2000s-39

Consumption with Habit Formation

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Série Scientifique
Scientific Series

CIRANO
Centre interuniversitaire de recherche en analyse des organisations

Montréal
Octobre 2000

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ISSN 1198-8177

Consumption with Habit Formation*

Aylin Seckin†

Résumé / Abstract

Dans un modèle intertemporel de consommation et d'épargne avec revenu stochastique et formation d'habitudes, nous avons démontré que l'épargne précautionnelle observée dans les données peut être attribuée non seulement à l'incertitude de revenu mais aussi à l'inséparabilité des préférences. Nous avons trouvé que, avec les préférences qui forment des habitudes, la consommation dépend non seulement du revenu permanent mais aussi de niveaux de consommations passés. De plus, plus les habitudes sont résistantes, moins grand sera l'effet de l'incertitude de revenu sur la consommation. Pour un coéfficient constant fixé de l'aversion au risque, le consommateur avec habitudes va avoir une épargne précautionnelle plus basse par unité de risque de revenu par rapport à celle avec des préférences temps-séparables. En introduisant la formation d'habitudes dans la consommation, et en supposant seulement des innovations i.i.d., nous avons trouvé une solution fermée qui explique les trois énigmes de consommation, l'excès de sensitivité, l'excès de lisseté et l'excès de croissance anticipée, et qui propose un meilleur modèle pour tester le trajet de la consommation pendant le cycle économique.

In a representative-agent model of intertemporal consumption-saving with stochastic income and habit formation, we have shown that precautionary savings observed in the data cannot be attributed only to income uncertainty, but also to the time-non-separability of preferences. We have found that, with habit-forming preferences, consumption depends not only on permanent income but also on past consumption and the stronger the habits the lower the effect of income uncertainty on consumption. For a given constant coefficient of risk aversion, habit-forming consumer will have smaller precautionary savings per unit of income risk faced than the one with time-separable preferences. By allowing habit forming preferences in consumption, a closed form solution, explaining excess-sensitivity, excess-smoothness and excess-growth puzzles of consumption, and thus, providing a better framework for empirically testing the behavior of consumption over the business cycle, is found with only i.i.d. income innovations.

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Mots Clés : Consommation/épargne intertemporelles, formation d'habitudes, programmation dynamique

Keywords: Intertemporal consumption-saving, habit formation, dynamic programming

JEL: E21

1. Introduction

Following Hall (1978), Flavin (1981), Hall and Mishkin (1982) found that consumers do not smooth out consumption as much as predicted by the Life Cycle-Permanent Income Hypothesis (LC-PIH). In fact, current consumption seems to be excessively sensitive to current and lagged income and changes in consumption can be explained by averages of past innovations to income. This is known as the excess sensitivity puzzle of consumption.

The other striking fact about aggregate consumption behavior is that aggregate consumption is smooth relative to aggregate income. Shifts in aggregate income cause relatively small shifts in aggregate consumption, and variations in consumption about trend are smaller than variations in income about trend. The explanation of these facts is that consumption is determined by permanent income not by current income, and permanent income is smooth relative to current income. Innovations to income generate relatively small innovations to permanent income, and thus to consumption. However, if current income is positively autocorrelated, the innovation variance of permanent income will be greater than that of current income. This anomaly in the joint behavior of consumption and income is known as "Deaton's paradox"[1]. Campbell and Deaton (1989) show that consumption is slow to adjust to innovations in income in the sense that changes in consumption are related to averages of previous innovations. This exposes both the smoothness and the sensitivity puzzles[2].

There is also the excess expected growth puzzle of consumption. Hall and Mishkin (1982), Deaton (1986), among others, have pointed out that there have been long periods of time in which average U.S. aggregate consumption growth has been positive despite real interest rates that were very low (close to zero) and rates of time preference that were assumed to be zero.

The aim of this paper is, by introducing habit formation in a consumption-saving model with uncertainty, to bring a theoretical explanation to these consumption puzzles.[3] We argue that habit formation itself leads to prudent behavior in addition to the usual precautionary saving motive against income uncertainty[4].

[1]Deaton (1986) argues that permanent income is noisier than current income in such a case so that the Permanent Income Theory fails to explain the excess smoothness puzzle of consumption. They concluded that the representative agent version of the permanent income hypothesis can be rejected because it fails to predict the fact that consumption is smooth, the very reason that it was proposed for in the first place.

[2]Hall and Mishkin(1982) found a growth rate of consumption 2 percent in excess the rate predicted by the PIH.

[3]Campbell and Deaton (1989) and Deaton (1992) suggest habit formation as one of several potential explanations for the excess smoothness puzzle, without however actually exploring its implications in a theoretical analysis.

[4]Kimball (1990) introduced the concept of prudence to characterize the "sensitivity of a decision variable to income risk". He argues that risk leads, in the presence of non-increasing absolute risk aversion, to a precautionary premium.

We will show that with habit formation, the effect of income uncertainty on consumption is lower, i.e. the stronger the habits the lower the effect of income uncertainty on consumption. This, basically, implies that high precautionary savings observed in the data cannot be attributed only to the precautionary savings against income uncertainty but also to the preferences, which exhibit habit formation in consumption. We will first show that even in the quadratic case, where the precautionary saving premium is zero, there is habit formation induced saving, and that consumption depends not only on permanent income but also on past consumption. Then, with the exponential utility function and using identification of parameters method, we will not only show that habit formation decreases precautionary saving per unit of variance of change in consumption, but also be able to explain the excess sensitivity, the excess smoothness, and the excess growth puzzles of consumption with only independently and identically distributed (i.i.d.) innovations to income[5]. We will also show that the marginal propensity to consume out of income (in the manner defined by Zeldes (1989) is lower while consumption growth is higher with habit persistence. With habit formation, "unanticipated changes in income" that is, the response of consump-

[5]Caballero (1990) needed to assume uncertainty about higher moments of the distribution of income.

tion changes to current changes in income is slower than would be expected with time-separable preferences. Moreover, consumption responds to all past (anticipated) income innovations, contrary to the predictions of the Permanent Income Hypothesis. Overall, with habit formation, consumption has a lower response to current permanent income than in the usual model, but also responds to a distributed lag of past permanent incomes, i.e., to past perceptions of the income stream, thus exhibiting a faster rate of growth.

Habit formation has been used in several contexts in economics. The implications of habit formation were first discussed in Duesenberry's work (1949). His proposition was that families are willing to sacrifice saving in order to protect their living standards. In the event of a fall in income, consumption will not fall proportionately, producing a ratchet effect.

Whereas time-separable preferences imply that current utility depends only on current consumption, time-non-separable preferences with habit formation imply that past real consumption patterns and levels form consumer habits which persist long enough to slow down the effects of current income changes on current consumption. For a given level of current expenditures, past purchases contribute to a habit stock. Hence, it is an increase of current consumption over and above the habit stock which raises current utility. An individual with preferences exhibiting habit formation who consumes a lot in period t-1 will get used to that high standard of consumption and would like to consume more. The stronger is the habit persistence, the more averse is the consumer to a fall in consumption and will require larger consumption in order to have a positive utility.

Several empirical papers in the consumption literature have found evidence for the role of habits in determining consumption. Constantinides (1990), Ferson and Constantinides (1991), Deaton and Paxson (1992), Dynan (1993), Carroll and Weil (1994), Heaton (1995), Garcia, Lusardi and Ng (1997), Fuhrer and Klein (1998) are among others[6].

This paper is organized as follows: Section 2 discusses the implications of habit forming preferences in consumption. Section 3 presents the general model with habit formation. Section 4 examines the model with certainty equivalence. The exponential utility model and the results are presented in section 5. Section 6 concludes the paper.

[6] On the other hand, Dunn and Singleton (1986) and Eichenbaum, Hansen and Singleton (1988), Muellbauer (1988), study the U.S. aggregate monthly consumption data and find no evidence of habit formation.

2. The General Model with Habit Formation

In this paper, we introduce habit-forming consumption into a consumption-saving model with income uncertainty. Suppose that a representative consumer maximizes the lifetime utility subject to the budget constraint.

$$Max_{\{c_t\}_{t=0}^{\infty},\{A_{t+1}\}_{t=0}^{\infty}} \quad E_0 \sum_{t=0}^{\infty} \beta^t U(c_t + \alpha x_t) \tag{1}$$

$$\text{s.t. } A_{t+1} = (1+r)[A_t + y_t - c_t] \tag{2}$$

where $\lim_{t\to\infty} A_t(1+r)^{-t} = 0$, and $E_t(.)$ denotes expectations conditional on the information available at time t. The initial asset level A_0 and consumption level c_0 are given together with an exogenous expected time pattern of income y_t. We assume that y_t follows an autoregressive process with a normal distribution. That is, $y_t = \mu y_{t-1} + \omega_t$, $0 < \mu < 1$ where $\omega_t \sim i.i.d.$ with mean zero and variance σ_ω^2. We assume that the rate of interest r is equal to the time preference ρ. Then β, the discount factor is equal to $\frac{1}{1+\rho}$, $0 < \beta < 1$, and α is the durability parameter, $0 < \alpha < 1$.

The individual makes decision about current period consumption, c_t, and the next period asset holdings, A_{t+1}, subject to the budget constraint. Since the preferences are time-non-separable in consumption, the current utility will depend not only on current consumption but also on the habit stock, x_t. The habit formation parameter α is between zero and one, and measures the strength of habit stock on current utility. The habit stock x_t is a weighted average of all past consumptions and can be defined as:

$$x_t \equiv (1-\zeta)\sum_{j=0}^{\infty}\zeta^j c_{t-1-j} \tag{3}$$

where weights add to one with (1− ζ) being the depreciation parameter of habit stock, $0 \leqslant \zeta \leqslant 1$. When the depreciation of habits is equal to one, ($\zeta = 0$), i.e., the case where past values of consumption before c_{t-1} do not affect consumption, we have a model which reflects one-period habit formation, i.e. $x_t = c_{t-1}$. For simplicity, we will assume this one-period habit formation model.

The utility function is assumed to have the following properties: $U(0) = 0$, $U'(0) = \infty$. The individual derives utility from consumption levels which are higher than a fraction of past consumption. The initial asset level A_0 and consumption level c_0 are given. Given the individual's expectations of the future (assuming that all present and past variables are observable), we can solve the maximization problem using dynamic programming. Then the Euler equation for consumption is:

$$\begin{aligned} & U'(c_t - \alpha c_{t-1}) - \alpha\beta E_t U'(c_{t+1} - \alpha c_t) \\ = \; & \beta(1+r)E_t[U'(c_{t+1} - \alpha c_t) - \alpha\beta U'(c_{t+2} - \alpha c_{t+1})] \end{aligned} \tag{2.1}$$

Now let us define net consumption as $\widehat{c}_t \equiv c_t - \alpha c_{t-1}$. For future use, it will be convenient to express the budget constraint in terms of $\widehat{c}_t$. Then,

$$\begin{aligned} c_{t+i} &= \widehat{c}_{t+i} + \alpha\widehat{c}_{t+i-1} + ... + \alpha^i\widehat{c}_t + \alpha^{i+1}c_{t-1} \\ &= (\sum_{j=0}^{i} \alpha^j \widehat{c}_{t+i-j}) + \alpha^{i+1}c_{t-1} \end{aligned} \tag{2.2}$$

Given the transversality condition, we can rewrite the lifetime budget constraint:

$$\sum_{i=0}^{\infty} \beta^i E_t \widehat{c}_{t+i} = (1-\alpha\beta)\{A_t + \sum_{i=0}^{\infty} \beta^i E_t y_{t+i}\} - \alpha c_{t-1}. \tag{2.3}$$

Equation (2.3) expresses the lifetime budget constraint of the individual as a function of the expected income stream. Note that the first order condition together with the lifetime budget constraint are sufficient to solve for the time path for consumption. More specific statements about the form of this path will require a more precise description of the form of the utility function and of the stochastic income process.

3. The Certainty Equivalence Model

Whereas the CE model led to Hall's random walk hypothesis, due to habit formation, c_t is no longer a random walk in our model. Using the definition of $\widehat{c}_t = c_t - \alpha c_{t-1}$, the quadratic utility function is given as:

$$U(\widehat{c}_t) = \nu_0 + \nu_1 \widehat{c}_t - \frac{1}{2}\nu_2 \widehat{c}_t^2$$

where ν_0, ν_1, and $\nu_2 > 0$.

When the rate of interest is equal to the rate of time preference, i.e., $r = \rho$, we have $\beta(1+r) = 1$, so that the constant term κ vanishes. Then, the Euler equation is:

$$\widehat{c}_t - \alpha\beta E_t \widehat{c}_{t+1} = E_t\{\widehat{c}_{t+1} - \alpha\beta \widehat{c}_{t+2}\} \tag{3.1}$$

Now, using equation (3.1) together with the lifetime budget constraint (2.3), we can solve for c_t:

$$c_t = (1 - \alpha\beta) y_t^p + \alpha\beta c_{t-1}$$

where y_t^p denotes permanent income:

$$y_t^p \equiv (1 - \beta)(A_t + \sum_{i=0}^{\infty} \beta^i E_t y_{t+i}) \tag{3.2}$$

Two effects are important here: first, the appearance of c_{t-1} in the last term due to the habit formation (the last term would be zero if $\alpha = 0$), second, the impact of changes in permanent income is smaller since:

$$(1 - \alpha\beta) < 1$$

Then the change in consumption, $c_{t+1} - c_t$ is:

$$c_{t+1} - c_t = \frac{(1 - \alpha\beta)(1 - \beta)}{1 - \beta\mu} \omega_{t+1} + \frac{\alpha(1 - \alpha\beta)(1 - \beta)}{1 - \beta\mu} \sum_{i=0}^{\infty} \alpha^i \omega_{t-i}. \tag{3.3}$$

We observe that, because (1-$\alpha\beta$) < 1, the marginal propensity to consume out of a current innovation in income is less than in the model without habit formation.

Furthermore, in addition to the unanticipated changes in income, ω_{t+1}, changes in consumption now respond to past changes in income, thus helping to explain the excess sensitivity of consumption to lagged income observed in the data.

Note that in the absence of habit formation, $\alpha = 0$, we obtain:

$$c_{t+1} - c_t = \frac{(1-\beta)}{1-\beta\mu}\omega_{t+1}$$

so that the change in consumption at time $t+1$ is only affected by the innovation to income at $t+1$.

4. Exponential Utility Model

In this section, we introduce a utility function with CARA (constant absolute risk aversion) preferences into the analysis of habit formation. The use of CARA preferences was dictated by the fact that this is the only specification (other than the Certainty Equivalence) which permits a closed form solution. Now, the utility function is assumed to be exponential:

$$U(c_t - \alpha c_{t-1}) = -\frac{1}{\Theta}e^{-\Theta[c_t - \alpha c_{t-1}]} \tag{4.1}$$

where $\Theta > 0$, is the coefficient of absolute risk aversion. We will assume that y_t follows an autoregressive process with a normal distribution. The first order condition for the dynamic programming problem can be stated as:

$$e^{-\Theta \hat{c}_t} = E_t[(1+\alpha\beta)e^{-\Theta \hat{c}_{t+1}} - \alpha\beta e^{-\Theta \hat{c}_{t+2}}] \tag{4.2}$$

Taking inspiration from Caballero (1990), we conjecture a solution for $\hat{c}_{t+i}$ as follows:

$$\hat{c}_{t+i} = \Gamma_{t+i-1} + \Phi_{t+i-1}\hat{c}_{t+i-1} + v_{t+i} \qquad i = 0, 1, 2, ... \tag{4.3}$$

where Γ, Φ and v are terms to be determined. v_{t+i} is the innovation to consumption.

We use our conjecture for $\hat{c}_{t+1}$ and $\hat{c}_{t+2}$, and substitute into the first order condition (4.2) to find:

$$\begin{aligned} e^{-\Theta \hat{c}_t(1-\Phi_t)+\Theta\Gamma_t} &= E_t[e^{-\Theta v_{t+1}} \times \{(1+\alpha\beta) \\ &\quad -\alpha\beta e^{-\Theta[\Gamma_{t+1}+(\Phi_{t+1}-1)\Gamma_t+(\Phi_{t+1}-1)\Phi_t\hat{c}_t+(\Phi_{t+1}-1)v_{t+1}+v_{t+2}]}\} \end{aligned} \tag{4.4}$$

Then matching coefficients of $\widehat{c}_t$ on both sides yields $\Phi_{t+1} = \frac{1}{\Phi_t} = 1$. Since we have assumed that the innovations to income are normally distributed, the innovations to consumption will also be normally distributed. Hence we can write $E_t e^{-\Theta v_{t+1}} = e^{-\Theta E_t v_{t+1} + \frac{\Theta^2}{2}\sigma_v^2}$. Assuming that Γ_t is time-varying but known, :

$$e^{\Theta[\Gamma_t + E_t v_{t+1} - \frac{\Theta}{2}\sigma_v^2]} = [(1+\alpha\beta) - \alpha\beta e^{-\Theta[\Gamma_{t+1} + E_t v_{t+2} - \frac{\Theta}{2}\sigma_v^2]}] \tag{4.5}$$

The above equality will hold when[7]

$$\Gamma_t = -E_t v_{t+1} + \frac{\Theta}{2}\sigma_v^2 \text{ and } \Gamma_{t+1} = -E_t v_{t+2} + \frac{\Theta}{2}\sigma_v^2. \tag{4.6}$$

We will now proceed to substitute our conjectured solution for $\hat{c}_t$ into the lifetime budget constraint:

$$\begin{aligned} &\frac{1}{1-\beta}\hat{c}_t + \sum_{i=1}^{\infty}\beta^i \sum_{j=1}^{i}\Gamma_{t+j-1} + \sum_{i=1}^{\infty}\beta^i \sum_{j=1}^{i} v_{t+j} + \alpha c_{t-1} \\ &-(1-\alpha\beta)\{A_t + E_t \sum_{i=0}^{\infty}\beta^i\{y_{t+i} - E_t y_{t+i}\} + \sum_{i=0}^{\infty}\beta^i E_t y_{t+i}\} = 0 \end{aligned} \tag{4.7}$$

where we have added and subtracted the terms $E_t y_{t+i}$, and used the fact that:

$$y_{t+i} - E_t y_{t+i} = \sum_{j=1}^{i}\mu^{i-j}\omega_{t+j} \tag{4.8}$$

[7]Note that if v_t is $i.i.d.$ with $E_t v_{t+1} = E_t v_{t+2} = 0$, $\Gamma = \frac{\Theta}{2}\sigma_v^2$, a constant. On the other hand, if v_t is serially correlated, then Γ_t will be time-varying.

Taking expectations and solving for $\hat{c}_t$:

$$\hat{c}_t = (1-\beta)(1-\alpha\beta)\{A_t + \sum_{i=0}^{\infty} \beta^i E_t y_{t+i}\} - (1-\beta)\sum_{i=1}^{\infty}\beta^i \sum_{j=1}^{i} \Gamma_{t+j-1} - (1-\beta)\alpha c_{t-1} \tag{4.9}$$

Now, we substitute for $\hat{c}_t$ from (4.9) back into equation (4.7). Since the resulting expression must be equal to zero, we have:

$$v_{t+1} = \left[\frac{(1-\beta)(1-\alpha\beta)}{(1-\beta\mu)}\right]\omega_{t+1} \tag{4.10}$$

Then c_t can be written as:

$$c_t = (1-\alpha\beta)y_t^p + \alpha\beta c_{t-1} - (1-\beta)\sum_{i=1}^{\infty}\beta^i\sum_{j=1}^{i}\Gamma_{t+j-1} \tag{4.11}$$

where

$$\sum_{i=1}^{\infty}\beta^i\sum_{j=1}^{i}\Gamma_{t+j-1} = \frac{\beta}{(1-\beta)^2}\Gamma \tag{4.12}$$

Given our assumption that ω_{t+i}'s are *i.i.d.* with zero mean, so that the v_{t+i}'s are $i.i.d.$ with zero mean, $\Rightarrow \Gamma_t = \Gamma = \frac{\Theta}{2}\sigma_v^2\ \forall t$. Hence, from (4.10) we obtain,

$$\Gamma = \frac{\Theta}{2}\left[\frac{(1-\alpha\beta)(1-\beta)}{(1-\beta\mu)}\right]^2 \sigma_\omega^2 \tag{4.13}$$

Then (4.11) becomes:

$$c_t = (1-\alpha\beta)y_t^p + \alpha\beta c_{t-1} - \frac{\beta\Theta}{2(1-\beta)}\left[\frac{(1-\alpha\beta)(1-\beta)}{(1-\beta\mu)}\right]^2 \sigma_\omega^2 \tag{4.14}$$

Solving for c_t in (4.14):

$$c_t = \underbrace{(1-\alpha\beta)y_t^p}_{1} + \underbrace{(1-\alpha\beta)\alpha\beta\sum_{i=0}^{\infty}(\alpha\beta)^i y_{t-i-1}^p}_{2} - \underbrace{\frac{\beta\Theta(1-\alpha\beta)(1-\beta)}{2(1-\beta\mu)^2}\sigma_\omega^2}_{3} \tag{4.15}$$

Now, looking at (4.15) directly, the excess sensitivity puzzle as well as the greater importance of the precautionary premium again become evident. The first term shows a smaller response to what is perceived to be permanent income. The second term stands for the response to lagged income through lagged permanent income. The last term in the expression is the precautionary saving term and it is smaller with habit formation. Comparing this term with the usual case without habit formation, we observe that precautionary saving term is smaller than the case without habit forming preferences in consumption. Thus, for a given value of the constant measure of risk aversion Θ, a consumer with habit formation will have smaller precautionary savings per unit of variance of change in consumption. The precautionary saving term for the consumer without habit formation is larger with:

$$\frac{\beta\Theta(1-\beta)}{2(1-\beta\mu)^2}\sigma_\omega^2$$

Therefore, we can say that per unit of income risk faced by the consumer, σ_ω^2, the precautionary saving term is smaller for the consumer with habit formation.

The change in consumption would be:

$$c_{t+1} - c_t = \frac{\Theta}{2(1-\alpha)}\left[\frac{(1-\alpha\beta)(1-\beta)}{(1-\beta\mu)}\right]^2 \sigma_\omega^2 + \left[\frac{(1-\beta)(1-\alpha\beta)}{(1-\beta\mu)}\right]\omega_{t+1} \quad + \left[\frac{(1-\beta)(1-\alpha\beta)}{(1-\beta\mu)}\right]\alpha\sum_{i=0}^{\infty}\alpha^i\omega_{t-i} \tag{4.16}$$

where the first term represents the precautionary premium, the second term is the “unanticipated changes in income” and the third term is the “anticipated changes in income”or averages of previous income innovations. The difference of (4.16) from equation (3.3) in the CE case is that, now we have an additional term representing the precautionary savings. Unlike the quadratic utility case, the CARA utility leads to a precautionary behavior. However, substituting for $\Gamma$the precautionary premium against income uncertainty is smaller with habit formation.

If there were no habit formation equation (4.16) would be written as:

$$c_{t+1} - c_t = \frac{\Theta}{2} \left[\frac{(1-\beta)}{(1-\beta\mu)} \right]^2 \sigma_\omega^2 + \left[\frac{(1-\beta)}{(1-\beta\mu)} \right] \omega_{t+1}$$

where the first term, which is the precautionary premium, is larger than the one with habit formation because the habit formation parameter affects the size of the precautionary term. The higher the parameter α, i.e., the stronger the habits, the lower the effect of income uncertainty on consumption. The reason is that the individual with habit forming preferences in consumption saves more, i.e., consumes less out of permanent income in order to achieve higher consumption growth. More precisely, the consumer chooses to consume less, first of all, because he or she has to take into account the negative externality of higher current consumption on future utility level.

However, this does not imply that the consumer does not save against income uncertainty. On the contrary, the precautionary saving behavior against income uncertainty also does exist, together with the saving induced by habit formation, but the magnitude of such a saving is less than the one in the case with no habit formation. Therefore, the income uncertainty affects less this type of an individual's consumption because there is habit formation induced savings to cushion him or her against income uncertainty. That is why the precautionary premium against income uncertainty does not need to be as high as the one of an individual with no habit formation.

We are now in a position to look at Zeldes' definition of the marginal propensity to consume to examine the excess sensitivity and the excess smoothness paradoxes. The marginal propensity to consume out of an unanticipated income change ($\frac{\Delta c}{\Delta y}$) with habit formation is defined as the change in current consumption from an innovation in income. Hence, from (4.16),

$$MPC_{HF} = \frac{(1-\beta)(1-\alpha\beta)}{(1-\beta\mu)} < MPC_{NoHF} = \frac{(1-\beta)}{(1-\beta\mu)}$$

That is, the response to current changes in income is slower than would be expected without habit persistence, i.e., $\alpha = 0$.

Second, notice also that consumption responds to all past (anticipated) income innovations. With $\alpha = 0.8$ for example, current consumption responds relatively strongly to past anticipated innovations in income. This implies that, with a positive coefficient on ω_{t-i} , consumption will have a higher rate of growth. (With $\alpha = 0$, this term disappears). Both results are in conformity with the "excess sensitivity" puzzle and with the empirical findings of Campbell and Deaton (1989).

Overall, with habit formation, consumption has a lower response to y_t^p than in the usual model, but also responds to a distributed lag of past permanent incomes, i.e., to past perceptions of the income stream, thus exhibiting a faster rate of growth.

Now, let us look at variances rather than levels of change of consumption. Note that:

$$Var\Delta c_t^{HF} = \left[\frac{(1-\beta)(1-\alpha\beta)}{(1-\beta\mu)}\right]^2 \sigma_\omega^2$$

In the case without habit formation we have,

$$Var\Delta c_t = \left[\frac{(1-\beta)}{(1-\beta\mu)}\right]^2 \sigma_\omega^2$$

for a AR(1) process. As the income process approaches a random walk, $\mu \to 1$ and $Var\Delta c_t = Var\Delta y_t = \sigma_\omega^2$. Campbell and Deaton pointed out that this prediction of the theory was counterfactual in view of the evidence from the data which imply

$Var\Delta c_t < Var\Delta y_t$. This is referred to as the "excess smoothness" puzzle. With habit formation, $Var\Delta c_t = (1-\alpha\beta)^2\sigma_\omega^2$, i.e., even when $\mu = 1$, $Var\Delta c_t < Var\Delta y_t$ in conformity with the empirical evidence.

While these results are dependent on the specific form of the stochastic income process, this also holds true when y_t follows a AR(1) process in differences which, according to Hansen and Singleton, Flavin among others, better characterizes the actual income process. Then,

$$(y_{t+1} - y_t) = \delta(y_t - y_{t-1}) + \omega_{t+1} \quad \text{so that} \quad y_{t+1} = (1+\delta)y_t - \delta y_{t-1} + \omega_{t+1}$$

In the absence of habit formation,

$$Var\Delta c_t = \left[\frac{(1+r)}{(1+r-\delta)}\right]^2 Var\Delta y_t$$

where $[\frac{(1+r)}{(1+r-\delta)}]^2 > 1$ so that $Var\Delta c_t > Var\Delta y_t$, whereas with habit formation:

$$Var\Delta c_t = \left[\frac{(1+r-\alpha)}{(1+r-\delta)}\right]^2 Var\Delta y_t$$

so that $Var\Delta c_t < Var\Delta y_t$ provided that $\alpha > \delta$. (Not a big restriction if $\delta = 0.442$ as in Campbell and Deaton's empirical findings).

5. Conclusion

When we introduce habit formation into the intertemporal consumption-saving model with income uncertainty, we obtain lower consumption than the case with no habit forming preferences in consumption. This, basically, implies that high precautionary savings observed in the data cannot be attributed only to the precautionary savings against income uncertainty but also to the preferences, which exhibit habit formation in consumption, as this model shows.

The model is similar to the one of Caballero in the sense that assuming only i.i.d. income innovations, we are able to obtain a closed form solution for consumption with habit formation. Allowing habit forming preferences in consumption, we have shown that there is indeed another type of precautionary savings besides the one against income uncertainty, precautionary savings induced by habit formation. The existence of the former decreases the level of savings against income uncertainty.

By allowing habit-forming preferences in consumption, we did not need to assume higher levels of labor income uncertainty to explain consumption puzzles. We have shown that the marginal propensity to consume out of an unanticipated income change is lower, while the marginal propensity to consume out of anticipated income changes is positive with habit-forming preferences. Hence, consumption growth is higher with habit formation. Moreover, we have found that the variance of change in consumption is less than the variance of change in income when there is habit formation, even in the case of a random walk income process. Overall, with habit formation, consumption has a lower response to permanent income than in the usual model, but also responds to a distributed lag of past permanent incomes, i.e., to past perceptions of the income stream, thus exhibiting a faster rate of growth.

Furthermore, the fact that we have obtained the closed form solution for consumption with habit formation will provide a better framework for empirically testing the behavior of consumption over the business cycle. This is the major contribution of this section of the thesis to the consumption literature.

Having solved all three empirical puzzles of consumption theoretically, the next step will be to empirically verify the predictions of the model and obtain an estimate for the habit formation parameter. This is left for future work.

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