Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.

Stock Market Volatility and the Great Moderation

Sean D. Campbell

2005-47

Stock Market Volatility and the Great Moderation

Sean D. Campbell
Board of Governors of the Federal Reserve System
August, 2005

Abstract: Using data on corporate profits forecasts from the Survey of Professional Forecasters, I decompose real stock returns into a fundamental news component and a return news component and analyze the effects of the Great Moderation on each. Empirically, the response of each component of real stock returns to the Great Moderation has been quite different. The volatility of fundamental news shocks has declined by 50% since the onset of the Great Moderation, suggesting a strong link between underlying fundamentals and the broader macroeconomy. Alternatively, the volatility of return news shocks has remained stable over the Great Moderation period. Since the bulk of stock market volatility is attributable to return shocks, the Great Moderation has not had a significant effect on stock return volatility. These empirical findings are shown to be consistent with Campbell and Cochrane's (1999) habit formation asset pricing model. In the face of a large decline in consumption volatility, the volatility of fundamental news shocks declines while the volatility of return shocks stagnate. Ultimately, the effect of a Great Moderation in consumption volatility on overall stock return volatility in the habit formation model is slight.

Keywords: Great Moderation, Stock Market Volatility, Fundamental News, Return News

Acknowledgements: I would like to thank Greg Duffee, Jim O'Brien, Matt Pritsker, Hao Zhou and participants in the Board of Governors' Finance Forum workshop for their comments. The usual disclaimer applies. The views in this paper are solely the responsibility of the author and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any person associated with the Federal Reserve System.

I. Introduction

One of the most prominent features of the U.S. economy over the past twenty years has been the large and persistent decline in the volatility of macroeconomic activity. Across a wide array of economic indicators including production, consumption and investment, the macroeconomy has become more stable since the middle of the 1980's. While this "Great Moderation" in macroeconomic volatility has been widely followed as it relates to real activity, Kim and Nelson (1999), McConnell and Perez-Quiros (2000), Stock and Watson (2002,2003), relatively little attention has been paid to its effects, empirically or theoretically, on the stock market.[1] In particular, how has the decline in macroeconomic volatility affected stock market volatility to date and what are the likely consequences of the Great Moderation on stock market volatility going forward?

In this paper I examine the effects of the Great Moderation on the volatility of the stock market. My analysis is both empirical and theoretical. Following Campbell and Shiller (1988 a,b), I decompose real stock returns into a component that reflects news about future fundamentals, i.e. earnings, dividends or cash flow, and a component that reflects news about future returns and analyze the effects of the Great Moderation on each of these components.

I identify news about future fundamentals from forecasts of future NIPA corporate profits after taxes from the Survey of Professional Forecasters (SPF). I then show that this profits news series is directly related to real stock returns. Using the SPF profits news to construct measures of fundamental and return news, I employ a structural break model to examine how the Great Moderation affected the volatility of each of these news components. In

[1] One notable exception to this point is the recent work of Lettau, Ludvigson and Wachter (2004).

the case of fundamental news, I find that the volatility of fundamental news declined significantly and in concert with the general decline in broad macroeconomic volatility that occurred in the middle of the 1980's. Over the period 1970-2005, I find that fundamental news volatility declined by roughly 50% beginning in the fourth quarter of 1981. Accordingly, fundamental news volatility is directly related to broader macroeconomic volatility. Return news volatility, however, exhibited no significant decline over the Great Moderation period. Consistent with previous research, Campbell (1991), Campbell and Vuolteenaho (2004), I find that the bulk of stock return volatility is due to variability in return news rather than fundamental news. Accordingly, the consequences of the Great Moderation on overall stock market volatility have, thus far, been slight.

In order to better understand the effects of the Great Moderation on stock return volatility, I examine the effect of a one-time, permanent decline in macroeconomic volatility on stock return volatility within the context of a fully specified, consumption based asset pricing model. Specifically, I examine the effect of a one time structural break in consumption volatility within the context of Campbell and Cochrane's (1999) habit formation asset pricing model (CCH). Using model parameters consistent with observed financial market data and consumption growth, I find that the effect of a Great Moderation sized decline in consumption volatility on stock return volatility is consistent with the empirical findings. In the face of a sharp decline in consumption growth volatility, fundamental news volatility declines substantially while return news volatility and overall stock market volatility stagnate.

The disconnect between fundamental macroeconomic volatility and stock return volatility stems from the fact that within the CCH model, the risk that investors are rewarded for assuming is unrelated to long run consumption risk. Unlike more traditional asset pricing models, such as the CCAPM, average Sharpe ratios and risk-free interest rates in the CCH economy are unrelated to consumption growth volatility. Instead, investors are rewarded for assuming what may be termed "habit risk". Importantly, the volatility or riskiness of "habit risk" is not related to the volatility of observable macroeconomic fundamentals such as consumption growth. As a result, large changes in consumption growth volatility do not lead to any significant decline in stock return volatility.

The contribution of this paper is two-fold. First, using a novel series on fundamental news shocks which are shown to be directly linked to real stock returns, I document how the Great Moderation has affected the volatility of stock returns. I document that the Great Moderation has had very different effects on the volatility of fundamental news and return news. The empirical analysis underscores the importance of analyzing fundamental news and return news separately. The important link between fundamental news volatility and the Great Moderation which I find would be completely obscured by a study that only examines the effect of the Great Moderation on total stock return volatility. Second, I show that these empirical results can be reconciled with a rational, consumption based asset pricing model. This finding is important since traditional asset pricing models, such as the CCAPM, predict that a permanent decline in fundamental volatility would ultimately result in a permanent decline in long run stock return volatility. Accordingly, the disconnect between stock market volatility and fundamental macroeconomic volatility need not be interpreted as a sign of market irrationality or as a general failure of equilibrium asset pricing models. Finally, the agreement between the predictions of the CCH model and the empirical results provides additional evidence on the importance of habit formation like effects in explaining stock return behavior.

The remainder of this paper is organized as follows. Section II outlines the Campbell-Shiller stock return decomposition, discusses the data and the identification of the fundamental and return news components of stock returns. Section III analyzes the volatility of real stock returns and each of its components over the Great Moderation. Section IV examines the effect of a one-time structural break in the volatility of consumption growth in the CCH model on stock return volatility. The conclusion is presented in Section V.

II. Stock Returns, Expected Returns, Fundamental News and Return News

Decomposing Stock Returns

Campbell and Shiller (1988 a,b) and Campbell (1991) provide the following two component decomposition of unexpected real stock returns,

$$r_{t+1} - E_t(r_{t+1}) = (E_{t+1} - E_t)\sum_{j=0}^{\infty} \rho^j \Delta F_{t+j+1} - (E_{t+1} - E_t)\sum_{j=1}^{\infty} \rho^j r_{t+j+1}, \tag{II.1}$$

$$r_{t+1} - E_t(r_{t+1}) = R_{\Delta F,t+1}^{\infty} - R_{r,t+1}^{\infty}, \tag{II.2}$$

where ΔF_{t+j} refers to the growth in fundamentals, r_{t+j} refers to the real stock return between period $t+j-1$ and $t+j$, and ρ is a discount factor related to the long run level of the dividend price ratio. The fundamental should be interpreted as the flow value of owning a share of stock. Empirically, the fundamental is often identified with dividends but may also be associated with earnings or even cash flow measures. This decomposition should be understood as an accounting identity in which unexpectedly high prices either reflect high future fundamentals or an increased willingness to hold stocks for the same expected stream of fundamentals (i.e. lower returns). In this sense, unexpected returns can be thought of in terms of fundamental "news" and return "news".[2]

This decomposition leads to a natural framework for analyzing stock return volatility,

$$\sigma_t^2\left(r_{t+1} - E_t(r_{t+1})\right) = \sigma_t^2\left(R^{\infty}_{\Delta F,t+1}\right) + \sigma_t^2\left(R^{\infty}_{r,t+1}\right) - 2\sigma_t\left(R^{\infty}_{\Delta F,t+1}, R^{\infty}_{r,t+1}\right), \tag{II.3}$$

in which stock return volatility is caused by the volatility of fundamental news, the volatility of return news and the covariance between the two. I construct a direct measure of fundamental news from the NIPA corporate profits forecasts from the Survey of Professional Forecasters (SPF). The Survey of Professional Forecasters is the oldest quarterly survey of macroeconomic forecasters in the United States. The survey was originally conducted by the American Statistical Association and the National Bureau of Economic Research. Since 1990, the survey has been administered by the Federal Reserve Bank of Philadelphia.[3] I then use these forecasts to construct empirical measures of $R^{\infty}_{\Delta F,t+1}$ and $R^{\infty}_{r,t+1}$ and analyze how each element of the above volatility decomposition has changed since the onset of the Great Moderation.

Beginning with Schwert (1989,1990), a variety of researchers have attempted to explain the movements in stock return volatility over time with movements in the underlying macroeconomy. Much of this work has concluded that there is no discernible link between macroeconomic and stock market volatility. This analysis differs from these previous studies in two main respects. First, these earlier studies typically examine how relatively high frequency, i.e. monthly or quarterly, changes in stock market volatility are linked to the broader

[2]Of course, another factor that could account for unexpectedly high returns today is the belief that prices (and hence returns) will be unexpectedly high tomorrow. These kinds of self-fulfilling prophecies or "bubbles" are ruled out in the above decomposition.

[3]Croushore (1993), provides a detailed description of the SPF and surveys the academic literature as well as the practical uses the survey has served since its inception in 1968.

macroeconomy. I focus on how a long-run, low frequency, arguably permanent change in the macroeconomy has affected stock market volatility. Second, this analysis separates the fundamental news component of stock returns from the return news component whereas much previous research has focused on total stock market return volatility. Accordingly, this analysis will allow for the fundamental and return news components of stock return volatility to react differently to the Great Moderation. Ultimately, a contribution of this paper will be to document how each component of stock return volatility has been affected by the onset of the Great Moderation.

I use forecast data from the Survey of Professional Forecasters (SPF) to construct an estimate of $R^{\infty}_{\Delta F,t+1}$. The SPF is a quarterly forecast of professional economic forecasters. I use data between the third quarter of 1970 (1970:3) and the first quarter of 2005 (2005:1). Each quarter the survey asks participants to forecast the level of a variety of macroeconomic variables. In this paper, I identify the SPF forecast of NIPA corporate profits after taxes with fundamentals. SPF Forecasts of the GDP deflator are used to construct forecasts of real corporate profits. The survey asks participants to forecast the level of NIPA corporate profits after taxes, and the GDP deflator, for the current quarter and each additional quarter over the next four quarters. I aggregate forecasts from different survey respondents within the SPF by selecting the median forecast at each date. This data on forecasted levels is then used to construct implied forecasts of growth rates. The growth rate forecasts from two adjacent quarters are then used to construct the implied revisions,

$$(E_{t+1}-E_t)\Delta F_{t+j},\ j=2,3,4, \qquad \text{(II.4)}$$

where F_t is defined as the level of real NIPA corporate profits. I then compute the weighted average revisions to these real growth forecasts at each point in time,

$$R^{3}_{\Delta F,t+1} \equiv (E_{t+1} - E_t)\left(\Delta F_{t+2} + \rho \Delta F_{t+3} + \rho^2 \Delta F_{t+4}\right), \qquad \text{(II.5)}$$

which I use as a proxy for $R^{\infty}_{\Delta F,t+1}$. I use a value of 0.99 for ρ in the case of quarterly data which is consistent with the long run average level of the dividend-price ratio.

The data on the fundamental news series, $R^{\infty}_{\Delta F,t+1}$, and each of the three revision series, $(E_{t+1} - E_t)\Delta F_{t+j}$, is summarized in Figure I and Table I. Figure I contains a time series plot of the constructed fundamental news series and Table I presents selected summary statistics for the fundamental news series and each of the revision series over the sample period, 1970:3 through 2005:1. The NBER recession dates are superimposed on the plot in Figure I for reference.

Looking at Figure I, fundamental news does appear to correspond with movements in the business cycle. In particular, fundamental news tends to be negative or declining during NBER recessionary periods. Looking at the summary statistics in Table I reveals that the revisions to SPF forecasts are roughly mean zero, indicating that the forecasters are not consistently surprised in the same direction. The standard deviation of forecast revisions declines as the horizon of the forecast lengthens. The standard deviation of forecast revisions pertaining to corporate profits growth in period $t+2$ is roughly 20% larger than the standard deviation of revisions to forecasts pertaining to period $t+4$ suggesting that forecasters' beliefs about the long term are more stable than their beliefs about the near term. Interestingly, each of the revision series and the fundamental news series exhibits excess kurtosis, which underscores the fact that relatively large revisions in either direction are not too uncommon. In particular, periods surrounding NBER recession dates often exhibit large upward and downward revisions to future forecasts of corporate profits.

Assessing the Quality of $R^{3}_{\Delta F,t+1}$

While the constructed fundamental news series, $R^{3}_{\Delta F,t+1}$, is related to the actual expectations of professional forecasters, that is no guarantee that it is an accurate measure of the true but unobserved fundamental news shock, $R^{\infty}_{\Delta F,t+1}$. If the forecasts are extremely poor and unreliable then they may not provide much of a signal about the future path of stock market fundamentals and may be largely ignored by the stock market. In order to assess the quality of this fundamental news measure, I examine the information content of the SPF forecasts along two separate dimensions. First, I examine whether SPF corporate profit forecasts are informative for future corporate profit realizations. Second, I examine whether the stock market reacts to the news contained in the SPF forecasts.

In order to argue that changes in the SPF forecasts reflect fundamental news it must be the case that the forecasts themselves are relevant for understanding movements in actual corporate profits. I measure the information content of SPF corporate earnings forecasts by estimating the system,

$$\begin{aligned} F_{t+h} &= \alpha_h + \beta_h F_{t+h|t} + v_{t+h} \\ h &= 1,2,3,4 \end{aligned}, \qquad \text{(II.6)}$$

where F_{t+h} represents real growth in NIPA corporate profits after taxes between quarter $t+h-1$ and $t+h$ and $F_{t+h|t}$ represents the corresponding SPF forecast. The system is estimated via an exactly identified GMM system using Newey-West estimates of the optimal weighting matrix. The estimation results are contained in Table II.

Before examining the information content of the SPF forecasts, it is useful to have an idea of how forecastable corporate profits are from a simple time series model. I estimate an AR(1) model for the growth in real NIPA corporate profits after taxes using the entire sample period, 1970:3 - 2005:1, for estimation. I use an AR(1) because it is parsimonious and represents a reasonable benchmark model against which other forecasts can be compared.[4] The first order autoregressive coefficient is estimated to be 0.19, indicating little persistence in the growth rate of corporate profits. This estimate translates into an R^2 of one step ahead forecasts of only 3.3%. Autoregressive forecasts at more distant horizons are even less accurate. The implied R^2 of forecasts beyond one quarter are all less than 1%.

Turning to the results contained in Table II indicates that the SPF forecasts represent a considerable improvement over and above the time series model. Each row of Table II contains the estimates of α_h and β_h along with their standard errors and the associated regression R^2. Looking at the top row of Table II, one quarter ahead SPF forecasts have significant information content for future corporate profit growth. Specifically, the one quarter ahead SPF forecasts explain roughly 10% of the variation in NIPA corporate profits and the associated estimate of

[4] Given the quarterly nature of the data, one might suggest that an AR(4) is a more reasonable benchmark. Using an AR(4) boosts the R^2 of one step ahead forecasts from 3.3% to 4.9%.

β_1 is large and significant (0.77).[5] As the forecast horizon lengthens, the information content of the SPF forecasts naturally decline. At the two and three quarter ahead horizons, SPF forecasts explain a little more than 2% of the variation in corporate earnings and the associated estimates of β_2 and β_3 are smaller (0.45 and 0.57) and less significant. The forecasts, however, especially in the case of two quarter ahead forecasts are informative about future profits when compared to the benchmark AR(1) model. SPF forecasts of corporate earnings four quarters ahead have little ability to account for future earnings growth since they explain less than 1% of the variation in corporate profitability. Taken together, these results indicate that SPF forecasts are a useful source of information about future movements in corporate profits. The forecasts are more informative at shorter forecast horizons but are significantly more informative than forecasts from a benchmark AR(1) model.

Aside from the question of how informative or accurate SPF forecasts are for future corporate profits, it is also important to examine the extent to which the stock market reacts to the news contained in these forecasts. This provides a market test of the SPF forecasts' applicability as a measure of fundamental news. In particular, even if SPF forecasts were excellent predictors of future earnings growth, if the stock market did not react to innovations in the forecasts it would be difficult to interpret the forecasts as a source of fundamental news.

---

[5]One can argue that the R^2 from the time series model should only be compared with that computed from the forecast error, $e_{t+h}=F_{t+h}-F_{t+h|t}$, and not the regression R^2 from Table II. Two points are worth noting. First, doing so lowers the R^2 from 10.2% to 9.3% in the case of the one step ahead forecasts. Second, Elliott, Kommunjer and Timmerman (2004) point out that the elicited forecast only has the interpretation of a conditional mean under quadratic loss. In the case that professional forecasters' loss functions are not quadratic, interpreting F_t as a conditional mean is problematic and the R^2 from Table II may be a better measure of the forecast's information content than is the R^2 computed from e_t. Moreover, in the case that the elicited forecast, $F_{t+h|t}$, is a scaled version of the conditional mean, $E_t(F_{t+h})$, it can still be informative about the revision process, $(E_{t+1}-E_t)\Delta F_{t+j}$.

Recall from the Campbell-Shiller decomposition of unexpected stock returns that,

$$r_{t+1} = E_t(r_{t+1}) + R^{\infty}_{\Delta F,t+1} - R^{\infty}_{r,t+1},$$

so that in the event that return news is uncorrelated with fundamental news, the population regression coefficient from regressing r_{t+1} onto $R^{\infty}_{\Delta F,t+1}$ is unity. In order to assess the degree to which the SPF expectation revisions are linked to real returns, I regress quarterly, real stock returns on the CRSP value-weighted portfolio, r_{t+1}, onto $R^{3}_{\Delta F,t+1}$ as well as each of its constituent components, $(E_{t+1} - E_t)\Delta F_{t+2}$, $(E_{t+1} - E_t)\Delta F_{t+3}$, $(E_{t+1} - E_t)\Delta F_{t+4}$.[6] The regression slope coefficients, standard errors and adjusted $R^{2'}s$ are contained in Table III. Table III contains the results from regressing each fundamental news measure onto real returns separately as well as the results from regressing all three measures onto the real return series.

First, consider the reaction of the stock market to the individual SPF forecast revisions. In the case of the first two revisions, $(E_{t+1} - E_t)\Delta F_{t+2}$, $(E_{t+1} - E_t)\Delta F_{t+3}$, real stock returns react strongly and significantly to changes in these profit forecasts. In both cases the point estimate of the slope coefficient is slightly larger than one (1.28 ans 1.13) and highly significant. As the length of the forecasting horizon increases the reaction of the stock market to forecast revisions decreases. The reaction of real stock returns to the most distant SPF forecast revisions, $(E_{t+1} - E_t)\Delta F_{t+4}$, is the smallest (0.40) and insignificant. Overall, however, real stock returns do react significantly to SPF forecast innovations as expected. This is best seen by

[6] Returns are deflated using the CPI-U as a deflator.

examining the relationship between real returns and the measure of fundamental news, $R^3_{\Delta F,t+1}$.

Positive fundamental news significantly increases real stock returns as evidenced by the large, positive and significant slope estimate (0.68). It is also interesting to note that the fundamental news measure summarizes well the information contained in all three revision series. The adjusted R^2 in the regression of real returns on $R^3_{\Delta F,t+1}$ is larger than in any of the univariate regressions or the multiple regression that uses each revision separately to explain real stock returns.

The regression R^2 indicates that fundamental news accounts for a little more than 7% of the variance in real stock returns over the sample period. This finding suggests that variation in expected returns and return news dominates the effect of fundamental news in determining real returns. While the amount of real return variation explained by fundamental news is small, this finding is not unexpected. Previous studies linking movements in the stock market to movements in fundamentals and movements in rates of return also find that movements in fundamentals only explain a modest portion of stock return variability. Campbell (1991), for example, finds that between 1952 and 1998, fundamental news explains between 8.5% to 10.0% of the variance in stock returns. Recent studies by Bernanke and Kuttner (2004) as well as Campbell and Vuolteenaho (2004), find similar results. Accordingly, the fact that the constructed fundamental news series only explains around 7% of the variation in real stock returns is consistent with the literature on the relation between fundamentals and stock returns.

In what follows, the revisions to SPF forecasts are used in conjunction with real stock returns to construct an estimate of the two components of real stock returns that are related to expected returns and fundamentals. Namely, I construct the variables,

$$\hat{R}^{\infty}_{\Delta F,t+1} \equiv R^{3}_{\Delta F,t+1} \tag{II.7}$$

$$\hat{R}^{\infty}_{r,t+1} - \hat{E}_t(r_{t+1}) \equiv -\left(r_{t+1} - R^{3}_{\Delta F,t+1}\right).[7] \tag{II.8}$$

Note that I do not take a stand on a model of expected returns to identify $R^{\infty}_{r,t+1}$ separately from $E_t(r_{t+1})$. This modeling choice is motivated by two considerations. First, there is much debate and little agreement over what set of variables reliably predict stock returns. Second, much empirical evidence indicates that the volatility of news to future returns dominates the volatility of expected returns. As a result, the gain from directly modeling expected returns is likely to be small. In what follows, I will use the term "return news" to refer to the term $R^{\infty}_{r,t+1} - E_t(r_{t+1})$ or its estimate, $-\left(r_{t+1} - R^{3}_{\Delta F,t+1}\right)$. Similarly the term "fundamental news " will refer to $R^{\infty}_{\Delta F_{t+1}}$ or its estimate $R^{3}_{\Delta F_{t+1}}$.

III. The Great Moderation and Stock Return Volatility: Fundamental and Return News

Structural Break Analysis

In order to assess the degree to which the three components of stock market volatility

---

[7]Note that in defining $\hat{R}^{\infty}_{r,t+1} - \hat{E}_t(r_{t+1})$, I subtract $R^{3}_{\Delta F,t+1}$ from r_{t+1} rather than $bR^{3}_{\Delta F,t+1}$ where b is the OLS slope estimate from Table III. One might reasonably prefer the latter. Since, however, the variance of $\hat{R}^{\infty}_{r,t+1} - \hat{E}_t(r_{t+1})$ is dominated by the variance of real returns, it makes little difference in the empirical analysis which way $\hat{R}^{\infty}_{r,t+1} - \hat{E}_t(r_{t+1})$ is constructed.

were affected by the Great Moderation, I examine the evidence in favor of a structural break in $\sigma_t^2\left(R_{\Delta F,t+1}^{\infty}\right)$, $\sigma_t^2\left(R_{r,t+1}^{\infty}\right)$ and $\sigma_t\left(R_{\Delta F_{t+1}},\ R_{r,t+1}^{\infty}\right)$. Much of the literature on the Great Moderation has interpreted the broad decline in the volatility of aggregate output, consumption, investment and other macroeconomic aggregates as a permanent phenomenon. This has led previous researchers to employ econometric tests of a single structural break as a means of testing for and characterizing the size of the Great Moderation. Stock and Watson (2002) and McConnell and Perez-Quiros (2000), for example, both employ single structural break tests in measuring the size and significance of the Great Moderation. I employ a similar structural break test to remain consistent with the permanent interpretation of the Great Moderation.

The structural break volatility model is specified is as follows,

$$|x_{t+1} - E(x_{t+1})| = \exp\left(\alpha + \beta D_{t \geq t^*} + v_{t+1}\right), \tag{III.1a}$$

$$1975{:}3 \leq t^* \leq 2000{:}1\,, \tag{III.1b}$$

where x_t represents either $\hat{R}_{\Delta F,t+1}^{\infty}$ or $\hat{R}_{r,t+1}^{\infty} - \hat{E}_t(r_{t+1})$ and the exponential model is employed to account for the positivity of the absolute value. In order to assess the evidence in favor of a structural break in the covariance between return news and fundamental news, I estimate the structural break model,

$$\left(\hat{R}_{\Delta F,t+1}^{\infty} - E(\hat{R}_{\Delta F,t+1}^{\infty})\right)\left(\hat{R}_{r,t+1}^{\infty} - E(\hat{R}_{r,t+1}^{\infty}) - \hat{E}_t(r_{t+1}) - E(\hat{E}_t(r_{t+1}))\right) = \alpha + \beta D_{t \geq t^*} + v_{t+1}\,, \tag{III.1c}$$

$$1975{:}3 \leq t^* \leq 2000{:}1\,. \tag{III.1d}$$

In each case the break date, t^*, must be constrained to lie away from the sample's endpoints in order to appeal to the asymptotic theory underlying the test. I selected the boundary points for the break date following Andrews' (1993) suggestion of using the middle 70% of the sample period. The model is estimated for each possible break date within the boundary points by GMM and the test statistic is defined to be the maximum Wald statistic over all possible break dates of the null hypothesis that $\beta = 0$. Andrews (1993) provides the asymptotic distribution of this test statistic, $W_{\max}$, under the null of no structural break. Using the boundary points referred to above, the critical values of the test at the 10%, 5% and 1% level are 7.17, 8.85 and 12.35, respectively.

I present the estimated break date, break size and its statistical significance in Table IV. In Figure II, I display the value of the Wald statistic for each possible break date along with the cutoff value for significance at the 10%, 5% and 1% level for each of the three tests. These plots can be used to construct a confidence interval for the break date.

Looking at Figure II and Table IV the case for a permanent change in the volatility of fundamental news, return news or the covariance between the two is strongest in the case of fundamental news. In the case of fundamental news the structural break test is significant at a level in between 1% and 5%. The estimated structural break parameter implies that the volatility of fundamental news abated by roughly 50%. This is a large decline in volatility but generally in line with the kind of volatility reduction that was experienced by other macroeconomic aggregates over this period. As an example, Stock and Watson (2003) find that the volatility of consumption and GDP growth declined by 40% after the onset of the Great Moderation. The estimated break date of 1981:4 is also largely consistent with the timing of the Great Moderation. While different authors use different dates for the Great Moderation all agree that the large volatility decline occurred sometime in the early to mid-1980's. The case for a structural break in the volatility of return news or the covariance between return news and fundamental news is much weaker. While the estimated break date is within reason in both cases the test statistic is well below the 10% critical value.

The results of the structural break tests indicate that the Great Moderation has affected the volatility of fundamental news shocks. The structural break analysis suggests that the volatility of fundamental news declined by roughly 50% since the onset of the Great Moderation. In this sense, stock market volatility is related to macroeconomic volatility. Both macroeconomic volatility and the volatility of fundamental news have declined in concert. The strong link between macroeconomic volatility and fundamental news volatility, however, does not carry over to return news. Since the volatility of fundamental news is small relative to the volatility of return news, the Great Moderation did not exhibit a large influence on overall stock return volatility.

These findings raise questions about how the fundamental news and return news components of stock returns could react so differently to the same underlying structural change in the macroeconomy. In what follows, I examine the effect the Great Moderation would have from the perspective of Campbell and Cochrane's (1999) habit formation asset pricing model. Using this model, I show that the apparent disconnect between fundamental news volatility and future return news volatility is entirely consistent with Campbell and Cochrane's (1999) habit formation model. This finding is further contrasted with the prediction of the traditional CCAPM which predicts that a permanent decline in fundamental volatility would ultimately result in a decline in stock return volatility.

IV. The Implications of the Great Moderation for Stock Market Volatility: An Asset Pricing Model With Habit Formation

Motivation for the Modeling Framework

The main empirical finding of this paper is that while the volatility of fundamental news has declined in response to the Great Moderation, the volatility of return news has not. From the perspective of the Campbell-Shiller decomposition,

$$r_{t+1} - E_t(r_{t+1}) = (E_{t+1} - E_t)\sum_{j=0}^{j=\infty} \rho^j \Delta F_{t+1+j} - (E_{t+1} - E_t)\sum_{j=1}^{j=\infty} \rho^j r_{t+1+j} = R^{\infty}_{\Delta F,t+1} - R^{\infty}_{r,t+1},$$

the volatility of return news, $R^{\infty}_{r,t+1}$, has not been materially influenced by the large, abrupt and arguably permanent drop in macroeconomic volatility since the middle of the 1980's. In this section, I examine the influence of the Great Moderation on the different components of stock return volatility through the lens of Campbell and Cochrane's (1999) habit formation asset pricing model (CCH). Specifically, I employ the CCH model and examine the effect of a one time structural break in the volatility of consumption growth on the volatility of the different components of real stock returns.

I choose to investigate the theoretical link between the volatility of fundamentals and return news with the CCH model for two reasons. First, as an asset pricing model, CCH is explicitly dynamic allowing for rich time variation in expected rates of return and hence provides a substantive role for $R^{\infty}_{r,t+1}$. In particular, even in an economy in which the distribution of fundamentals, i.e. consumption or dividend growth, is fixed CCH delivers time variation in expected rates of return. More traditional asset pricing models, such as the CCAPM, imply a fixed rate of return when the distribution of fundamentals is fixed. As a result, absent any time variation in the distribution of fundamentals, these models imply that return news, $R^{\infty}_{r,t+1}$, is identically zero. Time variation in expected rates of return can be added to these models by introducing time variation in the distribution of fundamentals but these models then imply that this is the only source of variation in expected rates of return. Since empirical evidence suggests that time variation in expected rates of return, i.e. $R^{\infty}_{r,t+1}$, is the main driver of stock return volatility both before and after the onset of the Great Moderation, assuming that the Great Moderation is the sole source of variation in expected rates of return is somewhat problematic.[8] Alternatively, the richness of CCH implies that a variety of factors influence expected returns and hence $R^{\infty}_{r,t+1}$. As a result the CCH model provides a framework for disentangling the importance of fundamental volatility relative to all other factors that drive expected returns.

Second, the CCH model is one of the few consumption based, rational asset pricing models that captures a variety of stylized features of the U.S. stock market that have bedeviled more traditional consumption based models for more than thirty years. In particular, CCH delivers expected rates of return, risk free rates and Sharpe ratios that are consistent with observed data. The large literature on the failure of the prototypical consumption based model, i.e. the CCAPM, has shown that this model is largely unable to account for even the most fundamental features of U.S. stock returns. Before conducting an analysis of the link between the volatility of macroeconomic fundamentals and the volatility of stock returns it is desirable to

[8]There are variants of the CCAPM that do allow for time variation in expected rates of return through time variation in the market risk premium. Lettau and Ludvigson (2001), for example, introduce time varying risk premia to the CCAPM. These models, however, are empirical and do not provide an equilibrium mapping between the distribution of fundamentals and risk premia. As a result, it is not possible to examine the implications of the Great Moderation within the context of these models.

work with a model that can successfully account for the more basic features of U.S. stock returns.

Before describing the model and how it behaves in the event of a Great Moderation in consumption volatility, it is useful to point out the related work of Lettau, Ludvigson and Wachter (2004) on the links between the stock market and the Great Moderation, as it is one of the only other papers that assesses the effects of the Great Moderation on the stock market. Their work differs from mine in several respects. First and foremost, Lettau, Ludvigson and Wachter (2004) focus on the level of asset prices and not their volatility. Specifically, they focus on whether or not the Great Moderation could account for the large run up in the level of stock prices observed over the 1990's.

Also, their modeling strategy is considerably different from mine. There are three key differences between our modeling strategies. First, they employ the CCAPM as their structural model and I employ Campbell and Cochrane's (1999) habit formation model. Second, they model the Great Moderation as a transitory event in the sense that there is always a positive probability of returning to a lower volatility regime. I follow the bulk of the Great Moderation literature in interpreting the Great Moderation as a one time permanent decline in the volatility of consumption growth. Lettau, Ludvigson and Wachter (2004) also model the volatility regime as a hidden state that must be inferred from the observed history of consumption growth. In this sense, learning plays a crucial role in their framework. I abstract from the effects of learning by assuming that the structural break in fundamental volatility is observed immediately once it occurs. Ultimately, the results of the analysis will suggest that including a learning process would not materially change the predictions of the CCH model.

In what follows, I provide a brief description of the CCH model, how asset returns are determined within the model and then I discuss how a one time break in the volatility of consumption growth would affect the volatility of stock returns and its constituent components, $R^{\infty}_{\Delta F,t+1}$ and $R^{\infty}_{r,t+1}$.

The Campbell & Cochrane (1999) Habit Formation Model

The CCH model is a representative agent, complete markets endowment economy. Below, I briefly describe the technology and preferences of the economy. The description presented here is brief. Readers are referred to Campbell and Cochrane (1999) for a more detailed description of the model.

Consumption growth is modeled as an exogenous process. The statistical model assumes that log consumption follows a random walk with i.i.d. normally distributed shocks,

$$\log\left(\frac{C_t}{C_{t-1}}\right) \equiv \Delta c_t \ , \tag{IV.1a}$$

$$\Delta c_t \sim i.i.d.\ N(g,\sigma), \tag{IV.1b}$$

where g represents the economy's long-run growth rate and σ represents the level of uncertainty surrounding future consumption. Since consumption is the only observable economic quantity that relates to the broader macroeconomy, I consider the Great Moderation to be reflected in a one time change in σ.

At this point it might be argued that the assumption on the consumption growth process is inconsistent with the observed data from the SPF. In particular, if consumption, and ultimately earnings and dividend, growth were i.i.d. then expectational terms of the form,

$$\left(E_{t+1}-E_t\right)\Delta F_{t+j},\ j>1\,,$$

would be identically zero whereas the SPF clearly shows that these revisions to expectations are non-zero. Importantly, however, CCH still provides a channel for fundamental news. In particular, fundamental news is operative through the term $\left(E_{t+1}-E_t\right)\Delta F_{t+1}$ which is non-zero in the CCH model. A richer structure for revisions to expected future fundamentals could be obtained within the CCH model by assuming an autoregressive structure for consumption growth. While a variant of the CCH model in which consumption growth is autocorrelated would be of interest, the substance of the analysis presented here would not be materially affected by this change in the model's structure.

Preferences in the CCH model are additively separable across time with discount factor, δ. The model's main departure from the standard consumption based model is in the specification of per-period preferences, $U(C_t)$. In particular, each period, the investor's utility is defined with respect to a reference level of consumption, X_t. Preferences take the form,

$$u\,(C_t,X_t)=U(C_t-X_t)=\frac{(C_t-X_t)^{1-\gamma}-1}{1-\gamma}\,, \qquad \text{(IV.2)}$$

so that risk aversion is time varying. The coefficient of relative risk aversion, η_t, takes the form,

$$\eta_t=\frac{\gamma C_t}{C_t-X_t}\equiv\frac{\gamma}{S_t}\,,$$

where $S_t \equiv \frac{C_t - X_t}{C_t}$ is defined to be the "surplus consumption ratio". The reference level of consumption, X_t, is modeled as an external habit in the sense that the agent takes the reference level as given and does not impute the effect of current choices on the future reference level. Rather than model the evolution of the reference level directly, as in Constandinides (1990) for example, a transformation of external habit, the log surplus consumption ratio is modeled as a heteroskedastic, autoregressive process that reacts to shocks to consumption growth as follows,

$$s_{t+1} = (1-\phi)\bar{s} + \phi s_t + \lambda(s_t)(\Delta c_{t+1} - g), \tag{IV.3}$$

where lowercase letters refer to logarithms of their uppercase counterparts. How the log surplus consumption ratio, s_{t+1}, responds to consumption shocks is governed by the sensitivity function, $\lambda(s_t)$. Importantly, note that the sensitivity of the future level of the log surplus consumption ratio depends on its current level. The model for preferences is completed by specifying a functional form for the sensitivity function.

Campbell and Cochrane (1999) require that the sensitivity function meet three separate criteria: (1) real interest rates are a linear function of the log surplus consumption ratio; (2) the reference level of consumption, X_t, is pre-determined in the steady state so that, $\frac{dx_{t+1}}{dc_{t+1}} = 0$, when $s_t = \bar{s}$; and (3) the reference level of consumption always moves non-negatively with consumption. These three considerations yield the following specification of the sensitivity function,

$$\lambda(s_t) \;=\; \frac{1}{\bar{S}}\sqrt{1-2(s_t-\bar{s})}-1 \quad s_t \leq s_{\max}, \tag{IV.4a}$$

$$\lambda(s_t) \;=\; 0 \quad s_t > s_{\max}, \tag{IV.4b}$$

$$\bar{S}=\sigma\left(\frac{\gamma}{1-\phi-\frac{B}{\gamma}}\right)^{\frac{1}{2}}, \tag{IV.4c}$$

where $s_{\max}$ is a bound on the log surplus consumption ratio that ensures the sensitivity function always remains positive and $\bar{s}$ is the steady state value of the log surplus consumption ratio.

The Investment Opportunity Set in the Campbell-Cochrane Habit Formation Model

Before turning to an analysis of how changes in consumption volatility will affect stock market volatility, it is useful to characterize the investment opportunity set in the CCH model. An understanding of how macroeconomic risk affects the investment opportunity set will provide some insight into how changing macroeconomic risk will affect the volatility of stock returns. In order to have intuition for how macroeconomic risk affects the investment opportunity set it is useful to consider how macroeconomic risk affects the model's stochastic discount factor (SDF).

The stochastic discount factor in the CCH model takes the particularly simple form,

$$M_{t+1} = \delta \left(\frac{C_{t+1}}{C_t} \frac{S_{t+1}}{S_t} \right)^{-\gamma} \equiv \delta F_{t+1}^{-\gamma}, \tag{IV.5}$$

or in its log form,

$$m_{t+1} = \ln(\delta) - \gamma(\Delta s_{t+1} + \Delta c_{t+1}) \equiv \ln(\delta) - \gamma f_{t+1}, \tag{IV.6}$$

and this representation of the model's SDF makes clear how CCH differs from more traditional asset pricing models such as the CCAPM.[9] In the CCAPM the stochastic discount factor is solely identified with consumption growth, $f_{t+1} \equiv \Delta c_{t+1}$. CCH augments the SDF with the change in the log-surplus consumption ratio. Also, note that this additional factor, Δs_t, is directly linked to the underlying macroeconomy in the sense that movements in Δc_{t+1} and Δs_{t+1} are perfectly conditionally correlated given the law of motion for s_t. The conditional mean and variance of the log SDF, determine both risk free rates and Sharpe ratios in the economy. They are given by,

$$E_t(m_{t+1}) = \ln(\delta) - \gamma E_t(f_{t+1}) = \ln(\delta) - \gamma g - \gamma(\phi - 1)(s_t - \bar{s}), \tag{IV.7}$$

$$Var_t(m_{t+1}) = \gamma^2 Var_t(f_{t+1}) = \gamma^2 \left(\frac{1 - \phi - B/\gamma}{\gamma} \left(1 - 2(s_t - \bar{s})\right) \right), \tag{IV.8}$$

and note that conditional on the current state of the log-surplus consumption ratio, $(s_t - \bar{s})$, the volatility of the log SDF is independent of the level of consumption volatility, σ. Furthermore, note that the expected value of the variance of the log SDF,

[9] In what follows, I will interchangeably refer to m_{t+1} and f_{t+1} as the stochastic discount factor.

$$E\left(Var_t(m_{t+1})\right)=\gamma^2 E(Var_t(f_{t+1}))=\gamma^2\left(\frac{1-\phi-B/\gamma}{\gamma}\right),$$

is itself independent of the level of consumption volatility. This feature of the CCH model's stochastic discount factor stands in stark contrast to other, more traditional, asset pricing models. More traditional asset pricing models, such as the CCAPM, directly link the SDF with consumption growth, $m_{t+1}=\ln(\delta)-\gamma\Delta c_{t+1}$, so that there is a direct relationship between the volatility of consumption and the volatility of the SDF.

This lack of dependence between consumption risk and the volatility of the SDF has clear implications for the investment opportunity set in the CCH model. In the CCH model, the equilibrium risk-free rate and Sharpe ratio are given by,

$$r_{f,t}=-\log(\delta)+\gamma g-\frac{\gamma^2}{2}E\left(Var_t(f_{t+1})\right)-B(s_t-\bar{s})=\log(\delta)+\gamma g-\frac{\gamma^2}{2}\left(\frac{1-\phi-B/\gamma}{\gamma}\right)-B(s_t-\bar{s}), \qquad \text{(IV.9)}$$

$$\frac{E_t\left(R^e_{t+1}\right)}{\sigma_t(R^e_{t+1})}\equiv SR_t=\gamma\left[E\left(Var_t(f_{t+!})\right)\left(1-2(s_t-\bar{s})\right)\right]^{0.5}=\gamma\left[\left(\frac{1-\phi-B/\gamma}{\gamma}\right)\left(1-2(s_t-\bar{s})\right)\right]^{0.5}, \qquad \text{(IV.10)}$$

so that both risk free rates and Sharpe ratios are dynamic and depend on the state of the economy, as summarized by $(s_t-\bar{s})$. It is useful to compare the average risk-free rate and average Sharpe ratio in the CCH economy with what would obtain in the standard CCAPM economy. Since the Sharpe ratio is a non-linear function of the state it is more tractable to work with the average squared Sharpe ratio, $E\left(SR_t^2\right)$. In the CCH economy, these quantities are given by,

$$E(r_{f,t}) = -\log(\delta) + \gamma g - \frac{\gamma^2}{2}\left(\frac{1-\phi-B/\gamma}{\gamma}\right), \qquad \text{(IV.11)}$$

$$E(SR_t^2) = \gamma^2\left(\frac{1-\phi-B/\gamma}{\gamma}\right), \qquad \text{(IV.12)}$$

which contrasts sharply with the corresponding expressions in the standard CCAPM economy,

$$E(r_{f,t}) = -\log(\delta) + \gamma g - \frac{\gamma^2}{2}\sigma^2, \qquad \text{(IV.13)}$$

$$E(SR_t^2) = \gamma^2\sigma^2, \qquad \text{(IV.14)}$$

since consumption risk plays no role in determining average risk free rates and Sharpe ratios in the CCH economy but plays a direct role in the CCAPM economy.

The average risk free rate and Sharpe ratio in the CCH model can be thought of as the risk-free rate and Sharpe ratio that would obtain under the traditional CCAPM if consumption growth were distributed according to,

$$\Delta c_t \sim N\left(g, \left(\frac{1-\phi-B/\gamma}{\gamma}\right)^{0.5}\right),$$

rather than,

$$\Delta c_t \sim N(g, \sigma).$$

In this way, CCH replaces consumption risk with something that might be termed "habit risk" in the sense that the fundamental volatility that drives Sharpe ratios and risk-free rates only depends on preference parameters.

The replacement of consumption risk with habit risk in the CCH model is central to its success as an asset pricing model. This is precisely the sense in which Campbell and Cochrane (1999) claim that their model "posits a fundamentally novel description of risk premia". As the authors put it, "[i]nvestors fear stocks primarily because they do poorly in recessions unrelated to the risks of long-run average consumption growth". The defining characteristic of the equity premium puzzle is that consumption growth is not volatile enough to explain either the relatively high Sharpe ratios of U.S. stock returns or the low real risk-free rates of interest observed in post-WWII data. Essentially, this fundamental source of risk is simply not risky enough to account for the high equity premia observed in the data. By introducing the notion of surplus consumption, s_t, CCH introduces a new source of risk in the economy that is able to account for the U.S. equity premium. Specifically, Campbell and Cochrane's (1999) calibrated version of the CCH model exactly matches the average risk free rate (0.94%) and average Sharpe ratio (0.43) of the post-WWII U.S. economy. This is achieved by resorting to an extremely high level of "habit risk" relative to consumption risk. The level of habit volatility, $\sqrt{\frac{1-\phi-B/\gamma}{\gamma}}$, in the calibrated version of their model is in excess of 22% per year as compared to consumption volatility of roughly 1.5%. Put differently, given their calibrated values of $\gamma,\ \sigma,\ g$, the risk-free rate and Sharpe ratio that would obtain in the corresponding CCAPM economy are 15.3% and 0.03. CCH matches the average risk-free rate and Sharpe ratio in the U.S. economy by changing the very notion of risk in asset pricing models. Traditional models that associate risk with fluctuations in consumption have scant ability to explain the observed facts concerning average rates of return and Sharpe ratios. Consequently, CCH introduces a new source of risk which is both quite large relative to consumption risk, and more importantly from the perspective of this paper, unrelated to the riskiness of observable macroeconomic quantities such as consumption or output. Ultimately, the lack of a direct link between the riskiness of the stock market and the riskiness of macroeconomic fundamentals, i.e. consumption, in the CCH model has direct consequences for the relation between macroeconomic and stock market volatility.

Stock Return Volatility and the Great Moderation in the CCH Model

In this section I examine how a one-time permanent decline in the volatility of consumption growth affects the volatility of the stock market in the CCH model. I consider the variant of CCH in which a share of stock is a claim to consumption. Specifically, I assume that dividends coincide with consumption in the model so that, $\Delta d_t = \Delta c_t$. Alternatively, one could model stocks as a claim on dividends that are imperfectly correlated with consumption growth so that, $\Delta d_t = \lambda \Delta c_t + v_t$. In this case, modeling the Great Moderation would amount to a significant decline in both consumption volatility, σ, as well as a proportional decline in the volatility of the idiosyncratic component of dividend growth, v_t. Also, I assume that the change in consumption volatility is not anticipated before it occurs and is fully realized once it occurs. In this sense, I abstract from the effects of any learning or transitional dynamics. As a result, I employ a comparative static analysis across a high and low consumption volatility economy to summarize the likely effects of a structural break in consumption volatility within a single economy. I analyze the effect of a Great Moderation in consumption volatility on stock return volatility by analyzing the effect of a decline in consumption volatility on the volatility of stock dividends and the volatility of the price dividend ratio. I then solve and simulate the CCH model for two different levels of consumption volatility and compare the characteristics of the resulting equilibria.

Consider the following decomposition of single period real stock returns,

$$R_{t+1} \equiv \frac{P_{t+1} + D_{t+1} - P_t}{P_t} = \left(\frac{1 + P_{t+1}/D_{t+1}}{P_t/D_t} \right) \frac{D_{t+1}}{D_t},$$

or in logs,

$$r_{t+1} = \Delta d_{t+1} + \ln(1 + P_{t+1}/D_{t+1}) - \ln(P_t/D_t),$$

so that the stock return may be thought of in terms of the dividend flow and the change in the stock's price-dividend ratio. Within the context of Campbell and Shiller's (1988a,b) decomposition the unexpected return can be written as,

$$r_{t+1} - E_t(r_{t+1}) = (\Delta d_{t+1} - g) + \ln(1 + P_{t+1}/D_{t+1}) - E_t\big(\ln(1 + P_{t+1}/D_{t+1})\big) \quad = \quad R^{\infty}_{\Delta F,t+1} - R^{\infty}_{r,t+1}.$$

Since consumption and dividend growth is i.i.d. in this model, stock prices contain no information about future dividend growth. As a result, the component of unexpected returns due to changes in the price-dividend ratio can be solely identified with $R^{\infty}_{r,t+1}$. This implies that the shock to dividends and shock to future returns can be identified as,

$$R^{\infty}_{\Delta F,t+1} = \Delta d_{t+1} - g, \tag{IV.15}$$

$$R^{\infty}_{r,t+1} = -\Big(\ln(1 + P_{t+1}/D_{t+1}) - E_t\big(\ln(1 + P_{t+1}/D_{t+1})\big)\Big). \tag{IV.16}$$

Accordingly, analyzing the effect of a Great Moderation on stock return volatility within the

CCH model amounts to analyzing how a change in the volatility of consumption growth affects the volatility of $(\Delta d_{t+1} - g)$ and $\left(\ln(1+P_{t+1}/D_{t+1}) - E_t\left(\ln(1+P_{t+1}/D_{t+1})\right)\right)$.

In the case of news about fundamentals, $R^{\infty}_{\Delta F,t+1} = \Delta d_{t+1} - g$, the effect is immediate. A reduction in consumption growth volatility directly translates, one for one, into a reduction in the volatility of $(\Delta d_{t+1} - g)$. The effect of declining consumption growth volatility on the volatility of the price-dividend ratio is less direct.

Campbell and Cochrane (1999) show that the equilibrium price-dividend ratio in the CCH economy is only a function of the state, $(s_t - \overline{s})$. Specifically, the price-dividend ratio satisfies the following functional equation,

$$\frac{P_t}{D_t}(s_t - \overline{s}) = E_t\left[M_{t+1}\frac{D_{t+1}}{D_t}\left[1 + \frac{P_{t+1}}{D_{t+1}}(s_{t+1} - \overline{s})\right]\right], \tag{IV.17}$$

where the expectation is taken with respect to the future state. While an analytical expression for $\frac{P_t}{D_t}(s_t - \overline{s})$ does not exist, Campbell and Cochrane (1999) demonstrate that the function is nearly a log-linear function of $(s_{t+1} - \overline{s})$,

$$\ln\left(\frac{P_t}{D_t}(s_t - \overline{s})\right) \equiv \frac{p_t}{d_t}(s_t - \overline{s}) \approx b_0 + b_1(s_t - \overline{s}), \tag{IV.18}$$

so that the volatility of the (log) price-dividend ratio roughly corresponds to the product of the slope parameter and the volatility of the state,

$$\sigma(p_t/d_t) \approx b_1 \sigma(s_t - \bar{s}).$$

As a result, the volatility of the (log) price dividend ratio, and hence the volatility of return news, will only be materially affected if either the slope of the equilibrium log price-dividend ratio function or the volatility of the state is affected by a decline in the volatility of consumption growth. In what follows, I examine how the slope of the equilibrium price dividend ratio is affected by a Great Moderation in consumption volatility. I then turn to the issue of how the volatility of the economy's state is affected by the Great Moderation.

Since there is no analytical expression for the equilibrium price-dividend ratio as a function of the model's underlying parameters, the only way to gauge how b_1 is affected by a change in consumption volatility is by numerically solving the model for different levels of σ.[10] I examine the sensitivity of the equilibrium log price-dividend ratio to changing consumption risk as follows. All model parameters except for consumption volatility are set to the calibrated values employed by Campbell and Cochrane (1999). These parameter values are listed at the top of Table V. I then compute the model's equilibrium for two different levels of consumption growth volatility, 1.38% and 2.30%. These levels of consumption volatility are consistent with pre and post-Great Moderation consumption data. After solving the model for each level of consumption volatility, I regress the log equilibrium price dividend ratio function, $\frac{p}{d}(s-\bar{s})$ onto

[10] Following Campbell and Cochrane (1999), I solve and simulate the model at the monthly frequency. I use the same parameter transformations between the annual and monthly frequency used by Campbell and Cochrane (1999). The model was solved and simulated using GAUSS computer code provided by the authors. The GAUSS code may be downloaded from,
http://gsbwww.uchicago.edu/fac/john.cochrane/research/Data_and_Programs/habit%20programs.

the log state, $(s-\bar{s})$ using 18 discrete points, $\left(p/d_i,(s_i-\bar{s})\right)$. In Table V, I present the underlying model parameters used in solving the CCH model as well as the parameters from the OLS regression,

$$\frac{p}{d}(s-\bar{s})=b_0+b_1(s-\bar{s})+\varepsilon,$$

along with the regression R^2.

Looking at the R^2 listed in Table 5 for both the low and high volatility model specification shows that the linear approximation is not overly restrictive. In each case the R^2 is in excess of 99% indicating that the log linear approximation is appropriate. Looking at the constant and slope terms, both of the estimated equilibrium price-dividend ratio functions are nearly identical. This result is driven by the fact that the stochastic discount factor, f_{t+1}, the fundamental driver of stock returns in the model is not affected by the change in consumption volatility. In this sense, stock returns are as risky in a low consumption volatility as in a high consumption volatility environment. Since the risk inherent in owning stocks does not change as consumption risk changes, the level and slope of the equilibrium price-dividend ratio is unaffected by a Great Moderation in consumption volatility.

Turning to the volatility of the state of the economy, $(s_t-\bar{s})$, it is useful to recall how the state of the economy is related to the SDF. Namely,

$$f_{t+1}=\Delta c_{t+1}+\Delta s_{t+1},$$

so that,

$s_{t+1} = s_t + \Delta s_{t+1} = f_{t+1} - \Delta c_{t+1}$.

The effect of a change in macroeconomic volatility, σ, on the state of the economy can be analyzed by appealing to the above equation. Recall that the conditional variance of the stochastic discount factor, f_{t+1}, is independent of the level of macroeconomic volatility. As a result, changing macroeconomic risk only affects the volatility of the state of the economy through the term $-\Delta c_{t+1}$. Formally we have that,

$$Var_t(s_{t+1}) = Var_t(f_{t+1}) + \sigma^2 - 2\sigma\sqrt{Var_t(f_{t+1})}, \tag{IV.19}$$

where the above expression uses the fact that the stochastic discount factor and consumption growth are perfectly conditionally correlated. Finally, taking the derivative of this expression with respect to σ yields,

$$\frac{dVar_t(s_{t+1})}{d\sigma} = 2\left(\sigma - \sqrt{Var_t(f_{t+1})}\right), \tag{IV.20}$$

so that reducing macroeconomic volatility will actually increase the volatility of the state whenever $\sqrt{Var_t(f_{t+1})}$ exceeds σ.

Finally, recall that the average volatility of f_{t+1} in Campbell and Cochrane's (1999) calibrated version of the model is in excess of 20%. Accordingly, reducing macroeconomic volatility actually increases the volatility of the state. Moreover, as discussed previously, the high level of volatility in f_{t+1} is required to match the stylized facts of the US stock market. Accordingly, versions of the CCH model in which the volatility of f_{t+1} is less than σ would be unable to account for the observed high average Sharpe ratios and low risk free rates observed in the US economy. Consequently, parameterizations of the CCH model that are consistent with the basic stylized facts of the U.S. stock market predict that the volatility of the economy's state and hence the volatility of return news shocks will only increase in the face of a large decline in macroeconomic volatility.

In order to provide a quantitative assessment of the effect of a large decline in consumption volatility consistent with the Great Moderation, I solve and then simulate the CCH model for 100,000 months. The model is solved and simulated for both high and low consumption growth volatility. I employ the same sets of parameter values that were used to analyze the behavior of the equilibrium price-dividend ratio. In Table 6, I report the mean, standard deviation and first order autocorrelation of different model variables across the two economies. All numbers are reported in annualized terms.

I display the model's fundamental, exogenous, driving variables in the top panel of Table 6. Consumption growth, Δc_t, has a constant mean of 1.9% per annum and its standard deviation changes from 2.30% to 1.38% resulting in a 40% decline. Looking at the change in the state variable, Δs_t, indicates that across the two economies there is little difference in the volatility of the state variable even though there is a large difference in the volatility of consumption growth. Consistent with the previous analysis, the standard deviation of the state variable increases slightly from 0.225 to 0.233. Looking at the model's SDF, f_{t+1}, it is apparent that its riskiness is unaffected by the Great Moderation. The volatility of the model's stochastic discount factor and hence the riskiness of the stock market is not materially affected by a significant decline in fundamental macroeconomic volatility.

In the middle panel of Table 6, I compare the financial market equilibria of the high and low consumption growth volatility economies. In both economies the average Sharpe ratio is both high and highly variable. Across the two economies, however, there is only a minor difference in both the average level of the Sharpe ratio and its volatility. The lack of any difference in the behavior of the Sharpe ratio across the two economies is consistent with the earlier theoretical analysis. The level of the Sharpe ratio is determined by the amount of variability in f_t which is shown to be nearly identical across the two economies. The time-variation in the Sharpe ratio is driven by time-variation in the state, s_t. Since the distribution of the underlying state variable does not differ appreciably across the two economies neither do the stochastic properties of the Sharpe ratio.

The average volatility of stock returns across both economies is also very similar. The average conditional standard deviation of returns, $\sigma_{t-1}(r_t)$ is 13.7% per year in the low volatility economy and 14.2% per year in the high volatility economy. Also, the temporal dependence in volatility is largely unaffected by the large change in consumption volatility. In both cases the first order autocorrelation in volatility is roughly 99%. Looking at the different components of stock return volatility, the majority of stock volatility is accounted for by variation in return news across both economies. Across both economies, return news explains over 90% of the volatility of stock returns. As a result, the fact that fundamental news volatility declines by 40% between the high and low volatility economies has essentially no effect on stock market volatility.

The simulation results of the CCH model indicate that changing consumption risk only has minor consequences for stock market volatility. In particular, though the volatility of fundamental news is affected by the Great Moderation, the volatility of return news is essentially unaffected by a large decline in consumption volatility. Consistent with the previous analysis, the volatility of return news actually increases slightly following the Great Moderation. Since the bulk of stock market volatility is attributable to return news variation, the Great Moderation does not exhibit an appreciable influence on total stock market volatility.

These features of the CCH model are remarkably consistent with the pattern in stock market volatility that has been observed over the period of the Great Moderation. The previously reported empirical results indicate that fundamental news has declined substantially since the onset of the Great Moderation. Specifically, the volatility of the SPF fundamental news series has declined by 50% since the third quarter of 1981. Over the same period, the volatility of measured return news has not abated. Empirically, the large reduction in fundamental news volatility has not spilled over into the volatility of return news. The CCH model provides a framework for interpreting these findings. In the CCH model, the risk inherent in the stock market is unrelated to long term economic risk. Accordingly, changes to the volatility of macroeconomic fundamentals such as consumption have no discernible effect on the riskiness, and hence volatility, of the stock market.

V. Conclusion

The large and persistent decline in macroeconomic volatility that has occurred since the middle of the 1980's represents one of the single largest changes to the macroeconomic landscape in the past twenty years. In this paper, I document how this Great Moderation in macroeconomic volatility has affected stock market volatility. Furthermore, I show that the experience thus far is consistent with a rational, consumption based asset pricing model.

The empirical results show that the Great Moderation has had very different influences on the two fundamental components of stock returns. The volatility of news about stock fundamentals, such as dividends, earnings or cash flow, have abated since the onset of the Great Moderation. In particular, the volatility of fundamental news shocks has declined by roughly 50% since the fourth quarter of 1981. The size of this reduction in volatility is consistent with the reduction in the volatility of a broad range of macroeconomic aggregates including real output and consumption growth over the same period. These findings indicate that the volatility of macroeconomic fundamentals share important links with the volatility of the component of stock returns that is directly related to news about fundamentals.

In contrast to the empirical findings on the links between fundamental news and macroeconomic volatility I find no significant link between macroeconomic volatility and the volatility of return news. The divergence in behavior between fundamental and return news is reconciled with Campbell and Cochrane's (1999) habit formation asset pricing model. The CCH model predicts that even very large changes in consumption and dividend volatility will only have negligible effects on return news volatility and ultimately overall stock return volatility. In this way, the CHH model provides a framework for reconciling the disparate trends in the volatility of real activity and the stock market.

The divergence between the behavior of fundamental news and return news shocks within the context of the CCH model derives from the model's stance on the underlying nature of stock market risk. Unlike the CCAPM, the risk of declining consumption is not the most important source of risk in the CCH economy. Declining surplus consumption, rather than declining consumption is the dominant source of stock market risk in the CCH economy. More importantly, the risk associated with surplus consumption is largely unaffected by changes in consumption risk. As a result, reductions in consumption volatility do not make stocks less risky and stock market volatility does not decline in response to a Great Moderation in consumption volatility.

References

Bernanke B., and Kuttner K. (2004), "What Explains the Stock Market's Reaction to Federal Reserve Policy," *Finance and Economics Discussion Series Working Paper*, 2004-16, Board of Governors of the Federal Reserve.

Campbell J. (1991), "A Variance Decomposition for Stock Returns," *The Economic Journal*, 101, 157-179.

Campbell J. and Cochrane (1999), "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior," *Journal of Political Economy*, 107, 205-251.

Campbell J., and Shiller R. (1988a), "The Dividend Price Ratio and Expectations of Future Dividends and Discount Factors," *Review of Financial Studies*, 1, 195-227.

Campbell J., and Shiller R. (1988b), "Stock Prices, Earnings and Expected Dividends," *Journal of Finance*, 43, 661-676.

Campbell J., and Vuolteenaho T. (2004), "Bad Beta, Good Beta," *American Economic Review*, 94(5), 1249-1275.

Constandinides G. (1990), "Habit Formation: A Resolution of the Equity Premium Puzzle," *The Journal of Political Economy*, 98, 3, 519-543.

Croushore D. (1993), "Introducing the Survey of Professional Forecasters," *Federal Reserve Bank of Philadelphia Business Review*, Nov/Dec.

Elliott G., Komumjer I., and Timmerman A. (2004)," Biases in Macroeconomic Forecasts: Irrationality or Asymmetric Loss?," working paper, UCSD.

Kim C., and Nelson C. (1999), "Has the U.S. Economy Become More Stable? A Bayesian Approach Based ona Markov-Switching Model of the Business Cycle," *Review of*

Economics and Statistics, 81,4,608-616.

Lettau M., and Ludvigson S. (2001), "Resurrecting the (C)CAPM: A Cross Sectional Test When Risk Premia are time Varying," *Journal of Political Economy*, 109, 6, 1238-1287.

Lettau M., Ludvigson S., and Wachter J. (2004), "The Declining Equity Premium: What Role Does Macroeconomic Risk Play?," working paper, New York University.

McConnell M., and Perez-Quiros G. (2000), "Output Fluctuations in the United States: What Has Changed Since the Early 1980's?," *American Economic Review*, 90, 5, 1464-1476.

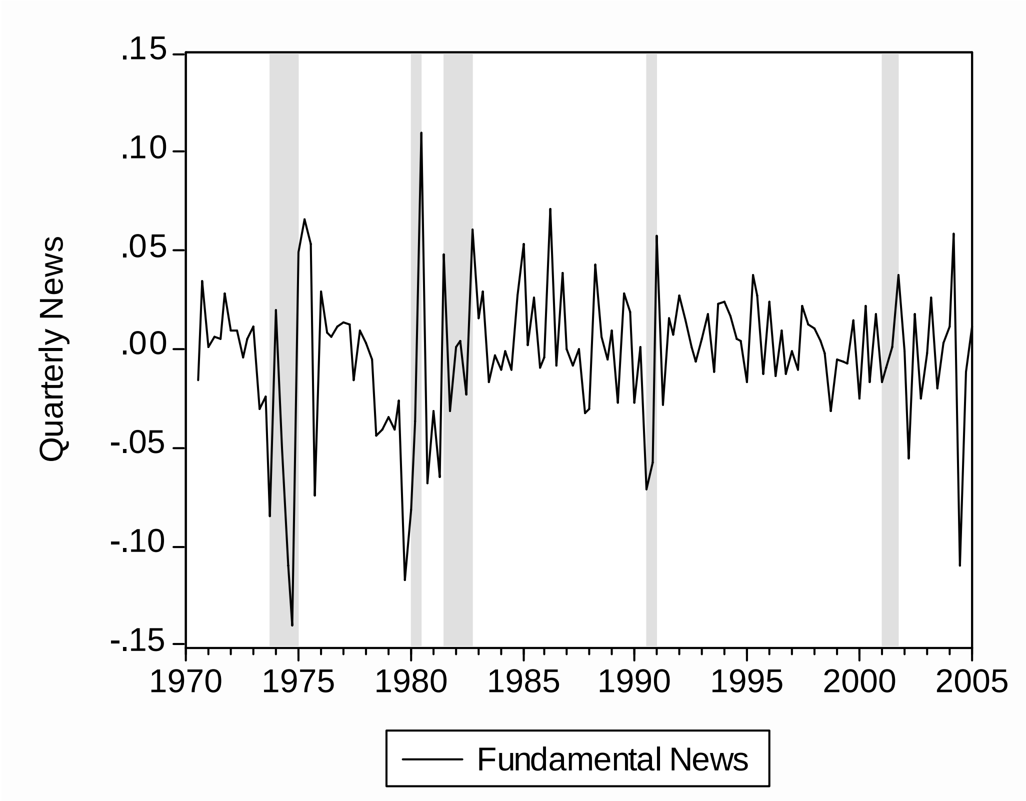
Schwert W. (1989), "Why Does Stock Market Volatility Change Over Time?," *Journal of Finance*, 44, 1115-1153.

Schwert W. (1990), "Stock Market Volatility," *Financial Analysts Journal*, May-June, 23-34.

Stock J., and Watson M. (2002) "Has the Business Cycle Changed and Why?," *NBER Macroeconomics Annual*, ed. M. Gertler and K. Rogoff, Cambridge: National Bureau of Economic Research.

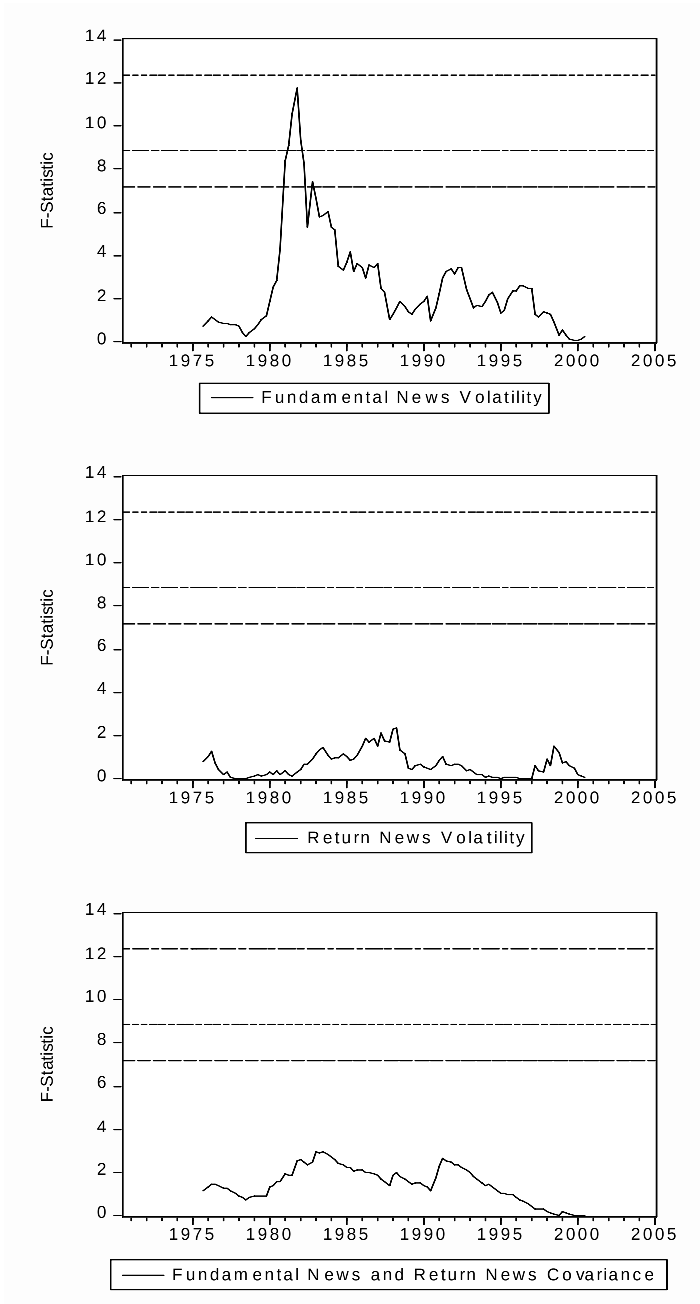
Stock J., and Watson M. (2003) "Has the Business Cycle Changed? Evidence and Explanations," FRB Kansas City Symposium 2003

Figure I
Fundamental News from the SPF
1970:3 - 2004:4



The above figure displays, $(E_{t+1} - E_t)(\Delta F_{t+2} + 0.99\Delta F_{t+3} + 0.99^2 \Delta F_{t+4})$, constructed from the Survey of Professional Forecasters (SPF) between 1970:3 and 2004:4. Specifically, ΔF_{t+j}, is identified with the growth in real corporate profits after taxes. The shaded regions depict the NBER recession dates.

Figure II
Volatility Structural Break Tests
Fundamental News and Return News



The above figure displays the series of F-statistics that are used to determine $F_{\max}$ for the Andrews' (1993) structural break test. The horizontal lines represent the 1%, 5% and 10% critical values respectively. For each series, the F-statistic was computed for each break date between 1975:3 through 2000:1.

Table I
Earnings Forecast Revisions and Fundamental News
Summary Statistics
1970:3 - 2005:1

	$(E_{t+1}-E_t)\Delta F_{t+2}$	$(E_{t+1}-E_t)\Delta F_{t+3}$	$(E_{t+1}-E_t)\Delta F_{t+4}$	$R^3_{\Delta F,t+1}$
Mean	-0.001	-0.004	0.003	-0.003
Median	0.000	-0.001	0.003	0.001
Std. Dev.	0.019	0.018	0.016	0.037
Skewness	-0.500	-0.856	0.400	-0.795
Kurtosis	7.205	5.000	6.855	5.283
Jarque-Bera	108.180	40.169	89.706	44.841
	(0.000)	(0.000)	(0.000)	(0.000)

The table above displays various summary statistics for each of the expectation revisions and for the fundamental news series. The Jarque-Bera statistic tests the null hypothesis that the data is distributed normally. The asymptotic p-value of the test is displayed below the statistic in parentheses.

Table II
Information Content of SPF Corporate Profit Forecasts
1970:3 - 2005:1

SPF Forecast	α_h	β_h	R^2 (%)
$F_{t+1\|t}$	0.01 (0.01)	0.77 (0.19)	10.18
$F_{t+2\|t}$	0.01 (0.01)	0.45 (0.25)	2.24
$F_{t+3\|t}$	0.00 (0.01)	0.57 (0.41)	2.76
$F_{t+4\|t}$	0.01 (0.01)	0.40 (0.40)	0.87

This table reports the results of the forecast rationality regression, $F_{t+h}=\alpha+\beta F_{t+h|t}+v_{t+h}$, for horizons ranging from one quarter ahead to four quarters ahead. The first column contains the estimated regression constants and the second column reports the slope coefficients for each SPF forecast. Tthe third column reports the regression R^2. The system was estimated via GMM and Newey-West standard errors are reported in parentheses.

Table III
Real Stock Returns and Fundamental News
1970:3 - 2005:1

$(E_{t+1}-E_t)\Delta e_{t+2}$	1.28 (0.35)	--	--	--	0.98 (0.31)
$(E_{t+1}-E_t)\Delta e_{t+3}$	--	1.13 (0.45)	--	--	0.71 (0.47)
$(E_{t+1}-E_t)\Delta e_{t+4}$	--	--	0.41 (0.40)	--	0.15 (0.32)
$R^3_{\Delta F,t+1}$	--	--	--	0.68 (0.21)	--
$\bar{R}^2$(%)	6.41	4.62	0.00	7.17	6.95

The table above displays OLS slope estimates from the regression, $r_{t+1}=\alpha+x_t^{/}\beta+v_{t+1}$, where x_t, represents the individual forecast revisions, $(E_{t+1}-E_t)\Delta e_{t+2}$, and the aggregate fundamental news shock, $R^3_{\Delta F,t+1}$ Newey-West standard errors are displayed in parentheses under the parameter estimates and the adjusted R^2 is displayed in the final row of the table..

Table IV
Structural Breaks in Fundamental News and Return News Volatility
1970:3 - 2005:1

Dependent Variable	t^*	α	β	$1-(\sigma_1/\sigma_0)$	W_{max}
$\lvert\hat{R}_{\Delta F,t+1}\rvert$	1981:4	-3.76 (0.16)	-0.70 (0.20)	0.50	11.75**
$\lvert\hat{R}_{r,t+1}-\hat{E}_t(r_{t+1})\rvert$	1976:2	-2.92 (0.14)	-0.31 (0.20)	0.27	2.34
$\left(\hat{R}_{r,t+1}-\hat{E}_t(r_{t+1})\right)\left(\hat{R}_{\Delta F^{\infty}_{t+1}}\right)$	1983:3	0.003 (0.001)	-0.002 (0.001)	--	2.98

The table above displays estimates from the structural break model, $\lvert x_{t+1}-E_t(x_{t+1})\rvert=\exp(\alpha+\beta D_{t^*}+v_{t+1})$, $1975{:}3 \leq t^* \leq 2000{:}1$. The model is estimate via GMM and Newey-West standard errors are reported in parentheses under the parameter estimates. The statistic, F_{max}, is a formal test for a single structural break and it is asymptotic distribution is given by Andrews (1993). *** signifies significance at the 1% level, ** signifies significance at the 5% level and * signifies significance at the 10% level.

Table V
CCH Equilibrium Log Price-Dividend Ratio Functions
Low vs. High Consumption Volatility

Model Parameters	g	r_f	ϕ	γ	B
	1.89%	0.94%	0.87	2.00	0.00

Consumption Volatility	b_0	b_1	R^2
σ=2.30%	5.59	0.56	0.99
σ=1.38%	5.62	0.56	0.99

The top panel of this table displays the model parameters used in numerically solving for the equilibrium log price-dividend ratio as a function of the log state, $(s-\bar{s})$. The bottom panel shows the result from fitting the equilibrium log-price dividend ratio function to a linear function using OLS. The parameters b_0, b_1 represent the constant and slope parameters, respectively. The R^2 summarizes the fit of the linear approximation.

Table VI
The Great Moderation and the CCH Model
Model Characteristics

	Mean		Standard Deviation		Autocorrelation	
	σ=2.3%	σ=1.4%	σ=2.3%	σ=1.4%	σ=2.3%	σ=1.4%
<u>Fundamental Variables</u>						
Δc_t	0.019	0.019	0.023	0.014	-0.001	-0.001
Δs_t	0.000	0.000	0.225	0.233	-0.007	-0.007
f_t	0.019	0.019	0.245	0.246	-0.007	-0.007
<u>Financial Variables</u>						
r_t	0.067	0.066	0.151	0.146	-0.006	-0.006
$E_{t-1}(r_t)$	0.071	0.070	0.014	0.014	0.991	0.991
$R^{\infty}_{\Delta F,t}$	0.000	0.000	0.023	0.014	-0.001	-0.001
$R^{\infty}_{r,t}$	0.000	0.000	0.128	0.133	-0.001	-0.001
$\sigma_{t-1}(r_t)$	0.142	0.137	0.049	0.051	0.988	0.988
SR_t	0.376	0.374	0.182	0.190	0.990	0.990
<u>Valuation Variables</u>						
p_t/d_t	3.066	3.094	0.272	0.282	0.991	0.991
P_t/D_t	22.181	22.853	5.129	5.435	0.977	0.976

The table above reports the mean, standard deviation and first order autocorellation in several model characteristics from the CCH model using a high value, 2.3%, and a low value, 1.9%, of consumption volatility. In each case the model was simulated for 100,000 periods. The other model parameters are fixed at the values reported in Table 5. All numbers are reported in annualized terms.