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Asset Prices with Gaussian Shocks and Habit Formation*

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Abstract

This paper provides an exact solution to asset-pricing models when the growth rate of the endowment is a first-order Gaussian autoregression and the utility function displays habit formation. It determines the conditions that guarantee the existence of a bounded solution. The equilibrium asset prices can be used to examine the equity premium puzzle and the risk-free rate puzzle.

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1. Introduction

Burnside (1998) has provided a closed-form solution for the price-dividend ratio in Lucas (1978) asset-pricing model when the growth rate of the endowment is a first-order Gaussian autoregression. Tsionas (2003) has extended the Burnside's model to the case of any distribution of shocks to endowment's growth rate. These models are useful in allowing comparisons among numerical methods used to approximate the nontrivial closed-form solution.

However, these models are unsuccessful in accounting for the joint behavior of asset prices and consumption. Two failures in particular have attracted much attention: Mehra and Prescott's (1985) equity premium puzzle, the fact that returns on the stock market exceed the returns on Treasury bills by an average of six percentage points; and Weil's (1989) risk-free rate puzzle, the fact that the return on Treasury bills is low on average.

A lot of papers have been developed in respect to theses puzzles. Habit formation has a long history in the study of consumption. Habit formation models assume that the utility is derived from consumption relative to its recent past rather than its absolute level. Preferences exhibiting habit formation constitute an important class of time non-separable preferences, which have received attention again recently[1]. The distinguishing feature of these models is that current utility depends not only on current consumption, but also on a habit stock formed from past consumption. The larger the habit, the less pleasure is received from a given amount of consumption, and the larger must be new purchases to gain the same benefit.

Abel (1990) introduces habit formation into the representative investor's utility function, and calculates the returns on stocks and bills. Abel suggests that the habit formation model resolves the equity premium puzzle and the risk-free rate puzzle, as the simulated risk premium on stocks is high and the risk-free rate is low. However, Abel's calculation is based on the assumption that consumption growth is i.i.d.. Fama and French (1988) and Poterba and

[1] See Sundaresan (1989), Constantinides (1990), Campbell and Cochrane (1999), Jermann (1998), Boldrin, Christianoz, and Fisher (2001).

Summers (1988) find evidence that consumption growth is negatively serially correlated.

In this paper we construct a new model that nests Burnside's model and Abel's habit formation model. That is, we use two modifications on the standard asset-pricing model: the growth rate of the endowment is a first-order Gaussian autoregression and the representative investor has habit formation utility function. The goal of this paper is to explore the asset-pricing implication of our new model.

The rest of the paper is organized as follows. We begin in Section 2 with the assumptions on technology and preference structure in which the habit formation is introduced. Then we describe the representative investor's consumption-portfolio problem, and discuss the equilibrium asset-pricing implication of the problem. Section 3 solves the model by iterating forward on the Euler equation for the price-dividend ratio. We also provide the price of one-period risk-free bond. Section 4 uses the equilibrium asset prices in the section 3 to study the equity premium puzzle and risk-free rate puzzle. We find that the plausible parameters in our model can generate high equity premium and low risk-free rate at the same time. Section 5 concludes.

2. The Model

The economy is similar, except for the investors' preferences and the endowment process, to the one studied by Lucas and Mehra and Prescott. We first describe the technology and investors' problem, and then compute equilibrium Euler equation.

2.1 Technology

There is one perishable consumption good, a fruit, which is produced by non-reproducible identical trees. The number of trees equals the size of constant population. At time *t*, each tree yields fruits or dividends in the amount D_t. The stochastic dividends are the only source of exogenous fundamental uncertainty. Assume that the growth of dividends, $x_t = \ln(D_t / D_{t-1})$, follows a Gaussian AR(1) process

$$x_t = (1-\rho)\mu + \rho x_{t-1} + \xi_t\,, \tag{1}$$

where ξ_t is i.i.d. $N(0,\sigma^2)$ and $|\rho|<1$.

The investors can also purchase one-period risk-free bond. A risk-free bonds are issued at each period t with the price b_t and mature at period t+1 paying one unit of consumption good. The gross rate of return on the bond is $R_t = 1/b_t$.

2.2 Investors

The economy is populated by a large constant number of identical infinitely lived investors. The representative investor has wealth W_t at time t and wants to use this wealth to maximize expected lifetime utility,

$$\max E_t\left\{\sum_{s=0}^{\infty}\beta^s u(C_{t+s},h_{t+s})\right\}, \tag{2}$$

subject to the budget constraints

$$W_t = C_t + R_t^{-1}L_t + P_t s_t\,,\;\; W_{t+1} = L_t + (P_{t+1}+D_{t+1})s_t\,.$$

Here E_t is the mathematical expectation conditional on information known at time t, $\beta\in(0,1)$ is a subjective time discount factor, P_t is the exdividend price of a tree in period t, s_t and L_t are, respectively, the investor's holdings of trees and the gross payout on the bond holding between periods t and t+1. The investor's period utility function, $u(C_t,h_t)$, depends not only on the current consumption C_t, but also on the habit stock h_t, where we follow Abel in defining the habit formation as $h_t = h(C_{t-1}) = C_{t-1}^{\gamma}$. Assume that the period utility function has the following isoelastic form $u(C_t,h_t) = (C_t/h_t)^{1-\alpha}/(1-\alpha)$. When parameter γ equals zero, the utility function reduces to the standard constant risk aversion utility function and α is the coefficient of relative risk aversion.

2.3 Equilibrium asset-pricing

In the assumed representative investor economy, optimal consumption and asset holdings and prices have to adjust at each period such that in general equilibrium C_t=D_t, $s_t = 1$, and $L_t = 0$ for each t. Using these market clearing conditions, we can write the first order conditions for the representative investor's problem as follows:

$$1 = E_t(M_{t+1}R_t), \tag{3}$$

$$1 = E_t\left[M_{t+1}\frac{P_{t+1}+D_{t+1}}{P_t}\right], \tag{4}$$

where the stochastic discount factor is defined as

$$M_{t+1} \equiv \beta\frac{u_C(t+1)+\beta E_{t+1}[u_h(t+2)\partial h_{t+2}/\partial C_{t+1}]}{u_C(t)+\beta E_t[u_h(t+1)\partial h_{t+1}/\partial C_t]} = \beta\frac{H_{t+2}}{E_t H_{t+1}}\lambda_t^{\gamma(\alpha-1)}\lambda_{t+1}^{-\alpha}.$$

Here $u_C(t) \equiv u(C_t, h_t)$, $\lambda_{t+1} \equiv D_{t+1}/D_t$, and $H_{t+1} \equiv 1-\beta\gamma\lambda_{t+1}^{1-\alpha}\lambda_t^{-\gamma(1-\alpha)}$.

3. Solution of the model

In this section, we present the price-dividend ratio, the condition under which the price-dividend ratio is bounded, and the bond price. We then use the asset prices to calculate the stock's risk premium and the bond's risk-free rate.

3.1 Price-dividend ratio

The following theorem provides a closed-form solution for the price-dividend ratio.

Theorem 1. *For this economy, the tree's price-dividend ratio* $v_t \equiv P_t/D_t$ *is*

$$v_t = \sum_{j=1}^{\infty}\frac{\beta^j e^{\gamma(\alpha-1)x_t}}{E_t H_{t+1}}\left\{e^{A_j+B_j(x_t-\mu)} - \beta\gamma e^{A_{j+1}+B_{j+1}(x_t-\mu)}\right\}, \tag{5}$$

where A_j and B_j will be defined later.

Proof. We can rewrite Euler equation (4) as $v_t = E_t[M_{t+1}(v_{t+1}+1)\lambda_{t+1}]$. Iterating forward on the equation above gives $v_t = \Sigma_{j=1}^{\infty}E_t[M_{t+1}\cdots M_{t+j}\lambda_{t+1}\cdots\lambda_{t+j}]$, where we have ruled out the asset bubbles. Applying the definition of SDF to each term in the preceding equation gives

$$
\begin{aligned}
& E_t[M_{t+1}\cdots M_{t+j}\lambda_{t+1}\cdots\lambda_{t+j}] \\
&= \frac{\beta^j \lambda_t^{\gamma(\alpha-1)}}{E_t H_{t+1}}\left\{E_t\left[\lambda_{t+1}^{(1-\gamma)(1-\alpha)}\cdots\lambda_{t+j-1}^{(1-\gamma)(1-\alpha)}\lambda_{t+j}^{1-\alpha}\right]-\beta\gamma E_t\left[\lambda_{t+1}^{(1-\gamma)(1-\alpha)}\cdots\lambda_{t+j}^{(1-\gamma)(1-\alpha)}\lambda_{t+j+1}^{1-\alpha}\right]\right\} \\
&= \frac{\beta^j \lambda_t^{\gamma(\alpha-1)}}{E_t H_{t+1}}\left\{E_t e^{(1-\gamma)(1-\alpha)(x_{t+1}+\cdots+x_{t+j})+\gamma(1-\alpha)x_{t+j}} - \beta\gamma E_t e^{(1-\gamma)(1-\alpha)(x_{t+1}+\cdots+x_{t+j+1})+\gamma(1-\alpha)x_{t+j+1}}\right\},
\end{aligned}
$$

where the second equality follows from the fact that $\lambda_{t+1}=e^{x_{t+1}}$. Burnside shows that

$$
\begin{aligned}
&\Sigma_{i=1}^{j} x_{t+i} = j\mu + \frac{\rho}{1-\rho}(1-\rho^j)(x_t-\mu)+\frac{1}{1-\rho}[(1-\rho^j)\xi_{t+1}+\cdots+(1-\rho)\xi_{t+j}], \\
&x_{t+j} = \mu+\rho^j(x_t-\mu)+\rho^{j-1}\xi_{t+1}+\cdots+\rho\xi_{t+j}.
\end{aligned}
$$

Therefore,

$$
\begin{aligned}
&(1-\gamma)(1-\alpha)(x_{t+1}+\cdots+x_{t+j})+\gamma(1-\alpha)x_{t+j} \\
&=(1-\gamma)(1-\alpha)[j\mu+\rho(1-\rho)^{-1}(1-\rho^j)(x_t-\mu)]+\gamma(1-\alpha)[\mu+\rho^j(x_t-\mu)] \\
&\quad +(1-\gamma)(1-\alpha)(1-\rho)^{-1}[(1-\rho^j)\xi_{t+1}+\cdots+(1-\rho)\xi_{t+j}]+\gamma(1-\alpha)(\rho^{j-1}\xi_{t+1}+\cdots+\xi_{t+j}).
\end{aligned}
$$

When a random variable η is normally distributed with mean μ_η and variance σ_η^2, the formula for the mean of $\exp(\eta)$ is $\exp(\mu_\eta+\sigma_\eta^2/2)$. Because ξ_t is an i.i.d. sequence of random variables with normal distribution, we have

$$
E_t e^{(1-\gamma)(1-\alpha)(x_{t+1}+\cdots+x_{t+j})+\gamma(1-\alpha)x_{t+j}} = e^{A_j+B_j(x_t-\mu)}\text{, where}
$$

$$
\begin{aligned}
A_j &= (1-\gamma)(1-\alpha)j\mu+\gamma(1-\alpha)\mu+0.5\{[(1-\gamma)(1-\alpha)(1-\rho)^{-1}(1-\rho^j)+\gamma(1-\alpha)\rho^{j-1}]^2 \\
&\quad +\cdots+[(1-\gamma)(1-\alpha)(1-\rho)^{-1}(1-\rho)+\gamma(1-\alpha)\rho^0]^2\}\sigma^2, \\
B_j &= (1-\gamma)(1-\alpha)\rho(1-\rho)^{-1}(1-\rho^j)+\gamma(1-\alpha)\rho^j.
\end{aligned}
$$

It follows that $E_t[M_{t+1}\cdots M_{t+j}\lambda_{t+1}\cdots\lambda_{t+j}] = \dfrac{\beta^j e^{\gamma(\alpha-1)x_t}}{E_t H_{t+1}}\{e^{A_j+B_j(x_t-\mu)}-\beta\gamma e^{A_{j+1}+B_{j+1}(x_t-\mu)}\}$,

which proves equation (5). *Q.E.D.*

The term $E_t H_{t+1}$ is time *t* measurable, and can be written as the function of state variable

$$
E_t H_{t+1} = 1-\beta\gamma e^{-\gamma(1-\alpha)x_t} E_t e^{(1-\alpha)[\mu+\rho(x_t-\mu)+\xi_{t+1}]} = 1-\beta\gamma e^{-\gamma(1-\alpha)x_t} e^{(1-\alpha)[\mu+\rho(x_t-\mu)]+0.5(1-\alpha)^2\sigma^2}.
$$

Theorem 2. *The series in equation (5) converges if and only if*

$$r = \beta e^{(1-\alpha)(1-\gamma)\mu + \frac{1}{2}\frac{(1-\alpha)^2(1-\gamma)^2}{(1-\rho)^2}\sigma^2} < 1. \qquad (6)$$

Proof. Define $z_j = \frac{\beta^j e^{\gamma(\alpha-1)x_t}}{E_t H_{t+1}}\{e^{A_j+B_j(x_t-\mu)} - \beta\gamma e^{A_{j+1}+B_{j+1}(x_t-\mu)}\}$, so that $v_t = \Sigma_{j=1}^{\infty} z_j$. Thus,

$$\frac{z_{j+1}}{z_j} = \beta \frac{1-\beta\gamma e^{A_{j+2}-A_{j+1}+(B_{j+2}-B_{j+1})(x_t-\mu)}}{1-\beta\gamma e^{A_{j+1}-A_j+(B_{j+1}-B_j)(x_t-\mu)}} e^{A_{j+1}-A_j+(B_{j+1}-B_j)(x_t-\mu)}, \text{ where}$$

$$A_{j+1} - A_j = (1-\gamma)(1-\alpha)\mu + 0.5[(1-\gamma)(1-\alpha)(1-\rho)^{-1}(1-\rho^{j+1}) + \gamma(1-\alpha)\rho^j]^2\sigma^2,$$
$$B_{j+1} - B_j = (\rho^{j+1} - \rho^j)[\gamma(1-\alpha) - (1-\gamma)(1-\alpha)\rho(1-\rho)^{-1}].$$

Then, it follows from $|\rho| < 1$ that $\lim_{j\to\infty} z_{j+1}/z_j = r$. If $r < 1$, the ratio test for convergence of series implies that the sum $\Sigma_{j=1}^{\infty} z_j$ converges. If $r > 1$, the ratio test implies that the sum diverges. If $r = 1$, the ratio test is not conclusive. But in this case, z_j can be shown to diverge to infinity. *Q.E.D.*

Theorem 3. *The mean of the price-dividend ratio is a finite constant if r* < 1.

Proof. Rewrite the price-dividend ratio as $v_t = \beta X e^{A_1+B_1(x_t-\mu)} + \Sigma_{j=2}^{\infty}\beta^j XY_j$, where

$$X = \frac{e^{\gamma(\alpha-1)x_t}}{E_t H_{t+1}}, \quad Y_j = (1-\beta\gamma)e^{A_{j+1}+B_{j+1}(x_t-\mu)}.$$

It follows from the definition of the endowment growth rate that the unconditional distribution of x_t is given by $x_t \sim N(\mu, \sigma^2/(1-\rho^2))$ for every integer *t*. Therefore,

$$E(\Sigma_{j=2}^{\infty} Y_j) = \Sigma_{j=2}^{\infty}(1-\beta\gamma)e^{A_{j+1}+0.5B_{j+1}^2\sigma^2/(1-\rho^2)}.$$

It is easy to show that

$$\lim_{j\to\infty} | e^{A_{j+1}+0.5B_{j+1}^2\sigma^2/(1-\rho^2)} / e^{A_j+0.5B_j^2\sigma^2/(1-\rho^2)} | = r.$$

The ratio test then implies that $E(\Sigma_{j=2}^{\infty} Y_j)$ is finite for *r* < 1. Since the mean of random variable *X* is finite, it follows from the Lebesgue Convergence Theorem that the mean of the price-dividend ratio is finite. *Q.E.D.*

The formula for the price-dividend ratio differs from Burnside's (1998) formula, in that habit formation also affects the price-dividend ratio. The theorem in Burnside considered the special case $\gamma = 0$, which corresponds to time-separable utility function.

3.2 Bond price

Rewrite the bond price as $b_t = E_t(M_{t+1})$. After substituting the expressions for SDF, we have

$$b_t = \beta E_t\left[\frac{H_{t+2}}{E_t H_{t+1}}\lambda_t^{\gamma(\alpha-1)}\lambda_{t+1}^{-\alpha}\right] = \frac{\beta e^{\gamma(\alpha-1)x_t}}{E_t H_{t+1}} E_t\left[e^{-\alpha x_{t+1}} - \beta\gamma e^{[-\alpha-\gamma(1-\alpha)]x_{t+1}} e^{(1-\alpha)x_{t+2}}\right].$$

We have known that

$$x_{t+1} = \mu + \rho(x_t - \mu) + \xi_{t+1},\ x_{t+2} = \mu + \rho^2(x_t - \mu) + \rho\xi_{t+1} + \xi_{t+2}.$$

Then,

$$\begin{aligned}
& e^{[-\alpha-\gamma(1-\alpha)]x_{t+1}+(1-\alpha)x_{t+2}} \\
&= e^{[-\alpha-\gamma(1-\alpha)][\mu+\rho(x_t-\mu)+\xi_{t+1}]+(1-\alpha)[\mu+\rho^2(x_t-\mu)+\rho\xi_{t+1}+\xi_{t+2}]} \\
&= e^{[-\alpha-\gamma(1-\alpha)][\mu+\rho(x_t-\mu)]+(1-\alpha)[\mu+\rho^2(x_t-\mu)]+[-\alpha-\gamma(1-\alpha)+(1-\alpha)\rho]\xi_{t+1}+(1-\alpha)\xi_{t+2}}
\end{aligned}$$

Thus, the bond price is

$$\begin{aligned}
b_t = \frac{\beta e^{\gamma(\alpha-1)x_t}}{E_t H_{t+1}}\{& e^{-\alpha[\mu+\rho(x_t-\mu)]+0.5\alpha^2\sigma^2} \\
& - \beta\gamma e^{[-\alpha-\gamma(1-\alpha)][\mu+\rho(x_t-\mu)]+(1-\alpha)[\mu+\rho^2(x_t-\mu)]+0.5[-\alpha-\gamma(1-\alpha)+(1-\alpha)\rho]^2\sigma^2+0.5(1-\alpha)^2\sigma^2}\}.
\end{aligned} \qquad (7)$$

3.3 The equity premium and the risk-free rate

In this subsection, we present the equity returns and the risk-free rate. The rate of return on equity (i.e. stock) is defined as $R_{t+1}^S = (P_{t+1} + D_{t+1})/P_t$. Thus, when the current state is x_t and next state is x_{t+1}, the period return is $R_{t+1}^S = (1+v_{t+1})\exp(x_{t+1})/v_t$. When the current state is x_t, the equity's expected rate of return is

$$E[R^S_{t+1} \mid x_t] = \frac{1}{v_t(x_t)} E\left\{[1+v_{t+1}(\mu+\rho(x_t-\mu)+\xi_{t+1})]\exp[\mu+\rho(x_t-\mu)+\xi_{t+1}] \mid x_t\right\}$$
$$= \frac{\exp[\mu+\rho(x_t-\mu)]}{v_t(x_t)} E\left\{[1+v_{t+1}(\mu+\rho(x_t-\mu)+\xi_{t+1})]\exp(\xi_{t+1}) \mid x_t\right\}.$$

As x_t and ξ_{t+1} are independent, it is easy to compute the equity's conditional expected rate of return as the function of x_t.

The unconditional expected return on the equity is $R^S = E_x\{E[R^S_{t+1} \mid x_t]\}$, where the notation E_x indicates the expectation over the unconditional distribution of x_t. The gross rate of return on the bond is $R^B_{t+1} = 1/b_t$ when the current state is x_t. Thus, the expected return on the risk-free bond is $R^B = E_x(R^B_{t+1})$. Therefore, the equity premium is $R^S - R^B$.

4. Numerical Solutions

In this section we present the major results of the model's numerical solutions.

4.1 parameter values

For the economies to be fully specified, it is necessary to choose the specific parameter values for β, μ, σ, ρ, and γ. The following values are taken directly from Abel, where they were chosen so that certain key statistics for the model economies would match those for the U.S. economy: β=0.99, μ=0.018, σ=0.036, ρ=-0.14, γ=1.

The next step is to choose parameter values for α, which should satisfy both condition (6) and $H_{t+1} > 0$ (See Abel). When γ=1, condition (6) obviously holds true. It suffices to calculate the bound for α by solving the condition $H_{t+1} > 0$. Incorporating the definition of consumption growth yields

$$H_{t+1} = 1 - \beta\gamma \exp[-\gamma(1-\alpha)x_t]\exp[(1-\alpha)x_{t+1}] > 0 .$$

Therefore, the inequality above is equivalent to

$$1 - \ln(\beta\gamma)/[\min(x) - \gamma\max(x)] < \alpha < 1 + \ln(\beta\gamma)/[\min(x) - \gamma\max(x)],$$

where max(x) and min(x) denote, respectively, the maximum and the minimum of random variable x_t. As x_t is normally distributed, max(x) = -min(x) = ∞, the limiting value of α is one. To avoid this problem, consider a normal distribution truncated at x_L and x_R, so that the density is $f(x)$/prob($x_L < x_t < x_R$) when $x_L < x_t < x_R$ and 0 otherwise, with f given by unconditional distribution of x_t. Then letting max(x) to be x_R, and min(x) to be x_L, parameter α would have a bound. For β =0.99, γ =1, x_L =-0.1, x_R =0.13, the bound for α is 0.9563< α <1.0437.

4.2 results

Panel A of Table 1 presents the unconditional expected rates of return and the equity premium under time-separable preferences and i.i.d. consumption growth. It displays the equity premium puzzle. Although R^S increases as α increases from 0.5 to 10, R^B also increases, the equity premium does not come anywhere close to 6 percent per year.

Panel B presents the unconditional expected rates of return and the equity premium under time-separable preferences and non i.i.d. consumption growth. However, it still cannot provide a resolution of the equity premium puzzle. Although the equity premium is larger than those in the case of the i.i.d. consumption growth, it is still far below 6 percent per year.

Panel C reports the unconditional expected rates of return under habit formation and non i.i.d. consumption growth. For α =1.0437, the equity premium is about 5 percent and the unconditional risk-free rate is 2.62 percent. The unconditional expected returns on stocks and bonds are much closer to their historical averages. We cannot directly compare the results displayed in Panel C with Abel's corresponding results, since two results are based on different methods.

5. Conclusions

The paper explored two modifications on the standard asset-pricing model: the growth rate of the endowment is a first-order Gaussian autoregression and the investor's preference is a habit formation utility function. The paper combined Burnside's and Abel's models. It was shown that the modifications not only improved on the standard asset-pricing model's implication for the equity premium puzzle and the risk-free rate puzzle, that is, our model was capable of explaining high risk premium and low risk-free rate at the same time, they also retained the advantage of Burnside's model, that is, the convenience of exact solution.

References

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

Boldrin, Michele, Lawrence J. Christiano, and Jonas D.M. Fisher (2001) Habit persistence, asset returns, and the business cycle, *American Economic Review* 91, 149-166.

Burnside, C. (1998) Solving asset-pricing models with Gaussian shocks. *Journal of Economic Dynamics and Control* 22, 329-340.

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

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

Fama, Eugene F., and Kenneth R. French (1988) Permanent and temporary components of stock prices, *Journal of Political Economy* 96, 246-273.

Jermann, U. (1998) Asset-pricing in production economies, *Journal of Monetary Economics*. 41, 257-276.

Lucas, Robert E., Jr. (1978) Asset prices in an exchange economy, *Econometrica* 46, 1429-1445.

Mehra, Rajnish and Edward Prescott (1985) The equity premium: a puzzle, *Journal of Monetary Economics* 15, 145-162.

Poteba, James M. and Lawrence H. Summers (1988) Mean reversion in stock prices: evidences and implications, *Journal of Financial Economics* 22, 27-59.

Sundaresan, Suresh M. (1989) Intertemporally dependent preferences and the volatility of consumption and wealth, *The Review of Financial Studies*, vol.2, no.1, pp.73-89.

Tsionas, E. (2003) Exact solution of asset-pricing models with arbitrary shocks distributions. *Journal of Economic Dynamics and Control* 27, 843-851.

Weil, Philippe (1989) The equity premium puzzle and the risk-free rate puzzle, *Journal of Monetary Economics* 24, 401-21.

Table 1: Unconditional Expected Returns

α	Stocks	Bonds	Equity Premium
A. Time-separable preferences and i.i.d. consumption growth ($\gamma = 0;\ \rho = 0$)			
0.5	1.0197	1.0191	6.6057e-004
1	1.0291	1.0278	0.0013
6	1.1079	1.0994	0.0086
10	1.1482	1.1334	0.0148
B. Time-separable preferences and non i.i.d. consumption growth ($\gamma = 0;\ \rho = -0.14$)			
0.5	1.0203	1.0191	0.0012
1	1.0291	1.0278	0.0013
6	1.1134	1.0999	0.0135
10	1.1644	1.1349	0.0296
C. Habit Formation and non i.i.d. consumption growth ($\gamma = 1;\ \rho = -0.14$)			
0.96	1.0496	1.0357	0.0139
0.98	1.0288	1.0299	-0.0011
1	1.0251	1.0264	-0.0013
1.01	1.0292	1.0254	0.0038
1.02	1.0373	1.0250	0.0123
1.03	1.0500	1.0252	0.0248
1.04	1.0682	1.0258	0.0424
1.0437	1.0766	1.0262	0.0504