Consumption-Based Asset Pricing

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Abstract

This chapter reviews the behavior of financial asset prices in relation to consumption. The chapter lists some important stylized facts that characterize US data, and relates them to recent developments in equilibrium asset pricing theory. Data from other countries are examined to see which features of the US experience apply more generally. The chapter argues that to make sense of asset market behavior one needs a model in which the market price of risk is high, time-varying, and correlated with the state of the economy. Models that have this feature, including models with habit-formation in utility, heterogeneous investors, and irrational expectations, are discussed. The main focus is on stock returns and short-term real interest rates, but bond returns are also considered.

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1 Introduction

The behavior of aggregate stock prices is a subject of enduring fascination to investors, policymakers, and economists. In recent years stock markets have continued to show some familiar patterns, including high average returns and volatile and procyclical price movements. Economists have struggled to understand these patterns. If stock prices are determined by fundamentals, then what exactly are these fundamentals and what is the mechanism by which they move prices?

Researchers, working primarily with US data, have documented a host of interesting stylized facts about the stock market and its relation to short-term interest rates and aggregate consumption.

1. The average real return on stock is high. In quarterly US data over the period 1947.2 to 1998.4, a standard data set that is used throughout this chapter, the average real stock return has been 8.1% at an annual rate.[2]

2. The average riskless real interest rate is low. 3-month Treasury bills deliver a return that is riskless in nominal terms and close to riskless in real terms because there is only modest uncertainty about inflation at a 3-month horizon. In the postwar quarterly US data, the average real return on 3-month Treasury bills has been 0.9% per year.

3. Real stock returns are volatile, with an annualized standard deviation of 15.6% in the US data.

4. The real interest rate is much less volatile. The annualized standard deviation of the ex post real return on US Treasury bills is 1.7%, and much of this is due to short-run inflation risk. Less than half the variance of the real bill return is forecastable, so the standard deviation of the ex ante real interest rate is considerably smaller than 1.7%.

[2]Here and throughout the chapter, the word return is used to mean a log or continuously compounded return unless otherwise stated. Thus the average return corresponds to a geometric average, which is lower than the arithmetic average of simple returns.

5. Real consumption growth is very smooth. The annualized standard deviation of the growth rate of seasonally adjusted real consumption of nondurables and services is 1.1% in the US data.

6. Real dividend growth is extremely volatile at short horizons because dividend data are not adjusted to remove seasonality in dividend payments. The annualized quarterly standard deviation of real dividend growth is 28.3% in the US data. At longer horizons, however, the volatility of dividend growth is intermediate between the volatility of stock returns and the volatility of consumption growth. At an annual frequency, for example, the volatility of real dividend growth is only 6% in the US data.

7. Quarterly real consumption growth and real dividend growth have a very weak correlation of 0.05 in the US data, but the correlation increases at lower frequencies to 0.25 at a 4-year horizon.

8. Real consumption growth and real stock returns have a quarterly correlation of 0.23 in the US data. The correlation increases to 0.34 at a 1-year horizon, and declines at longer horizons.

9. Quarterly real dividend growth and real stock returns have a very weak correlation of 0.03 in the US data, but the correlation increases dramatically at lower frequencies to reach 0.47 at a 4-year horizon.

10. Real US consumption growth is not well forecast by its own history or by the stock market. The first-order autocorrelation of the quarterly growth rate of real nondurables and services consumption is a modest 0.2, and the log price-dividend ratio forecasts less than 4% of the variation of real consumption growth at horizons of 1 to 4 years.

11. Real US dividend growth has some short-run forecastability arising from the seasonality of dividend payments. But it is not well forecast by the stock market. The log price-dividend ratio forecasts no more than 8% of the variation of real dividend growth at horizons of 1 to 4 years.

12. The real interest rate has some positive serial correlation; its first-order autocorrelation in postwar quarterly US data is 0.5. However the real interest rate is not well forecast by the stock market, since the log price-dividend ratio forecasts less than 1% of the variation of the real interest rate at horizons of 1 to 4 years.

13. Excess returns on US stock over Treasury bills are highly forecastable. The log price-dividend ratio forecasts 10% of the variance of the excess return at a 1-year horizon, 22% at a 2-year horizon, and 38% at a 4-year horizon.

These facts raise two important questions for students of macroeconomics and finance.

- **Why is the average real stock return so high in relation to the average short-term real interest rate?**
- **Why is the volatility of real stock returns so high in relation to the volatility of the short-term real interest rate?**

Mehra and Prescott (1985) call the first question the "equity premium puzzle".[3] Finance theory explains the expected excess return on any risky asset over the riskless interest rate as the quantity of risk times the price of risk. In a standard consumption-based asset pricing model of the type studied by Rubinstein (1976), Lucas (1978), Grossman and Shiller (1981) and Hansen and Singleton (1983), the quantity of stock market risk is measured by the covariance of the excess stock return with consumption growth, while the price of risk is the coefficient of relative risk aversion of a representative investor. The high average stock return and low riskless interest rate (stylized facts 1 and 2) imply that the expected excess return on stock, the equity premium, is high. But the smoothness of consumption (stylized fact 5) makes the covariance of stock returns with consumption low; hence the equity premium can only be explained by a very high coefficient of risk aversion.

Shiller (1982), Hansen and Jagannathan (1991), and Cochrane and Hansen (1992), building on the work of Rubinstein (1976), have related the equity premium puzzle to the volatility

[3]For excellent recent surveys, see Kocherlakota (1996) or Cochrane (2001).

of the stochastic discount factor, or equivalently the volatility of the intertemporal marginal rate of substitution of a representative investor. Expressed in these terms, the equity premium puzzle is that an extremely volatile stochastic discount factor is required to match the ratio of the equity premium to the standard deviation of stock returns (the Sharpe ratio of the stock market).

Some authors, such as Kandel and Stambaugh (1991), have responded to the equity premium puzzle by arguing that risk aversion is indeed much higher than traditionally thought. However this can lead to the "riskfree rate puzzle" of Weil (1989). If investors are very risk averse, then they have a strong desire to transfer wealth from periods with high consumption to periods with low consumption. Since consumption has tended to grow steadily over time, high risk aversion makes investors want to borrow to reduce the discrepancy between future consumption and present consumption. To reconcile this with the low real interest rate we observe, we must postulate that investors are extremely patient; their preferences give future consumption almost as much weight as current consumption, or even greater weight than current consumption. In other words they have a low or even negative rate of time preference.

I will call the second question the "equity volatility puzzle". To understand the puzzle, it is helpful to classify the possible sources of stock market volatility. Recall first that prices, dividends, and returns are not independent but are linked by an accounting identity. If an asset's price is high today, then either its dividend must be high tomorrow, or its return must be low between today and tomorrow, or its price must be even higher tomorrow. If one excludes the possibility that an asset price can grow explosively forever in a "rational bubble", then it follows that an asset with a high price today must have some combination of high dividends over the indefinite future and low returns over the indefinite future. Investors must recognize this fact in forming their expectations, so when an asset price is high investors expect some combination of high future dividends and low future returns. Movements in prices must then be associated with some combination of changing expectations ("news") about future dividends and changing expectations about future returns; the latter can in

turn be broken into news about future riskless real interest rates and news about future excess returns on stocks over short-term debt.

Until the early 1980's, most financial economists believed that there was very little predictable variation in stock returns and that dividend news was by far the most important factor driving stock market fluctuations. LeRoy and Porter (1981) and Shiller (1981) challenged this orthodoxy by pointing out that plausible measures of expected future dividends are far less volatile than real stock prices. Their work is related to stylized facts 6, 9, and 11.

Later in the 1980's Campbell and Shiller (1988a,b), Fama and French (1988a,b, 1989), Poterba and Summers (1988) and others showed that there appears to be a forecastable component of stock returns that is important when returns are measured over long horizons. The variables that predict returns are ratios of stock prices to scale factors such as dividends, earnings, moving averages of earnings, or the book value of equity. When stock prices are high relative to these scale factors, subsequent long-horizon real stock returns tend to be low. This predictable variation in stock returns is not matched by any equivalent variation in long-term real interest rates, which are comparatively stable and do not seem to move with the stock market. In the late 1970's, for example, real interest rates were unusually low yet stock prices were depressed, implying high forecast stock returns; the 1980's saw much higher real interest rates along with buoyant stock prices, implying low forecast stock returns. Thus excess returns on stock over Treasury bills are just as forecastable as real returns on stock. This work is related to stylized facts 12 and 13. Campbell (1991) used this evidence to show that much of stock market volatility is associated with changing forecasts of excess stock returns. Changing forecasts of dividend growth and real interest rates are less important empirically.

The equity volatility puzzle is closely related to the equity premium puzzle. A complete model of stock market behavior must explain both the average level of stock prices and their movements over time. One strand of work on the equity premium puzzle makes this explicit by studying not the consumption covariance of measured stock returns, but the

consumption covariance of returns on hypothetical assets whose dividends are determined by consumption. The same model is used to generate both the volatility of stock prices and the implied equity premium. This was the approach of Mehra and Prescott (1985), and many subsequent authors have followed their lead.

Unfortunately, it is not easy to construct a general equilibrium model that fits all the stylized facts given above. The standard model of Mehra and Prescott (1985) gets variation in stock prices relative to dividends only from predictable variation in consumption growth which moves the expected dividend growth rate and the riskless real interest rate. The model is not consistent with the empirical evidence for predictable variation in excess stock returns. Bond market data pose a further challenge to this standard model of stock returns. In the model, stocks behave very much like long-term real bonds; both assets are driven by long-term movements in the riskless real interest rate. Thus parameter values that produce a large equity premium tend also to produce a large term premium on real bonds. While there is no direct evidence on real bond premia, nominal bond premia have historically been much smaller than equity premia.

Since the data suggest that predictable variation in excess returns is an important source of stock market volatility, researchers have begun to develop models in which the quantity of stock market risk or the price of risk change through time. ARCH models and other econometric methods show that the conditional variance of stock returns is highly variable. If this conditional variance is an adequate proxy for the quantity of stock market risk, then perhaps it can explain the predictability of excess stock returns. There are several problems with this approach. First, changes in conditional variance are most dramatic in daily or monthly data and are much weaker at lower frequencies. There is some business-cycle variation in volatility, but it does not seem strong enough to explain large movements in aggregate stock prices (Bollerslev, Chou, and Kroner 1992, Schwert 1989). Second, forecasts of excess stock returns do not move proportionally with estimates of conditional variance (Harvey 1989, 1991, Chou, Engle, and Kane 1992). Finally, one would like to derive stock market volatility endogenously within a model rather than treating it as an exogenous variable. There is little

evidence of cyclical variation in consumption or dividend volatility that could explain the variation in stock market volatility.

A more promising possibility is that the price of risk varies over time. Time-variation in the price of risk arises naturally in a model with a representative agent whose utility displays habit-formation. Campbell and Cochrane (1999), building on the work of Abel (1990), Constantinides (1990), and others, have proposed a simple asset pricing model of this sort. Campbell and Cochrane suggest that assets are priced as if there were a representative agent whose utility is a power function of the difference between consumption and "habit", where habit is a slow-moving nonlinear average of past aggregate consumption. This utility function makes the agent more risk-averse in bad times, when consumption is low relative to its past history, than in good times, when consumption is high relative to its past history. Stock market volatility is explained by a small amount of underlying consumption (dividend) risk, amplified by variable risk aversion; the equity premium is explained by high stock market volatility, together with a high average level of risk aversion.

Similar ideas have been put forward in the recent literature on behavioral finance. Kahneman and Tversky (1979) used experimental evidence to argue that agents behave as if their utility function is kinked at a reference point which is close to the current level of wealth. Benartzi and Thaler (1995) argued that Kahneman and Tversky's "prospect theory" could explain the equity premium puzzle if agents frequently evaluate their utility and reset their reference points, so that the kink in utility increases their effective risk aversion. Barberis, Huang, and Santos (2001), building on behavioral evidence of Thaler and Johnson (1990), argue that prospect theory should be extended to make agents effectively less risk averse if their wealth has recently risen, very much in the spirit of a habit-formation model.

Time-variation in the price of risk can also arise from the interaction of heterogeneous agents. Constantinides and Duffie (1996) develop a simple framework with many agents who have identical utility functions but heterogeneous streams of labor income; they show how changes in the cross-sectional distribution of income can generate any desired behavior of the market price of risk. Dumas (1989), Grossman and Zhou (1996), Wang (1996), Sandroni

(1999) and Chan and Kogan (2001) move in a somewhat different direction by exploring the interactions of agents who have different levels of risk aversion.

Some aspects of asset market behavior could also be explained by irrational expectations of investors. If investors are excessively pessimistic about economic growth, for example, they will overprice short-term bills and underprice stocks; this would help to explain the equity premium and riskfree rate puzzles. If investors overestimate the persistence of variations in economic growth, they will overprice stocks when growth has been high and underprice them when growth has been low, producing time-variation in the price of risk (Barsky and De Long 1993, Barberis, Shleifer, and Vishny 1998).

This chapter has three objectives. First, it tries to summarize recent work on stock price behavior, much of which is highly technical, in a way that is accessible to a broader professional audience. Second, the chapter summarizes stock market data from other countries and asks which of the US stylized facts hold true more generally. The recent theoretical literature is used to guide the exploration of the international data. Third, the chapter systematically compares stock market data with bond market data. This is an important discipline because some popular models of stock prices are difficult to reconcile with the behavior of bond prices.

The organization of the chapter is as follows. Section 2 introduces the international data and reviews stylized facts 1-9 to see which of them apply outside the United States. (Additional details are given in a Data Appendix available on the author's web page.) Section 3 discusses the equity premium puzzle, taking the volatility of stock returns as given. Section 4 discusses the stock market volatility puzzle. This section also reviews stylized facts 10-13 in the international data.

Sections 3 and 4 drive one towards the conclusion that the price of risk is both high and time-varying. It must be high to explain the equity premium puzzle, and it must be time-varying to explain the predictable variation in stock returns that seems to be responsible for the volatility of stock returns. Section 5 discusses models which produce this result, including models with habit-formation in utility, heterogeneous investors, and irrational expectations.

Section 6 draws some implications for research in macroeconomics, including the modelling of investment, labor supply, and the welfare costs of economic fluctuations.

2 International Stock Market Data

The stylized facts described in the previous section apply to postwar quarterly US data. Most empirical work on stock prices uses this data set, or a longer annual US time series originally put together by Shiller (1981). But data on stock prices, interest rates, and consumption are also available for many other countries.

In this chapter I use an updated version of the international developed-country data set in Campbell (1999). The dataset includes Morgan Stanley Capital International (MSCI) stock market data covering the period since 1970. I combine the MSCI data with macroeconomic data on consumption, short- and long-term interest rates, and the price level from the International Financial Statistics (IFS) of the International Monetary Fund. I am able to use consumption of nondurables and services for the US, but must use total consumption expenditure for the other countries in the dataset. For some countries the IFS data are only available quarterly over a shorter sample period, so I use the longest available sample for each country. Sample start dates range from 1970.1 to 1982.2, and sample end dates range from 1997.4 to 1999.3. I work with data from 11 countries: Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States.

For some purposes it is useful to have data over a much longer span of calendar time. I have been able to obtain annual data for Sweden over the period 1920-1998 and the UK over the period 1919-1998 to complement the US annual data for the period 1891-1998. The Swedish data come from Frennberg and Hansson (1992) and Hassler, Lundvik, Persson, and Söderlind (1994), while the UK data come from Barclays de Zoete Wedd Securities (1995) and Economist (1987).[4]

In working with international stock market data, it is important to keep in mind that different national stock markets are of very different sizes, both absolutely and in proportion

[4]The annual data end in 1994 or 1995 and are updated using the more recently available quarterly data. Full details about the construction of the quarterly and annual data are given in a Data Appendix available on the author's web page. Dimson, Marsh, and Staunton (2000) report summary statistics for a more comprehensive long-term annual international dataset.

to national GDP's. Campbell (1999, Table 1) reports that in the quarterly MSCI data for 1993 the Japanese MSCI index was worth only 65% of the US MSCI index, the UK MSCI index was worth only 30% of the US index, the French and German MSCI indexes were worth only 11% of the US index, and all other countries' indexes were worth less than 10% of the US index. The US and Japan together accounted for 66% of the world MSCI capitalization, while the US, Japan, the UK, France, and Germany together accounted for 86%. The same table shows that different countries' stock market values are very different as a fraction of GDP. If one thinks that total wealth-output ratios are likely to be fairly constant across countries, then this indicates that national stock markets are very different fractions of total wealth in different countries. In highly capitalized countries such as the UK and Switzerland, the MSCI index accounted for about 80% of GDP in 1993, whereas in Germany and Italy it accounted for less than 20% of GDP. The theoretical convention of treating the stock market as a claim to total consumption, or as a proxy for the aggregate wealth of an economy, makes much more sense in the highly capitalized countries.[5]

Table 1 reports summary statistics for international asset returns. For each country the table reports the mean, standard deviation, and first-order autocorrelation of the real stock return and the real return on a short-term debt instrument.[6]

The first line of Table 1 gives numbers for the standard postwar quarterly US data set summarized in the introduction. The top panel gives numbers for the 11-country quarterly MSCI data, and the bottom panel gives numbers for the long-term annual data sets. The table shows that the first four stylized facts given in the introduction are fairly robust across countries.

1. Stock markets have delivered average real returns of 4.5% or better in almost every

[5]Stock ownership also tends to be much more concentrated in the countries with low capitalization. La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1997) have related these international patterns to differences in the protections afforded outside investors by different legal systems.

[6]As explained in the Data Appendix, the best available short-term interest rate is sometimes a Treasury bill rate and sometimes another money market interest rate. Both means and standard deviations are given in annualized percentage points. To annualize the raw quarterly numbers, means are multiplied by 400 while standard deviations are multiplied by 200 (since standard deviations increase with the square root of the time interval in serially uncorrelated data).

country and time period. The exceptions to this occur in short-term quarterly data, and are concentrated in markets that are particularly small relative to GDP (Italy, 3.2%), or that predominantly represent claims on natural resources (Australia, 3.5%). The very poor performance of the Japanese stock market in the 1990's has reduced the average Japanese return to 4.7%.

2. Short-term debt has rarely delivered an average real return above 3%. The exceptions to this occur in two countries, Germany and the Netherlands, whose sample periods begin in the late 1970's and thus exclude much of the surprise inflation of the oil-shock period.

3. The annualized standard deviation of stock returns ranges from 15% to 27%. It is striking that the market with the highest volatility, Italy, is the smallest market relative to GDP and the one with the lowest average return.

4. In quarterly data the annualized volatility of real returns on short debt is 2.9% for the UK, 2.8% for Italy and Sweden, 2.5% for Australia, 2.3% for Japan, and below 2% for all other countries. Volatility is higher in long-term annual data because of large swings in inflation in the interwar period, particularly in 1919-21. Much of the volatility in these real returns is probably due to unanticipated inflation and does not reflect volatility in the ex ante real interest rate.

These numbers show that high average stock returns, relative to the returns on short-term debt, are not unique to the United States but characterize many other countries as well. Recently a number of authors have suggested that average excess returns in the US may be overstated by sample selection or survivorship bias. If economists study the US because it has had an unusually successful economy, then sample average US stock returns may overstate the true mean US stock return. Brown, Goetzmann, and Ross (1995) present a formal model of this effect. While survivorship bias may affect data from all the countries included in Table 1, it is reassuring that the stylized facts are so consistent across these countries.[7]

[7]Jorion and Goetzmann (1999) consider international stock-price data from earlier in the 20th Century and argue that the long-term average real growth rate of stock prices has been higher in the US than elsewhere. However they do not have data on dividend yields, which are an important component of total return and are likely to have been particularly important in Europe during the troubled interwar period.

Table 2 turns to data on aggregate consumption and stock market dividends. The table is organized in the same way as Table 1. It illustrates the robustness of two more of the stylized facts given in the introduction.

5. In the postwar period the annualized standard deviation of real consumption growth is never above 3%. This is true even though data are used on total consumption, rather than nondurables and services consumption, for all countries other than the US. Even in the longer annual data, which include the turbulent interwar period, consumption volatility slightly exceeds 3% only in the US.

6. The volatility of dividend growth is much greater than the volatility of consumption growth, but generally less than the volatility of stock returns. The exceptions to this occur in countries with highly seasonal dividend payments; these countries have large negative autocorrelations for quarterly dividend growth and much smaller volatility when dividend growth is measured over a full year rather than over a quarter.

Table 3 reports the contemporaneous correlations among real consumption growth, real dividend growth, and stock returns. It turns out that these correlations are somewhat sensitive to the timing convention used for consumption. A timing convention is needed because the level of consumption is a flow during a quarter rather than a point-in-time observation; that is, the consumption data are time-averaged.[8] If we think of a given quarter's consumption data as measuring consumption at the beginning of the quarter, then consumption growth for the quarter is next quarter's consumption divided by this quarter's consumption. If on the other hand we think of the consumption data as measuring consumption at the end of the quarter, then consumption growth is this quarter's consumption divided by last quarter's consumption. Table 4 uses the former, "beginning-of-quarter" timing convention

Dimson, Marsh, and Staunton (2000) do have dividend yields for the early 20th Century and find that US stock returns were not extraordinarily high relative to other countries in that period.

[8]Time-averaging is one of a number of interrelated issues that arise in relating measured consumption data to the theoretical concept of consumption. Other issues include measurement error, seasonal adjustment, and durable goods. Grossman, Melino, and Shiller (1987), Wheatley (1988), Miron (1986), and Heaton (1995) handle time-averaging, measurement error, seasonality, and durability, respectively, in a much more careful way than is possible here, while Wilcox (1992) provides a detailed account of the sampling procedures used to construct US consumption data.

because this produces a higher contemporaneous correlation between consumption growth and stock returns.

The timing convention has less effect on correlations when the data are measured at longer horizons. Table 4 also shows how the correlations among real consumption growth, real dividend growth, and real stock returns vary with the horizon. Each pairwise correlation among these series is calculated for horizons of 1, 4, 8, and 16 quarters in the quarterly data and for horizons of 1, 2, 4, and 8 years in the long-term annual data. The table illustrates three more stylized facts from the introduction.

7. Real consumption growth and dividend growth are generally weakly positively correlated in the quarterly data. In many countries the correlation increases strongly with the measurement horizon. However long-horizon correlations remain close to zero for Australia and Canada, and are substantially negative for Italy (with a very small stock market) and Japan (with anomalous dividend behavior). The correlations of consumption and dividend growth are positive and often quite large in the longer-term annual data sets.

8. The correlations between real consumption growth rates and stock returns are quite variable across countries. They tend to be somewhat higher in high-capitalization countries (with the notable exception of Switzerland), which is consistent with the view that stock returns proxy more accurately for wealth returns in these countries. Correlations typically increase with the measurement horizon out to 1 or 2 years, and are moderately positive in the longer-term annual data sets.

9. The correlations between real dividend growth rates and stock returns are small at a quarterly horizon but increase dramatically with the horizon. This pattern holds in every country. The correlations also increase strongly with the horizon in the longer-term annual data.

After this preliminary look at the data, I now use some simple finance theory to interpret the stylized facts.

3 The Equity Premium Puzzle

3.1 The Stochastic Discount Factor

To understand the equity premium puzzle, consider the intertemporal choice problem of an investor, indexed by k, who can trade freely in some asset i and can obtain a gross simple rate of return $(1+R_{i,t+1})$ on the asset held from time t to time $t+1$. If the investor consumes C_{kt} at time t and has time-separable utility with discount factor δ and period utility $U(C_{kt})$, then her first-order condition is

$$U'(C_{kt}) = \delta \mathrm{E}_t \left[(1 + R_{i,t+1})U'(C_{k,t+1})\right] . \tag{1}$$

The left hand side of (1) is the marginal utility cost of consuming one real dollar less at time t; the right hand side is the expected marginal utility benefit from investing the dollar in asset i at time t, selling it at time $t+1$, and consuming the proceeds. The investor equates marginal cost and marginal benefit, so (1) must describe the optimum.

Dividing (1) by $U'(C_{kt})$ yields

$$1 = \mathrm{E}_t \left[(1 + R_{i,t+1})\, \delta \frac{U'(C_{k,t+1})}{U'(C_{kt})}\right] = \mathrm{E}_t \left[(1 + R_{i,t+1})\, M_{k,t+1}\right] , \tag{2}$$

where $M_{k,t+1} = \delta U'(C_{k,t+1})/U'(C_t)$ is the intertemporal marginal rate of substitution of the investor, also known as the *stochastic discount factor*. This way of writing the model in discrete time is due originally to Rubinstein (1976), while the continuous-time version of the model is due to Breeden (1979). Grossman and Shiller (1981), Shiller (1982), Hansen and Jagannathan (1991), and Cochrane and Hansen (1992) have developed the implications of the discrete-time model in detail. Cochrane (2001) gives a textbook exposition of finance using this framework.

The derivation just given for equation (2) assumes the existence of an investor maximizing a time-separable utility function, but in fact the equation holds more generally. The existence of a positive stochastic discount factor is guaranteed by the absence of arbitrage in markets in which non-satiated investors can trade freely without transactions costs. In general there can be many such stochastic discount factors—for example, different investors k whose marginal

utilities follow different stochastic processes will have different $M_{k,t+1}$—but each stochastic discount factor must satisfy equation (2). It is common practice to drop the subscript k from this equation and simply write

$$1 = \mathrm{E}_t \left[(1 + R_{i,t+1}) \, M_{t+1} \right] \ . \tag{3}$$

In complete markets the stochastic discount factor M_{t+1} is unique because investors can trade with one another to eliminate any idiosyncratic variation in their marginal utilities.

To understand the implications of (3) it is helpful to write the expectation of the product as the product of expectations plus the covariance,

$$\mathrm{E}_t[(1 + R_{i,t+1}) \, M_{t+1}] = \mathrm{E}_t[(1 + R_{i,t+1})]\mathrm{E}_t[M_{t+1}] + \mathrm{Cov}_t[R_{i,t+1}, M_{t+1}]. \tag{4}$$

Substituting into (3) and rearranging gives

$$1 + \mathrm{E}_t[R_{i,t+1}] = \frac{1 - \mathrm{Cov}_t[R_{i,t+1}, M_{t+1}]}{\mathrm{E}_t[M_{t+1}]}. \tag{5}$$

An asset with a high expected simple return must have a low covariance with the stochastic discount factor. Such an asset tends to have low returns when investors have high marginal utility. It is risky in that it fails to deliver wealth precisely when wealth is most valuable to investors. Investors therefore demand a large risk premium to hold it.

Equation (5) must hold for any asset, including a riskless asset whose gross simple return is $1+R_{f,t+1}$. Since the simple riskless return has zero covariance with the stochastic discount factor (or any other random variable), it is just the reciprocal of the expectation of the stochastic discount factor:

$$1 + R_{f,t+1} = \frac{1}{\mathrm{E}_t[M_{t+1}]}. \tag{6}$$

This can be used to rewrite (5) as

$$1 + \mathrm{E}_t[R_{i,t+1}] = (1 + R_{f,t+1})(1 - \mathrm{Cov}_t[R_{i,t+1}, M_{t+1}]). \tag{7}$$

For simplicity I now follow Hansen and Singleton (1983) and assume that the joint conditional distribution of asset returns and the stochastic discount factor is lognormal and

homoskedastic. While these assumptions are not literally realistic—stock returns in particular have fat-tailed distributions with variances that change over time—they do make it easier to discuss the main forces that should determine the equity premium.

When a random variable X is conditionally lognormally distributed, it has the convenient property that

$$\log \mathrm{E}_t X = \mathrm{E}_t \log X + \tfrac{1}{2}\mathrm{Var}_t \log X \ , \tag{8}$$

where $\mathrm{Var}_t \log X \equiv \mathrm{E}_t[(\log X - \mathrm{E}_t \log X)^2]$. If in addition X is conditionally homoskedastic, then $\mathrm{Var}_t \log X = \mathrm{E}[(\log X - \mathrm{E}_t \log X)^2] = \mathrm{Var}(\log X - \mathrm{E}_t \log X)$. Thus with joint conditional lognormality and homoskedasticity of asset returns and consumption, I can take logs of (3) and obtain

$$0 = \mathrm{E}_t r_{i,t+1} + \mathrm{E}_t m_{t+1} + \left(\tfrac{1}{2}\right)[\sigma_i^2 + \sigma_m^2 + 2\sigma_{im}] \ . \tag{9}$$

Here $m_t = \log(M_t)$ and $r_{it} = \log(1 + R_{it})$, while σ_i^2 denotes the unconditional variance of log return innovations $\mathrm{Var}(r_{i,t+1} - \mathrm{E}_t r_{i,t+1})$, σ_m^2 denotes the unconditional variance of innovations to the stochastic discount factor $\mathrm{Var}(m_{t+1} - \mathrm{E}_t m_{t+1})$, and σ_{im} denotes the unconditional covariance of innovations $\mathrm{Cov}(r_{i,t+1} - \mathrm{E}_t r_{i,t+1},\, m_{t+1} - \mathrm{E}_t m_{t+1})$.

Equation (9) has both time-series and cross-sectional implications. Consider first an asset with a riskless real return $r_{f,t+1}$. For this asset the return innovation variance σ_f^2 and the covariance σ_{fm} are both zero, so the riskless real interest rate obeys

$$r_{f,t+1} = -\mathrm{E}_t m_{t+1} - \frac{\sigma_m^2}{2} \ . \tag{10}$$

This equation is the log counterpart of (6).

Subtracting (10) from (9) yields an expression for the expected excess return on risky assets over the riskless rate:

$$\mathrm{E}_t[r_{i,t+1} - r_{f,t+1}] + \frac{\sigma_i^2}{2} = -\sigma_{im} \ . \tag{11}$$

The variance term on the left hand side of (11) is a Jensen's Inequality adjustment arising from the fact that we are describing expectations of log returns. In effect this term converts the expected excess return from a geometric average to an arithmetic average. It would

disappear if we rewrote the equation in terms of the log expectation of the ratio of gross simple returns: $\log \mathrm{E}_t[(1 + R_{i,t+1})/(1 + R_{f,t+1})] = -\sigma_{im}$. The right hand side of (11) says that the risk premium is determined by the negative of the covariance of the asset with the stochastic discount factor. This equation is the log counterpart of (7).

The covariance σ_{im} can be written as the product of the standard deviation of the asset return σ_i, the standard deviation of the stochastic discount factor σ_m, and the correlation between the asset return and the stochastic discount factor ρ_{im}. Since $\rho_{im} \geq -1$, $-\sigma_{im} \leq \sigma_i\sigma_m$. Substituting into (11),

$$\sigma_m \geq \frac{\mathrm{E}_t[r_{i,t+1} - r_{f,t+1}] + \sigma_i^2/2}{\sigma_i} \,. \tag{12}$$

This inequality was first derived by Shiller (1982); a multi-asset version was derived by Hansen and Jagannathan (1991) and developed further by Cochrane and Hansen (1992). The right hand side of (12) is the excess return on an asset, adjusted for Jensen's Inequality, divided by the standard deviation of the asset's return—a logarithmic Sharpe ratio for the asset. (12) says that the standard deviation of the log stochastic discount factor must be greater than this Sharpe ratio for all assets i, that is, it must be greater than the maximum possible Sharpe ratio obtainable in asset markets.

Table 4 uses (12) to illustrate the equity premium puzzle. For each data set the first column of the table reports the average excess return on stock over short-term debt, adjusted for Jensen's Inequality by adding one-half the sample variance of the excess log return to get a sample estimate of the numerator in (12). This adjusted or arithmetic average excess return is multiplied by 400 to express it in annualized percentage points. The second column of the table gives the annualized standard deviation of the excess log stock return, a sample estimate of the denominator in (12). This standard deviation was reported earlier in Table 1. The third column gives the ratio of the first two columns, multiplied by 100; this is a sample estimate of the lower bound on the standard deviation of the log stochastic discount factor, expressed in annualized percentage points. In the postwar US data the estimated lower bound is a standard deviation greater than 50% a year; in the other quarterly data sets it is between 15% and 20% for Australia and Italy, between 20% and 30% for Canada

and Japan, and above 30% for all the other countries. In the long-run annual data sets the lower bound on the standard deviation exceeds 30% for all three countries.

3.2 Consumption-Based Asset Pricing with Power Utility

To understand why these numbers are disturbing, I now follow Rubinstein (1976), Lucas (1978), Breeden (1979), Grossman and Shiller (1981), Mehra and Prescott (1985) and other classic papers on the equity premium puzzle and assume that there is a representative agent who maximizes a time-separable power utility function defined over aggregate consumption C_t:

$$U(C_t) = \frac{C_t^{1-\gamma} - 1}{1-\gamma}\,, \tag{13}$$

where γ is the coefficient of relative risk aversion. This utility function has several important properties.

First, it is scale-invariant; with constant return distributions, risk premia do not change over time as aggregate wealth and the scale of the economy increase. This is important because over the past two centuries wealth and consumption have increased manyfold, yet riskless interest rates and risk premia do not seem to have trended up or down. Power utility is one of the few utility specifications that are consistent with this fact. Related to this, if different investors in the economy have different wealth levels but the same power utility function, then they can be aggregated into a single representative investor with the same utility function as the individual investors.

A possibly less desirable property of power utility is that the elasticity of intertemporal substitution, which I write as ψ, is the reciprocal of the coefficient of relative risk aversion γ. Epstein and Zin (1991) and Weil (1989) have proposed a more general utility specification that preserves the scale-invariance of power utility but breaks the tight link between the coefficient of relative risk aversion and the elasticity of intertemporal substitution. I discuss this form of utility in section 3.4 below.

Power utility implies that marginal utility $U'(C_t) = C_t^{-\gamma}$, and the stochastic discount factor $M_{t+1} = \delta(C_{t+1}/C_t)^{-\gamma}$. The assumption made previously that the stochastic discount

factor is conditionally lognormal will be implied by the assumption that aggregate consumption is conditionally lognormal (Hansen and Singleton 1983). Making this assumption for expositional convenience, the log stochastic discount factor is $m_{t+1} = \log(\delta) - \gamma \Delta c_{t+1}$, where $c_t = \log(C_t)$, and (9) becomes

$$0 = \mathrm{E}_t r_{i,t+1} + \log \delta - \gamma \mathrm{E}_t \Delta c_{t+1} + \left(\tfrac{1}{2}\right) \left[\sigma_i^2 + \gamma^2 \sigma_c^2 - 2\gamma \sigma_{ic}\right] . \tag{14}$$

Here σ_c^2 denotes the unconditional variance of log consumption innovations $\mathrm{Var}(c_{t+1} - \mathrm{E}_t c_{t+1})$, and σ_{ic} denotes the unconditional covariance of innovations $\mathrm{Cov}(r_{i,t+1} - \mathrm{E}_t r_{i,t+1},\, c_{t+1} - \mathrm{E}_t c_{t+1})$.

Equation (10) now becomes

$$r_{f,t+1} = -\log \delta + \gamma \mathrm{E}_t \Delta c_{t+1} - \frac{\gamma^2 \sigma_c^2}{2} . \tag{15}$$

This equation says that the riskless real rate is linear in expected consumption growth, with slope coefficient equal to the coefficient of relative risk aversion. The conditional variance of consumption growth has a negative effect on the riskless rate which can be interpreted as a precautionary savings effect.

Equation (11) becomes

$$\mathrm{E}_t[r_{i,t+1} - r_{f,t+1}] + \frac{\sigma_i^2}{2} = \gamma \sigma_{ic} . \tag{16}$$

The log risk premium on any asset is the coefficient of relative risk aversion times the covariance of the asset return with consumption growth. Intuitively, an asset with a high consumption covariance tends to have low returns when consumption is low, that is, when the marginal utility of consumption is high. Such an asset is risky and commands a large risk premium.

Table 4 uses (16) to illustrate the equity premium puzzle. As already discussed, the first column of the table reports a sample estimate of the left hand side of (16), multiplied by 400 to express it in annualized percentage points. The second column reports the annualized standard deviation of the excess log stock return (given earlier in Table 1), the fourth column reports the annualized standard deviation of consumption growth (given earlier in Table 2), the fifth column reports the correlation between the excess log stock return and

consumption growth, and the sixth column gives the product of these three variables which is the annualized covariance σ_{ic} between the log stock return and consumption growth.

Finally, the table gives two columns with implied risk aversion coefficients. The column headed RRA(1) uses (16) directly, dividing the adjusted average excess return by the estimated covariance to get estimated risk aversion.[9] The column headed RRA(2) sets the correlation of stock returns and consumption growth equal to one before calculating risk aversion. While this is of course a counterfactual exercise, it is a valuable diagnostic because it indicates the extent to which the equity premium puzzle arises from the *smoothness* of consumption rather than the *low correlation* between consumption and stock returns. The correlation is hard to measure accurately because it is easily distorted by short-term measurement errors in consumption, and Table 4 indicates that the sample correlation is quite sensitive to the measurement horizon. By setting the correlation to one, the RRA(2) column indicates the extent to which the equity premium puzzle is robust to such issues. A correlation of one is also implicitly assumed in the volatility bound for the stochastic discount factor, (12), and in many calibration exercises such as Mehra and Prescott (1985), Abel (1999), or Campbell and Cochrane (1999).

Table 4 shows that the equity premium puzzle is a robust phenomenon in international data. The coefficients of relative risk aversion in the RRA(1) column are generally extremely large. They are usually many times greater than 10, the maximum level considered plausible by Mehra and Prescott (1985). In a few cases the risk aversion coefficients are negative because the estimated covariance of stock returns with consumption growth is negative, but in these cases the covariance is extremely close to zero. Even when one ignores the low correlation between stock returns and consumption growth and gives the model its best chance by setting the correlation to one, the RRA(2) column still has risk aversion coefficients above 10 in all countries except Australia and Japan. Thus the fact shown in Table 3, that for some countries the correlation of stock returns and consumption increases with the horizon,

[9]The calculation is done correctly, in natural units, even though the table reports average excess returns and covariances in percentage point units. Equivalently, the ratio of the quantities given in the table is multiplied by 100.

is unable by itself to resolve the equity premium puzzle.

Gabaix and Laibson (2000) have argued that adjustment costs in consumption might artificially reduce the variability of consumption in the short run and bias upwards the estimated risk aversion coefficients in Table 4. Their model implies that consumption growth should be more volatile when it is measured over longer horizons; equivalently, short-term consumption growth should be positively autocorrelated. The autocorrelation coefficients for consumption growth, shown in Table 2, do not support this model since they are typically small and often negative.[10] The results of other studies of US consumption growth are mixed at best. Campbell and Mankiw (1989), Cochrane (1994), and Lettau and Ludvigson (2001) find that US consumption growth is almost unforecastable, although discrete-state Markov models estimated by Cecchetti, Lam, and Mark (1990, 1993), Kandel and Stambaugh (1991), and Mehra and Prescott (1985) imply modest but persistent predictable variation in US consumption growth.

The risk aversion estimates in Table 4 are of course point estimates and are subject to sampling error. No standard errors are reported for these estimates. However authors such as Cecchetti, Lam, and Mark (1993) and Kocherlakota (1996), studying the long-run annual US data, have found small enough standard errors that they can reject risk aversion coefficients below about 8 at conventional significance levels.

Of course, the validity of these tests depends on the characteristics of the data set in which they are used. Rietz (1988) has argued that there may be a peso problem in these data. A peso problem arises when there is a small positive probability of an important event, and investors take this probability into account when setting market prices. If the event does not occur in a particular sample period, investors will appear irrational in the sample and economists will misestimate their preferences. While it may seem unlikely that this could be an important problem in 100 years of annual data, Rietz (1988) argues that an economic catastrophe that destroys almost all stock-market value can be extremely unlikely and yet

[10]These autocorrelations are biased upwards by the time-averaging of consumption data, but outside the US are biased downwards by the durable component of total consumption expenditure. The absence of positive autocorrelations in consumption growth is also evidence against the Constantinides (1990) model of habit formation, discussed in section 5.1, which has similar implications for consumption growth.

have a major depressing effect on stock prices.

One difficulty with this argument is that it requires not only a potential catastrophe, but one which affects stock market investors more seriously than investors in short-term debt instruments. Many countries that have experienced catastrophes, such as Russia or Germany, have seen very low returns on short-term government debt as well as on equity. A peso problem that affects both asset returns equally will affect estimates of the average levels of returns but not estimates of the equity premium.[11] The major example of a disaster for stockholders that did not negatively affect bondholders is the Great Depression of the early 1930's, but of course this is included in the long-run annual data for Sweden, the UK, and the US, all of which display an equity premium puzzle.

Also, the consistency of the results across countries requires investors in all countries to be concerned about catastrophes. If the potential catastrophes are uncorrelated across countries, then it becomes less likely that the data set includes no catastrophes; thus the argument seems to require a potential international catastrophe that affects all countries simultaneously.

Even if the equity premium puzzle is not entirely spurious, there are several reasons to think that stock returns exceeded their true long-run mean in the late 20th Century. Dimson, Marsh, and Staunton (2000) find that international returns were generally higher in the late 20th Century than in the early 20th Century. Siegel (1994) reports similar results for US data going back to the early 19th Century. Fama and French (2000) point out that average US stock returns in the late 20th Century were considerably higher than accountants' estimates of the return on equity for US corporations. Thus if one uses average returns as an estimate of the true cost of capital, one is forced to the implausible conclusion that corporations destroyed stockholder value by retaining and reinvesting earnings rather than paying them

[11] This point is relevant for the study of Jorion and Goetzmann (1999). These authors measure average growth rates of real stock prices, as a proxy for real stock returns, but they do not look at real returns on short-term debt. They find low real stock-price growth rates in many countries in the early 20th Century; in some cases these may have been accompanied by low returns to holders of short-term debt. Note also that stock-price growth rates are a poor proxy for total stock returns in periods where investors expect low growth rates, since dividend yields will tend to be higher in such periods.

out.

Unusually high stock returns in the late 20th Century could have resulted from unexpectedly favorable conditions for economic growth. But they could also have resulted from a structural decline in the equity premium. Several economists have recently argued that the equity premium is now far lower than it was in the early 20th Century (Heaton and Lucas 1999, Jagannathan, McGrattan, and Scherbina 2001).

3.3 The Riskfree Rate Puzzle

One response to the equity premium puzzle is to consider larger values for the coefficient of relative risk aversion γ. Kandel and Stambaugh (1991) have advocated this.[12] However this leads to a second puzzle. Equation (15) implies that the unconditional mean riskless interest rate is

$$\mathrm{E}\, r_{f,t+1} = -\log\delta + \gamma g - \frac{\gamma^2\sigma_c^2}{2}\,, \tag{17}$$

where g is the mean growth rate of consumption. Since g is positive, as shown in Table 3, high values of γ imply high values of γg. Ignoring the term $-\gamma^2\sigma_c^2/2$ for the moment, this can be reconciled with low average short-term real interest rates, shown in Table 1, only if the discount factor δ is close to or even greater than one, corresponding to a low or even negative rate of time preference. This is the riskfree rate puzzle emphasized by Weil (1989).

Intuitively, the riskfree rate puzzle is that if investors are risk-averse then with power utility they must also be extremely unwilling to substitute intertemporally. Given positive average consumption growth, a low riskless interest rate and a high rate of time preference, such investors would have a strong desire to borrow from the future to reduce their average consumption growth rate. A low riskless interest rate is possible in equilibrium only if investors have a low or negative rate of time preference that reduces their desire to borrow.[13]

[12] One might think that introspection would be sufficient to rule out very large values of γ, but Kandel and Stambaugh (1991) point out that introspection can deliver very different estimates of risk aversion depending on the size of the gamble considered. This suggests that introspection can be misleading or that some more general model of utility is needed.

[13] As Abel (1996) and Kocherlakota (1996) point out, negative time preference is consistent with finite utility in a time-separable model provided that consumption is growing, and marginal utility shrinking, sufficiently rapidly. The question is whether negative time preference is plausible.

Of course, if the risk aversion coefficient γ is high enough then the negative quadratic term $-\gamma^2\sigma_c^2/2$ in equation (17) dominates the linear term and pushes the riskless interest rate down again. The quadratic term reflects precautionary savings; risk-averse agents with uncertain consumption streams have a precautionary desire to save, which can work against their desire to borrow. But a reasonable rate of time preference is obtained only as a knife-edge case.

Table 5 illustrates the riskfree rate puzzle in international data. The table first shows the average riskfree rate from Table 1 and the mean consumption growth rate and standard deviation of consumption growth from Table 2. These moments and the risk aversion coefficients calculated in Table 4 are substituted into equation (17), and the equation is solved for an implied time preference rate. The time preference rate is reported in percentage points per year; it can be interpreted as the riskless real interest rate that would prevail if consumption were known to be constant forever at its current level, with no growth and no volatility. Risk aversion coefficients in the RRA(2) range imply negative time preference rates in every country except Switzerland, whereas larger risk aversion coefficients in the RRA(1) range imply time preference rates that are often positive but always implausible and vary wildly across countries.

An interesting issue is how mismeasurement of average inflation might affect these calculations. There is a growing consensus that in recent years conventional price indices have overstated true inflation by failing to fully capture the effects of quality improvements, consumer substitution to cheaper retail outlets, and price declines in newly introduced goods. If inflation is overstated by, say, 1%, the real interest rate is understated by 1%, which by itself might help to explain the riskfree rate puzzle. Unfortunately the real growth rate of consumption is also understated by 1%, which worsens the riskfree rate puzzle. When $\gamma > 1$, this second effect dominates and understated inflation makes the riskfree rate puzzle even harder to explain.

3.4 Bond Returns and the Equity Premium and Riskfree Rate Puzzles

Some authors have argued that the riskfree interest rate is low because short-term government debt is more liquid than long-term financial assets. Short-term debt is "moneylike" in that it facilitates transactions and can be traded at minimal cost. The liquidity advantage of debt reduces its equilibrium return and increases the equity premium (Bansal and Coleman 1996, Heaton and Lucas 1996).

The difficulty with this argument is that it implies that all long-term assets should have large excess returns over short-term debt. Long-term government bonds, for example, are not moneylike and so the liquidity argument implies that they should offer a large term premium. But historically, the term premium has been many times smaller than the equity premium. This point is illustrated in Table 6, which reports two alternative measures of the term premium. The first measure is the average log yield spread on long-term bonds over the short-term interest rate, while the second is the average quarterly excess log return on long bonds. In a long enough sample these two averages should coincide if there is no upward or downward drift in interest rates.

The average yield spread is typically between 0.5% and 1.5%. A notable outlier is Italy, which has a negative average yield spread in this period. Average long bond returns are quite variable across countries, reflecting differences in inflationary experiences; however the average excess bond return rarely exceeds 2% per year. Thus both measures suggest that term premia are far smaller than equity premia.

Table 7 develops this point further by repeating the calculations of Table 5, using bond returns rather than equity returns. The average excess log return on bonds over short debt, adjusted for Jensen's Inequality, is divided by the standard deviation of the excess bond return to calculate a bond Sharpe ratio which is a lower bound on the standard deviation of the stochastic discount factor. The Sharpe ratio for bonds is several times smaller than the Sharpe ratio for equities, indicating that term premia are small even after taking account of the lower volatility of bond returns.

This finding is not consistent with a strong liquidity effect at the short end of the term structure, but it is consistent with a consumption-based asset pricing model if bond returns have a low correlation with consumption growth. Table 7 shows that sample consumption correlations often are lower for bonds, so that RRA(1) risk aversion estimates for bonds, which use these correlations, are often comparable to those for equities.

A direct test of the liquidity story is to measure excess returns on stocks over long bonds, rather than over short debt. If the equity premium is due to a liquidity effect on short-term interest rates, then there should be no "equity-bond premium" puzzle. Table 8 carries out this exercise and finds that the equity-bond premium puzzle is just as severe as the standard equity premium puzzle.[14]

3.5 Separating Risk Aversion and Intertemporal Substitution

Epstein and Zin (1989, 1991) and Weil (1989) use the theoretical framework of Kreps and Porteus (1978) to develop a more flexible version of the basic power utility model. That model is restrictive in that it makes the elasticity of intertemporal substitution, ψ, the reciprocal of the coefficient of relative risk aversion, γ. Yet it is not clear that these two concepts should be linked so tightly. Risk aversion describes the consumer's reluctance to substitute consumption across states of the world and is meaningful even in an atemporal setting, whereas the elasticity of intertemporal substitution describes the consumer's willingness to substitute consumption over time and is meaningful even in a deterministic setting. The Epstein-Zin-Weil model retains many of the attractive features of power utility but breaks the link between the parameters γ and ψ.

The Epstein-Zin-Weil objective function is defined recursively by

$$U_t = \left\{ (1-\delta) C_t^{\frac{1-\gamma}{\theta}} + \delta \left(\mathrm{E}_t \, U_{t+1}^{1-\gamma} \right)^{\frac{1}{\theta}} \right\}^{\frac{\theta}{1-\gamma}}, \tag{18}$$

where $\theta \equiv (1-\gamma)/(1-1/\psi)$. When $\gamma = 1/\psi$, $\theta = 1$ and the recursion (18) becomes linear;

[14] The excess return of equities over bonds must be measured with the appropriate correction for Jensen's Inequality to adjust from a geometric to an arithmetic mean. From equation (16), the appropriate measure is the log excess return on equities over short-term debt, less the log excess return on bonds over short-term debt, plus one-half the variance of the log equity return, less one-half the variance of the log bond return.

it can then be solved forward to yield the familiar time-separable power utility model.

The intertemporal budget constraint for a representative agent can be written as

$$W_{t+1} = (1 + R_{w,t+1})\,(W_t - C_t), \tag{19}$$

where W_{t+1} is the representative agent's wealth, and $(1 + R_{w,t+1})$ is the gross simple return on the portfolio of all invested wealth.[15]

This form of the budget constraint is appropriate for a complete-markets model in which wealth includes human capital as well as financial assets. Epstein and Zin use dynamic programming arguments to show that (18) and (19) together imply an Euler equation of the form

$$1 = \mathrm{E}_t \left[\left\{ \delta \left(\frac{C_{t+1}}{C_t} \right)^{-\frac{1}{\psi}} \right\}^{\theta} \left\{ \frac{1}{(1 + R_{w,t+1})} \right\}^{1-\theta} (1 + R_{i,t+1}) \right]. \tag{20}$$

If I assume that asset returns and consumption are homoskedastic and jointly lognormal, then this implies that the riskless real interest rate is

$$r_{f,t+1} = -\log \delta + \frac{1}{\psi}\,\mathrm{E}_t[\Delta c_{t+1}] + \frac{\theta - 1}{2}\,\sigma_w^2 - \frac{\theta}{2\psi^2}\,\sigma_c^2. \tag{21}$$

The riskless interest rate is a constant, plus $1/\psi$ times expected consumption growth. In the power utility model, $1/\psi = \gamma$ and $\theta = 1$, so (21) reduces to (15).

The premium on risky assets, including the wealth portfolio itself, is

$$\mathrm{E}_t[r_{i,t+1}] - r_{f,t+1} + \frac{\sigma_i^2}{2} = \theta\,\frac{\sigma_{ic}}{\psi} + (1 - \theta)\sigma_{iw}. \tag{22}$$

This says that the risk premium on asset i is a weighted combination of asset i's covariance with consumption growth (divided by the elasticity of intertemporal substitution ψ) and asset i's covariance with the return on wealth. The weights are θ and $1 - \theta$ respectively. The Epstein-Zin-Weil model thus nests the consumption CAPM with power utility ($\theta = 1$) and the traditional static CAPM ($\theta = 0$).

[15] This is often called the "market" return and written $R_{m,t+1}$, but I have already used m to denote the stochastic discount factor so I write $R_{w,t+1}$ to avoid confusion.

Equations (21) and (22) seem to indicate that Epstein-Zin-Weil utility might be helpful in resolving the equity premium and riskfree rate puzzles. First, in (21) a high risk aversion coefficient does not necessarily imply a low average riskfree rate, because

$$\mathrm{E}r_{f,t+1} = -\log\delta + \frac{g}{\psi} + \frac{\theta-1}{2}\,\sigma_w^2 - \frac{\theta}{2\psi^2}\,\sigma_c^2. \tag{23}$$

The average consumption growth rate is divided by ψ here, and in the Epstein-Zin-Weil framework ψ need not be small even if γ is large.

Second, (22) suggests that it might not even be necessary to have a high risk aversion coefficient to explain the equity premium. If $\theta \neq 1$, then the risk premium on an asset is determined in part by its covariance with the wealth portfolio, σ_{iw}. If the return on wealth is more volatile than consumption growth, as implied by the common use of a stock index return as a proxy for the return on wealth, then σ_{iw} may be much larger than σ_{ic}, and this may help to explain the equity premium.

Unfortunately, there are serious difficulties with both these potential escape routes from the equity premium and riskfree rate puzzles. The difficulty with the first is that there is direct empirical evidence for a low elasticity of intertemporal substitution in consumption. The difficulty with the second is that consumption and wealth are linked through the intertemporal budget constraint; if consumption is smooth and wealth is volatile, this itself is a puzzle that must be explained, not an exogenous fact that can be used to resolve other puzzles. I now develop these points in detail by analyzing the dynamic behavior of stock returns and short-term interest rates in relation to consumption.

4 The Dynamics of Asset Returns and Consumption

4.1 Time-Variation in Conditional Expectations

Equations (21) and (22) imply a tight link between rational expectations of asset returns and of consumption growth. Expected asset returns are perfectly correlated with expected consumption growth, with a standard deviation $1/\psi$ times as large. Equivalently, the standard deviation of expected consumption growth is ψ times as large as the standard deviation of expected asset returns.

This suggests a way to estimate ψ. Hansen and Singleton (1983), followed by Campbell and Mankiw (1989), Hall (1988), and others, have proposed an instrumental variables (IV) regression approach. If we define an error term $\eta_{i,t+1} \equiv r_{i,t+1} - \mathrm{E}_t[r_{i,t+1}] - \gamma(\Delta c_{t+1} - \mathrm{E}_t[\Delta c_{t+1}])$, then we can rewrite (21) and (22) as a regression equation,

$$r_{i,t+1} = \mu_i + \left(\frac{1}{\psi}\right) \Delta c_{t+1} + \eta_{i,t+1}. \tag{24}$$

In general the error term $\eta_{i,t+1}$ will be correlated with realized consumption growth so OLS is not an appropriate estimation method. However $\eta_{i,t+1}$ is uncorrelated with any variables in the information set at time t. Hence any lagged variables correlated with asset returns can be used as instruments in an IV regression to estimate $1/\psi$.

Table 9 illustrates two-stage least squares estimation of (24). In each panel the first set of results uses the short-term real interest rate, while the second set uses the real stock return. The instruments are the asset return, the consumption growth rate, and the log price-dividend ratio. The instruments are lagged twice to avoid difficulties caused by time-aggregation of the consumption data (Campbell and Mankiw 1989, 1991, Wheatley 1988).

For each asset and set of instruments, the table first reports the R^2 statistics and significance levels for first-stage regressions of the asset return and consumption growth rate onto the instruments. The table then shows the IV estimate of $1/\psi$ with its standard error, and (in the column headed "Test (1)") the R^2 statistic for a regression of the residual on the instruments together with the associated significance level of a test of the over-identifying restrictions of the model.

The quarterly results in Table 9 show that the short-term real interest rate is highly forecastable in every country except Germany. The real stock return is also forecastable in some countries, but there is relatively weak evidence for forecastability in consumption growth. In fact the R^2 statistic for forecasting consumption growth is lower than the R^2 statistic for stock returns in many of the quarterly data sets. The IV estimates of $1/\psi$ are very imprecise; they are sometimes large and positive, often negative, but they are almost never significantly different from zero. The overidentifying restrictions of the model are often strongly rejected, particularly when the short-term interest rate is used in the model. Results are similar for the annual data sets in Table 10, except that twice-lagged instruments have almost no ability to forecast real interest rates or stock returns in the annual US data.[16]

Campbell and Mankiw (1989, 1991) have explored this regression in more detail, using both US and international data, and have found that predictable variation in consumption growth is often associated with predictable variation in income growth. This suggests that some consumers keep their consumption close to their income, either because they follow "rules of thumb", or because they are liquidity-constrained, or because they are "buffer-stock" savers (Deaton 1991, Carroll 1992). After controlling for the effect of predictable income growth, there is little remaining predictable variation in consumption growth to be explained by consumers' response to variation in real interest rates.

One problem with IV estimation of (24) is that the instruments are only very weakly correlated with the regressor because consumption growth is hard to forecast in this data set. Nelson and Startz (1990) and Staiger and Stock (1997) have shown that in this situation asymptotic theory can be a poor guide to inference in finite samples; the asymptotic standard error of the coefficient tends to be too small and the overidentifying restrictions of the model may be rejected even when the model is true. To circumvent this problem, one can reverse

[16]Campbell, Lo, and MacKinlay (1997), Table 8.2, shows much greater forecastability of returns using once-lagged instruments in a similar annual US data set. Even with twice-lagged instruments, US annual returns become forecastable once one increases the return horizon beyond one year, as shown in Table 11 below.

the regression (24) and estimate

$$\Delta c_{t+1} = \tau_i + \psi r_{i,t+1} + \zeta_{i,t+1}. \tag{25}$$

If the orthogonality conditions hold, then the estimate of ψ in (25) will asymptotically be the reciprocal of the estimate of $1/\psi$ in (24). In a finite sample, however, if ψ is small then IV estimates of (25) will be better behaved than IV estimates of (24).

In Table 9 ψ is estimated to be close to zero everywhere except in Germany, where the standard error of the estimate is also large. The estimates are typically more precise than those for $1/\psi$. The overidentifying restrictions of the model are sometimes rejected, but less often and less strongly than when (24) is estimated. These results suggest that the elasticity of intertemporal substitution ψ is small, so that the generality of the Epstein-Zin-Weil model, which allows ψ to be large even if γ is large, does not actually help one fit the data on consumption and asset returns.

Two caveats are worth noting. First, Attanasio and Weber (1993) and Beaudry and van Wincoop (1996) have found higher values for ψ using disaggregated cohort-level and state-level consumption data. Second, Bansal and Yaron (2000) have pointed out that estimates like those reported in Table 9 depend on the assumption that consumption growth and asset returns are homoskedastic. Time-varying second moments would introduce a time-varying intercept into the IV regression and could bias the estimates of the elasticity of intertemporal substitution.

4.2 A Loglinear Asset Pricing Framework

In order to understand the second moments of stock returns, it is essential to have a framework relating movements in stock prices to movements in expected future dividends and discount rates. The present value model of stock prices is intractably nonlinear when expected stock returns are time-varying, and this has forced researchers to use one of several available simplifying assumptions. The most common approach is to assume a discrete-state Markov process either for dividend growth (Mehra and Prescott 1985) or, following Hamilton (1989), for conditionally expected dividend growth (Abel 1994, 1999, Cecchetti, Lam, and

Mark 1990, 1993, Kandel and Stambaugh 1991). The Markov structure makes it possible to solve the present value model, but the derived expressions for returns tend to be extremely complicated and so these papers usually emphasize numerical results derived under specific numerical assumptions about parameter values.[17]

An alternative framework, which produces simpler closed-form expressions and hence is better suited for an overview of the literature, is the loglinear approximation to the exact present value model suggested by Campbell and Shiller (1988a). Campbell and Shiller's loglinear relation between prices, dividends, and returns provides an accounting framework: High prices must eventually be followed by high future dividends or low future returns, and high prices must be associated with high expected future dividends or low expected future returns. Similarly, high returns must be associated with upward revisions in expected future dividends or downward revisions in expected future returns.

The loglinear approximation starts with the definition of the log return on some asset i, $r_{i,t+1} \equiv \log(P_{i,t+1} + D_{i,t+1}) - \log(P_{it})$. The timing convention here is that prices are measured at the end of each period so that they represent claims to next period's dividends. The log return is a nonlinear function of log prices p_{it} and $p_{i,t+1}$ and and log dividends $d_{i,t+1}$, but it can be approximated around the mean log dividend-price ratio, $(\overline{d_{it} - p_{it}})$, using a first-order Taylor expansion. The resulting approximation is

$$r_{i,t+1} \approx k + \rho p_{i,t+1} + (1 - \rho) d_{i,t+1} - p_{it} \ , \tag{26}$$

where ρ and k are parameters of linearization defined by $\rho \equiv 1/(1 + \exp(\overline{d_{it} - p_{it}}))$ and $k \equiv -\log(\rho) - (1 - \rho)\log(1/\rho - 1)$. When the dividend-price ratio is constant, then $\rho = P_i/(P_i + D_i)$, the ratio of the ex-dividend to the cum-dividend stock price. In the postwar quarterly US data shown in Table 10, the average price-dividend ratio has been 28.3 on an annual basis, implying that ρ should be about 0.966 in annual data.[18]

[17] A partial exception to this statement is that Abel (1994) derives several analytical results for the first moments of returns in a Markov model for expected dividend growth.

[18] Strictly speaking both ρ and k should have asset subscripts i, but I omit these for simplicity. The asset pricing formulas later in this chapter assume that all assets have the same ρ, which simplifies some expressions but does not change any of the qualitative conclusions.

The Taylor approximation (26) replaces the log of the sum of the stock price and the dividend in the exact relation with a weighted average of the log stock price and the log dividend. The log stock price gets a weight ρ close to one, while the log dividend gets a weight $1-\rho$ close to zero because the dividend is on average much smaller than the stock price, so a given percentage change in the dividend has a much smaller effect on the return than a given percentage change in the price.

Equation (26) is a linear difference equation for the log stock price. Solving forward, imposing the terminal condition that $\lim_{j\to\infty} \rho^j p_{i,t+j} = 0$, taking expectations, and subtracting the current dividend, one gets

$$p_{it} - d_{it} = \frac{k}{1-\rho} + \mathrm{E}_t \sum_{j=0}^{\infty} \rho^j [\Delta d_{i,t+1+j} - r_{i,t+1+j}] \; . \tag{27}$$

This equation says that the log price-dividend ratio is high when dividends are expected to grow rapidly, or when stock returns are expected to be low. The equation should be thought of as an accounting identity rather than a behavioral model; it has been obtained merely by approximating an identity, solving forward subject to a terminal condition, and taking expectations. Intuitively, if the stock price is high today, then from the definition of the return and the terminal condition that the stock price is non-explosive, there must either be high dividends or low stock returns in the future. Investors must then expect some combination of high dividends and low stock returns if their expectations are to be consistent with the observed price.

Equation (27) can also be understood as a dynamic generalization of the famous formula, often attributed to Myron Gordon (1962) but probably due originally to John Burr Williams (1938), that applies when the discount rate is a constant R and the expected dividend growth rate is a constant G. In this case the price-dividend ratio is a constant given by

$$\frac{P_t}{D_t} = \frac{1+G}{R-G}. \tag{28}$$

Equation (27) is equivalent to (28) when expected returns and dividend growth rates are constant.

The terminal condition used to obtain (27) is perhaps controversial. Models of "rational bubbles" do not impose this condition. Blanchard and Watson (1982) and Froot and Obstfeld (1991) have proposed simple, explicit models of explosive bubbles in asset prices. There are however several reasons to rule out such bubbles. The theoretical circumstances under which bubbles can exist are quite restrictive; Tirole (1985), for example, uses an overlapping generations framework and finds that bubbles can only exist if the economy is dynamically inefficient, a condition which seems unlikely on prior grounds and which is hard to reconcile with the empirical evidence of Abel, Mankiw, Summers, and Zeckhauser (1989). Santos and Woodford (1997) also conclude that the conditions under which bubbles can exist are fragile. Empirically, bubbles imply explosive behavior of prices in relation to dividends and other measures of fundamentals; there is no evidence of this, although nonlinear bubble models are hard to reject using standard linear econometric methods.[19]

Equation (27) describes the log price-dividend ratio rather than the log price itself. This is a useful way to write the model if dividends follow a loglinear unit root process, so that log dividends and log prices are nonstationary. In this case changes in log dividends are stationary, so from (27) the log price-dividend ratio is stationary provided that the expected stock return is stationary. Thus log stock prices and dividends are cointegrated, and the stationary linear combination of these variables involves no unknown parameters since it is just the log ratio.

Table 10 reports some summary statistics for international stock prices in relation to dividends. The table gives the average price-dividend ratio, the standard deviation of the log price-dividend ratio in natural units, the first-order autocorrelation of the log price-dividend ratio, average growth rates of prices, dividends, and the log price-dividend ratio in percentage points per year, and a test statistic for the null hypothesis that the log price-dividend ratio has a unit root. Following standard practice, the price-dividend ratio is measured as the ratio of the current stock price to the total of dividends paid during the past year.

Average price-dividend ratios vary considerably across countries. The extreme outlier is

[19]Campbell, Lo, and MacKinlay (1997), Chapter 7, gives a somewhat more detailed textbook discussion of the literature on rational bubbles.

Japan, which has an average price-dividend ratio of 93. Price-dividend ratios have tended to increase over the sample period, as illustrated by the faster average growth rates of prices than of dividends; this reflects both the depressed stock markets of the 1970's, when many of the sample periods begin, and the rapid increases in stock prices of the late 1990's. For similar reasons the autocorrelations of price-dividend ratios tend to be high, and unit root tests rarely reject the unit root null hypothesis.

One reaction to these findings is that price-dividend ratios are truly stationary, but unit root tests lack power to reject the null hypothesis. However there has been increasing interest in the possibility that permanent changes in dividend growth rates or expected returns generate permanent changes in dividend-price ratios.

One way in which this can occur is through shifts in corporate financial policy. If a firm permanently reduces its dividends and devotes the resources to repurchasing shares, current dividends fall but the growth rate of dividends per share increases because the number of shares outstanding starts to decline over time. One can adjust for this change by working with the total value of the firm, rather than the price per share, and calculating dividends plus repurchases. Liang and Sharpe (1999) have done this calculation for selected S&P 500 firms in the 1990's, and have found that repurchases add 75 to 100 basis points to the conventionally measured dividend-price ratio.

Concerns about the instability of corporate financial policy have stimulated research on alternative valuation ratios such as the price-earnings or market-book ratio. Vuolteenaho (2000), for example, derives an expression for the market-book ratio, analogous to (27), that relates it to expected future stock returns and accounting return on equity (ROE).

So far I have written asset prices as linear combinations of expected future dividends and returns. Following Campbell (1991), I can also write asset returns as linear combinations of *revisions* in expected future dividends and returns. Substituting (27) into (26), I obtain

$$r_{i,t+1} - \mathrm{E}_t\, r_{i,t+1} = (\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=0}^{\infty} \rho^j \Delta d_{i,t+1+j} - (\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=1}^{\infty} \rho^j r_{i,t+1+j} \ . \qquad (29)$$

This equation says that unexpected stock returns must be associated with changes in expectations of future dividends or real returns. An increase in expected future dividends is

associated with a capital gain today, while an increase in expected future returns is associated with a capital loss today. The reason is that with a given dividend stream, higher future returns can only be generated by future price appreciation from a lower current price.

4.3 The Equity Volatility Puzzle

I now use this accounting framework to illustrate the equity volatility puzzle. The intertemporal budget constraint for a representative agent, (19), implies that aggregate consumption is the dividend on the portfolio of all invested wealth, denoted by subscript w:

$$d_{wt} = c_t. \tag{30}$$

Many authors, including Grossman and Shiller (1981), Lucas (1978), and Mehra and Prescott (1985), have assumed that the aggregate stock market, denoted by subscript e for equity, is a good proxy for the portfolio of all wealth and thus is priced as if it pays consumption as its dividend.[20] Here I follow Campbell (1986) and Abel (1996) and make the slightly more general assumption that the dividend on equity equals aggregate consumption raised to a power λ. In logs, we have

$$d_{et} = \lambda c_t \ . \tag{31}$$

Abel (1996) shows that the coefficient λ can be interpreted as a measure of leverage. When $\lambda > 1$, dividends and stock returns are more volatile than the returns on the aggregate wealth portfolio. This framework has the additional advantage that a riskless real bond with infinite maturity—an inflation-indexed consol, denoted by subscript b—can be priced merely by setting $\lambda = 0$.

The representative-agent asset pricing model with Epstein-Zin-Weil utility, conditional lognormality, and homoskedasticity (equations (21) and (22)) implies that

$$\mathrm{E}_t r_{e,t+1} = \mu_e + \left(\frac{1}{\psi}\right) \mathrm{E}_t \Delta c_{t+1}, \tag{32}$$

[20]This does not require that measured dividends literally equal measured consumption. For example, consumption could equal dividends plus repurchases if firms are repurchasing shares. Or consumption could be financed in part by labor income, which can be thought of as the dividend on human capital. If human capital returns and stock returns are perfectly correlated, the stock market is a proxy for total wealth even though it does not equal total wealth.

where μ_e is an asset-specific constant term. The expected log return on equity, like the expected log return on any other asset, is just a constant plus expected consumption growth divided by the elasticity of intertemporal substitution ψ. Power utility is the special case where the coefficient of relative risk aversion γ is the reciprocal of ψ so the effect of expected consumption growth on expected asset returns is proportional to γ; but this is not true in general.

Substituting equations (31) and (32) into equations (27) and (29), I find that

$$p_{et} - d_{et} = \frac{k_e}{1-\rho} + \left(\lambda - \frac{1}{\psi}\right) \mathrm{E}_t \sum_{j=0}^{\infty} \rho^j \Delta c_{t+1+j} \ , \tag{33}$$

and

$$r_{e,t+1} - \mathrm{E}_t\, r_{e,t+1} = \lambda(\Delta c_{t+1} - \mathrm{E}_t \Delta c_{t+1}) + \left(\lambda - \frac{1}{\psi}\right) (\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=1}^{\infty} \rho^j \Delta c_{t+1+j} \ . \tag{34}$$

Expected future consumption growth has offsetting effects on the log price-dividend ratio. It has a direct positive effect by increasing expected future dividends λ-for-one, but it has an indirect negative effect by increasing expected future real interest rates $(1/\psi)$-for-one. The unexpected log return on the stock market is λ times contemporaneous unexpected consumption growth (since contemporaneous consumption growth increases the contemporaneous dividend λ-for-one), plus $(\lambda - 1/\psi)$ times the discounted sum of revisions in expected future consumption growth.

For future reference I note that (34) can be inverted to express consumption growth as a function of the unexpected return on equity and revisions in expectations about future returns on equity. Rearranging (34) and using (32),

$$\Delta c_{t+1} - \mathrm{E}_t\, \Delta c_{t+1} = \left(\frac{1}{\lambda}\right) (r_{e,t+1} - \mathrm{E}_t r_{e,t+1}) + \left(\frac{1}{\lambda} - \psi\right) (\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=1}^{\infty} \rho^j r_{e,t+1+j} \ . \tag{35}$$

An innovation in the equity return raises wealth by a factor $(1/\lambda)$, and this raises consumption by the same factor. Increases in expected future equity returns have offsetting income and substitution effects on consumption; the positive income effect is $(1/\lambda)$, and the negative substitution effect is $-\psi$.

These equations can be simplified if I assume that expected aggregate consumption growth, which I write as z_t, follows an AR(1) process with mean g and positive persistence ϕ:

$$\Delta c_{t+1} = z_t + \epsilon_{c,t+1}, \tag{36}$$

$$z_{t+1} = (1-\phi)g + \phi z_t + \epsilon_{z,t+1}. \tag{37}$$

This is a linear version of the model used by Cecchetti, Lam, and Mark (1990, 1993) and Kandel and Stambaugh (1991), in which expected consumption growth follows a persistent discrete-state Markov process. The contemporaneous shocks to realized consumption growth $\epsilon_{c,t+1}$ and expected future consumption growth $\epsilon_{z,t+1}$ may be positively or negatively correlated. The correlation between these contemporaneous shocks controls the univariate autocovariances of consumption growth; the first-order autocovariance is $\phi\text{Var}(z_t) + \text{Cov}(\epsilon_{z,t+1}, \epsilon_{c,t+1})$, and higher-order autocovariances die out geometrically at rate ϕ. Thus consumption growth inherits the positive serial correlation of the z_t process unless the contemporaneous shocks are sufficiently negatively correlated. An important special case of the model sets $\epsilon_{z,t+1} = \phi\epsilon_{c,t+1}$ to make consumption growth itself an AR(1) process; this is a linear version of the model of Mehra and Prescott (1985).[21]

From equation (21), the riskless interest rate is linear in expected consumption growth z_t, so this model implies a homoskedastic AR(1) process for the riskless interest rate, with persistence ϕ. It is a discrete-time version of the Vasicek (1977) model of the term structure of interest rates. Campbell, Lo, and MacKinlay (1997), Chapter 11, gives a detailed textbook exposition of this model following Singleton (1990) and Sun (1992).

Equations (36) and (37) allow me to rewrite (33) and (34) as

$$p_{et} - d_{et} = \frac{k}{1-\rho} + \left(\lambda - \frac{1}{\psi}\right)\left[\frac{g}{1-\rho} + \frac{z_t - g}{1-\rho\phi}\right], \tag{38}$$

[21] As noted earlier, the empirical evidence on serial correlation in consumption growth is mixed. Table 2 shows small negative autocorrelation in 7 out of 12 quarterly datasets, but only 1 out of 3 annual data sets. Measurement problems may bias these autocorrelations in either direction. Durability of consumption tends to bias autocorrelation downwards, but time-averaging and seasonal adjustment tend to bias it upwards. Empirical estimates of discrete-state Markov models by Cecchetti, Lam, and Mark (1990, 1993), Kandel and Stambaugh (1991), and Mehra and Prescott (1985) find some evidence for modest but persistent predictable variation in US consumption growth. However Campbell and Mankiw (1989, 1990), Hall (1988), Cochrane (1994), and Lettau and Ludvigson (2001) find that US consumption growth is almost unforecastable.

and

$$r_{e,t+1} - \mathrm{E}_t\, r_{e,t+1} = \lambda \epsilon_{c,t+1} + \left(\lambda - \frac{1}{\psi}\right)\left(\frac{\rho}{1-\rho\phi}\right)\epsilon_{z,t+1}. \tag{39}$$

Equation (39) shows why it is difficult to match the volatility of stock returns within this standard framework. The most obvious way to generate volatile stock returns is to assume a large λ, that is, a volatile dividend. Increasing λ, however, has mixed effects; it increases the volatility of the first term in (39) proportionally, but as long as $\lambda < 1/\psi$ it diminishes the volatility of the second term because the dividend and real interest rate effects of expected consumption growth offset each other more exactly. The overall volatility of stock returns may actually fall, or grow only slowly, with λ until the point is reached where $\lambda > 1/\psi$. The empirical evidence for small ψ presented in Table 10 suggests that very high λ will be needed to generate volatile stock returns. A similar point has been made by Abel (1999), who emphasizes that predictable variation in expected consumption growth can dampen stock market volatility and exacerbate the equity premium puzzle.

This model also tends to produce highly volatile returns on real (inflation-indexed) bonds. By setting $\lambda = 0$ in (38) and (39), the log yield and unexpected return on a real consol bond, denoted by a subscript b, are

$$y_{bt} = d_{bt} - p_{bt} = -\frac{k_b}{1-\rho} + \left(\frac{1}{\psi}\right)\left[\frac{g}{1-\rho} + \frac{z_t - g}{1-\rho\phi}\right], \tag{40}$$

and

$$r_{b,t+1} - \mathrm{E}_t\, r_{b,t+1} = -\left(\frac{1}{\psi}\right)\left(\frac{\rho}{1-\rho\phi}\right)\epsilon_{z,t+1}. \tag{41}$$

When ψ is small, even modest variation in z_t will tend to produce large variation in the riskfree interest rate and in the yields and returns on long-term real bonds. The correlation of stock and real bond returns is positive if $\lambda < 1/\psi$, but turns negative if λ is large enough so that $\lambda > 1/\psi$.

Of course, all these calculations are dependent on the assumption made at the beginning of this subsection, that stocks are priced as if they pay a multiple λ of log aggregate consumption. More general models, allowing separate variation in dividends and consumption, can in principle generate volatile stock returns without excessive variation in real interest

rates. For example, we might modify (31) to allow a second autonomous component of the dividend:

$$d_{et} = \lambda c_t + a_t, \tag{42}$$

where Δa_{t+1} has a similar structure to consumption growth, being forecast by an AR(1) state variable:

$$\Delta a_{t+1} = y_t + \epsilon_{a,t+1}, \tag{43}$$

$$y_{t+1} = (1-\theta)\nu + \theta y_t + \epsilon_{y,t+1}. \tag{44}$$

This modification of the basic model would add a term $\nu/(1-\rho) + (y_t - \nu)/(1-\rho\theta)$ to the formula for the log price-dividend ratio, (38), and would add a term $\epsilon_{a,t+1} + \rho\epsilon_{y,t+1}/(1-\rho\theta)$ to the formula for the unexpected log stock return, (39). Cecchetti, Lam, and Mark (1993) estimate a discrete-state Markov model allowing for this sort of separate variability in consumption and dividends. While such a model provides a more realistic description of dividends, it requires large predictable movements in dividends to explain stock market volatility. There is evidence for such dividend variation in some countries, but not in others as I show in section 4.5.

Lettau and Ludvigson (2001) have recently approached these issues from a somewhat different point of view. They divide the aggregate wealth portfolio into two components, financial wealth and human wealth. They use the Federal Reserve Board's Flow of Funds accounts to measure aggregate financial wealth in the US. While human wealth is not directly observable, they argue that it should be cointegrated with current labor income since labor income follows a unit root process. They also use the intertemporal budget constraint to argue that aggregate consumption should be cointegrated with total wealth if the returns on wealth are stationary. This implies that aggregate consumption, financial wealth, and labor income should be cointegrated. Lettau and Ludvigson find evidence to support this hypothesis in US data.

Cointegration among three variables implies that there exists a stationary linear combination of the variables, and that this combination forecasts the growth rates of at least one variable. Lettau and Ludvigson find that there is very little forecastability in consumption

growth or labor income growth; instead, wealth growth is forecastable. These results are consistent with earlier findings of Campbell and Mankiw (1989), Hall (1988), and particularly Cochrane (1994).

Cointegration between consumption and wealth implies that in the very long run the annualized growth rates of consumption and wealth must be identical and therefore must have identical volatilities. In the short run, however, we know that consumption is far smoother than wealth; this is precisely the equity volatility puzzle. How can we reconcile the observed short-run properties of consumption and wealth with the properties we know they must have in the long run? There are only two possibilities. First, it may be that the annualized volatility of consumption growth increases with the horizon over which it is measured, so that ultimately it reaches the high volatility of wealth growth. This would require that consumption is not a random walk, but has positive serial correlation in growth rates. Second, it may be that the annualized volatility of wealth growth decreases with the horizon over which it is measured, so that ultimately it reaches the low volatility of consumption growth. This would require that wealth is not a random walk, but has negative serial correlation in growth rates. These two possibilities represent fundamentally different views of the world. Is the world safe as suggested by consumption, or risky as suggested by the stock market? The work of Lettau and Ludvigson implies that the former view is correct: Wealth is mean-reverting and adjusts over long horizons to match the smoothness of consumption. A satisfactory model of equity volatility must be consistent with this finding.

4.4 Implications for the Equity Premium Puzzle

I now return to the basic model in which the log dividend is a multiple of log aggregate consumption, and use the formulas derived in the previous subsection to gain a deeper understanding of the equity premium puzzle. The discussion of the puzzle in section 3 treated the covariance of stock returns with consumption as exogenous, but given a tight link between stock dividends and consumption the covariance can be derived from the stochastic properties of consumption itself. This is the approach of many papers including Abel (1994,

1999), Kandel and Stambaugh (1991), Mehra and Prescott (1985), and Rietz (1988).

An advantage of this approach is that it clarifies the implications of Epstein-Zin-Weil utility. The Epstein-Zin-Weil Euler equation is derived by imposing a budget constraint that links consumption and wealth, and it explains risk premia by the covariances of asset returns with both consumption growth and the return on the wealth portfolio. The stochastic properties of consumption, together with the budget constraint, can be used to substitute either consumption or wealth out of the Epstein-Zin-Weil model.

To understand this point, note that equation (34) applies to the return on the wealth portfolio when $\lambda = 1$. Setting $e = w$ and $\lambda = 1$, (34) becomes

$$r_{w,t+1} - \mathrm{E}_t\, r_{w,t+1} = \Delta c_{t+1} - \mathrm{E}_t \Delta c_{t+1} + \left(1 - \frac{1}{\psi}\right)(\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=1}^{\infty} \rho^j \Delta c_{t+1+j}, \tag{45}$$

an equation derived by Restoy and Weil (1998). It follows that the covariance of any asset return with the wealth portfolio must satisfy

$$\sigma_{iw} = \sigma_{ic} + \left(1 - \frac{1}{\psi}\right)\sigma_{ig}, \tag{46}$$

where σ_{ig} denotes the covariance of asset return i with revisions in expectations of future consumption growth:

$$\sigma_{ig} \equiv \mathrm{Cov}(r_{i,t+1} - \mathrm{E}_t r_{i,t+1}, (\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=1}^{\infty} \rho^j \Delta c_{t+1+j}). \tag{47}$$

The letter g is used here as a mnemonic for consumption growth.

Substituting this expression into the formula for risk premia in the Epstein-Zin-Weil model, (22), that formula simplifies to

$$\mathrm{E}_t[r_{i,t+1}] - r_{f,t+1} + \frac{\sigma_i^2}{2} = \gamma\sigma_{ic} + \left(\gamma - \frac{1}{\psi}\right)\sigma_{ig}. \tag{48}$$

The risk premium on any asset is the coefficient of risk aversion γ times the covariance of that asset with consumption growth, plus $(\gamma - 1/\psi)$ times the covariance of the asset with revisions in expected future consumption growth. The second term is zero if $\gamma = 1/\psi$, the power utility case, or if there are no revisions in expected future consumption growth.[22]

[22]Using a continuous-time model, Svensson (1989) also emphasizes that risk premia in the Epstein-Zin-Weil model are determined only by risk aversion when investment opportunities and expected consumption growth are constant.

I now return to the assumption made in the previous subsection that expected consumption growth is an AR(1) process given by (37). Under this assumption,

$$(\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=1}^{\infty} \rho^j \Delta c_{t+1+j} = \left(\frac{\rho}{1 - \rho\phi} \right) \epsilon_{z,t+1}. \tag{49}$$

Equations (39), (48), and (49) imply that

$$\begin{aligned} \mathrm{E}_t[r_{e,t+1}] - r_{f,t+1} + \frac{\sigma_e^2}{2} &= \gamma \left[\lambda \sigma_c^2 + \left(\lambda - \frac{1}{\psi} \right) \left(\frac{\rho}{1 - \rho\phi} \right) \sigma_{cz} \right] \\ &+ \left(\gamma - \frac{1}{\psi} \right) \left[\frac{\lambda\rho}{1 - \rho\phi} \sigma_{cz} + \left(\lambda - \frac{1}{\psi} \right) \left(\frac{\rho}{1 - \rho\phi} \right)^2 \sigma_z^2 \right]. \end{aligned} \tag{50}$$

This expression nests many of the leading cases explored in the literature on the equity premium puzzle. To understand it, it is helpful to break the equity premium into two components, the premium on real consol bonds over the riskless interest rate, and the premium on equities over real consol bonds:

$$\begin{aligned} \mathrm{E}_t[r_{b,t+1}] - r_{f,t+1} + \frac{\sigma_b^2}{2} &= \gamma \left[-\frac{1}{\psi} \left(\frac{\rho}{1 - \rho\phi} \right) \sigma_{cz} \right] \\ &+ \left(\gamma - \frac{1}{\psi} \right) \left[-\frac{1}{\psi} \left(\frac{\rho}{1 - \rho\phi} \right)^2 \sigma_z^2 \right]. \end{aligned} \tag{51}$$

$$\begin{aligned} \mathrm{E}_t[r_{e,t+1} - r_{b,t+1}] + \frac{\sigma_e^2}{2} - \frac{\sigma_b^2}{2} &= \gamma\lambda \left[\sigma_c^2 + \left(\frac{\rho}{1 - \rho\phi} \right) \sigma_{cz} \right] \\ &+ \left(\gamma - \frac{1}{\psi} \right) \lambda \left[\frac{\rho}{1 - \rho\phi} \sigma_{cz} + \left(\frac{\rho}{1 - \rho\phi} \right)^2 \sigma_z^2 \right]. \end{aligned} \tag{52}$$

Equations (51) and (52) add up to equation (50). The first term in each of these expressions represents the premium under power utility, while the second term represents the effect on the premium of moving to Epstein-Zin utility and allowing the coefficient of risk aversion to differ from the reciprocal of the intertemporal elasticity of substitution.

Under power utility, the real bond premium in (51) is determined by the covariance σ_{cz} of realized consumption growth and innovations to expected future consumption growth. If this

covariance is positive, then an increase in consumption is associated with higher expected future consumption growth, higher real interest rates, and lower bond prices. Real bonds accordingly have hedge value and the real bond premium is negative. If σ_{cz} is negative, then the real bond premium is positive.[23]

Under Epstein-Zin utility with $\gamma < 1/\psi$, assets that covary negatively with expected future consumption growth have higher risk premia. Since real bonds have this characteristic, Epstein-Zin utility with $\gamma < 1/\psi$ tends to produce large term premia. This runs counter to the empirical observation in Tables 7 and 8 that term premia are only modest; while the term premia measured in the tables are on nominal rather than real bonds, nominal term premia should if anything be larger than rela term premia because they include a reward for bearing inflation risk which is unlikely to be negative. This suggests that Epstein-Zin utility will require $\gamma > 1/\psi$ to fit the behavior of bond prices.

The premium on equities over real bonds is proportional to the coefficient λ that governs the volatility of dividend growth. Under power utility the equity-bond premium is just risk aversion γ times λ times terms in σ_c^2 and σ_{cz}. Since both σ_c^2 and σ_{cz} must be small to match the observed moments of consumption growth, it is hard to rationalize the large equity-bond premium shown in Table 9. Epstein-Zin utility with $\gamma > 1/\psi$ adds a second term in σ_{cz} and σ_z^2. The σ_z^2 term is positive, which would help to rationalize the equity-bond premium.

In conclusion, Epstein-Zin-Weil utility might help the consumption-based model to fit the patterns of risk premia in the data if $\gamma > 1/\psi$. Given the evidence for small ψ reported in section 4.1, however, this still requires a large risk aversion coefficient γ. Thus Epstein-Zin-Weil utility does not provide an easy solution to the equity premium puzzle.

Campbell (1993) uses these relations in a different way. Instead of substituting the wealth return out of the Epstein-Zin-Weil model, Campbell substitutes consumption out of the model to get a discrete-time version of the intertemporal CAPM of Merton (1973). Setting $e = w$ and $\lambda = 1$ in (35), the innovation in consumption is

$$\Delta c_{t+1} - \mathrm{E}_t \Delta c_{t+1} = r_{w,t+1} - \mathrm{E}_t r_{w,t+1} + (1-\psi)(\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=1}^{\infty} \rho^j r_{w,t+1+j}. \tag{53}$$

[23]Campbell (1986) develops this intuition in a univariate model for consumption growth.

Thus the covariance of any asset return with consumption growth must satisfy

$$\sigma_{ic} = \sigma_{iw} + (1 - \psi)\sigma_{ih}, \tag{54}$$

where σ_{ih} denotes the covariance of asset return i with revisions in expected future returns on wealth:

$$\sigma_{ih} \equiv \mathrm{Cov}(r_{i,t+1} - \mathrm{E}_t r_{i,t+1}, (\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{j=1}^{\infty} \rho^j r_{w,t+1+j}). \tag{55}$$

The letter h here is used as a mnemonic for hedging demand (Merton 1973), a term commonly used in the finance literature to describe the component of asset demand that is determined by investors' responses to changing investment opportunities.

σ_{ic} can now be substituted out of (22) to obtain

$$\mathrm{E}_t[r_{i,t+1}] - r_{f,t+1} + \frac{\sigma_i^2}{2} = \gamma\sigma_{iw} + (\gamma - 1)\sigma_{ih}. \tag{56}$$

The risk premium on any asset is the coefficient of risk aversion γ times the covariance of that asset with the return on the wealth portfolio, plus $(\gamma - 1)$ times the covariance of the asset with revisions in expected future returns on wealth. The second term is zero if $\gamma = 1$; in this case it is well known that intertemporal asset demands are zero and asset pricing is myopic. Campbell (1996) uses this formula to study US stock price data, assuming that the log return on wealth is a linear combination of the stock return and the return on human capital (proxied by innovations to labor income). He argues that mean-reversion in US stock prices implies a positive covariance σ_{ew} between US stock returns and the current return on wealth, but a negative covariance σ_{eh} between US stock returns and revisions in expected future returns on wealth. Equation (56) then implies that increases in γ above one have only a damped effect on the equity premium, so high risk aversion is needed to explain the equity premium puzzle. This conclusion is reached without any reference to measured aggregate consumption data.

4.5 What Does the Stock Market Forecast?

All the calculations in sections 4.3 and 4.4 rely heavily on the assumptions of the representative-agent model with power utility, lognormal distributions, constant variances, and a determin-

istic link between stock dividends and consumption. They leave open the possibility that the stock market volatility puzzle could be resolved by relaxing these assumptions, for example to allow independent variation in dividends in the manner discussed at the end of section 4.3.

A more direct way to understand the stock market volatility puzzle is to use the loglinear asset pricing framework to study the empirical relationships between log price-dividend ratios and future consumption or dividend growth rates, real interest rates, and excess stock returns. According to equation (27), the log price-dividend ratio embodies rational forecasts of dividend growth rates and stock returns, which in turn are the sum of real interest rates and excess stock returns, discounted to an infinite horizon. One can compare the empirical importance of these different forecasts by regressing long-horizon consumption and dividend growth rates, real interest rates, and excess stock returns onto the log price-dividend ratio.

Table 11 reports the results of this exercise. For comparative purposes real output growth, realized stock market volatility, and the excess bond return are also included as dependent variables. The regressions are divided into two groups; Panel A includes the regressions whose dependent variables are growth rates of consumption, output, or dividends, while Panel B includes the regressions whose dependent variables are the real interest rate, the excess stock return, a measure of realized volatility in excess stock returns, or the excess bond return. For each quarterly data set the dependent variables are computed in natural units over 4, 8, and 16 quarters (1, 2, and 4 years) and regressed onto the log price-dividend ratio divided by its standard deviation. Thus the regression coefficient gives the effect of a one standard deviation change in the log price-dividend ratio on the cumulative growth rate or rate of return in natural units. The table reports the regression coefficient, heteroskedasticity- and autocorrelation-consistent t statistic, and R^2 statistic.

In the benchmark postwar quarterly US data, the log price-dividend ratio has no clear ability to forecast consumption growth, output growth, dividend growth, or the real interest rate at any horizon. What it does forecast is the excess return on stocks, with t statistics that start above 2.4 and increase, and with R^2 statistics that start at 0.10 and increase to

0.38 at a 4-year horizon. In the introduction these results were summarized as stylized facts 10, 11, 12, and 13. Table 11 extends them to international data.

10. Regressions of consumption growth on the log price-dividend ratio give very mixed results across countries. There are statistically significant positive coefficients in Germany and the Netherlands, but statistically significant negative coefficients in Japan. The other countries resemble the US in that they have no statistically significant consumption growth forecasts. The regressions with output growth as the dependent variable show a similar pattern across countries.

11. Results are somewhat more promising for real dividend growth in many countries. Positive and statistically significant coefficients are found in Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, and the UK. It seems clear that changing forecasts of real dividend growth have some role to play in explaining stock market movements.

12. The short-term real interest rate does not seem to be a promising candidate for the driving force behind stock market fluctuations. One would expect to find high price-dividend ratios forecasting low real interest rates, but the regression coefficients are significantly positive in France, Italy, Japan, Sweden, and the UK. This presumably reflects the fact that stock markets in most countries were depressed in the 1970's, when real interest rates were low, and buoyant during the 1980's, when real interest rates were high.

13. Finally, in some countries the log price-dividend ratio is a powerful forecaster of excess stock returns. The results are particularly striking in the US, Australia, and the UK, but there is also some predictability in France, Germany, and Japan.

In the long-term annual data for Sweden, the UK, and the US, I use horizons of 1 year, 4 years, and 8 years. In the US data the log price-dividend ratio fails to forecast real dividend growth, suggesting that authors such as Barsky and De Long (1993) overemphasize the role of dividend forecasts in interpreting long-run US experience. Consistent with the quarterly results, the log price-dividend ratio also fails to forecast consumption growth, output growth, or the real interest rate, but does forecast excess stock returns.

The UK data are similar, although here the 8-year regression coefficients for consump-

tion growth and dividend growth are even statistically significant with the wrong (negative) sign. The 8-year regression coefficient for the real interest rate is also significantly negative, consistent with the idea that the UK stock market is related to the real interest rate. But much the strongest relation is between the log price-dividend ratio and future excess returns on the UK stock market. The Swedish data are quite different; here the log price-dividend ratio forecasts short-run dividend growth positively but has little predictive power for consumption growth, output growth, the real interest rate, or the excess log stock return.

The right-hand column of Table 11, Panel B, considers one more dependent variable, the excess bond return. The predictive power of the stock market for excess stock returns does not generally carry over to excess bond returns; there are significant negative coefficients only in the UK (and positive coefficients in Sweden).

There are some econometric pitfalls in interpreting the regression results in Table 11. The price-dividend ratio is extremely persistent, and its innovations are highly positively correlated with stock returns. Stambaugh (1999) shows that these two conditions create a negative bias in the coefficient of a regression that forecasts stock returns from the price-dividend ratio. The negative coefficients in Table 11 might be attributable to this bias rather than to true predictability of stock returns. Lewellen (2001) points out, however, that the negative bias is concentrated in samples where the price-dividend ratio appears to be less persistent than it truly is. He suggests a bias correction that conditions on the measured persistence of the price-dividend ratio relative to the upper bound of unity; this correction is small in recent US data, since the price-dividend ratio has a measured first-order autocorrelation close to one.

Concerns about the instability of corporate financial policy have led some authors to use other variables to forecast US stock returns. For example, Campbell and Shiller (1988b, 2001) look at the price-earnings ratio, Lewellen (1999) and Vuolteenaho (2000) use the market-book ratio, Lamont (1998) combines the two by using the dividend payout ratio, Baker and Wurgler (2000) look at the share of equity in new finance, and Lettau and Ludvigson (2001) look at the level of consumption in relation to aggregate financial wealth and labor

income. Other authors have considered interest-rate variables such as recent changes in short-term interest rates (Campbell 1987, Hodrick 1992) or yield spreads between long-term and short-term interest rates (Campbell 1987, Fama and French 1989, Keim and Stambaugh 1986).

While many of these variables have some predictive power, the dramatic runup in stock prices in the late 1990's diminished the statistical evidence for predictability in almost all cases (but see Lettau and Ludvigson 2001 and Lewellen 2001). While this poses a challenge to the view that stock returns are forecastable, it also poses a challenge to the view that stocks are priced with constant discount rates, because the dividend growth forecasts needed to rationalize late-1990's stock prices with a constant discount rate seem extraordinarily optimistic (Campbell and Shiller 2001, Heaton and Lucas 1999, Shiller 2000).

Overall, these results suggest that a new model of stock market volatility may be needed. The standard model of section 4.3 drives all stock market fluctuations from changing forecasts of long-run consumption growth, dividend growth, and real interest rates; forecasts of excess stock returns are constant. The data for many countries suggest instead that forecasts of consumption growth, dividend growth, and real interest rates are variable only in the short run, so that long-run forecasts of these variables are fairly stable; changing forecasts of excess stock returns make an important contribution to the fluctuations of the stock market.

4.6 Changing Volatility in Stock Returns

One reason why excess stock returns might be predictable is that the risk of stock market investment, as measured for example by the volatility of stock returns, might vary over time. With a constant price of risk, shifts in the quantity of risk will lead to changes in the equity risk premium.

There is a vast literature documenting the fact that stock market volatility does change with time. However, the variation in volatility is concentrated at high frequencies; it is most dramatic in daily or monthly data and is much less striking at lower frequencies. There is some business-cycle variation in volatility, but it does not seem strong enough to explain large

movements in aggregate stock prices (Bollerslev, Chou, and Kroner 1992, Schwert 1989).

A second difficulty is that there is only weak evidence that periods of high stock market volatility coincide with periods of predictably high stock returns. Some papers do find a positive relationship between conditional first and second moments of returns (Bollerslev, Engle, and Wooldridge 1988, French, Schwert, and Stambaugh 1987, Harvey 1989), but other papers find that when short-term nominal interest rates are high, the conditional volatility of stock returns is high while the conditional mean stock return is low (Campbell 1987, Glosten, Jagannathan, and Runkle 1993).

French, Schwert, and Stambaugh (1987) emphasize that innovations in volatility are strongly negatively correlated with innovations in returns. This could be indirect evidence for a positive relationship between volatility and expected returns, but it could also indicate that negative shocks to stock prices raise volatility, perhaps by raising financial or operating leverage of companies (Black 1976).

Some researchers have built models that allow for independent variation in the quantity and price of risk. Harvey (1989, 1991) uses the Generalized Method of Moments to estimate such a system, and finds that the price of risk appears to vary countercyclically. Chou, Engle, and Kane (1992) find similar results using a GARCH framework.[24]

Within the confines of this chapter it is not possible to do justice to the sophistication of the econometrics used in this literature. Instead I illustrate the empirical findings of the literature by constructing a crude measure of ex post volatility for excess stock returns—the average over 4, 8, or 16 quarters of the squared quarterly excess stock return—and regressing it onto the log price-dividend ratio. The results of this regression are reported in the third column of Table 12, Panel B. There are several significant coefficients in these regressions, but they are all positive, indicating that high price-dividend ratios predict high, not low volatility in these data.

[24]There is also recent work emphasizing that the quantity of risk should be measured by the consumption covariance of stock returns rather than their volatility; these two measures of risk may differ if stock returns and consumption growth are not perfectly correlated. Whitelaw (2000) builds a regime-switching model with state-dependent transition probabilities in which the consumption covariance of stock returns moves with the business cycle.

These results reinforce the conclusion of the literature that the price of risk seems to vary over time in relation to the level of aggregate consumption. Section 5 discusses economic models that have this property.

4.7 What Does the Bond Market Forecast?

I conclude this section by briefly comparing the results of Table 11 with those that can be obtained using bond market data. Table 12 repeats the regressions of Table 11 using the yield spread between long-term and short-term bonds as the regressor. Many authors have found that in US data, yield spreads have some ability to forecast excess bond returns (Campbell and Shiller 1991, Fama and Bliss 1987). This contradicts the expectations hypothesis of the term structure, the hypothesis that excess bond returns are unforecastable. Other authors have found that yield spreads are powerful forecasters of macroeconomic conditions, particularly output growth (Chen 1991, Estrella and Hardouvelis 1991). Fama and French (1989) have argued that both price-dividend ratios and yield spreads capture short-term cyclical conditions, although yield spreads are more highly correlated with conventional measures of the US business cycle.

The results of Table 12 are strikingly different from those of Table 11. In the quarterly data, yield spreads forecast positive output growth in every country except Italy and Japan, and positive consumption growth in many countries. Outside the US, there is also a strong tendency for yield spreads to forecast low real interest rates. Thus the findings of Chen (1991) and Estrella and Hardouvelis (1991) carry over to international data.

Yield spreads are less consistently successful as forecasters of excess stock returns, stock market volatility, or even excess bond returns; the ability of the yield spread to forecast excess bond returns appears to be primarily a US rather than an international phenomenon.[25] Similar conclusions are reported by Hardouvelis (1994) and Bekaert, Hodrick, and Marshall (1999). While these authors do report some evidence for predictability of excess bond returns in international data, the evidence is much weaker than in US data.

[25]Results at a one-quarter horizon, not reported in the table, are qualitatively consistent with the long-horizon results.

One important point to note, however, is that the small-sample bias emphasized by Stambaugh (1999) tends to bias the coefficients of bond returns on yield spreads downwards, that is, towards zero. Correcting the bias therefore strengthens the evidence for predictability of excess bond returns; this is the opposite of the situation when stock returns are regressed on price-dividend ratios. Bekaert, Hodrick, and Marshall (1997) explore this effect.

These results are consistent with the view that there is some procyclical variation in the short-term real interest rate which is not matched by the long-term real interest rate. Thus yield spreads tend to rise at business cycle troughs when real interest rates are predictably low and future output and consumption growth are predictably high.

This interpretation is complicated by the fact that yields are measured on nominal bonds rather than real bonds. Inflationary expectations and monetary policy therefore have a large impact on yield spreads. The particular characteristics of US monetary policy may help to explain why previously reported US results do not carry over to other countries in Table 13. US monetary policy has tended to smooth real and nominal interest rates, which reduces the forecastability of real interest rates and increases the sensitivity of the yield spread to changes in bond-market risk premia. Mankiw and Miron (1986) have found that the yield spread was a better forecaster of US interest rates in the period before the founding of the Federal Reserve, while Kugler (1988) has found that the yield spread is a better forecaster of interest rates in Germany and Switzerland and has related this to the characteristics of German and Swiss monetary policy. The findings in Table 12 are consistent with this literature.

5 Cyclical Variation in the Price of Risk

In previous sections I have documented a challenging array of stylized facts and have discussed the problems they pose for standard asset pricing theory. Briefly, the equity premium puzzle suggests that risk aversion must be high on average to explain high average excess stock returns, while the equity volatility puzzle suggests that risk aversion must vary over time to explain predictable variation in excess returns and the associated volatility of stock prices. This section describes some models that display these features.

5.1 Habit Formation

Constantinides (1990) and Sundaresan (1989) have argued for the importance of habit formation, a positive effect of today's consumption on tomorrow's marginal utility of consumption.

Several modeling issues arise at the outset. Writing the period utility function as $U(C_t, X_t)$, where X_t is the time-varying habit or subsistence level, the first issue is the functional form for $U(\cdot)$. Abel (1990, 1999) has proposed that $U(\cdot)$ should be a power function of the ratio C_t/X_t, while Boldrin, Christiano, and Fisher (2001), Campbell and Cochrane (1999), Constantinides (1990), and Sundaresan (1989) have used a power function of the difference $C_t - X_t$. The second issue is the effect of an agent's own decisions on future levels of habit. In standard "internal habit" models such as those in Constantinides (1990) and Sundaresan (1989), habit depends on an agent's own consumption and the agent takes account of this when choosing how much to consume. In "external habit" models such as those in Abel (1990, 1999) and Campbell and Cochrane (1999), habit depends on aggregate consumption which is unaffected by any one agent's decisions. Abel calls this "catching up with the Joneses". The third issue is the speed with which habit reacts to individual or aggregate consumption. Abel (1990, 1999), Dunn and Singleton (1986), and Ferson and Constantinides (1991) make habit depend on one lag of consumption, whereas Boldrin, Christiano, and Fisher (2001), Constantinides (1990), Sundaresan (1989), Campbell and Cochrane (1999), and Heaton (1995) assume that habit reacts only gradually to changes in consumption.

The choice between ratio models and difference models of habit is important because

ratio models have constant risk aversion whereas difference models have time-varying risk aversion. To see this, consider Abel's (1990, 1999) specification in which an agent's utility can be written as a power function of the ratio C_t/X_t,

$$U_t = \sum_{j=0}^{\infty} \delta^j \frac{(C_{t+j}/X_{t+j})^{1-\gamma} - 1}{1-\gamma}, \tag{57}$$

where X_t summarizes the influence of past consumption levels on today's utility. For simplicity, specify X_t as an external habit depending on only one lag of aggregate consumption:

$$X_t = \overline{C}_{t-1}^{\kappa}, \tag{58}$$

where $\overline{C}_{t-1}$ is aggregate past consumption and the parameter κ governs the degree of time-nonseparability. Since there is a representative agent, in equilibrium aggregate consumption equals the agent's own consumption, so in equilibrium

$$X_t = C_{t-1}^{\kappa}. \tag{59}$$

With this specification of utility, in equilibrium the first-order condition is

$$1 = \delta \mathrm{E}_t \left[(1 + R_{i,t+1})(C_t/C_{t-1})^{\kappa(\gamma-1)} (C_{t+1}/C_t)^{-\gamma} \right]. \tag{60}$$

Assuming homoskedasticity and joint lognormality of asset returns and consumption growth, this implies the following restrictions on risk premia and the riskless real interest rate:

$$r_{f,t+1} = -\log \delta - \gamma^2 \sigma_c^2/2 + \gamma \mathrm{E}_t \Delta c_{t+1} - \kappa(\gamma - 1)\Delta c_t, \tag{61}$$

$$\mathrm{E}_t[r_{i,t+1} - r_{f,t+1}] + \sigma_i^2/2 = \gamma \sigma_{ic}. \tag{62}$$

Equation (61) says that the riskless real interest rate equals its value under power utility, less $\kappa(\gamma-1)\Delta c_t$. Holding consumption today and expected consumption tomorrow constant, an increase in consumption yesterday increases the marginal utility of consumption today. This makes the representative agent want to borrow from the future, driving up the real interest rate. Equation (62) describing the risk premium is exactly the same as (16), the risk premium formula for the power utility model. The external habit simply adds a term to the Euler equation (60) which is known at time t, and this does not affect the risk premium.

Abel (1990, 1999) nevertheless argues that catching up with the Joneses can help to explain the equity premium puzzle. This argument is based on two considerations. First, the average level of the riskless rate in (61) is $-\log\delta-\gamma^2\sigma_c^2/2+(\gamma-\kappa(\gamma-1))g$, where g is the average consumption growth rate. When risk aversion γ is very large, a positive κ reduces the average riskless rate. Thus catching up with the Joneses enables one to increase risk aversion to solve the equity premium puzzle without encountering the riskless rate puzzle. Second, a positive κ is likely to make the riskless real interest rate more variable because of the term $-\kappa(\gamma-1)\Delta c_t$ in (61). If one solves for the stock returns implied by the assumption that stock dividends equal consumption, a more variable real interest rate increases the covariance of stock returns and consumption σ_{ic} and drives up the equity premium.

The second of these points can be regarded as a weakness rather than a strength of the model. The puzzle illustrated in Table 4 is that the ratio of the measured equity premium to the measured covariance σ_{ic} is large; increasing the consumption covariance σ_{ic} does not by itself help to explain the size of this ratio. Also, Table 1 shows that the real interest rate is fairly stable ex post, while Table 6 shows that at most half of its variance is forecastable. Thus the standard deviation of the expected real interest rate is quite small, and this is not consistent with large values of κ and γ in (61).

This difficulty with the riskless real interest rate is a fundamental problem for habit formation models. Time-nonseparable preferences make marginal utility volatile even when consumption is smooth, because consumers derive utility from consumption relative to its recent history rather than from the absolute level of consumption. But unless the consumption and habit processes take particular forms, time-nonseparability also creates large swings in expected marginal utility at successive dates, and this implies large movements in the real interest rate. I now present an alternative specification in which it is possible to solve this problem, and in which risk aversion varies over time.

Campbell and Cochrane (1999) build a model with external habit formation in which a representative agent derives utility from the difference between consumption and a time-varying subsistence or habit level. They assume that log consumption follows a random walk.

This fits the observation that most countries do not have highly predictable consumption or dividend growth rates (Tables 6 and 8). The consumption growth process is

$$\Delta c_{t+1} = g + \epsilon_{c,t+1} \ , \tag{63}$$

where $\epsilon_{c,t+1}$ is a normal homoskedastic innovation with variance σ_c^2. This is just the ARMA(1,1) model (36) of the previous section, with constant expected consumption growth.

The utility function of the representative agent takes the form

$$\mathrm{E}_t \sum_{j=0}^{\infty} \delta^j \frac{(C_{t+j} - X_{t+j})^{1-\gamma} - 1}{1-\gamma}. \tag{64}$$

Here X_t is the level of habit, δ is the subjective discount factor, and γ is the utility curvature parameter. Utility depends on a power function of the difference between consumption and habit; it is only defined when consumption exceeds habit.

It is convenient to capture the relation between consumption and habit by the surplus consumption ratio S_t, defined by

$$S_t \equiv \frac{C_t - X_t}{C_t}. \tag{65}$$

The surplus consumption ratio is the fraction of consumption that exceeds habit and is therefore available to generate utility in (64). If habit X_t is held fixed as consumption C_t varies, the local coefficient of relative risk aversion is

$$\frac{-Cu_{CC}}{u_C} = \frac{\gamma}{S_t} \ , \tag{66}$$

where u_C and u_{CC} are the first and second derivatives of utility with respect to consumption. Risk aversion rises as the the surplus consumption ratio S_t declines, that is, as consumption approaches the habit level. Note that γ, the curvature parameter in utility, is no longer the coefficient of relative risk aversion in this model.

To complete the description of preferences, one must specify how the habit X_t evolves over time in response to aggregate consumption. Campbell and Cochrane suggest an AR(1) model for the log surplus consumption ratio, $s_t \equiv \log(S_t)$:

$$s_{t+1} = (1-\varphi)\bar{s} + \varphi s_t + \lambda\left(s_t\right)\epsilon_{c,t+1} \ . \tag{67}$$

The parameter φ governs the persistence of the log surplus consumption ratio, while the "sensitivity function" $\lambda(s_t)$ controls the sensitivity of s_{t+1} and thus of log habit x_{t+1} to innovations in consumption growth $\epsilon_{c,t+1}$.

Equation (67) specifies that today's habit is a complex nonlinear function of current and past consumption. A linear approximation may help to understand it. If I substitute the definition $s_t \equiv \log(1 - \exp(x_t - c_t))$ into (67) and linearize around the steady state, I find that (67) is approximately a traditional habit-formation model in which log habit responds slowly and linearly to log consumption,

$$x_{t+1} \approx (1-\varphi)\alpha + \varphi x_t + (1-\varphi)c_t = \alpha + (1-\varphi)\sum_{j=0}^{\infty} \varphi^j c_{t-j} \ . \tag{68}$$

The linear model (68) has two serious problems. First, when consumption follows an exogenous process such as (63) there is nothing to stop consumption falling below habit, in which case utility is undefined. This problem does not arise when one specifies a process for s_t, since any real value for s_t corresponds to positive S_t and hence $C_t > X_t$. Second, the linear model typically implies a highly volatile riskless real interest rate. The process (67) with a non-constant sensitivity function $\lambda(s_t)$ allows one to control or even eliminate variation in the riskless interest rate.

To derive the real interest rate implied by this model, one first calculates the marginal utility of consumption as

$$u'(C_t) = (C_t - X_t)^{-\gamma} = S_t^{-\gamma} C_t^{-\gamma}. \tag{69}$$

The gross simple riskless rate is then

$$(1 + R_{t+1}^f) = \left(\delta \mathrm{E}_t \frac{U'(C_{t+1})}{U'(C_t)}\right)^{-1} = \left(\delta \mathrm{E}_t \left(\frac{S_{t+1}}{S_t}\right)^{-\gamma} \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\right)^{-1} \ . \tag{70}$$

Taking logs, and using equations (63) and (67), the log riskless real interest rate is

$$r_{t+1}^f = -\log(\delta) + \gamma g - \gamma(1-\varphi)(s_t - \bar{s}) - \frac{\gamma^2 \sigma_c^2}{2}\left[\lambda(s_t) + 1\right]^2 \ . \tag{71}$$

The first two terms on the right hand side of (71) are familiar from the power utility model (17), while the last two terms are new. The third term (linear in $(s_t - \bar{s})$) reflects

intertemporal substitution. If the surplus consumption ratio is low, the marginal utility of consumption is high. However, the surplus consumption ratio is expected to revert to its mean, so marginal utility is expected to fall in the future. Therefore, the consumer would like to borrow and this drives up the equilibrium risk free interest rate. Note that what determines intertemporal substitution is mean-reversion in marginal utility, not mean-reversion in consumption itself. In this model consumption follows a random walk so there is no mean-reversion in consumption; but habit formation causes the consumer to adjust gradually to a new level of consumption, creating mean-reversion in marginal utility.

The fourth term (linear in $[\lambda(s_t) + 1]^2$) reflects precautionary savings. As uncertainty increases, consumers become more willing to save and this drives down the equilibrium riskless interest rate. Note that what determines precautionary savings is uncertainty about marginal utility, not uncertainty about consumption itself. In this model the consumption process is homoskedastic so there is no time-variation in uncertainty about consumption; but habit formation makes a given level of consumption uncertainty more serious for marginal utility when consumption is low relative to habit.

Equation (71) can be made to match the observed stability of real interest rates in two ways. First, it is helpful if the habit persistence parameter φ is close to one, since this limits the strength of the intertemporal substitution effect. Second, the precautionary savings effect offsets the intertemporal substitution effect if $\lambda(s_t)$ declines with s_t. In fact, Campbell and Cochrane parameterize the $\lambda(s_t)$ function so that these two effects exactly offset each other everywhere, implying a constant riskless interest rate. With a constant riskless rate, real bonds of all maturities are also riskless and there are no real term premia. Thus in the Campbell-Cochrane model the equity premium is also an equity-bond premium.

The sensitivity function $\lambda(s_t)$ is not fully determined by the requirement of a constant riskless interest rate. Campbell and Cochrane choose the function to satisfy three conditions: 1) The riskless real interest rate is constant.[26] 2) Habit is predetermined at the steady state $s_t = \bar{s}$. 3) Habit is predetermined near the steady state, or, equivalently, positive shocks

[26] Wachter (2001) relaxes this condition and explores implications of the model for bond prices as well as stock prices.

to consumption may increase habit but never reduce it. To understand conditions 2) and 3), recall that the traditional notion of habit makes it a predetermined variable. On the other hand habit cannot be predetermined everywhere, or a sufficiently low realization of consumption growth would leave consumption below habit. To make habit "as predetermined as possible", Campbell and Cochrane assume that habit is predetermined at and near the steady state. This also eliminates the counterintuitive possibility that positive shocks to consumption cause declines in habit.

Using these three conditions, Campbell and Cochrane show that the steady-state surplus consumption ratio must be a function of the other parameters of the model, and that the sensitivity function $\lambda(s_t)$ must take a particular form. Campbell and Cochrane pick parameters for the model by calibrating it to fit postwar quarterly US data. They choose the mean consumption growth rate $g = 1.89\%$ per year and the standard deviation of consumption growth $\sigma_c = 1.50\%$ per year to match the moments of the US consumption data.

Campbell and Cochrane follow Mehra and Prescott (1985) by assuming that the stock market pays a dividend equal to consumption. They also consider a more realistic model in which the dividend is a random walk whose innovations are correlated with consumption growth. They show that results in this model are very similar because the implied regression coefficient of dividend growth on consumption growth is close to one, which produces similar asset price behavior. They use numerical methods to find the price-dividend ratio for the stock market as a function of the state variable s_t. They set the persistence of the state variable, φ, equal to 0.87 per year to match the persistence of the log price-dividend ratio. They choose $\gamma = 2.00$ to match the ratio of unconditional mean to unconditional standard deviation of return in US stock returns. These parameter values imply that at the steady state, the surplus consumption ratio $\bar{S} = 0.057$ so habit is about 94% of consumption. Finally, Campbell and Cochrane choose the discount factor $\delta = 0.89$ to give a riskless real interest rate of just under 1% per year.

It is important to understand that with these parameter values the model uses high average risk aversion to fit the high unconditional equity premium. Steady-state risk aversion

is $\gamma/\bar{S} = 2.00/0.057 = 35$. In this respect the model resembles a power utility model with a very high risk aversion coefficient.

There are however two important differences between the Campbell-Cochrane habit formation model and the power utility model with high risk aversion. First, the model with habit formation avoids the riskfree rate puzzle. Evaluating equation (71) at the steady state surplus consumption ratio and using the restrictions on the sensitivity function $\lambda(s_t)$, the constant riskless interest rate in the Campbell-Cochrane model is

$$r_{t+1}^f = -\log(\delta) + \gamma g - \left(\frac{\gamma}{\bar{S}}\right)^2 \frac{\sigma_c^2}{2}. \tag{72}$$

In the power utility model the same large coefficient γ would appear in the consumption growth term and the consumption volatility term (equation (17)); in the Campbell-Cochrane model the curvature parameter γ appears in the consumption growth term, and this is much lower than the steady-state risk aversion coefficient $\gamma/\bar{S}$ which appears in the consumption volatility term. Thus a much lower value of the discount factor δ is consistent with the average level of the risk free interest rate, and the model implies a less sensitive relationship between mean consumption growth and interest rates. This property of the model is similar to that of an Epstein-Zin-Weil model with an elasticity of intertemporal substitution ψ that exceeds the reciprocal of risk aversion.

Second, the Campbell-Cochrane model has risk aversion that varies with the level of consumption, whereas a power utility model has constant risk aversion. The time-variation in risk aversion generates predictable movements in excess stock returns like those documented in Table 11, enabling the model to match the volatility of stock prices even with a smooth consumption series and a constant riskless interest rate.

It is instructive to compare the Campbell-Cochrane (1999) and Constantinides (1990) models of habit formation. The Campbell-Cochrane model assumes random walk consumption and implies negative autocorrelation of stock returns. The Constantinides model, by contrast, assumes unforecastable asset returns and implies positive autocorrelation of consumption growth. Thus these two models take different stands on the question of whether wealth or consumption accurately represents long-run risk. The Constantinides model fits

the equity premium with low risk-aversion, but it achieves this success at the cost of a positively serially correlated consumption process that contradicts the empirical findings of Cochrane (1994) and Lettau and Ludvigson (2001).

Recent work in behavioral finance has explored similar themes. Barberis, Huang, and Santos (2000) combine a standard power utility function in consumption with the prospect theory of Kahneman and Tversky (1979). Appealing to experimental evidence of Thaler and Johnson (1990), they argue that aversion to losses varies with past outcomes; past success reduces effective risk aversion as investors feel they are "gambling with house money". This creates a time-varying price of risk which explains aggregate stock market volatility in a similar manner to Campbell and Cochrane (1999). The Barberis-Huang-Santos model has a lower aversion to consumption risk than the Campbell-Cochrane model, because it generates risk-averse behavior from direct aversion to wealth fluctuations as well as from standard aversion to consumption fluctuations.

5.2 Models with Heterogeneous Agents

All the models considered so far assume that assets can be priced as if there is a representative agent who consumes aggregate consumption. An alternative view is that aggregate consumption is not an adequate proxy for the consumption of stock market investors.

One simple explanation for a discrepancy between these two measures of consumption is that there are two types of agents in the economy: constrained agents who are prevented from trading in asset markets and simply consume their labor income each period, and unconstrained agents. The consumption of the constrained agents is irrelevant to the determination of equilibrium asset prices, but it may be a large fraction of aggregate consumption. Campbell and Mankiw (1990) argue that predictable variation in consumption growth, correlated with predictable variation in income growth, suggests an important role for constrained agents, while Mankiw and Zeldes (1991) use US panel data to show that the consumption of stockholders is more volatile and more highly correlated with the stock market than the consumption of nonstockholders. Such effects are likely to be even more important in countries

with low stock market capitalization and concentrated equity ownership.

The constrained agents in the above model do not directly influence asset prices, because they are assumed not to hold or trade financial assets. Another strand of the literature argues that there may be some investors who buy and sell stocks for exogenous, perhaps psychological reasons. These "noise traders" can influence stock prices because other investors, who are rational utility-maximizers, must be induced to accommodate their shifts in demand. If utility-maximizing investors are risk-averse, then they will only buy stocks from noise traders who wish to sell if stock prices fall and expected stock returns rise; conversely they will only sell stocks to noise traders who wish to buy if stock prices rise and expected stock returns fall. Campbell and Kyle (1993), Cutler, Poterba, and Summers (1991), De Long, Shleifer, Summers, and Waldmann (1990), and Shiller (1984) develop this model in some detail. The model implies that rational investors do not hold the market portfolio—instead they shift in and out of the stock market in response to changing demand from noise traders—and do not consume aggregate consumption since some consumption is accounted for by noise traders. This makes the model hard to test without having detailed information on the investment strategies of different market participants.

It is also possible that utility-maximizing stock market investors are heterogeneous in important ways. If investors are subject to large idiosyncratic risks in their labor income and can share these risks only indirectly by trading a few assets such as stocks and Treasury bills, their individual consumption paths may be much more volatile than aggregate consumption. Even if individual investors have the same power utility function, so that any individual's consumption growth rate raised to the power $-\gamma$ would be a valid stochastic discount factor, the aggregate consumption growth rate raised to the power $-\gamma$ may not be a valid stochastic discount factor.

This problem is an example of Jensen's Inequality. Since marginal utility is nonlinear, the average of investors' marginal utilities of consumption is not generally the same as the marginal utility of average consumption. The problem disappears when investors' individual consumption streams are perfectly correlated with one another as they will be in a com-

plete markets setting. Grossman and Shiller (1982) point out that it also disappears in a continuous-time model when the processes for individual consumption streams and asset prices are diffusions.

Constantinides and Duffie (1996) have provided a simple framework within which the effects of heterogeneity can be understood. Constantinides and Duffie postulate an economy in which individual investors k have different consumption levels C_{kt}. The cross-sectional distribution of individual consumption is lognormal, and the change from time t to time $t+1$ in individual log consumption is cross-sectionally uncorrelated with the level of individual log consumption at time t. All investors have the same power utility function with time discount factor δ and coefficient of relative risk aversion γ.

In this economy each investor's own intertemporal marginal rate of substitution is a valid stochastic discount factor. Hence the cross-sectional average of investors' intertemporal marginal rates of substitution is a valid stochastic discount factor. I write this as

$$M_{t+1}^{*} \equiv \delta \mathrm{E}_{t+1}^{*}\left[\left(\frac{C_{k,t+1}}{C_{kt}}\right)^{-\gamma}\right], \tag{73}$$

where E_t^* denotes an expectation taken over the cross-sectional distribution at time t. That is, for any cross-sectionally random variable X_{kt}, $\mathrm{E}_t^* X_{kt} = \lim_{K\to\infty}(1/K)\sum_{k=1}^{K} X_{kt}$, the limit as the number of cross-sectional units increases of the cross-sectional sample average of X_{kt}.[23] Note that $\mathrm{E}_t^* X_{kt}$ will in general vary over time and need not be lognormally distributed conditional on past information.

The assumption of cross-sectional lognormality means that the log stochastic discount factor, $m_{t+1}^{*} \equiv \log(M_{t+1}^{*})$, can be written as a function of the cross-sectional mean and variance of the change in log consumption:

$$m_{t+1}^{*} = -\log(\delta) - \gamma \mathrm{E}_{t+1}^{*}\Delta c_{k,t+1} + \left(\frac{\gamma^2}{2}\right)\mathrm{Var}_{t+1}^{*}\Delta c_{k,t+1}, \tag{74}$$

where Var_t^* is defined analogously to E_t^* as $\mathrm{Var}_t^* X_{kt} = \lim_{K\to\infty}(1/K)\sum_{k=1}^{K}(X_{kt} - \mathrm{E}_t^* X_{kt})^2$, and like E_t^* will in general vary over time.

An economist who knows the underlying preference parameters of investors but does not understand the heterogeneity in this economy might attempt to construct a representative-

agent stochastic discount factor, M_{t+1}^{RA}, using aggregate consumption:

$$M_{t+1}^{RA} \equiv \delta \left(\frac{\mathrm{E}_{t+1}^{*}[C_{k,t+1}]}{\mathrm{E}_{t}^{*}[C_{kt}]} \right)^{-\gamma}. \tag{75}$$

The log of this stochastic discount factor can also be related to the cross-sectional mean and variance of the change in log consumption:

$$\begin{aligned} m_{t+1}^{RA} &= -\log(\delta) - \gamma \mathrm{E}_{t+1}^{*} \Delta c_{k,t+1} - \left(\frac{\gamma}{2} \right) [\mathrm{Var}_{t+1}^{*} c_{k,t+1} - \mathrm{Var}_{t}^{*} c_{kt}] \\ &= -\log(\delta) - \gamma \mathrm{E}_{t+1}^{*} \Delta c_{k,t+1} - \left(\frac{\gamma}{2} \right) [\mathrm{Var}_{t+1}^{*} \Delta c_{k,t+1}], \end{aligned} \tag{76}$$

where the second equality follows from the relation $c_{k,t+1} = c_{kt} + \Delta c_{k,t+1}$ and the fact that $\Delta c_{k,t+1}$ is cross-sectionally uncorrelated with c_{kt}.

The difference between these two variables can now be written as

$$m_{t+1}^{*} - m_{t+1}^{RA} = \frac{\gamma(\gamma+1)}{2} \mathrm{Var}_{t+1}^{*} \Delta c_{k,t+1}. \tag{77}$$

The time series of this difference can have a nonzero mean, helping to explain the risk-free rate puzzle, and a nonzero variance, helping to explain the equity premium puzzle. If the cross-sectional variance of log consumption growth is negatively correlated with the level of aggregate consumption, so that idiosyncratic risk increases in economic downturns, then the true stochastic discount factor m_{t+1}^{*} will be more strongly countercyclical than the representative-agent stochastic discount factor constructed using the same preference parameters; this has the potential to explain the high price of risk without assuming that individual investors have high risk aversion. Mankiw (1986) makes a similar point in a two-period model.

An important unresolved question is whether the heterogeneity we can measure has the characteristics that are needed to help resolve the asset pricing puzzles. In the Constantinides-Duffie model the heterogeneity must be large to have important effects on the stochastic discount factor; a cross-sectional standard deviation of log consumption growth of 20%, for example, is a cross-sectional variance of only 0.04, and it is variation in this number over

time that is needed to explain the equity premium puzzle. Interestingly, the effect of heterogeneity is strongly increasing in risk aversion since $\text{Var}^*_{t+1}\Delta c_{k,t+1}$ is multiplied by $\gamma(\gamma+1)/2$ in (77). This suggests that heterogeneity may supplement high risk aversion but cannot altogether replace it as an explanation for the equity premium puzzle.

Cogley (1998) looks at US panel data on consumption and finds that measured heterogeneity has only small effects on the SDF. Lettau (1997) reaches a similar conclusion by assuming that individuals consume their income, and calculating the risk-aversion coefficients needed to put model-based stochastic discount factors inside the Hansen-Jagannathan volatility bounds. This procedure is conservative in that individuals trading in financial markets are normally able to achieve some smoothing of consumption relative to income. Nevertheless Lettau finds that high individual risk aversion is still needed to satisfy the Hansen-Jagannathan bounds.

These conclusions may not be surprising given the Grossman-Shiller (1982) result that the aggregation problem disappears in a continuous-time diffusion model. In such a model, the cross-sectional variance of consumption is locally deterministic and hence the false SDF M^{RA}_{t+1} correctly prices risky assets. In a discrete-time model the cross-sectional variance of consumption can change randomly from one period to the next, but in practice these changes are likely to be small. This limits the effects of consumption heterogeneity on asset pricing.

It is also important to note that idiosyncratic shocks are assumed to be permanent in the Constantinides-Duffie model. Heaton and Lucas (1996) calibrate individual income processes to micro data from the Panel Study of Income Dynamics (PSID). Because the PSID data show that idiosyncratic income variation is largely transitory, Heaton and Lucas find that investors can minimize its effects on their consumption by borrowing and lending. This prevents heterogeneity from having any large effects on aggregate asset prices.

To get around this problem, several recent papers have combined heterogeneity with constraints on borrowing. Heaton and Lucas (1996) and Krusell and Smith (1997) find that borrowing constraints or large costs of trading equities are needed to explain the equity premium. Constantinides, Donaldson, and Mehra (2001) focus on heterogeneity across gen-

erations. In a stylized three-period overlapping generations model young agents have the strongest desire to hold equities because they have the largest ratio of labor income to financial wealth. If these agents are prevented from borrowing to buy equities, the equilibrium equity premium is large.[27]

Heterogeneity in preferences may also be important. Several authors have recently argued that trading between investors with different degrees of risk aversion or time preference, possibly in the presence of market frictions or portfolio insurance constraints, can lead to time-variation in the market price of risk (Dumas (1989), Grossman and Zhou (1996), Wang (1996), Sandroni (1999), Chan and Kogan (2000)). Intuitively, risk-tolerant agents hold more risky assets so they control a greater share of wealth in good states than in bad states; aggregate risk aversion therefore falls in good states, producing effects similar to those of habit formation.

5.3 Irrational Expectations

So far I have maintained the assumption that investors have rational expectations and understand the time-series behavior of dividend and consumption growth. A number of papers have explored the consequences of relaxing this assumption. (See for example Barberis, Shleifer, and Vishny 1998, Barsky and De Long 1993, Cecchetti, Lam, and Mark 2000, Chow 1989, or Hansen, Sargent, and Tallarini 1997).

In the absence of arbitrage, there exist positive state prices that can rationalize the prices of traded financial assets. These state prices equal subjective state probabilities multiplied by ratios of marginal utilities in different states. Thus given any model of utility, there exist subjective probabilities that produce the necessary state prices and in this sense explain the observed prices of traded financial assets. The interesting question is whether these subjective probabilities are sufficiently close to objective probabilities, and sufficiently related to known psychological biases in behavior, to be plausible.

Many of the papers in this area work in partial equilibrium and assume that stocks

[27]Konstantinov (2000), however, presents an alternative calibration with a much lower implied equity premium.

are priced by discounting expected future dividends at a constant rate. This assumption makes it easy to derive any desired behavior of stock prices directly from assumptions on dividend expectations. Barsky and De Long (1993), for example, assume that investors believe dividends to be generated by a doubly integrated process, so that the dividend growth rate has a unit root. These expectations imply that rapid dividend growth increases stock prices more than proportionally, so that the price-dividend ratio rises when dividends are growing strongly. If dividend growth is in fact stationary, then the high price-dividend ratio is typically followed by dividend disappointments, low stock returns, and reversion to the long-run mean price-dividend ratio. Thus Barsky and De Long's model can account for the volatility puzzle and the predictability of stock returns.[28]

Another potentially important form of irrationality is a failure to understand the difference between real and nominal magnitudes. Modigliani and Cohn (1979) argued that investors suffer from inflation illusion, in effect discounting real cash flows at nominal interest rates. Ritter and Warr (1999) and Sharpe (1999) argue that inflation illusion may have led investors to bid up stock prices as inflation has declined since the early 1980s.

A limitation of these models is that they do not consider general equilibrium issues, in particular the implications of irrational beliefs for aggregate consumption. Using for simplicity the fiction that dividends equal consumption, investors' irrational expectations about dividend growth should be linked to their irrational expectations about consumption growth. Interest rates are not exogenous, but like stock prices, are determined by investors' expectations. Thus it is significantly harder to build a general equilibrium model with irrational expectations.

To see how irrationality can affect asset prices, consider first a static model in which log consumption follows a random walk ($\phi = 0$) with drift g. Investors understand that consumption is a random walk, but they expect it to grow at rate $\hat{g}$ instead of g. Equation

[28] Shiller (2000) discusses psychological factors that contribute to the formation of extrapolative expectations, with special reference to the runup in stock prices during the 1990's. Barberis, Shleifer, and Vishny (1998) present a related model.

(38) implies that the log price-dividend ratio is

$$p_{et} - d_{et} = \frac{k}{1-\rho} + \left(\lambda - \frac{1}{\psi}\right)\left(\frac{\hat{g}}{1-\rho}\right), \tag{78}$$

equation (21) implies that the riskless interest rate is

$$r_{f,t+1} = -\log\delta + \frac{\hat{g}}{\psi} + \frac{\theta-1}{2}\sigma_w^2 - \frac{\theta}{2\psi^2}\sigma_c^2, \tag{79}$$

and the rationally expected equity premium is

$$\mathrm{E}_t[r_{e,t+1}] - r_{f,t+1} + \frac{\sigma_e^2}{2} = \gamma\lambda\sigma_c^2 + \lambda(g - \hat{g}). \tag{80}$$

The first term on the right hand side of (80) is the standard formula for the equity premium in a model with serially uncorrelated consumption growth. This is investors' irrational expectation of the equity premium. The second term arises because dividend growth is systematically different from what investors expect.

This model illustrates that irrational pessimism among investors ($\hat{g} < g$) can lower the average riskfree rate and increase the equity premium. Thus pessimism has the same effects on asset prices as a low rate of time preference and a high coefficient of risk aversion, and it can help to explain both the riskfree rate puzzle and the equity premium puzzle.[29]

To explain the volatility puzzle, a more complicated model of irrationality is needed. Suppose now that log consumption growth follows an AR(1) process, a special case of (36), but that investors believe the persistence coefficient to be $\hat{\phi}$ when in fact it is ϕ.[30] In this case the riskfree interest rate is given by

$$r_{f,t+1} = \mu_f + \frac{\hat{\phi}}{\psi}(\Delta c_t - g), \tag{81}$$

[29]The effect of pessimism on the average price-dividend ratio is ambiguous, for the usual reason that lower riskfree rates and lower expected dividend growth have offsetting effects. Hansen, Sargent, and Tallarini (1997) also emphasize that irrational pessimism can be observationally equivalent to lower time preference and higher risk aversion.

[30]An alternative formulation would be to assume, following (36), that log consumption growth is predicted by a state variable x_t that investors observe, but that investors misperceive the persistence of this process to be $\hat{\phi}$ rather than ϕ. In this case investors correctly forecast consumption growth over the next period, but incorrectly forecast subsequent consumption growth. Investors' irrationality has no effect on the riskfree interest rate but causes time-variation in equity and bond premia.

while the rationally expected equity premium is

$$\mathrm{E}_t[r_{e,t+1}] - r_{f,t+1} + \frac{\sigma_e^2}{2} = \mu_e - (\hat{\phi} - \phi)\left[\left(\frac{\rho\hat{\phi}}{1-\rho\hat{\phi}}\right)\left(\lambda - \frac{1}{\psi}\right) + \lambda\right](\Delta c_t - g), \qquad (82)$$

where μ_f and μ_e are constants. If $\hat{\phi}$ is larger than ϕ, and if the term in square brackets in (82) is positive, then the equity premium falls when consumption growth has been rapid, and rises when consumption growth has been weak. This model, which can be seen as a general equilibrium version of Barsky and De Long (1993), fits the apparent cyclical variation in the market price of risk.

One difficulty with this explanation for stock market behavior is that it has strong implications for bond market behavior. When investors become "irrationally exuberant", their optimism should lead to a strong desire to borrow from the future, which should drive up the riskless interest rate and the real bond premium even while it drives down the equity premium. Barsky and De Long (1993) work in partial equilibrium so they do not confront this problem. Cecchetti, Lam, and Mark (2000) handle it by allowing the degree of investors' irrationality itself to be stochastic and time-varying.[31]

[31]The work of Rietz (1988) can be understood in a similar way. Rietz argues that investors are concerned about an unlikely but serious event that has not actually occurred. Given the data we have, investors appear to be irrational but in fact, with a long enough data sample, they will prove to be rational.

6 Some Implications for Macroeconomics

The research summarized in this chapter has important implications for various aspects of macroeconomics. I conclude by briefly discussing some of these.

A first set of issues concerns the modelling of production, and hence of investment. This chapter has followed the bulk of the asset pricing literature by concentrating on the relation between asset prices and consumption, without asking how consumption is determined in relation to investment and production. Ultimately this is unsatisfactory, and authors such as Cochrane (1991, 1996) and Rouwenhorst (1995) have argued that asset pricing should place a renewed emphasis on the investment decisions of firms.

Standard macroeconomic models with production, such as the canonical real business cycle model of Prescott (1986), imply that asset prices are extremely stable. The real interest rate equals the marginal product of capital, which is perturbed only by technology shocks and changes in the quantity of capital; when the model is calibrated to US data the standard deviation of the real interest rate is only a few basis points. The return on capital is equally stable because capital can costlessly be transformed into consumption goods, so its price is always fixed at one and uncertainty in the return comes only from uncertainty about dividends.

If real business cycle models are to generate volatile asset returns, they must be modified to include adjustment costs in investment so that changes in the demand for capital cause changes in the value of installed capital, or Tobin's q, rather than changes in the quantity of capital. Baxter and Crucini (1993) and Jermann (1998), among others, show how this can be done. The adjustment costs affect not only asset prices, but other aspects of the model; the response of investment to shocks falls, for example, so larger shocks are needed to explain the cyclical behavior of investment.

The modelling of labor supply is an equally difficult problem. Any model in which workers choose their labor supply implies a first-order condition of the form

$$\frac{\partial U}{\partial C_t} G_t = -\frac{\partial U}{\partial N_t}, \tag{83}$$

where G_t is the real wage and N_t is labor supply. A well-known difficulty in business cycle theory is that with a constant real wage, the marginal utility of consumption $\partial U/\partial C_t$ will be perfectly correlated with the marginal disutility of work $-\partial U/\partial N_t$. Since the marginal utility of consumption is declining in consumption while the marginal disutility of work is increasing in hours, this implies that consumption and hours worked will be negatively correlated. In the data, of course, consumption and hours worked are positively correlated since they are both procyclical.

This problem can be resolved if the real wage is procyclical; then when consumption and hours increase in an expansion the decline in marginal utility of consumption is more than offset by an increase in the real wage. In a standard model with log utility of consumption only a 1% increase in the real wage is needed to offset the decline in marginal utility caused by a 1% increase in consumption. But preferences of the sort suggested by the asset pricing literature, with high risk aversion and low intertemporal elasticity of substitution, have rapidly declining marginal utility of consumption. These preferences imply that a much larger increase in the real wage will be needed to offset the effect on labor supply of a given increase in consumption. Boldrin, Christiano, and Fisher (2001) try to resolve this problem by using a two-sector framework with limited mobility of labor between sectors. In this framework the first-order condition (83) does not hold contemporaneously, but only in expectation.

Models with production also help one to move away from the common assumption that stock market dividends equal consumption or equivalently, that the aggregate stock market equals total national wealth. This assumption is clearly untrue even for the United States, and is even less appropriate for countries with smaller stock markets. While one can relax the assumption by writing down exogenous correlated time-series processes for dividends and consumption in the manner of section 4.3, it will ultimately be more satisfactory to derive both dividends and consumption within a general equilibrium model.

Another important set of issues concerns the links between different national economies and their financial markets. In this chapter I have treated each national stock market as a

separate entity with its own pricing model. That is, I have assumed that national economies are entirely closed so that there is no integrated world capital market. This assumption may be appropriate for examining long-term historical data, but it seems questionable under modern conditions. There is much work to be done on the pricing of national stock markets in a model with a perfectly or partially integrated world capital market.

Finally, the asset pricing literature is important in understanding the welfare costs of macroeconomic fluctuations. As Atkeson and Phelan (1994) and Alvarez and Jermann (2000) emphasize, asset market data reveal the tradeoff between average growth and volatility of wealth that is offered by asset markets, and this tradeoff must reflect investors' preferences. Economic policymakers should take this into account when they face policy tradeoffs between economic growth and macroeconomic stability.

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TABLE 1

INTERNATIONAL STOCK AND BILL RETURNS

Country	Sample Period	$\overline{r_e}$	$\sigma(r_e)$	$\rho(r_e)$	$\overline{r_f}$	$\sigma(r_f)$	$\rho(r_f)$
USA	1947.2 - 1998.4	8.085	15.645	0.083	0.896	1.748	0.508
AUL	1970.1 - 1999.1	3.540	22.699	0.005	2.054	2.528	0.645
CAN	1970.1 - 1999.2	5.431	17.279	0.072	2.713	1.855	0.667
FR	1973.2 - 1998.4	9.023	23.425	0.048	2.715	1.837	0.710
GER	1978.4 - 1997.4	9.838	20.097	0.090	3.219	1.152	0.348
ITA	1971.2 - 1998.2	3.168	27.039	0.079	2.371	2.847	0.691
JAP	1970.2 - 1999.1	4.715	21.909	0.021	1.388	2.298	0.480
NTH	1977.2 - 1998.4	14.070	17.228	-0.030	3.377	1.591	-0.085
SWD	1970.1 - 1999.3	10.648	23.839	0.022	1.995	2.835	0.260
SWT	1982.2 - 1999.1	13.744	21.828	-0.128	1.393	1.498	0.243
UK	1970.1 - 1999.2	8.155	21.190	0.084	1.301	2.957	0.478
USA	1970.1 - 1998.4	6.929	17.556	0.051	1.494	1.687	0.571
SWD	1920 - 1998	7.084	18.641	0.096	2.209	5.800	0.710
UK	1919 - 1998	7.713	22.170	-0.023	1.255	5.319	0.589
USA	1891 - 1998	7.169	18.599	0.047	2.020	8.811	0.338

TABLE 2

INTERNATIONAL CONSUMPTION AND DIVIDENDS

Country	Sample Period	$\overline{\Delta c}$	$\sigma(\Delta c)$	$\rho(\Delta c)$	$\overline{\Delta d}$	$\sigma(\Delta d)$	$\rho(\Delta d)$
USA	1947.2 - 1998.4	1.964	1.073	0.216	2.159	28.291	-0.544
AUL	1970.1 - 1999.1	2.099	2.056	-0.324	0.656	34.584	-0.450
CAN	1970.1 - 1999.2	2.082	1.971	0.105	-0.488	5.604	0.522
FR	1973.2 - 1998.4	1.233	2.909	0.029	-0.255	13.108	-0.133
GER	1978.4 - 1997.4	1.681	2.431	-0.327	1.189	8.932	0.078
ITA	1971.2 - 1998.2	2.200	1.700	0.283	-3.100	19.092	0.298
JAP	1970.2 - 1999.1	3.205	2.554	-0.275	-2.350	4.351	0.354
NTH	1977.2 - 1998.4	1.841	2.619	-0.257	4.679	4.973	0.294
SWD	1970.1 - 1999.3	0.962	1.856	-0.266	4.977	14.050	0.386
SWT	1982.2 - 1999.1	0.524	2.112	-0.399	6.052	7.698	0.271
UK	1970.1 - 1999.2	2.203	2.507	-0.006	0.591	7.047	0.313
USA	1970.1 - 1998.4	1.812	0.907	0.374	0.612	16.803	-0.578
SWD	1920 - 1998	1.770	2.816	0.150	1.551	12.894	0.315
UK	1919 - 1998	1.551	2.886	0.294	1.990	7.824	0.233
USA	1891 - 1998	1.789	3.218	-0.116	1.516	14.019	-0.087

TABLE 3

HORIZON EFFECTS ON CORRELATIONS OF REAL CONSUMPTION GROWTH, DIVIDEND GROWTH, AND STOCK RETURNS

Country	Sample Period	$\rho(\Delta c, \Delta d)$				$\rho(\Delta c, r_e)$				$\rho(\Delta d, r_e)$			
		1	4	8	16	1	4	8	16	1	4	8	16
USA	1947.3 - 1998.3	0.053	0.135	0.205	0.249	0.229	0.340	0.267	0.029	0.034	0.055	0.215	0.471
AUL	1970.2 - 1998.4	-0.058	-0.044	0.076	-0.039	0.162	0.282	0.261	0.422	0.091	-0.007	0.191	0.390
CAN	1970.2 - 1999.1	-0.107	-0.120	-0.057	-0.088	0.188	0.352	0.272	0.068	-0.046	0.176	0.414	0.476
FR	1973.2 - 1998.3	0.076	0.059	0.053	0.166	-0.099	-0.117	-0.320	-0.138	0.094	0.176	0.147	0.134
GER	1978.4 - 1997.3	0.029	0.118	0.291	0.278	0.027	-0.151	-0.091	-0.249	0.057	0.298	0.421	0.481
ITA	1971.2 - 1998.1	0.107	-0.106	-0.226	-0.193	-0.028	-0.033	-0.040	-0.201	0.080	0.296	0.382	0.716
JAP	1970.2 - 1998.4	-0.030	-0.147	-0.217	-0.230	0.112	0.398	0.400	0.235	0.029	0.103	0.120	0.317
NTH	1977.2 - 1998.3	0.087	0.211	0.331	0.348	0.024	0.174	0.238	0.183	0.122	0.285	0.466	0.624
SWD	1970.2 - 1999.2	0.074	0.201	0.285	0.370	0.027	0.092	0.114	0.082	0.099	0.090	0.294	0.575
SWT	1982.2 - 1998.4	-0.019	-0.009	0.138	0.237	-0.119	0.015	0.092	-0.087	0.173	0.218	0.556	0.732
UK	1970.2 - 1999.1	0.046	0.104	0.118	0.328	0.125	0.197	0.359	0.441	-0.100	0.007	0.284	0.650
USA	1970.2 - 1998.3	-0.029	0.131	0.256	0.420	0.286	0.359	0.324	0.144	0.015	-0.049	0.020	0.330
SWD	1920 - 1997	0.261	0.359	0.354	0.084	0.209	0.287	0.387	0.137	0.285	0.447	0.648	0.684
UK	1920 - 1997	0.083	0.335	0.516	0.422	0.422	0.467	0.458	0.390	0.161	0.442	0.594	0.782
USA	1891 - 1997	0.178	0.151	0.202	0.098	0.452	0.491	0.396	0.138	0.476	0.503	0.676	0.784

TABLE 4

THE EQUITY PREMIUM PUZZLE

Country	Sample Period	$\overline{aer_e}$	$\sigma(er_e)$	$\sigma(m)$	$\sigma(\Delta c)$	$\rho(er_e, \Delta c)$	$cov(er_e, \Delta c)$	RRA(1)	RRA(2)
USA	1947.2 - 1998.3	8.071	15.271	52.853	1.071	0.205	3.354	240.647	49.326
AUL	1970.1 - 1998.4	3.885	22.403	17.342	2.059	0.144	6.640	58.511	8.421
CAN	1970.1 - 1999.1	3.968	17.266	22.979	1.920	0.202	6.694	59.266	11.966
FR	1973.2 - 1998.3	8.308	23.175	35.848	2.922	-0.093	-6.315	$<$ 0	12.270
GER	1978.4 - 1997.3	8.669	20.196	42.922	2.447	0.029	1.446	599.468	17.542
ITA	1971.2 - 1998.1	4.687	27.068	17.314	1.665	-0.006	-0.252	$<$ 0	10.400
JAP	1970.2 - 1998.4	5.098	21.498	23.715	2.561	0.112	6.171	82.620	9.260
NTH	1977.2 - 1998.3	11.421	16.901	67.576	2.510	0.032	1.344	849.991	26.918
SWD	1970.1 - 1999.2	11.539	23.518	49.066	1.851	0.015	0.674	1713.197	26.501
SWT	1982.2 - 1998.4	14.898	21.878	68.098	2.123	-0.112	-5.181	$<$ 0	32.076
UK	1970.1 - 1999.1	9.169	21.198	43.253	2.511	0.093	4.930	185.977	17.222
USA	1970.1 - 1998.3	6.353	16.976	37.425	0.909	0.274	4.233	150.100	41.178
SWD	1920 - 1997	6.540	18.763	34.855	5.622	0.167	8.830	74.062	12.400
UK	1919 - 1997	8.674	21.277	40.767	5.630	0.351	21.042	41.223	14.483
USA	1891 - 1997	6.723	18.496	36.345	6.437	0.495	29.450	22.827	11.293

TABLE 5

THE RISKFREE RATE PUZZLE

Country	Sample Period	$\overline{r_f}$	$\overline{\Delta c}$	$\sigma(\Delta c)$	RRA(1)	TPR(1)	RRA(2)	TPR(2)
USA	1947.2 - 1998.3	0.896	1.951	1.071	240.647	-136.270	49.326	-81.393
AUL	1970.1 - 1998.4	2.054	2.071	2.059	58.511	-46.512	8.421	-13.880
CAN	1970.1 - 1999.1	2.713	2.170	1.920	59.266	-61.154	11.966	-20.618
FR	1973.2 - 1998.3	2.715	1.212	2.922	$<$ 0	N/A	12.270	-5.735
GER	1978.4 - 1997.3	3.219	1.673	2.447	599.468	9757.265	17.542	-16.910
ITA	1971.2 - 1998.1	2.371	2.273	1.665	$<$ 0	N/A	10.400	-19.765
JAP	1970.2 - 1998.4	1.388	3.233	2.561	82.620	-41.841	9.260	-25.735
NTH	1977.2 - 1998.3	3.377	1.671	2.510	849.991	21349.249	26.918	-18.769
SWD	1970.1 - 1999.2	1.995	1.001	1.851	1713.197	48590.956	26.501	-12.506
SWT	1982.2 - 1998.4	1.393	0.559	2.123	$<$ 0	N/A	32.076	6.636
UK	1970.1 - 1999.1	1.301	2.235	2.511	185.977	676.439	17.222	-27.838
USA	1970.1 - 1998.3	1.494	1.802	0.909	150.100	-175.916	41.178	-65.701
SWD	1920 - 1997	2.209	1.730	2.811	74.062	90.793	12.400	-13.165
UK	1919 - 1997	1.255	1.472	2.815	41.223	7.913	14.483	-11.749
USA	1891 - 1997	2.020	1.760	3.218	22.827	-11.162	11.293	-11.247

TABLE 6

INTERNATIONAL YIELD SPREADS AND BOND EXCESS RETURNS

Country	Sample Period	$\overline{s}$	$\sigma(s)$	$\rho(s)$	$\overline{er_b}$	$\sigma(er_b)$	$\rho(er_b)$
USA	1947.2 - 1998.4	1.177	0.991	0.782	0.295	8.823	0.073
AUL	1970.1 - 1999.1	0.946	1.604	0.751	0.817	8.582	0.171
CAN	1970.1 - 1999.2	1.114	1.636	0.835	1.512	9.074	0.014
FR	1973.2 - 1998.4	0.992	1.508	0.748	2.127	7.942	0.303
GER	1978.4 - 1997.4	1.073	1.486	0.884	1.335	7.256	0.132
ITA	1971.2 - 1998.2	-0.157	1.928	0.762	0.417	9.599	0.359
JAP	1970.2 - 1999.1	0.665	1.447	0.849	2.067	9.232	-0.081
NTH	1977.2 - 1998.4	1.336	1.735	0.613	2.592	7.712	0.060
SWD	1970.1 - 1999.3	1.024	1.928	0.726	1.170	7.924	0.269
SWT	1982.2 - 1999.1	0.653	1.595	0.782	1.816	6.382	0.240
UK	1970.1 - 1999.2	1.068	2.076	0.896	2.006	11.309	-0.023
USA	1970.1 - 1998.4	1.498	1.180	0.743	1.909	10.420	0.034
SWD	1920 - 1998	0.378	1.184	0.325	0.057	8.877	-0.342
UK	1919 - 1998	1.220	1.510	0.676	0.872	9.041	-0.087
USA	1891 - 1998	0.737	1.533	0.595	0.359	6.666	0.072

TABLE 7

THE BOND PREMIUM PUZZLE

Country	Sample Period	$\overline{aer_b}$	$\sigma(er_b)$	$\sigma(m)$	$\sigma(\Delta c)$	$\rho(er_b, \Delta c)$	$cov(er_b, \Delta c)$	RRA(1)	RRA(2)
USA	1947.2 - 1998.3	0.663	8.842	7.503	1.071	0.080	0.762	87.051	7.002
AUL	1970.1 - 1998.4	1.328	8.584	15.474	2.059	0.115	2.036	65.248	7.514
CAN	1970.1 - 1999.1	2.048	9.088	22.532	1.920	0.163	2.852	71.812	11.733
FR	1973.2 - 1998.3	2.446	7.981	30.642	2.922	-0.022	-0.523	< 0	10.488
GER	1978.4 - 1997.3	1.502	7.291	20.601	2.447	0.109	1.942	77.359	8.420
ITA	1971.2 - 1998.1	0.852	9.643	8.840	1.665	-0.012	-0.197	< 0	5.310
JAP	1970.2 - 1998.4	2.410	9.261	26.020	2.561	0.009	0.213	1132.286	10.160
NTH	1977.2 - 1998.3	2.827	7.751	36.477	2.510	0.024	0.465	608.349	14.530
SWD	1970.1 - 1999.2	1.677	7.885	21.265	1.851	0.080	1.170	143.256	11.486
SWT	1982.2 - 1998.4	2.182	6.395	34.126	2.123	-0.135	-1.832	< 0	16.075
UK	1970.1 - 1999.1	2.774	11.337	24.468	2.511	0.139	3.967	69.917	9.743
USA	1970.1 - 1998.3	2.429	10.464	23.213	0.909	0.238	2.259	107.540	25.541
SWD	1920 - 1997	0.272	8.800	3.086	5.622	-0.069	-1.698	< 0	1.098
UK	1919 - 1997	1.036	8.862	11.689	5.630	0.293	7.308	14.176	4.153
USA	1891 - 1997	0.497	6.641	7.477	6.437	0.114	2.432	20.423	2.323

TABLE 8

THE EQUITY-BOND PREMIUM PUZZLE

Country	Sample Period	$\overline{aer_{eb}}$	$\sigma(er_{eb})$	$\sigma(m)$	$\sigma(\Delta c)$	$\rho(er_{eb}, \Delta c)$	$cov(er_{eb}, \Delta c)$	RRA(1)	RRA(2)
USA	1947.2 - 1998.3	7.408	16.097	49.253	1.071	0.150	2.592	305.896	45.967
AUL	1970.1 - 1998.4	2.557	21.436	12.658	2.059	0.104	4.604	58.930	6.146
CAN	1970.1 - 1999.1	1.920	16.371	13.330	1.920	0.122	3.843	56.786	6.941
FR	1973.2 - 1998.3	5.862	22.022	26.883	2.922	-0.090	-5.792	< 0	9.201
GER	1978.4 - 1997.3	7.167	20.126	36.860	2.447	-0.010	-0.496	< 0	15.065
ITA	1971.2 - 1998.1	3.834	26.356	15.590	1.665	-0.001	-0.055	< 0	9.364
JAP	1970.2 - 1998.4	2.688	22.382	14.794	2.561	0.104	5.958	55.579	5.777
NTH	1977.2 - 1998.3	8.593	17.006	52.403	2.510	0.021	0.879	1013.977	20.874
SWD	1970.1 - 1999.2	9.863	22.435	44.238	1.851	-0.012	-0.497	< 0	23.894
SWT	1982.2 - 1998.4	12.716	21.570	59.591	2.123	-0.073	-3.348	< 0	28.069
UK	1970.1 - 1999.1	6.395	17.400	36.233	2.511	0.022	0.963	654.932	14.427
USA	1970.1 - 1998.3	3.924	17.646	25.998	0.909	0.123	1.974	232.408	28.606
SWD	1920 - 1997	6.268	20.136	34.378	5.622	0.186	10.528	65.753	12.231
UK	1919 - 1997	7.638	17.595	41.575	5.630	0.277	13.734	53.264	14.770
USA	1891 - 1997	6.226	19.110	34.337	6.437	0.439	27.018	24.287	10.669

TABLE 9

PREDICTABLE VARIATION IN RETURNS AND CONSUMPTION GROWTH

(1) $r_{i,t+1} = \mu_i + (1/\psi)\Delta c_{t+1} + \eta_{i,t+1}$

(2) $\Delta c_{t+1} = \tau_i + \psi r_{i,t+1} + \xi_{i,t+1}$

Country	Sample Period	Asset	First-stage regressions		$(1\hat{/}\psi)$	$\hat{\psi}$	Test	Test
			r_i	Δc	(s.e.)	(s.e.)	(1)	(2)
USA	1947.2 - 1998.3	r_f	0.167	0.037	0.705	0.066	0.155	0.037
			0.000	0.064	0.734	0.107	0.000	0.024
		r_e	0.052	0.037	-9.455	-0.030	0.022	0.019
			0.015	0.064	7.376	0.032	0.106	0.146
AUL	1970.2 - 1998.4	r_f	0.414	0.010	7.064	0.107	0.003	0.002
			0.000	0.575	5.167	0.101	0.839	0.875
		r_e	0.051	0.010	17.405	0.027	0.009	0.005
			0.043	0.575	13.796	0.026	0.601	0.749
CAN	1970.2 - 1999.1	r_f	0.271	0.026	-0.899	-0.090	0.160	0.024
			0.000	0.379	0.838	0.172	0.000	0.255
		r_e	0.020	0.026	7.239	0.126	0.001	0.001
			0.414	0.379	5.679	0.101	0.929	0.928
FR	1973.2 - 1998.3	r_f	0.503	0.005	-4.044	-0.095	0.007	0.003
			0.000	0.495	3.573	0.144	0.693	0.867
		r_e	0.084	0.005	-2.872	-0.002	0.078	0.005
			0.029	0.495	10.190	0.032	0.021	0.795
GER	1978.4 - 1997.3	r_f	0.045	0.052	0.331	1.494	0.017	0.018
			0.431	0.095	0.338	1.147	0.537	0.519
		r_e	0.030	0.052	-4.984	-0.091	0.013	0.016
			0.089	0.095	4.821	0.083	0.628	0.567

TABLE 9 (ctd.)

PREDICTABLE VARIATION IN RETURNS AND CONSUMPTION GROWTH

(1) $r_{i,t+1} = \mu_i + (1/\psi)\Delta c_{t+1} + \eta_{i,t+1}$

(2) $\Delta c_{t+1} = \tau_i + \psi r_{i,t+1} + \xi_{i,t+1}$

Country	Sample Period	Asset	First-stage regressions		$(1\hat{/}\psi)$	$\hat{\psi}$	Test	Test
			r_i	Δc	(s.e.)	(s.e.)	(1)	(2)
ITA	1971.2 - 1998.1	r_f	0.413	0.017	-4.126	-0.055	0.059	0.014
			0.000	0.736	3.559	0.108	0.045	0.489
		r_e	0.042	0.017	4.867	0.007	0.036	0.016
			0.400	0.736	10.455	0.034	0.150	0.432
JAP	1970.2 - 1998.4	r_f	0.176	0.043	-0.362	-0.106	0.146	0.041
			0.018	0.051	0.365	0.276	0.000	0.103
		r_e	0.115	0.043	10.622	0.054	0.022	0.017
			0.000	0.051	4.727	0.028	0.289	0.393
NTH	1977.2 - 1998.3	r_f	0.350	0.036	-0.601	-0.163	0.178	0.033
			0.000	0.025	0.406	0.266	0.001	0.256
		r_e	0.015	0.036	-2.612	-0.133	0.008	0.012
			0.809	0.025	5.678	0.163	0.707	0.597
SWD	1970.2 - 1998.3	r_f	0.290	0.003	10.873	0.043	0.004	0.002
			0.000	0.919	15.863	0.079	0.812	0.905
		r_e	0.083	0.003	-3.313	-0.001	0.079	0.003
			0.056	0.919	20.570	0.018	0.012	0.826
SWT	1982.2 - 1998.4	r_f	0.112	0.006	2.514	0.360	0.001	0.001
			0.000	0.909	3.951	0.526	0.982	0.983
		r_e	0.010	0.006	11.801	0.063	0.001	0.001
			0.741	0.909	26.241	0.153	0.966	0.968

TABLE 9 (ctd.)

PREDICTABLE VARIATION IN RETURNS AND CONSUMPTION GROWTH

(1) $r_{i,t+1} = \mu_i + (1/\psi)\Delta c_{t+1} + \eta_{i,t+1}$

(2) $\Delta c_{t+1} = \tau_i + \psi r_{i,t+1} + \xi_{i,t+1}$

Country	Sample Period	Asset	First-stage regressions		$(1\hat{/}\psi)$	$\hat{\psi}$	Test	Test
			r_i	Δc	(s.e.)	(s.e.)	(1)	(2)
UK	1970.2 - 1999.1	r_f	0.310	0.069	1.902	0.302	0.046	0.030
			0.000	0.009	0.806	0.131	0.074	0.181
		r_e	0.065	0.069	-3.372	-0.051	0.043	0.044
			0.222	0.009	3.417	0.042	0.089	0.081
USA	1970.2 - 1998.3	r_f	0.283	0.067	1.765	0.120	0.150	0.055
			0.000	0.071	0.815	0.110	0.000	0.047
		r_e	0.050	0.067	1.446	0.006	0.052	0.070
			0.129	0.071	8.429	0.027	0.056	0.020
SWD	1920 - 1997	r_f	0.317	0.041	3.327	0.174	0.026	0.017
			0.000	0.356	2.084	0.151	0.379	0.535
		r_e	0.018	0.041	-1.575	-0.075	0.014	0.025
			0.624	0.356	3.560	0.101	0.586	0.390
UK	1920 - 1997	r_f	0.261	0.063	2.269	0.196	0.067	0.037
			0.001	0.178	1.401	0.127	0.082	0.250
		r_e	0.129	0.063	4.064	0.031	0.125	0.062
			0.124	0.178	3.948	0.024	0.009	0.098
USA	1891 - 1997	r_f	0.013	0.059	-0.229	-0.142	0.012	0.051
			0.760	0.009	0.938	0.295	0.524	0.069
		r_e	0.018	0.059	-0.326	-0.031	0.017	0.049
			0.526	0.009	2.411	0.126	0.417	0.079

TABLE 10

INTERNATIONAL STOCK PRICES AND DIVIDENDS

Country	Sample Period	$\overline{P/D}$	$\sigma(p-d)$	$\rho(p-d)$	ADF(1)	$\overline{\Delta p}$	$\overline{\Delta d}$	$\overline{\Delta p - d}$
USA	1947.2 - 1998.4	28.312	0.301	0.941	-0.875	4.149	2.159	2.307
AUL	1970.1 - 1999.1	26.359	0.263	0.857	-3.099	-0.422	0.656	-1.163
CAN	1970.1 - 1999.2	32.372	0.277	0.924	-0.925	1.852	-0.488	1.999
FR	1973.2 - 1998.4	24.698	0.567	0.967	-1.141	3.483	-0.255	3.738
GER	1978.4 - 1997.4	29.033	0.322	0.918	-1.285	6.001	1.189	5.136
ITA	1971.2 - 1998.2	42.822	0.324	0.878	-3.442	0.554	-3.100	4.238
JAP	1970.2 - 1999.1	93.403	0.626	0.966	-1.843	3.142	-2.350	5.690
NTH	1977.2 - 1998.4	23.795	0.358	0.945	-0.390	9.207	4.679	4.498
SWD	1970.1 - 1999.3	39.506	0.479	0.958	-1.596	7.846	4.977	2.756
SWT	1982.2 - 1999.1	53.607	0.313	0.893	-1.283	11.642	6.052	6.328
UK	1970.1 - 1999.2	19.402	0.303	0.920	-1.185	2.599	0.591	1.533
USA	1970.1 - 1998.4	29.955	0.298	0.921	-0.260	3.214	0.612	2.699
SWD	1920 - 1998	28.441	0.379	0.818	-0.440	3.118	1.551	1.895
UK	1919 - 1998	21.197	0.245	0.542	-3.570	2.558	1.990	0.568
USA	1891 - 1998	23.751	0.321	0.787	-0.812	2.617	1.516	1.006

TABLE 11 – PANEL A

FORECASTING WITH THE LOG PRICE-DIVIDEND RATIO

Country	Sample Period	Horizon	Cons. Growth			Output Growth			Dividend Growth		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
USA	1947.2 - 1998.3	4.000	0.002	1.286	0.022	0.001	0.137	0.000	-0.003	-0.352	0.001
		8.000	0.003	0.784	0.014	-0.002	-0.320	0.003	-0.019	-1.201	0.025
		16.000	0.007	0.950	0.036	0.001	0.134	0.001	-0.043	-1.723	0.073
AUL	1970.2 - 1998.4	4.000	-0.001	-0.802	0.009	0.004	1.670	0.039	0.047	1.824	0.051
		8.000	-0.003	-1.238	0.029	0.002	0.523	0.005	0.083	1.926	0.101
		16.000	-0.006	-1.691	0.072	-0.004	-1.350	0.017	0.045	0.953	0.027
CAN	1970.2 - 1999.1	4.000	-0.003	-0.661	0.013	-0.002	-0.494	0.004	0.044	3.000	0.237
		8.000	-0.007	-0.918	0.029	-0.011	-1.836	0.048	0.055	1.964	0.112
		16.000	-0.021	-1.342	0.085	-0.029	-2.004	0.131	0.018	0.388	0.006
FR	1973.2 - 1998.3	4.000	-0.002	-0.464	0.005	0.001	0.387	0.006	0.082	2.800	0.348
		8.000	-0.005	-0.558	0.016	0.002	0.231	0.005	0.152	3.046	0.448
		16.000	-0.007	-0.569	0.031	0.002	0.142	0.002	0.231	4.601	0.475
GER	1978.4 - 1997.3	4.000	0.004	1.469	0.053	0.007	2.142	0.107	0.050	3.947	0.208
		8.000	0.007	2.081	0.079	0.009	1.822	0.091	0.075	3.670	0.166
		16.000	0.012	5.976	0.172	0.009	1.767	0.050	0.030	0.723	0.014

TABLE 11 – PANEL A (ctd.)

FORECASTING WITH THE LOG PRICE-DIVIDEND RATIO

Country	Sample Period	Horizon	Cons. Growth			Output Growth			Dividend Growth		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
ITA	1971.2 - 1998.1	4.000	-0.005	-1.113	0.052	-0.005	-1.079	0.034	0.106	3.670	0.221
		8.000	-0.008	-1.049	0.074	-0.009	-1.119	0.083	0.210	9.351	0.402
		16.000	-0.008	-0.677	0.038	-0.005	-0.453	0.014	0.283	5.298	0.243
JAP	1970.2 - 1998.4	4.000	-0.009	-2.325	0.170	-0.004	-0.887	0.040	0.034	5.298	0.362
		8.000	-0.014	-2.140	0.239	-0.008	-0.887	0.057	0.062	4.108	0.423
		16.000	-0.024	-2.915	0.397	-0.011	-0.982	0.058	0.102	2.636	0.374
NTH	1977.2 - 1998.3	4.000	0.011	3.223	0.224	0.008	2.377	0.139	0.032	5.299	0.212
		8.000	0.024	3.979	0.382	0.017	2.758	0.228	0.049	3.088	0.152
		16.000	0.039	3.287	0.391	0.030	3.322	0.308	0.017	0.458	0.007
SWD	1970.2 - 1998.3	4.000	0.002	0.767	0.013	0.003	1.124	0.015	0.099	3.947	0.308
		8.000	0.003	0.799	0.024	-0.001	-0.244	0.001	0.170	2.810	0.338
		16.000	0.001	0.166	0.002	-0.014	-1.372	0.061	0.176	1.934	0.186
SWT	1982.2 - 1998.4	4.000	-0.001	-0.243	0.002	-0.002	-0.516	0.011	0.056	2.167	0.338
		8.000	0.000	0.020	0.000	-0.008	-0.903	0.033	0.053	1.165	0.121
		16.000	0.006	1.113	0.046	-0.022	-1.418	0.074	0.064	0.857	0.087

TABLE 11 – PANEL A (ctd.)

FORECASTING WITH THE LOG PRICE-DIVIDEND RATIO

Country	Sample Period	Horizon	Cons. Growth			Output Growth			Dividend Growth		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
UK	1970.2 - 1999.1	4.000	0.009	2.237	0.096	0.005	1.567	0.041	0.029	2.528	0.101
		8.000	0.008	1.105	0.027	0.002	0.261	0.002	0.043	2.145	0.101
		16.000	-0.007	-0.487	0.010	-0.010	-0.914	0.034	0.014	0.344	0.005
USA	1970.2 - 1998.3	4.000	0.001	0.379	0.005	0.003	0.772	0.013	0.010	1.530	0.011
		8.000	-0.001	-0.125	0.001	0.001	0.111	0.001	0.004	0.276	0.001
		16.000	-0.006	-0.917	0.027	-0.009	-0.916	0.023	-0.017	-0.737	0.011
SWD	1920 - 1997	1.000	-0.001	-0.587	0.003	-0.002	-0.947	0.008	0.065	5.527	0.238
		4.000	-0.016	-1.477	0.047	-0.025	-1.982	0.110	0.123	2.887	0.143
		8.000	-0.032	-2.419	0.160	-0.053	-2.843	0.251	0.127	2.873	0.130
UK	1920 - 1997	1.000	0.003	1.075	0.012	-0.001	-0.444	0.001	0.020	1.786	0.063
		4.000	-0.005	-0.784	0.006	0.006	0.683	0.007	-0.030	-1.116	0.026
		8.000	-0.023	-2.440	0.094	0.004	0.377	0.001	-0.110	-3.456	0.171
USA	1891 - 1997	1.000	0.000	0.010	0.000	-0.007	-1.609	0.019	0.019	1.264	0.016
		4.000	-0.005	-0.577	0.005	-0.010	-0.684	0.005	0.026	0.681	0.009
		8.000	0.005	0.413	0.002	-0.001	-0.037	0.000	-0.027	-0.492	0.005

TABLE 11 – PANEL B

FORECASTING WITH THE LOG PRICE-DIVIDEND RATIO

Country	Sample Period	Horizon	Real Int. Rate			Excess Stock Return			Stock Volatility			Excess Bond Return		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
USA	1947.2 - 1998.3	4.000	0.004	0.777	0.016	-0.053	-2.415	0.103	0.001	1.130	0.009	-0.003	-0.229	0.001
		8.000	0.003	0.316	0.005	-0.107	-2.579	0.219	0.001	1.681	0.051	-0.001	-0.024	0.000
		16.000	-0.003	-0.143	0.001	-0.184	-3.273	0.377	0.001	1.581	0.122	-0.007	-0.205	0.001
AUL	1970.2 - 1998.4	4.000	-0.003	-0.329	0.006	-0.105	-4.555	0.223	0.005	1.978	0.089	-0.023	-1.507	0.055
		8.000	-0.009	-0.434	0.012	-0.154	-4.056	0.287	0.005	2.716	0.183	-0.045	-1.902	0.096
		16.000	-0.030	-0.874	0.035	-0.252	-5.271	0.535	0.004	4.559	0.303	-0.046	-1.645	0.065
CAN	1970.2 - 1999.1	4.000	0.005	0.961	0.023	-0.031	-1.024	0.025	0.000	0.136	0.001	0.003	0.153	0.001
		8.000	0.009	0.666	0.014	-0.052	-0.816	0.033	0.000	0.260	0.002	0.026	0.757	0.026
		16.000	0.022	0.944	0.021	-0.153	-1.674	0.172	-0.000	-0.170	0.001	0.058	0.827	0.050
FR	1973.2 - 1998.3	4.000	0.020	3.263	0.381	-0.015	-0.425	0.004	0.001	0.313	0.002	0.011	0.697	0.012
		8.000	0.042	2.956	0.437	-0.050	-1.228	0.028	0.001	0.583	0.020	0.021	0.794	0.020
		16.000	0.079	2.875	0.442	-0.159	-3.524	0.198	0.000	0.268	0.006	0.020	0.373	0.009
GER	1978.4 - 1997.3	4.000	-0.000	-0.114	0.001	-0.025	-0.578	0.012	0.005	1.987	0.104	0.011	0.575	0.016
		8.000	-0.003	-0.775	0.019	-0.074	-0.980	0.059	0.005	2.033	0.292	0.017	0.695	0.020
		16.000	-0.001	-0.465	0.005	-0.224	-4.713	0.385	0.005	6.018	0.413	-0.056	-1.999	0.143

TABLE 11 – PANEL B (ctd.)

FORECASTING WITH THE LOG PRICE-DIVIDEND RATIO

Country	Sample Period	Horizon	Real Int. Rate			Excess Stock Return			Stock Volatility			Excess Bond Return		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
ITA	1971.2 - 1998.1	4.000	0.011	1.289	0.045	-0.067	-1.703	0.047	0.001	0.519	0.004	-0.005	-0.234	0.001
		8.000	0.027	1.679	0.081	-0.140	-2.572	0.104	-0.001	-0.515	0.008	0.020	0.677	0.011
		16.000	0.064	2.219	0.129	-0.101	-1.499	0.030	-0.000	-0.656	0.006	0.057	0.960	0.043
JAP	1970.2 - 1998.4	4.000	0.011	2.262	0.098	-0.077	-2.002	0.123	0.003	1.506	0.111	0.004	0.277	0.002
		8.000	0.026	2.388	0.178	-0.145	-2.301	0.208	0.003	1.430	0.190	0.014	0.492	0.012
		16.000	0.057	2.185	0.294	-0.226	-2.478	0.263	0.004	1.763	0.311	0.047	1.094	0.084
NTH	1977.2 - 1998.3	4.000	-0.003	-0.703	0.025	0.013	0.313	0.005	0.001	0.763	0.010	0.018	0.826	0.037
		8.000	-0.002	-0.176	0.003	0.013	0.136	0.002	0.000	0.186	0.001	0.031	0.664	0.033
		16.000	0.008	0.353	0.016	-0.112	-0.738	0.066	0.000	0.401	0.007	-0.034	-0.487	0.020
SWD	1970.2 - 1998.3	4.000	0.024	5.331	0.322	-0.028	-0.723	0.014	0.002	0.851	0.019	0.014	0.745	0.022
		8.000	0.050	4.648	0.371	-0.045	-0.472	0.017	0.003	0.922	0.067	0.050	2.458	0.192
		16.000	0.094	3.697	0.330	-0.144	-1.070	0.079	0.004	1.442	0.156	0.075	2.654	0.281
SWT	1982.2 - 1998.4	4.000	0.003	0.739	0.029	-0.014	-0.321	0.004	0.005	2.642	0.084	0.021	2.062	0.059
		8.000	0.002	0.287	0.006	-0.015	-0.133	0.002	0.004	1.514	0.118	0.049	1.847	0.108
		16.000	0.000	0.004	0.000	-0.015	-0.079	0.001	0.001	0.765	0.021	0.040	0.616	0.026

TABLE 11 – PANEL B (ctd.)

FORECASTING WITH THE LOG PRICE-DIVIDEND RATIO

Country	Sample Period	Horizon	Real Int. Rate			Excess Stock Return			Stock Volatility			Excess Bond Return		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
UK	1970.2 - 1999.1	4.000	0.022	2.108	0.205	-0.088	-3.046	0.149	-0.005	-1.147	0.070	-0.021	-1.084	0.030
		8.000	0.033	1.655	0.128	-0.141	-2.628	0.226	-0.002	-0.721	0.012	-0.049	-1.553	0.076
		16.000	0.037	1.123	0.044	-0.222	-3.541	0.380	0.001	0.446	0.008	-0.083	-1.719	0.143
USA	1970.2 - 1998.3	4.000	-0.004	-0.498	0.015	-0.028	-0.824	0.024	-0.000	-0.503	0.003	-0.001	-0.040	0.000
		8.000	-0.018	-0.995	0.071	-0.059	-0.731	0.053	0.001	0.368	0.005	-0.004	-0.082	0.000
		16.000	-0.060	-2.507	0.224	-0.095	-0.898	0.085	0.001	0.623	0.047	-0.029	-0.461	0.009
SWD	1920 - 1997	1.000	-0.002	-0.204	0.001	0.007	0.289	0.002	0.007	0.900	0.019	0.009	0.452	0.010
		4.000	0.009	0.178	0.002	-0.018	-0.343	0.002	0.012	2.110	0.144	0.011	0.457	0.007
		8.000	0.021	0.207	0.005	-0.064	-0.790	0.018	0.012	3.096	0.241	0.003	0.039	0.000
UK	1920 - 1997	1.000	-0.009	-0.756	0.028	-0.087	-2.835	0.170	-0.007	-0.758	0.007	-0.035	-4.052	0.152
		4.000	-0.055	-1.803	0.116	-0.221	-9.801	0.451	0.010	1.005	0.035	-0.066	-3.489	0.194
		8.000	-0.127	-2.984	0.218	-0.213	-6.042	0.417	0.009	1.071	0.053	-0.076	-2.360	0.120
USA	1891 - 1997	1.000	0.004	0.510	0.002	-0.037	-2.183	0.037	-0.000	-0.110	0.000	0.004	0.527	0.003
		4.000	0.011	0.263	0.002	-0.135	-2.350	0.123	-0.000	-0.055	0.000	-0.021	-0.773	0.015
		8.000	-0.006	-0.073	0.000	-0.273	-4.194	0.289	-0.002	-0.620	0.003	-0.080	-1.689	0.091

TABLE 12 – PANEL A

FORECASTING WITH THE YIELD SPREAD

Country	Sample Period	Horizon	Cons. Growth			Output Growth			Dividend Growth		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
USA	1947.2 - 1998.3	4.000	0.003	1.716	0.040	0.007	2.267	0.066	0.011	1.571	0.018
		8.000	0.002	0.569	0.007	0.007	1.478	0.039	0.024	2.528	0.050
		16.000	-0.004	-0.889	0.017	0.001	0.275	0.001	0.015	1.106	0.013
AUL	1970.2 - 1998.4	4.000	0.003	1.688	0.037	0.008	2.745	0.147	0.002	0.081	0.000
		8.000	0.005	2.186	0.073	0.011	1.802	0.147	0.032	0.834	0.016
		16.000	0.003	0.824	0.015	0.013	2.915	0.151	0.052	1.294	0.039
CAN	1970.2 - 1999.1	4.000	0.010	4.203	0.213	0.017	5.770	0.429	0.016	1.118	0.037
		8.000	0.014	3.533	0.149	0.025	4.360	0.376	0.056	3.758	0.169
		16.000	0.015	2.068	0.083	0.027	2.871	0.203	0.080	2.843	0.228
FR	1973.2 - 1998.3	4.000	-0.001	-0.336	0.002	0.007	2.822	0.141	0.002	0.187	0.000
		8.000	-0.005	-0.802	0.019	0.004	1.377	0.029	0.013	0.704	0.004
		16.000	0.015	3.792	0.150	0.005	0.877	0.017	-0.002	-0.059	0.000
GER	1978.4 - 1997.3	4.000	0.005	2.800	0.099	0.008	2.686	0.181	0.070	5.278	0.454
		8.000	0.007	2.773	0.106	0.012	3.923	0.180	0.132	6.312	0.571
		16.000	0.009	1.809	0.118	0.014	1.662	0.153	0.096	2.779	0.176

TABLE 12 – PANEL A (ctd.)

FORECASTING WITH THE YIELD SPREAD

Country	Sample Period	Horizon	Cons. Growth			Output Growth			Dividend Growth		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
ITA	1971.2 - 1998.1	4.000	0.003	0.934	0.026	0.007	1.858	0.077	-0.076	-2.971	0.124
		8.000	0.001	0.244	0.002	-0.000	-0.074	0.000	-0.052	-0.972	0.027
		16.000	0.000	0.079	0.000	-0.003	-0.522	0.005	-0.066	-1.193	0.015
JAP	1970.2 - 1998.4	4.000	-0.003	-0.837	0.014	0.001	0.518	0.004	0.005	0.470	0.008
		8.000	-0.007	-1.227	0.055	-0.002	-0.305	0.003	0.015	1.277	0.024
		16.000	-0.008	-1.520	0.039	-0.001	-0.128	0.000	0.032	2.405	0.035
NTH	1977.2 - 1998.3	4.000	0.005	1.866	0.060	0.006	2.233	0.089	0.020	2.064	0.104
		8.000	0.010	2.402	0.122	0.011	3.559	0.151	0.045	1.944	0.223
		16.000	0.002	0.283	0.002	0.002	0.376	0.003	0.035	1.350	0.065
SWD	1970.2 - 1998.3	4.000	0.002	0.967	0.014	0.008	2.503	0.120	0.057	1.541	0.110
		8.000	0.002	0.512	0.010	0.009	1.545	0.061	0.060	1.100	0.049
		16.000	0.002	0.442	0.005	0.006	1.082	0.016	-0.006	-0.149	0.000
SWT	1982.2 - 1998.4	4.000	0.004	3.097	0.114	0.009	4.123	0.290	0.032	1.998	0.148
		8.000	0.009	3.313	0.287	0.020	6.099	0.460	0.057	3.082	0.296
		16.000	0.010	3.618	0.381	0.032	8.304	0.439	0.026	1.710	0.040

TABLE 12 – PANEL A (ctd.)

FORECASTING WITH THE YIELD SPREAD

Country	Sample Period	Horizon	Cons. Growth			Output Growth			Dividend Growth		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
UK	1970.2 - 1999.1	4.000	0.007	1.308	0.054	0.011	2.849	0.173	-0.009	-0.806	0.010
		8.000	0.009	1.004	0.041	0.015	1.937	0.134	0.002	0.075	0.000
		16.000	0.001	0.109	0.001	0.009	0.774	0.032	-0.020	-0.574	0.013
USA	1970.2 - 1998.3	4.000	0.006	3.439	0.194	0.013	3.972	0.276	0.020	2.723	0.053
		8.000	0.006	1.900	0.099	0.016	3.218	0.189	0.039	3.729	0.154
		16.000	0.002	0.515	0.004	0.009	1.920	0.046	0.026	2.501	0.049
SWD	1920 - 1997	1.000	-0.004	-1.812	0.017	-0.000	-0.226	0.000	0.026	1.384	0.041
		4.000	-0.011	-2.192	0.028	-0.017	-2.786	0.067	0.030	1.057	0.011
		8.000	-0.021	-2.076	0.088	-0.031	-2.682	0.114	0.011	0.545	0.001
UK	1920 - 1997	1.000	-0.001	-0.376	0.002	0.005	1.532	0.025	-0.009	-1.202	0.014
		4.000	-0.014	-1.486	0.052	0.004	0.412	0.003	-0.039	-1.350	0.043
		8.000	-0.023	-2.991	0.080	-0.009	-0.880	0.008	-0.066	-1.911	0.053
USA	1891 - 1997	1.000	0.002	0.441	0.002	0.007	1.321	0.018	-0.006	-0.441	0.002
		4.000	0.006	0.705	0.010	0.018	0.860	0.019	0.010	0.385	0.002
		8.000	0.010	0.632	0.011	0.045	0.999	0.072	0.006	0.139	0.000

TABLE 12 – PANEL B

FORECASTING WITH THE YIELD SPREAD

Country	Sample Period	Horizon	Real Int. Rate			Excess Stock Return			Stock Volatility			Excess Bond Return		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
USA	1947.2 - 1998.3	4.000	0.006	1.689	0.051	0.019	1.153	0.015	-0.001	-1.328	0.038	0.033	4.100	0.131
		8.000	0.007	1.061	0.025	-0.000	-0.020	0.000	-0.001	-1.613	0.053	0.037	2.787	0.087
		16.000	0.011	0.871	0.020	0.017	0.409	0.005	-0.000	-0.187	0.001	0.042	1.604	0.060
AUL	1970.2 - 1998.4	4.000	-0.014	-2.184	0.106	-0.007	-0.236	0.001	-0.003	-1.077	0.020	0.006	0.683	0.004
		8.000	-0.025	-1.861	0.089	0.001	0.036	0.000	-0.003	-1.267	0.060	-0.017	-1.139	0.015
		16.000	-0.043	-2.168	0.078	0.065	2.300	0.038	-0.001	-1.053	0.016	-0.031	-1.084	0.030
CAN	1970.2 - 1999.1	4.000	-0.011	-2.124	0.114	0.054	1.864	0.087	-0.002	-1.370	0.064	0.024	1.940	0.068
		8.000	-0.023	-1.843	0.144	0.063	2.310	0.070	-0.001	-0.861	0.053	0.024	1.030	0.032
		16.000	-0.053	-2.109	0.225	0.053	0.925	0.037	-0.001	-0.565	0.031	-0.007	-0.307	0.001
FR	1973.2 - 1998.3	4.000	-0.012	-2.001	0.139	0.050	1.481	0.047	-0.000	-0.071	0.000	0.007	0.475	0.005
		8.000	-0.017	-1.413	0.084	0.077	2.111	0.075	0.000	0.140	0.001	0.005	0.207	0.001
		16.000	-0.022	-1.444	0.040	0.091	2.614	0.074	0.002	1.500	0.124	-0.027	-0.940	0.020
GER	1978.4 - 1997.3	4.000	-0.008	-4.710	0.419	0.051	1.862	0.058	0.001	0.531	0.005	0.013	0.808	0.026
		8.000	-0.010	-3.599	0.258	0.081	2.104	0.079	0.002	1.553	0.037	-0.003	-0.127	0.001
		16.000	0.001	0.179	0.001	-0.078	-2.723	0.057	0.004	4.259	0.311	-0.055	-2.937	0.165

TABLE 12 – PANEL B (ctd.)

FORECASTING WITH THE YIELD SPREAD

Country	Sample Period	Horizon	Real Int. Rate			Excess Stock Return			Stock Volatility			Excess Bond Return		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
ITA	1971.2 - 1998.1	4.000	-0.014	-1.758	0.083	0.020	0.410	0.004	-0.003	-1.801	0.039	0.018	1.323	0.019
		8.000	-0.027	-1.453	0.088	0.054	0.870	0.017	-0.001	-0.649	0.015	0.018	0.659	0.009
		16.000	-0.051	-2.136	0.093	0.089	1.262	0.026	0.001	1.479	0.030	-0.007	-0.213	0.001
JAP	1970.2 - 1998.4	4.000	-0.007	-1.425	0.041	0.016	0.520	0.005	-0.002	-1.736	0.039	0.011	1.042	0.016
		8.000	-0.011	-1.352	0.033	-0.001	-0.021	0.000	-0.001	-1.382	0.022	-0.003	-0.145	0.000
		16.000	0.003	0.373	0.001	-0.019	-0.659	0.002	0.000	0.282	0.001	-0.032	-1.482	0.038
NTH	1977.2 - 1998.3	4.000	-0.011	-3.702	0.450	0.057	1.889	0.126	0.000	0.036	0.000	0.026	2.405	0.104
		8.000	-0.015	-2.798	0.273	0.092	1.846	0.159	-0.000	-0.684	0.007	0.032	1.658	0.062
		16.000	-0.001	-0.122	0.000	-0.031	-0.780	0.010	0.000	0.417	0.006	-0.018	-0.591	0.011
SWD	1970.2 - 1998.3	4.000	-0.022	-4.943	0.303	-0.056	-2.191	0.056	-0.004	-2.478	0.065	-0.005	-0.477	0.003
		8.000	-0.042	-5.461	0.295	-0.056	-1.725	0.031	-0.003	-2.581	0.079	-0.015	-0.928	0.019
		16.000	-0.072	-7.219	0.271	-0.078	-1.730	0.032	-0.001	-1.436	0.027	-0.041	-5.335	0.113
SWT	1982.2 - 1998.4	4.000	-0.010	-5.455	0.483	0.069	2.227	0.129	-0.001	-0.497	0.007	0.014	1.042	0.037
		8.000	-0.017	-7.014	0.596	0.108	3.007	0.184	-0.001	-0.823	0.017	-0.002	-0.111	0.000
		16.000	-0.021	-6.257	0.559	0.016	0.354	0.003	0.001	1.317	0.057	-0.046	-1.905	0.096

TABLE 12 – PANEL B (ctd.)

FORECASTING WITH THE YIELD SPREAD

Country	Sample Period	Horizon	Real Int. Rate			Excess Stock Return			Stock Volatility			Excess Bond Return		
			$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$	$\hat{\beta}(k)$	$t(\hat{\beta}(k))$	$R^2(k)$
UK	1970.2 - 1999.1	4.000	-0.027	-4.448	0.343	0.040	1.581	0.033	0.001	0.671	0.006	0.010	0.712	0.008
		8.000	-0.052	-5.684	0.362	0.026	0.643	0.009	0.001	0.753	0.005	-0.002	-0.073	0.000
		16.000	-0.100	-4.544	0.396	0.009	0.173	0.001	0.003	1.627	0.067	-0.042	-1.410	0.046
USA	1970.2 - 1998.3	4.000	0.004	0.823	0.021	0.036	1.524	0.049	-0.003	-1.650	0.116	0.040	3.678	0.136
		8.000	0.003	0.344	0.002	0.028	1.748	0.019	-0.002	-2.036	0.168	0.038	1.725	0.062
		16.000	0.001	0.046	0.000	0.082	2.910	0.123	-0.001	-1.248	0.048	0.025	1.232	0.014
SWD	1920 - 1997	1.000	-0.014	-2.418	0.057	-0.005	-0.201	0.001	-0.011	-2.193	0.044	0.036	3.748	0.161
		4.000	-0.042	-2.162	0.062	-0.028	-0.578	0.006	0.002	0.571	0.004	-0.017	-1.106	0.021
		8.000	-0.045	-1.211	0.026	0.065	1.417	0.025	0.002	0.831	0.005	-0.009	-0.269	0.002
UK	1920 - 1997	1.000	-0.031	-5.615	0.339	0.018	0.612	0.007	0.022	1.496	0.041	0.010	1.088	0.013
		4.000	-0.109	-4.696	0.474	0.002	0.059	0.000	0.017	1.217	0.047	-0.008	-0.528	0.003
		8.000	-0.157	-3.690	0.289	0.076	1.549	0.046	0.003	0.475	0.003	0.015	0.343	0.004
USA	1891 - 1997	1.000	-0.020	-2.541	0.051	0.014	0.775	0.006	-0.000	-0.070	0.000	0.037	6.341	0.311
		4.000	-0.060	-2.089	0.073	0.087	2.169	0.065	0.001	0.208	0.001	0.067	3.007	0.195
		8.000	-0.105	-1.528	0.100	0.110	1.814	0.057	-0.001	-0.264	0.001	0.094	2.715	0.153