Life-cycle consumption under social interactions

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Abstract

In this paper we examine how social interactions affect consumption decisions at various levels of aggregation in a life-cycle economy made up of peer groups. For this purpose, we consider two analytically solvable life-cycle models, one under certainty equivalent behavior and one under prudence, and explicitly allow for three different forms of social interactions in peer groups, namely conformism, altruism, and jealousy. We show that whether social interactions have any effects on individuals’ optimal consumption decisions critically depends on intertemporal rather than static considerations. This is true regardless of whether individuals’ preferences are time separable or exhibit habit formation, and whether information within peer groups is homogeneous or disparate. It implies that analyzing the effects of social interactions in static rather than intertemporal settings is likely to be misleading. We also show that social interactions, when coupled with either habit formation or prudence, can significantly strengthen the effects of habit formation or prudence in the direction of resolving two well-known puzzles in the literature on the permanent income hypothesis, namely excess smoothness and excess sensitivity. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

It has long been recognized that an individual’s utility, in addition to his/her own current and past consumption decisions, may also be influenced by a variety of social interactions such as conformism, altruism, or jealousy towards peers’ behavior. Pioneering contributions to this literature include Veblen’s (1899) analysis of ‘conspicuous consumption’ and Duesenberry’s (1949) relative consumption hypothesis. Among the different forms of social interactions, conformism, also known as the ‘band-wagon effect’, has been emphasized as an important factor for individuals’ decisions, for example, by Leibenstein (1950) and Jones (1984). Other forms of social interactions with important implications for consumption decisions in peer groups include altruism and jealousy. Becker (1981), for example, argues that the family is a peer group within which altruism is common, both due to the fact that marriage is often founded on altruistic motives, and also because the reference peer group is small and there are therefore considerable possibilities for interactions. Outside the context of the family, Clark and Oswald (1996), using a survey of British workers, for example, find that levels of job satisfaction reported by workers are at best weakly correlated with workers’ own income, but are significantly negatively correlated with their co-workers’ income, suggesting that jealousy could be an important factor in interactions among these workers.

It is often argued that if individuals, say, are conformist, then they will increase their consumption levels so as to ‘keep up with the Joneses’. Such an argument can overlook the fact that, ceteris paribus, increased consumption means lower savings, and thus, lower consumption levels at some point in the future. Thus, in an intertemporal setting, it is not immediate how the consumption decisions of individuals who are by intention conformist compare to the consumption decisions of individuals who are self-centered. In this paper we study a life-cycle economy made up of peer groups to examine how social interactions affect the time profiles of optimal consumption decisions at various levels of aggregation. We consider two analytically solvable life-cycle models, one under certainty equivalent behavior and one under prudence, and explicitly allow for the effects of social interactions. We derive the optimal consumption decisions at the individual-specific and economy-wide levels under three different forms of social interactions in peer groups, namely conformism, altruism,
and jealousy, and contrast the resultant decision rules to those in the absence of social interactions. We show that whether social interactions have any effects on individuals’ optimal consumption decisions critically depends on intertemporal rather than static considerations. This is true regardless of whether individuals’ preferences are time separable or exhibit habit formation, and whether information within peer groups is homogeneous or disparate. If individuals decide to keep up with the Joneses, then they do so to adapt their *lifetime consumption profiles* to those of their peers. This implies that analyzing the effects of social interactions in static rather than intertemporal settings, as is often done in the literature, is likely to be misleading.\(^3\)

We also show that social interactions, when coupled with habit formation, can have important implications for consumption at the economy-wide level.\(^4\) In particular, social interactions can significantly strengthen the effects of habit formation in the direction of resolving two well-known puzzles in the literature on the permanent income hypothesis, namely excess smoothness and excess sensitivity.\(^5\) Allowing for habit formation as well as social interactions, economy-wide average consumption may be significantly smoother than economy-wide average labor income, even if permanent labor income is not smoother than current labor income. This is in contrast to the predictions of the permanent income hypothesis, but in line with the consensus in the empirical literature, and addresses the excess smoothness puzzle. Furthermore, social interactions can significantly strengthen the sensitivity of changes in economy-wide average consumption to *anticipated* changes in economy-wide average labor income, helping to overcome the excess sensitivity puzzle.\(^6\)

While social interactions generally have important effects on optimal consumption decisions at the individual-specific and economy-wide levels, we also show that under certain circumstances it is possible that the optimal consumption decisions of individuals who are by intention conformist are the same as the optimal consumption decisions of self-centered individuals. Thus there are circumstances, albeit rather extreme, under which the pursuit of self-interest without any regard for the interest of others could result in the same time

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\(^3\) See, for example, Pollak (1976), Jones (1984), Kapteyn et al. (1997), and Clark and Oswald (1998) for influential studies of the effects of social interactions in static settings.

\(^4\) The same holds true when social interactions are coupled with prudence.

\(^5\) Throughout this paper we follow Deaton (1992) and refer to the life-cycle model with a representative, infinitely-lived, and self-centered consumer having quadratic preferences and a rate of time preference that is constant and equal to the market real rate of interest as the permanent income hypothesis.

\(^6\) See, for example, Deaton (1992) and Muellbauer and Lattimore (1995) for reviews of the empirical literature on excess smoothness and excess sensitivity of consumption at the economy-wide level.
profiles of individual-specific and economy-wide consumption levels as the ones implied by socially motivated individuals.

The remainder of this paper is organized as follows: Section 2 sets out the life-cycle model under social interactions, distinguishing between conformism and altruism/jealousy. Particular attention will be paid to the specification of individuals’ labor income processes and the structure of their information sets. Section 3 discusses the conceptual difficulties involved in determining the optimal consumption decisions in a life-cycle model under social interactions. These difficulties are due to what we call ‘ex ante belief indeterminacies’. We discuss alternative ways of resolving these difficulties, and derive the individual-specific optimal consumption decisions under both homogeneous and disparate information sets, and also allowing for habit formation. We then use these decision rules to analyze the conditions under which social interactions affect individuals’ consumption decisions. We show, in particular, that whether individuals in any given period attempt to keep up with their peers is determined by intertemporal considerations, reflecting the shape of their peers’ lifetime consumption profiles. Section 4 relaxes the assumption of certainty equivalence implicit in the analysis of Section 3 and considers the case of individuals motivated by prudence as well as social interactions. Section 5 discusses the aggregate implications of the life-cycle model under social interactions, and shows in particular that social interactions may help to overcome two widely analyzed puzzles associated with the permanent income hypothesis, namely excess smoothness and excess sensitivity. Finally, Section 6 provides a brief summary of the main findings of the paper, and concludes with some suggestions for future research.

2. A life-cycle model under social interactions

We consider an economy composed of a large number of peer groups. Each peer group, indexed by $h$, $h = 1, 2, \ldots, H$, in turn consists of a small number of individuals, indexed by $i$, $i = 1, 2, \ldots, N_h$. Thus, there are a total of $N$ individuals, $N = \sum_{h=1}^{H} N_h$, in the economy, with $H$ large. We denote by $c_{iht}$ the consumption expenditure of individual $i$ in peer group $h$ incurred at the beginning of period $t$. Average consumption in peer group $h$ is defined by

$$c_{ht} = \left( \frac{1}{N_h} \right) \sum_{j=1}^{N_h} c_{jht},$$

(1)

Note that in our notation individuals are uniquely identified in the economy as a whole by the combination of the indices $i$ and $h$. It is also worth noting that we will take the peer groups as given, and thus will not examine the factors that determine the formation of peer groups.
and economy-wide average consumption is given by

\[ c_t = \left( \frac{1}{N} \right) \sum_{h=1}^{H} N_h c_{ht}. \] (2)

In arriving at his/her consumption decision, we allow for individual \( i \) in peer group \( h \) to take account of weighted averages of past as well as anticipated current and future period consumption levels of all other individuals in his/her peer group. We denote this weighted average in period \( t \) by \( \tilde{c}_{ht,-i} = \sum_{j=1, j \neq i}^{N_h} \omega_{jh} c_{jht} \). It is also convenient to denote weighted average consumption in peer group \( h \) that includes the consumption of individual \( i \) by \( \tilde{c}_{ht} = \sum_{j=1}^{N_h} \omega_{jh} c_{jht} \). Throughout the paper, we assume without loss of generality that \( \sum_{j=1}^{N_h} \omega_{jh} = 1 \), for all \( h \). Interesting examples of weighting schemes, besides the case of equally placed individuals (so that \( \omega_{ih} = 1/N_h, i = 1, 2, \ldots, N_h \)), include the case where individuals at the tails of a peer group’s consumption distribution are attached a weight of zero and \( \tilde{c}_{ht,-i} \) is therefore a measure of average consumption of a middle-band of consumers in the peer group, or when non-zero weights are attached only to the consumption of, say, the top 5% or 10% of the individuals in the peer group.\(^8\)

We assume that the labor income of individual \( i \) in peer group \( h \) received at the beginning of period \( t \), \( y_{iht} \), is generated by

\[ \log y_{iht} = \alpha_{ih} + \mu t + \sum_{s=1}^{t} v_s + \xi_{iht}, \] (3)

or, in first-difference form,

\[ \Delta \log y_{iht} = \mu + v_t + \Delta \xi_{iht}, \] (4)

with individual-specific random component, \( \alpha_{ih} \), economy-wide drift, \( \mu \), economy-wide random component, \( v_t \), and the residual random component, \( \xi_{iht} \). The random components \( \alpha_{ih}, v_t, \) and \( \xi_{iht} \) are assumed to be mutually independent, \( i = 1, 2, \ldots, N_h, h = 1, 2, \ldots, H, t = 1, 2, \ldots, \) and distributed identically as normal variates with zero means and constant variances:\(^9\)

\[ \alpha_{ih} \sim \text{iid } N(0, \sigma^2_{\alpha}), \quad v_t \sim \text{iid } N(0, \sigma^2_v), \quad \text{and} \quad \xi_{iht} \sim \text{iid } N(0, \sigma^2_{\xi}). \] (5)

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8 See, for example, Kapteyn et al. (1997) for a further discussion of how the weights attached to a particular individual in a peer group may be linked to the individual’s social characteristics. Our assumption that the individuals in a peer group apply the same set of weights to weight other individuals’ consumption levels simplifies the exposition, but is also in line with some of the empirical literature.

9 As will be seen below, these distributional assumptions are much stronger than what is needed for most of the analytical results of this paper to hold.
The notation \( \Phi_i, \) denotes weak convergence in probability. The assumption that individual-specific labor income follows a random walk enables us to directly contrast our results in this paper to the findings of the permanent income hypothesis literature. In contrast to much of this literature, however, we specify the random walk to be geometric rather than arithmetic. While this is arguably more appealing even within a representative agent framework, the geometric specification in our framework is particularly desirable given its plausible implications for the economy’s labor income distribution, in contrast to those of an arithmetic random walk specification. It should also be noted that we have specified individuals’ labor income such that the economy-wide shocks, \( v_t, \) have permanent effects, but not the individual-specific shocks, \( \xi_i. \) This ensures that the labor income distribution is not continually becoming more dispersed, as would be the case if the individual-specific shocks, \( \xi_i, \) had permanent effects. In line with our earlier notation for consumption at different levels of aggregation, we will denote unweighted peer group average labor income by \( y_{ht} = (1/N_h) \sum_{j=1}^{N_h} y_{jht}, \) its weighted counterpart by \( \tilde{y}_{ht} = \sum_{j=1}^{N_h} \omega_{jht} y_{jht}, \) and economy-wide average labor income by \( y_t = (1/N) \sum_{h=1}^{H} N_h y_{ht}. \) Note that \( y_t \overset{P}{\to} \exp(\sigma^2/2 + \sigma^2/2)\tilde{y}_t, \) where \( \tilde{y}_t = \exp(\mu t + \sum_{s=1}^{t} v_s), \) as \( H \to \infty. \)

The wealth level of individual \( i \) in peer group \( h \) at the beginning of period \( t \) is denoted by \( A_{ih}, \) with \( A_h \) denoting the unweighted peer group average, \( \bar{A}_h \) the weighted peer group average, and \( \bar{A} \) the unweighted economy-wide average.

It will be helpful, in what follows, to decompose the information set of individual \( i \) in peer group \( h \) at the beginning of period \( t, \) \( \Omega_{ih}, \) into a ‘common component’, \( \Psi_{t-1}, \) containing all the publicly available information at the beginning of period \( t, \) and a private (or individual-specific) component, \( \Phi_{ih}, \) which is made up of information that at the beginning of period \( t \) is known only to individual \( i \) in peer group \( h: \)

\[
\Omega_{ih} = \Psi_{t-1} \cup \Phi_{ih}. \tag{6}
\]

We assume that \( \Psi_{t-1} \) and \( \Phi_{ih} \) are non-decreasing in \( t, \) with \( \Psi_{t-1} \) in turn being the union of a component relating to peer group \( h, \) \( \Psi_{h,t-1}, \) and a component relating to all other peer groups, \( \Psi_{t-1,-h}. \) The information set \( \Psi_{h,t-1} \) contains unweighted and weighted peer group averages of consumption, labor income, and wealth dated \( t - 1 \) and earlier:

\[
\Psi_{h,t-1} =
\{ c_{h,t-1}, c_{h,t-2}, \ldots ; \tilde{c}_{h,t-1}, \tilde{c}_{h,t-2}, \ldots ; y_{h,t-1}, y_{h,t-2}, \ldots ; \tilde{y}_{h,t-1}, \tilde{y}_{h,t-2}, \ldots ; A_{h,t-1}, A_{h,t-2}, \ldots ; \bar{A}_{h,t-1}, \bar{A}_{h,t-2}, \ldots \},
\]

\[
\Psi_{t-1} =
\{ c_{t-1}, c_{t-2}, \ldots ; \tilde{c}_{t-1}, \tilde{c}_{t-2}, \ldots ; y_{t-1}, y_{t-2}, \ldots ; \tilde{y}_{t-1}, \tilde{y}_{t-2}, \ldots ; A_{t-1}, A_{t-2}, \ldots ; \bar{A}_{t-1}, \bar{A}_{t-2}, \ldots \},
\]

\(10\) The notation \( \overset{P}{\to} \) denotes weak convergence in probability.
and $\Psi_{t-1,-h}$ contains unweighted and weighted peer group averages of consumption, labor income, and wealth dated $t-1$ and earlier for peer groups $l = 1, 2, \ldots, H, l \neq h$:

$$
\Psi_{t-1,-h} = 
\{ c_{l,t-1} \}, \ldots, \tilde{c}_{l,t-1}, \ldots, y_{l,t-1} \}, \ldots, \tilde{y}_{l,t-1} \}, \ldots ; \\
A_{l,t-1}, A_{l,t-2}, \ldots, \tilde{A}_{l,t-1}, \tilde{A}_{l,t-2}, \ldots ; l = 1, 2, \ldots, H, l \neq h \}.
$$

(8)

The private information set, $\Phi_{iht}$, of individual $i$ in peer group $h$ is assumed to contain current and lagged values of his/her consumption, his/her labor income, and his/her beginning-of-period wealth:

$$
\Phi_{iht} = \{ c_{iht}, c_{ih,t-1}, \ldots, y_{iht}, y_{ih,t-1}, \ldots ; A_{iht}, A_{ih,t-1}, \ldots \}.
$$

(9)

We will distinguish between two different information structures. The information structure characterized by (6)–(9) will be referred to as the disparate information case. Individuals’ information sets will be called homogeneous if the information set of individual $i$ in peer group $h$ is given by the union of the public information set and all individuals’ private information sets.\(^\text{11}\) We denote the homogeneous information set by $\Omega_t$:

$$
\Omega_t = \bigcup_{h=1}^{H} \bigcup_{j=1}^{N_h} \Omega_{jht}.
$$

(10)

We model intertemporal consumption choices within each peer group by allowing for the presence of various forms of social interactions in individuals’ current-period utility functions. We consider three forms of social interactions: conformism, altruism, and jealousy. As was alluded to in the Introduction, the motivation behind these interdependent utility specifications originates in the pioneering contributions of Veblen (1899), Duesenberry (1949), and Leibenstein (1950). Duesenberry (1949, p. 32) argued that ‘for one consumer, the number and strength of impulses to consume more depends on the ratio of his expenditures to expenditures by other individuals’ than only on his own level of consumption expenditure. In the spirit of Duesenberry’s arguments, we assume that each individual’s current-period utility is a function not only of that individual’s own current- and past-period consumption levels, but also of weighted averages of the current- and past-period consumption levels of all other individuals in

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\(^{11}\) As will become clear below, the relevant distinction in our model is really whether information within peer groups is homogeneous or disparate. We do not draw a distinction between the cases where information is homogeneous within peer groups but disparate across peer groups, and where information is homogeneous both within and across peer groups, as such a distinction is not material to our results.
his/her peer group.\footnote{We abstract from possible interaction effects between ‘neighboring’ peer groups.} Our specification thus embeds ‘the two major forms of endogenous taste change’ (Pollak, 1976): social interactions and habit formation.\footnote{One might argue, as in Postlewaite (1998), that social interactions arise not because individuals are concerned with their standing in their peer group per se, but because of the presence of social arrangements that imply that an individual’s standing in his/her peer group affects the individual’s own consumption opportunities. As our interest in this paper will be on the short- to medium-run implications of the life-cycle model (11)–(13), it seems a defensible modelling strategy to incorporate social interactions directly into the utility function even if they arose due to social arrangements, as social arrangements are unlikely to change at such horizons.} We assume that individual $i$ in peer group $h$ solves the intertemporal optimization problem:\footnote{To keep the determination of analytical decision rules for consumption tractable, we assume perfect credit markets and infinite lifetimes in this paper. For a discussion of the computational difficulties that arise in the solution of a life-cycle model under finite lifetimes and borrowing constraints, see, for example, Binder et al. (2000).}

$$
\max_{\{c_{ih,t+s}\}_{s=0}^{\infty}} \mathbb{E}\left( \sum_{s=0}^{\infty} \beta_{ih}^s u(c_{ih,t+s}, c_{ih,t+s-1}, \tilde{c}_{h,t+s-1,i}, \tilde{c}_{h,t+s-1,i}) | \Omega_{ih} \right) \tag{11}
$$

subject to the period-by-period budget constraints,

$$A_{ih,t+s} = (1 + r)A_{ih,t+s-1} + y_{ih,t+s} - c_{ih,t+s}, \quad s = 0, 1, \ldots, \tag{12}$$

the transversality condition,

$$\lim_{s \to \infty} (1 + r)^{-s} \mathbb{E}(A_{ih,t+s} | \Omega_{ih}) = 0, \tag{13}$$

and given initial consumption levels, $c_{ih,t-1}$ and $\tilde{c}_{h,t-1,i}$, as well as initial wealth levels, $A_{ih,t-1}$ and $\tilde{A}_{h,t-1,i}$. In (11)–(13), $\beta_{ih} = 1/(1 + \rho_{ih})$ ($\rho_{ih} > 0$) represents individual $i$’s constant discount factor, $r$ is the constant market real rate of interest, and $\mathbb{E}( \cdot | \Omega_{ih} )$ denotes the mathematical conditional expectations operator. To ensure the existence and non-explosiveness of the optimal consumption decision rules, we assume that the rate of growth of all individuals’ labor incomes is strictly less than $r$ and that $\beta_{ih}(1 + r) \geq 1$, for all $i, h$.\footnote{We thus allow, in particular, for the rate of time preference, $\rho_{ih}$, to be equal to the market real rate of interest, $r$. See the Mathematical Appendix for further details.}

To gain a clear understanding of the implications of social interactions for individual-specific and economy-wide optimal consumption decisions, it is helpful to obtain analytical decision rules. We therefore consider quadratic and
negative exponential specifications of the current-period utility function, \( u_{iht} \). \(^{16}\)

Our analysis of conformism will be based on the following quadratic specification:

\[
\begin{align*}
    u_{iht} &= -\left(\frac{1}{2}\right)[c_{iht} - \eta_{ih} c_{ih,t-1} - c_{ih}]^2 \\
            &\quad - \left(\frac{\theta_{ih}}{2}\right)[c_{iht} - \eta_{ih} c_{ih,t-1} - (\tilde{c}_{ht,-i} - \eta_{ih} \tilde{c}_{h,t-1,-i})]^2, \\
\end{align*}
\]

with \( \eta_{ih}, \ c_{ih}, \) and \( \theta_{ih} \) being contained in compact sets on \([0,1), \mathbb{R}^+ \) and \( \mathbb{R}^+_0 \), respectively, all defined such that individual \( i \)'s marginal utility is positive and diminishing in \( c_{iht} \). The parameter \( \theta_{ih} \) measures the strength of the desire of individual \( i \) in peer group \( h \) for conformism. Our approach to modeling conformism is similar to Jones (1984) in that it specifies individuals’ preferences as a function of an individual-specific component as well as a component representing individuals' desire to keep up with the Joneses. \(^{17}\) The parameter \( \eta_{ih} \) measures the strength of individual \( i \)'s preference for habit formation. The formulation of habit formation in (14) is similar to the specifications used, for example, by Muellbauer (1988) and Abel (1990).

We shall analyze the case of altruism/jealousy using both quadratic and negative exponential specifications of the current-period utility function. Our analysis of altruism/jealousy under quadratic utility will be based on:

\[
\begin{align*}
    u_{iht} &= -\left(\frac{1}{2}\right)[c_{iht} - \eta_{ih} c_{ih,t-1} + \tau_{ih}(\tilde{c}_{ht,-i} - \eta_{ih} \tilde{c}_{h,t-1,-i}) - c_{ih}]^2, \\
\end{align*}
\]

with \( \eta_{ih}, \ c_{ih}, \) and \( \tau_{ih} \) being contained in compact sets on \([0,1), \mathbb{R}^+ \) and \((-1,1)\), respectively, all defined such that individual \( i \)'s marginal utility is positive and diminishing in \( c_{iht} \). The parameter \( \tau_{ih} \) measures the degree of altruism or

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\(^{16}\)In the absence of social interactions and habit formation, and if information is homogeneous across individuals, our model specifications reduce to the quadratic specification in Hall (1978) and the negative exponential specification in Caballero (1990), respectively. The analysis of social interactions in the case of constant relative risk aversion (CRR\(\)A) utility is beyond the scope of the present paper. Instead, we consider certainty equivalent and constant absolute risk aversion (CAR\(\)A) behavior as first benchmarks. For a discussion of the type of numerical techniques that would be needed to effectively analyze social interactions under CRR\(\)A-specifications of the current-period utility function, see Binder et al. (2000).

\(^{17}\)It has been argued that a drawback of this utility specification is that since individuals’ utilities are assumed to change smoothly as the individuals deviate from their social comparison level, the difference between the behavior of by intention conformist and of self-centered individuals would necessarily be a matter of degree rather than kind (see, for example, Bernheim, 1994). We show in this paper, however, that if one embeds the utility specification (14) in a life-cycle model, the difference between the optimal consumption decisions of by intention conformist and of self-centered individuals does not need to vary smoothly with changes in \( \theta_{ih} \). This is because in a life-cycle model this difference critically depends on parameters other than \( \theta_{ih} \) also.
jealousy in individual $i$’s preferences, with an altruistic individual having a positive $\tau_{ih}$, and a jealous individual having a negative $\tau_{ih}$.\footnote{Our approach to modelling altruism and jealousy is similar to the specifications employed in the experimental game literature. See, for example, McKelvey and Palfrey (1992) and Mason and Phillips (1999).} It is worth noting that since we allow $\tau_{ih}$ to take both positive and negative values, our analysis allows for situations where some individuals in a peer group are altruistic while others are jealous. The parameter $\eta_{ih}$ in (15) again measures the strength of individual $i$’s preferences for habit formation. To allow for prudence, we shall consider the following negative exponential specification of current-period utility of altruistic/jealous individuals:\footnote{For simplicity, this specification abstracts from habit formation.}

$$u_{ih} = -\left(\frac{1}{K_{ih}}\right)\exp[-K_{ih}(c_{ih} + \tau_{ih}c_{ih}, -i)],$$

(16)

with $K_{ih}$ and $\tau_{ih}$ being contained in compact sets on $\mathbb{R}^+$ and $(-1,1)$, respectively. The degree of altruism or jealousy in individual $i$’s preferences is again measured by $\tau_{ih}$.

In what follows, we also define the present discounted value of total lifetime resources of individual $i$ in peer group $h$ by

$$L_{ih} = (1 + r)A_{ih,t} - 1 + \left(\sum_{s=0}^{\infty} \frac{y_{ih,t+s}}{(1+r)^s}\right),$$

(17)

and the weighted group average present discounted value of total lifetime resources by

$$\bar{L}_{ht} = (1 + r)\bar{A}_{h,t} - 1 + \left(\sum_{j=1}^{N_h} \sum_{s=0}^{\infty} \frac{\omega_{jh}y_{jh,t+s}}{(1+r)^s}\right).$$

(18)

The existence of the conditional expectations $E(L_{ih} | \Omega_{ih})$ and $E(\bar{L}_{ht} | \Omega_{ih})$ is ensured since by assumption the expected rate of growth of $y_{ih,t}$ is strictly less than $r$, for all $i,h$.

\footnote{It is beyond the scope of this paper to discuss in detail how the utility functions (14)-(16) might be derived from an axiomatic representation of preferences. However, it is of interest to note that the utility functions (15) (under $\eta_{ih} = 0$) and (16) satisfy the preference axioms of Ok and Koçkesen (1997) for ‘negatively interdependent utility functions’. In particular, in the terminology of Ok and Koçkesen, the utility functions (15) and (16) are continuous, decomposable, homothetic, additive with respect to the external effect, and exhibit nonvanishing absolute income effects. The utility function (14) modelling conformism falls outside the class of ‘negatively interdependent utility functions’ considered by Ok and Koçkesen. Development of sets of plausible axioms for utility functions under conformism and/or habit formation is an interesting topic for future research.}
3. Individual-specific optimal consumption decisions under certainty equivalence

In this section, we derive and analyze the implications of the individual-specific optimal consumption decisions implied by the life-cycle model of Section 2 under the quadratic current-period utility specifications (14) (conformism) and (15) (altruism/jealousy), for which certainty equivalence does hold.

3.1. The infinite regress problem

Under the current-period utility functions (14) and (15) the Euler equation for individual \( i \) in peer group \( h \) is given by

\[
E \left[ \frac{\partial U_{ih,t}}{\partial c_{ih,t}} + \beta_{ih} \frac{\partial U_{ih,t+1}}{\partial c_{ih,t+1}} | \Omega_{ih,t} \right] = \beta_{ih}(1 + r)E \left[ \frac{\partial U_{ih,t+1}}{\partial c_{ih,t+1}} + \beta_{ih} \frac{\partial U_{ih,t+2}}{\partial c_{ih,t+2}} | \Omega_{ih,t} \right].
\]

(19)

The derivation of the marginal utilities \( \frac{\partial U_{ih,t}}{\partial c_{ih,t}} \) and \( \frac{\partial U_{ih,t+1}}{\partial c_{ih,t+1}} \) depends on how individual \( i \) perceives the effect of his own consumption decision, \( c_{ih,t} \), on the weighted average consumption of all other individuals in his peer group, \( \tilde{c}_{ht, - i} \). We abstract from strategic interactions in a game-theoretic sense, and impose the restrictions that \( E(\tilde{c}_{ht, x, - i / \partial c_{ih,t+s}} | \Omega_{ih,t}) = 0 \) for \( s = 0, 1, \ldots \). Thus, we assume that individuals fully take account of the direct effect of their own decisions on \( \tilde{c}_{ht,t} \), but take all other individuals’ consumption decisions as given, treating them as an external effect.\(^\text{21}\) The Euler equation (19) can then be re-written as

\[
e_{ih}c_{ih,t} - \eta_{ih}c_{ih,t-1} - f_{ih}E(c_{ih,t+1} | \Omega_{ih,t}) + \beta_{ih}^2(1 + r)\eta_{ih}E(c_{ih,t+2} | \Omega_{ih,t}) - \zeta_{ih}c_{ih} = \\
\gamma_{ih}[e_{ih}E(\tilde{c}_{ht} | \Omega_{ih,t}) - \eta_{ih}\tilde{c}_{ht-1} - f_{ih}E(\tilde{c}_{ht+1} | \Omega_{ih,t}) + \\
\beta_{ih}^2(1 + r)\eta_{ih}E(\tilde{c}_{ht+2} | \Omega_{ih,t}) - \zeta_{ih}c_{ih}],
\]

(20)

where

\[
e_{ih} = 1 + \beta_{ih}(1 + r + \eta_{ih})\eta_{ih},
\]

(21)

\[
f_{ih} = \beta_{ih}(1 + r + \eta_{ih}) + \beta_{ih}^2(1 + r)\eta_{ih}^2,
\]

(22)

\[
\gamma_{ih} = \begin{cases} 
\theta_{ih}/[1 + (1 + \omega_{ih}\theta_{ih})] & \text{if } u_{ih,t} \text{ is given by (14) (conformism),} \\
- \tau_{ih}/[1 - \omega_{ih}\tau_{ih}] & \text{if } u_{ih,t} \text{ is given by (15) (altruism/jealousy),}
\end{cases}
\]

(23)

\(^\text{21}\) This follows much of the recent social interactions literature. See, for example, Brock and Durlauf (2000).
and

\[
\zeta_{ih} = \begin{cases} 
[1 - \beta_{ih}(1 + r + \eta_{ih}) + \beta_{ih}^2(1 + r)\eta_{ih}]/[1 + \omega_{ih}\theta_{ih}] \\
\quad \text{if } u_{ih} \text{ is given by (14) (conformism),} \\
[1 - \beta_{ih}(1 + r + \eta_{ih}) + \beta_{ih}^2(1 + r)\eta_{ih}]/[1 + (1 - \omega_{ih})\tau_{ih}] \\
\quad \text{if } u_{ih} \text{ is given by (15) (altruism/jealousy).}
\end{cases}
\] (24)

As is shown in the Mathematical Appendix, upon ruling out explosive individual-specific consumption decisions this fourth-order difference equation under rational expectations can be reduced to a second-order rational expectations equation, namely\textsuperscript{22}

\[
[1 + \beta_{ih}(1 + r)\eta_{ih}]c_{iht} - \eta_{ih}c_{ih, t-1} - \beta_{ih}(1 + r)E(c_{ih, t+1}|\Omega_{iht}) - \varphi_{ih}c_{ih}
= \gamma_{ih}\{[1 + \beta_{ih}(1 + r)\eta_{ih}]E(\tilde{c}_{ih}|\Omega_{iht}) - \eta_{ih}\tilde{c}_{h, t-1}
- \beta_{ih}(1 + r)E(\tilde{c}_{h, t+1}|\Omega_{iht}) - \varphi_{ih}c_{ih}\},
\] (25)

where

\[
\varphi_{ih} = \begin{cases} 
[1 - \beta_{ih}(1 + r)]/[1 + \omega_{ih}\theta_{ih}] \\
\quad \text{if } u_{ih} \text{ is given by (14) (conformism),} \\
[1 - \beta_{ih}(1 + r)]/[1 + (1 - \omega_{ih})\tau_{ih}] \\
\quad \text{if } u_{ih} \text{ is given by (15) (altruism/jealousy).}
\end{cases}
\] (26)

The individual-specific optimal consumption decisions, \(c_{ih, t}\), can now be obtained using the Euler equation (25) and the period-by-period budget constraints (12). This is, however, complicated by what may be called ‘\textit{ex ante} belief indeterminacies’: namely the dependence of the optimal consumption decisions on \textit{ex ante} expectations which are neither observable nor deducible. Consider the Euler equation (25) under either conformism or altruism/jealousy, so that \(\gamma_{ih} \neq 0\). Individual \(i\) in peer group \(h\) needs to form expectations about the current and future weighted average consumption decisions in his peer group, which in turn requires him to form expectations about the current and future consumption decisions of all other individuals in his peer group. Knowing that all other individuals face the same Euler equation as (25), a natural way for individual \(i\) in peer group \(h\) to resolve this difficulty would be to solve (25) for \(c_{ih, t}\), then aggregate over all individuals with their respective weights and take conditional expectations of the resulting expression with respect to \(\Omega_{iht}\), his own information set. This yields the individual’s expectations about current-period

\textsuperscript{22} See the proof of Proposition 1. While this proof considers the case of homogeneous information, the part of the proof dealing with the reduction of a fourth-order rational expectations model to a second-order rational expectations model remains valid under disparate information also.
weighted group average consumption that he needs in order to solve his decision problem. But it is easily seen that such a solution will still be a function of this individual’s expectations about the expectations of all other individuals in his peer group, which are unknown at the beginning of period \( t \). The individual might then plausibly try to use (25) and its group-wide analog to determine these expectations. It is readily verified, however, that the individual will only be able to determine these expectations as functions of another set of yet higher-order expectations of all other individuals in his peer group. Therefore, he will be facing an ‘infinite regress in expectations’ problem which he cannot resolve without further assumptions on how the individuals in the group form expectations about other individuals’ consumption decisions. Any solution would depend on \textit{ex ante} unobservable individual expectations.\footnote{See, for example, Binder and Pesaran (1998) for a more formal discussion of the ‘infinite regress in expectations’ problem and how it arises in multivariate linear rational expectations models under social interactions and disparate information.}

We shall consider two approaches to resolve the ‘infinite regress in expectations’ problem. First, we follow the standard practice in the literature on decision making under social interactions and assume that the information sets across individuals are homogeneous within peer groups. The homogeneity assumption in effect allows individuals in each peer group to deduce current and future expectations of all other individuals in their group. This is a rather restrictive assumption and clearly it is desirable to examine the implications of relaxing it. Our second approach therefore follows Binder and Pesaran (1998) who allow the information sets to be disparate within peer groups, but render individuals’ expectations deducible for the other individuals in the group by assuming that all individuals in the group, by convention, form their expectations about the decision and forcing variables of other individuals in the group only on the basis of the public information set, \( \Psi_{t-1} \).\footnote{See, for example, Young (1996) for an explicit model of the dynamic process of a convention being formed through the accumulation of precedent.} This approach, as will be seen in more detail below, has the attractive feature that it yields solutions that reflect the disparity of information across individuals and are consistent with the key property of the rational expectations hypothesis, namely the orthogonality of individual-specific expectations errors to the variables in the individual’s information set.

3.2. Homogeneous information

We first consider the case where information is homogeneous across individuals. Proposition 1 gives the individual-specific optimal consumption decisions for this case.
Proposition 1 (Individual-specific optimal consumption decisions under conformism, habit formation, and homogeneous information). Suppose (i) the current-period utility function is given by (14), and (ii) information sets are homogeneous. Then the individual-specific optimal consumption decisions in peer group \( h \) under the life-cycle model (11)–(13) are given by

\[
c_{ht} = (I_{N_h} - \gamma_h \omega_h)^{-1} A_{h1} (I_{N_h} - \gamma_h \omega_h') c_{h,t-1}
\]

\[
+ (I_{N_h} - \gamma_h \omega_h')^{-1} A_{h2} (I_{N_h} - \gamma_h \omega_h) E(L_{ht} | \Omega_t)
\]

\[
+ (I_{N_h} - \gamma_h \omega_h')^{-1} A_{h3},
\]

(27)

where

\[
c_{ht} = (c_{1ht}, c_{2ht}, \ldots, c_{N_hht})', \quad L_{ht} = (L_{1ht}, L_{2ht}, \ldots, L_{N_hht})',
\]

\[
\omega_h = (\omega_{1h}, \omega_{2h}, \ldots, \omega_{N_hh})', \quad \gamma_h = (\gamma_{1h}, \gamma_{2h}, \ldots, \gamma_{N_hh}),
\]

\[
\gamma_{ih} = \left( \frac{\eta_{ih}}{1 + (1 + \omega_{ih}) \theta_{ih}} \right),
\]

(28)

\( I_{N_h} \) is the \( N_h \)-dimensional identity matrix, \( A_{h1} \) is a diagonal matrix with its \( i \)th diagonal element given by \( \lambda_{ih} \),

\[
\lambda_{ih} = \left( \frac{\eta_{ih}}{\beta_{ih}(1 + r)^2} \right),
\]

(29)

\( A_{h2} \) is a diagonal matrix with its \( i \)th diagonal element given by \( \phi_{ih} \),

\[
\phi_{ih} = \left( \frac{(1 + r - \eta_{ih})(\beta_{ih}(1 + r)^2 - 1)}{\beta_{ih}(1 + r)^3} \right).
\]

(30)

and \( A_{h3} \) is a diagonal matrix with its \( i \)th diagonal element given by

\[
\delta_{ih} = \left( \frac{(1 - (1 + \omega_{ih}) \gamma_{ih})(1 - \beta_{ih}(1 + r))}{\beta_{ih} r (1 + r)} \right) c_{ih},
\]

(31)

\( i = 1, 2, \ldots, N_h \).

(Individual-specific optimal consumption decisions under altruism/jealousy, habit formation, and homogeneous information). Suppose (i) the current-period utility function is given by (15), and (ii) information sets are homogeneous. Then the individual-specific optimal consumption decisions in peer group \( h \) under the life-cycle model (11)–(13) are given by (27), where

\[
\gamma_{ih} = \left( \frac{\tau_{ih}}{1 - \omega_{ih} \tau_{ih}} \right),
\]

(32)

\[
\delta_{ih} = \left( \frac{(1 - \omega_{ih} \gamma_{ih})(1 - \beta_{ih}(1 + r))}{\beta_{ih} r (1 + r)} \right) c_{ih},
\]

(33)

and \( \lambda_{ih} \) and \( \phi_{ih} \) are given by (29) and (30), respectively.
The proofs of this and all other subsequent propositions are given in the Mathematical Appendix.

Given that the decision rules under conformism and under altruism/jealousy are the same except for the definitions of $\gamma_{ih}$ and $\delta_{ih}$, in what follows we focus on the case of conformism. Clearly, the qualitative implications for the case of jealousy are the same as those for conformism, while for the case of altruism the sign of $\gamma_{ih}$ is reversed as compared to the case of conformism.

The set of individual-specific optimal consumption decisions (27) represents a first-order panel vector autoregression, PVAR(1), with a rich set of testable within-equation and cross-equation parametric restrictions. To write (27) in a familiar panel vector autoregressive form and understand the dynamic properties of the decision rules, note that under the labor income specification (3) and (5) we have that

$$E(L_{iht} | \Omega_t) = (1 + r) A_{ih,t-1} + \left(1 + \frac{\exp(\sigma_t^2/2 - \xi_{ith})(1 + g)}{r - g}\right) y_{ith}.$$  

(34)

Substituting (34) in (27), and stacking the endogenous variables $c_{ith}$ and $A_{ith}$ for all $i = 1, 2, \ldots, N_h$ in a vector $x_{ht}$, we have

$$x_{ht} = D_{1h} x_{ht-1} + D_{2h} y_{ht},$$  

(35)

where $y_{ht} = (y_{1ht}, y_{2ht}, \ldots, y_{Nht})'$, and the coefficient matrices $D_{1h}$ and $D_{2h}$ directly follow from the decision rules (27) and the period-by-period budget constraints (12). It may be verified that the eigenvalues of $D_{1h}$ are given by $\eta_{1h}, \eta_{2h}, \ldots, \eta_{Nh}, 1/[\beta_{1h}(1 + r)], 1/[\beta_{2h}(1 + r)], \ldots, 1/[\beta_{Nh}(1 + r)]$, which fall into $[0, 1)$ if $0 < \eta_{ih} < 1$, $i = 1, 2, \ldots, N_h$, (as we had assumed), and if $\rho_{ih} < r$, $i = 1, 2, \ldots, N_h$. In the case where $\rho_{ih} = r$ (or $\beta_{ih}(1 + r) = 1$) for some $i$, the PVAR(1) model in (35) will contain unit roots, in addition to the (geometric) unit root in $y_{ith}$, and there exists no long-run relationship between $c_{ith}$ (or $A_{ith}$) and $y_{ht}$. In this case initial assets have permanent effects on consumption decisions and even in the long run consumption depends on initial assets as well as on labor income.

Analyzing how the individual-specific consumption decisions (27) differ from their counterparts under the permanent income hypothesis, note that (27) comprises three additive components. Each individual’s consumption decision depends on the past consumption levels of all other individuals in his peer group, their expected present discounted values of total lifetime resources, and

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25When $\beta_{ih}(1 + r) > 1$, then for the optimal consumption decisions in (27) to be nonnegative regardless of the past consumption levels, it is necessary that individuals’ expected present discounted values of total lifetime resources are sufficiently large relative to their bliss points. Throughout this paper we assume that this condition is satisfied.
their bliss points, with weights determined by the individuals' placement in the peer group \((\omega_{jh})\) as well as the strength of their preference for conformism \((\gamma_{jh})\), and thus \(\theta_{jh}\). Allowing for conformism, habit formation, and patience \((\rho_{ih} < r)\) in general thus significantly alters the qualitative structure of the consumption decisions as compared to those under the permanent income hypothesis.

(Note that the permanent income hypothesis decision rules can be obtained by setting \(\rho_{ih} = r\) as well as setting \(\eta_{ih}\) and \(\theta_{ih}\) (and hence \(\gamma_{ih}\)) equal to zero, for all \(i, h\).)

Yet deeper insights into the differences between the consumption decisions under conformism, habit formation, and patience and those under the permanent income hypothesis may be obtained by rewriting the set of individual-specific consumption decisions (27) for one specific individual, say individual \(i\), abandoning the matrix notation. From (27), after some algebra, the consumption decision of individual \(i\) in peer group \(h\) can be rewritten as

\[
c_{iht} = \left( \lambda_{ih} + \omega_{ih} \gamma_{ih} \left( \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} \left( \lambda_{ih} - \lambda_{jh} \right) \right) \right) c_{ih,t-1} + \gamma_{ih} \left( \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} \left( \lambda_{ih} + \lambda_{jh} \right) \right) c_{ih,t-1} + \phi_{ih} + \omega_{ih} \gamma_{ih} \left( \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} \left( \phi_{ih} - \phi_{jh} \right) \right) E(L_{ih}|\Omega_t) + \gamma_{ih} \left( \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} \left( \phi_{ih} - \phi_{jh} \right) \right) E(L_{jh}|\Omega_t) + \delta_{ih} + \gamma_{ih} \left( \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} \delta_{jh} \right),
\]

with \(\gamma_{ih}, \lambda_{ih}, \phi_{ih}, \) and \(\delta_{ih}\) given by (28)–(31), respectively. The decision rule (36) nests as a special case the familiar decision rule in the absence of conformism and habit formation,

\[
c_{iht} = \phi_{ih} E(L_{ih}|\Omega_t) + \left( \frac{1 - \beta_{ih}(1 + r)}{\beta_{ih}r(1 + r)} \right) c_{ih},
\]

where

\[
\phi_{ih} = \frac{\beta_{ih}(1 + r)^2 - 1}{\beta_{ih}(1 + r)^2}. \tag{38}
\]

Note that (37) implies that individual \(i\)'s optimal consumption decision is a function of his own (expected present discounted value of total) lifetime resources, \(E(L_{ih}|\Omega_t)\), and his own bliss point, \(c_{ih}\), only. Reinroducing conformism, but still abstracting from habit formation, (36) implies that the optimal
consumption decision becomes
\[ c_{ih} = \left( \phi_{ih} + \omega_{ih} \gamma_{ih} \left( \frac{\sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} (\phi_{jh} - \phi_{ih})}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}} \right) \right) E(L_{ih} \mid \Omega_t) \]
\[ + \gamma_{ih} \left( \frac{\sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} (\phi_{jh} - \phi_{ih}) + \sum_{k=1}^{N_h} \omega_{kh} \gamma_{kh} (\phi_{kh} - \phi_{ih})}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}} \right) E(L_{jh} \mid \Omega_t) \]
\[ + \delta_{ih} + \gamma_{ih} \left( \frac{\sum_{j=1}^{N_h} \omega_{jh} \delta_{jh}}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}} \right), \] (39)

with \( \gamma_{ih}, \phi_{ih}, \) and \( \delta_{ih} \) given by (28), (38), and (31), respectively. Thus, under conformism, individuals do take into account not only their own lifetime resources and their own bliss point, but also the lifetime resources and bliss points of all other individuals in their peer group. It is important to note, however, that differences in individuals’ lifetime resources do not lead to adjustments in the optimal consumption decisions under conformism, (39), as compared to the case of self-centered individuals, (37), per se. Rather, if individual \( i \), say, has lower labor income and wealth levels in period \( t \) than all his peers, he will only adjust his period \( t \) consumption decision to take account of the higher labor income and wealth levels of his peers if his rate of time preference, \( \rho_{ih} \), differs from that of his peers. If individual \( i \)’s rate of time preference is the same as that of all of his peers, that is, \( \rho_{ih} = \rho_{jh} = \rho_h \), for all \( i, j \), then from (39) we have that
\[ c_{ih} = \phi_{h} E(L_{ih} \mid \Omega_t) + \delta_{ih} + \gamma_{ih} \left( \frac{\sum_{j=1}^{N_h} \omega_{jh} \delta_{jh}}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}} \right), \] (40)

where
\[ \phi_{h} = \frac{\beta_{h}(1 + r)^2 - 1}{\beta_{h}(1 + r)^2}, \] (41)
\[ \delta_{ih} = \frac{(1 - (1 + \omega_{ih}) \gamma_{ih}) (1 - \beta_{h}(1 + r))}{\beta_{h} r (1 + r)} c_{ih}, \] (42)

and \( \gamma_{ih} \) is given by (28), and the only adjustment in the consumption decision implied by the presence of conformism is in the intercept term.

To gain more insight into how (by intention) conformist individuals adjust their consumption decisions for their peers’ lifetime resources if their peers’ rates of time preference differ from their own, consider the following simple numerical experiment. Suppose that the peer group has three members, \( N_h = 3 \), all members of the peer group being equally placed \( (\omega_{ih} = \frac{1}{3}, i = 1, 2, 3) \), that the interest rate is \( r = (1.03)^{0.25} - 1 \) (taking time to be of quarterly frequency), and that \( \rho_{1h} = (1.02)^{0.25} - 1, \rho_{2h} = (1.01)^{0.25} - 1, \) and \( \rho_{3h} = (1.00)^{0.25} - 1, \) so that all individuals are patient (and their consumption decision rules are stable), individual 1 being least patient, and individual 3 most patient. Table 1 gives the
Table 1

Decision rule coefficients in a peer group of self-centered individuals and in a peer group of conformist individuals (time separable preferences)

<table>
<thead>
<tr>
<th></th>
<th>Self-centered individuals</th>
<th>Conformist individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_{iht}$</td>
<td>$\begin{pmatrix}</td>
<td>$\begin{pmatrix}</td>
</tr>
<tr>
<td></td>
<td>9.7806 0 0</td>
<td>9.7454 0.1522 0.3409</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>0 12.2166 0</td>
<td>$10^{-3}$ -0.1875 12.2165 0.1887</td>
</tr>
<tr>
<td></td>
<td>0 0 14.6707</td>
<td>-0.3409 -0.1535 14.7060</td>
</tr>
</tbody>
</table>

The element in the $i$th row and $j$th column of each matrix gives the coefficient on $E(L_{ih}\mid \Omega_t)$ in individual $i$’s decision rule.

coefficients on $E(L_{ih}\mid \Omega_t)$ in the decision rule (39) for all three individuals under the two scenarios that all individuals are self-centered ($\theta_{ih} = 0$, $i = 1, 2, 3$) and that all individuals are conformist ($\theta_{ih} = 0.25$, $i = 1, 2, 3$). (In the coefficient matrices in Table 1, the element in the $i$th row and $j$th column of each matrix gives the coefficient on $E(L_{ih}\mid \Omega_t)$ in individual $i$’s decision rule.)

As to be expected, in the absence of conformism, the coefficient on $E(L_{ih}\mid \Omega_t)$ is higher the more patient individual $i$ is, and the coefficients on other individuals’ lifetime resources are zero, as individuals are self-centered. In the presence of conformism, individuals adjust their consumption decisions positively for the lifetime resources of peers who are more patient than themselves, and negatively for the lifetime resources of peers who are less patient than themselves. (The signs of these adjustments under the above parameterizations are the same if individuals’ preferences for conformism are allowed to differ.) While the net adjustments of the period $t$ consumption levels depend on the relative magnitudes of the peers’ lifetime resources (note that individuals also adjust the coefficient on their own lifetime resources), Table 1 illustrates that increases or decreases in their peers’ lifetime resources do not lead to adjustments in individuals’ optimal consumption decisions per se. Rather, whether an individual in any given period will keep up with the Joneses is determined by intertemporal considerations, reflecting the shape of the Joneses’ lifetime consumption profiles. Clearly, the implications of social interactions in an intertemporal setting may then just be the opposite of those in a static setting, and analyses of the effects of social interactions in static settings can therefore be highly misleading.

What are the implications of incorporating the second facet of endogenous taste change, namely habit formation, into individuals’ decision rules? To understand these implications, let us first isolate how habit formation by itself affects individuals’ optimal consumption decisions. If $\theta_{ih} = 0$ (and thus $\gamma_{ih} = 0$), for all $i, h$, then the optimal consumption decision (36) reduces to

$$c_{iht} = \lambda_{ih}c_{ih,t-1} + \phi_{ih}E(L_{ih}\mid \Omega_t) + \left(\frac{1 - \beta_{ih}(1 + r)}{\beta_{ih}(1 + r)}\right)c_{ih}$$

(43)
where $\lambda_{ih}$ and $\phi_{ih}$ are given by (29) and (30), respectively. The decision rule (43) has three particularly notable implications. First, a self-centered individual whose preferences exhibit habit formation will consume less during the early stages of his life cycle than a self-centered individual whose preferences are time separable. Since under habit formation consumption levels must be continually increasing in order to offset the negative effect that past consumption has on current-period utility, individuals’ consumption levels will be lower during the early stages of the life cycle than they are in the absence of habit formation. Thus the strength of an individual’s preference for habit formation affects the shape of his lifetime consumption profile. Second, under habit formation a self-centered individual will increase his current-period consumption in response to an unanticipated increase in his current-period labor income by a smaller amount than a self-centered individual whose preferences are time separable. This is because an individual who values habit formation is concerned about the negative effects of an increase in his consumption level today on utility derived ceteris paribus from his future consumption levels. The higher the degree of habit formation, the smaller the effect of an unanticipated increase in period $t$ labor income on consumption in period $t$. Third, a self-centered individual whose preferences exhibit habit formation will also increase his current-period consumption in response to an anticipated increase in his current-period labor income. This is effectively for the same reasons as those underlying the individual’s response to unanticipated changes in his labor income. At the time when he first learns about the future increase in labor income (that is, when the increase in labor income is unanticipated), habit formation leads the individual to be careful about not raising his utility standard by too much. The individual will increase his consumption by less than the ‘annuity’ value of the increase in his lifetime resources, leading to further adjustments in his consumption levels, beyond those made at the time when he first learned about the future increase in his labor income, once he has already anticipated the increase in his labor income. Note that this is in contrast to a self-centered individual whose preferences are time separable. Such an individual adjusts his consumption level in one step at the time when he first learns about the future increase in his labor income.

Keeping the above points in mind, we now consider the properties of the optimal consumption decisions under habit formation and conformism given by (36). From (36), it is easily seen that individuals will adjust their consumption decisions to take account of their peers’ past consumption levels and their peers’ lifetime resources if their peers either have a different rate of time preference, $\rho_{jh}$, or have a different habit formation coefficient, $\eta_{jh}$: The coefficients $\lambda_{jh}$ and $\phi_{jh}$ in (36) will differ across $j$ if either individuals’ rates of time preference, $\rho_{jh}$, or individuals’ coefficients of habit formation, $\eta_{jh}$, differ. In either case, it is again intertemporal considerations, and not differences in individuals’ labor income and/or wealth levels per se that induce individuals to adjust their
Recall the implications of the strength of a self-centered individual’s preference for habit formation for the shape of his lifetime consumption path discussed above.

<table>
<thead>
<tr>
<th>Self-centered individuals</th>
<th>Conformist individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-3} \times \begin{pmatrix} 7.3535 &amp; 0 &amp; 0 \ 0 &amp; 4.9263 &amp; 0 \ 0 &amp; 0 &amp; 2.4992 \end{pmatrix}$</td>
<td>$10^{-3} \times \begin{pmatrix} 7.3885 &amp; -0.1517 &amp; -0.3384 \ 0.1867 &amp; 4.9263 &amp; -0.1867 \ 0.3384 &amp; 0.1517 &amp; 2.4642 \end{pmatrix}$</td>
</tr>
</tbody>
</table>

*The element in the $i$th row and $j$th column of each matrix gives the coefficient on $E(L_{iht} | \Omega_t)$ in individual $i$’s decision rule.

In order to illustrate the quantitative importance of the interaction of habit formation and conformism motives, once again consider a peer group with three equally placed members, the interest rate being $r = (1.03)^{0.25} - 1$, and $\rho_{ih} = (1.02)^{0.25} - 1$, $i = 1, 2, 3$, so that all individuals in the peer group are equally patient. Also suppose that the peers’ habit formation coefficients are $\eta_{1h} = 0.25$, $\eta_{2h} = 0.5$, and $\eta_{3h} = 0.75$. Table 2 gives the coefficients on $E(L_{jht} | \Omega_t)$ in the decision rule (36) for all three individuals under the two scenarios that all individuals are self-centered ($\theta_{ih} = 0$, $i = 1, 2, 3$), and that all individuals are conformist ($\theta_{ih} = 0.25$, $i = 1, 2, 3$). (In the coefficient matrices in Table 2, the element in the $i$th row and $j$th column of each matrix again gives the coefficient on $E(L_{jht} | \Omega_t)$ in individual $i$’s decision rule.)

As to be expected from our discussion above, in the absence of conformism, the coefficient on $E(L_{iht} | \Omega_t)$ is lower the more strongly the individual values habit formation. Under conformism individuals adjust their consumption decisions positively with respect to the lifetime resources of peers who value habit formation less strongly, and negatively with respect to the lifetime resources of peers who value habit formation more strongly. While the net adjustments of the consumption levels depend on the relative magnitudes of the peers’ lifetime resources, Table 2 again illustrates that whether an individual in any given period will keep up with the Joneses is determined by intertemporal considerations, reflecting the shape of the Joneses’ lifetime consumption profiles.

Our discussion of Proposition 1 so far has emphasized the conditions under which conformism, with or without habit formation, leads to consumption paths that can be qualitatively significantly different from those of self-centered individuals. The extent to which the optimal consumption decisions differ critically depends on the degree of parameter heterogeneity within peer groups with

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26 Recall the implications of the strength of a self-centered individual’s preference for habit formation for the shape of his lifetime consumption path discussed above.
respect to $\rho_{ih}$ and $\eta_{ih}$. If individuals’ rates of time preference and their valuations of habit formation are homogeneous within peer groups, then the apparent paradox can arise that by intention conformist individuals act just as self-centered individuals would. This result critically depends on whether or not there is an intercept term in individuals’ decision rules. If all individuals in peer group $h$ have the same rate of time preference, $\rho_{ih} = \rho_h$, for all $i$, with $\rho_h$ not equal to the market interest rate, $r$, and all individuals in the group value habit formation equally strongly (that is, $\eta_{ih} = \eta_h$, for all $i$), then each individual’s consumption level depends only on his own lagged consumption level and his own lifetime resources, but not on the lagged consumption levels and the lifetime resources of his peers. The conformism effect in this case enters the decision rule only through the intercept term, implying a very limited form of interaction among individuals’ consumption decisions.\footnote{This is, of course, not to say that the effects of conformism on individuals’ consumption decisions through the intercept term would necessarily have to be small. The size of these effects depends in particular on individuals’ degrees of patience and their bliss consumption levels.}

In particular, individual $i$ will not adjust his consumption decisions to any changes in the lifetime resources of peer $j$, $j \neq i$, regardless of the strength of individual $i$’s preference for conformism. From (36), it is also clear that under certain, albeit rather extreme, conditions the interaction among individuals’ consumption decisions may not only be limited, but there may be an \textit{exact equivalence} between the optimal consumption decisions of individuals adhering to a self-centered pursuit of their own interests and the optimal consumption decisions of individuals who are socially motivated in that they would like to conform. The optimal consumption decisions (36) display this apparent paradox if all individuals in the peer group have the same degree of preference for habit formation, $\eta_h$, and the same rate of time preference, $\rho_h$, with the rate of time preference furthermore being equal to the market interest rate, $r$.\footnote{It may be of interest to note that Gali (1994) in examining the role of conformism in a Lucas-type asset pricing model obtains a related result. In particular, he shows that equilibrium asset prices in a homogeneous information economy in which individuals value conformism may be the same as those in a corresponding economy in which individuals are self-centered, but only if the degree of risk aversion of the individuals in the latter economy is properly adjusted. We, in contrast, show that under quadratic preferences there may be an \textit{exact equivalence} between the decisions of individuals who are by intention conformist and those of individuals who are by intention non-conformist, even when individuals’ preferences are not time separable and display heterogeneity with respect to the degree of conformism and/or individuals’ bliss points.}

Some intuition for this equivalence result can be obtained by further inspecting the Euler equation (25). Under the conditions $\eta_{ih} = \eta_h$ and $\rho_{ih} = \rho_h = r$, for all $i$, and assuming information homogeneity, (25) becomes

\[ (1 + \eta_h)c_{ih,t} - \eta_h c_{ih,t-1} - E(c_{ih,t+1}|\Omega_t) = \gamma_{ih}[(1 + \eta_h)\bar{c}_{ht} - \eta_h \bar{c}_{ht-1} - E(\bar{c}_{ht+1}|\Omega_t)]. \]

\[(44)\]
Since in the presence of conformism $1 > \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} > 0$, this means that the individual-specific and group-wide problems can be solved separately, and correspond to the standard Euler equations

$$\left(1 + \eta_h\right) c_{ih,t} = \eta_h c_{ih,t-1} + \mathbb{E}(c_{ih,t+1} | \Omega_t)$$

at the individual level, and its analog at the peer group level,

$$\left(1 + \eta_h\right) \tilde{c}_{ht} = \eta_h \tilde{c}_{ht-1} + \mathbb{E}(\tilde{c}_{ht+1} | \Omega_t).$$

Seen from this perspective, it becomes clear that the conditions needed for the equivalence result to hold are the same as the ones needed for perfect cross-sectional aggregation of individual-specific decisions.

### 3.3. Disparate information

It is the exception rather than the rule that individuals would know the current-period labor income levels and current-period wealth levels of all other individuals in their peer group when making their own consumption decisions. It is therefore important to examine whether our results derived under homogeneous information are qualitatively robust to information heterogeneity. In order to isolate the effects of allowing for disparate information in a life-cycle model with social interactions, and in order to keep the exposition as simple as possible, we abstract from habit formation, and set $\eta_{ih} = 0$, for all $i,h$.

To overcome the infinite regress problem arising under disparate information, we follow Binder and Pesaran (1998) and assume that individuals form their expectations about the decision and forcing variables of other individuals in their peer group solely on the basis of publicly available information. In particular, we assume that (i) individual $i$’s beliefs about individual $j$’s current and future consumption levels $(i \neq j)$ are given by

$$\mathbb{E}(c_{jh,t+s} | O_{ih}) = \mathbb{E}(c_{jh,t+s} | \Psi_{t-1}),$$

for $i,j = 1,2,\ldots,N_h$, $h = 1,2,\ldots,H$, and $s = 0,1,\ldots$, and that (ii) individual $i$’s beliefs about individual $j$’s current and future labor income levels $(i \neq j)$ are given by

$$\mathbb{E}(y_{jh,t+s} | O_{ih}) = \mathbb{E}(y_{jh,t+s} | \Psi_{t-1}),$$

for $i,j = 1,2,\ldots,N_h$, $h = 1,2,\ldots,H$, and $s = 0,1,\ldots$.\footnote{These assumptions appear plausible in cases where the correlation of private information across individuals is not too large. See Binder and Pesaran (1998).} It readily follows from the discussion in Binder and Pesaran (1998) that the individual-specific optimal consumption decisions derived using (47) and (48) satisfy the key property of the rational expectations hypothesis, namely the orthogonality of each individual’s
expectations errors to the variables in his information set. The following proposition gives the individual-specific optimal consumption decisions under conformism or altruism/jealousy when individuals’ information sets are disparate.

Proposition 2 (Individual-specific optimal consumption decisions under conformism and disparate information). Suppose (i) the current-period utility function is given by (14) with \( \eta_{ih} = 0 \), for all \( i, h \), (ii) information sets are disparate, and (iii) individuals’ expectations about the decision and forcing variables of other individuals satisfy (47) and (48). Then the individual-specific optimal consumption decisions in peer group \( h \) under the life-cycle model (11)–(13) are given by

\[
c_{iht} = \phi_{ih} E(L_{iht}|\Omega_{iht}) + \left( \frac{\gamma_{ih}}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}} \right) \left( \sum_{j=1}^{N_h} \omega_{jh} \phi_{jh} E(L_{jht}|\Psi_{t-1}) \right) \\
- \gamma_{ih} \phi_{ih} E(\tilde{L}_{ht}|\Psi_{t-1}) - \left( \frac{\gamma_{ih}}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}} \right) \left( \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} \phi_{jh} \right) E(\tilde{L}_{ht}|\Psi_{t-1}) \\
+ \delta_{ih} + \gamma_{ih} \left( \frac{\sum_{j=1}^{N_h} \omega_{jh} \delta_{jh}}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}} \right),
\]

where \( \gamma_{ih}, \phi_{ih}, \) and \( \delta_{ih} \) are given by (28), (38), and (31), respectively.

(Individual-specific optimal consumption decisions under altruism/jealousy and disparate information). Suppose (i) the current-period utility function is given by (15) with \( \eta_{ih} = 0 \), for all \( i, h \), (ii) information sets are disparate, and (iii) individuals’ expectations about the decision and forcing variables of other individuals satisfy (47) and (48). Then the individual-specific optimal consumption decisions in peer group \( h \) under the life-cycle model (11)–(13) are given by (49), where \( \gamma_{ih}, \phi_{ih}, \) and \( \delta_{ih} \) are given by (32), (38), and (33), respectively.

Noting that the decision rules under conformism and under altruism/jealousy are, as under homogeneous information, the same except for the definitions of \( \gamma_{ih} \) and \( \delta_{ih} \), in what follows we again focus on the case of conformism. The individual-specific optimal consumption decisions of individual \( i \) in (49) comprise three additive components: The terms in \( E(L_{iht}|\Omega_{iht}) \) and in \( E(L_{iht}|\Psi_{t-1}) \) that depend on the individual’s own lifetime resources, the terms in \( E(L_{jht}|\Psi_{t-1}) \), for all \( j \neq i \), that depend on the lifetime resources of all other individuals in his peer group, and an intercept term that is the same as the intercept term in the consumption decision under homogeneous information, (27). An important difference between the decision rules under disparate and homogeneous information is that under the former individuals cannot adjust their consumption decisions to unanticipated changes in their peers’ lifetime resources in the same period as these changes occur. As individuals need to forecast their peers’ lifetime resources on the basis of public information (which includes only lagged
peer group averages of labor income and wealth levels), their adjustments to their peers’ labor income fluctuations only occur with a lag and then only with respect to their peer group average.\footnote{It is worth noting that our model of social interactions and disparate information operates quite differently than the information aggregation bias models of Goodfriend (1992) and Pischke (1995). In Goodfriend’s and Pischke’s models, individuals are self-centered and thus are not per se concerned about the consumption decisions of others. However, observing other individuals’ past consumption decisions helps individuals in these models to disentangle the individual-specific and economy-wide components of labor income innovations, which matters to individuals as these components are assumed to have different serial correlation structures. As discussed, for example, by Deaton (1992), such a signal extraction specification has observational implications similar to those of habit formation. Embedding such a signal extraction framework within our model of conformism and disparate information would therefore be an interesting avenue for future research.}

As under homogeneous information, a necessary condition for any such adjustment to occur is that individuals’ rates of time preference display heterogeneity. Therefore, regardless of whether the information structure is homogeneous or disparate, whether an individual in any given period will keep up with the Joneses is determined by intertemporal considerations. If all individuals in the peer group have the same rate of time preference, $\rho_{ih} = \rho_h$, for all $i$, then the optimal consumption decisions (49) reduce to

$$c_{ih} = \phi_h \mathbf{E}(L_{iht} | \Omega_{ih}) + \delta_{ih} + \gamma_{ih} \left( \frac{\sum_{j=1}^{N_h} \omega_{jh} \delta_{jh}}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}} \right), \quad (50)$$

with $\gamma_{ih}$, $\phi_h$, and $\delta_{ih}$ given by (28), (41), and (42), respectively. Note that (50) is the same as (40), that is, if all individuals in the peer group have the same rate of time preference, then the optimal consumption decisions under disparate information are the same as those under homogeneous information. Inspecting the Euler equation under disparate information, (25), it can be understood why this is the case. From (25), under the condition that $\rho_{ih} = \rho_h$, for all $i$, the Euler equation under disparate information (and no habit formation) is given by

$$c_{ih} = \beta_h (1 + r) \mathbf{E}(c_{ih,t+1} | \Omega_{ih}) - \varphi_{ih} c_{ih}$$

$$= \gamma_{ih} [\mathbf{E}(\bar{c}_{ih} | \Omega_{ih}) - \beta_h (1 + r) \mathbf{E}(\bar{c}_{ih,t+1} | \Omega_{ih}) - \varphi_{ih} c_{ih}], \quad (51)$$

where

$$\varphi_{ih} = \left( \frac{1 - \beta_h (1 + r)}{1 + \omega_{ih} \theta_{ih}} \right). \quad (52)$$

The only term in the individual-specific and group-wide problems in (51) that prevents perfect aggregation to be possible even in the presence of a conformism motive is the intercept term, $\varphi_{ih} c_{ih}$. However, this term is known to all individuals in the peer group under both disparate and homogeneous information,
and therefore does not lead to any differences in the solutions under disparate and homogeneous information.

4. Individual-specific optimal consumption decisions under prudence

In this section we consider the implications of allowing for a prudence motive for the optimal consumption decisions of altruistic/jealous individuals. In the absence of an altruism/jealousy motive ($\tau_{ih} = 0$, for all $i, h$), it is well known that under the negative exponential utility specification (16) there are non-trivial implications of labor income uncertainty for individuals’ optimal consumption decisions, as risk averse intertemporally optimizing individuals will want to provide for future contingencies through precautionary saving. Our main interest in this section is in how the presence of a prudence motive affects the results obtained above for the case of a quadratic current-period utility specification. To maintain analytical tractability, we assume in this section that the labor income, $y_{ih}$, follows an arithmetic random walk process,

$$\Delta y_{ih} = \mu + v_i + \xi_{ih},$$

with an economy-wide drift, $\mu$, an economy-wide random component, $v_i$, and the residual random component, $\xi_{ih}$. The random components $v_i$ and $\xi_{ih}$ are assumed to be mutually independent, $i = 1, 2, \ldots, N_h$, $h = 1, 2, \ldots, H$, $t = 1, 2, \ldots$, and distributed identically as normal variates with zero means and constant variances:

$$v_i \sim \text{iid } N(0, \sigma_v^2), \quad \xi_{ih} \sim \text{iid } N(0, \sigma_\xi^2).$$

As we had discussed in Section 2, a geometric random walk specification where only the economy-wide shocks, $v_i$, have permanent effects, has more plausible implications for the economy’s labor income distribution. For the case of negative exponential current-period utility, a geometric random walk specification for labor income makes analytical computation of the individual-specific optimal consumption decisions significantly more cumbersome, however.\(^{31}\) We thus employ the labor income specification (53) and (54), noting that our numerical experiments that we report below are based on values of $\sigma_v^2$ and $\sigma_\xi^2$ for which the distribution of the logarithm of labor income is becoming at most mildly more dispersed in the short to medium run. Proposition 3 gives the individual-specific optimal consumption decisions for the life-cycle model (11)–(13) under altruism/jealousy and prudence, assuming that information is homogeneous across individuals.

\(^{31}\)See, for example, Binder et al. (2000) for a discussion of the analytical solution of a life-cycle model with negative exponential current-period utility without social interactions if labor income follows a geometric random walk.
Proposition 3 (Individual-specific optimal consumption decisions under altruism/jealousy, prudence, and homogeneous information). Suppose (i) the current-period utility function is given by (16), (ii) labor income is generated by (53) and (54), and (iii) information sets are homogeneous. Then the individual-specific optimal consumption decisions in peer group \( h \) under the life-cycle model (11)–(13) are given by

\[
c_{ih} = y_{ih} + rA_{ih,t-1} + \left( \frac{1}{r} \right) \mu - \left( \frac{1}{r} \right) \left[ (1 - \omega_{ih} \gamma_{ih}) \Gamma_{ih} + \gamma_{ih} \Gamma_{h} \right],
\]

with \( \gamma_{ih} \) given by (32),

\[
\Gamma_{ih} = \left( \frac{1}{K_{ih}} \right) \log \beta_{ih}(1 + r) + \Gamma_{ih}^{\#},
\]

\[
\Gamma_{ih}^{\#} = \left( \frac{K_{ih}}{2} \right) \left[ \frac{1}{\tau_{ih}} + \frac{N_{i}}{\sum_{j=1}^{N_{i}} \omega_{ij}} \right] \sigma_{v}^{2} + \sigma_{x}^{2} + \tau_{ih}^{2} \left( \frac{N_{i}}{\sum_{j=1}^{N_{i}} \omega_{ij}^{2}} \right),
\]

and

\[
\Gamma_{h} = \frac{\sum_{j=1}^{N_{i}} \omega_{ij} \left( 1 - \omega_{ij} \gamma_{ij} \right) \Gamma_{ij}}{1 - \sum_{j=1}^{N_{i}} \omega_{ij} \gamma_{ij}}.
\]

The optimal consumption decisions under prudence contain, compared to their counterparts under certainty equivalent behavior, an additional additive term reflecting individuals’ desire to insure themselves against future contingencies through precautionary saving. There are two components to this effect, \( \Gamma_{ih}^{\#} \): precautionary saving due to uncertainty about future economy-wide innovations in labor income and precautionary saving due to uncertainty about individual \( i \)'s own as well as his peers’ future individual-specific innovations in labor income.

From (55) and (56), it is clear that heterogeneity in peers’ rates of time preference is not a necessary condition for prudent individuals to adjust their consumption decisions with respect to those of their peers (in fact, as \( \log \beta_{ih}(1 + r) \) enters \( \Gamma_{ih} \) additively, it does not affect precautionary saving at all). Still, one of the main tenets of our analysis under certainty equivalent behavior remains also true under (55): Prudent individuals who value social interactions adjust their consumption decisions with respect to those of their peers because of intertemporal rather than static considerations. This again underlines the

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\[32 \text{Writing the optimal consumption decisions (55) in panel vector autoregressive form by stacking the endogenous variables } c_{ih} \text{ and } A_{ih}, \text{ it is readily verified that the resulting PVAR(1) contains a unit root, in addition to the unit root in } y_{ih}, \text{ and there exists no long-run relationship between } c_{ih} \text{ (or } A_{ih} \text{) and } y_{ih}.\]
Table 3
Precautionary saving under jealousy: percentage increase compared to precautionary saving in the absence of jealousy

<table>
<thead>
<tr>
<th></th>
<th>$\sigma_{z} = \sigma_{\epsilon}$</th>
<th>$\sigma_{z} = 2\sigma_{\epsilon}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(a) Homogeneous peer group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\tau_{ih} = 0.25, i = 1, 2, 3$</td>
<td>2.50</td>
<td>14.00</td>
</tr>
<tr>
<td>$\tau_{ih} = 0.5, i = 1, 2, 3$</td>
<td>12.50</td>
<td>40.00</td>
</tr>
<tr>
<td>$\tau_{ih} = 0.75, i = 1, 2, 3$</td>
<td>37.50</td>
<td>90.00</td>
</tr>
<tr>
<td><strong>(b) Heterogeneous peer group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\kappa_{ih} = 0.05, i = 1, 2, 3$</td>
<td>5.11</td>
<td>20.00</td>
</tr>
<tr>
<td></td>
<td>13.06</td>
<td>40.00</td>
</tr>
<tr>
<td></td>
<td>23.30</td>
<td>60.00</td>
</tr>
<tr>
<td>$\kappa_{ih} = 0.06, \kappa_{ih} = 0.05, \kappa_{ih} = 0.04$</td>
<td>1.26</td>
<td>14.87</td>
</tr>
<tr>
<td></td>
<td>14.24</td>
<td>40.58</td>
</tr>
<tr>
<td></td>
<td>42.42</td>
<td>82.01</td>
</tr>
</tbody>
</table>

*The entry in the $i$th row of each vector gives the precautionary saving of individual $i$.

importance of analyzing the effects of social interactions in an intertemporal rather than a static setting.

To gain insight into the potential quantitative importance of social interactions for individuals’ precautionary saving, we consider a numerical experiment supposing as in the previous section that the peer group has three members, $N_{h} = 3$, with all individuals being equally placed ($\omega_{ih} = \frac{1}{3}, i = 1, 2, 3$). We also assume that the interest rate is $r = (1.03)^{0.25} - 1$. Table 3 illustrates how jealousy may increase individuals’ precautionary saving compared to the precautionary saving decisions of self-centered (yet prudent) individuals. For the case of self-centered individuals Caballero (1990) has already argued that the level of precautionary saving generated by a model with negative exponential current-period utility can be large empirically. Here our concern is only regarding the relative magnitude of precautionary saving under jealousy and in the absence of jealousy. What matters for this relative magnitude is the relative size of the volatility of economy-wide labor income innovations, $\sigma_{\tau}^{2}$, compared

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33 We do not report any numerical results for the case of altruism. While altruism may under certain parameter settings also increase individuals’ precautionary saving, such increases are on a significantly smaller scale than those induced by jealousy as reported below.
to the volatility of individual-specific labor income innovations, $\sigma^2_\xi$, but not their absolute values.

Table 3a considers the case where individuals’ degrees of risk aversion and their jealousy motives are homogeneous within peer groups (and thus all individuals decide upon the same amount of precautionary saving). We set $\kappa_{ih} = 0.05$, $i = 1, 2, 3$, and consider the two cases where $\sigma_\xi = \sigma_v$ and where $\sigma_\xi = 2\sigma_v$.

The results in Table 3a clearly show that jealousy can increase individuals’ precautionary saving quite dramatically. Precautionary saving is increasing both in the degree of individuals’ preference for jealousy and in the size of the volatility of individual-specific labor income innovations relative to the volatility of economy-wide labor income innovations.

Table 3b considers the case where there is heterogeneity in individuals’ preferences for jealousy and possibly also their degrees of risk aversion (and thus individuals decide upon different amounts of precautionary saving). We set $\tau_{1h} = -0.25$, $\tau_{2h} = -0.5$, $\tau_{3h} = -0.75$, and again consider the two cases where $\sigma_\xi = \sigma_v$ and where $\sigma_\xi = 2\sigma_v$.

Table 3b shows that for given degrees of jealousy, relatively modest heterogeneity in individuals’ degrees of risk aversion can have sizable effects on individuals’ precautionary saving. In particular, an individual who is less jealous but more risk averse than his peers will decrease his precautionary saving as compared to when his peers’ degrees of risk aversion are the same as his, and an individual who is more jealous but less risk averse than his peers will increase his precautionary saving as compared to when his peers’ degrees of risk aversion are the same as his.

5. Aggregate implications

We now consider the implications of social interactions for the time-series properties of aggregate consumption series. The empirical literature examining aggregate (U.S.) consumption data has focussed on the following two predictions of the permanent income hypothesis:

(i) Changes in current-period consumption should vary closely with the innovations in labor income, unless permanent income is significantly smoother than current labor income.
(ii) Changes in consumption should not respond to anticipated changes in labor income.

The general consensus in the literature is that in both these respects the permanent income hypothesis is rejected. In contrast to the prediction under (i), changes in current-period aggregate consumption are less than proportionately
related to unanticipated changes in current-period aggregate labor income, even if permanent labor income is not significantly smoother than current labor income (excess smoothness). Furthermore, changes in aggregate consumption do respond to anticipated changes in aggregate labor income (excess sensitivity). Various modifications of the permanent income hypothesis have been suggested in the literature that can help address these puzzles. Among these are habit formation (for example, Muellbauer, 1988), borrowing constraints (for example, Deaton, 1991), aggregation with finite lifetimes (for example, Clarida, 1991), and aggregation with imperfect information about the composition of labor income (for example, Pischke, 1995). In this section we show that social interactions, when combined with habit formation, can significantly strengthen the effects of habit formation in the direction of resolving the excess smoothness and excess sensitivity puzzles. To simplify the exposition and to focus on the implications of the life-cycle model with endogenous taste change, we assume that information is homogeneous and set $\rho_{ih} = r$, for all $i, h$.35

5.1. An error correction representation

The economy-wide time-series implications of the life-cycle model under the quadratic current-period utility functions (14) and (15), and difference stationary (log) labor income, (3), are perhaps best understood by examining an error correction representation of the decision rule for economy-wide average consumption.36 Consider first the homogeneous parameter case where there is habit formation (but no social interactions), with $\eta_{ih} = \eta$, for all $i, h$. Lagging the economy-wide current-period decision rule for this case one period, subtracting the resultant expression from the economy-wide current-period decision rule, and noting that $\Delta A_{t-1} = y_{t-1}^d - c_{t-1}$, where $y_{t}^d = rA_{t-1} + y_{t}$ denotes economy-wide average disposable labor income at the beginning of period $t$, one

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34 There is also a growing literature testing the predictions of the permanent income hypothesis for individuals’ consumption changes in response to anticipated changes in their labor income. For a survey of this literature see, for example, Browning and Lusardi (1996). As of yet, there appears to be no broad consensus as to whether there is an excess sensitivity puzzle at the individual level. But it is worth noting that our model’s predictions are consistent with consumption responding to anticipated changes in labor income at the economy-wide level even if the consumption decisions of many individuals in the economy are not responsive to such changes in labor income and are thus consistent with the implications of the permanent income hypothesis in this regard.

35 Similar results can also be obtained under the negative exponential current-period utility specification (16), once the variance processes of $\epsilon_t$ and $\tilde{\epsilon}_{mi}$ are allowed to be time varying. (See Caballero, 1990, who discusses this issue for the case of self-centered individuals.)

36 The economy-wide average consumption decisions can be obtained by aggregating the individual-specific consumption decisions derived in Section 3 using (1) and (2).
obtains\(^{37}\)

\[
\Delta c_t = \left(\frac{\eta}{1 + r}\right)\Delta c_{t-1} - \left(\frac{r(1 + r - \eta)}{1 + r}\right)(c_{t-1} - y^d_{t-1})
+ \left(\frac{r(1 + r - \eta)}{(1 + r)(r - g)}\right)\Delta y_t,
\]

(59)

where \(g\) is the expected rate of growth of economy-wide average labor income, \(g = \exp(\mu + \sigma^2_r/2) - 1\). Note that (59) implies that the larger the habit coefficient \(\eta\), the smaller the change in consumption in the current period due to deviations of consumption from disposable income in the previous period and due to (unanticipated and anticipated) current-period changes in labor income. In other words, the larger \(\eta\), the smoother economy-wide average consumption will be, and the excess sensitivity is likely to be less of a problem. When the parameters \(\eta_{ih}\) and \(\gamma_{ih}\) and the initial endowments \(A_{ih,t-1}\) differ across individuals, the cross-sectional aggregation of the resultant heterogeneous error correction decision rules will be difficult and in general does not result in a finite-order aggregate error correction model.\(^{38}\) We use the functional form of (59) to measure how much the addition of social interactions to a life-cycle model with habit formation may add to the smoothness of economy-wide average consumption by inspecting the size of the coefficients in a regression of stochastically simulated aggregate time series of \(\Delta c_t/y_{t-1}\) on simulated time series of \(\Delta c_{t-1}/y_{t-1}, (c_{t-1} - y^d_{t-1})/y_{t-1}\), and \(\Delta y_t/y_{t-1}\), respectively.

For simplicity, we consider numerical experiments based on an economy with a large number of peer groups of size three \((N_h = 3)\) that are homogeneous with respect to the preference parameters.\(^{39}\) The preference parameters within peer groups, however, are allowed to differ. In all the numerical experiments time is taken to be measured in quarters. We also set \(r = (1.03)^{0.25} - 1, g = 0.02, \sigma_x = \sigma_z = 0.001, \) and let \(A_{ih,t-1} = 100, i = 1, 2, 3, \) and \(y_{ih,t} = 100\exp(\xi_{ih,t}), i = 1, 2, 3.\(^{40}\) To measure the increase in the smoothness of economy-wide average consumption implied by allowing for both habit formation and jealousy, we generate simulated economy-wide average consumption and wealth series under the permanent income hypothesis, under the life-cycle model with habit

\(^{37}\)See Pesaran (1992) for a similar error correction representation for the case of the permanent income hypothesis.

\(^{38}\)See Pesaran (1999) for a discussion of cross-sectional aggregation of linear dynamic models.

\(^{39}\)For brevity’s sake, we focus on the case of jealousy in this section. The numerical results both for the case of conformism and for the case of altruism are discussed in a note available from the authors upon request.

\(^{40}\)We experimented with other values of \(\sigma_x, \sigma_z, \) and \(\sigma_v\), but found that our results are robust to small changes in these parameters.
formation alone, and under the life-cycle model with both habit formation and jealousy. We consider two parameter settings:

Scenario 1:
\[
\eta_{1h} = 0.95, \ \eta_{2h} = 0.50, \ \eta_{3h} = 0.05, \ \tau_{1h} = -0.05, \\
\tau_{2h} = -0.50, \ \tau_{3h} = -0.95, \ \omega_{1h} = \frac{1}{3}, \ \ i = 1, 2, 3,
\]

Scenario 2:
\[
\eta_{1h} = 0.95, \ \eta_{2h} = 0.50, \ \eta_{3h} = 0.05, \ \tau_{1h} = -0.05, \ \tau_{2h} = -0.50, \\
\tau_{3h} = -0.95, \ \omega_{1h} = \frac{4}{5}, \ \omega_{2h} = \frac{1}{4}h, \ \text{and} \ \omega_{3h} = \frac{1}{4}h.
\]

Scenario 2 represents a more heterogeneous parameter configuration as compared to Scenario 1, in that it allows for different weights assigned to the individuals in each peer group, with the individual who values habit formation most strongly and is least jealous having the largest weight. For both scenarios, we average across 500 peer groups to generate time series of length 150 observations, but base our analysis only on the last 125 observations, dropping the first 25 observations to avoid dependence of our results on the choice of initial conditions. We then estimate the aggregate error correction regressions

\[
\frac{\Delta c_i}{y_{i-1}} = b_1 \left( \frac{\Delta c_{i-1}}{y_{i-1}} \right) - b_2 \left( \frac{c_{i-1} - y_{i-1}^d}{y_{i-1}} \right) + b_3 \left( \frac{\Delta y_i}{y_{i-1}} \right) + u_i,
\]

where we have deflated both sides of the error correction specification (59) by \(y_{i-1}\) to ensure that all the variables in the regression equation are stationary. Recall that since \(y_i\) is assumed to follow a geometric random walk, \(\Delta y_i\) will not be stationary. We find that for all models this regression has a close to perfect fit, which is to be expected considering that the only source of parameter heterogeneity is within groups. Nevertheless, these regressions provide information on how the magnitudes of the coefficients vary under the different model specifications, namely the permanent income hypothesis, the life-cycle model with habit formation only, and the life-cycle model allowing both for habit formation and for jealousy.\(^{41}\)

Table 4 clearly shows that under both scenarios, the time path of economy-wide average consumption is smoothest under the life-cycle model with both habit formation and jealousy, as both the error correction coefficient, \(b_2\), and the coefficient on the actual labor income change, \(b_3\), significantly decrease in size when habit formation is augmented with jealousy. A comparison of the results

---

\(^{41}\) Besides checking the goodness of fit, we also verified that the estimated coefficients in those cases where perfect aggregation is possible are close to their true values. For example, under the permanent income hypothesis, the implied true value of \(b_3\) under both scenarios is \(r/(r - g) = 3.0223\), as compared to the estimated value of 3.0251 given in the first column of Table 4.
Table 4
Smoothness of economy-wide average consumption under the permanent income hypothesis, under the life-cycle model with habit formation, and under the life-cycle model with both habit formation and jealousy:

\[
\Delta c_t = b_1 \left( \frac{\Delta c_{t-1}}{y_{t-1}} \right) - b_2 \left( \frac{c_{t-1} - y_{t-1}}{y_{t-1}} \right) + b_3 \left( \frac{\Delta y_t}{y_{t-1}} \right) + u_t
\]

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Permanent income hypothesis</th>
<th>Habit formation</th>
<th>Habit formation and jealousy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>( b_1 ) = 0.0020, (0.0036)</td>
<td>( b_2 ) = 0.0074, (0.0000)</td>
<td>( b_3 ) = 3.0251, (0.0108)</td>
</tr>
<tr>
<td></td>
<td>0.2676, (0.0113)</td>
<td>0.0037, (0.0000)</td>
<td>1.5126, (0.0178)</td>
</tr>
<tr>
<td></td>
<td>0.4358, (0.0168)</td>
<td>0.0024, (0.0000)</td>
<td>1.0091, (0.0193)</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>( b_1 ) = 0.0020, (0.0036)</td>
<td>( b_2 ) = 0.0074, (0.0000)</td>
<td>( b_3 ) = 3.0251, (0.0108)</td>
</tr>
<tr>
<td></td>
<td>0.2676, (0.0113)</td>
<td>0.0037, (0.0000)</td>
<td>1.5126, (0.0178)</td>
</tr>
<tr>
<td></td>
<td>0.6199, (0.0169)</td>
<td>0.0017, (0.0000)</td>
<td>0.6982, (0.0156)</td>
</tr>
</tbody>
</table>

*Parameter estimates and standard errors (in brackets).

obtained under the two scenarios also suggests that the degree of smoothness is increasing in the degree of heterogeneity of the peer groups, in particular the weights \( \omega_{ih} \) attached by individuals to the consumption decisions and lifetime resources of others in their peer group.

5.2. Excess smoothness

To shed light on how a life-cycle model with habit formation and jealousy may overcome the excess smoothness puzzle, consider first the implications of a life-cycle model with habit formation only for the excess smoothness puzzle. At the economy-wide level, an econometrician using aggregate data only will measure the effect of an unanticipated increase in period \( t \) economy-wide average labor income of size \( \zeta_0 \) on economy-wide average consumption in period \( t \) as \( q(0) = \text{E}(c_t | y_t = \zeta_0, \Psi_{t-1}) - \text{E}(c_t | \Psi_{t-1}) \), where \( q_t = y_t - \text{E}(y_t | \Psi_{t-1}) \).

Let us consider the case where \( \zeta_0 = 1 \). Under the permanent income hypothesis it is then readily verified that \( q(0) = r/(r - g) \). Under habit formation, with \( \eta_{ih} = \eta \), for all \( i, h \), \( q(0) = [(r(1 + r - \eta))]/[(r - g)(1 + r)] \), and \( q(0) \) is therefore...
monotonically declining in the size of $\eta$. The higher the degree of habit formation, the smaller the effect of an unanticipated increase in period $t$ labor income on consumption in period $t$. Also note that whether consumption is smoother than labor income and, if so, by how much, depends on the relative size of the expected growth rate of labor income, $g$, and the preference for habit formation, $\eta$. Using these insights about the optimal economy-wide average consumption decisions under habit formation only, we can now turn to the implications of the life-cycle model in the presence of both habit formation and jealousy. From (36) (with $\gamma_{th}$ given by (32)), it can be seen that when the $\eta_{th}$'s differ across the individuals in the peer groups, jealousy may act so as to strengthen the habit motive (either through the coefficients on the individual’s own lagged consumption levels and his own lifetime resources, or through the coefficients on all other individuals’ lagged consumption levels and their lifetime resources). A life-cycle model with both habit formation and jealousy may therefore resolve the excess smoothness puzzle more readily than a life-cycle model with habit formation only.

In this subsection we measure the degree of consumption smoothing along the lines carried out in the empirical literature on the excess smoothness puzzle, namely by measuring the effect of an unanticipated increase in period $t$ economy-wide average labor income of size $q_t = \zeta_0$ on economy-wide average consumption in period $t + s$,

$$q(s) = E(c_{t+s}|q_t = \zeta_0, \Psi_{t-1}) - E(c_{t+s}|\Psi_{t-1}), \quad s = 0, 1, \ldots,$$

where we consider $\zeta_0 = 1$.\footnote{It may be worth noting that $q(s)$ defined by (63) is a generalized impulse response function for the change in consumption with respect to a shock in labor income of size $\zeta_0$. (The non-linearity arises due to the geometric random walk specification of labor income (3).) See Koop et al. (1996) for a detailed discussion of impulse response analysis in non-linear models.} This effect can be readily computed analytically even in the presence of habit formation and jealousy, as well as parameter heterogeneity. To do so, stack $c_{ih,t+s}$ and $A_{ih,t+s}$ for all (three) individuals in peer group $h$ in a first-order system with the forcing variable $y_{t+s}$:

$$x_{h,t+s} = M_{1h}x_{h,t+s-1} + M_{2h}y_{t+s},$$

where $x_{h,t+s} = (c_{1h,t+s}, c_{2h,t+s}, c_{3h,t+s}, A_{1h,t+s}, A_{2h,t+s}, A_{3h,t+s})'$, and the coefficient matrices $M_{1h}$ and $M_{2h}$ directly follow from the decision rules (27) and the period-by-period budget constraints (12). Then it is readily verified that

$$E(x_{h,t+s}|q_t = \zeta_0, \Psi_{t-1}) - E(x_{h,t+s}|\Psi_{t-1})$$

$$= \sum_{l=0}^{s} M_{1h}^{-1}M_{2h}[E(y_{t+l}|q_t = \zeta_0, \Psi_{t-1}) - E(y_{t+l}|\Psi_{t-1})].$$
Averaging across the first three elements on the left-hand side of the above expression, the change in average consumption in peer group $h$ for period $t + s$ is computed. All that remains is to average across all peer groups.

Table 5a illustrates how jealousy can strengthen the effect of habit formation in the direction of reducing the size of the increase in economy-wide average consumption resulting from an unanticipated increase of economy-wide average labor income. For purposes of comparison, it is worth noting that in the absence of habit formation and jealousy (namely under the permanent income hypothesis) the increase in economy-wide average consumption with $g = 0.005$ is more than three times larger than the initial increase in economy-wide average labor income. The extent to which habit formation and jealousy result in a smaller initial increase in economy-wide average consumption critically depends on the expected growth rate of labor income. This is illustrated in Table 5b where for the purpose of comparison with much of the empirical literature on the excess smoothness puzzle we have carried out the computations with $g = 0$. Recall that under the permanent income hypothesis, the response coefficient of economy-wide average consumption with respect to a unit unanticipated increase in economy-wide average labor income is unity. Finally, from both Table 5a and b it is also clear that the extent to which jealousy helps to resolve the excess smoothness puzzle also depends on the degree of heterogeneity of individuals’ preference for habit formation, on the degree of heterogeneity of their preference for jealousy, and on the disparity of the weights $\omega_{ih}$ across the members of the peer group.

For the parameter configuration $\eta_{1h} = 0.95$, $\eta_{2h} = 0.50$, $\eta_{3h} = 0.05$, $\tau_{1h} = -0.05$, $\tau_{2h} = -0.50$, $\tau_{3h} = -0.95$, $\omega_{1h} = \frac{3}{5}$, $\omega_{2h} = \frac{3}{10}$, $\omega_{3h} = 1/10$, $\zeta_0 = 1$, and $g = 0$ the dynamics of the adjustment of economy-wide average consumption in response to an unanticipated increase in economy-wide average labor income measured by the impulse responses $q(s) = E(c_{t+s}|Q_t = \zeta_0, \Psi_{t-1}) - E(c_{t+s}|\Psi_{t-1})$, $s = 0, 1, \ldots, 100$, are shown in Fig. 1. The figure displays the impulse response profiles for the permanent income hypothesis, the life-cycle model with habit formation, and the life-cycle model with both habit formation and jealousy. Under habit formation alone and under joint habit formation and jealousy it takes more than nine years for the economy-wide average consumption to fully adjust to the initial increase in economy-wide average labor income. The adjustment path under joint habit formation and jealousy trails that under habit formation alone until after the size of the increase in economy-wide average consumption has begun to exceed the initial increase in economy-wide average labor income.

5.3. Excess sensitivity

The decision rule for economy-wide average consumption under $\eta_{ih} = \eta$ and $\tau_{ih} = 0$ for all $i, h$, that is, homogeneous habit formation and no jealousy
Table 5
Change in economy-wide average current-period consumption in response to an unanticipated increase of economy-wide average current-period labor income

<table>
<thead>
<tr>
<th>Habit formation, no jealousy</th>
<th>Habit formation and jealousy</th>
<th>Habit formation and jealousy</th>
<th>Habit formation and jealousy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_{ih} = 0, i = 1, 2, 3$</td>
<td>$\tau_{ih} = -0.25, i = 1, 2, 3$</td>
<td>$\tau_{ih} = -0.25, \tau_{2h} = -0.50, \tau_{3h} = -0.75$</td>
<td>$\tau_{ih} = -0.05, \tau_{2h} = -0.50, \tau_{3h} = -0.95$</td>
</tr>
<tr>
<td>$\eta_{1h} = 0.75, \eta_{2h} = 0.50, \eta_{3h} = 0.25; \omega_{ih} = 1/3, i = 1, 2, 3$</td>
<td>1.5223</td>
<td>1.5223</td>
<td>1.3632</td>
</tr>
<tr>
<td>$\eta_{1h} = 0.95, \eta_{2h} = 0.50, \eta_{3h} = 0.05; \omega_{ih} = 1/3, i = 1, 2, 3$</td>
<td>1.5223</td>
<td>1.5223</td>
<td>1.2359</td>
</tr>
<tr>
<td>$\eta_{1h} = 0.95, \eta_{2h} = 0.50, \eta_{3h} = 0.05; \omega_{1h} = 3/5, \omega_{2h} = 3/10, \omega_{3h} = 1/10$</td>
<td>1.5223</td>
<td>1.3642</td>
<td>0.9074</td>
</tr>
</tbody>
</table>

(b) $\zeta_0 = 1, g = 0$

<table>
<thead>
<tr>
<th>Habit formation, no jealousy</th>
<th>Habit formation and jealousy</th>
<th>Habit formation and jealousy</th>
<th>Habit formation and jealousy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_{ih} = 0, i = 1, 2, 3$</td>
<td>$\tau_{ih} = -0.25, i = 1, 2, 3$</td>
<td>$\tau_{ih} = -0.25, \tau_{2h} = -0.50, \tau_{3h} = -0.75$</td>
<td>$\tau_{ih} = -0.05, \tau_{2h} = -0.50, \tau_{3h} = -0.95$</td>
</tr>
<tr>
<td>$\eta_{1h} = 0.75, \eta_{2h} = 0.50, \eta_{3h} = 0.25; \omega_{ih} = 1/3, i = 1, 2, 3$</td>
<td>0.5037</td>
<td>0.5037</td>
<td>0.4510</td>
</tr>
<tr>
<td>$\eta_{1h} = 0.95, \eta_{2h} = 0.50, \eta_{3h} = 0.05; \omega_{ih} = 1/3, i = 1, 2, 3$</td>
<td>0.5037</td>
<td>0.5037</td>
<td>0.4089</td>
</tr>
<tr>
<td>$\eta_{1h} = 0.95, \eta_{2h} = 0.50, \eta_{3h} = 0.05; \omega_{1h} = 3/5, \omega_{2h} = 3/10, \omega_{3h} = 1/10$</td>
<td>0.5037</td>
<td>0.4472</td>
<td>0.3003</td>
</tr>
</tbody>
</table>
is given by

\[
c_t = \left( \frac{\eta}{1 + r} \right) c_{t-1} + \left( \frac{r(1 + r - \eta)}{1 + r} \right) A_{t-1} \\
+ \left( \frac{r(1 + r - \eta)}{(1 + r)^2} \right) \left( \sum_{s=0}^{\infty} \frac{E(y_{t+s} | \Psi_t)}{(1 + r)^s} \right)
\] (66)

Taking conditional expectations of (66) with respect to \( \Psi_{t-1} \) and subtracting the resultant expression from (66), also noting the Euler equation condition \( E(c_t | \Psi_{t-1}) = c_{t-1} + \eta \Delta c_{t-1} \), yields

\[
\Delta c_t = \eta \Delta c_{t-1} + \pi [y_t - E(y_t | \Psi_{t-1})],
\] (67)

\footnote{In deriving (66) once again we are assuming that only aggregate observations are included in the information set available to the econometrician.}
where \( \pi = [r(1 + r - \eta)]/[(1 + r)(r - g)] \). Since \( 0 \leq \eta < 1 \), and noting that \( E(y_t | \Psi_{t-1}) = (1 + g)y_{t-1} \), (67) can be rewritten as

\[
\Delta c_t = \pi [y_t - E(y_t | \Psi_{t-1})] + \pi \sum_{s=1}^{\infty} \eta^{s} (\Delta y_{t+s} - g y_{t+s-1} - 1).
\]

(68)

Dividing on both sides of (68) by \( y_{t-1} \), collecting terms in \( \Delta y_{t-s} \), and truncating the infinite sum, one obtains

\[
\frac{\Delta c_t}{y_{t-1}} = \pi \left( \frac{y_t - E(y_t | \Psi_{t-1})}{y_{t-1}} \right) + \pi \eta \left( \frac{\Delta y_{t-1}}{y_{t-1}} \right) + \pi \eta (\eta - g) \left( \frac{\Delta y_{t-2}}{y_{t-1}} \right)

+ \pi \eta [\eta^2 - g(1 + \eta)] \left( \frac{\Delta y_{t-3}}{y_{t-1}} \right)

+ \pi \eta [\eta^3 - g(1 + \eta + \eta^2)] \left( \frac{\Delta y_{t-4}}{y_{t-1}} \right).
\]

(69)

Thus, if one estimates a regression of \( \Delta c_t/y_{t-1} \) on an intercept, \( [y_t - E(y_t | \Psi_{t-1})]/y_{t-1} \), \( \Delta y_{t-1}/y_{t-1} \), \( \Delta y_{t-2}/y_{t-1} \), \( \Delta y_{t-3}/y_{t-1} \), and \( \Delta y_{t-4}/y_{t-1} \), the coefficients on the lagged actual labor income changes will be non-zero, the coefficients reflecting the gradual adjustment to unanticipated changes in labor income implied by the coefficients on \( y_t - E(y_t | \Psi_{t-1}) \) and \( \Delta c_{t-1} \) in (67). Note that under the permanent income hypothesis \( \eta = 0 \), and thus all the coefficients on the (normalized) lagged actual labor income changes are predicted to be zero. Using this insight, excess sensitivity has been measured in the empirical literature by inspecting the coefficients on the lagged actual labor income changes in a regression of \( \Delta c_t/y_{t-1} \) on an intercept, \( [y_t - E(y_t | \Psi_{t-1})]/y_{t-1} \), \( \Delta y_{t-1}/y_{t-1} \), \( \Delta y_{t-2}/y_{t-1} \), \( \Delta y_{t-3}/y_{t-1} \), and \( \Delta y_{t-4}/y_{t-1} \).44 Using this understanding of the economy-wide average optimal consumption decisions under habit formation only, we can now turn to the implications of the simultaneous presence of both habit formation and jealousy. As we had discussed above, if there is heterogeneity in the degrees of preference for habit formation, \( \eta_{jh} \), among the individuals in the peer groups, jealousy may act so as to strengthen the habit motive. A life-cycle model with both habit formation and jealousy may then more readily resolve the excess sensitivity puzzle than a life-cycle model with habit formation only.

To examine the extent to which habit formation and jealousy may combine to overcome the excess sensitivity puzzle, we generate simulated economy-wide average consumption series under the permanent income hypothesis, under habit formation alone, and under both habit formation and jealousy, and then use these simulated series to estimate the excess sensitivity regression (69). We

44 Higher-order lags of actual labor income changes may, of course, also be included.
again consider the two scenarios already used for Table 4, (60) and (61). For both scenarios, we average across 500 peer groups to generate time series of length 150 observations, but base our analysis only on the last 125 observations, dropping the first 25 observations to avoid dependence of our results on the choice of initial conditions. We then estimate the regression

$$\frac{\Delta c_t}{y_{t-1}} = b_0 + b_1 \left( \frac{y_t - E(y_t | \Psi_{t-1})}{y_{t-1}} \right) + b_2 \left( \frac{\Delta y_{t-1}}{y_{t-1}} \right) + b_3 \left( \frac{\Delta y_{t-2}}{y_{t-1}} \right) + b_4 \left( \frac{\Delta y_{t-3}}{y_{t-1}} \right) + b_5 \left( \frac{\Delta y_{t-4}}{y_{t-1}} \right) + u_t,$$

(70)

Table 6
Excess sensitivity of economy-wide average consumption under the permanent income hypothesis, habit formation, and habit formation and jealousy

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Permanent income hypothesis</th>
<th>Habit formation</th>
<th>Habit formation and jealousy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b_1$</td>
<td>3.0223</td>
<td>1.5218</td>
<td>1.0185</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1877)$</td>
<td>$(0.0210)$</td>
<td>$(0.0329)$</td>
</tr>
<tr>
<td>$b_2$</td>
<td>$10^{-5} \times 0.0680$</td>
<td>0.3674</td>
<td>0.3662</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1930)$</td>
<td>$(0.0216)$</td>
<td>$(0.0338)$</td>
</tr>
<tr>
<td>$b_3$</td>
<td>$-10^{-5} \times 0.1632$</td>
<td>0.1754</td>
<td>0.1955</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1909)$</td>
<td>$(0.0213)$</td>
<td>$(0.0335)$</td>
</tr>
<tr>
<td>$b_4$</td>
<td>$-10^{-5} \times 0.0680$</td>
<td>0.1102</td>
<td>0.1346</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1943)$</td>
<td>$(0.0217)$</td>
<td>$(0.0340)$</td>
</tr>
<tr>
<td>$b_5$</td>
<td>$-10^{-5} \times 0.1484$</td>
<td>0.0654</td>
<td>0.0833</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1922)$</td>
<td>$(0.0215)$</td>
<td>$(0.0337)$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 2</th>
<th>Permanent income hypothesis</th>
<th>Habit formation</th>
<th>Habit formation and jealousy</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b_1$</td>
<td>3.0223</td>
<td>1.5218</td>
<td>0.7048</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1877)$</td>
<td>$(0.0210)$</td>
<td>$(0.0408)$</td>
</tr>
<tr>
<td>$b_2$</td>
<td>$10^{-5} \times 0.0680$</td>
<td>0.3674</td>
<td>0.3547</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1930)$</td>
<td>$(0.0216)$</td>
<td>$(0.0420)$</td>
</tr>
<tr>
<td>$b_3$</td>
<td>$-10^{-5} \times 0.1632$</td>
<td>0.1754</td>
<td>0.2028</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1909)$</td>
<td>$(0.0213)$</td>
<td>$(0.0415)$</td>
</tr>
<tr>
<td>$b_4$</td>
<td>$-10^{-5} \times 0.0680$</td>
<td>0.1102</td>
<td>0.1477</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1943)$</td>
<td>$(0.0217)$</td>
<td>$(0.0423)$</td>
</tr>
<tr>
<td>$b_5$</td>
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<td>0.0654</td>
<td>0.0938</td>
</tr>
<tr>
<td></td>
<td>$(10^{-5} \times 0.1922)$</td>
<td>$(0.0215)$</td>
<td>$(0.0418)$</td>
</tr>
</tbody>
</table>

*Parameter estimates and standard errors (in brackets).
where we again divide all variables by $y_{t-1}$ to ensure that all the variables are stationary. Note that this regression is misspecified except under the permanent income hypothesis, where the regression fits perfectly.

Table 6 indicates that habit formation and jealousy combined may overcome the excess sensitivity puzzle more readily than habit formation alone. The sensitivity of the current-period change in economy-wide average consumption to lagged changes in economy-wide average labor income is highest under both habit formation and jealousy, and is increasing in the degree of heterogeneity of the peer groups, in particular the weights $\omega_{ih}$ attached by individuals to the consumption and lifetime resources of others in their peer group.

6. Conclusion

In this paper we have studied within the framework of a life-cycle model the implications of a number of different forms of social interactions, namely conformism, altruism, and jealousy, for the optimal consumption decisions in an economy made up of peer groups. We have derived the individual-specific optimal consumption decisions and their economy-wide counterparts both under homogeneous and disparate information, and also allowing for the potential presence of habit formation and prudence.

We have shown that whether social interactions affect an individual’s optimal consumption decisions critically depends on intertemporal rather than static considerations. This is true regardless of whether individuals’ preferences are time separable or exhibit habit formation, and of whether information within peer groups is homogeneous or disparate. If individuals decide to adjust their consumption decisions to account for the consumption decisions of their peers, then they do so by adjusting their lifetime consumption profiles to correspond more closely to their peers’ lifetime consumption profiles. This implies that it is important to analyze the effects of social interactions in an intertemporal rather than static setting.

We have also shown that social interactions, when coupled with either habit formation or prudence, can have important aggregate implications, and can help to overcome two well known puzzles associated with the permanent income hypothesis: At the economy-wide level, social interactions can help to quantitatively explain why consumption is significantly smoother than labor income even if individuals’ (log) labor income is difference stationary. Furthermore, social interactions can also help to quantitatively explain why, at the economy-wide level, consumption is rather sensitive to anticipated changes in labor income.

We have not attempted in this paper to disentangle the empirical roles of different modifications of the permanent income hypothesis in resolving the excess smoothness and excess sensitivity puzzles. For such work, the functional
forms for current-period utility that we have employed in this paper (quadratic and negative exponential) in order to obtain analytical insights into the effects of social interactions on life-cycle consumption will be unsatisfactory. However, we conjecture that many of our results will be qualitatively robust to CRRA-specifications of current-period utility.

Acknowledgements

We are grateful to Harald Uhlig for helpful comments, and to the European Commission for financial support under Grant ERBFMBICT 983303.

Mathematical appendix.

Proof of Proposition 1. The Euler equation for individual $i$ in peer group $h$ for the life-cycle model (11) and (12) under the utility specifications (14) and (15) is given by (20), which under homogenous information can be rewritten as

$$z_{ih} - \beta_{ih}(1 + r + \eta_{ih})E(z_{ih,t+1} | \Omega_t) + \beta_{ih}^2(1 + r)\eta_{ih}E(z_{ih,t+2} | \Omega_t) = 0, \quad (A.1)$$

where

$$z_{ih} = (1 + \theta_{ih})(c_{ih} - \eta_{ih}c_{ih,t-1}) - \eta_{ih}\tilde{c}_{ht,-i} - \eta_{ih}\tilde{c}_{ht-1,-i} - c_{ih}. \quad (A.2)$$

Note that (A.1) is a fourth-order difference equation under rational expectations in $c_{ih}$, $i = 1, 2, \ldots, N_h$. Ruling out explosive solutions, (A.1) can be reduced to a second-order rational expectations equation in $c_{ih}$, $i = 1, 2, \ldots, N_h$. To see this, define the expectations revision process

$$\tilde{c}_{ih} = E(z_{ih,t+s} | \Omega_t) - E(z_{ih,t+s} | \Omega_{t-1}), \quad (A.3)$$

and use it in (A.1) to obtain

$$\beta_{ih}^2(1 + r)\eta_{ih}z_{ih,t+2} - \beta_{ih}(1 + r + \eta_{ih})z_{ih,t+1} + z_{ih} = \tilde{c}_{ih}, \quad (A.4)$$

where $\tilde{c}_{ih}$ is a martingale difference process defined by

$$\tilde{c}_{ih} = \beta_{ih}(1 + r)\eta_{ih}\tilde{c}_{ih,t+2}^0 + \beta_{ih}^2(1 + r)\eta_{ih}\tilde{c}_{ih,t+1}^1 - \beta_{ih}(1 + r + \eta_{ih})\tilde{c}_{ih,t+1}^0. \quad (A.5)$$

The roots of the characteristic equation associated with (A.4) are given by $1/(\beta_{ih}\eta_{ih})$, and $1/[\beta_{ih}(1 + r)]$. By assumption the former root falls outside the unit circle, and can be readily shown to result in explosive individual-specific consumption decisions. Writing the left-hand side of (A.4) as

$$[\beta_{ih}^2(1 + r)\eta_{ih}F - \beta_{ih}(1 + r + \eta_{ih}) + F^{-1}]z_{ih,t+1}, \quad (A.6)$$
where $F$ denotes the forward operator, and factorizing the resultant operator so that
\begin{equation}
(\beta_{ih}(1 + r) - F^{-1})(1 - \beta_{ih}\eta_{ih}F)z_{ih,t+1} = 0,
\end{equation}
it follows that for the individual-specific optimal consumption decisions to be non-explosive, we must have:
\begin{equation}
\left(\frac{1}{1 - \beta_{ih}\eta_{ih}F}\right)\tilde{z}_{ih} = \beta_{ih}(1 + r)c_{ih,t+1}^0.
\end{equation}
Under (A.8), we therefore need to solve
\begin{equation}
z_{ih} = \beta_{ih}(1 + r)E(z_{ih,t+1}|\Omega_t),
\end{equation}
subject to the budget constraint (12), $\forall i$. Using (A.2) and substituting for $z_{ih}$ in terms of $c_{ih}$ and $\tilde{c}_{ih,i}$, we have
\begin{equation}
c_{ih} = \left(\frac{\eta_{ih}}{1 + \beta_{ih}(1 + r)\eta_{ih}}\right)c_{ih,t-1} + \left(\frac{\beta_{ih}(1 + r)}{1 + \beta_{ih}(1 + r)\eta_{ih}}\right)E(c_{ih,t+1}|\Omega_t) + x_{ih},
\end{equation}
for $i = 1, 2, \ldots, N_h$, where
\begin{equation}
x_{ih} = \left(\frac{\gamma_{ih}}{1 - \omega_{ih}\gamma_{ih}}\right)(\tilde{c}_{ih,-i} - \left(\frac{\eta_{ih}}{1 + \beta_{ih}(1 + r)\eta_{ih}}\right)\tilde{c}_{ih,-1,i} - \left(\frac{\beta_{ih}(1 + r)}{1 + \beta_{ih}(1 + r)\eta_{ih}}\right)E(\tilde{c}_{ih+1,-1,i}|\Omega_t) + \left(\frac{\beta_{ih}(1 + r)}{1 + \beta_{ih}(1 + r)\eta_{ih}}\right)\frac{\delta_{ih}}{1 - \omega_{ih}\gamma_{ih}}).
\end{equation}
To solve the Euler equation (A.10) of individual $i$, we shall proceed in two steps. In the first step, we take the profiles $\{c_{jht}\}$ as given for all $j \neq i$, $j = 1, 2, \ldots, N_h$, and eliminate the future expectations $E(c_{ih,t+1}|\Omega_t)$ and $E(\tilde{c}_{ih,t+1,i}|\Omega_t)$ using the lifetime budget constraints of all individuals in the peer group. We then obtain $c_{ih}$ as a function of $c_{jht}$, $j = 1, 2, \ldots, N_h$, $j \neq i$, of $c_{jht-1}$, $j = 1, 2, \ldots, N_h$, and of the expected present discounted values of total lifetime resources of all individuals, $E(L_{jht}|\Omega_t)$, $j = 1, 2, \ldots, N_h$. (See (A.26) below.) Stacking this latter equation for all $i, i = 1, 2, \ldots, N_h$, the resulting equation system under homogeneous information can be readily solved for $c_{ih}$ as a function of $c_{jht-1}$ and $E(L_{jht}|\Omega_t)$, $j = 1, 2, \ldots, N_h$, for all $i = 1, 2, \ldots, N_h$.
Taking the profiles $\{c_{jht}\}$ as given for all $j \neq i$, $j = 1, 2, \ldots, N_h$, consider the quasi-difference transformation
\begin{equation}
m_{ih} = c_{ih} - d_{ih}c_{ih,t-1},
\end{equation}
\footnote{Related factorizations have been used, for example, by Muellbauer (1988) and Deaton (1992).}
\footnote{See, for example, Binder and Pesaran (1997) for a detailed discussion of the use of this quasi-difference transformation for the solution of linear rational expectations models.
where $a_{ih}$ is any root of the quadratic equation (associated with (A.10))

$$
\left( \frac{\beta_{ih}(1 + r)}{1 + \beta_{ih}(1 + r)\eta_{ih}} \right) a_{ih}^2 - a_{ih} + \left( \frac{\eta_{ih}}{1 + \beta_{ih}(1 + r)\eta_{ih}} \right) = 0
$$

(A.13)

that falls inside the unit circle. Applying this transformation to (A.10), one obtains

$$
E(m_{ih,t+1} | \Omega_t) = d_{ih}(m_{ih,t} - \tilde{x}_{ht,-i}),
$$

(A.14)

with $d_{ih}$ defined as

$$
d_{ih} = \left( \frac{1 + \beta_{ih}(1 + r)(\eta_{ih} - a_{ih})}{\beta_{ih}(1 + r)} \right).
$$

(A.15)

$$
\tilde{x}_{ht,-i} = \left( \frac{\gamma_{ih}}{1 - \omega_{ih}\gamma_{ih}} \right) \left( \tilde{z}_{ht,-i} \right) - \left( \frac{1}{d_{ih}} \right) E(\tilde{z}_{h,t+1,-i} | \Omega_t) + \left( \frac{\beta_{ih}r(1 + r)}{1 + \beta_{ih}(1 + r)(\eta_{ih} - a_{ih})} \right) \left( \frac{\delta_{ih}}{1 - \omega_{ih}\gamma_{ih}} \right),
$$

(A.16)

and

$$
\tilde{z}_{ht,-i} = \tilde{z}_{ht,-i} - a_{ih}\tilde{c}_{h,t-1,-i}.
$$

(A.17)

Leading (A.14) $s$ periods forward, $s = 1, 2, \ldots$, taking conditional expectations with respect to $\Omega_t$, and substituting recursively to obtain $E(m_{ih,t+s} | \Omega_t)$ as a function of $m_{ih,t}$, $\tilde{x}_{ht,-i}$, $E(\tilde{x}_{h,t+1,-i} | \Omega_t)$, \ldots, $E(\tilde{x}_{h,t+s-1,-i} | \Omega_t)$, one obtains

$$
E(m_{ih,t+s} | \Omega_t) = d_{ih}^s m_{ih,t} - E\left( \sum_{q=0}^{s-1} d_{ih}^{-q}\tilde{x}_{h,t+q,-i} | \Omega_t \right).
$$

(A.18)

From individual $\tilde{r}$'s expected lifetime budget constraint,

$$
E\left( \sum_{s=0}^{\infty} \frac{c_{ih,t+s}}{(1 + r)^s} | \Omega_t \right) = E(L_{ih,t} | \Omega_t),
$$

(A.19)

it follows that

$$
E\left( \sum_{s=0}^{\infty} \frac{m_{ih,t+s}}{(1 + r)^s} | \Omega_t \right) = \left( \frac{1 + r - a_{ih}}{1 + r} \right) E(L_{ih,t} | \Omega_t) - a_{ih}c_{ih,t-1}.
$$

(A.20)

Substituting (A.18) into (A.20), and assuming that the non-explosiveness condition, $\beta_{ih}(1 + r) \geq 1$ holds, one obtains

$$
c_{ih,t} = \left( \frac{a_{ih}d_{ih}}{1 + r} \right)c_{ih,t-1} + \left( \frac{(1 + r - a_{ih})(1 + r - d_{ih})}{(1 + r)^2} \right) E(L_{ih,t} | \Omega_t) + \left( \frac{d_{ih}}{1 + r} \right) E\left( \sum_{s=0}^{\infty} \tilde{x}_{h,t+s,-i} | \Omega_t \right).
$$

(A.21)
Averaging the expected lifetime budget constraint, (A.19), using the weights $\omega_{ih}$ across all $j \neq i$ yields
\[
E\left(\sum_{s=0}^{\infty} \frac{\tilde{z}_{j,t+s-i}}{(1+r)^s} \mid \Omega_t \right) = E(\tilde{L}_{ht,-i} \mid \Omega_t),
\] (A.22)
and therefore
\[
E\left(\sum_{s=0}^{\infty} \frac{\tilde{z}_{j,t+s-i}}{(1+r)^s} \mid \Omega_t \right) = \left(1 + r - a_{ih}\right)E(\tilde{L}_{ht,-i} \mid \Omega_t) - a_{ih}\tilde{c}_{h,t-1,-i},
\] (A.23)
and
\[
E\left(\sum_{s=0}^{\infty} \frac{\tilde{z}_{j,t+s+1-i}}{(1+r)^s} \mid \Omega_t \right) = (1 + r - a_{ih})E(\tilde{L}_{ht,-i} \mid \Omega_t) - (1 + r)\tilde{c}_{ht,-i}.
\] (A.24)
Substituting (A.23) and (A.24) back into (A.21), one finally obtains
\[
c_{ih,t} = \left(\frac{\gamma'_{ih}}{1 - \omega_{ih} \gamma_{ih}}\right)\tilde{c}_{ht,-i} + \left(\frac{a_{ih} d_{ih}}{1 + r}\right)\tilde{c}_{ih,t-1}
- \left(\frac{a_{ih} d_{ih}}{1 + r}\right)\left(\frac{\gamma_{ih}}{1 - \omega_{ih} \gamma_{ih}}\right)\tilde{c}_{h,t-1,-i}
+ \left(\frac{1 + r - a_{ih}(1 + r - d_{ih})}{(1 + r)^2}\right)E(L_{ih} \mid \Omega_t)
+ \left(\frac{1 + r - a_{ih}(d_{ih} - 1 - r)}{(1 + r)^2}\right)\left(\frac{\gamma_{ih}}{1 - \omega_{ih} \gamma_{ih}}\right)E(\tilde{L}_{ht,-i} \mid \Omega_t)
+ \left(\frac{\beta_{ih}(1 + r)}{1 + \beta_{ih}(1 + r)(\eta_{ih} - a_{ih})}\right)\left(\frac{d_{ih} \delta_{ih}}{1 - \omega_{ih} \gamma_{ih}}\right).
\] (A.25)
It is now easily established that (A.25) is invariant to the choice of $a_{ih}$ in (A.13); namely, the same expression results on the right-hand side of (A.25) irrespective of whether $a_{ih1} = \eta_{ih}$ (implying $d_{ih} = 1/[\beta_{ih}(1 + r)]$) or $a_{ih2} = 1/[\beta_{ih}(1 + r)]$ (implying $d_{ih} = \eta_{ih}$) is used for $a_{ih}$ in (A.25). Thus (A.25) can be rewritten as
\[
(1 - \omega_{ih} \gamma_{ih})c_{ih}
= \gamma_{ih} \tilde{c}_{ht,-i} + \delta_{ih} + \left(\frac{\eta_{ih}(1 - \omega_{ih} \gamma_{ih})}{\beta_{ih}(1 + r)^2}\right)\tilde{c}_{ih,t-1} - \left(\frac{\eta_{ih} \gamma_{ih}}{\beta_{ih}(1 + r)^2}\right)\tilde{c}_{h,t-1,-i}
+ \left(\frac{\beta_{ih}(1 + r) - 1}{\beta_{ih}(1 + r)^3}\right)(1 + r - \eta_{ih})(E(L_{ih} \mid \Omega_t) - \gamma_{ih} E(\tilde{L}_{ht} \mid \Omega_t)).
\] (A.26)
The solution (27) in the paper can now be derived in a straightforward manner by stacking (A.26) for all $i$, $i = 1, 2, \ldots, N_h$. □
Proof of Proposition 2. Rewrite the Euler equation for individual \(i\), (20), under \(\eta_{ih} = 0\) as

\[
E(c_{ih,t+1}|\Omega_{ih}) = \left( \frac{1}{\beta_{ih}(1+r)} \right) (c_{ih} - \bar{x}_{ht,-i}),
\]

(A.27)

where

\[
\bar{x}_{ht,-i} = \left( \frac{\gamma_{ih}}{1 - \omega_{ih}\gamma_{ih}} \right) \left[ E(\tilde{c}_{ht,-i}|\Omega_{ih}) - \beta_{ih}(1+r)E(\tilde{c}_{ht+1,-i}|\Omega_{ih}) \right] + \beta_{ih}r(1+r) \left( \frac{\delta_{ih}}{1 - \omega_{ih}\gamma_{ih}} \right).
\]

(A.28)

As in the proof of Proposition 1, we solve the Euler equation (A.27) for individual \(i\) in two steps. The first step is conceptually similar to the homogeneous information case and eliminates the future expectations \(E(\tilde{c}_{ht,-i}|\Omega_{ih})\) and \(E(\tilde{c}_{ht+1,-i}|\Omega_{ih})\) using the lifetime budget constraints of all individuals in the peer group. We then obtain \(c_{ih} \) as a function of \(E(c_{jht}|\Omega_{ih})\), for all \(j \neq i\), and of the expected present discounted values of total lifetime resources of all individuals, \(E(L_{jht}|\Omega_{ih}), \ j = 1, 2, \ldots, N_h\). (See (A.34) below.) Under disparate information, solution of this latter equation is not as straightforward as under homogeneous information, however, due to the infinite regress problem. To overcome the infinite regress problem, in the second step we apply the solution approach of Binder and Pesaran (1998).

In the first step, the profiles \(\{c_{jht}\}\) are again taken as given for all \(j \neq i\). Then shifting (A.27) \(s\) periods forward, taking conditional expectations with respect to \(\Omega_{ih}\), and substituting recursively to obtain \(E(c_{ih,t+s}|\Omega_{ih})\) as a function of \(c_{ih}, \bar{x}_{ht,-i}, E(\bar{x}_{ht+1,-i}|\Omega_{ih}), \ldots, E(\bar{x}_{ht+s-1,-i}|\Omega_{ih})\), one obtains

\[
E(c_{ih,t+s}|\Omega_{ih}) = \left( \frac{1}{\beta_{ih}(1+r)} \right)^s c_{ih} - E\left( \sum_{q=0}^{s-1} \frac{\bar{x}_{ht+q,-i}}{[\beta_{ih}(1+r)]^{s-q}}|\Omega_{ih} \right).
\]

(A.29)

Substituting (A.29) back into individual \(i\)'s expected lifetime budget constraint,

\[
E\left( \sum_{s=0}^{\infty} \frac{c_{ih,t+s}}{(1+r)^s}|\Omega_{ih} \right) = E(L_{ih}t|\Omega_{ih}),
\]

(A.30)

yields

\[
c_{ih} = \left( \frac{\beta_{ih}(1+r)^2 - 1}{\beta_{ih}(1+r)^2} \right) E(L_{ih}t|\Omega_{ih}) + \left( \frac{1}{\beta_{ih}(1+r)^2} \right) E\left( \sum_{s=0}^{\infty} \frac{\bar{x}_{ht+s,-i}}{(1+r)^s}|\Omega_{ih} \right).
\]

(A.31)
Note from the lifetime budget constraint that
\[ E \left( \sum_{s=0}^{\infty} \frac{\tilde{c}_{ht+s} - i}{(1 + r)^s} | \Omega_{ih} \right) = E(\tilde{L}_{ht} - i | \Omega_{ih}), \]  
(A.32)
and that
\[ E \left( \sum_{s=0}^{\infty} \frac{\tilde{c}_{ht+s+1} - i}{(1 + r)^s} | \Omega_{ih} \right) = (1 + r)E(\tilde{L}_{ht} - i | \Omega_{ih}) - (1 + r)E(\tilde{c}_{ht} - i | \Omega_{ih}). \]  
(A.33)

Substituting (A.32) and (A.33) back into (A.31), one obtains
\[ c_{ih} = \gamma_{ih}E(\tilde{c}_{ht} | \Omega_{ih}) + z_{ih} + \delta_{ih}, \]  
(A.34)
where \( \delta_{ih} \) is given by (33), and
\[ z_{ih} = \left( \frac{\beta_{ih}(1 + r)^2 - 1}{\beta_{ih}} \right) \left[ E(L_{ih} | \Omega_{ih}) - \gamma_{ih}E(\tilde{L}_{ih} | \Omega_{ih}) \right]. \]  
(A.35)

To overcome the infinite regress problem arising in the solution of (A.35), we invoke assumptions (47) and (48), postulating that all individuals in the peer group form their expectations about the decision and forcing variables of other individuals in their group solely on the basis of publicly available information. Observing (47), (A.34) can be rewritten as
\[ c_{ih} = \gamma_{ih}E(\tilde{c}_{ht} | \Psi_{t-1}) + \omega_{ih} \left[ c_{ih} - E(c_{ih} | \Psi_{t-1}) \right] + z_{ih} + \delta_{ih}. \]  
(A.36)

Taking the conditional expectation of (A.36) with respect to \( \Psi_{t-1} \), and subtracting the resultant expression from (A.34), one obtains
\[ c_{ih} - E(c_{ih} | \Psi_{t-1}) = \left( \frac{1}{1 - \omega_{ih} \gamma_{ih}} \right) \left[ z_{ih} - E(z_{ih} | \Psi_{t-1}) \right]. \]  
(A.37)

Now substituting (A.37) back into (A.36) yields
\[ c_{ih} = \gamma_{ih}E(\tilde{c}_{ht} | \Psi_{t-1}) + \left( \frac{\omega_{ih} \gamma_{ih}}{1 - \omega_{ih} \gamma_{ih}} \right) \left[ z_{ih} - E(z_{ih} | \Psi_{t-1}) \right] + z_{ih} + \delta_{ih}. \]  
(A.38)

Aggregating (A.38) with weights \( \omega_{jh} \), one obtains
\[ \tilde{c}_{ht} = \left( \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh} \right) E(\tilde{c}_{ht} | \Psi_{t-1}) + \left( \sum_{j=1}^{N_h} \left( \frac{\omega_{jh} \gamma_{jh}}{1 - \omega_{jh} \gamma_{jh}} \right) \left[ z_{jh} - E(z_{jh} | \Psi_{t-1}) \right] \right) + \tilde{z}_{ht} + \left( \sum_{j=1}^{N_h} \omega_{jh} \delta_{jh} \right), \]  
(A.39)
where $\tilde{z}_{ht} = (\sum_{j=1}^{N_h} \omega_{jh} z_{jht})$. Taking the conditional expectation of (A.39) with respect to $\Psi_{t-1}$, solving for $E(\tilde{c}_{ht}|\Psi_{t-1})$, and then substituting the resultant expression back into (A.38), one obtains

$$c_{ih} = z_{ih} + \left(\frac{\gamma_{ih}}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}}\right)E(\tilde{z}_{ht}|\Psi_{t-1})$$

$$+ \left(\frac{\omega_{ih} \gamma_{ih}}{1 - \omega_{ih} \gamma_{ih}}\right)[z_{ih} - E(z_{ih}|\Psi_{t-1})] + \delta_{ih}$$

$$+ \gamma_{ih} \left(\frac{\sum_{j=1}^{N_h} \omega_{jh} \delta_{jh}}{1 - \sum_{j=1}^{N_h} \omega_{jh} \gamma_{jh}}\right).$$

(A.40)

Using the definition of $z_{ih}$ given by (A.35), it is now straightforward to derive the individual-specific optimal consumption decisions (49).

**Proof of Proposition 3.** Following Binder et al. (2000), one may obtain (55) as the limiting solution of the finite horizon problem

$$\max_{\{c_{s,t+s}\}_{t=0}^{T}} \mathbb{E}\left(\sum_{s=0}^{T-t} \beta_{ihs}^{-s} \left(-\frac{1}{\kappa_{ih}}\right) \exp[-\kappa_{ih}(c_{ih,t+s} + \tau_{ih} \tilde{c}_{h,t+s-i})]\Omega_t\right)$$

subject to the budget constraints,

$$A_{ih,t+s} = (1 + r)A_{ih,t+s-1} + y_{ih,t+s} - c_{ih,t+s}, \quad s = 0, 1, \ldots, T - t,$$  

(A.42)

with $A_{ih,t-1}$ and $A_{ihT}$ given, $i = 1, 2, \ldots, N_h$. Solving the period-by-period budget constraint (A.42) and its weighted peer group level analog

$$\tilde{A}_{h,t+s} = (1 + r)\tilde{A}_{h,t+s-1} + \tilde{y}_{h,t+s} - \tilde{c}_{h,t+s}, \quad s = 0, 1, \ldots, T - t,$$  

(A.43)

for $c_{ih,t+s}$ and $\tilde{c}_{h,t+s}$, respectively, and substituting back into the objective function (A.41), it is readily verified that the period $t + s$ Euler equation for individual $i$ in peer group $h$ can be written as

$$(2 + r)A_{ih,t+s} = (1 + r)A_{ih,t+s-1} + A_{ih,t+s+1}$$

$$+ \gamma_{ih}((2 + r)\tilde{A}_{h,t+s} - (1 + r)\tilde{A}_{h,t+s-1} - \tilde{A}_{h,t+s+1})$$

$$- (1 - \gamma_{ih})\mu + \Gamma_{ih},$$  

(A.44)

with $\Gamma_{ih}$ defined by (56). Averaging (A.44) across all $i$, $i = 1, 2, \ldots, N_h$, with weights $\omega_{ih}$ yields

$$(2 + r)\tilde{A}_{h,t+s} = (1 + r)\tilde{A}_{h,t+s-1} + \tilde{A}_{h,t+s+1} - \mu + \Gamma_h,$$  

(A.45)
with $\Gamma_h$ defined by (58). Stacking the peer group level Euler equations (A.45) for $s = 0, 1, \ldots, T - t - 1$, one obtains the system of linear equations

$$
\begin{pmatrix}
\tilde{A}_{ht} \\
\tilde{A}_{ht+1} \\
\vdots \\
\tilde{A}_{h,T-2} \\
\tilde{A}_{h,T-1}
\end{pmatrix}
= 
\begin{pmatrix}
\Gamma_h - \mu \\
\Gamma_h - \mu \\
\vdots \\
\Gamma_h - \mu \\
\Gamma_h - \mu
\end{pmatrix}
+ 
\begin{pmatrix}
(1 + r)\tilde{A}_{ht-1} \\
0 \\
\vdots \\
0 \\
\tilde{A}_{hT}
\end{pmatrix},
$$

(A.46)

where $D$ is a tridiagonal coefficient matrix,

$$
D =
\begin{pmatrix}
2 + r & -1 & 0 & \cdots & 0 & 0 & 0 \\
-(1 + r) & 2 + r & -1 & \cdots & 0 & 0 & 0 \\
\vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\
0 & 0 & 0 & \cdots & -(1 + r) & 2 + r & -1 \\
0 & 0 & 0 & \cdots & 0 & -(1 + r) & 2 + r
\end{pmatrix}.
$$

(A.47)

Inverting the tridiagonal coefficient matrix $D$, after some algebra one obtains

$$
\tilde{A}_{h,t+s} = 
\left(\frac{1 + s}{r}\right) - \left(\frac{1 + T - t}{r}\frac{(1 + r)^{1+s} - 1}{(1 + T - t - 1)}\right)(\Gamma_h - \mu)
\right) + 
\left(1 - \frac{(1 + r)^{1+s} - 1}{(1 + r)^{1+T-t} - 1}\right)\tilde{A}_{ht-1}
+ 
\left(\frac{(1 + r)^{1+s} - 1}{(1 + r)^{1+T-t} - 1}\right)\tilde{A}_{hT}.
$$

(A.48)

Substituting (A.48) back into the period $t + s$ Euler equation for individual $i$ in peer group $h$, (A.44), and then stacking the resulting Euler equations for $s = 0, 1, \ldots, T - t - 1$, one obtains a system of linear equations in structure similar to (A.46). Solving this new system, and then taking limits as $T \to \infty$, one obtains

$$
A_{ih,t} = \left(\frac{1}{r}\right)[(1 - \omega_{ih}\gamma_{ih})\Gamma_{ih} + \gamma_{ih}\Gamma_h] - \left(\frac{1}{r}\right)\mu + A_{ih,t-1}.
$$

(A.49)

Substituting (A.49) into the period $t$ budget constraint of individual $i$ in peer group $h$, one arrives at (55).
References


