Why does the slope of the term structure forecast excess returns?

Gregory R. Duffee[*]

Haas School of Business
University of California – Berkeley

First version: January 2001
This Draft: January 24, 2001

ABSTRACT

In the U.S., the slope of the term structure is positively correlated with expected future excess returns to both stocks and long-maturity bonds. This paper empirically investigates possible explanations for this pattern. The results pose a significant challenge for representative agent, consumption-based asset-pricing models. I find that when the term structure is more steeply sloped than average, (1) future volatilities of both aggregate consumption growth and stock market returns are much lower than average; (2) future correlations between aggregate consumption growth and returns to both stocks and bonds are roughly zero; (3) the well-documented positive relation between excess returns and subsequent growth in real variables (e.g., labor income and GDP) disappears. These facts are inconsistent with the hypothesis that a representative agent has standard power utility, recursive utility, or habit formation preferences.

[*]Voice 510-642-1435, fax 510-643-1420, email duffee@haas.berkeley.edu. Address correspondence to 545 Student Services Building #1900, Berkeley, CA 94720. I thank participants in a workshop at the Federal Reserve Bank of San Francisco for helpful comments. The most recent version of this paper is at www.haas.berkeley.edu/∼duffee.

1 Introduction

When the term structure is more steeply sloped than average, future excess returns to stocks and long-term bonds (over short-term interest rates) tend to be higher than average. In this paper I attempt to interpret this well-known pattern in the context of representative-agent, consumption-based utility theory. The results pose a significant challenge to the theory.

Since Rubinstein (1976) and Lucas (1978), economists have attempted to explain the behavior of asset returns with equilibrium models in which a representative agent makes portfolio decisions to maximize utility defined over consumption. In these models, an asset's risk premium is proportional to the covariance between the asset's return and the change in the marginal utility of (aggregate per capita) consumption.

Because we cannot observe marginal utility directly, tests of consumption-based models rely on specifications of preferences that allow us to infer the dynamics of marginal utility from observables. The standard time-additive power utility framework used by Mehra and Prescott (1985) implies that an asset's expected excess return is proportional to the covariance between the asset's return and the growth of log consumption. The recursive utility framework of Epstein and Zin (1989) and Weil (1989) adds another explanatory variable, allowing expected excess returns to also depend on the covariance between the asset's return and the return to total wealth. The state-of-the-art perspective (e.g., Campbell (1999)) is that neither set of preferences can explain the observed time-variation in expected excess returns to stocks and bonds. There is little evidence that either the volatility of consumption growth or covariances of asset returns with consumption growth vary through time. Covariances between asset returns and wealth (at least the portion of wealth that we can measure) do vary through time, but they do not appear to vary systematically with expected excess returns.

Habit formation frameworks, developed by Sundaresan (1989), Constantinides (1990) and Abel (1990), appear more promising. For example, the model of Campbell and Cochrane (1999) implies that an asset's expected excess return is the product of a time-varying price of consumption risk and the covariance between the asset's return and the growth of log consumption. The price of risk depends on how close current consumption is to a 'consumption habit.' Thus, expected excess returns can vary through time even if covariances do not. The conventional view is that expected excess returns to stocks and bonds positively covary with the slope of the term structure because the slope is countercyclical. When the slope is steep, economic output is relatively low, consumption is correspondingly low relative to habit, and the price of risk is correspondingly high.

However, this logic falters when we take a slightly closer look at the relation between the slope of the term structure and expected excess returns to long-term bonds. As noted by Fama and French (1993), the sign differs depending on whether the term-structure slope is steeper (positive expected returns) or flatter (negative expected returns) than usual. Therefore either the price of consumption risk or the covariance between long-term bond returns and the growth of log consumption has to change sign. Thus if asset prices (and in particular, bond prices) are consistent with habit formation preferences of a risk-averse representative agent, the slope of the term structure should have predictive power for covariances between the growth of log consumption and bond returns.

This intuition motivates my paper. I investigate the link between the slope of the term structure and covariances between consumption growth and asset returns. As noted above, there is little existing evidence for predictable variations in such covariances. However, research to date has not looked at the predictive power of the slope. This is surprising, because the slope forecasts future consumption growth. In other words, we already know that the slope has predictive power for the first moment of consumption growth; it is worth exploring whether it has predictive power for second moments.

The analysis, based on quarterly data from 1952 through 1999, produces two main results. The first result overturns the conventional wisdom that consumption volatility is largely unpredictable. There is a strong *negative* relation between the slope of the term structure and the volatility of consumption growth. When the term structure is flatter than usual at the end of quarter t, the standard deviations of growth in log consumption in quarters $t+1$, $t+2$, and $t+3$ are about 1.4 times the corresponding standard deviations when the term structure is steeper than usual. This is not good news for consumption-based models; it says that excess returns are higher when consumption volatility is lower.

Second, there is a strong *negative* relation between the slope of the term structure and correlations between consumption growth and aggregate stock returns. In fact, when the term structure is steeper than usual at the end of quarter t, the quarter $t+1$ correlation is essentially zero. Thus in either a power utility or habit formation framework, we should observe that expected excess stock returns are positive when the term structure is flatter than usual, and zero when the term structure is steeper than usual. In contrast to the results for stock returns, the correlation between consumption growth and long-term bond returns is weak–near zero–regardless of the shape of the term structure. In particular, there is no evidence that the sign of the correlation changes with the slope.

The most surprising of these findings is that stock returns and consumption growth are uncorrelated when the term structure is steeply sloped. I explore this issue further by considering the ability of stock and bond returns to forecast future growth in consumption, GDP, and labor income. I find that when the term structure slope is flatter than usual, future stock and bond returns lead growth in consumption, GDP, and labor income. But when the slope is steeper than usual, this forecasting power disappears.

The main message of these results is that the relation between the macroeconomy and asset (stock and bond) markets depends critically on the information impounded into the slope of the term structure. When the slope is steep, asset returns and the macroeconomy are largely decoupled; when the slope is flatter, the relation is much tighter. A byproduct of this message is that representative agent, consumption-based asset-pricing models are inconsistent with the fact that expected excess returns to stocks and bonds are higher when the slope of the term structure is steep.

The next section reviews what we know about the slope of the term structure, expected excess returns, and consumption-based preferences. Section 3 presents the empirical results. Some concluding comments are offered in Section 4. A description of the data is contained in the Appendix.

2 What do we know?

2.1 Earlier evidence

In the U.S., the return to long-term Treasury bonds less the contemporaneous return to short-term Treasury bills is, on average, slightly positive. This excess return is also predictable with the slope of the yield curve, a decades-old result that is equivalent to the failure of the expectations hypothesis of interest rates. A textbook summary of the evidence is in Chapter 10 of Campbell, Lo, and MacKinlay (1997). Fama and French (1993) note that the low mean and predictable variation together imply that when the slope of the term structure is steep, expected excess returns to bonds exceed zero, while the sign is reversed when the slope is relatively flat or inverted.

The relation between excess returns to the stock market (nominal stock returns less short-term Treasury bill returns) and the slope of the term structure is weaker and more recently discovered. Campbell (1987) first noted that information in the Treasury term structure could forecast excess stock returns. Fama and French (1989) found that the spread between long-term Aaa bond yields and short-term Treasury yields forecast excess stock market returns, although the statistical strength of the forecastability depended on both the sample period (stronger post-war) and the horizon over which forecasts were made (stronger at shorter horizons). Chen (1991) uses the slope of the Treasury term structure to forecast quarterly excess stock returns and finds statistically significant forecasting power for returns one and two quarters ahead.

To get a concrete sense of the predictive power of the term-structure slope in the data set examined in this paper, Table 1 reports the results of regressions of quarterly excess returns on the slope of the term structure. The slope is measured by the difference between a five-year zero-coupon bond yield, interpolated from Treasury coupon bonds, and a three-month Treasury bill yield. The regression is

$$r^k_{t+i} - r^f_{t+i} = b_0 + b_1 SL_t + e^k_{t+i}, \ k \in \{s, b\}, \tag{1}$$

where r^k_{t+i} is the log return in quarter $t+i$ to either the stock market ($k = s$) or long-term Treasury bonds ($k = b$), r^f_{t+i} is the log return to short-maturity Treasury bills, and SL_t is the demeaned slope of the term structure at the end of quarter t. I demean the slope so that the constant term corresponds to the unconditional mean excess return in the sample. The construction of the return data is described in the Appendix. The sample period is 1952:3 through 1999:4, which is the period for which all of the data are available from the Center for Research in Security Prices (CRSP). The t-statistics are adjusted for generalized heteroskedasticity and one lag of moving average residuals using the technique of Newey and West (1987).

The table illustrates that excess returns to long-term bonds are, on average, positive but statistically indistinguishable from zero, and strongly positively associated with the slope. A 100 basis point increase in the slope corresponds to an additional 2.8 percent excess return over the next four quarters. Excess stock returns are, on average, strongly positive, and weakly positively associated with the slope. A 100 basis point increase in the slope corresponds to an additional 3.5 percent excess return over the next four quarters. In results not reported in detail here, I found that this positive relation disappeared from the data after 1983. Thus earlier research, which did not have access to the more recent data, found a stronger relation than reported here and in Campbell (1999). For our purposes, a weak positive relation will turn out to be just as much of a puzzle as a strong positive relation; the real puzzle will be why the relation is not negative.

The slope of the term structure also forecasts economic growth. Chen (1991) and Estrella and Hardouvelis (1991) regress growth rates of real output and consumption on the slope of the yield curve and find that the slope is positively associated with real growth over the next one to two years. Visual evidence is in Figure 1, which plots both the slope of the term structure and the log change in aggregate consumption. Consumption is measured by real expenditures on nondurables and services and is expressed per capita. More details are in the Appendix. The quarter-t slope is measured at quarter-end. The quarter-t change in consumption is measured by log consumption during quarter $t + 1$ less log consumption during quarter t. This flow variable can be thought of as contemporaneous with the point-measured slope if we imagine that all consumption in quarter t takes place at the beginning of the quarter. Campbell (1999) discusses consumption timing conventions in more detail.

We can see from the figure that the recessions of the mid-1970s, the early 1980s, and the early 1990s were all preceded by declines in the slope of the term structure. More formal evidence comes from regressions of log changes in consumption or GDP in quarter $t + i$ on the slope of the term structure at the end of quarter t. The log change in consumption (GDP) from quarter $t + i$ to quarter $t + i + 1$ is denoted Δc_{t+i} (Δgdp_{t+i}).

$$\Delta x_{t+i} = b_{x,i,0} + b_{x,i,1} SL_t + e_{x,t+i}, \; x \in \{c, gdp\}, \; i = -8, \ldots, 8 \tag{2}$$

The sample period is $t \in \{1952{:}3,\ 1999{:}4\}$ for $i \leq 2$. For $i > 3$, the sample period is shorter because the last observations of Δc_t and Δgdp_t are for 2000:2. Figure 2 plots estimated coefficients for each of the 34 regressions (17 each for consumption and GDP, from eight quarterly lags to eight quarterly leads). Also plotted are two-standard-error confidence bounds. The standard errors are adjusted for generalized heteroskedasticity and one lag of moving average residuals using the technique of Newey and West (1987).

Figure 2 displays the standard results that a higher slope at the end of quarter t corresponds to higher consumption and output growth, both contemporaneously and in the future. There is also evidence that consumption and GDP growth slightly lead the slope of the term structure. We will return to the timing between consumption growth and the slope in Section 3.3. We now consider how this empirical evidence is interpreted in the context of consumption-based asset-pricing models.

2.2 Consumption-based preferences

This review closely follows Campbell (1999), which contains more detail. In a discrete-time framework, the gross nominal return to any asset i, denoted $1 + R_{i,t}$, satisfies

$$1 = E_t[(1 + R_{i,t+1})M_{t+1}]. \tag{3}$$

The random variable M_{t+1} is the stochastic discount factor. Equation (3) is a requirement of no arbitrage. In a utility-based framework, we can think of M_{t+1} as the ratio of the marginal utility of a dollar at time $t+1$ to the marginal utility of a dollar at time t. Denote

$r_{i,t} \equiv \log(1+R_{i,t})$, $m_{i,t} \equiv \log(M_{i,t})$, and the riskless nominal rate as r^f_{t+1}. If we assume conditional joint log-normality of $1+R_{i,t+1}$ and M_{t+1}, (3) implies

$$E_t(r_{i,t+1}) - r^f_{t+1} + (1/2)Var_t(r_{i,t+1}) = -Cov_t(r_{t+1}, m_{t+1}). \tag{4}$$

The left-hand-side of (4) is the expected excess return to the asset; the variance term adjusts for Jensen's inequality created by using log returns instead of returns. Consumption-based asset-pricing models put additional content on the right-hand-side by writing m_{t+1} as a function of consumption. For example, time-separable power utility implies

$$m_{t+1} = \log(\delta) - \gamma\Delta c_{t+1} \tag{5}$$

where δ is the rate of time preference, γ is the coefficient of relative risk aversion, and Δc_{t+1} is the change in log consumption. This simple framework is nested in recursive utility, developed by Epstein and Zin (1989) and Weil (1989). In this more general framework, m_{t+1} can be expressed as

$$m_{t+1} = \theta[\log(\delta) - (1/\psi)\Delta c_{t+1}] - (1-\theta)r_{w,t+1} \tag{6}$$

where the elasticity of intertemporal substitution is ψ, $\theta \equiv (1-\gamma)/(1-(1/\psi))$, and the log return to total tradeable wealth, including human capital, is $r_{w,t+1}$. Substituting (6) into (4) yields

$$E_t(r_{i,t+1}) - r^f_{t+1} + (1/2)Var_t(r_{i,t+1}) = (\theta/\psi)Cov_t(r_{i,t+1}, \Delta c_{t+1}) + (1-\theta)Cov_t(r_{i,t+1}, r_{w,t+1}) \tag{7}$$

An important limitation on our ability to test (7) is poor data. The first problem is that consumption is poorly measured. We have very little individual-level data on consumption. In a representative agent model, individual consumption equals per capita aggregate consumption, but aggregate consumption is also measured with substantial noise. Second, consumption is measured infrequently (at best, monthly). This makes it difficult to observe whether there is any time-variation in $Cov_t(r_{i,t+1}, \Delta c_{t+1})$. Third, total wealth, which includes both financial and human wealth, is poorly measured. Financial wealth is measured reasonably well, but human wealth is unobserved. As noted by Roll (1977), even a slight mismeasurement in wealth can substantially distort tests of equations such as (7).

These data problems make it difficult to interpret the empirical evidence that (7) cannot explain the observed time-variation in expected excess returns to stocks and bonds. There is substantial evidence of time-variation in the volatility of returns to financial assets, but this variation appears unrelated to variation in expected excess returns.[1] There is no evidence of substantial time-variation in either the volatility of consumption growth or in covariances of asset returns with consumption growth. We could chalk up these results to poor data, but an alternative explanation is that (6) does not correctly describe preferences.

An alternative preference specification is habit formation, developed by Sundaresan (1989), Constantinides (1990) and Abel (1990). In the habit formation model used by Campbell and Cochrane (1999), surplus consumption is defined as

$$S_t = \frac{C_t - X_t}{C_t} \tag{8}$$

where X_t is the consumption 'habit,' determined by consumption prior to time t. Denoting $s_t \equiv \log(S_t)$, the log of the stochastic discount factor is

$$m_{t+1} = \log(\delta) - \gamma(\Delta s_{t+1} + \Delta c_{t+1}). \tag{9}$$

An important component of this model is that the volatility of log surplus consumption depends on the level of surplus consumption. The conditional standard deviation of s_{t+1} is proportional to a function $\lambda(s_t)$. In the model, s_t and c_t are perfectly conditionally correlated (there is a single shock), allowing expected excess returns to be written as

$$E_t(r_{i,t+1}) - r^f_{t+1} + (1/2)Var_t(r_{i,t+1}) = \gamma(1 + \lambda(s_t))Cov_t(r_{i,t+1}, \Delta c_{t+1}) \tag{10}$$

Habit formation produces time-variation in expected excess returns without variation in $Cov_t(r_{i,t+1}, \Delta c_{t+1})$. If $\lambda(s_t)$ is a decreasing function, consumption gambles are costliest when surplus is low; when current consumption is low relative to habit. This is consistent with the observation by Fama and French (1989) that expected excess returns to assets tend to be countercyclical.

Formal tests of (10) are hindered by the unobservability of s_t. Nonetheless, the empirical evidence discussed earlier in this section suggests that a time-varying price of risk is, by itself,

[1] See Campbell (1999) and Whitelaw (2000) for discussions and references.

insufficient to explain the behavior of expected excess returns to long-term bonds. Because these expected excess returns change sign over time, either $(1 + \lambda(s_t))$ or $Cov_t(r^b_{t+1}, \Delta c_{t+1})$ must change sign. If the former changes sign, consumers switch from avoiding consumption gambles to seeking consumption gambles. This is both intuitively implausible and hard to reconcile with the fact that expected excess returns to other assets, such as stocks, do not appear to exhibit sign changes. Thus the covariance term must change sign.

There is no *a priori* reason to reject models that require the sign of $Cov_t(r^b_{t+1}, \Delta c_{t+1})$ to depend on the slope of the term structure. In fact, Ahn, Dittmar, and Gallant (1999) construct a general equilibrium consumption-based model that accomodates such a relation. Empirically, however, we are brought back to the problem noted with power utility and recursive utility–there is no empirical evidence that covariances move with expected excess returns, let alone that they switch sign.

This lack of evidence indicates that either our models of representative-agent, consumption-based asset prices are wrong, consumption data is too poor to allow us to observe time-varying conditional second moments, or researchers simply have not used the right conditioning information. Existing research has not examined the predictive power of the term-structure slope for conditional variances and covariances involving consumption growth. Given the close link between the term structure and predictable variations in future aggregate output, this is a surprising gap. In the next section, I take a detailed look at the ability of the slope to forecast standard deviations, correlations, and covariances involving consumption growth.

3 The empirical evidence

The main goal of this section is to understand the empirical relation between the slope of the term structure and subsequent covariances between consumption growth and asset returns. It will be illuminating to decompose covariances into standard deviations and correlations. Therefore the first issue addressed here is the predictive power of the term structure slope for subsequent volatilities of consumption growth and asset returns.

3.1 The slope and conditional standard deviations

Perhaps the most intuitive way to see the predictive power of the slope for the volatility of consumption growth is to split the data sample in two, based on whether the slope of the term structure at the end of quarter t is greater or less than average. Then compute sample standard deviations ($sdev$) of Δc_{t+i} for each subsample:

$$sdev(\Delta c_{t+i}|SL_t > 0),\ sdev(\Delta c_{t+i}|SL_t < 0), i > 0. \tag{11}$$

It is worth repeating two definitions from Section 2: SL_t is the demeaned slope at the end of quarter t and Δc_{t+i} is the change in log consumption from quarter $t+i$ to quarter $t+i+1$. (This log change is also multiplied by 100%.) Therefore Δc_{t+1} does not depend on consumption realized before the observation of the term structure.

Table 2 reports these conditional standard deviations for $i = 1, 2, 3$. Three sample periods are considered. The first is the full sample 1952:3 through 1999:4. Because observations of both the slope and consumption growth are most volatile during the Fed monetarist experiment during 1979 through 1982, I also report results for pre-experiment (1952:3 through 1977:4) and post-experiment (1983:1 through 1999:4) periods.

The results demonstrate that the volatility of consumption growth is substantially higher when the slope of the term structure is flatter than usual. In the full sample, the ratios of low-slope standard deviations to high-slope standard deviations range from 1.33 to 1.45. This pattern holds over the subperiods. In the non-experiment subperiods, the ratios range from 1.13 to 1.58. They average 1.32 in the early period and 1.34 in the later period. F-tests overwhelmingly reject the hypothesis of constant variances. These tests are not reported in detail because the assumption of normality may be inappropriate. Alternative statistical tests are discussed below.

This evidence indicates that consumption growth is far from iid. Instead, a steep term structure slope forecasts high-mean, low-volatility consumption growth. Although in this paper, our primary focus is on covariances of returns with consumption growth, these results on volatility have implications for general equilibrium models of asset pricing. A common approach to exploring issues such as the equity premium puzzle is to model the stock market as a claim on the consumption process (e.g., Whitelaw (2000)). Then the variance of consumption growth is used to measure the risk exposure associated with stocks. These results indicate that this risk exposure is higher when the term structure is flatter. In power utility or recursive utility setups, this implies higher expected excess stock returns when the term structure is flatter, which is counterfactual.

A natural question is whether this pattern in consumption volatility carries over to the volatility of asset returns. The remainder of Table 2 reports versions of (11) for excess returns to the aggregate stock market (denoted er^s_t) and long-term bonds (er^b_t). The returns are expressed in percent. The evidence indicates that the predictive power of the slope for asset return volatility is weaker than that for consumption growth volatility. In the full sample, ratios of low-slope standard deviations to high-slope standard deviations are about 1.19 for stock returns and 1.06 for bond returns.

I now take a more formal look at the relation between the slope of the term structure and future volatility of consumption growth and asset returns. Following the two-step procedure used by Schwert (1989) and subsequently adopted by many others, I first construct innovations to the time series. Denoting the dependent variable by x_{t+i}, I use ordinary least squares to estimate

$$x_{t+i} = b_0 + b_1 SL_t + b_2 x_{t+i-1} + \epsilon_{t+i}. \tag{12}$$

I then estimate the relation between the volatility of the shock in (12) and the slope of the term structure. I use both squared residuals, and following Schwert (1989), absolute residuals in this stage. The use of absolute residuals is more robust to outliers.

$$\epsilon_{t+i}^2 = c_0 + c_1 SL_t + \eta_{t+i} \tag{13}$$

$$|\epsilon_{t+i}| = d_0 + d_1 SL_t + \zeta_{t+i} \tag{14}$$

Because SL_t is mean-zero, the constant term is the sample mean of the dependent variable. The results of this second stage are reported in Table 3. Asymptotic t-statistics are corrected for generalized heteroskedasticity using the technique of White (1980). There is a statistically significant negative relation between the slope of the term structure and the subsequent volatility of innovations in consumption growth. The evidence is somewhat stronger for absolute residuals than squared residuals. The relation between the slope and the subsequent volatility of innovations in returns is also negative, but statistically weaker. Of course, if our goal were to simply link the slope of the term structure to the volatility of asset returns, we would use higher-frequency data to obtain more powerful results.

Recall from (7) and (10) that the variance of log asset returns affects expected asset returns through Jensen's inequality. It is worth noting that even though variances are lower when the slope is steep, the Jensen's inequality term is not large enough to significantly affect the conclusions from Table 1 about the predictability of excess returns. For example, Table 3 indicates that a 100 basis point increase in the quarter-t slope corresponds to $43(\%^2)$ decrease in the variance of stock returns over the next three quarters. Plugging this into the Jensen's inequality term corresponds to a decrease in expected excess returns of about 22 basis points over the three quarters. This is swamped by the numbers in Table 1, where a 100 basis point increase in the slope corresponds to an increase in expected excess log returns over three quarters of 317 basis points.

3.2 The slope, conditional correlations, and covariances

As with conditional volatilities, perhaps the most intuitive way to see the predictive power of the slope for correlations involving consumption growth is to split the data sample based on the slope of the term structure at the end of quarter t and compute correlation matrices for each subsample. The variables of interest are Δc_{t+1}, er^s_{t+1}, er^b_{t+1} and the log change in real per capita labor income, Δli_{t+1}. The latter variable is included because, as argued by Lettau and Ludvigson (2001), it is a proxy for the return to human capital. The definition of labor income follows Lettau and Ludvigson.

Table 4 reports these conditional correlation matrices for the three sample periods examined in Table 2. Three features of this table are striking. First, the correlation between the stock market and consumption growth strongly depends on the slope. When the slope is less steep than usual, the contemporaneous correlation between future stock returns and consumption growth is around 0.4 in all sample periods. But when the slope is steeper than usual, the correlation is roughly zero, ranging from 0.06 to -0.16 across the samples.

Second, the correlation between the stock market and labor income growth also strongly depends on the slope. When the slope is less steep, the contemporaneous correlation between future stock returns and labor income is 0.30 in the full sample. When the slope is steeper, the correlation is -0.07.

Third, there is no clear relation between the slope and the magnitude of the correlation between long-term bond returns and consumption growth. When the slope is less steep than usual, the correlation is close to zero and of uncertain sign, ranging from 0.12 to -0.17 in the samples. When the slope is steeper than usual, the correlations remain small, ranging from 0.18 to 0.06. Although none are negative, suggesting that correlations are higher when the slope is steeper, in the full sample the correlation is actually lower when the slope is steeper: 0.06 versus 0.12.

All three observations are bad news for consumption-based asset-pricing models. The first observation suggests that in either power utility or habit formation models, expected excess stock returns should be roughly zero when the slope is steeper than usual. At those times, stocks have consumption betas of zero; regardless of the price of risk, stocks should earn no risk premium. The second observation suggests that with recursive utility, expected excess stock returns should also be lower when the slope is steep. Labor income is an important component to the return to human capital. Therefore a lower correlation between the stock market and labor income suggests a lower correlation between the stock market and total wealth. Hence with (7), both sources of time-variation in expected excess returns lead to a counterfactual conclusion. The third observation indicates that neither power utility nor habit formation can explain the sign-switching in expected excess returns to bonds. The relation between excess returns to long-term bonds and consumption growth is weak regardless of the state of the term structure.

A graphical look at the relation between stock returns and consumption growth will help summarize some of the empirical evidence. Figure 3 displays two scatter plots of er^s_{t+1} and Δc_{t+1}, based on the slope of the term structure at the end of quarter t. In the upper scatter plot, which corresponds to steeper slopes, mean consumption growth is higher than in the lower scatter plot, (compare the vertical solid lines), mean excess stock returns are higher (compare the horizontal solid lines), and both consumption growth and stock returns are less volatile (compare the dispersion of the clouds). In the upper scatter plot, there is no observable correlation, while in the lower plot the two variables are clearly positively correlated. For example, in the bottom panel, there are 11 quarters in which the stock market fell by at least 10 percent; contemporaneous consumption growth (again, measured by the change from quarter $t+1$ to quarter $t+2$) was below its sample mean in 10 of the 11 quarters.

We now combine the information about volatilities and correlations into information about covariances. As with Table 3, I follow a two-step procedure. Quarter $t+1$ residuals in consumption growth and asset returns are calculated by regressions on variables determined prior to quarter $t+1$. Then the product of the residuals is regressed on the demeaned slope of the yield curve.

$$\Delta c_{t+1} = b_0 + b_1 SL_t + b_2 \Delta c_{t-1} + \epsilon_{c,t+1} \tag{15}$$

$$er^k_{t+1} = b_{k,0} + b_{k,1} SL_t + b_2 er^k_t + \epsilon_{k,t+1}, \; k \in \{s, b\} \tag{16}$$

$$(\epsilon_{c,t+1})(\epsilon_{k,t+1}) = d_0 + d_1 SL_t + \eta_{t+1}, \; k \in \{s, b\} \tag{17}$$

In (15), Δc_{t-1} is used as an explanatory variable instead of Δc_t because Δc_t is partially determined by consumption realized after the end of quarter t. In (17), the estimated coefficient d_0 is the mean covariance in the sample and d_1 tells us how this covariance changes conditional on a 100 basis point change in the quarter-t slope of the term structure. The top panel of Table 5 reports the results from (17). Three sample periods are examined: The full 1952:3 through 1999:4 period and the pre-experiment (1952:3–1977:4) and post-experiment (1983:1–1999:4) periods. Asymptotic t statistics are corrected for generalized heteroskedasticity using the technique of White (1980).

The results are not surprising, given what we have seen in Tables 2 through 4. The average covariance between stock returns and consumption growth is positive and (aside from the short post-experiment period) statistically significant. A steeper slope in quarter t reduces this covariance. The point estimate for the full sample indicates that an increase (decrease) in the slope of 119 basis points corresponds to a zero (doubled) covariance. In the full sample, this difference is overwhelmingly statistically significant. In each of the subsamples, the economic significance of the slope is actually larger than in the full sample, but the periods are too short to draw statistically strong conclusions.

By contrast, the average covariance between bond returns and consumption growth is statistically indistinguishable from zero, as is the relation between the slope and the covariance. The point estimates indicate that in the full sample, a steep slope corresponds to a slightly lower covariance, while in the subsamples, the reverse holds.

Panel B of Table 5 offers a slightly different perspective on the relation between the slope of the term structure and covariances between consumption growth and asset returns. I reestimate (15) through (17), replacing the constant term and the demeaned slope SL_t with two dummy variables. The first equals one if the slope is greater than its sample mean and the second equals one if the slope is less than its sample mean. The table reports the estimated coefficients on the dummy variables of (17). The results indicate that when the slope is steeper than usual, the covariances between consumption growth and both stock and bond returns are statistically indistinguishable from zero.

If all of these estimates of covariances between consumption growth and asset returns were indistinguishable from zero, we could reconcile them with consumption-based theories by chalking the results up to bad consumption data. If these estimates did not exhibit any time-variation, could chalk the results up to a combination of bad data and infrequent observations. But there is enough information in the consumption data to infer a strong pattern in the covariance between consumption growth and stock returns. Thus the lack of a pattern in covariances involving bond returns likely reflects the true economic relation between aggregate consumption and the bond market.

3.3 Data-mining for evidence of habit formation

If someone has strong priors that habit formation accounts for the positive relation between the slope and expected excess returns, they might interpret the preceding evidence as follows. Although a steep slope corresponds to a low covariance between stock returns and consumption growth, that covariance is not literally zero. As long as it is positive, and the variation in risk premia owing to habit formation is sufficiently strong, then the relatively low consumption associated with a steep term structure can drive high expected excess returns. The relation between bond returns and the slope is more difficult to finesse. The covariance between consumption growth and bond returns is always close to zero, but it possibly switches sign depending on the slope. If the magnitude of the change in the covariance is small, tests such as those in Table 5 will not pick it up. This sign-switching, combined with large variations in risk premia owing to habit formation, can conceivably produce what we see in the data.

I cannot rule out this story. However, we have already seen some evidence that casts doubt on it. The top panel of Figure 2 shows that when the slope of the term structure is steep in quarter t, contemporaneous and future consumption growth is high, indicating that consumption in quarter t is low relative to future consumption. But it is not particularly low relative to *past* consumption. A steep slope in quarter t corresponds to flat or increasing consumption for a few quarters prior to t. If habit is based on consumption within, say, the past year, a steep slope should correspond to high surplus consumption, not low surplus consumption.

Theory does not provide guidance on persistence of habit. I therefore perform some exploratory data analysis to estimate this persistence. I operationally measure log surplus consumption in quarter t as log consumption less the mean of log consumption during the previous k quarters.

$$s_t \equiv c_t - \frac{1}{k}\sum_{i=1}^{k} c_{t-i} \tag{18}$$

I then choose k to maximize the R^2 in a regression of quarter $t+1$ excess stock returns on s_t.

$$er^s_{t+1} = b_0 + b_1 s_t + e_{t+1} \tag{19}$$

The sample period is $t \in \{1952{:}2,\ 1999{:}3\}$; I consider a range of k from one to twelve quarters.

I do not report the results in detail here. I found that $k = 9$ in (18) produced an $R^2 = 0.0208$ in (19), which was the maximum among all k.

Given this measure of surplus consumption (with $k = 9$), we can ask whether it captures the explanatory power of the slope for future excess returns. I therefore repeat the regressions in Table 1, now including both the slope and s_t as explanatory variables. The results are displayed in Table 6. A comparison of these results with those in Table 1 reveal that the inclusion of s_t has very little effect on the estimated slope coefficients. This is because s_t is essentially unrelated to the slope of the term structure. The sample correlation between s_t and SL_t is only -0.08. Also note that, although s_t has modest explanatory power for excess stock returns (not surprisingly, given the way in which s_t was constructed), it has no explanatory power for excess bond returns.

The evidence reported in sections 3.1, 3.2, and 3.3 is difficult to incorporate into the standard representative-agent, consumption-based theories of asset pricing. It also raises broader questions about the relation between asset returns and business cycles. I investigate some of these questions below.

3.4 Predicting business cycles with asset returns

Asset returns forecast business cycles. Increases in stock prices correspond to contemporaneous and future increases in aggregate consumption, output, and income.[2] Returns to long-term bonds also forecast business cycles, although this forecasting power is typically expressed in terms of changes in interest rates.[3] The evidence in Tables 4 and 5 suggests that the strength of these forecasts may depend on the slope of the term structure. We have seen that the relation between the excess stock return in quarter t and consumption growth from quarter t to quarter $t + 1$ depends on the slope of the term structure. Is the same dependence to be found in more distant growth rates and with other macroeconomic variables? I explore this question here.

My approach is to slightly modify linear forecasts of macroeconomic growth rates by allowing the parameters to depend on the term structure slope. Define D_SLOPE_t as a dummy variable that equals one if the slope of the term structure is greater than its sample mean at the end of quarter t. I estimate regressions of the following form:

$$\Delta x_{t+i} = b_0 + b_1 D\_SLOPE_t + (b_2 + b_3 D\_SLOPE_t) er^k_{t+1} + e_{k,t+i}, \;\; k = \{s, b\} \qquad (20)$$

[2]See, e.g., Fischer and Merton (1984) or Barro (1989).

[3]See Estrella and Mishkin (1998) for some recent evidence.

where Δx_{t+i} is the change in the log of aggregate consumption, GDP, or labor income from quarter $t+i$ to quarter $t+i+1$. (All variables are aggregate, real, per capita.) The results of estimating (20) from 1952:3 through 1999:4 are displayed in Table 7. The coefficient b_1 reflects the direct forecasting power of the quarter-t slope for future macroeconomic growth. The coefficient b_2 reflects the forecasting power of stock (er^s_{t+1}) or bond (er^b_{t+1}) return when the quarter-t slope is less steep than usual, while the sum b_2+b_3 reflects the forecasting power when the slope is steeper than usual. Asymptotic t-statistics are adjusted for generalized heteroskedasticity and one lag of moving average residuals using the technique of Newey and West (1987).

There are three main points to take from Table 7. First, when the term structure slope at the end of quarter t is flatter than usual, the stock market excess return in quarter $t+1$ is a strong forecaster of the growth of consumption, GDP, and labor income from both $t+1$ to $t+2$ and $t+2$ to $t+3$. Each of these six estimates of b_2 is significantly greater than zero at the five percent level. The forecasting power dies off for growth from $t+3$ to $t+4$.

Second, the forecasting power of the stock market significantly differs when the term structure slope is steeper than usual. For five of the six regressions for which b_2 is significant, b_3 is negative and significantly different from zero. The sum b_2+b_3 is statistically indistinguishable from zero in each of the regressions. (This is not reported in the table.) In other words, when the slope is steeper than usual, the forecasting ability of the stock market is nonexistent.

Third, the relation between bond returns and macroeconomic growth roughly corresponds to that between stock returns and macroeconomic growth. When the slope is flatter than usual, bond excess returns forecast future growth in consumption, output, and income; the growth is concentrated from quarter $t+2$ to quarter $t+3$. When the slope is steeper than usual, this forecasting power disappears.

These results are puzzling. Their main message is that the relation between asset returns and the business cycle is predictably strong or weak, depending on the slope of the term structure. More generally, these results suggest that the kinds of shocks that hit the economy when the term structure is steep are qualitatively different from the kinds of shocks that hit when the term structure is less steep. In this paper, I make no attempt to explore the reasons why these qualitative differences exist. Instead, I simply note that the results imply linear regressions (including vector autoregressions) that link asset returns with business cycles are misspecified. The usual joke about the stock market is that it has forecasted $x+y$ of the past x recessions, $y>0$.[4] The results here suggest that the y recessions that did not materialize may have been forecasted when the slope of the term structure was steep.

[4]This formulation of the joke seems to take much of the humor out of it ...

3.5 What drives stock and bond prices?

What kinds of news cause movements in stock and bond prices? Stock prices should respond to news about expected future cash flows and discount rates, while bond prices should respond to news about expected future interest rates. Realizations of cash flows, discount rates, and future interest rates are noisy measures of these expectations. Thus a standard test of models of asset-price determination is to regress asset returns on future realizations of relevant variables.[5] I follow the same approach here in examining whether the explanatory power of future variables for current asset returns depends on the slope of the yield curve.

I start with stock returns. Following the results of Fama (1990), I use future realizations of output growth to explain quarterly excess stock returns. I also use growth in after-tax profits $\Delta\pi_t$, which are a more direct measure of expected future cash flows. The regression is

$$er^s_{t+1} = b_0 + b_1\Delta\pi_t + b_2\Delta\pi_{t+1} + b_3\Delta gdp_{t+1} + b_4\Delta gdp_{t+2} + e_{s,t+1}. \tag{21}$$

The inclusion of $\Delta\pi_t$ in (21) does not necessarily capture variations in expected returns. Recall that growth rates in real variables are defined as the change from the current quarter to the next quarter, thus $\Delta\pi_t$ is not known until the end of quarter $t + 1$. The number of leads included in the regression was determined by data-mining; I had included more leads but they were found to have no explanatory power.

I estimate (21) on two samples formed by splitting the data from 1952:3 through 1999:4 based on the slope of the term structure at the end of quarter t. For each sample, three regressions are estimated: One uses only GDP growth, another uses only after-tax profits, and the third includes both sets of explanatory variables. Asymptotic t-statistics are adjusted for generalized heteroskedasticity using the technique of White (1980). The results are displayed in Table 8.

The table reports that when the slope of the term structure is flatter than usual, growth in both after-tax profits and GDP help explain stock returns (although the growth of GDP has more explanatory power). The R^2 of the regression when all four variables are included is 26 percent. Not surprisingly, given the results throughout the rest of this paper, the explanatory power of these variables is substantially weaker when the slope is steeper than usual. No single explanatory variable is statistically significant at the five percent level, and the R^2 using all variables is only four percent.

Before attempting to interpret this evidence, I note another key result in the table.

[5] See Fama (1990) for an implementation of this approach and references to earlier research.

Notwithstanding the differences in R^2, the residual standard error is higher when the term structure slope is flatter. This is consistent with the evidence from Table 2, which reported that excess stock returns are more volatile when the slope is flatter. Thus it appears that when the slope is flatter than usual, the economy is subject to a type of shock that jointly affects stock returns and output. When the slope is steeper than usual, this source of uncertainty disappears.

I now turn to bond returns. The expectations hypothesis of interest rates implies that returns to long-term bonds are determined by changes in expectations of future short-term interest rates. Although the expectations hypothesis is a simplistic description of bond behavior, the link between long-term bond yields and future short-term interest rates is robust.[6] I therefore use contemporaneous and future changes in short-term interest rates (three-month bill yields, denoted y_t) to explain excess returns to long-term bonds. I also include future changes in GDP growth, which may contain information about both bond risk premia and future short-term interest rates.

$$er^b_{t+1} = b_0 + b_1 \Delta y_{t+1} + b_2 \Delta y_{t+2} + b_3 \Delta gdp_{t+1} + b_4 \Delta gdp_{t+2} + e_{b,t+1} \tag{22}$$

The change Δy_t is defined as the three-month bill yield at the end of quarter t less the three-month bill yield at the end of quarter $t-1$. As with (21), the number of leads included in (22) was determined by data-mining. I estimate (22) on two samples formed by splitting the data from 1952:3 through 1999:4 based on the slope of the term structure at the end of quarter t. The results are displayed in Table 9, which mirrors Table 8 in construction.

The results show that regardless of the slope of the term structure, excess returns to long-term bonds are closely related to short-term interest rates. When the changes in short-term yields are the only explanatory variables, the R^2 is 49 percent for the steeper-slope regression and 56 percent for the flatter-slope regression. There are, however, two differences across the sets of results. First, when the slope is steeper than usual, long-term bond prices react to information about both current-quarter and next-quarter short-term rates. When the slope is less steep, bond prices react to current-quarter rates but not next-quarter rates, suggesting that short-term rates may be less forecastable at such times. Second, the growth of GDP has more explanatory power when the slope is less steep, which is consistent with the results from the stock return regressions.

The evidence in Tables 8 and 9 does not do much to advance our understanding of what drives stock and bond returns. If anything, they deepen our confusion. In particular, when

[6] See Campbell and Shiller (1991).

the term structure is steep, stock returns do not appear to be related to profits or output. In results that are not detailed here, I have run many additional regressions, attempting to find a variable–such as real interest rates, inflation, or investment–that has more explanatory power. The results of these regressions can be inferred from their absence in this paper.

4 Concluding comments

This paper began as an attempt to explain, in the context of representative-agent consumption models, why the slope of the term structure forecasts excess returns to stocks and bonds. This exercise failed. More precisely, if we did not know that a higher slope corresponded to higher expected returns, the combination of these asset-pricing models and the evidence reported here would lead us to believe that a higher slope corresponded to *lower* expected excess returns for stocks and unchanged expected excess returns for bonds.

A potential response to this inconsistency is to retain the idea of consumption-based models but reject the assumption of a representative agent. But it is not clear how models with heterogeneous agents will be more successful at generating a covariance between bond returns and (individual) consumption growth that switches sign, depending on the slope of the term structure. The fact that expected excess returns to bonds change sign over time is a major challenge for any asset-pricing model.

Perhaps the more interesting conclusion here is that the relation between asset returns and the macroeconomy is highly dependent on the slope of the term structure. When the slope is flatter than usual, the economy appears to be subject to a kind of shock that affects the current stock market and future short-run (one or two quarters out) economic activity. This shock drives the observed correlation between the stock market and future output. But when the slope is steeper than usual, whatever drives the shock is missing. At those times, stock returns are largely unrelated to future output. What creates this shock? A plausible suspect is monetary policy. When the slope is relatively flat, the central bank is more concerned about the possibility of a recession and may be more prone to take action. Testing this story is beyond the scope of the current paper, but is an interesting question for future work.

Appendix

This appendix describes the sources of the data used in this paper.

1. Excess stock returns

   Monthly raw aggregate stock returns are measured by the continuously-compounded return to the Center for Research in Security Prices (CRSP) NYSE/Amex/Nasdaq value-weighted index. Monthly excess returns are produced by subtracting the continuously-compounded return to a three-month Treasury bill, also from CRSP. Quarterly excess returns are constructed by summing the monthly excess returns. The data are expressed in percent and range from 1952:3 through 1999:4.

2. Excess bond returns

   Monthly raw returns to long-maturity Treasury bonds are measured by the continuously-compounded return to a CRSP-constructed portfolio of Treasury bonds with maturities between five and ten years. Monthly and quarterly excess returns are produced following the construction of stock returns. The data are expressed in percent and range from 1952:3 through 1999:4.

3. Term structure slope

   The slope of the term structure is measured by the difference between a five-year zero-coupon Treasury bond yield (interpolated from coupon bond yields by CRSP) and a three-month Treasury bill yield (also from CRSP). The yields are expressed in percent/year and range from 1952:3 through 1999:4.

4. Short-term interest rates

   Short-term interest rates are measured by a three-month Treasury bill yield, from CRSP. The rates are expressed in percent/year and range from 1952:3 through 1999:4.

5. NIPA data

   National Income and Product Accounts (NIPA) data are from the Bureau of Economic Analysis (BEA) web site (publication date November 29, 2000). Gross domestic product (GDP) is divided by the GDP deflator and by mid-quarter U.S. population (also from the BEA web site). Aggregate consumption is measured by the sum of real expenditures on nondurables (divided by the nondurables deflator) and services (divided by the services deflator), divided by the U.S. population. The definition of labor income follows Lettau and Ludvigson (2001). It is divided by the deflator for personal consumption expenditures (PCE) and U.S. population. After-tax corporate profits are measured by the NIPA measure of profits after tax, adjusted for inventory valuation and capital consumption. The result is divided by the PCE deflator. The NIPA data range from 1947:1 through 2000:3.

Quarters Ahead (i)	Stock Return Regressions Constant	Slope	R^2	Bond Return Regressions Constant	Slope	R^2
1	1.579	0.953	0.014	0.143	0.734	0.055
(189 obs)	(2.64)	(1.70)		(0.67)	(2.05)	
2	1.545	0.999	0.016	0.140	0.700	0.051
(188 obs)	(2.58)	(1.44)		(0.65)	(2.49)	
3	1.566	1.222	0.024	0.145	0.802	0.066
(187 obs)	(2.59)	(1.76)		(0.67)	(3.15)	
4	1.597	0.308	0.002	0.152	0.537	0.030
(186 obs)	(2.61)	(0.52)		(0.68)	(1.88)	

Table 1: Forecasting Excess Returns With the Term Structure Slope, 1952:3–1999:4

Quarter $t + i$ excess log returns to stock and Treasury bond portfolios are regressed on the demeaned slope of the yield curve as of the end of quarter t. The stock portfolio is the CRSP value-weighted index. The bond portfolio is a portfolio of Treasury bonds with maturities between five and ten years. Excess returns are produced by subtracting the return to a three-month Treasury bill. The slope is measured by the five-year zero-coupon yield less the three-month zero-coupon yield. All variables are expressed in percent. Asymptotic t-statistics, adjusted for generalized heteroskedasticity and one lag of moving-average residuals, are in parentheses.

Sample period	Variable	Slope > mean	Slope < mean
1952:3-1999:4	Δc_{t+1}	0.400	0.530
	Δc_{t+2}	0.383	0.554
	Δc_{t+3}	0.378	0.549
	er^s_{t+1}	7.251	8.799
	er^s_{t+2}	7.676	8.543
	er^s_{t+3}	7.225	9.041
	er^b_{t+1}	3.158	3.202
	er^b_{t+2}	2.975	3.431
	er^b_{t+3}	3.149	3.228
1952:3-1977:4	Δc_{t+1}	0.444	0.566
	Δc_{t+2}	0.425	0.569
	Δc_{t+3}	0.422	0.573
	er^s_{t+1}	7.531	8.645
	er^s_{t+2}	7.736	8.756
	er^s_{t+3}	8.176	8.526
	er^b_{t+1}	2.345	1.901
	er^b_{t+2}	2.321	2.010
	er^b_{t+3}	2.078	2.250
1983:1-1999:4	Δc_{t+1}	0.341	0.386
	Δc_{t+2}	0.315	0.404
	Δc_{t+3}	0.275	0.434
	er^s_{t+1}	7.124	8.215
	er^s_{t+2}	7.784	7.824
	er^s_{t+3}	4.974	10.002
	er^b_{t+1}	3.544	2.901
	er^b_{t+2}	3.634	2.647
	er^b_{t+3}	3.752	2.795

Table 2: The volatilities of asset returns and aggregate consumption growth, conditioned on the slope of the yield curve

The log change in aggregate per capita real consumption on nondurables and services from quarter $t+i$ to quarter $t+i+1$ is denoted Δc_{t+i}. The excess log return to the aggregate stock market in quarter $t+i$ is denoted er^s_{t+i}. The excess log return to a portfolio of long-term Treasury bonds in quarter $t+i$ is denoted er^b_{t+i}. The quarter-end term-structure slope is measured by the five-year zero-coupon yield less the three-month zero-coupon yield. All variables are expressed in percent. This table reports $sdev(x_{t+i}|slope_t > mean\ slope)$ and $sdev(x_{t+i}|slope_t < mean\ slope)$.

Dependent Variable	Squared residuals Constant	Squared residuals Slope	Absolute residuals Constant	Absolute residuals Slope
Δc_{t+1}	0.194	-0.058	0.341	-0.049
(190 obs)	(8.32)	(-2.24)	(17.15)	(-2.53)
Δc_{t+2}	0.190	-0.050	0.336	-0.046
(190 obs)	(8.16)	(-2.18)	(16.97)	(-2.48)
Δc_{t+3}	0.192	-0.043	0.339	-0.034
(189 obs)	(8.17)	(-1.94)	(16.97)	(-1.87)
er^s_{t+1}	64.78	-6.700	6.092	-0.459
(189 obs)	(6.80)	(-0.79)	(15.99)	(-1.20)
er^s_{t+2}	64.84	-15.39	6.127	-0.795
(188 obs)	(7.04)	(-1.41)	(16.28)	(-1.97)
er^s_{t+3}	64.60	-21.82	6.115	-1.192
(187 obs)	(7.11)	(-2.61)	(16.50)	(-3.69)
er^b_{t+1}	9.527	-4.158	2.201	-0.144
(189 obs)	(6.29)	(-1.01)	(14.02)	(-0.49)
er^b_{t+2}	9.652	-4.358	2.253	-0.190
(188 obs)	(6.47)	(-1.38)	(14.51)	(-0.78)
er^b_{t+3}	9.530	-2.143	2.279	-0.077
(187 obs)	(6.88)	(-0.95)	(14.97)	(-0.37)

Table 3: Using the term structure slope to forecast the volatility of consumption and asset returns, 1952:3 through 1999:4

Innovations in log consumption growth (Δc_t), excess log returns to the stock market (er^s_t), and excess log returns to a portfolio of long-maturity Treasury bonds (er^b_t) are constructed by regressing the quarter $t+i$ observation on its own lag and the demeaned slope of the term structure at the end of quarter t. All variables are in percent. Squared and absolute innovations are then regressed on the slope variable. This table reports parameter estimates from this second stage. Asymptotic t statistics, corrected for generalized heteroskedasticity, are in parentheses.

Sample period	Variable	Slope > mean				Slope < mean			
		Δc_{t+1}	Δli_{t+1}	er^s_{t+1}	er^b_{t+1}	Δc_{t+1}	Δli_{t+1}	er^s_{t+1}	er^b_{t+1}
1952:3-1999:4	Δc_{t+1}	1.00				1.00			
	Δli_{t+1}	0.42	1.00			0.66	1.00		
	er^s_{t+1}	0.03	-0.07	1.00		0.39	0.30	1.00	
	er^b_{t+1}	0.06	0.02	0.19	1.00	0.12	0.04	0.21	1.00
1952:3-1977:4	Δc_{t+1}	1.00				1.00			
	Δli_{t+1}	0.46	1.00			0.70	1.00		
	er^s_{t+1}	0.06	0.01	1.00		0.41	0.40	1.00	
	er^b_{t+1}	0.09	-0.03	0.23	1.00	-0.17	-0.17	0.05	1.00
1983:1-1999:4	Δc_{t+1}	1.00				1.00			
	Δli_{t+1}	0.37	1.00			0.42	1.00		
	er^s_{t+1}	-0.16	-0.08	1.00		0.43	0.07	1.00	
	er^b_{t+1}	0.18	0.05	0.22	1.00	-0.14	0.16	0.04	1.00

Table 4: Conditional correlations among asset returns and real variables

Log-differenced aggregate consumption, Δc_t, is defined in Table 2. Log-differenced labor income, Δli_t, is defined similarly. The excess log return to the aggregate stock market in quarter t+1 is denoted er^s_{t+1}. The excess log return to a portfolio of long-term Treasury bonds in quarter $t+1$ is denoted er^b_{t+1}. All variables are expressed in percent. The correlations are conditioned on whether the slope of the yield curve at the end of quarter t is steeper or flatter than its mean.

Panel A. Conditioning on the slope of the yield curve

Sample period	Stock market Constant	Stock market Slope	Bond market Constant	Bond market Slope
1952:3–1999:4	0.997	-0.838	0.113	-0.275
(189 obs)	(3.48)	(-3.15)	(1.05)	(-1.25)
1952:3–1977:4	1.146	-0.950	-0.033	0.165
(102 obs)	(2.81)	(-1.53)	(-0.32)	(1.22)
1983:1–1999:4	0.486	-1.360	0.003	0.184
(67 obs)	(0.94)	(-1.95)	(0.03)	(1.63)

Panel B. Conditioning on whether the slope is steeper than usual

Sample period	Stock market Slope > mean	Stock market Slope < mean	Bond market Slope > mean	Bond market Slope < mean
1952:3–1999:4	0.216	1.818	0.065	0.247
(189 obs)	(0.81)	(3.49)	(0.57)	(1.03)
1952:3–1977:4	0.473	1.794	0.150	-0.183
(102 obs)	(1.20)	(2.60)	(1.14)	(-1.16)
1983:1–1999:4	-0.407	1.458	0.159	-0.141
(87 obs)	(-0.87)	(1.58)	(0.84)	(-1.01)

Table 5: Conditional covariances between consumption growth and excess returns to stocks and bonds

Panel A: A two-step procedure is used to estimate the relation between the slope of the term structure at the end of quarter t and the covariances between consumption growth and asset returns in quarter $t+1$. In step one, quarter $t+1$ innovations in log consumption growth and excess log returns are constructed by regressing each variable on the demeaned slope and a lag of the dependent variable. In step two, the product of the innovations in consumption growth and asset returns is regressed on the demeaned slope. The panel reports the results from step two. Panel B: The same as Panel A except the slope variable is replaced with a dummy indicating whether the slope is greater or less than its sample mean. Asymptotic t statistics, corrected for generalized heteroskedasticity, are in parentheses.

Quarters Ahead (i)	Stock Return Regressions Slope	Rel Cons	R^2	Bond Return Regressions Slope	Rel Cons	R^2
1	0.865	-0.845	0.032	0.724	-0.088	0.057
(189 obs)	(1.49)	(-1.62)		(2.00)	(-0.45)	
2	0.920	-0.750	0.030	0.690	-0.096	0.052
(188 obs)	(1.31)	(-1.51)		(2.37)	(-0.46)	
3	1.142	-0.763	0.038	0.785	-0.163	0.071
(187 obs)	(1.58)	(-1.54)		(2.97)	(-0.80)	
4	0.229	-0.759	0.016	0.524	-0.123	0.032
(186 obs)	(0.38)	(-1.44)		(1.80)	(-0.59)	

Table 6: Forecasting Excess Returns With the Term Structure Slope and Relative Consumption, 1952:3–1999:4

Quarter $t + i$ excess log returns to stock and Treasury bond portfolios are regressed on the demeaned slope of the yield curve as of the end of quarter t and relative consumption during quarter t. The stock portfolio is the CRSP value-weighted index. The bond portfolio is a portfolio of Treasury bonds with maturities between five and ten years. Excess returns are produced by subtracting the return to a three-month Treasury bill. The slope is measured by the five-year zero-coupon yield less the three-month zero-coupon yield. Relative consumption is measured by log consumption during quarter t less the mean of the previous nine quarters of log consumption. All variables are expressed in percent. Asymptotic t-statistics are adjusted for generalized heteroskedasticity and one lag of moving-average residuals.

Dependent Variable	Stock return regressions b_1	b_2	b_3	R^2	Bond return regressions b_1	b_2	b_3	R^2
Δc_{t+1}	0.167	0.024	-0.022	0.126	0.157	0.019	-0.012	0.040
	(2.22)	(4.12)	(-2.88)		(2.10)	(0.95)	(-0.52)	
Δc_{t+2}	0.176	0.014	-0.018	0.065	0.150	0.033	-0.030	0.053
	(2.35)	(3.01)	(-2.62)		(1.99)	(2.43)	(-1.48)	
Δc_{t+3}	0.171	0.003	-0.005	0.032	0.165	0.020	-0.030	0.041
	(2.27)	(0.52)	(-0.68)		(2.23)	(0.92)	(-1.28)	
Δgdp_{t+1}	0.562	0.040	-0.036	0.150	0.600	-0.017	-0.039	0.103
	(3.84)	(3.55)	(-2.46)		(4.13)	(-0.40)	(-0.84)	
Δgdp_{t+2}	0.606	0.051	-0.038	0.213	0.617	0.098	-0.123	0.160
	(4.37)	(5.58)	(-2.63)		(4.36)	(4.58)	(-3.91)	
Δgdp_{t+3}	0.419	0.023	-0.014	0.074	0.419	0.063	-0.058	0.072
	(2.78)	(1.69)	(-0.85)		(2.78)	(1.65)	(-1.33)	
Δli_{t+1}	0.179	0.031	-0.039	0.057	0.144	0.012	-0.008	0.008
	(1.38)	(2.41)	(-2.21)		(1.03)	(0.35)	(-0.20)	
Δli_{t+2}	0.249	0.022	-0.017	0.047	0.252	0.024	-0.023	0.025
	(1.89)	(2.12)	(-1.24)		(1.93)	(1.49)	(-0.71)	
Δli_{t+3}	0.040	-0.010	0.025	0.015	0.091	0.004	-0.014	0.003
	(0.29)	(-0.56)	(1.38)		(0.68)	(0.13)	(-0.34)	

Table 7: Forecasting real activity with asset returns and the term structure slope, 1952:3 through 1999:4

Log-differenced quarterly real per capita consumption, Δc_t, is defined in Table 1. Log-differenced quarterly real per capita GDP, Δgdp_t, and labor income, Δli_t, are defined similarly. The variable D_SLOPE_t is a dummy variable that equals one if the slope of the Treasury term structure at the end of quarter t exceeds its mean. Excess log returns to stock and Treasury bond markets, er^s_{t+1} and er^b_{t+1}, are defined in Table 1. All variables are expressed in percent. This table reports results from the regression

$$\Delta x_{t+i} = b_0 + b_1 D\_SLOPE_t + (b_2 + b_3 D\_SLOPE_t) er^k_{t+1} + e_{k,t+i},\ x = \{c, gdp, li\},\ k = \{s, b\}.$$

Heteroskedasticity-consistent t-statistics, corrected for one lag of moving average residuals, are in parentheses.

	Slope > mean						Slope < mean					
Regression	Δgdp_{t+1}	Δgdp_{t+2}	$\Delta \pi_t$	$\Delta \pi_{t+1}$	RSE	R^2	Δgdp_{t+1}	Δgdp_{t+2}	$\Delta \pi_t$	$\Delta \pi_{t+1}$	RSE	R^2
[1]	0.996	0.155	-	-	7.280	0.013	3.010	1.860	-	-	7.820	0.227
	(1.08)	(0.19)					(3.68)	(2.77)				
[2]	-	-	0.118	0.148	7.235	0.025	-	-	0.399	0.321	8.180	0.155
			(1.00)	(1.30)					(3.04)	(1.64)		
[3]	0.894	-0.382	0.128	0.145	7.277	0.035	2.747	0.900	0.156	0.231	7.752	0.258
	(0.99)	(-0.43)	(1.02)	(1.26)			(3.13)	(1.06)	(0.91)	(1.38)		

Table 8: Explaining stock returns with current and future real variables, 1952:3 through 1999:4

Excess log stock returns in quarter $t+1$ are regressed on the log change in real GDP in quarters $t+1$ and $t+2$ and the log change in real aggregate after-tax profits in quarters t and $t+1$. The data are split into two samples, based on whether the slope of the Treasury term structure in quarter t is greater or less than average. All variables are expressed in percent. There are 96 observations in the first sample and 93 observations in the second sample. The columns labeled RSE report the standard error of the residual. Heteroskedasticity-consistent t-statistics are in parentheses.

	Slope > mean						Slope < mean					
Regression	Δy_{t+1}	Δy_{t+2}	Δgdp_{t+1}	Δgdp_{t+2}	RSE	R^2	Δy_{t+1}	Δy_{t+2}	Δgdp_{t+1}	Δgdp_{t+2}	RSE	R^2
[1]	-2.480	-0.801	-	-	2.285	0.494	-1.748	0.239	-	-	2.153	0.558
	(-8.14)	(-2.14)					(-9.86)	(0.87)				
[2]	-	-	-0.746	-0.222	3.138	0.046	-	-	-0.585	1.160	3.031	0.124
			(-2.48)	(-0.63)					(-1.26)	(3.50)		
[3]	-2.477	-0.669	-0.411	-0.225	2.273	0.510	-1.726	0.175	0.108	0.317	2.144	0.571
	(-8.37)	(-1.75)	(-1.98)	(-0.74)			(-9.79)	(0.69)	(0.32)	(1.32)		

Table 9: Explaining bond returns with current and future changes in short-term interest rates and output, 1952:3 through 1999:4

Excess log returns to long-term Treasury bonds in quarter $t+1$ are regressed on the changes in three-month Treasury bill yields and log real GDP in quarters $t+1$ and $t+2$. The data are split into two samples, based on whether the slope of the Treasury term structure in quarter t is greater or less than average. All variables are expressed in percent. There are 94 observations in the first sample and 93 observations in the second sample. The columns labeled RSE report the standard error of the residual. Heteroskedasticity-consistent t-statistics are in parentheses.

References

Abel, Andrew B., 1990, Asset prices under habit formation and catching up with the Joneses, *American Economic Review* 80, 38-42.

Ahn, Dong-Hyun, Robert F. Dittmar, and A. Ronald Gallant, 1999, Quadratic term structure models: Theory and evidence, Working paper, University of North Carolina.

Barro, Robert J., 1989, The stock market and the macroeconomy: Implications of the October 1987 crash, in R. W. Kamphuis, R. C. Kormendi, and J. W. H. Watson (eds.), *Black Monday and the Future of Financial Markets,* Dow Jones Irwin, Homewood, Ill.

Campbell, John Y., 1987, Stock returns and the term structure, *Journal of Financial Economics* 18, 373-399.

Campbell, John Y., 1999, Asset prices, consumption, and the business cycle, Chapter 19 in John B. Taylor and Michael Woodford, eds., *Handbook of Macroeconomics, Volume 1*, North-Holland: Amsterdam, 1231-1303.

Campbell, John Y., and John H. Cochrane, 1999, By force of habit: A consumption-based explanation of aggregate stock market behavior, *Journal of Political Economy* 107, 205-251.

Campbell, John Y., Andrew W. Lo, and A. Craig MacKinlay, 1997, *The Econometrics of Financial Markets* Princeton University Press, Princeton, NJ.

Campbell, John Y., and Robert J. Shiller, 1991, Yield spreads and interest rate movements: A bird's eye view, *Review of Economic Studies* 58, 495-514.

Chen, Nai-Fu, Financial investment opportunities and the macroeconomy, 1991, *Journal of Finance* 46, 529-554.

Constantinides, George M., 1990, Habit formation: A resolution of the equity premium puzzle, *Journal of Political Economy* 98, 519-543.

Epstein, Lawrence, and Zin, Stanley, 1989, Substitution, risk aversion, and the temporal behavior of consumption and asset returns: A theoretical framework, *Econometrica* 57, 937-969.

Estrella, Arturo, and Gikas A. Hardouvelis, 1991, The term structure as a predictor of real economic activity, *Journal of Finance* 46, 555-576.

Estrella, Arturo, and Frederic S. Mishkin, 1998, Predicting U.S. recessions: Financial variables as leading indicators, *Review of Economics and Statistics* 80, 45-61.

Fama, Eugene F., 1990, Stock returns, expected returns, and real activity, *Journal of Finance* 45, 1089-1108.

Fama, Eugene F., and Kenneth R. French, 1989, Business conditions and expected returns on stocks and bonds, *Journal of Financial Economics* 25, 23-49.

Fama, Eugene F., and Kenneth R. French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics* 33, 3-56.

Fischer, Stanley, and Robert C. Merton, 1984, Macroeconomics and finance: The role of the stock market, *Carnegie-Rochester Conference Series on Public Policy* 21, 57-108.

Lettau, Martin, and Sydney Ludvigson, 2001, Consumption, aggregate wealth and expected stock returns, *Journal of Finance*, forthcoming.

Lucas, Robert E., Jr., 1978, Asset prices in an exchange economy, *Econometrica* 46, 1429-1446.

Mehra, Rajnish, and Prescott, Edward, 1985, The equity premium: A puzzle, *Journal of Monetary Economics* 15, 145-161.

Newey, Whitney K., and Kenneth D. West, 1987, A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica* 55, 703-708.

Roll, Richard R., A critique of the asset pricing theory's tests, part I: On past and potential testability of the theory, *Journal of Financial Economics* 4, 129-176.

Rubinstein, Mark, 1976, The valuation of uncertain income streams and the pricing of options, *Bell Journal of Economics* 7, 407-425.

Schwert, G. William, 1989, Why does stock market volatility change over time, *Journal of Finance* 44, 1115-1153.

Sundaresan, Suresh, 1989, Intertemporally dependent preferences and the volatility of consumption and wealth, *Review of Financial Studies* 2, 73-88.

Weil, Philippe, 1989, The equity premium puzzle and the risk-free rate puzzle, *Journal of Monetary Economics* 24, 401-421.

White, Halbert, 1980, A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity, *Econometrica* 48, 817-838.

Whitelaw, Robert F., 2000, Stock market risk and return: An equilibrium approach, *Review of Financial Studies* 13, 521-547.

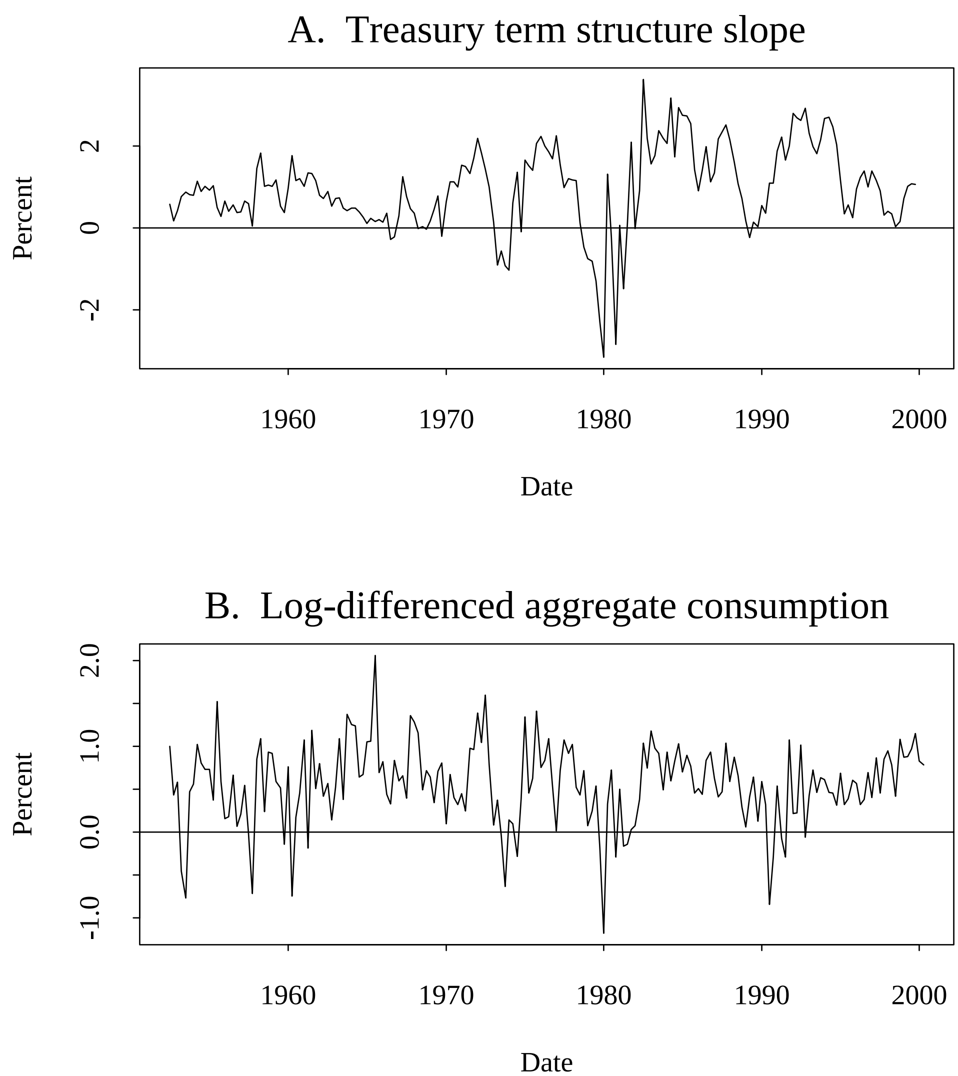

Figure 1: The slope of the term structure and consumption growth

The term structure slope at the end of quarter t is the difference between a five-year zero-coupon Treasury yield (interpolated from coupon bonds) and the three-month Treasury bill yield. Consumption growth in quarter t is measured by 100 times the log change, from quarter t to quarter $t+1$, of aggregate per capita real consumption on nondurables and services.

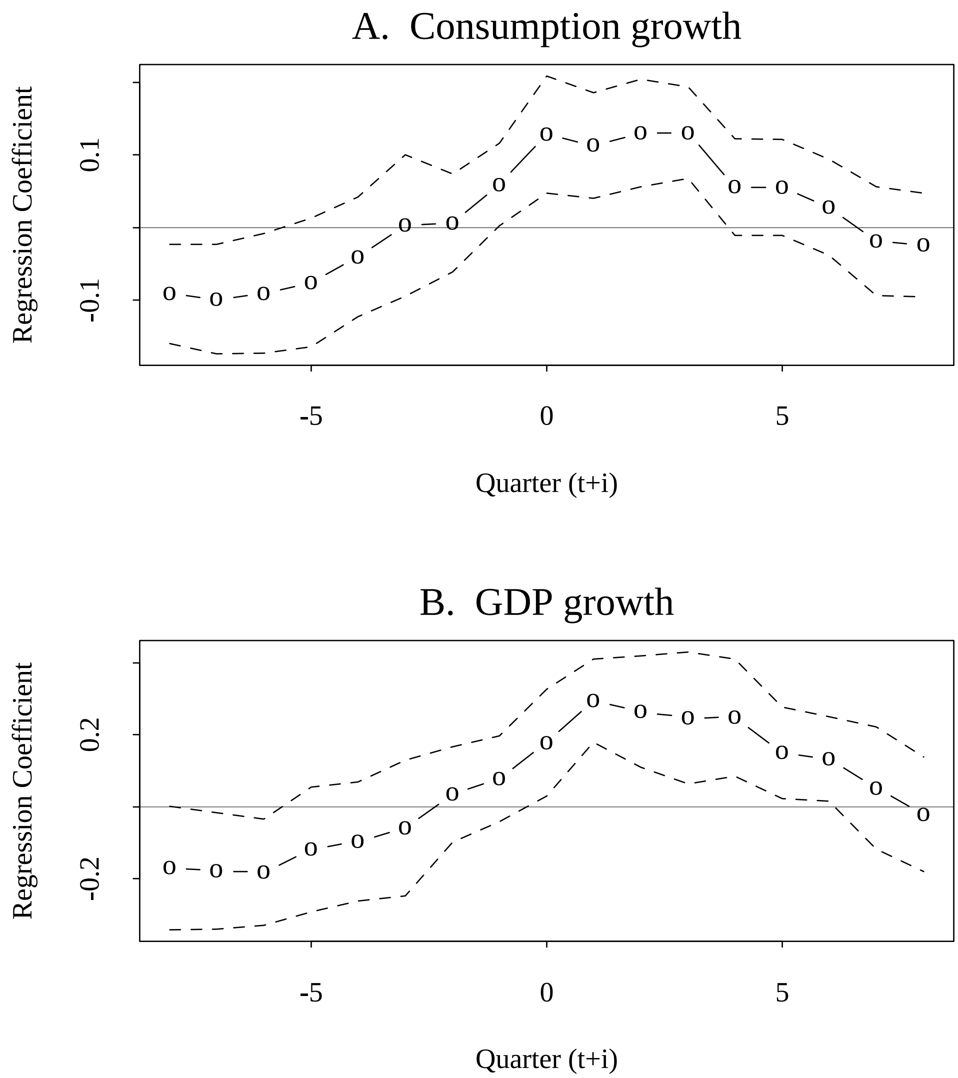

Figure 2: Regressions of lags and leads of consumption and GDP growth on the slope of the term structure, 1952:3 through 1999:4

Quarterly changes in log consumption and GDP Δc_t and Δgdp_t are defined in the notes to Table 2. This figure reports estimated coefficients from regressions of Δc_{t+i} and Δgdp_{t+i} on the slope of the Treasury term structure at the end of quarter t. For each real variable, 17 regressions are estimated ($i = -8, \ldots, 8$). The dashed lines are +/- two heteroskedasticity-consistent standard errors, adjusted for one lag of moving average residuals.

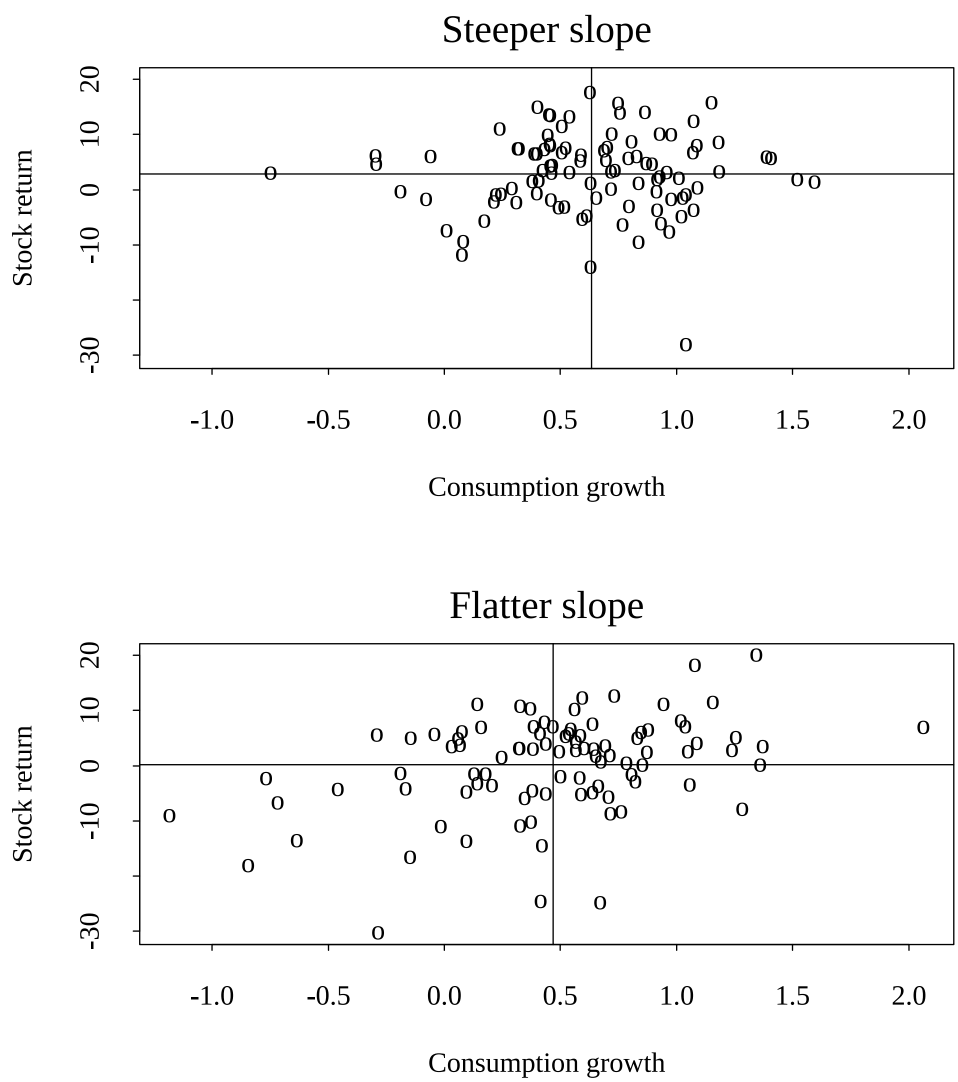

Figure 3: Scatter plots of excess stock market returns and contemporaneous consumption growth, conditioned on the slope of the yield curve

Quarterly changes in log consumption and quarterly excess stock returns are defined in the notes to Table 2. Quarter $t+1$ realizations are sorted into two groups, based on whether the slope of the term structure at the end of quarter t was greater or less than average. These panels display scatter plots of the two groups. The solid lines are the group-specific means of the variables.