Lecture 5: Asset Pricing Model with Habit Formation

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Habit model:

- Assume:
  \[
  U = E \sum_{t=0}^{\infty} \beta^t u(c_t, h_t),
  \]
  with \( u \) given, for instance, by the formula
  \[
  u(c, h) = \frac{(c - \theta h)^{1-\sigma}}{1 - \sigma},
  \]
  where \( \theta > 0 \) is a parameter and \( h_t \) is the habit level.

- The habit level \( h_t \) satisfies a law of motion, e.g. it is a function of past consumption choices:
  \[
  h_t = (1 - \delta) h_{t-1} + c_{t-1} = \sum_{j=1}^{\infty} (1 - \delta)^{j-1} c_{t-j}
  \]
External habits (keeping up with the Joneses) – agents take $h$ as exogenous. Internal habits – agents recognize the effect of current consumption on future habits.

In addition to asset pricing, habits are used in DSGE models to deliver hump-shaped business cycle dynamics.

Microfoundations are weak: very little empirical evidence and unclear how such a model aggregates.
If agent’s utility is \( v(c, h) = u(c - h) \) instead of \( u(c) \), and \( h \) grows over time so that its distance to \( c \) is always rather small, then a given percentage change in \( c \) generates a larger percentage change in \( c - h \):

\[
\frac{\Delta (c - h)}{c - h} = \frac{\Delta c}{c} \frac{c}{c - h} > \frac{\Delta c}{c}.
\]

This is just a “leverage” effect coming from the “subsistence level” \( h \). Hence for a given volatility of \( c \), we certainly get more volatility of marginal utility of consumption \( \frac{\partial u}{\partial c} \). This will allow us to become closer to the Hansen-Jagannathan bounds: marginal utility of consumption is volatile, which is what you need for the equity premium puzzle.
Time-varying risk aversion:

- When agents’ consumption becomes closer to the habit level $h$, they fear further negative shocks since their utility is concave.
- The curvature of the utility function, i.e. the “index of relative risk aversion”, is
  \[ I_R(c) = \frac{-cv''(c)}{v'(c)} = \frac{-cu''(c - h)}{u'(c - h)}, \]
  which is time-varying.
- When $u$ is CRRA, $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$. Direct calculation yields
  \[ I_R(c) = \gamma \frac{c}{c - h}, \]
  As $c \to h$, $I_R(c) \to \infty$. Hence “time-varying risk aversion”, and hence time-varying risk premia.
Multiplicative habits

- Utility:
  \[ E_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_t/X_t)^{1-\gamma} - 1}{1 - \gamma}, \]

- Assume habit is external then
  \[ M_{t+1} = \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} \left( \frac{X_t}{X_{t+1}} \right)^{\gamma-1} \]

- Assume one lag for simplicity:
  \[ X_t = C_{t-1}^{\kappa} \]

then
  \[ M_{t+1} = \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} \left( \frac{C_{t-1}}{C_t} \right)^{\kappa(\gamma-1)} \]
Implications:

- Assume joint-log normality of consumption growth and asset returns then the risk free rate is:

  \[ r_{f,t+1} = -\log \beta - \gamma^2 \frac{\sigma_c^2}{2} + \gamma E_t \Delta c_{t+1} - \kappa (\gamma - 1) \Delta c_t \]

  The equity premium is unchanged relative to the CRRA model:

  \[ E_t (r_{t+1} - r_{f,t+1}) + \frac{\sigma_r^2}{2} = \gamma \sigma_c \]

- On average:

  \[ r_{f,t+1} = -\log \beta - \gamma^2 \frac{\sigma_c^2}{2} + (\gamma (1 - \kappa) + \kappa) g \]

  so increasing \( \gamma \) will not have as large an impact on reducing \( r_f \) when \( 0 < k < 0 \)

- Increasing \( \gamma \) for \( 0 < \kappa < 1 \) will also raise the variability of the interest rate in the short-run – this will tend to be counterfactual.

- Overall difficult to argue this model solves the risk-free rate puzzle for very high \( \gamma \).
Utility:

\[ E_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_t - X_t)^{1-\gamma} - 1}{1 - \gamma}, \]

where \( \gamma \) denotes the risk-aversion coefficient, \( X_t \) the external habit level and \( C_t \) consumption.

Assume that consumption growth is i.i.d and log-normal:

\[ \Delta c_{t+1} = g + u_{t+1}, \text{ where } u_{t+1} \sim i.i.d. N(0, \sigma^2). \]
Define the surplus consumption ratio \( S_t \equiv (C_t - X_t)/C_t \). Note that \( 0 < S_t < 1 \).

Assume that \( s_t = \log(S_t) \) is related to consumption through the following heteroskedastic AR(1) process:

\[
s_{t+1} = (1 - \phi)s_t + \phi s_t + \lambda(s_t)(\Delta c_{t+1} - g).
\]

This is a generalization of a standard AR(1), i.e. \( X_t = (1 - \delta)X_{t-1} + C_{t-1} \). The function \( \lambda(.) \) introduces a nonlinearity, which will prove important.
Pricing kernel:

- **External habits:** The habit is assumed here to depend only on aggregate, not on individual, consumption. Thus, the inter-temporal marginal rate of substitution is here:

  \[
  M_{t+1} = \beta \frac{U_c(C_{t+1}, X_{t+1})}{U_c(C_t, X_t)}
  = \beta \left( \frac{S_{t+1}}{S_t} \right) \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma}
  = \beta e^{-\gamma} \left[ g + (\phi-1)(s_t-\ddot{s}) + (1+\lambda(s_t))(\Delta c_{t+1}-g) \right].
  \]

- **In contrast, with internal habits,** the consumer is forward-looking and realizes that increasing \( C \) today will result in a higher habit in the future. In this case the SDF is more complicated:

  \[
  M_{t+1} = \beta \frac{U_c(t+1) + \sum_{j=1}^{\infty} \beta^j U_x(t+1+j) \frac{\partial X_{t+1+j}}{\partial C_{t+1}}}{U_c(t) + \sum_{j=1}^{\infty} \beta^j U_x(t+j) \frac{\partial X_{t+j}}{\partial C_t}}.
  \]
Campbell and Cochrane use the following sensitivity function:

$$\lambda(s_t) = \frac{1}{\overline{S}} \sqrt{1 - 2(s_t - \overline{s})} - 1, \text{ when } s \leq s_{\text{max}}, \text{ 0 elsewhere,}$$

where $\overline{S}$ and $s_{\text{max}}$ are respectively the steady-state and upper bound of the surplus-consumption ratio, which we set as:

$$\overline{S} = \sigma \sqrt{\frac{\gamma}{1 - \phi}},$$

and

$$s_{\text{max}} = \overline{s} + \frac{1 - \overline{S}^2}{2}.$$

These two values for $\overline{S}$ and $s_{\text{max}}$ are one possible choice, which they justify to make the habit locally predetermined.
Fig. 1.—a, Sensitivity function \( \lambda(s) \). b, Implied sensitivity of habit \( x \) to contemporaneous consumption. The vertical solid line in this and subsequent figures shows the steady-state surplus consumption ratio \( \bar{S} \). The dashed vertical line shows the maximum surplus consumption ratio \( S_{\text{max}} \).
Risk free rate:

- This sensitivity function allows them to have a constant risk-free interest rate. To see this, note that the risk-free rate is

\[ r_{t+1}^f = -\log \beta + \gamma g - \gamma (1 - \phi)(s_t - \bar{s}) - \frac{\gamma^2 \sigma^2}{2} (1 + \lambda(s_t))^2. \]

- Two effects where \( s_t \) appears: intertemporal substitution and precautionary savings. When \( s_t \) is low, households have a low IES which drives the risk free rate up. High risk aversion induces more precautionary savings which drives the risk free rate down.

- CC offset these two effects by picking \( \lambda \) such that

\[ \gamma (1 - \phi)(s_t - \bar{s}) + \frac{\gamma^2 \sigma^2}{2} (1 + \lambda(s_t))^2 = \text{constant}. \]
By picking a different $\lambda$, you can have a risk-free rate which depends, say, linearly on the state variable $s_t$, i.e.

$$r^f_{t+1} = A - Bs_t.$$ 

Extensions of the CC model to study the yield curve (Wachter, JFE) or the forward premium puzzle (Verdelhan, JF) consider the case $B < 0$ and $B > 0$, modifying slightly the CC model.

Depending on the value of the structural parameters, the model implies constant, pro- or counter-cyclical interest rates.
Key mechanism

- Time-varying local risk-aversion coefficient:
  \[
  \gamma_t = -\frac{CU_{CC}}{UC} = \frac{\gamma}{S_t}.
  \]

- Counter-cyclical market price of risk. Start from:
  \[
  SR_t = \left| \frac{E_t(R_{t+1}^e)}{\sigma_t(R_{t+1}^e)} \right| \leq \frac{\sigma_t(M_{t+1})}{E_t(M_{t+1})} = MPR_t,
  \]
  with an equality for assets that perfectly correlated with the SDF.

- In this model the market price of risk is:
  \[
  MPR_t = \gamma \sigma (1 + \lambda(s_t)) = \frac{\gamma \sigma}{\bar{S}} \sqrt{1 - 2(s_t - \bar{s})}.
  \]

At the steady-state, \(\overline{SR} = \gamma \sigma / \bar{S}\), but the market price of risk is countercyclical, and hence so is the Sharpe ratio.
Proof of result on MPR:

- In this model, the SDF is conditionally log-normally distributed, hence we can apply the general formula:

\[ SR_t = \sqrt{e Var_t(\log M_{t+1})} - 1 \approx \sigma_t(\log M_{t+1}) \]

Proof: use the log-normal formula

\[ E(\exp(X)) = \exp( E(X) + \frac{1}{2} Var(X) ) \]

and compute

\[ E_t(M_{t+1}) = e^{E_t(\log M_{t+1}) + \frac{1}{2} Var_t(\log M_{t+1})}, \]

and

\[ Var_t(M_{t+1}) = E_t(M_{t+1}^2) - [E_t(M_{t+1})]^2, \]

\[ = e^{2E_t(\log M_{t+1}) + 2Var_t(\log M_{t+1})} - e^{2E_t(\log M_{t+1}) + Var_t(\log M_{t+1})}, \]

hence the result.
Solving the model

- Solving numerically this model is complicated, because of the important nonlinearities.

- The aggregate market is represented as a claim to the future consumption stream. Let $P_t$ denote the ex-dividend price of this claim. Then, $E_t[M_{t+1}R_{t+1}] = 1$ implies that in equilibrium $P_t$ satisfies:

$$E_t \left( M_{t+1} \frac{P_{t+1} + C_{t+1}}{P_t} \right) = 1$$

$$\frac{P_t}{C_t} = E_t \left( M_{t+1} \left( \frac{P_{t+1}}{C_{t+1}} + 1 \right) \frac{C_{t+1}}{C_t} \right)$$

$$= E_t \left( \beta \left( \frac{S_{t+1}}{S_t} \right)^{-\gamma} \left( \frac{C_{t+1}}{C_t} \right)^{1-\gamma} \left( \frac{P_{t+1}}{C_{t+1} + 1} \right) \right)$$
Solution:

- The state variable is $s_t$.
- We solve for a fixed point, i.e. $\frac{P_t}{C_t} = h(s_t)$ with

$$h(s_t) = E_{u_{t+1}} \left( \beta \left( \frac{S_{t+1}}{S_t} \right)^{-\gamma} \left( \frac{C_{t+1}}{C_t} \right)^{1-\gamma} (h(s_{t+1}) + 1) \right),$$

with

$$\Delta c_{t+1} = g + u_{t+1},$$

$$s_{t+1} = (1 - \phi)\bar{s} + \phi s_t + \lambda(s_t)u_{t+1},$$

$$u_{t+1} \sim i.i.d. N(0, \sigma^2).$$
This implies the following fixed point equation in \( h(s) \):

\[
h(s) = \beta \int_{-\infty}^{\infty} \exp(f(s, u)) d\Phi(u).
\]

where

\[
f(u, s) = -\gamma ((1 - \phi) (\tilde{s} - s) + \lambda(s) u) + (1 - \gamma) g + (1 - \gamma) u (h ((1 - \phi) \tilde{s} + \phi s + \lambda(s) u) + 1)
\]

To compute this fixed point we need to evaluate the integral on the right hand side.
Recipe:

- Set a grid for $s$, \{s_1, s_2, ..., s_N\};
- Take a guess for $h$, i.e. \{h(s_1), h(s_2), ..., h(s_N)\};
- For each value of $s$ in the grid, compute the RHS of the fixed-point equation numerically. We need to interpolate $h$ to find its value at the point $(1 - \phi)\tilde{s} + \phi s + \lambda(s)u$ since it lies outside the grid.
- To compute the integral numerically, one way is to use a quadrature, e.g. $\int k(u)du = \sum_i \omega_i k(u_i)$ for some points $u_i$.
- This gives a new guess for $h$ using the fixed-point equation. We keep iterating on this equation until convergence.
- Once we know $h$, we have the P-D ratio and the rest can be computed simply, as in Mehra-Prescott. (See Wachter, Finance research letters, for a note detailing the computation of that model.)
### TABLE 1

<table>
<thead>
<tr>
<th>Parameter Choices</th>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assumed:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean consumption growth (%)*</td>
<td>g</td>
<td>1.89</td>
</tr>
<tr>
<td>Standard deviation of consumption growth (%)*</td>
<td>σ</td>
<td>1.50</td>
</tr>
<tr>
<td>Log risk-free rate (%)*</td>
<td>r/</td>
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</tr>
<tr>
<td>Persistence coefficient*</td>
<td>θ</td>
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<tr>
<td>Utility curvature</td>
<td>γ</td>
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<tr>
<td>Standard deviation of dividend growth (%)*</td>
<td>σ_υ</td>
<td>11.2</td>
</tr>
<tr>
<td>Correlation between Δd and Δc</td>
<td>ρ</td>
<td>.2</td>
</tr>
<tr>
<td><strong>Implied:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective discount factor*</td>
<td>δ</td>
<td>.89</td>
</tr>
<tr>
<td>Steady-state surplus consumption ratio</td>
<td>S̄</td>
<td>.057</td>
</tr>
<tr>
<td>Maximum surplus consumption ratio</td>
<td>S_{max}</td>
<td>.094</td>
</tr>
</tbody>
</table>

* Annualized values, e.g., 12g, \sqrt{12σ}, 12r/, θ^n, and δ^n, since the model is simulated at a monthly frequency.


We choose the free parameters of the model to match certain moments of the postwar data. Table 1 summarizes our parameter choices. We take the mean and standard deviation of log consumption growth, \( g \) and \( σ \), to match the consumption data. We choose the serial correlation parameter \( θ \) to match the serial correlation of log price/dividend ratios. We choose the subjective discount factor \( δ \) to match the risk-free rate with the average real return on Treasury bills. Since the ratio of unconditional mean to unconditional standard deviation of excess returns is the heart of the equity premium puzzle, we search for a value of \( γ \) so that the returns on the consumption claim match this ratio in the data.

We take the standard deviation of dividend growth, \( σ_υ \), from the CRSP data as well. Assigning a value \( ρ \) for the correlation between dividend growth and consumption growth is a little trickier. If dividend growth were uncorrelated with consumption growth, a claim to dividend growth would have no risk premium. However, correlations are difficult to measure because they are sensitive to small changes in timing or time aggregation. Campbell (1999) reports correlations in postwar U.S. data varying from .05 to almost .25 as the measurement interval increases from 1 to 16 quarters and correlations in long-run annual U.S. data varying from almost .2 to just over .1 as the measurement interval increases from 1 to 8 years. In the very long run, one expects the correlation to approach 1.0 since dividends and consumption should share the same long-run trends. Furthermore, these point estimates are subject to large sampling
Basic results:

- The model matches the level of the riskless rate and the equity return, and their volatilities.
  - no variation in expected cash flows, no variation in the risk-free rate, but a lot of variation in risk premia.

- Intuition: Risk premia are higher after a sequence of some bad shocks, which push $C$ close to $X$, hence a very low $s$.
  - Suggests that risk premia should be highest in the depth of a recession.

- Covariance of returns with $s_t$ is the key source of risk here.
error. The usual standard error formula $1/\sqrt{T}$ for a correlation coefficient is .1 in a century and .15 in postwar data, so we cannot convincingly reject zero or accurately measure economically interesting correlations of .2 or .3. Given these results, we do not try to match a particular correlation but choose a baseline correlation of .2 to show that the model works well even with quite a low correlation between consumption and dividends. The results are insensitive to the precise value of this correlation.

III. Solution and Evaluation

In this section we solve the model numerically and characterize its behavior. Then we simulate data by drawing shocks from a random number generator, and we show how the simulated data replicate many interesting statistics found in actual data. Finally, we feed the model historical consumption shocks to see what it tells us about historical movements in stock prices.

A. Asset Prices and the Surplus Consumption Ratio

Stationary Distribution of the Surplus Consumption Ratio

Figure 2 presents the stationary distribution of the surplus consumption ratio. The figure plots the distribution of the continuous-time

![Figure 2](image)

**Fig. 2.**—Unconditional distribution of the surplus consumption ratio. The solid vertical line indicates the steady-state surplus consumption ratio $S$, and the dashed vertical line indicates the upper bound of the surplus consumption ratio $S_{\text{max}}$. 


version of the process, calculated in the appendix (Campbell and Cochrane 1998a). This distribution is an excellent approximation to histograms of the discrete-time process for simulation time intervals of a year or less. With this stationary distribution and the slow mean reversion of the state variable in mind, one can get a good idea of the behavior of other quantities plotted against the state variable \( S \).

The plot verifies that the unconditional distribution is well behaved: it does not pile up at the boundaries or wash out. The distribution of the surplus consumption ratio is negatively skewed. The surplus consumption ratio spends most of its time above the steady-state value \( \bar{S} \), but there is an important fat tail of low surplus consumption ratios. We shall refer to a low surplus consumption ratio as a "recession" and a high surplus consumption ratio as a "boom." Thus the model predicts occasional deep recessions not matched by large booms.

Price/Dividend Ratios and the Surplus Consumption Ratio

Figure 3 presents the price/dividend ratios of the consumption claim and the dividend claim as functions of the surplus consumption ratio. These are the central quantities for our simulations; all other variables are calculated from the price/dividend ratio.

The price/dividend ratios increase with the surplus consumption

![Graph](image.png)

**Fig. 3.**—Price/dividend ratios as functions of the surplus consumption ratio
ratio. When consumption is low relative to habit in a recession, the curvature of the utility function is high, and prices are depressed relative to dividends. Since the price/dividend ratios are nearly linear functions of the surplus consumption ratio and the distribution of the surplus consumption ratio is negatively skewed, the distribution of price/dividend ratios inherits this negative skewness despite i.i.d. lognormal consumption growth.

The price/dividend ratio of the dividend claim is almost exactly the same as the price/dividend ratio of the consumption claim despite the very low (.2) correlation of dividend growth with consumption growth. Dividend growth is much more volatile than consumption growth, so the regression coefficient $\beta = \rho \frac{\sigma_{\Delta d}}{\sigma_{\Delta c}}$ of dividend growth on consumption growth is roughly one. The systematic or priced components of the two assets are similar, and therefore so are their prices.

Conditional Moments of Returns

Figure 4 presents the expected consumption claim and dividend claim returns and the risk-free interest rate as functions of the surplus consumption ratio. As consumption declines toward habit, expected returns rise dramatically over the constant risk-free rate.

![Graph](image.png)

**Fig. 4.**—Expected returns and risk-free rate as functions of the surplus consumption ratio.
Figure 5 presents the conditional standard deviations of returns as functions of the surplus consumption ratio. As consumption declines toward habit, the conditional variance of returns increases. Thus the model produces several effects that have been emphasized in the autoregressive conditional heteroscedasticity (ARCH) literature: highly autocorrelated conditional variance in stock returns, a "leverage effect" that price declines increase volatility, and countercyclical variation in volatility.

In figure 4, the expected return of the dividend claim is almost exactly the same as that of the consumption claim. In figure 5 the dividend claim has a noticeably higher standard deviation than the consumption claim but the same dependence on the surplus consumption ratio. The return on the dividend claim is

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t} = \frac{(P_{t+1}/D_{t+1})}{P_t/D_t} + 1 \times \frac{D_{t+1}}{D_t}. \quad (20)$$

The expected returns are nearly identical because the price/dividend ratio and price/consumption ratio are nearly identical functions of state, and dividend and consumption growth are not predictable. The conditional standard deviation of the dividend claim inherits the same dependence on state through the nearly identical $P/D$ term but adds the extra, constant, standard deviation of dividend growth.
Conditional Sharpe Ratios

Comparing figures 4 and 5, we see that conditional means and conditional standard deviations are different functions of the surplus consumption ratio, so the Sharpe ratio of conditional mean to conditional standard deviation of excess returns varies over time. To get a precise measure, figure 6 presents the Sharpe ratio as a function of the surplus consumption ratio. The top line is the maximum possible Sharpe ratio, calculated from the Hansen-Jagannathan bound, equation (7).

The consumption claim nearly attains the Sharpe ratio bound, implying that it is nearly conditionally mean-variance efficient. The consumption claim model has only one shock. Hence the only reason the consumption claim (or any claim whose return depends on the single shock) is not exactly conditionally mean-variance efficient is that it is non-linearly related to the shock. For the consumption claim, the effects of such non-linearity are slight.

The dividend claim has a slightly higher mean return and a substantially higher standard deviation since there is a second dividend growth shock as well as the consumption (discount rate) shock. Hence, the dividend claim has a somewhat lower Sharpe ratio and is less conditionally efficient. However, since the dividend payoff is correlated only .2 with the consumption claim payoff, it is surprising how close the Sharpe ratios are. In equation (20), most of the variation in the dividend claim return is due to changing risk premia and
Additional results:

- Volatility of returns is higher in bad times.
- The model also matches the time-series predictability evidence: dividend growth is not predictable, but returns are predictable, and the volatility of the P-D ratio is accounted for by this latter term ("discount rate news").
- Long-run equity premium: because of mean-reversion in stock prices, excess returns on stocks at long horizons are even more puzzling than the standard one-period ahead puzzle. CC note that if the state variable is stationary, the long-run standard deviation of the SDF will not depend on the current state. Key point: in their model, $S^{-\gamma}$ is not stationary – variance is growing with horizon!
The first four moments match the postwar statistics exactly because we chose parameters to fit those moments. In particular, we picked the parameter $\gamma = 2.00$ to exactly match the Sharpe ratio for log returns of 0.43 in postwar data. The model also matches the Sharpe ratio for simple returns of 0.50. A $\gamma$ value of about four matches the dividend claim Sharpe ratio to the postwar value without much effect on other statistics.

We chose to match the postwar time series because they are a significantly harder target. The long historical time series feature a much larger standard deviation of consumption growth, a lower Sharpe ratio, and a higher risk-free rate. A $\gamma$ of about 0.7 matches the 0.22 Sharpe ratio for log returns in the long-term data, with little effect on the other statistics.

It is noteworthy that the model can match the mean and standard deviation of excess stock returns, with a constant low interest rate and a discount factor $\delta = 0.89$ less than one, by any choice of parameters. These moments are the equity premium and risk-free rate puzzles, which we discuss below.

The remaining moments were not used to pick parameters, so we can use them to check the model’s predictions. The choice of $\gamma$ matches the ratio of mean return to standard deviation, but it says nothing about the level of mean and standard deviation of returns. The ratio 0.43 could be generated by a mean of 0.43 percent and a standard deviation of 1 percent. In fact, the mean and standard deviation of excess returns are almost exactly equal to the corresponding values in the postwar data, using either the consumption claim or the dividend claim.

The mean price/dividend ratio is a bit below that found in post-
dend ratio of the dividend claim is almost exactly the same function of state as the price/dividend ratio of the consumption claim.

To our eyes, the model provides a tantalizing account of cyclical and longer-term fluctuations in stock prices. When consumption declines for several years in a row, coming nearer to our constructed habit, stock prices fall. Model and actual price/dividend ratios fall in the sharp recessions of the late nineteenth and early twentieth centuries, and the model also captures the long-term rise and then decline from 1890 to 1915. The model accounts for the boom of the 1920s. The decline in consumption in the Great Depression was so extreme that the model predicts an even larger fall in stock prices than actually occurred. Then the model tracks the recovery during World War II, the consumption and stock boom of the 1960s (though with a lag), the secular and cyclical declines of the 1970s, and the consumption and stock market boom of the 1980s.

It is a little embarrassing that the worst performance occurs in the last few years. Growth in consumption of nondurables and services was surprisingly slow in the early 1990s, bringing consumption near our implied habit level (fig. 8), so our model predicts a fall in price/dividend ratios rather than the increase we see in the data. Possible excuses include a shift in corporate financial policy toward the repurchase of equity rather than dividend payments; an increase in the consumption of stock market investors that is not properly cap-