>
</tr>
<tr>
<td>1984</td>
<td>0.242</td>
<td>0.016</td>
<td>-0.197</td>
</tr>
<tr>
<td>1985</td>
<td>0.005</td>
<td>0.022</td>
<td>0.173</td>
</tr>
<tr>
<td>1986</td>
<td>-0.014</td>
<td>0.081</td>
<td>0.380</td>
</tr>
<tr>
<td>1988</td>
<td>-0.034</td>
<td>-0.046</td>
<td>0.360</td>
</tr>
<tr>
<td>1989</td>
<td>0.086</td>
<td>-0.020</td>
<td>0.155</td>
</tr>
<tr>
<td>1990</td>
<td>0.000</td>
<td>-0.058</td>
<td>-0.476</td>
</tr>
<tr>
<td>1991</td>
<td>0.054</td>
<td>-0.049</td>
<td>-0.023</td>
</tr>
<tr>
<td>mean</td>
<td>0.037</td>
<td>-0.023</td>
<td>0.136</td>
</tr>
<tr>
<td>stdev</td>
<td>0.081</td>
<td>0.049</td>
<td>0.290</td>
</tr>
<tr>
<td>corr(( \Delta y, r ))</td>
<td>-0.420</td>
<td>0.121</td>
<td>1.000</td>
</tr>
<tr>
<td>beta</td>
<td>-0.117</td>
<td>0.021</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Table 5. The regression $\Delta y_{(90\%)} - \Delta y_{(10\%)} = \alpha + \beta r + \varepsilon$.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std Error</th>
<th>t Stat</th>
<th>p-value (one tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.08</td>
<td>0.03</td>
<td>2.89</td>
<td>0.01</td>
</tr>
<tr>
<td>$r$</td>
<td>-0.14</td>
<td>0.09</td>
<td>-1.56</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Adj R-Sq 0.14

Table 6. Mean share of stocks, top and bottom 50%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Top 50% pr stocks</th>
<th>Bottom 50% pr stocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>0.53</td>
<td>0.07</td>
</tr>
<tr>
<td>1982</td>
<td>0.53</td>
<td>0.09</td>
</tr>
<tr>
<td>1983</td>
<td>0.61</td>
<td>0.10</td>
</tr>
<tr>
<td>1984</td>
<td>0.52</td>
<td>0.09</td>
</tr>
<tr>
<td>1985</td>
<td>0.60</td>
<td>0.11</td>
</tr>
<tr>
<td>1986</td>
<td>0.57</td>
<td>0.12</td>
</tr>
<tr>
<td>1988</td>
<td>0.49</td>
<td>0.06</td>
</tr>
<tr>
<td>1989</td>
<td>0.43</td>
<td>0.05</td>
</tr>
<tr>
<td>1990</td>
<td>0.37</td>
<td>0.03</td>
</tr>
<tr>
<td>1991</td>
<td>0.36</td>
<td>0.03</td>
</tr>
<tr>
<td>Yearly Average</td>
<td>0.50</td>
<td>0.08</td>
</tr>
</tbody>
</table>
Table 7. Log growth rate of mean real income, top and bottom 50%.

<table>
<thead>
<tr>
<th>Year</th>
<th>Δy (top 50%)</th>
<th>Δy (bottom 50%)</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>0.013</td>
<td>-0.034</td>
<td>0.363</td>
</tr>
<tr>
<td>1982</td>
<td>-0.028</td>
<td>-0.013</td>
<td>0.209</td>
</tr>
<tr>
<td>1983</td>
<td>-0.017</td>
<td>-0.035</td>
<td>0.417</td>
</tr>
<tr>
<td>1984</td>
<td>0.044</td>
<td>0.010</td>
<td>-0.197</td>
</tr>
<tr>
<td>1985</td>
<td>0.019</td>
<td>0.047</td>
<td>0.173</td>
</tr>
<tr>
<td>1986</td>
<td>0.045</td>
<td>0.022</td>
<td>0.380</td>
</tr>
<tr>
<td>1988</td>
<td>0.014</td>
<td>0.024</td>
<td>0.360</td>
</tr>
<tr>
<td>1989</td>
<td>0.043</td>
<td>0.010</td>
<td>0.155</td>
</tr>
<tr>
<td>1990</td>
<td>0.003</td>
<td>-0.008</td>
<td>-0.476</td>
</tr>
<tr>
<td>1991</td>
<td>-0.003</td>
<td>-0.035</td>
<td>-0.023</td>
</tr>
</tbody>
</table>

mean 0.013 -0.001 0.136
stdev 0.026 0.028 0.290
corr(Δy, r) -0.059 0.015 1.000
beta -0.005 0.001 1.000

Table 8. The regression $\Delta y_{(Top \, 50\%)} - \Delta y_{(Bottom \, 50\%)} = \alpha + \beta r + \epsilon$.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std Error</th>
<th>t Stat</th>
<th>p-value (one tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.02</td>
<td>0.01</td>
<td>1.68</td>
<td>0.07</td>
</tr>
<tr>
<td>r</td>
<td>-0.01</td>
<td>0.03</td>
<td>-0.22</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Adj R-Sq 0.00
Table 9. Stockratio, income risk (betainc), mean income (meaninc) and mean financial assets (fina), for all deciles.

<table>
<thead>
<tr>
<th>Decile</th>
<th>stockratio</th>
<th>betainc</th>
<th>meaninc</th>
<th>fina</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0114</td>
<td>0.0205</td>
<td>130433</td>
<td>318662</td>
</tr>
<tr>
<td>2</td>
<td>0.0355</td>
<td>-0.0202</td>
<td>133395</td>
<td>223177</td>
</tr>
<tr>
<td>3</td>
<td>0.0673</td>
<td>-0.0720</td>
<td>131995</td>
<td>260526</td>
</tr>
<tr>
<td>4</td>
<td>0.1067</td>
<td>0.0131</td>
<td>136841</td>
<td>174713</td>
</tr>
<tr>
<td>5</td>
<td>0.1582</td>
<td>-0.0054</td>
<td>136920</td>
<td>188842</td>
</tr>
<tr>
<td>6</td>
<td>0.2307</td>
<td>-0.0084</td>
<td>139981</td>
<td>196768</td>
</tr>
<tr>
<td>7</td>
<td>0.3226</td>
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<td>140007</td>
<td>224355</td>
</tr>
<tr>
<td>8</td>
<td>0.4483</td>
<td>0.0011</td>
<td>139000</td>
<td>268213</td>
</tr>
<tr>
<td>9</td>
<td>0.6257</td>
<td>0.0063</td>
<td>141294</td>
<td>321508</td>
</tr>
<tr>
<td>10</td>
<td>0.8783</td>
<td>-0.1169</td>
<td>119597</td>
<td>426824</td>
</tr>
</tbody>
</table>

Table 10. Cross-sectional regression: \( \text{Stockratio}_i = \alpha_1 + \alpha_2 \text{betainc}_i + \varepsilon_i \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std Error</th>
<th>t Stat</th>
<th>p-value (one tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.23</td>
<td>0.09</td>
<td>2.55</td>
<td>0.02</td>
</tr>
<tr>
<td>betainc</td>
<td>-3.1</td>
<td>2.05</td>
<td>-1.51</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Adj R-Sq 0.12

Table 11. Cross-sectional regression: \( \text{Stockratio}_i = \alpha_1 + \alpha_2 \text{betainc}_i + \alpha_3 \text{fina}_i + \varepsilon_i \)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std Error</th>
<th>t Stat</th>
<th>p-value (one tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.35</td>
<td>0.30</td>
<td>-1.16</td>
<td>0.14</td>
</tr>
<tr>
<td>betainc</td>
<td>-0.60</td>
<td>2.15</td>
<td>-0.28</td>
<td>0.39</td>
</tr>
<tr>
<td>fina</td>
<td>0.24</td>
<td>0.12</td>
<td>2.00</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Adj R-Sq 0.36
**Table 12.** Cross-sectional regression: $\text{Stockratio}_i = \alpha_1 + \alpha_2 \text{betainc}_i + \alpha_3 \text{fina}_i + \alpha_4 \text{meaninc}_i + \varepsilon_i$

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Std Error</th>
<th>t Stat</th>
<th>p-value (one tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-5.44</td>
<td>2.57</td>
<td>-2.12</td>
<td>0.04</td>
</tr>
<tr>
<td>betainc</td>
<td>-3.65</td>
<td>2.36</td>
<td>-1.55</td>
<td>0.09</td>
</tr>
<tr>
<td>fina</td>
<td>0.35</td>
<td>0.11</td>
<td>3.05</td>
<td>0.01</td>
</tr>
<tr>
<td>meaninc</td>
<td>3.53</td>
<td>1.77</td>
<td>1.99</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Adj R-Sq 0.55
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