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External Habit Persistence and Individual Portfolio Choice

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Abstract

This paper shows that a common form of external habit persistence, despite having much success in asset pricing, implies an extreme degree of conformity in investors' portfolio choice. If an investor with this utility function uses US aggregate consumption as her external habit benchmark, she has to hold *all* non-redundant securities contained in the US aggregate wealth portfolio. Even for an investor who uses the average consumption of a more narrowly-defined community as her benchmark, she is still required to hold non-zero positions in all (non-redundant) individual stocks held by any other member of the community. If markets are incomplete, even if an individual investor holds a financial portfolio that conforms perfectly with that associated with the external habit benchmark, it is still impossible for the investor to ensure that consumption exceeds habit in all states of the world. Because of this implication, this form of external habit is unlikely to describe the preferences of *individual investors*—notwithstanding its success as a model for the *representative agent* in asset pricing.

Keywords: portfolio conformity; external habit persistence; difference model; portfolio choice; incomplete markets

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1. Introduction

When an agent's marginal utility depends positively on the past consumption of other agents, but not on her own past consumption, she is said to exhibit *external* habit persistence.[1] These models have received much attention recently—due to their success in asset pricing—against the grim backdrop of the poor performance of earlier consumption-based models. Specifically, Campbell and Cochrane (1999, 2000), using a representative-agent model in which consumption and habit enter as a difference in the period utility function (henceforth the difference model), generate a large, volatile, and state-dependent equity premium from a smooth aggregate consumption process—an achievement that has eluded earlier models of consumption-based asset pricing.[2] In spite of such success as a description of the *representative agent* in asset pricing, the difference model, we argue, is unlikely to describe the preferences of *individual investors*.

As emphasized by Campbell and Cochrane (1999, 2000), the fact that own consumption and the external habit benchmark enter as a difference is important, for it is this feature in their model that generates a time-varying risk aversion, and the associating attractive features for asset pricing.[3] Ironically, the fact that own consumption and external habit entering as a difference is also the culprit behind an extreme degree of conformity in individual portfolio choice required by the model. To see this point, note first that own consumption has to be bounded below by habit when an investor exhibits habit persistence of the difference form, or marginal utility will be undefined. In order for an investor to maintain her own consumption above the external habit benchmark, she has to hold *every* non-redundant asset contained in the benchmark.

To illustrate the bite of this portfolio restriction at a practical level, consider a common specification in which an investor uses (a moving average of) past US aggregate consumption as her external habit benchmark. For this investor to avoid having consumption fall below habit, she has to hold *all* individual stocks from *all* markets represented in US aggregate wealth. For example, if the US aggregate wealth portfolio contains a positive position in Samsung, and Samsung's stocks are non-redundant, then an investor with US aggregate consumption as her external habit benchmark will also have to hold Samsung's stocks—it is not enough for the investor to just participate in the stock market or hold the shares of some other Korean companies. One may argue that US aggregate consumption may not be the most reasonable benchmark to use even for US investors. Indeed, an investor's main concern may be her position relative to people with whom she has regular contact, such as her colleagues or neighbors. For concreteness, consider an investor who uses her colleagues' average consumption as her benchmark. Our results imply that such an investor needs to hold non-zero positions in *all* (non-redundant) individual stocks from *all* markets held by any of her colleagues. In particular, it only takes *one* of her colleagues to hold some shares in Air New Zealand for her to be required to do the same. Failure for the investor to hold the airline's stocks implies that her consumption will fall below habit in some states, making her marginal utility undefined.

It appears highly unrealistic that even for a narrowly-defined community (such as within the same company or neighborhood), every member in the community will hold *all* individual stocks from *all* markets held by *any* other member of the community. Yet, this is the only way to ensure internal consistency between an investor's external habit benchmark and her portfolio choice when the investor exhibits external habit persistence of the difference form. For this reason, we argue that the difference model of external habit is unlikely to describe the preferences of individual investors.

We are not claiming that peer effects in portfolio choice are unimportant. To be sure, Duflo and Saez (2002) demonstrate the presence of peer influence among employees of a large university, both in their decision to participate in Tax Deferred Accounts, and in their choice of mutual fund vendor. Hong et al. (2004), using US survey data, show that social households are more likely to participate in the stock market, and the effect of sociability are stronger in US states where stock market participation rates are higher. DeMarzo et al. (2004) demonstrate that peer effects can also help explain the home bias puzzle in international portfolio choice.

Rather than trying to show that peer effects are absent, what we emphasize here is that if individuals within a community behave according to the difference model of external habit—a specification considered desirable in the existing literature—an extreme degree of conformity will result. We show that our conclusion obtains as long as some general conditions are met, and no specific functional form describing how the external habit benchmark X depends on aggregate consumption has to be assumed. Specifications of X found in the existing literature can be broadly classified into two categories: one that depends only on past aggregate consumption, and one that depends on both current and past aggregate consumption. We show that our conclusion is robust to both categories of X.

Finance research has shown a renewed interest in investor portfolio choice. Van Nieuwerburgh and Veldkamp (2010) build a theoretical framework to jointly solve for investors' information and portfolio choices. Fagereng et al. (2017) and Kuhnen (2015) examine empirical and experimental evidence, respectively, on how investors make portfolio decisions in practice. Bacchetta et al. (2023) and Hu (2025) study investors' portfolio allocation across countries. Ameriks et al. (2020) and Calvo-Pardo et al. (2022) make use of survey evidence to examine the impact of investors' subjective expectations on their portfolio choice. Badarinza et al. (2016) and Cochrane (2022) provide comprehensive surveys of this literature.

The remainder of this paper is organized as follows. In Section 2, we present the difference model of external habit. In Section 3, we derive the model's extreme prediction regarding investors' participation decisions with respect to different securities. We first consider external habit benchmarks that depend only on past aggregate consumption, followed by benchmarks that depend on both current and past aggregate consumption. When security returns following a lognormal process, we show that both forms of external habit implies an extreme degree of portfolio conformity. For an investor who uses US aggregate consumption as her external habit benchmark, she has to hold *all* non-redundant securities contained in the US aggregate wealth portfolio. Otherwise, she risks having her consumption fall below habit, making her utility undefined. Section 4 examines further implications of the theoretical results derived in Section 3. Even for an investor who uses the average consumption of a more narrowly-defined community as her benchmark, she is still required to hold non-zero positions in all (non-redundant) individual stocks held by any other member of the community. When markets are incomplete, even if an individual investor holds a financial portfolio that conforms perfectly with that associated with the external habit benchmark, it is still impossible for her to ensure that consumption exceeds habit in all states of the world. Section 5 offers some concluding remarks.

2. The Difference Model of External Habit

We consider a habit persistence utility function of the following form:

$$U(C_t, X_t) = \frac{(C_t - X_t)^{1-\gamma} - 1}{1-\gamma}. \tag{1}$$

Each investor maximizes the expected utility of the current and all future periods given by

$$E \sum_{t=0}^{\infty} \delta^t \frac{(C_t - X_t)^{1-\gamma} - 1}{1-\gamma}, \tag{2}$$

where C_t is the level of own consumption, X_t the level of external habit, δ the subjective discount factor, and γ the utility curvature parameter. The coefficient of relative risk aversion (RRA) implied by this utility function is no longer constant. Defining the surplus consumption ratio S_t as $S_t \equiv \frac{C_t - X_t}{C_t}$, RRA is time-varying and related to the surplus consumption ratio as

$$RRA_t = -\frac{C_t U_{cc}(C_t, X_t)}{U_c(C_t, X_t)} = \frac{\gamma}{S_t}. \tag{3}$$

Thus, in bad states when consumption is low relative to habit, RRA increases. This in turn leads to a higher price of risk and higher expected returns in bad states.

Because C_t and X_t enter as a difference, this specification is often termed a difference model—to distinguish it from ratio models, in which C_t and X_t enter as a ratio. Habit is *external*, in the sense that it depends only on aggregate national consumption, but not on the investor's own consumption. In Section 4.1, we will also consider an alternative notion of external habit, where an investor is concerned with her relative standing in a more narrowly-defined community, such as her workplace or her neighborhood.

As emphasized by Campbell and Cochrane (1999, 2000), the fact that C_t and X_t enter as a difference in Equation (1) is important—for it is this feature in their model that gives rise to a time-varying risk aversion, and a volatile and state-dependent equity premium. Santos and Veronesi (2010) show that the time-varying risk aversion feature of the Campbell–Cochrane model is important in explaining the cross section of stock returns. Chue (2005) shows that this feature can generate time-varying international stock market comovement. More recently, Pflueger and Rinaldi (2022) show that time-varying risk aversion magnifies the effects of monetary policy.

Yet, it is also clear from Equation (1) that since C_t and X_t enter as a difference, C_t has to lie above X_t, or marginal utility becomes undefined. In particular, if Equation (1) describes the preferences of an individual investor, she has to make explicit consumption and portfolio decisions in order to keep her own consumption C_t from falling below X_t. In this study, we examine what these decisions are, and whether they are reasonable.[4]

Specifications of external habit X_t found in the extant literature can be broadly classified into two categories: specifications that we term *predetermined habit*, in which X_t depends *only* on past aggregate consumption ($C_{a,t-1}$, $C_{a,t-2}$, ...); and specifications that we term *concurrent habit*, in which X_t depends on *both* current and past aggregate consumption ($C_{a,t}$, $C_{a,t-1}$, $C_{a,t-2}$, ...), such that the determination of X_t and $C_{a,t}$ is concurrent.[5] Our goal here is not to show that one of these two specifications of external habit is superior, but rather, to demonstrate the robustness of our results to both types of habit.

3. Implications for Portfolio Choice

In this section, after defining the structure of asset returns, we will examine the restrictions imposed by the difference model of external habit on individual portfolio choice. We will study both the predetermined and the concurrent habit specifications.

3.1. Asset Returns

Suppose there are N risky and 1 riskless securities. Denoting $R_{i,t+1}$ as the gross simple return (including dividends) of security i from time t to $t+1$, and $R > 1$ as the gross simple return on the riskless asset, we assume that R is constant over time, and the conditional distributions of the risky returns are jointly lognormal with time-varying conditional first and second moments μ_t, Σ_t that depend on time t information:

$$\begin{pmatrix} \log(R_{1,t+1}) \\ \vdots \\ \log(R_{N,t+1}) \end{pmatrix} \sim N(\mu_t, \Sigma_t). \tag{4}$$

We rule out redundant assets, so the variance–covariance matrix Σ_t is full rank. The intertemporal budget constraint of an investor with period t wealth W_t (before C_t takes place) can be written as

$$W_{t+1} = (W_t - C_t)\left[\sum_{i=1}^{N} \alpha_{i,t}(R_{i,t+1} - R) + R\right], \tag{5}$$

where $\alpha_{i,t}$ represents the fraction of the investor's invested wealth ($W_t - C_t$) allocated to risky asset i. A similar budget constraint also holds at the aggregate level.

3.2. Predetermined Habit

We refer to the stock of habit X_t as predetermined when it is a function of past aggregate consumption only. Representing X_t as $X(C_{a,t-1}, C_{a,t-2}, \ldots)$, and assuming that X_t is differentiable in $C_{a,t-1}$ with $\frac{\partial X_t}{\partial C_{a,t-1}} > 0$, and $X_t \to \infty$ when $C_{a,t-1} \to \infty$, we can derive a tight relationship between the aggregate portfolio α_a, and an individual investor's portfolio α.

Proposition 1. *Consider an investor who maximizes expected utility given by Equation (2), with the stock of external habit X_t defined as a function of past aggregate consumption only. Representing X_t as $X(C_{a,t-1}, C_{a,t-2}, \ldots)$, and assuming that the aggregate consumption–wealth ratio $\frac{C_{a,s}}{W_{a,s}} = k_a$ with $0 < k_a < 1$, and that X_t is differentiable in $C_{a,t-1}$ with $\frac{\partial X_t}{\partial C_{a,t-1}} > 0$ and $X_t \to \infty$ when $C_{a,t-1} \to \infty$, then the investor will hold a positive position in security i if the aggregate portfolio α_a contains a positive position in security i.*

Proof. The form of the utility function in Equation (2) implies that the condition $C_t > X_t$ has to be maintained for all dates t. Since $C_t \leq W_t$, this further implies that $W_t > X_t$ has to be maintained for all t. Consider time period $t = s$: Since X_s is a function of past aggregate consumption only, $W_s > X_s$ can be maintained for *all* states provided that at least $\frac{X(C_{a,s-1}, C_{a,s-2}, \ldots)}{R}$ is invested in the riskless asset at time $s - 1$. This requires that $W_{s-1} > \frac{X(C_{a,s-1}, C_{a,s-2}, \ldots)}{R}$. Since this requirement applies to any time period s, $W_t > \frac{X(C_{a,t}, C_{a,t-1}, \ldots)}{R}$ has to be maintained for all dates t.

The remainder of the proof establishes by contradiction that, if the aggregate portfolio α_a contains a positive position in security i, an investor who maximizes expected utility given by Equation (2) has to hold a positive position in security i as well. Suppose the aggregate portfolio contains a positive position in security i at time $t = s$ (i.e., $\alpha_{a,i,s} > 0$), but the investor's own portfolio does not (i.e., $\alpha_{i,s} \leq 0$). The fact that asset returns are jointly lognormal, and security i is non-redundant imply that for any finite positive constant G, there is a positive probability for $R_{i,s+1} - R > G$ and $R_{i,s+1} - R_{j,s+1} > G$, for all $j \neq i$. Thus, $\alpha_{a,i,s} > 0$ but $\alpha_{i,s} \leq 0$ implies that $W_{a,s+1} - W_{s+1}$ can exceed any finite constant with a positive probability. Together with the fact that $C_{a,s+1} = k_a W_{a,s+1}$ and $X(C_{a,s+1}, C_{a,s}, \ldots)$ is differentiable and strictly increasing in $C_{a,s+1}$, there is a positive probability for $W_{s+1} < \frac{X(C_{a,s+1}, C_{a,s}, \ldots)}{R}$. This contradicts the requirement established above that $W_t > \frac{X(C_{a,t}, C_{a,t-1}, \ldots)}{R}$ has to be maintained for all t. □

This proposition shows that, in order to keep her own consumption above the external habit benchmark for all states, an investor has to hold *all* non-redundant securities contained in the benchmark. Intuitively, when returns are lognormal, there is always a nonzero probability for the return on a particular security to exceed those on all other assets by an arbitrarily large (but finite) amount. Thus, when the benchmark portfolio contains asset i but an individual portfolio does not, there will be states of the world in which the return on asset i is so high that the individual investor is no longer able to keep up with the benchmark.

When habit is predetermined (i.e., depends only on past aggregate consumption), although a high aggregate consumption will not affect X_t *immediately*, it will raise X_{t+1}. To ensure that C_{t+1} can exceed X_{t+1} for *all* states, an investor then has to place enough wealth in the riskless asset at time t when $C_{a,t}$ takes place. But since $C_{a,t}$ is a function of $W_{a,t}$ (which in turn depends on the return on the aggregate portfolio), how much riskless asset has to be held by the investor depends on the returns on the securities held in the aggregate portfolio. It is this dependence that motivates the individual investor to conform to the holdings of the aggregate portfolio.

A common form of predetermined habit is that considered by Constantinides (1990), in which X_t is expressed as a geometrically-weighted, moving average of past aggregate consumption:[6]

$$X_{t+1} = b \sum_{j=0}^{\infty} a^j C_{a,t-j} \tag{6}$$

$$= aX_t + bC_{a,t}. \tag{7}$$

The parameter a measures the persistence of habit, while b controls the importance of habit relative to current consumption. Both a and b are assumed to lie between 0 and 1. It is easy to verify that this specification is a special case of the general class of predetermined habit considered above, and Proposition 1 applies.

3.3. Concurrent Habit

In this subsection, we show that when habit is concurrent so that X_t is a function of both past and current aggregate consumption, the relationship between α_a and α derived above for predetermined habit still obtains. In fact, the proof is even simpler: When habit is concurrent, aggregate consumption has an *immediate* effect on X_t, so the intermediate step of investing in the riskless asset (as described in the previous subsection) can be omitted. Specifically, to make sure that C_t exceeds X_t (which depends on the contemporaneous aggregate consumption $C_{a,t}$), an investor has to hold all securities that are contained in the aggregate portfolio. Failure to do so implies that there is a nonzero probability for the investor's wealth W_t to fall below aggregate wealth $W_{a,t}$ by an arbitrarily large amount, and a high enough $C_{a,t}$ can raise X_t above W_t, making the condition $C_t > X_t$ impossible to satisfy.

Proposition 2. *Consider an investor who maximizes expected utility given by Equation (2), with the stock of external habit X_t defined as a function of both current and past aggregate consumption. Representing X_t as $X(C_{a,t}, C_{a,t-1}, C_{a,t-2}, \ldots)$, and assuming that the aggregate consumption-wealth ratio $\frac{C_{a,s}}{W_{a,s}} = k_a$ with $0 < k_a < 1$, and that X_t is differentiable in $C_{a,t}$ with $\frac{\partial X_t}{\partial C_{a,t}} > 0$ and $X_t \to \infty$ when $C_{a,t} \to \infty$, then the investor will hold a positive position in security i if the aggregate portfolio α_a contains a positive position in security i.*

Proof. The investor's need to ensure $C_t > X_t$, and the fact that $C_t \leq W_t$ imply that $W_t > X_t$ has to be maintained for all dates t. As in the proof to Proposition 1 above, the remainder of this proof establishes by contradiction that if the aggregate portfolio α_a contains a positive position in security i, an investor who maximizes expected utility given by Equation (2) has to hold a positive position in security i as well. Suppose the aggregate portfolio contains a positive position in security i at time $t = s$ ($\alpha_{a,i,s} > 0$), but the investor's own portfolio does not ($\alpha_{i,s} \leq 0$). The fact that asset returns are jointly lognormal, and security i is non-redundant imply that for any finite positive constant G, there is a positive probability for $R_{i,s+1} - R > G$ and $R_{i,s+1} - R_{j,s+1} > G$, for all $j \neq i$. Thus, $\alpha_{a,i,s} > 0$ but $\alpha_{i,s} \leq 0$ implies that $W_{a,s+1} - W_{s+1}$ can exceed any finite constant with a positive probability. Together with the fact that $C_{a,s+1} = k_a W_{a,s+1}$ and $X(C_{a,s+1}, C_{a,s}, \ldots)$ is differentiable and strictly increasing in $C_{a,s+1}$, there is a positive probability for $W_{s+1} < X(C_{a,s+1}, C_{a,s}, \ldots)$. This contradicts the requirement established above that $W_t > X(C_{a,t}, C_{a,t-1}, \ldots)$ has to be maintained for all t. □

As discussed in Campbell and Cochrane (1999), habit X_t in their model is predetermined only when the surplus consumption ratio $S_t \equiv \frac{C_{a,t} - X_t}{C_{a,t}}$ is at its steady state. Everywhere else in the state space, X_t is concurrent, and Campbell and Cochrane (1999) show that $\frac{\partial \log X_t}{\partial \log C_{a,t}} > 0$ in these cases.[7] For parameter values considered by the authors, both $C_{a,t}$ and X_t are positive, so $\frac{\partial \log X_t}{\partial \log C_{a,t}} > 0$ implies that $\frac{\partial X_t}{\partial C_{a,t}} > 0$. These parameter values also imply that $S_t \leq S_{\max} < 1$, so that by writing X_t as $C_{a,t}(1 - S_t)$, we can see that $X_t \to \infty$ when $C_{a,t} \to \infty$. Thus, Proposition 2 applies to every point in the state space of the Campbell–Cochrane model—except when the surplus consumption ratio is *exactly* at its steady state.[8]

4. Are These Implications Reasonable?

These two propositions demonstrate that the condition $C > X$ imposes important restrictions on investor portfolio choice. To fully appreciate the restrictiveness of Propositions 1 and 2, consider a US investor who maximizes expected utility given by Equation (2). Regardless of whether the investor has predetermined or concurrent habit, the propositions imply that, as long as security i is contained in the US aggregate portfolio, it has to be held by the investor as well. Thus, if the US aggregate wealth portfolio contains a positive position in a small foreign company that is a non-redundant asset, an external habit investor will always choose to hold the company's shares as well.

4.1. Narrowly-Defined Communities

One may argue that the restrictive implications of the difference model discussed above do not really indicate any problems with the functional form as defined in Equation (1), but are due to the assumption that habit X_t depends on *aggregate* consumption. Indeed, to the extent that investors care about relative standing, they may well use people with whom they interact regularly—such as their neighbors or colleagues—as their benchmark for comparison.

To be concrete, consider a neighborhood in which every resident still has the period utility function as given by Equation (1), but the role of aggregate consumption in X_t is replaced by the average consumption in the neighborhood. Clearly, this modification makes Propositions 1 and 2 less restrictive: investors here are only required to hold all stocks contained in the average wealth portfolio of their neighbors, rather than all stocks held in the aggregate US portfolio. But even this requirement seems too strong to be realistic: it only takes one member in the community to hold an obscure (but non-redundant) security for everyone else in the community to be required to do the same. In other words, even within a more narrowly-defined community, this utility function still demands an extreme degree of conformity in investors' participation decisions with respect to different stocks.

4.2. Incomplete Markets

Our analysis so far has implicitly assumed that markets are complete, so that movements in the external habit benchmark X_t are spanned by payoffs on the $N + 1$ available securities. This will no longer be the case if markets are incomplete. In this case, even if an individual investor holds a financial portfolio that conforms *perfectly* with that associated with the external habit benchmark, $C_t > X_t$ is still not guaranteed. There can be states of the world that are uninsurable, say, when the entrepreneurial (or labor) income gap between an individual investor and her community average is so large that C_t will fall below X_t.

A simple way to see this point is to model the private businesses and human capital as assets whose returns are lognormally-distributed. Because markets are incomplete, these assets can be non-redundant with respect to traded securities—yet the portfolio conformity required by Propositions 1 and 2 still applies. But precisely because these assets are non-traded, the requirement of portfolio conformity is necessarily violated. It becomes *impossible* for an investor to ensure that $C_t > X_t$ in all states of the world when markets are incomplete—even if there were perfect conformity in the holdings of traded securities. Table 1 summarizes the degree of portfolio conformity required by the difference model of external habit.

Table 1. Portfolio conformity required by the difference model of external habit.

Reference Group	Complete Markets	Incomplete Markets
Entire US population	Hold all securities held by any other US investor	Impossible to guarantee $C_t > X_t$
Narrowly-defined community (e.g., office, neighborhood)	Hold all securities held by any other community member	Impossible to guarantee $C_t > X_t$

5. Concluding Remarks

As a description of an economy's representative agent, the difference model of external habit has generated many appealing implications for asset pricing. Yet, because of its implications for investors' portfolio choice, this model is unlikely to describe the preferences of individual investors. In light of these results, an important direction for future research is to construct more reasonable specifications of individual preferences that, at the same time, can aggregate to generate the asset pricing implications of the difference model. The ratio model of external habit is a promising candidate. Even though this model—when used as a description of the representative agent—does not give rise to variations in risk aversion as in the difference model, Chan and Kogan (2002) show that when individual investors with time-invariant (but heterogeneous) risk aversion are aggregated together, economy-wide risk aversion becomes time-varying and countercyclical.

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Notes

1 In contrast, when an agent's *own* past consumption raises her marginal utility for current consumption, she is said to exhibit *internal* habit persistence. Early theoretical contributions to this class of preferences include Ryder and Heal (1973), Sundaresan (1989), and Constantinides (1990).

2 Santos and Veronesi (2010) show that a slightly-modified version of the Campbell-Cochrane model can explain the cross section of expected stock returns, while Wachter (2006) demonstrates the success of a similar model in explaining the term structure of interest rates. In an international setting, Chue (2005) uses the model to generate time-varying international stock market comovement. More recently, Campbell et al. (2020) make use of the model to account for the change in stock-bond correlation over time and Pflueger and Rinaldi (2022) use it to study the effects of monetary policy.

3 In contrast, models in which consumption and habit enter as a ratio (henceforth ratio models) have constant risk aversion. Properties of the ratio model have been studied by Abel (1990, 1999) and Gali (1994), and, in models of social status, by Bakshi and Chen (1996), Smith (2001), Zhang (2006), Smoluk and Voyer (2014), and Chue (2024).

4 Campbell and Cochrane (1999), by contrast, ensure that the *representative agent*'s consumption (which is equal to aggregate consumption $C_{a,t}$) always exceeds habit by directly specifying a process for $\frac{C_{a,t}-X_t}{C_{a,t}}$ that is bounded below by 0. The portfolio problem faced by an *individual investor* with this utility function, however, has not been examined by the authors.

5 The predetermined and concurrent habits defined here are sometimes referred to as preferences that exhibit *catching* up with the Joneses and *keeping* up with the Joneses respectively. See Abel (1990) for a further discussion on this distinction.

6 We have modified Constantinides' specification in two ways: First, habit here is external (X_t is a function of past *aggregate* consumption), whereas habit in Constantinides' model is internal (X_t is a function of the investor's *own* past consumption); second, we have adapted Constantinides' continuous-time model to our discrete-time setup.

7 This point can be most clearly seen from Figure 1b in Campbell and Cochrane (1999).

8 Because the steady state is just a single point on a continuous state space, for the surplus consumption ratio to be exactly at this point is a zero-probability event.

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