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Market Organization and the Prices of Financial Assets

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ABSTRACT

Several empirical regularities in the prices of financial assets are at odds with the predictions of standard economic theory. I address these regularities and explore the extent to which they are resolved in the context of two markets organized in very different ways. The first setting is a neoclassical economy with *incomplete* markets and *heterogeneous* agents. Market incompleteness naturally arises because of the non-existence of markets in which consumers or households can co-insure idiosyncratic income shocks for obvious moral hazard reasons. The second setting is an overlapping generations economy with three generations in which the young generation is constrained from borrowing and investing in equities. The borrowing constraints naturally arise because human capital alone does not collateralize major loans in modern economies for reasons of moral hazard and adverse selection.

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1. Introduction

Several empirical regularities in the prices of financial assets are at odds with the predictions of standard economic theory. My objective in this essay is to address these regularities and explore the extent to which they are resolved in the context of two very different economic settings. The first setting is a neoclassical economy with *incomplete* markets and *heterogeneous* agents. Market incompleteness naturally arises because of the non-existence of markets in which consumers or households can co-insure idiosyncratic income shocks for obvious moral hazard reasons. The second setting is an overlapping generations economy with three generations in which the young generation is constrained from borrowing and investing in equities. The borrowing constraints naturally arise because human capital alone does not collateralize major loans in modern economies for reasons of moral hazard and adverse selection.

I begin with an overview of the empirical regularities in the prices of financial assets that are at odds with the predictions of standard economic theory. The aggregate equity return, the long-term bond return, and the returns of various subclasses of financial assets are too large, too variable, and too predictable. One such regularity that has received a lot of attention in the literature is the "equity risk premium puzzle". It is the inability of the neoclassical economic theory to reconcile the historically large realized premium of stock market return over the risk free rate with its low covariability with aggregate consumption growth.

In Table 1, I report the sample mean of the annual arithmetic aggregate equity return and of the equity premium. I proxy the aggregate equity return with the S&P Composite Index return. I proxy the annual risk-free rate with the rolled-over return on three-month Treasury bills and certificates. The reported real return is CPI-adjusted for inflation. Over the period 1872 to 2000, the sample mean of the real equity return is 8.9 percent and of the premium is 6.9 percent. Over the period 1926 to 2000, the sample mean of the equity return is 9.7 percent and of the premium is 9.3 percent. Over the post-war period 1951 to 2000, the sample mean of the equity return is 9.9 percent and that of the premium is 8.7 percent. These sample means are large. In Table 2, I report the equity premium across countries. The sample means are large across most countries.

Is it possible that the sample mean of the equity premium overstates the unconditional mean premium? Over the period 1872 to 2000, the price-dividend ratio increased by a factor of 4.6 and the price-earnings ratio by a factor of 2.5. Over the period 1926 to 2000, the price-dividend ratio increased by a factor of 3.9 and the price-earnings ratio increased by a factor of 2.6.[1] One may consider adjusting downwards the sample-mean estimate of the unconditional mean return on equity. The size of the adjustment ought to relate to the perceived cause of the increase of these financial ratios. In the year 1998, 52 percent of the United States adult population held equity either directly or indirectly, compared to 36 percent of the adult population in 1989. This equitization has been brought about by the increased accessibility of information on the stock market, electronic trading, the growth of mutual funds, the growth of defined-contribution pension plans, and demographic changes. Other regime shifts include the advent of the technology/media/telecoms "new economy" and changes in the taxation of dividends and capital gains. Explanations of the price increase that rely on economic models that are less than fully rational include cultural and psychological factors and tap into the rich and burgeoning literature on behavioral economics and finance.

In Constantinides (2002), I discussed how one may process this information and adjust the sample mean estimate of the unconditional mean premium by subtracting the mean annual growth of the price-dividend ratio. In Table 1, I report the mean annual growth of various financial ratios. Over the period 1951 to 2000, the mean annual growth of the price-dividend ratio is 3.4, the price-earnings ratio is 2.7, the price-book equity ratio is 3.2, and the price-National Income ratio is 1.3. Even if I subtract the entire mean annual growth of the price-earnings ratio from the sample mean, the adjusted estimate of the unconditional mean premium is 6.0 percent and is large. The corresponding estimate over the 1926 to 2000 period is 8.0 percent.

[1] The increase in these financial ratios should be interpreted with caution. The increase in the price-dividend ratio is due in part to an increase in share repurchases and a decrease in the fraction of dividend-paying firms.

An alternative approach is to consider the longer sample period 1872 to 2000. Over this period, the mean annual growth of the price-dividend ratio and price-earnings ratio is 1.2 percent and 0.7 percent, respectively. Thus, this type of adjustment is largely a non-issue over the full sample. Essentially, the change in the financial ratios is “amortized” over 129 years and makes little difference in the estimate. Over the full period 1872 to 2000, the sample mean equity premium is 6.9 percent and the annual Sharpe ratio is 36 percent. Any adjustment with the average growth of the financial ratios still leaves the unconditional mean premium large and in need of an economic explanation.

Summing up, the average premium of the arithmetic rate of return of the S&P Composite Index over the risk-free rate, measured over the last one hundred and thirty years, is almost *seven percent* and the annual Sharpe ratio is 36 percent. If the equity premium is a stationary process, then the average premium is an unbiased estimate of the *unconditional* mean equity premium. One may introduce one’s own prior beliefs and shave about one percent off the premium. The premium and the Sharpe ratio are still large and challenge economic theory for an explanation.

The neoclassical economic model parsimoniously links the returns of all assets to per capita consumption growth through the Euler equations of consumption.[2] According to the theory, the risk premia of financial assets are explained by their covariance with per capita consumption growth. However, per capita consumption growth covaries too little with the returns of most classes of financial assets. Attempts to leverage the low co-variability typically backfire, implying that the observed risk-free rate is too low and has too low variance. I discuss in some depth the aggregate equity puzzle because it exemplifies many of the problems that arise in attempting to explain the premium of any subclass of financial assets.

The covariance of per capita consumption growth with the aggregate equity return is *positive*. The rational model explains why the aggregate equity premium is positive.

[2] See Breeden (1979), Lucas (1978), Merton (1973), and Rubinstein (1976)

However, the covariance is typically one order of magnitude lower than what is needed to explain the premium. Thus, the equity premium is a *quantitative* puzzle.[3]

The equity premium puzzle is *robust*. One may address the problem by testing the Euler equations of consumption or by calibrating the economy. Either way, it is a puzzle. In calibrating an exchange economy, the model cannot generate the first and second unconditional moments of the equity returns. In testing and rejecting the Euler equations of consumption, one abstracts from the market clearing conditions. Variations in the assumptions on the supply side of the economy do not resolve the puzzle.

The challenge is a *dual puzzle* of the equity premium that is too high and the risk-free rate that is too low relative to the predictions of the model. In calibrating an economy, the strategy of increasing the risk aversion coefficient in order to lever the effect of the problematic low covariance of consumption growth with equity returns increases the predicted risk-free rate and aggravates the risk-free-rate puzzle. In testing the Euler equations of consumption, the rejections are strongest when the risk-free rate is included in the set of test assets.

Several generalizations of essential features of the model have been proposed to mitigate its poor performance. They include alternative assumptions on preferences;[4] rare but disastrous market-wide events;[5] distorted beliefs and learning;[6] incomplete

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[3] Ferson and Constantinides (1991), Grossman and Shiller (1981), Hansen and Jagannathan (1991), Hansen and Singleton (1982), and many others tested and rejected the Euler equations of consumption. Mehra and Prescott (1985) calibrated an economy to match the process of consumption growth. They demonstrated that the unconditional mean annual premium of the aggregate equity return over the risk-free rate is, at most, 0.35 percent. This is too low, no matter how one estimates the unconditional mean equity premium. Weil (1989) stressed that the puzzle is a dual puzzle of the observed too high equity return and too low risk-free rate.

[4] For example, Abel (1990), Bansal and Yaron (2004), Benartzi and Thaler (1995), Boldrin, Christiano, and Fisher (2001), Braun, Constantinides and Ferson (1993), Cagetti (2002), Campbell and Cochrane (1999), Constantinides (1990), Epstein and Zin (1991), and Ferson and Constantinides (1991).

[5] For example, Barro (2005), Danthine and Donaldson (1999), Mehra and Prescott (1988), and Rietz (1988).

[6] Cecchetti, Lam and Mark (2000), Danthine and Donaldson (1999), Guidolin (2004), and Weitzman (2005).

markets;[7] market imperfections;[8] and liquidity risk.[9] They also include a better understanding of data problems such as limited participation of consumers in the stock market;[10] temporal aggregation;[11] and the survival bias of the United States capital market.[12]

The low covariance of the growth rate of aggregate consumption with equity returns is a major stumbling block in explaining the mean aggregate equity premium and the cross-section of asset returns, in the context of a representative-consumer economy with time separable preferences. Mankiw and Shapiro (1986) found that the market beta often explains asset returns better than the consumption beta does. Over the years, a number of different economic models have been proposed that effectively increase the covariance of equity returns with the growth rate of aggregate consumption, by proxying the growth rate of aggregate consumption with the stock market return in the Euler equations of consumption.[13]

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[7] For example, Bewley (1982), Brav, Constantinides, and Geczy (2002), Constantinides, Donaldson, and Mehra (2002), Constantinides and Duffie (1996), De Santis (2004), Heaton and Lucas (1996), Jacobs and Wang (2004), Krebs (2002), Mankiw (1986), Mehra and Prescott (1985), and Storesletten, Telmer, and Yaron (2001, 2004).

[8] For example, Aiyagari and Gertler (1991), Bansal and Coleman (1996), Constantinides, Donaldson, and Mehra (2002), Daniel and Marshall (1997), Danthine, Donaldson, and Mehra (1992), He and Modest (1995), Heaton and Lucas (1996), and Parker and Julliard (2005).

[9] See, Alvarez and Jermann (2001) and Lustig (2004).

[10] For example, Attanasio, Banks and Tanner (2002), Brav, Constantinides, and Geczy (2002), Brav and Geczy (1995), Mankiw and Zeldes (1991), and Vissing-Jorgensen (2002).

[11] See, Gabaix and Laibson (2001), Heaton (1995), and Lynch (1996).

[12] See Brown, Goetzmann, and Ross (1995). However, Jorion and Goetzmann (1999, Table 6) found that the average real capital gain rate of a United States equities index exceeds the average rate of a global equities index that includes both markets that have and have not survived by merely one percent per year.

[13] Friend and Blume (1975) explained the mean equity premium with low RRA coefficient by assuming a single-period economy in which the end-of-period consumption inevitably equals the end-of-period wealth. In the Epstein and Zin (1991) model, even though the preferences are defined over consumption alone, the stock market return enters directly in the Euler equations of consumption. Bakshi and Chen (1996) introduced a set of preferences defined over consumption and wealth—the spirit of capitalism—that also have the effect of introducing the stock market return in the Euler equations of consumption.

Many of these generalizations contribute in part toward our better understanding of the economic mechanism that determines the pricing of assets. I refer the reader to the textbooks by Campbell, Lo, and McKinlay (1997) and Cochrane (2001); and the articles by Campbell (2001, 2003), Cochrane (1997), Cochrane and Hansen (1992), Constantinides (2002), Kocherlakota (1996), and Mehra and Prescott (2003).

2. An overview of the neo-classical economic model

I begin with the standard assumptions of neoclassical economic model, as adapted in finance. There are *I* consumers $i, i = 1, ..., I$, each consuming c_t^i units of the consumption good in period *t* and having von Neumann-Morgenstern preferences

$$E_0\left[U_i\left(c_0^i, ..., c_t^i, c_{t+1}^i, ...\right)\right]. \tag{2.1}$$

There are *J* capital assets, $j = 1, ..., J$, traded by the consumers in perfect markers and having returns $R_{j,t+1}$ between periods *t* and *t+1*. Utility maximization by the i^{th} consumer in trading the j^{th} asset at time *t* yields the following Euler equation of consumption between periods *t* and *t+1*:

$$E_t\left[-\frac{\partial U_i}{\partial c_t^i} + \frac{\partial U_i}{\partial c_{t+1}^i} R_{j,t+1}\right] = 1. \tag{2.2}$$

In the standard theory, preferences are typically specialized to be time separable as

$$E_0\left[\sum_{t=0}^{\infty}\beta^t u_i\left(c_t^i\right)\right] \tag{2.3}$$

with constant subjective discount factor β. There is no empirical justification for this specialization of preferences. In any case, with time separable preferences as in equation (2.3), the Euler equation of consumption simplifies into the following equation:

$$E_t\left[\beta\frac{\partial u_i\left(c_{t+1}^i\right)/\partial c_{t+1}^i}{\partial u_i\left(c_t^i\right)/\partial c_t^i}R_{j,t+1}\right]=1. \tag{2.4}$$

In the standard theory, the model is typically further specialized by assuming that the market is complete. There is little, if any, empirical justification for this assumption either. In this essay, I relax this assumption, considering instead an *incomplete market*, and explore its implications in the pricing of financial assets.

In any case, under the assumption of market completeness, the equilibrium in this heterogeneous-consumer economy is isomorphic in its pricing implications to the equilibrium in a representative-consumer economy. For our purposes, market completeness implies that there exists a period utility function $u\left(C_t\right)$ of per capita consumption $C_t \equiv I^{-1}\sum_{i=1}^{I}c_t^i$, such that we may replace the I consumer-specific Euler equations (2.4) with the following Euler equation of consumption of the representative consumer:

$$E_t\left[\beta\frac{\partial u\left(C_{t+1}\right)/\partial C_{t+1}}{\partial u\left(C_t\right)/\partial C_t}R_{j,t+1}\right]=1. \tag{2.5}$$

It is often assumed that the period utility function is of the power form, $u\left(C_t\right)=\left(1-A\right)^{-1}\left(C_t\right)^{1-A}$, with constant relative risk aversion (RRA) coefficient *A*. With power utility, the Euler equation (2.5) further simplifies into the following:

$$E_t\left[\beta\left(\frac{C_{t+1}}{C_t}\right)^{-A}R_{j,t+1}\right]=1. \qquad (2.6)$$

An advantage of the assumption that the period utility function is of the power form is that per capita consumption appears in the Euler equation only as per capita consumption *growth*, C_{t+1}/C_t, which may be stationary even if the consumption *level* is non-stationary.

In empirical work and calibration, per capita consumption growth in the Euler equation (2.6) is often taken to be the aggregate consumption growth, where the aggregate consumption is taken from the National Income and Product Accounts (NIPA). However, the aggregate consumption reported by NIPA is the sum total over all households, irrespective of whether these households are marginal in the equities and bond markets or not. Leaving aside the *limited stock market participation* by households, I condition down the Euler equation (2.6) into unconditional form and linearize it under the assumption that the logarithm of the consumption growth and the logarithm of asset returns are bivariate normally distributed:

$$\begin{aligned}&\ln E\left[R_{i,t+1}\right]\equiv E\left[\ln R_{i,t+1}\right]+\frac{1}{2}\operatorname{var}\left(\ln R_{i,t+1}\right)\\&=-\ln\beta+A\times E\left[\ln\frac{C_{t+1}}{C_t}\right]-\frac{1}{2}A^2\times\operatorname{var}\left(\ln\frac{C_{t+1}}{C_t}\right)+A\times\operatorname{cov}\left(\ln R_{i,t+1},\ln\frac{C_{t+1}}{C_t}\right)\end{aligned} \qquad (2.7)$$

I take the difference of the linearized Euler equations for the market return and for the risk free rate and find that the unconditional mean equity premium is equal to the product of the RRA coefficient of the representative consumer and the covariance of the market return with per capita consumption growth:[14]

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[14] I make use of the property that the risk free rate $R_{F,t+1}$ is known at time *t*. The *conditional* covariance $\operatorname{cov}_t\left(\ln R_{F,t+1},\ln\frac{C_{t+1}}{C_t}\right)$ is zero and, therefore the *unconditional* covariance $\operatorname{cov}\left(\ln R_{F,t+1},\ln\frac{C_{t+1}}{C_t}\right)$ is approximately zero.

$$\ln E\left[R_{M,t+1}\right]-\ln E\left[R_{F,t+1}\right]=A\times\text{cov}\left(\ln R_{M,t+1}\,,\ln\frac{C_{t+1}}{C_t}\right). \tag{2.8}$$

I also find that the risk free rate is equal to the sum of the subjective discount rate $\left(-\ln\beta\right)$ and the product of the RRA coefficient and the mean growth rate in consumption, less one-half the product of the squared RRA coefficient and the variance of consumption growth:

$$\ln E\left[R_{F,t+1}\right]=-\ln\beta+A\times E\left[\ln\frac{C_{t+1}}{C_t}\right]-\frac{1}{2}A^2\times\text{var}\left(\ln\frac{C_{t+1}}{C_t}\right). \tag{2.9}$$

The *elasticity of substitution in consumption* is defined as the increase in expected consumption growth for a unit increase in the risk free rate, $\psi\equiv\partial E\left[\ln\frac{C_{t+1}}{C_t}\right]/\ln E\left[R_{F,t+1}\right]$. With time-separable preferences and constant RRA coefficient, equation (2.9) implies that the product of the RRA coefficient and the elasticity equals one, $RRA\times\psi=1$. Even with time-separable preferences but variable RRA coefficient, the product of the RRA coefficient and the elasticity approximately equals one.[15] In terms of the elasticity, equation (2.9) may be written as

$$\ln E\left[R_{F,t+1}\right]=-\ln\beta+\frac{1}{\psi}\times E\left[\ln\frac{C_{t+1}}{C_t}\right]-\frac{1}{2\psi^2}\times\text{var}\left(\ln\frac{C_{t+1}}{C_t}\right). \tag{2.10}$$

Empirically, the covariance of per capita consumption growth with the market return is low and cannot generate the mean equity premium, as in equation (1.8), with a reasonable value of the RRA coefficient. If one assumes a sufficiently high value of the

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[15] In models with time-non-separable preferences such as models that capture habit persistence or the Epstein-Zin (1991) model of preferences, the product $RRA\times\psi$ need not equal one. With Epstein-Zin preferences, the risk free rate is given by equation (1.10) in terms of the elasticity and not by equation (1.9) in terms of the RRA coefficient.

RRA coefficient in order to generate a realistic mean premium, the Euler equation of consumption with respect to the risk free rate, equation (2.9), now generates a risk free rate which is much higher than the historically observed risk free rate. Thus the puzzle is a dual puzzle that the observed mean equity premium is too high and the risk free rate is too low.[16] These are but two of the implications of the Euler equations (2.5) that are at odds with the data either in both empirical work and calibration.

In the next section, I relax the assumption of market completeness and explore its ramifications in better understanding the equity premium, the risk free rate and the Euler equations of consumption.

3. Incomplete markets and idiosyncratic income shocks

In economic recessions, investors are exposed to the double hazard of stock market losses and job loss. Investment in equities not only fails to hedge the risk of job loss but accentuates its implications. Investors require a hefty equity premium in order to be induced to hold equities.

The argument hinges on the fact that the market for job-loss insurance is incomplete. Moral hazard impedes the development of unemployment insurance markets and extant unemployment compensation provides inadequate protection for investors wealthy enough to be significant players in the financial markets. For example, with job-loss insurance, an increase by one percent in the probability of job loss merely manifests itself as a one percent decrease in per capita consumption growth—a risk which is too

[16] Note that the risk free rate is decreasing in the RRA coefficient for sufficiently high value of this coefficient. However, it takes an absurdly high value of the RRA coefficient to lower the risk free rate in this way.

small to generate the observed equity premium. Job loss is but one example of idiosyncratic income shocks that have the potential to generate a sizable equity premium.

The observed correlation of per capita consumption growth with stock returns is low. Over the years, I have grown skeptical of how meaningful an economic construct per capita consumption is, and how hard we should push per capita consumption to explain returns. Per capita consumption is a meaningful economic concept only if the market is complete or effectively so.[17] Any time that we model the household sector by a representative consumer and proxy consumption with per capita (or, aggregate) consumption, we suppress the potentially major economic impact of uninsurable idiosyncratic income shocks.

I begin to formalize these ideas with the observation that, in the competitive equilibrium of a complete market economy, heterogeneous households allocate their consumption in a way that they equalize, state by state, their marginal rate of substitution. Negishi (1960) pointed out that the same consumption allocation is attained when a social planner maximizes the judiciously weighted sum of the households' utility functions. For this result to hold, the weight of each household's utility function is chosen to be inversely proportional to the Lagrange multiplier of the budget constraint of the respective household. The claim follows from the observation that the households' first-order conditions are identical to the first-order conditions of a social planner.

Constantinides (1982) further showed that the social planner's problem can be split into two sub-problems.[18] In the first sub-problem, one constructs an increasing and concave utility function out of the social planner's weighted sum of the households' utility functions. In the second sub-problem, the social planner maximizes the above-constructed utility function and ends up allocating consumption at each state equal to the total consumption allocated at that state in the heterogeneous-household economy. This implies that the equilibrium in a heterogeneous-household, full-information economy is isomorphic in its pricing implications to the equilibrium in a representative-household, full-information economy, if households have von Neumann-Morgenstern preferences. The strong assumption of market completeness is indirectly built into asset pricing

[17] The market is effectively complete when all households have preferences that imply two-fund separation.

[18] See also the discussion in an unpublished earlier draft of Mehra and Prescott (1985).

models in finance and neoclassical macroeconomic models through the assumption of the existence of a representative household.

Bewley (1982), Mankiw (1986), and Mehra and Prescott (1985) suggested the potential of enriching the asset-pricing implications of the representative-household paradigm, by relaxing the assumption of complete markets.[19] Constantinides and Duffie (1996) found that incomplete markets substantially enrich the implications of the representative-household model. Their main result is a proposition demonstrating, by construction, the existence of household income processes, consistent with given aggregate income and dividend processes, such that equilibrium equity and bond price processes match the given equity and bond price processes.

The starting point in the Constantinides and Duffie (1996) theory, are the $I \times J$ Euler equations (1.4) of individual consumption by the I consumers for the J assets, specialized for preferences that imply constant relative risk aversion:

$$E_t\left[\beta g_{i,t+1}^{-A} R_{j,t+1}\right] = 1, \quad i = 1,\dots,I; \quad j = 1,\dots,J \,. \tag{3.1}$$

The consumption growth of the i^{th} consumer is $g_{i,t+1} \equiv c_{t+1}^i / c_t^i$ and the RRA coefficient is A. The point of departure from standard theory is the recognition that market incompleteness rules out the step of replacing the Euler equations (3.1) by the Euler equation (2.6) of the representative consumer.

A stochastic discount factor (SDF), or pricing kernel, is defined as any random variable m_{t+1} with the following property:

$$E_t\left[m_{t+1} R_{j,t+1}\right] = 1, \quad j = 1,\dots,J \,. \tag{3.2}$$

Therefore, equation (3.1) states that each consumer's marginal rate of substitution, $\beta g_{i,t+1}^{-A}$, is a valid SDF.

[19] There is an extensive literature on the hypothesis of complete consumption insurance. See Altonji, Hayashi and Kotlikoff (1992), Attanasio and Davis (1997), Cochrane (1991), and Mace (1991).

I sum the $I \times J$ Euler equations (3.1) across households and obtain the expression

$$E_t\left[\beta\left\{I^{-1}\sum_{i=1}^{I} g_{i,t+1}^{-A}\right\}R_{j,t+1}\right]=1, \quad j=1,\ldots,J\ . \tag{3.3}$$

Equation (3.3) states that the weighted sum of the consumers' marginal rate of substitution is a valid SDF also:

$$m_{t+1}=\beta\left\{I^{-1}\sum_{i=1}^{I} g_{i,t+1}^{-A}\right\}. \tag{3.4}$$

I expand equation (3.4) as a Taylor series up to cubic terms and obtain the following approximation for the SDF:

$$m_{t+1}=\beta\, g_{t+1}^{-A}\left\{1+\frac{A\,(A+1)}{2}I^{-1}\sum_{i=1}^{I}\left(\frac{g_{i,t+1}}{g_{t+1}}-1\right)^2-\frac{A\,(A+1)\,(A+2)}{6}I^{-1}\sum_{i=1}^{I}\left(\frac{g_{i,t+1}}{g_{t+1}}-1\right)^3\right\} \tag{3.5}$$

The term $g_{t+1} \equiv I^{-1}\sum_{i=1}^{I} g_{i,t+1}$ is the sample mean of the consumption growth rate across consumers; $I^{-1}\sum_{i=1}^{I}\left(\frac{g_{i,t+1}}{g_{t+1}}-1\right)^2$ is the squared coefficient of variation of the consumption growth rate across consumers; and $I^{-1}\sum_{i=1}^{I}\left(\frac{g_{i,t+1}}{g_{t+1}}-1\right)^3$ is a measure of the skewness of the cross sectional variation of consumption growth.

The theory requires that the idiosyncratic income shocks have three properties in order to explain the returns on financial assets. First, they must be *uninsurable*. If there exist a complete set of markets, the equilibrium of a heterogeneous-household, full-information economy is isomorphic in its pricing implications to the equilibrium of a representative-household, full-information economy and household consumption growth cannot do better than aggregate consumption growth in explaining the returns. To see this, note that, if a complete set of markets exists, then the heterogeneous households are able to equalize, state by state, their marginal rates of substitution. In particular for any state s at time $t+1$, there exists a state-specific but consumer-independent parameter λ_s such that $g_{i,t} = g_t = \lambda_s$, $i = 1,...,I$. The SDF in equations (3.5) simplifies into

$$m_{t+1} = \beta\, g_{t+1}^{-A} \tag{3.6}$$

or, equivalently, into[20]

$$m_{t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-A}. \tag{3.7}$$

Therefore, if there exist a complete set of markets, the equilibrium of a heterogeneous-household, full-information economy is isomorphic in its pricing implications to the equilibrium of a representative-household, full-information economy and household consumption growth cannot do better than aggregate consumption growth in explaining the returns.

Second, the theory requires that the idiosyncratic income shocks be *persistent*. If the shocks are transient, then households can smooth their consumption by borrowing or by drawing down their savings.[21]

[20] When there is a complete set of markets, equation (4.7) follows from the fact that, for any state *s*, $\frac{C_{t+1}}{C_t} = \frac{I^{-1}\sum_{i=1}^{I} c_{t+1}^i}{I^{-1}\sum_{i=1}^{I} c_t^i} = \lambda_s = g_{t+1}$. I expect that the SDF given by equation (4.7) is less susceptible to observation error than the SDF given by equation (4.6).

[21] Aiyagari and Gertler (1991) and Heaton and Lucas (1996) found that consumers facing *transient* shocks come close to the complete-markets rule of complete risk sharing even with transaction costs and/or borrowing costs, *provided that the supply of bonds is not restricted to an unrealistically low level*.

Third, the conditional variance, or some higher moment of the income shocks, must be counter-cyclical. In equation (3.5), the SDF is monotone increasing in the conditional variance. If the conditional variance is counter-cyclical, then the SDF is counter-cyclical and co-varies negatively with the market return, even though aggregate consumption has low covariance with the market return. In principle, this negative co-variation gives rise to an equity premium that is absent in a complete market. Even if the conditional variance is not counter-cyclical, the cyclical or counter-cyclical behavior of some higher moment of the income shocks may generate a high equity premium. For example, in equation (3.5), the SDF is monotone decreasing in the conditional skewness. If the conditional skewness is cyclical, then the SDF is counter-cyclical and co-varies negatively with the market return, giving rise to an equity premium.

A good example of a major uninsurable income shock is job loss. Job loss is *uninsurable* because unemployment compensation is inadequate. Layoffs have *persistent* implications on household income, even though the laid-off workers typically find another job quickly.[22] Layoffs are *counter-cyclical* as they are more likely to occur in recessions.

Recall that the main result in Constantinides and Duffie (1996) is a proposition demonstrating, by construction, the existence of household income processes, consistent with given aggregate income and dividend processes, such that equilibrium equity and bond price processes match the given equity and bond price processes. The proposition implies that the Euler equations of household (but not necessarily of per capita) consumption must hold. Furthermore, since the given price processes have embedded in them whatever predictability of returns by the price-dividend ratios, dividend growth rates, and other instruments that the researcher cares to ascribe to returns, the equilibrium price processes have this predictability built into them by construction.

[22] The empirical evidence is sensitive to the model specification. Heaton and Lucas (1996) modeled the income process as *univariate* and provided empirical evidence from the Panel Study on Income Dynamics (PSID) that the idiosyncratic income shocks are transitory. Storesletten, Telmer, and Yaron (2001) modeled the income process as *bivariate* and provided empirical evidence from the PSID that the idiosyncratic income shocks have a highly persistent component that becomes more volatile during economic contractions. Storesletten, Telmer, and Yaron (2000) corroborated the latter evidence by studying household consumption over the life cycle.

The first implication of the theory is an explanation of the counter-cyclical behavior of the equity risk premium: the risk premium is highest in a recession because the stock is a poor hedge against the uninsurable income shocks, such as job loss, that are more likely to arrive during a recession.

The second implication is an explanation of the unconditional equity premium puzzle: even though per capita consumption growth is poorly correlated with stocks returns, investors require a hefty premium to hold stocks over short-term bonds because stocks perform poorly in recessions, when the investor is most likely to be laid off.

In principle, I may directly test the $I \times J$ system of Euler equations (3.1) of household consumption. In the US, the best available disaggregated consumption data are provided by the department of Labor Statistics' Consumer Expenditure Survey (CEX) of quarterly consumption of selected households (not individual consumers). In practice the direct test is difficult because household consumption data are reported with substantial error.

Brav, Constantinides, and Geczy (2002) provided empirical evidence on the importance of uninsurable idiosyncratic income risk on pricing. They put forth a series of candidate SDFs: the marginal rate of substitution of the representative consumer as in equations (3.6) or (3.7); the Taylor series expansion of the SDF up to quadratic terms; the Taylor series expansion of the SDF up to cubic terms, as in equation (3.5); and a log-linearized expansion of the SDF. They estimated the RRA coefficient and tested the set of Euler equations of household consumption on the premium of the value-weighted and the equally weighted market portfolio return over the risk free rate and on the premium of value stocks over growth stocks.[23]

Brav et al (2002) did not reject the Euler equations of household consumption with RRA coefficient between two and four when the candidate SDF is the Taylor series expansion of the SDF up to cubic terms, as in equation (3.5). A RRA coefficient between two and four is economically plausible. They rejected the Euler equations of household

[23] In related studies, Jacobs (1999) studied the PSID database on food consumption; Cogley (2002) and Vissing-Jorgensen (2002) studied the CEX database on broad measures of consumption; Jacobs and Wang (2004) studied the CEX database by constructing synthetic cohorts; and Ait-Sahalia, Parker, and Yogo (2004) instrumented the household consumption with the purchases of certain luxury goods.

consumption with any value of the RRA coefficient when the Taylor series expansion of the SDF does not include the cubic terms. This implies that, in addition to the mean and variance, the *skewness* of the cross-sectional distribution is important in explaining the equity premium. They also found that the log-linearized expansion of the SDF fails to explain the premia, possibly because the log-linearization downplays the effect of outliers. These results emphasize the role of the higher moments of the cross-sectional distribution in explaining the premia.

Krebs (2002) provided a theoretical justification as to why it is possible that neither the variance nor the skewness, but higher moments of the cross-sectional distribution are important in explaining the equity premium. He extended the Constantinides and Duffie (1996) model by introducing rare idiosyncratic income shocks that drive consumption close to zero. In his model, the conditional variance and skewness of the idiosyncratic income shocks are nearly constant over time. Despite this, Krebs demonstrated that the original proposition of Constantinides and Duffie remains valid, that is, there exist household income processes, consistent with given aggregate income and dividend processes, such that equilibrium equity and bond price processes match the given equity and bond price processes. Essentially, he provided a theoretical justification as to why it may be hard to empirically detect the rare but catastrophic shocks in the low-order cross-sectional moments of household consumption growth.

Jacobs and Wang (2004) expanded the set test assets employed by Brav et al (2002) to the set of the 25 Fama-French size and value portfolios and provided additional empirical evidence on the importance of uninsurable idiosyncratic income risk on pricing. They found that a two-factor asset pricing model, with the mean and cross-sectional variance of the household consumption growth rate as factors, significantly outperforms the capital asset pricing model in explaining the cross-section of asset returns.

Korniotis (2005) investigated the potential incompleteness of the market across U.S. states while assuming complete consumption insurance within each state. He tested the Euler equation of consumption for each state, where state consumption is proxied by the annual state-wide sales at retail establishments. He found that a factor pricing model that recognizes this incompleteness with the cross-sectional variance of the state consumption as a factor has modest success in explaining the cross-section of asset returns. He also found that a factor pricing model that simultaneously recognizes this incompleteness and non-linear external habit better explains the cross-section of asset returns.

4. Borrowing constraints in an overlapping generations economy

In this section, I explore the impact of borrowing constraints in the context of the overlapping generations model introduced in Constantinides, Donaldson, and Mehra (2002) and address its implications on the risk free rate and the equity premium. The demographic structure of an overlapping generations economy is a natural setting in which to address the impact of borrowing constraints. The model has three generations in which the young generation is constrained from borrowing and investing in equities. Borrowing constraints arises because human capital alone does not collateralize major loans in modern economies for reasons of moral hazard and adverse selection.

There has been considerable confusion in the literature as to the sense in which an OLG economy differs from an Arrow-Debreu economy. As Gaenakoplos (1987) makes clear, the basic difference is that in an OLG economy there is no market clearing at infinity, irrespective of whether the market is complete or incomplete. The particular OLG economy that I discuss is incomplete. However, it is the borrowing constraint that drives the main results and not the market incompleteness or the lack of market clearing at infinity. Indeed, the limited participation in the borrowing constrained economy generates a plausible mean equity premium while the borrowing unconstrained version of the same economy generates a negligible mean equity premium.

In the Constantinides et al (2002) economy, consumers live for three periods. In the first period, a period of human capital acquisition, consumers receive a relatively low endowment income. In the second period, consumers are employed and receive wage income subject to large uncertainty. In the third period, consumers retire and consume the assets accumulated in the second period. The key feature is that the bulk of the *future* income of the young consumers is derived from their wages forthcoming in their middle age, while the *future* income of the middle-aged consumers is derived primarily from their savings in equity and bonds.

The young would like to invest in equity, given the observed large equity premium. However, they are unwilling to decrease their current consumption in order to save by investing in equity, because the bulk of their lifetime income is derived from their wages forthcoming in their middle age. They would like to borrow, but the borrowing constraint prevents them from doing so. Human capital alone does not collateralize major loans in modern economies for reasons of moral hazard and adverse selection. The model explains why many consumers do not participate in the stock market in the early phase of their life cycle.

The future income of the middle-aged consumers is derived from their current savings in equity and bonds. Therefore, the risk of holding equity and bonds is concentrated in the hands of the middle-aged saving consumers. This concentration of risk generates the high equity premium and the demand for bonds, in addition to the demand for equity, by the middle-aged.[24] The model recognizes and addresses simultaneously, at least in part, the equity premium, the limited participation in the stock market, and the demand for bonds.

Constantinides et al (2002) calibrated the model to match the following eight targets: the average share of income going to labor; the average share of income going to the labor of the young; the average share of income going to interest on government debt; the coefficient of variation of the 20-year wage income of the middle aged; the coefficient of variation of the 20-year aggregate income; the 20-year autocorrelation of the labor income; the 20-year autocorrelation of the aggregate income; and the 20-year cross-correlation of the labor income and the aggregate income. Since the length of one period in this model is twenty years, for all securities (equity, bond or consol), the annualized mean return is defined as the mean of $(20)^{-1}$ln(20-year holding period return); and the annualized standard deviation of the return is defined as the standard deviation of

[24] See also the discussion in the related papers by Bertaut and Haliasos (1997), Bodie, Merton, and Samuelson (1992), Jagannathan and Kocherlakota (1996) and Storesletten, Telmer, and Yaron (2001).

$(20)^{-0.5}$ ln(20-year holding period return). Below, I reproduce the first panel of Table 1 in Constantinides et.al. (2002).[25]

	Borrowing-constrained	Borrowing-unconstrained
Mean equity return	8.4	10.2
Std of equity return	23.0	42.0
Mean bond return	5.1	9.0
Std of bond return	15.4	27.6
Mean premium over bond	3.4	1.1
Std of premium over bond	18.4	31.6
Mean consol return	3.7	9.9
Std of consol return	19.1	27.6
Mean premium over consol	4.7	0.3
Std of premium over consol	10.5	5.2
Corr of wages and dividend	-0.43	-0.43
Corr of wages and premium	-0.02	0.00

The borrowing constraint decreases the mean return of the 20-year or consol bond by about a factor of two. This observation is robust to the calibration of the correlation and auto-correlation of the labor income of the middle-aged with the aggregate income. The borrowing constraint goes a long way, albeit not all the way, towards resolving the risk free rate puzzle. If the young were able to borrow, they would do so and purchase equity; the borrowing activity of the young would raise the bond return, thereby exacerbating the risk-free rate puzzle.

Second, the mean equity premium over the 20-year or consol bond is about 4%. This is satisfactory given that long term bond returns typically command a premium over the short term risk free rate. This premium drastically decreases when the borrowing constraint is relaxed. If the young were able to borrow, the increase in the bond return would induce the middle-aged to shift their portfolio holdings in favor of the bond; the increase in the demand for equity by the young and the decrease in the demand for equity by the middle-aged work in opposite directions; on balance, the effect would be to increase the return on both equity and the bond while simultaneously shrinking the equity premium.

[25] The RRA coefficient is set at 6; the coefficient of variation of the (20-year) aggregate income is set at 0.20; the coefficient of variation of the (20-year) wages is set at 0.25; the auto-correlation of aggregate income, the auto-correlation of wages, and the correlation of aggregate income and wages are all set at 0.1. The consol bond is in positive net supply and the one-period (20-year) bond is in zero net supply.

Third, the correlation of the labor income of the middle-aged and the equity premium over the 20-year bond is much smaller in absolute value than the exogenously-imposed correlation of the labor income of the middle-aged and the dividend. Thus, equity is attractive to the young because of the large mean equity premium *and* the low correlation of the premium with the wage income of the middle-aged, thereby corroborating another important dimension of the model. In equilibrium, it turns out that the correlation of the wage income of the middle-aged and the equity return is low.[26] The young consumers would like to invest in equity because equity return has low correlation with their future consumption, if their future consumption is derived from their future wage income. However, the borrowing constraint prevents them from purchasing equity on margin. Furthermore, since the young consumers are relatively poor and have an incentive to smooth their intertemporal consumption, they are unwilling to decrease their current consumption in order to save by investing in equity. Therefore, the young choose not participate in the equity market.

Finally, the borrowing constraint lowers the standard deviation of the annualized, 20-year equity and bond returns. However, the standard deviation of the equity return and particularly the standard deviation of the bond return remain high.

In related work, Storesletten, Telmer, and Yaron (2001, 2004) explored the interaction of life cycle effects and the uninsurable idiosyncratic wage income shocks and found that the interaction plays an important role in explaining asset returns. Heaton and Lucas (1999) explored whether changes in market participation patterns account for the recent rise in stock prices and found that they do not.

Constantinides, Donaldson, and Mehra (2002, 2005) addressed yet another major misspecification of per capita consumption. They included *inter vivos* gifts and *post mortem* bequests in the definition of consumption thereby increasing the covariance of equity returns with the growth rate of consumption. In the context of an overlapping-generations economy, they modeled the "consumption" of the old households as consisting of the "joy of giving", c_B, in the form of *inter vivos* gifts and *post mortem*

[26] The low correlation of the wage income of the middle-aged and the equity return is a property of the equilibrium and obtains for a wide range of values of the assumed correlation of the wage income of the middle-aged and the dividend.

bequests, in addition to the direct consumption, c_D, of durable goods, services, and the service flow from non-durables goods.

The direct consumption of the old folks who are rich enough to be non-trivial investors in the capital markets is dictated by the state of their health and their medical expenses rather than fluctuations of their wealth. The correlation between the direct consumption of the old and the stock market return is *low*, a prediction that is born out empirically. Constantinides et al (2005) captured this feature by assuming that direct consumption is held constant because of a binding constraint on direct consumption.

Even though the direct consumption of the old folks is dictated by the state of their health and their medical expenses rather than the fluctuations of their wealth, these folks care about their wealth just as much as younger folks do because they derive utility from bequeathing their wealth. The bequest equals the wealth of the old, net of the direct consumption of the old, and is *a fortiori* highly correlated with the stock market return. Thus, in an economy that recognizes bequests, the marginal rate of substitution with respect to the bequests of the old, is better able to explain the mean equity premium and the risk free rate than the marginal rate of substitution with respect to the direct consumption of the old.

How does the OLG economy with bequests as in Constantinides et al (2005) differ in its pricing implications from the OLG economy without bequests as in Constantinides et al (2002), if the wage and dividend processes in the two economies are identical? In the economy with bequests, the middle-aged consumers receive all the bonds and equity for free as opposed to purchasing them from the old. Their budget is larger and the bond and equity prices are higher than in the in economy without bequests. The risk free rate is lower but the effect on the mean equity premium is ambiguous. This line of research is still in progress and its implications remains to be tested.

5. Concluding remarks

I examined the observed asset returns and conclude that the evidence does not support the case for abandoning the rational economic model. I argued that the standard model is greatly enhanced by relaxing some of its assumptions. In particular, I argued that we go a long way toward addressing market behavior by recognizing that consumers face uninsurable and idiosyncratic income shocks, for example, the loss of employment. The prospect of such events is higher in economic downturns and this observation takes us a long way toward understanding both the unconditional moments of asset returns and their variation along the business cycle.

I also argued that we should account for borrowing constraints. In this context, life cycle considerations are important and often overlooked in finance. Borrowing constraints become important when placed in the context of the life cycle. The fictitious representative consumer that holds all the stock market and bond market wealth does not face credible borrowing constraints. Young consumers, however, do face credible borrowing constraints. I traced their impact on the equity premium, the demand for bonds—who holds bonds if the equity premium is so high? —and on the limited participation of consumers in the capital markets.

Has the equity premium puzzle been resolved? I don't think so. However, the pursuit of an explanation has helped us broaden the scope of our investigation in several important ways. We are now interested in understanding the mean, higher moments, co-variability, and predictability of the return of different classes of financial assets. At the macro level, we study the short-term risk-free rate, the term premium of long-term bonds over the risk-free rate, and the aggregate equity premium of the stock market over the risk-free rate. At the micro level, we study the premium of individual stock returns and of classes of stocks, such as the small-capitalization versus large-capitalization stocks, the "value" versus "growth" stocks, and the past losing versus winning stocks.

Our pursuit has led us to study a broader class of preferences, evolution of state variables, beliefs and learning mechanisms, market incompleteness, market imperfections, and notions of liquidity than those embedded in the standard neoclassical model. Our pursuit has also helped us gain a better understanding of data problems such as limited participation of consumers in the stock market; temporal aggregation and survival biases. In my eclectic discussion of these issues, I hope to have convinced the reader that the organization of the markets, specifically *market incompleteness* and *borrowing constraints in the life cycle*, provide a promising vantage point from which to study the prices of asset and their returns both theoretically and empirically.

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TABLE 1

The long-term expected premium in the U.S.

	1872-2000	1872-1950	1951-2000	1926-2000
Sample Mean Premium	6.87	5.69	8.72	9.30
Mean Annual Growth of:				
Price/Dividends	1.18	-0.22	3.39	1.81
Price/Earnings	0.71	-0.57	2.73	1.28
Price/Book Equity	1.18	-0.11	3.18	2.26
Price/National Income	NA	NA	1.27	NA
Premium Adjusted for:				
Price/Dividends	5.69	5.91	5.33	7.49
Price/Earnings	6.16	6.26	5.99	8.02
Price/Book Equity	5.69	5.80	5.54	7.04
Price/National Income	NA	NA	7.45	NA

Data sources: Davis, Fama and French (2000), Ibbotson (2001), Shiller (2001), and Vuolteenaho (2000).

Table 2:
The long-term expected premium across countries, 1900-2000

Country	*Mean Equity Return*	*Treasury Bill Return*	*Mean Equity Premium*	*Annualized Growth of P/D Ratio*	*Adjusted Mean Equity Premium*
Australia	9.0	0.6	8.4	0.5	**7.9**
Belgium	4.8	0.0	4.8	0.3	**4.5**
Canada	7.7	1.8	5.9	1.6	**4.3**
Denmark	6.2	3.0	3.2	1.9	**1.3**
France	6.3	-2.6	8.9	1.3	**7.6**
Germany	8.8	0.1	8.7	1.2	**7.5**
Ireland	7.0	1.4	5.6	0.9	**4.7**
Italy	6.8	-2.9	9.7	0.6	**9.1**
Japan	9.3	-0.3	9.6	2.2	**7.4**
Netherlands	7.7	0.8	6.9	1.2	**5.7**
South Africa	9.1	1.0	8.1	3.2	**4.9**
Spain	5.8	0.6	5.2	0.0	**5.2**
Sweden	9.9	2.2	7.7	1.0	**6.7**
Switzerland	6.9	1.2	5.7	NA	**NA**
United K.	7.6	1.2	6.4	0.6	**5.8**
United States	8.7	1.0	7.7	1.3	**6.4**

1900-2000 source: Dimson, Marsh and Staunton. Germany, years 1922-23 excluded; Switzerland since 1911.