EXPECTATIONS-BASED REFERENCE-DEPENDENT LIFE-CYCLE CONSUMPTION

MICHAELA PAGEL
COLUMBIA GSB

ABSTRACT. This study incorporates a recent preference specification of expectations-based loss aversion, which has been applied broadly in microeconomics, into a classic macro model to offer a unified explanation for three empirical observations about life-cycle consumption. First, loss aversion explains excess smoothness or sensitivity, that is, the empirical observation that consumption responds to income shocks with a lag. Intuitively, such lagged responses allow the agent to delay painful losses in consumption until his expectations have adjusted. Second, the preferences generate a hump-shaped consumption profile. Early in life, consumption is low due to a first-order precautionary-savings motive. However, as uncertainty resolves over time, this motive is dominated by time-inconsistent overconsumption that eventually leads to declining consumption toward the end of life. Third, consumption drops at retirement. Prior to retirement, the agent wants to overconsume his uncertain income before his expectations catch up. Post-retirement, however, income is no longer uncertain, so that overconsumption is associated with a sure loss in future consumption. As an empirical contribution, I structurally estimate the preference parameters using life-cycle consumption data. My estimates match those obtained in experiments and other micro studies and generate the degree of excess smoothness observed in macro consumption data.

JEL Codes: E03, D03, D91, D14.

1. INTRODUCTION

In the last 30 years, authors of the consumption literature have debated numerous explanations for the three major empirical observations about life-cycle consumption: excess smoothness and sensitivity in consumption, a hump-shaped consumption profile, and a drop in consumption at retirement.[1] This study offers a new, unified, and parsimonious explanation based on expectations-based reference-dependent preferences, which have been developed by Koszegi and Rabin (2006, 2007, 2009) to discipline and broadly apply the insights of prospect theory. The preferences formalize the idea that changes in expectations about consumption generate instantaneous utility and

E-mail: mpagel@columbia.edu. I am indebted to Adam Szeidl, Matthew Rabin, and Botond Koszegi for their extensive advice and support. I thank Nick Barberis, Ulrike Malmendier, Ted O'Donoghue, Yuriy Gorodnichenko, Josh Schwartzstein, Brett Green, Stefano DellaVigna, David Laibson, Martin Lettau, Per Krusell, Hanno Lustig, and seminar or conference participants at UC Berkeley (and Haas), Yale SOM, Cornell University, the Federal Reserve Bank of St. Louis, Stanford, IIES Stockholm, EIEF, UC Irvine, Sciences Po, DePaul University in Chicago, UC San Diego, Tilburg University, Huntsman School of Business, and University of Konstanz for their helpful comments and suggestions. All errors remain my own.

[1]Refer to Attanasio and Weber (2010) for a comprehensive survey of the life-cycle consumption literature.

This article has been published in *The Review of Economic Studies* 84, no. 2 (April 2017): 885-934,

https://doi.org/10.1093/restud/rdx003, published by Oxford University Press.

that losses in expectations about consumption hurt more than gains please. While these preferences have been shown to explain evidence in various micro domains, this study validates the preferences in a classic macro domain. The intuition of my results reflect the micro evidence that the preferences were developed to explain and may provide new foundations for key ideas in the macro consumption literature. Moreover, I show that the preferences generate new behavior and welfare predictions. These welfare predictions are important. For instance, whether consumption, which represents two-thirds of GDP, should be excessively smooth matters for labor market reforms and countercyclical policies.

First, I explain the preferences in greater detail. In each period, the agent's instantaneous utility has two components. "Consumption utility" is determined by his level of consumption and corresponds to the standard model of utility. "Gain-loss utility" is determined by his consumption relative to his reference point and corresponds to a prospect-theory model of utility. The agent's reference point is determined by his previous expectations about both his present consumption and his entire stream of future consumption. The agent experiences "contemporaneous" gain-loss utility when he compares his actual present consumption with his probabilistic expectations about present consumption. In this comparison, he encounters a sensation of gain or loss relative to each consumption outcome that he had previously expected. In addition, the agent experiences "prospective" gain-loss utility when he compares his updated expectations about future consumption with his previous expectations, encountering gain-loss utility over what he has learned about future consumption. Thus, gain-loss utility can be interpreted as utility over good and bad news about consumption.

I analyze an agent with such news-utility preferences in a life-cycle consumption model. The agent lives for a finite number of periods; at the beginning of each period, he observes the realization of a permanent and transitory income shock, and then, decides how much to consume and save. First, I assume that the agent's consumption utility is an exponential-utility function. This assumption produces a closed-form solution, which provides a precise understanding of the intuition behind the preferences' implications. Then, I show that all the implications hold if instead I assume a power-utility function.[2]

As the key contribution, these preferences generate excess smoothness and sensitivity in consumption, which refer to the empirical observations that consumption initially underresponds to income shocks and then adjusts with a delay. Empirical evidence for these inherently related consumption phenomena is provided by Deaton (1986) and Campbell and Deaton (1989), in response to the seminal paper by Flavin (1981).[3] Such consumption responses are puzzling from the per-

[2] I assume a standard model environment, as proposed by Carroll (2001) and Gourinchas and Parker (2002), but my results are robust to many alternative environmental assumptions such as borrowing constraints, different income profiles, different savings devices, portfolio choice, endogenous labor supply, mortality risk, an endogenous retirement date, different pension designs, and income risk after retirement.

[3] The empirical evidence is surveyed in Jappelli and Pistaferri (2010). My model features only contemporaneous and not future income shocks but a delayed response to past income shocks can be interpreted as a response to expectedly

spective of the standard model, in which consumption fully adjusts immediately, but can be explained by expectations-based loss aversion. A simplified intuition is that, in the event of an adverse income shock, unexpected losses in present consumption are more painful than expected reductions in the future. Therefore, the agent delays unexpected losses in consumption until his expectations have adjusted in the future. Losses in present consumption are more painful than losses in future consumption because the latter depend on future income shocks and are, thus, to some extent still uncertain, as future expectations adjust.

Beyond resolving these puzzles, the preferences are consistent with a hump-shaped life-cycle consumption profile that is characterized by increasing consumption at the beginning but decreasing consumption toward the end of life. Empirical evidence for a hump-shaped profile is provided by Fernandez-Villaverde and Krueger (2007) and Gourinchas and Parker (2002).[4] In my model, this hump results from the interaction of two features of the preferences: a first-order precautionary-savings motive and a time inconsistency. First, the preferences motivate precautionary savings because loss aversion causes expected fluctuations in consumption to be painful. However, these fluctuations hurt relatively less higher on the concave utility curve, which brings about an additional motive to save. This savings motive depends on concavity and is a first-order consideration, as opposed to the precautionary-savings motive under standard preferences. Second, the preferences are subject to a time inconsistency. The agent behaves inconsistently because he takes present expectations as given when increasing current consumption, but he takes future expectations into account when increasing future consumption. However, when the future arrives, he will take future expectations as given and considers only the pleasure of increasing consumption above expectations rather than increasing consumption and expectations. Thus, the agent overconsumes in the future relative to the present optimal plan. To summarize, the precautionary-savings motive keeps consumption low at the beginning of life. However, the need for precautionary savings decreases when uncertainty resolves over time and is dominated by the time inconsistency, causing overconsumption at some point. This overconsumption forces the agent to choose a declining-consumption path by the end of his life.

Finally, the preferences predict a drop in consumption at retirement, an empirical observation debated by Battistin et al. (2009) and Haider and Stephens (2007) among others.[5] During retirement income uncertainty is absent in a standard life-cycle model, which eliminates both the precautionary-savings motive and time-inconsistent overconsumption. The agent stops overcon-

high income.

[4]The hump-shaped life-cycle profile constitutes a puzzle as consumption must be monotonic if utility is an additively separable function of consumption, discounting is geometric, and markets are complete.

[5]A series of studies, for example, Banks et al. (1998), Bernheim et al. (2001), Battistin et al. (2009), Haider and Stephens (2007), and Schwerdt (2005) find that consumption drops at retirement, taking work-related expenses into account, and my data also display such a drop. Moreover, Ameriks et al. (2007) and Hurd and Rohwedder (2003) provide evidence that the drop in consumption is anticipated. However, Aguiar and Hurst (2005) find that the drop is absent when controlling properly for health shocks and home production.

suming because he no longer allocates uncertain labor income but allocates certain income. Certainty implies that overconsumption today is associated with a sure loss in future consumption. Because the sure loss hurts more than overconsumption gives pleasure, the agent suddenly controls his time-inconsistent desire to overconsume and his consumption drops at retirement. This result is robust to assuming small uncertainty, such as inflation or pension risk, or discrete uncertainty, such as health shocks.

The intuition for the excess-smoothness result is new and different from the result by Koszegi and Rabin (2009) that the news-utility agent consumes windfall gains but delays windfall losses. This result depends on unexpected windfall gains and losses and an initially certain consumption path whereas my result is about a differential response of present and future consumption due to adjusting expectations.[6] In contrast, my results for both the precautionary-savings and overconsumption motives were obtained by Koszegi and Rabin (2009) in a two-period, two-outcome model. Beyond these three implications, the preferences generate several new and testable predictions. For instance, excess smoothness increases in the agent's horizon and is prevalent for temporary shocks only if the agent does not face additional permanent shocks. I argue that these new comparative statics can help to empirically distinguish between news utility and other theoretical explanations. By way of providing alternative explanations more formally, this study explores habit-formation, hyperbolic-discounting, temptation-disutility, and standard preferences. However, only news utility provides a unified and robust explanation independent of the assumptions that other explanations rely on, for example, a power-utility function, hump-shaped income profiles, or borrowing constraints. Nevertheless, this study's main contribution is that the intuition of my results connects robust micro evidence on reference-dependent preferences to several compelling concepts in the macro consumption literature. For instance, loss aversion is an experimentally robust risk preference, which explains important behavioral phenomena, such as the endowment effect, as well as macro phenomena, such as stock market non-participation and the equity-premium puzzle.[7] The explanation of the equity-premium puzzle relates well to the explanation of the excess-smoothness puzzle, as loss aversion smoothes consumption relative to movements in either asset prices or permanent income. To explain the other life-cycle facts, the preferences intuitively unify precautionary savings, which have been studied extensively in the standard consumption literature, and time-inconsistent overconsumption, which is reminiscent of hyperbolic discounting. Moreover, I draw potentially important welfare conclusions. While excess smoothness increases welfare, the hump-shaped consumption profile and the drop in consumption at retirement decrease welfare.

To quantitatively evaluate the model, I structurally estimate the preference parameters. I follow

[6]To elaborate on the result about windfall gains and losses, I explore an extension assuming that the agent receives large income shocks every couple periods but receives merely small or discrete income shocks in the in-between periods. Small or discrete uncertainty allows the agent to make a credible plan to overconsume less and implies that he will consume entire small gains and delay entire small losses.

[7]The endowment effect refers to the phenomenon that people become less willing to give up items once they own them. If somebody owns an item, foregoing it feels like a loss.

the two-stage method-of-simulated-moments approach of Gourinchas and Parker (2002) and use pseudo-panel data from the Consumer Expenditure Survey. I can identify all preference parameters because each parameter generates specific variation in consumption growth over the life cycle. Then, I compare my estimates to those found in the experimental literature eliciting attitudes towards small and large wealth gambles and intertemporal consumption tradeoffs. In turn, I show that my estimates are not only in line with the micro literature but also match the empirical evidence for excess smoothness and sensitivity in aggregate data.

The rest of the paper is organized as follows. After a literature review, I explain the model environment, preferences, and equilibrium in Section 2.1. Then, I derive the model's predictions in closed form under the assumption of exponential utility in Section 2.2. After introducing the power-utility model, I structurally estimate the model's parameters in Section 2.3 to assess whether the quantitative predictions match the empirical evidence. Finally, Section 3 concludes.

LITERATURE REVIEW. Expectations-based reference-dependent preferences have been developed in the dynamic version by Koszegi and Rabin (2009) following the static version of Koszegi and Rabin (2006, 2007), which has been used to explain experimental and other microeconomic evidence in many contexts.[8]

Excess smoothness in consumption cannot be generated by a time-separable utility function as made clear by Ludvigson and Michaelides (2001), among others. To obtain excess smoothness, a predominant additional assumption is used, namely, borrowing constraints. However, the implied asymmetry in excess smoothness could not ultimately be confirmed empirically as surveyed in Jappelli and Pistaferri (2010). For instance, while Krueger and Perri (2011) finds the opposite, Shea (1995) finds that consumption is more excessively sensitive to expected income declines than increases, which is inconsistent with borrowing constraints but consistent with a static model of loss aversion, as considered in Bowman et al. (1999). Theoretically, in the standard model, the agent expects borrowing constraints and ensures that they are not binding for most income paths, as analyzed by Deaton (1991), among others. However, Deaton (1991) also notes that it is possible to construct a microeconomic model with impatient agents and particular income processes in which borrowing constraints bind frequently. Moreover, borrowing constraints are binding more often in a model that features a time-inconsistency problem, as analyzed by Angeletos et al. (2001) and Laibson et al. (2012). In these models, sophisticated hyperbolic-discounting preferences im-

[8] Heidhues and Koszegi (2008, 2014), Herweg and Mierendorff (2012), and Herweg et al. (2010) explore the implications for consumer pricing and principal-agent contracts. Among others, Sprenger (2010) provides direct evidence for the implications of stochastic reference points, Abeler et al. (2012) for labor supply, Gill and Prowse (2012) for real-effort tournaments, Meng (2013) for the disposition effect, and Ericson and Fuster (2011) for the endowment effect (not confirmed by Heffetz and List (2011)). Crawford and Meng (2011) provide suggestive evidence for labor supply, Pope and Schweitzer (2011) for golf players' performance, and Sydnor (2010) for deductible choice. All of these studies consider the static preferences but the notion that agents are loss averse with respect to news about future consumption is supported indirectly by all experiments, which use monetary payoffs because these concern future consumption.

ply that the agent restricts his consumption opportunities with illiquid savings against which he can borrow up to some constraint at a high interest rate. To the extent that the hyperbolic agent's borrowing constraint binds or his liquid asset holdings bunch at zero, his consumption is excessively smooth.[9] Demand for commitment is also generated by temptation-disutility preferences, as specified in Gul and Pesendorfer (2004) and analyzed by Bucciol (2012) in a life-cycle context. Furthermore, Caballero (1995) assumes that agents consume near-rationally, and Fuhrer (2000) and Michaelides (2002) assume internal multiplicative habit formation. However, I confirm the conclusion of Michaelides (2002) that habit formation generates unreasonably high wealth accumulation when calibrated to match the empirical degree of excess smoothness. In addition, Flavin and Nakagawa (2008) define a utility function over two consumption goods, one representing non-durable consumption and one representing housing, which is characterized by adjustment costs. As the utility function depends non-separably on the two goods, non-durable consumption is excessively smooth and sensitive. A similar utility function is assumed by Chetty and Szeidl (2010); however, this function is separable in the two goods, which implies that consumption is excessively smooth and sensitive with respect to the durable good only. Moreover, Reis (2006) assumes that agents face costs when processing information, and thus, optimally decide to update their consumption plans sporadically; such inattention has been shown to matter in the aggregate by Gabaix and Laibson (2002). Furthermore, Tutoni (2010) assumes that consumers are rationally inattentive, as in Sims (2003), and Attanasio and Pavoni (2011) show that excessively smooth consumption results from incomplete consumption insurance due to a moral hazard problem.

Several studies show that the standard and hyperbolic agents' consumption profiles are hump shaped under the assumption of power utility, sufficient impatience, and a hump-shaped income profile, such as Carroll (1997), Gourinchas and Parker (2002), and Laibson et al. (2012). Other studies that generate a hump-shaped consumption profile are Caliendo and Huang (2008) with overconfidence, Attanasio (1999) with family size effects, Deaton (1991) with borrowing constraints, Feigenbaum (2008) and Hansen and Imrohoroglu (2008) with mortality risk, Bullard and Feigenbaum (2007) and Heckman (1974) with consumption-leisure choice, and Fernandez-Villaverde and Krueger (2007) with consumer durables. Caliendo and Huang (2007) and Park (2011) assume that the agent has a shorter planning horizon than his true horizon. In addition, Park (2011) shows that short-term planning can generate the hump in a well-calibrated general-equilibrium model. Last, Caliendo and Huang (2011) show that a hump-shaped profile and an anticipated drop in consumption can be generated by assuming implementation costs of savings.

[9] Laibson et al. (2012) put forward an interpretation of excess sensitivity that focuses on a high marginal propensity to consume out of transitory income shocks, as the permanent income model predicts this propensity to consume would be close to zero. A high marginal propensity to consume out of transitory income shocks is prevalent for all preference specifications that feature a time-inconsistency problem if the agent has access to an illiquid asset, as he tries to make wealth inaccessible to his future selves.

2. The Life-Cycle Consumption Model

First, I define a generalized life-cycle model environment to formally introduce the preferences and equilibrium concept.

2.1. **Model environment, preferences, and equilibrium.**

The model environment. The agent lives for a total of T discrete periods indexed by $t \in \{1,...,T\}$. At the beginning of each period, a vector of random shocks S_t, distributed according to F_{S_t}, is realized; the shocks are independent of each other and over time. The realization of the vector of random shocks S_t is denoted by s_t. The model's exogenous state variables are represented by the vector Z_t, which evolves according to the following law of motion

$$Z_t = f^Z(Z_{t-1}, S_t). \tag{1}$$

After observing the realization of the vector of random shocks s_t and the vector of state variables Z_t, the agent decides how much to consume, C_t. The model's endogenous state variable is cash-on-hand X_{t+1} and is determined by the following budget constraint

$$X_{t+1} = f^X(X_t - C_t, Z_t, S_{t+1}). \tag{2}$$

All of the model's variables that are indexed by t are realized in period t. Because the agent's preferences are defined over both consumption and expectations or "beliefs," I explicitly define his probabilistic beliefs about each of the model's period $t+\tau$ variables from the perspective of any prior period t as follows.

Definition 1. Let $I_t = \{X_t, Z_t, s_t\}$ denote the agent's information set in some period $t \leq t+\tau$. Then, the agent's probabilistic beliefs about any model variable $V_{t+\tau}$ conditional on period t information is denoted by $F^t_{V_{t+\tau}}(v) = Pr(V_{t+\tau} < v | I_t)$, and $F^{t+\tau}_{V_{t+\tau}}$ is degenerate.

Throughout this study, I assume rational expectations, that is, the agent's beliefs about any of the model's variables equal the objective probabilities determined by the economic environment.

Expectations-based reference-dependent preferences. Having outlined the model environment, I now introduce the agent's preferences. To facilitate the exposition, I first explain the static model of expectations-based reference dependence, as specified in Koszegi and Rabin (2006, 2007), and then, I introduce the dynamic model of Koszegi and Rabin (2009). The agent's utility function consists of two components. First, he experiences consumption utility $u(c)$, which corresponds to the standard model of utility and is determined solely by consumption c. Second, he experiences gain-loss utility $\mu(u(c) - u(r))$. The gain-loss function $\mu(\cdot)$ corresponds to the prospect-theory model of utility determined by consumption c relative to the reference point r. The gain-loss function $\mu(\cdot)$ is piecewise linear with slope η and a coefficient of loss aversion λ, that is, $\mu(x) = \eta x$ for $x > 0$ and $\mu(x) = \eta\lambda x$ for $x \leq 0$. The slope $\eta > 0$ weights the gain-loss utility component relative to the consumption utility component and the coefficient of loss aversion $\lambda > 1$ implies that losses are weighted more heavily than gains. Koszegi and Rabin (2006, 2007) allow for stochastic consumption, distributed according to F_c, and a stochastic reference point, distributed according to F_r. Then, the agent experiences gain-loss utility by evaluating each possible consumption outcome relative to all other possible outcomes

$$\int_{-\infty}^{\infty}(\eta\int_{-\infty}^{c}(u(c)-u(r))dF_r(r)+\eta\lambda\int_{c}^{\infty}(u(c)-u(r))dF_r(r))dF_c(c). \tag{3}$$

In addition, the authors make the central assumption that the distribution of the reference point F_r equals the agent's fully probabilistic rational beliefs about consumption c.

In the dynamic model of Koszegi and Rabin (2009), the utility function consists of consumption utility, contemporaneous gain-loss utility about current consumption, and prospective gain-loss utility about the entire stream of future consumption. Thus, lifetime utility in each period t is

$$E_t[\sum_{\tau=0}^{T-t}\beta^{\tau}U_{t+\tau}] = u(C_t)+n(C_t,F_{C_t}^{t-1})+\gamma\sum_{\tau=1}^{T-t}\beta^{\tau}\boldsymbol{n}(F_{C_{t+\tau}}^{t,t-1})+E_t[\sum_{\tau=1}^{T-t}\beta^{\tau}U_{t+\tau}], \tag{4}$$

where $\beta \in [0,1)$ is an exponential discount factor. The first term on the right-hand side of equation (4), $u(C_t)$, corresponds to consumption utility in period t. The subsequent terms in equation (4) consider consumption and beliefs. The second term in equation (4), $n(C_t,F_{C_t}^{t-1})$, corresponds to gain-loss utility over contemporaneous consumption; here, the agent compares his present consumption C_t with his beliefs $F_{C_t}^{t-1}$. According to Definition 1, the agent's beliefs $F_{C_t}^{t-1}$ correspond to the conditional distribution of consumption in period t given the information available in period $t-1$. Thus, the agent experiences gain-loss utility over "news" about contemporaneous consumption by evaluating his contemporaneous consumption C_t relative to his previous beliefs $F_{C_t}^{t-1}$ as follows

$$n(C_t,F_{C_t}^{t-1}) = \eta\int_{-\infty}^{C_t}(u(C_t)-u(c))dF_{C_t}^{t-1}(c)+\eta\lambda\int_{C_t}^{\infty}(u(C_t)-u(c))dF_{C_t}^{t-1}(c). \tag{5}$$

The third term in equation (4), $\gamma\sum_{\tau=1}^{\infty}\beta^{\tau}\boldsymbol{n}(F_{C_{t+\tau}}^{t,t-1})$, corresponds to gain-loss utility, experienced in period t, over the entire stream of future consumption. Prospective gain-loss utility about period $t+\tau$ consumption depends on $F_{C_{t+\tau}}^{t-1}$, the agent's beliefs with which he entered the period, and on $F_{C_{t+\tau}}^{t}$, the agent's updated beliefs about consumption in period $t+\tau$. Importantly, the prior and updated beliefs about consumption $C_{t+\tau}$, namely $F_{C_{t+\tau}}^{t-1}$ and $F_{C_{t+\tau}}^{t}$, are not independent distribution functions because the realization of future shocks is contained in both distribution functions. Thus, there exists a joint distribution of prior and updated beliefs, which I denote by $F_{C_{t+\tau}}^{t,t-1} \neq F_{C_{t+\tau}}^{t}F_{C_{t+\tau}}^{t-1}$.[10] Because the agent compares his newly formed beliefs with his prior beliefs, he ex-

[10]I calculate prospective gain-loss utility $\boldsymbol{n}(F_{C_{t+\tau}}^{t,t-1})$ by generalizing the "outcome-wise" comparison, specified in

periences gain-loss utility over news about future consumption by evaluating his updated beliefs about future consumption $F^{t}_{C_{t+\tau}}$ relative to his previous beliefs $F^{t-1}_{C_{t+\tau}}$ as follows

$$(7) \qquad \boldsymbol{n}(F^{t,t-1}_{C_{t+\tau}}) = \int_{-\infty}^{\infty}(\eta\int_{-\infty}^{c}(u(c)-u(r))+\eta\lambda\int_{c}^{\infty}(u(c)-u(r)))dF^{t,t-1}_{C_{t+\tau}}(c,r).$$

The agent exponentially discounts prospective gain-loss utility by $\beta \in [0,1]$. Moreover, he discounts prospective gain-loss utility relative to contemporaneous gain-loss utility by a factor $\gamma \in [0,1]$. Thus, he puts the weight $\gamma\beta^{\tau} < 1$ on prospective gain-loss utility regarding consumption in period $t+\tau$. Because both contemporaneous and prospective gain-loss utility are experienced over news, the preferences can be referred to as news utility.

To describe explicitly the probabilistic structure of the agent's beliefs about any of the model's variables at any future date, I now define an "admissible consumption function." I consider a stationary consumption function that depends only on this period's cash-on-hand X_t, the vector of exogenous state variables Z_t, the realization of the vector of shocks s_t, and calendar time t because the agent fully updates his beliefs in each period and because the shocks are independent over time,

Definition 2. The consumption function in any period t is admissible if it can be written as a function $C_t = g_t(X_t, Z_t, s_t)$ that is strictly increasing in the realization of each shock $\frac{\partial g_t(X_t,Z_t,s_t)}{\partial s_t} > 0$. Repeated substitution of the law of motion, equation (1), and the budget constraint, equation (2), allows me to rewrite $C_{t+\tau} = g_{t+\tau}(X_{t+\tau}, Z_{t+\tau}, S_{t+\tau}) = h^{t}_{t+\tau}(X_t, Z_t, s_t, S_{t+1}, ..., S_{t+\tau})$.

Via the admissible consumption function, I can now explicitly describe the beliefs in the formulas describing contemporaneous and prospective gain-loss utility, that is, equations (5) and (7). For contemporaneous gain-loss utility, contemporaneous consumption C_t and beliefs $F^{t-1}_{C_t}(c)$ are described by $C_t = g_t(X_t, Z_t, s_t) = h^{t-1}_{t}(X_{t-1}, Z_{t-1}, s_{t-1}, s_t)$ and $F^{t-1}_{C_t}(c) = Pr(h^{t-1}_{t}(X_{t-1}, Z_{t-1}, s_{t-1}, S_t) < c)$.

Koszegi and Rabin (2006, 2007) and reported in equation (3), to account for the potential dependence of the distributions of the reference point F_r and consumption F_c, that is,

$$(6) \qquad \boldsymbol{n}(F_{c,r}) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\mu(u(c)-u(r))dF_{c,r}(c,r).$$

If the distributions of the reference point F_r and consumption F_c are independent, equation (6) reduces to equation (3). However, if F_r and F_c are non-independent, equations (6) and (3) yield different values. Suppose that the distributions of the reference point F_r and consumption F_c are perfectly correlated, as though no updates of information occur. The outcome-wise comparison, Equation (3), would yield a negative value because the agent experiences gain-loss disutility over his previously expected uncertainty, which seems unrealistic. In contrast, my generalized comparison, Equation (6), would yield zero value because the agent considers the dependence of prior and updated beliefs, which captures future uncertainty, thereby separating uncertainty that has been realized from uncertainty that has not been realized. Thus, I call this gain-loss formulation the "separated comparison." Koszegi and Rabin (2009) generalize the outcome-wise comparison to a "percentile-wise" ordered comparison. The separated and ordered comparisons are equivalent for contemporaneous gain-loss utility. However, for prospective gain-loss utility, they are qualitatively similar but are quantitatively slightly different. As a linear operator, the separated comparison is more tractable and simplifies the equilibrium-finding process because it preserves the outcome-wise nature of contemporaneous gain-loss utility. As the psychological intuition of the separated comparison is also reasonable, I see this modification as a minor contribution to exploring the preferences.

For prospective gain-loss utility, the probabilistic structure of the beliefs about prospective consumption $C_{t+\tau}$ can be described by $C_{t+\tau} = h^t_{t+\tau}(X_t, Z_t, s_t, S_{t+1}, ..., S_{t+\tau})$ with the joint distribution of the agent's prior and updated beliefs $F^{t,t-1}_{C_{t+.\tau}}(c,r)$ determined by
$F^{t,t-1}_{C_{t+\tau}}(c,r) = Pr(h^t_{t+\tau}(X_{t-1}, Z_{t-1}, s_{t-1}, s_t, S_{t+1}, ..., S_{t+\tau}) < c, h^{t-1}_{t+\tau}(X_{t-1}, Z_{t-1}, s_{t-1}, S_t, S_{t+1}, ..., S_{t+\tau}) < r)$.

In addition, I consider hyperbolic-discounting preferences, as developed by Laibson (1997); the hyperbolic agent's lifetime utility is given by $u(C^b_t) + bE_t[\sum_{\tau=1}^{T-t} \beta^\tau u(C^b_{t+\tau})]$ where $b \in [0,1]$ is the hyperbolic-discount factor. Needless to say, standard preferences, as analyzed by Carroll (2001), Gourinchas and Parker (2002), and Deaton (1991), are a special case of the described models for either the weight of gain-loss versus consumption utility $\eta = 0$ or the hyperbolic-discount factor $b = 1$, and I restrict my focus to $u(\cdot)$ being a hyperbolic absolute risk aversion (HARA) function.[11]

Model equilibrium. I define the model's "monotone-personal" equilibrium in the spirit of the preferred-personal equilibrium solution concept, as defined by Koszegi and Rabin (2009), but within the outlined environment and admissible consumption function as follows.

Definition 3. The family of admissible consumption functions $C_t = g_t(X_t, Z_t, s_t)$ is a monotone-personal equilibrium for the news-utility agent if, in any contingency, $C_t = g_t(X_t, Z_t, s_t)$ maximizes (4) subject to (2) and (1) under the assumption that all future consumption corresponds to $C_{t+\tau} = g_{t+\tau}(X_{t+\tau}, Z_{t+\tau}, s_{t+\tau})$. In each period t, the agent takes his beliefs about consumption $\{F^{t-1}_{C_{t+\tau}}\}^{T-t}_{\tau=0}$ as given in the maximization problem.

The monotone-personal equilibrium can be obtained by simple backward induction; thus, it is time consistent in the sense that beliefs map into correct behavior and vice versa. In other words, I derive the equilibrium consumption function under the premise that the agent enters period t, takes his beliefs as given, optimizes over consumption, and rationally expects to behave in this manner in the future. If I obtain a consumption function by backward induction that is admissible, then the monotone-personal equilibrium corresponds to the preferred-personal equilibrium as defined by Koszegi and Rabin (2009). For the hyperbolic-discounting agent, the monotone-personal equilibrium corresponds to the solution of Laibson (1997). The consistency requirement of the monotone-personal equilibrium concept rules out that the agent may decline first-order stochastically dominated gambles, among other things. As an example, suppose the agent believes he will consume $\bar{c}$ for certain tomorrow and is then offered the lottery $(\bar{c}, 1-p; \bar{c}+\varepsilon, p)$ today, which will resolve tomorrow and first-order stochastically dominates consuming $\bar{c}$. Then, he would compare the expected utility of learning about the gamble today and taking the gamble tomorrow to his expected utility of declining the gamble. Even if the agent would like to decline the gamble, he could not do so because he knows that he would deviate and take the gamble tomorrow as it dominates consuming $\bar{c}$ once the agent takes his beliefs as given. Thus, declining a dominated gamble is not a feasi-

[11] $u(c)$ is a HARA function if its risk tolerance $-\frac{u''(c)}{u'(c)}$ function is linear in consumption c.

ble option under the monotone-personal equilibrium solution concept.[12]

I prove the existence and uniqueness of the monotone-personal equilibrium for an environment assuming exponential utility and permanent and transitory normal shocks under one parameter condition. According to this condition, the joint distribution of the vector of shocks F_{S_t} must be dispersed sufficiently such that the equilibrium consumption functions fall into the class of admissible consumption functions.[13] For other environments, such as power utility and permanent and transitory log-normal shocks, simulations using numerical backward induction suggest that the monotone-personal equilibrium exists and is unique for most reasonable calibrations.[14]

2.2. **Theoretical predictions about consumption.** In the following subsections, I explain the closed-form solution of the exponential-utility model in detail to illustrate the model's predictions formally and intuitively. After briefly outlining the model's monotone-personal equilibrium, I analyze the second-to-last period's decision problem to explain the model's theoretical predictions. In Section 2.2.1, I examine excess smoothness and sensitivity in consumption. In Section 2.2.2, I discuss the hump-shaped consumption profile and in Section 2.2.3, I analyze the consumption drop at retirement. Then, I discuss several more subtle consumption implications and new comparative statics in Section 2.2.4.

I begin by briefly explaining the model's environment and stating the equilibrium consumption function to convey a general impression of the model's solution. The agent's utility function is exponential $u(C) = -\frac{1}{\theta}e^{-\theta C}$, where the coefficient of risk aversion is $\theta \in (0, \infty)$. His additive income process $Y_t = P_{t-1} + S_t^P + S_t^T$ is characterized by a permanent shock $S_t^P \sim N(\mu_{Pt}, \sigma_{Pt}^2)$ with realization s_t^P and a transitory shock $S_t^T \sim N(\mu_{Tt}, \sigma_{Tt}^2)$ with realization s_t^T, and his permanent income is $P_t = P_{t-1} + S_t^P$. As before, I denote the agent's cash-on-hand by X_t, consumption by C_t, and end-of-period asset holdings by $A_t = X_t - C_t$, such that his budget constraint is given by

$$X_{t+1} = (X_t - C_t)(1+r) + Y_{t+1} \Rightarrow A_{t+1} = A_t(1+r) + Y_{t+1} - C_{t+1} \tag{8}$$

where $1 + r$ denotes risk-free interest.

Proposition 1. *A unique monotone-personal equilibrium exists in the finite-horizon exponential-utility model if* $\sqrt{\sigma_{Pt}^2 + (1 - a(T-t))^2 \sigma_{Tt}^2} \geq \sigma_t^*$ *for all* $t \in \{1, ..., T\}$. *The admissible consumption function is*

$$C_t = (1 - a(T-t))(1+r)A_{t-1} + P_{t-1} + \bar{s}_t - a(T-t)\Lambda_t \tag{9}$$

[12] Koszegi and Rabin (2007) prove that agents never take first-order stochastically dominated options in an unacclimating personal equilibrium.

[13] Moreover, in Section 2.2.4 and Appendix B.5.1, I argue that the model's equilibrium is not affected qualitatively or quantitatively, if this condition does not hold.

[14] Carroll (2011) and Harris and Laibson (2002) demonstrate the existence and uniqueness of equilibria for the standard and sophisticated hyperbolic-discounting agents in similar environments. In these models, the equilibrium consumption functions fall in the class of admissible consumption functions.

with $\bar{s}_t$ denoting the realization of the income shocks $\bar{s}_t = s_t^P + (1-a(T-t))s_t^T$, $a(\cdot)$ denoting the annuitization function $a(T-t) = \frac{\sum_{j=0}^{T-t-1}(1+r)^j}{\sum_{j=0}^{T-t}(1+r)^j}$, and the function Λ_t given by

$$\Lambda_t = \frac{1}{\theta} log(\frac{1-a(T-t)}{a(T-t)} \frac{\psi_t + \gamma Q_t \eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_t))}), \tag{10}$$

where the distribution function of the realization of the income shocks $\bar{s}_t$ is denoted by $F_{\bar{S}}(\bar{s}_t) = Pr(S_t^P + (1-a(T-t))S_t^T < \bar{s}_t)$ and ψ_t and Q_t are constants.

The proof of this proposition and all the following ones are found in Appendix B.5 and the optimal consumption function is derived in Appendix B.2.1. All of the following propositions are derived within this model environment and hold in any monotone-personal equilibrium, if one exists. The agent's consumption function, equation (9), depends on his income, assets, horizon, and interest rate, with the latter two captured by the annuitization function. The function Λ_t, equation (10), varies with the income shock realization $\bar{s}_t$ but is independent of permanent income P_t or assets A_t. The standard and hyperbolic-discounting agents' monotone-personal equilibria have the same structure except that the corresponding functions Λ_t^s and Λ_t^b determining consumption vary only with the agents' horizons.

2.2.1. *Excess smoothness and sensitivity in consumption.* Excess smoothness and sensitivity in consumption are two robust empirical observations, which emerged from tests of the permanent income hypothesis. This hypothesis postulates that the marginal propensity to consume out of permanent income shocks is one and that future consumption growth is not predictable using past income. However, numerous studies find that the marginal propensity to consume is less than one because consumption underresponds to permanent income shocks; thus, according to Deaton (1986), consumption is excessively smooth. Moreover, numerous studies find that past changes in income have predictive power for future consumption growth because consumption adjusts with a delay; thus, according to Flavin (1985), consumption is excessively sensitive. Campbell and Deaton (1989) explain how these observations are intrinsically related; consumption underresponds to permanent income shocks, and thus, adjusts with a delay. In this spirit, I define excess smoothness and sensitivity for the exponential-utility model as follows.

Definition 4. Consumption is excessively smooth if $\frac{\partial C_t}{\partial s_t^P} < 1$ everywhere and is excessively sensitive if $\frac{\partial \Delta C_{t+1}}{\partial s_t^P} > 0$ everywhere.

This definition has an empirical analogue given by an ordinary least squares (OLS) regression of period $t+1$ consumption growth on the realization of the permanent shock s^P in periods $t+1$ and t. For the two OLS coefficients β_1 and β_2, Definition 4 implies that consumption is excessively smooth if $\beta_1 = \frac{\partial C_{t+1}}{\partial s_{t+1}^P}|_{s_{t+1}^P = \mu_{Pt+1}} < 1$ and excessively sensitive if $\beta_2 = \frac{\partial \Delta C_{t+1}}{\partial s_t^P}|_{s_t^P = \mu_{Pt}} > 0$.

Proposition 2. *The news-utility agent's consumption is excessively smooth and sensitive.*

First, I verbally explain the intuition for this result and then describe the agent's first-order condition in greater detail to explain the intuition more formally.[15] In simplified terms, the intuition is that in the event of an adverse income shock, unexpected losses in present consumption are more painful than expected reductions in the future. Accordingly, the agent delays unexpected losses in consumption until his expectations have adjusted in the future. The agent prefers to delay losses in present consumption because they are more painful than losses in future consumption that depend on future income shocks and, are thus, somewhat uncertain as future expectations adjust. Because the agent always likes unexpected gains in present consumption, he is subject to a baseline overconsumption problem that is explained in more detail in Section 2.2.2.[16] However, the agent overconsumes less in the event of a favorable income shock because he has a larger utility gain from delaying losses than overconsuming gains. Thus, relative to his baseline consumption, the agent overconsumes in the event of adverse income shocks but underconsumes in the event of favorable income shocks.

To explain this result in greater detail, I flesh out the agent's decision-making problem in the second-to-last period assuming that transitory shocks are absent, that end-of-period asset holdings and permanent income in period $T-2$ are zero $A_{T-2} = P_{T-2} = 0$, and that the permanent income shock is independent and identically distributed (i.i.d.) normal $S^P_{T-1}, S^P_T \sim F_P = N(\mu_P, \sigma_P^2)$ with realizations s^P_{T-1} and s^P_T. In period $T-1$, the agent chooses how much to consume C_{T-1} and save $s^P_{T-1} - C_{T-1}$ according to his first-order condition

$$
\begin{aligned}
(11) \qquad & u'(C_{T-1})(1+\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))) \\
&= (1+r)u'((s^P_{T-1}-C_{T-1})(1+r)+s^P_{T-1})(\psi_{T-1}+\gamma Q_{T-1}\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))).
\end{aligned}
$$

I explain each component in detail. The left-hand side of the first-order condition stems from marginal consumption and contemporaneous gain-loss utility in period $T-1$. While marginal consumption utility $u'(C_{T-1})$ is self-explanatory, I now derive marginal gain-loss utility. When experiencing a utility gain, the agent compares his actual consumption to all consumption outcomes that would have been less favorable and multiplies the differences by the weight of gain-loss versus consumption utility η, that is, $\eta \int_{-\infty}^{C_{T-1}} (u(C_{T-1}) - u(c)) F^{T-2}_{C_{T-1}}(c)$. When experiencing a utility loss, the agent compares his actual consumption to all outcomes that would have been more fa-

[15]Proposition 2 can be generalized to a HARA utility function, arbitrary horizons, and arbitrary income uncertainty.

[16]Koszegi and Rabin (2009) find that the news-utility agent delays surprise losses in consumption but overconsumes surprise gains in a model without previously expected uncertainty. In this no-uncertainty environment, the news-utility agent makes an initial plan that corresponds to a standard agent's plan as the former does not expect to experience any news utility. In turn, the authors find that the news-utility agent overconsumes surprise gains relative to the standard agent's consumption plan. In the same setup, the agent's consumption would also be excessively smooth and sensitive, according to Definition 4, for gains if they are sufficiently large, and thus, are not consumed entirely or if they are expected. In a model in which the news-utility agent expects to receive either good or bad news, the standard agent's consumption plan would not be a feasible equilibrium and the news-utility agent would plan to overconsume in the event of both good and bad news. In such a situation, he plans to overconsume more in the event of bad news and less in the event of good news, and thus, effectively underconsumes the gain, as in my model.

vorable and multiplies the differences by the weight of gain-loss versus consumption utility times the coefficient of loss aversion $\eta\lambda$, that is, $\eta\lambda\int_{C_{T-1}}^{\infty}(u(C_{T-1})-u(c))F_{C_{T-1}}^{T-2}(c)$. Because the agent takes his beliefs as given in the monotone-personal equilibrium, his marginal consumption and marginal contemporaneous gain-loss utility equals $\eta F_{C_{T-1}}^{T-2}(C_{T-1})+\eta\lambda(1-F_{C_{T-1}}^{T-2}(C_{T-1}))$, which can be rewritten as the expression in Equation (11), $\eta(\lambda-(\lambda-1)F_{C_{T-1}}^{T-2}(C_{T-1}))$. This expression can be simplified by replacing the agent's beliefs about consumption $F_{C_{T-1}}^{T-2}(C_{T-1})$ with his beliefs about the income shock $F_P(s_{T-1}^P)$ because any admissible consumption function is increasing in the shock realization.

The first term on the left-hand side of equation (11) is marginal expected consumption and gain-loss utility over future consumption $C_T=(s_{T-1}^P-C_{T-1})(1+r)+s_{T-1}^P+S_T^P$. I denote the expected marginal consumption and gain-loss utility of the income shock by ψ_{T-1}, which equals the expected marginal utility of the income shock $\beta E_{T-1}[u'(S_T^P)]$ plus the expected marginal gain-loss utility of the income shock $\beta E_{T-1}[\eta(\lambda-1)\int_{S_T^P}^{\infty}(u'(S_T^P)-u'(s))dF_P(s)]$.[17] Note that expected gains and losses partly cancel each other out; so that only the overweighted part of the coefficient of loss aversion $\lambda-1$ times the loss utility remains. Consequently, marginal expected consumption and gain-loss utility is $(1+r)u'((s_{T-1}^P-C_{T-1})(1+r)+s_{T-1}^P)\psi_{T-1}$.

The second term on the left-hand side of equation (11) is marginal prospective gain-loss utility over future consumption. I denote the expected marginal utility of the income shock by $Q_{T-1}=\beta E_{T-1}[u'(S_T^P)]$. As the agent's admissible consumption is increasing in the shock realization and he takes his beliefs as given, his marginal prospective gain-loss utility corresponds to the same weighted sum of his beliefs about the income shock $F_P(s_{T-1}^P)$. Then, the agent's optimal consumption is given by

$$C_{T-1}=s_{T-1}^P-\frac{1}{2+r}\frac{1}{\theta}log((1+r)\frac{\psi_{T-1}+\gamma Q_{T-1}\eta(\lambda-(\lambda-1)F_P(s_{T-1}^P))}{(1+\eta(\lambda-(\lambda-1)F_P(s_{T-1}^P)))}). \tag{12}$$

The fraction in equation (12) that is subtracted from the agent's period $T-1$ permanent income, s_{T-1}^P, is increasing in the income shock s_{T-1}^P iff the expected marginal gain-loss utility of the income shock is positive, that is, $\psi_{T-1}>Q_{T-1}$. The expected marginal gain-loss utility $\psi_{T-1}-Q_{T-1}$ is constant because the future reference point adjusts to the current savings plan. In contrast, marginal contemporaneous and prospective gain-loss utility varies with the weighted beliefs about income $\eta(\lambda-(\lambda-1)F_P(s_{T-1}^P))$. Thus, a positive share of future marginal utility is inelastic to the present income shock, which implies that future marginal utility is less sensitive to changes in savings than present marginal utility. Present marginal gain-loss utility is relatively high or low in the event of an adverse or positive shock. In contrast, expected marginal gain-loss utility is constant because the future reference point will have adjusted to the current plan. Thus, the agent consumes relatively more in the event of an adverse shock and relatively less in the event of a positive shock. After all, gain-loss utility is concave as it is proportional to consumption utility and thus requires

[17]Exponential utility implies that $u'(x+y)=u'(x)u'(y)$ and thus works well with additive risk.

to be smoothed out. According to Definition 4, consumption is excessively smooth $\frac{\partial C_{T-1}}{\partial s_{T-1}^P} < 1$ and excessively sensitive $\frac{\partial \Delta C_T}{\partial s_{T-1}^P} > 0$. In contrast, the standard agent's consumption is $C_{T-1}^s = s_{T-1}^P - \frac{1}{2+r}\frac{1}{\theta}log((1+r)Q_{T-1})$, and the hyperbolic agent's consumption is $C_{T-1}^b = s_{T-1}^P - \frac{1}{2+r}\frac{1}{\theta}log((1+r)bQ_{T-1})$. Thus, the consumption of these agents is neither excessively smooth nor excessively sensitive.

To illustrate excess smoothness and sensitivity in greater detail, I now describe the infinite-horizon equilibrium of the exponential-utility model with $T \to \infty$, which is derived in Appendix B.2.2. The infinite-horizon first-order condition normalized by P_t is given by

$$(13) \qquad u'(C_t)(1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_t))) = ru'(rA_t+P_t)(\psi+\gamma Q\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_t))).$$

I now explain each component of equation (13). The left-hand side represents normalized marginal contemporaneous consumption and gain-loss utility. The first part of the right-hand side represents marginal continuation utility $ru'(rA_t+P_t)\psi$ and marginal prospective gain-loss utility $ru'(rA_t+P_t)\gamma Q\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_t))$. In turn, the first-order condition can be solved for optimal consumption using the budget constraint to substitute end-of-period asset holdings. Now suppose $u'(C_t) \approx ru'(rA_t+P_t)Q$; then, it can be seen easily that the realization of the income shock $\bar{s}_t$ introduces variation in the agent's first-order condition iff $\psi > Q$, which, in turn, introduces excess smoothness and sensitivity. The intuition is that expected marginal gain-loss utility contained in $\psi - Q$ is constant as future expectations adjust. In contrast, present marginal gain-loss utility is either high or low in the event of an adverse or favorable income realization and the news-utility agent consumes relatively more or less because he wants to smooth out gain-loss utility that is concave as consumption utility.

To illustrate the quantitative implications of excess smoothness and sensitivity, I run the linear regression of consumption growth on income growth $\Delta C_{t+1} = \alpha + \beta_1 \Delta Y_{t+1} + \beta_2 \Delta Y_t + \varepsilon_{t+1}$. For the news-utility model, I obtain an OLS coefficient on lagged income growth of $\beta_2 \approx 0.18$ and a marginal propensity to consume out of permanent shocks of approximately 71%.[18] By contrast, for the standard model, this marginal propensity is one.[19]

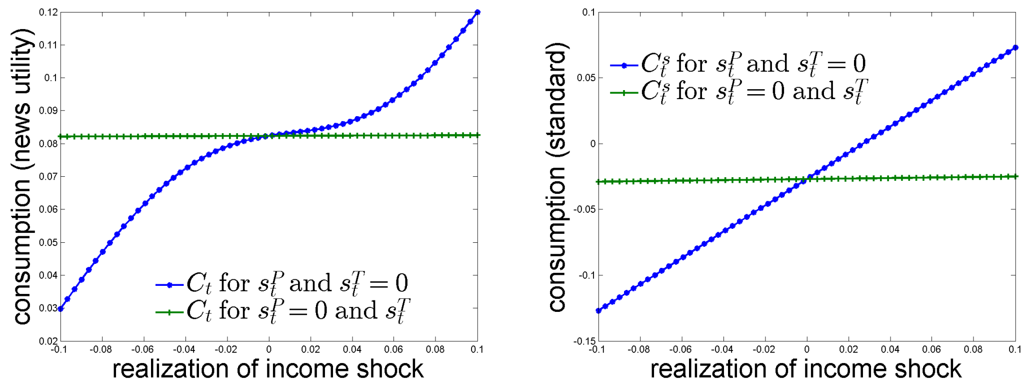
For illustration, Figure 1 displays the news-utility and standard agents' consumption functions for realizations within 2 standard deviations of each shock, while the other is held constant. The flatter part of the news-utility consumption function generates excess smoothness and sensitivity.

2.2.2. *The hump-shaped consumption profile.* Fernandez-Villaverde and Krueger (2007), among

[18] I retain the normal income process outlined in Section 2.2 assuming that permanent and transitory shocks are i.i.d. such that income equals $Y_t = P_{t-1} + s_t^P + s_t^T \sim N(P_{t-1} + \mu_P + \mu_T, \sigma_P^2 + \sigma_T^2)$. The calibration is found in the caption of Figure 1.

[19] Running the regression $\Delta C_{t+1} = \alpha + \beta_1 (s_{t+1}^P - \mu_P) + \beta_2 \Delta(s_t^P - \mu_P) + \varepsilon_{t+1}$ yields $\beta_1^s \approx 1$ and $\beta_2^s \approx 0$ in the standard model and $\beta_1 \approx 0.71$ and $\beta_2 \approx 0.31$ in the news-utility model. The transitory shock introduces a spurious negative correlation between consumption growth ΔC_{t+1} and income growth ΔY_t because $\Delta Y_{t+1} = s_{t+1}^P + s_{t+1}^T - s_t^T$ and $\Delta Y_t = s_t^P + s_t^T - s_{t-1}^T$.

FIGURE 1. **EXPONENTIAL-UTILITY CONSUMPTION FUNCTIONS**



In this figure, I display the news-utility and standard agents' consumption functions for realizations within 2 standard deviations of each shock, while the other is held constant. I choose the agent's horizon T, his retirement period R, the interest rate r, and the volatility of the income process (to roughly generate the volatility of the log-normal income process that is typically used) in accordance with the life-cycle literature; $\mu_P = \mu_T = 0$, $\sigma_P = 5\%$, $\sigma_T = 7\%$, $r = 2\%$, , $A_0 = 0$, and $P_0 = 0.1$. Additionally, I choose the preference parameters in line with the microeconomic literature and experimental evidence, which is explained in detail in Section 2.3.2, $\beta = 0.978$, $\theta = 2$, $\eta = 1$, $\lambda = 2$, and $\gamma = 0.75$.

others, show that lifetime consumption profiles are hump-shaped, even when controlling for cohort, family size, number of earners, and time effects.[20] In the following subsection, I demonstrate that the preferences generate a hump-shaped consumption profile as the net result of two competing features–an additional first-order precautionary-savings motive and an overconsumption problem exacerbated by the agent's prospective gain-loss discount factor γ. I explain both of these within the second-to-last period setting in Section 2.2.1.

Precautionary savings and prospective news discounting. Income uncertainty has a first-order effect on savings in the news-utility model. This "first-order precautionary-savings motive" is added to the precautionary savings motive of the standard agent, which is a second-order motive.[21]

Definition 5. A first-order precautionary-savings motive exists iff $\frac{\partial(s_{T-1}^P - C_{T-1})}{\partial \sigma_P}|_{\sigma_P=0} > 0$.

At the same time, the agent wishes to increase his consumption and decrease his savings because he has an overconsumption problem and discounts prospective gain-loss utility relative to contemporaneous gain-loss utility if $\gamma < 1$. Lemma 1 formalizes these conflicting effects.

Lemma 1.

1. Precautionary savings: news utility introduces a first-order precautionary-savings motive.

[20] Moreover, Fernandez-Villaverde and Krueger (2007) find suggestive evidence that non-separability between consumption and leisure, which was promoted by Attanasio (1999) and previous studies, cannot explain more than 20% of the hump in consumption.

[21] This result is highlighted by Koszegi and Rabin (2009) in a two-period, two-outcome model but can be generalized to any HARA utility function, arbitrary horizons, and labor income uncertainty.

2. Implications for consumption growth: there exists an upper bound for the discount factor on prospective versus contemporaneous gain-loss utility $\bar{\gamma}^s < 1$, implicitly determined by equalizing news-utility and standard consumption growth $\Delta C_T = \Delta C_T^s$, such that, iff $\bar{\gamma}^s < \gamma$, the news-utility agent's consumption growth in period T is higher than the standard agent's consumption growth for any realization of the permanent and transitory income shocks s_{T-1}^P and s_T^P, and $\frac{\partial \bar{\gamma}^s}{\partial \sigma_P} < 0$.

The intuition for the first part of Lemma 1 is as follows. The agent anticipates being exposed to gain-loss fluctuations in period T, which are painful in expectation because losses hurt more than gains give pleasure. In addition, the painfulness of these fluctuations is proportional to marginal consumption utility, which is reduced higher up the concave utility curve. Thus, the agent has an additional incentive to increase savings. I now develop a more formal intuition for the standard and additional precautionary-savings motive and demonstrate that expected marginal gain-loss utility is positive, that is, $\psi_{T-1} > Q_{T-1}$. As shown in Section 2.2.1, the marginal value of savings is $(1+r)u'((s_{T-1}^P - C_{T-1})(1+r) + s_{T-1}^P)\psi_{T-1}$, where ψ_{T-1} equals the expected marginal consumption plus expected marginal gain-loss utility of the income shock

$$(14) \qquad \beta E_{T-1}[u'(S_T^P)] + \beta E_{T-1}[\eta(\lambda-1)\int_{S_T^P}^{\infty}(u'(S_T^P) - u'(s))dF_P(s)].$$

The integral in equation (14) reflects the expected marginal utility of all gains and losses, which partly cancel each other out, such that only the overweighted component of the losses remains, that is, the weight of gain-loss versus consumption utility times the overweighted coefficient of loss aversion $\eta(\lambda-1)(\cdot)$. The key point is that this integral is always positive if utility is concave, $u'' < 0$. Thus, it captures the additional precautionary-savings motive, which implies that the expected marginal gain-loss utility is positive $\psi_{T-1} - Q_{T-1} > 0$ and is increasing in the weight of gain-loss versus consumption utility η, the coefficient of loss aversion λ, and income uncertainty σ_P. This precautionary-savings motive is first order, that is, $\frac{\partial(s_{T-1}^P - C_{T-1})}{\partial \sigma_P}|_{\sigma_P=0} > 0$, because the news-utility agent is first-order risk averse. In contrast, the standard precautionary-savings motive is captured by the expected marginal utility of the income shock $Q_{T-1} = \beta E_{T-1}[u'(S_T^P)]$, which is larger than the marginal utility of the expected income shock $\beta u'(E_{T-1}[S_T])$ if the utility function is prudent $u''' > 0$, according to Jensen's inequality. This standard precautionary-savings motive is second order, that is, $\frac{\partial(s_{T-1}^P - C_{T-1})}{\partial \sigma_P}|_{\sigma_P=0} = 0$, as the standard agent is second-order risk averse.[22]

The intuition for the second part of Lemma 1 is as follows. The agent is subject to time-inconsistent overconsumption because the monotone-personal equilibrium assumes that the agent wakes up

[22]As shown by Benartzi and Thaler (1995) and Barberis et al. (2001), first-order risk aversion resolves the equity premium puzzle highlighting that agents must have implausibly high second-order risk aversion to reconcile the historical equity premium because aggregate consumption is smooth compared with asset prices. The excess-smoothness puzzle highlights that aggregate consumption is overly smooth compared to labor income, and again, first-order instead of second-order risk aversion is a necessary ingredient for resolving the puzzle. In a canonical asset-pricing model, Pagel (fthc) demonstrates that news-utility preferences constitute an additional step towards resolving the equity-premium puzzle as they match the historical level and the variation of the equity premium while simultaneously implying plausible attitudes towards small and large wealth gambles.

in any period, takes his expectations as given, and optimizes over consumption. Thus, the agent prefers to enjoy the pleasant surprise of increasing present consumption above expectations instead of increasing both his future consumption and expectations. However, when the future arrives, he takes his expectations as given, and thus, puts a different weight on marginal consumption utility than at present. This problem is exacerbated if the discount factor on prospective versus contemporaneous gain-loss utility is smaller than 1, $\gamma < 1$, which implies that the agent is more concerned about contemporaneous than prospective gain-loss utility. Thus, he wishes to increase his consumption and decrease his savings. Consequently, the presence of news utility might increase or decrease consumption relative to the standard model depending on the net effect of two parameters, the uncertainty about permanent income $\sigma_P > 0$ and the prospective gain-loss discount factor $\gamma < 1$.

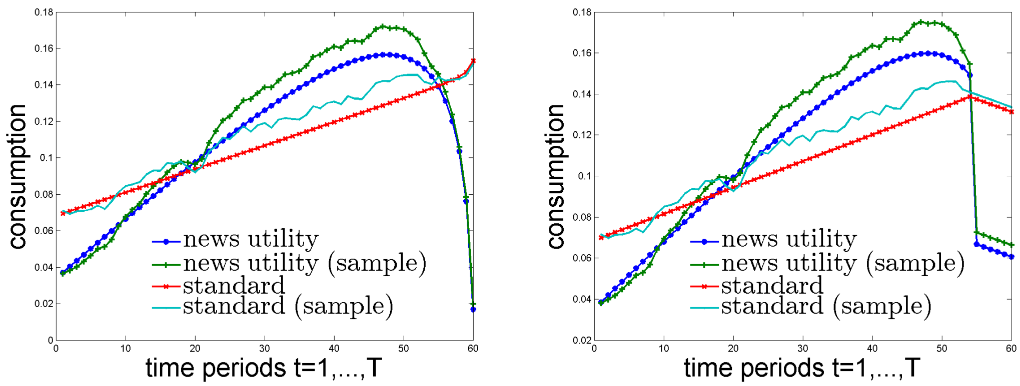
The resulting hump-shaped consumption profile. The two competing news-utility features–the additional precautionary-savings motive and the overconsumption problem–make it likely that the life-cycle consumption profile is hump shaped because the precautionary-savings motive accumulates with income uncertainty as the agent's horizon increases.

Definition 6. The agent's consumption profile is hump shaped if consumption is increasing at the beginning of life $\Delta C_1 > 0$ and decreasing $\Delta C_T < 0$ at the end of life.

Proposition 3. *Suppose permanent income uncertainty $\sigma_{Pt} = \sigma_P$ for all t and T is large; then, a σ_P in $[\underline{\sigma_P}, \overline{\sigma_P}]$ exists such that, if $\gamma < 1$, $log((1+r)\beta) \in [-\triangle, \triangle]$, and $\triangle$ is small, the news-utility agent's lifetime consumption path is hump shaped.*

The basic intuition is illustrated in Lemma 1. The relative strengths of the additional precautionary-savings motive and the overconsumption problem exacerbated by the discount factor on prospective versus contemporaneous news utility $\gamma < 1$ determine whether the presence of gain-loss utility increases or decreases the news-utility agent's consumption relative to the standard model. Toward the end of life, the additional precautionary-savings motive is relatively small and the discount factor on prospective versus contemporaneous news utility $\gamma < 1$ is likely to decrease consumption growth. However, when the agent's horizon increases the precautionary-savings motive accumulates because uncertainty accumulates; hence, at the beginning of life, the presence of gain-loss utility is likely to reduce consumption and increase consumption growth unless γ is very small. More formally, the two conditions on consumption growth, $\Delta C_{t+1} \lesseqgtr 0$, reduce to the function that adds on to consumption, $\Lambda_t \lesseqgtr 0$, as the agent's horizon $T-t$ becomes small or large. The sign of Λ_t is determined by the relative values of the expected marginal gain-loss utility, $\frac{\psi_t}{Q_t} > 1$, and the discount factor on prospective versus contemporaneous news utility $\gamma < 1$. If the agent's horizon $T-t$ is small, $\frac{\psi_t}{Q_t}$ is small, such that $\gamma < 1$ is likely to cause the function that adds on to consumption Λ_t to be negative. However, as $T-t$ increases, $\frac{\psi_t}{Q_t}$ increases, such that $\gamma < 1$ loses relative importance and Λ_t is more likely to be positive as ψ_t increases at a first-order rate and faster than Q_t.

FIGURE 2. **EXPONENTIAL-UTILITY LIFE-CYCLE PROFILES**



This figure displays the news-utility and standard agents' life-cycle consumption profiles; both the average consumption profiles of a sample of 300 identical agents, who encounter different realizations of the permanent and transitory income shocks s_t^P and s_t^T, and the consumption profiles if $s_t^P = 0$ and $s_t^T = 0$ for all t. I use the same calibration as in Section 2.2.1 explained in the caption of Figure 1.

Figure 2 displays the news-utility and standard agents' life-cycle consumption profiles. The figure displays the average consumption profile of a sample of 300 identical agents who encounter different realizations of the permanent and transitory income shocks s_t^P and s_t^T, and the consumption profile of one agent for whom $s_t^P = 0$ and $s_t^T = 0$ for all t. As can be observed from Figure 2, the news-utility agent's consumption profile is hump shaped, that is, consumption increases in the beginning but decreases toward the end of life. This hump is very robust for different parameter choices, which I discuss in Section 2.3.2. In contrast, the standard agent's profile is V-shaped, which demonstrates that exponential utility and a random-walk income process do not promote the desired hump. Moreover, Figure 2 displays the hump in the presence of a retirement period that induces a fairly different-looking consumption profile toward the end of life, which I explain next.

2.2.3. *Consumption during and at the start of retirement.*

Consumption during retirement. I now add a retirement period at the end of life. More specifically, I assume that in periods $t \in \{T-R, ..., T\}$, the agent earns his permanent income without uncertainty. First, I formalize a general prediction of the news-utility agent's consumption during retirement, i.e., $C_{T-R+0,1,2,...}$.[23]

Proposition 4. *If uncertainty is absent, the monotone-personal equilibrium of the news-utility agent correspond to the standard agent's equilibrium iff the discount factor on prospective versus contemporaneous gain-loss utility is weakly larger than the inverse of the coefficient of loss aversion $\gamma \geq \frac{1}{\lambda}$. Iff $\gamma < \frac{1}{\lambda}$ then the monotone-personal equilibrium of the news-utility agent corresponds to a hyperbolic-discounting agent's monotone-personal equilibrium with the hyperbolic-*

[23]This generalizes a result obtained by Koszegi and Rabin (2009) in a two-period model and can be further generalized to any HARA utility function.

discount factor given by $b = \frac{1+\gamma\eta\lambda}{1+\eta}$.

The news-utility agent is likely to follow the standard agent's path if uncertainty is absent and if the agent's prospective gain-loss discount factor is high enough. The basic intuition is that when the agent decides to increase present consumption, he also considers a certain loss in future consumption, which is very painful. Thus, unless the agent discounts prospective gain-loss utility significantly, he decides to not increase present consumption. More formally, suppose that the agent allocates his deterministic cash-on-hand between present consumption C_{T-1} and future consumption C_T. Under rational expectations, he cannot fool himself; hence, he cannot experience actual gain-loss utility in equilibrium in a deterministic model. Accordingly, his expected utility maximization problem corresponds to the standard agent's maximization problem determined by equalizing marginal consumption utilities in the present and future with the discount factor and interest rate $u'(C_{T-1}) = \beta(1+r)u'(C_T)$. Suppose that the agent's beliefs about consumption in both periods correspond to this equilibrium path. Taking his beliefs as given, the agent deviates if the gain from consuming more currently exceeds the discounted loss from consuming less in the future, that is,

$$u'(C_{T-1})(1+\eta) > \beta(1+r)u'(C_T)(1+\gamma\eta\lambda).$$

Thus, he follows the standard agent's path iff the discount factor on prospective versus contemporaneous gain-loss utility is weakly larger than the inverse of the coefficient of loss aversion, $\gamma \geq \frac{1}{\lambda}$, because the pain of the certain loss in future consumption is greater than the pleasure gained from present consumption. However, if $\gamma < \frac{1}{\lambda}$, the agent deviates and has to choose a consumption path that just meets the consistency constraint, thereby behaving as a hyperbolic-discounting agent with hyperbolic discount factor $b = \frac{1+\gamma\eta\lambda}{1+\eta} < 1$. Thus, during retirement, the implications of the agent's prospective gain-loss discount factor γ are simple: it needs to be sufficiently high to keep the agent on the standard agent's track.

The drop in consumption at retirement. The empirical evidence on the prevalence of a drop in consumption at retirement is a topic of debate in the literature. While a series of studies, summarized in Attanasio and Weber (2010), have found that consumption drops at retirement, Aguiar and Hurst (2005) cannot confirm this finding when controlling for the sudden reduction of work-related expenses, the substitution of home production for market-purchased goods and services, and health shocks. In my data, I find such a drop in consumption at retirement even for non-work-related spending. Moreover, I think that the evidence provided by Schwerdt (2005) is compelling because the author explicitly controls for home production and focuses on German retirees, who receive large state-provided pensions, which require little self organization, and for whom health is a complement to consumption owing to proper health insurance. Moreover, Ameriks et al. (2007) and Hurd and Rohwedder (2003) provide evidence that the drop in consumption is anticipated. First, I define a drop in consumption as follows.

Definition 7. A drop in consumption at retirement occurs if consumption growth at retirement ΔC_{T-R} is negative and smaller than consumption growth after retirement ΔC_{T-R+1}.

For example, suppose the prospective gain-loss discount factor is weakly larger than the inverse of the coefficient of loss aversion $\gamma \geq \frac{1}{\lambda}$, in which case the news-utility agent's post-retirement consumption growth is close to zero equaling that of the standard agent, that is, $\frac{1}{\theta}log(\beta(1+r)) \approx 0$. By contrast, consumption growth at the start of retirement is negative for the news-utility agent but not the standard agent, that is, $\frac{1}{\theta}log(\beta(1+r)) + \frac{1}{\theta}g^s < 0$ as $g^s \in \{log(\frac{1+\gamma\eta\lambda}{1+\eta\lambda}), log(\frac{1+\gamma\eta}{1+\eta})\} < 0$.[24]

Proposition 5. *If the prospective gain-loss discount factor is less than 1,* $\gamma < 1$*,* $log((1+r)\beta) \in [-\triangle, \triangle]$*, and* $\triangle$ *is small, the news-utility agent's monotone-personal consumption path is characterized by a drop at retirement.*

After the start of retirement, the agent is less inclined to overconsume than before. The basic intuition for overconsumption in the pre-retirement period is that the agent allocates house money, that is, labor income that he was not certain that he would receive, and thus, wants to consume before his expectations catch up, iff the prospective gain-loss discount factor is less than one, $\gamma < 1$. During retirement, the agent associates a certain loss in future consumption with an increase in present consumption. In contrast, in the pre-retirement period, the agent finds the loss in future consumption merely as painful as a slightly less favorable realization of his labor income, that is, the agent trades off being somewhere in the gain domain currently versus being somewhere in the gain domain in the future instead of a sure gain currently with a sure loss in the future. The agent's first-order condition in period $T-1$ in the absence of uncertainty in period T is given by

$$(15) \quad u'(C_{T-1})(1+\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))) = \beta(1+r)u'(C_T)(1+\gamma\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))).$$

In equation (15), it can be seen immediately that iff the prospective gain-loss discount factor equals 1, $\gamma = 1$, contemporaneous and prospective marginal gain-loss utility cancel each other out. However, iff $\gamma < 1$, the agent reduces the weight on future utility relative to present utility by a factor between $\frac{1+\gamma\eta\lambda}{1+\eta\lambda} < \frac{1+\gamma\eta}{1+\eta} < 1$. During retirement, the news-utility agent follows the standard agent's consumption path if the prospective gain-loss discount factor γ is sufficiently high and otherwise follows a hyperbolic-discounting agent's consumption path with discount factor $b = \frac{1+\gamma\eta\lambda}{1+\eta}$. Because $min\{\frac{1+\gamma\eta\lambda}{1+\eta}, 1\} > \frac{1+\gamma\eta}{1+\eta}$ iff $\gamma < 1$, the agent's factor that reduces the weight on future utility is necessarily lower in the pre-retirement period than during retirement, which implies that consumption drops at the start of retirement.[25] The other agents' consumption paths do not exhibit such a drop. Quantitatively, Figure 2 displays a noticeable drop in news-utility consumption at re-

[24] This and the following results can be generalized to a HARA utility function, arbitrary horizons, and arbitrary income uncertainty.

[25] The drop in consumption is robust to uncertainty becoming small in the pre-retirement period even if the agent chooses a flat consumption profile as described in Section 2.2.4.

tirement.

The assumption of no uncertainty during retirement is made in all standard life-cycle consumption models, as these are abstracted from portfolio choice; thus, the drop in consumption at retirement is a necessary artifact of news-utility preferences in the standard environment. However, the drop is robust to three alternative assumptions: small income uncertainty during retirement due to, for instance, inflation risk; potentially large discrete income uncertainty, due to, for instance, health shocks; or mortality risk.[26] Furthermore, if I were to observe a consumption path that is much flatter during retirement than before retirement and interpret this observation from the perspective of the standard model, I may conclude that the agent does not decumulate assets sufficiently rapidly after retirement compared to his pre-retirement asset decumulation. Such a lack of asset decumulation during retirement constitutes another life-cycle consumption puzzle that is observed by Hurd (1989), Disney (1996), and Bucciol (2012) and explained by the model.[27]

Excess smoothness and sensitivity of consumption in the pre-retirement period. I now outline an additional result about excess smoothness and sensitivity of consumption in the pre-retirement period.[28] I refer to excess smoothness and sensitivity again because the intuition explained in Section 2.2.1 is based on no uncertainty being associated with the bad news in present consumption but uncertainty being associated with the bad news in future consumption as future expectations adjust. Because uncertainty is absent after the start of retirement, this intuition is not applicable in the pre-retirement period. Nevertheless, consumption is excessively smooth and sensitive in the pre-retirement period iff the prospective gain-loss discount factor is smaller than 1, that is, $\gamma < 1$. Quantitatively, the first intuition about the adjustability of expectations brings about the bulk of excess smoothness and sensitivity in consumption.

Corollary 1. *Iff the prospective gain-loss discount factor is less than 1, $\gamma < 1$, the news-utility agent's monotone-personal equilibrium consumption is excessively smooth and sensitive in the pre-retirement period.*

[26] The drop in consumption is due to the fact that the agent overconsumes before retirement but consumes efficiently after retirement. If income uncertainty is very small, the agent is credibly able to plan a flat consumption level independent of the realization of his income shock because the benefits of smoothing consumption perfectly do not warrant the decrease in expected utility from experiencing gain-loss utility. In such a small-uncertainty situation, the agent is able to stick to a flat consumption level that induces less overconsumption after retirement than before retirement, such that consumption drops. I formally explain this result about overconsumption in Section 2.2.4. Moreover, discrete uncertainty after retirement induces less overconsumption than before retirement for the same reason that no uncertainty causes less overconsumption. If uncertainty is discrete, overconsumption is associated with a discrete gain in present consumption and a discrete loss in future consumption. Because the discrete loss hurts more than the discrete gain, the agent may credibly plan a consumption level that induces less overconsumption than the baseline continuous-outcome equilibrium. Finally, mortality risk does not affect the result because the agent would not experience gain-loss utility relative to being dead.

[27] In addition this can be explained by bequest motives (Hurd (1989)) and medical expenditures shocks (Nardi et al. (2011)).

[28] This result can be generalized to a HARA utility function, arbitrary horizons, and arbitrary income uncertainty.

Iff the prospective gain-loss discount factor is less than 1, $\gamma < 1$, the agent cares more about contemporaneous than prospective gain-loss utility, and thus, overconsumes in the presence of uncertainty, as explained in the beginning of Section 2.2.2. Moreover, the agent overconsumes more when experiencing a relatively bad realization because losses are overweighted and he can effectively reduce his sense of loss by delaying the cut in consumption. Because the agent overconsumes relatively more in the event of a bad shock and relatively less in the event of a good shock, consumption is excessively smooth and sensitive. Mathematically, the agent behaves like a hyperbolic-discounting agent, weighting future consumption by a factor $b \in \{\frac{1+\gamma\eta\lambda}{1+\eta\lambda}, \frac{1+\gamma\eta}{1+\eta}\} < 1$. Thus, the agent's weight on future consumption is particularly low when the income realization is relatively bad, that is, $F_P(s^P_{T-1}) \approx 0$. In turn, variation in $F_P(s^P_{T-1})$ leads to variation in consumption growth as in Section 2.2.1. Moreover, for any weight of gain-loss versus consumption utility η and coefficient of loss aversion λ, consumption is more excessively smooth and sensitive if the prospective gain-loss discount factor γ is low.

2.2.4. *Discussion and new predictions about consumption.* Many different explanations exist for excess smoothness and sensitivity, the hump-shaped consumption profile, and the drop in consumption at retirement as reviewed in Section 1. One of the contributions of this study is that it uses a single calibration to provide a parsimonious and unified explanation, which appears very robust toward different choices of parameter values and different assumptions about the model environment. Loss aversion and present bias have been documented empirically for poor, rich, as well as professional individuals (see Angner and Loewenstein (fthc), DellaVigna (2009), and Barberis (2013)). If a rich household is somewhat less loss averse or present biased than the average household, the consumption profile predicted by the model would still feature excess smoothness, a hump shape, and a drop at retirement, although all of these features would be somewhat smaller in magnitude. This is quite consistent with the empirical evidence. Although the evidence seems to be less strong for rich households, the literature does not find that rich households' consumption does not feature excess smoothness, a hump, or a drop at retirement. As discussed in Jappelli and Pistaferri (2010), the evidence is very mixed for whether households not constrained in their borrowing have excessively smooth consumption and whether excess smoothness is asymmetric. Gourinchas and Parker (2002) and Fernandez-Villaverde and Krueger (2007) document a hump-shaped consumption profile throughout all income and occupation classes controlling for time, cohort, and family size effects, but find that consumption peaks later for rich households. Bernheim et al. (2001) find that the drop in consumption for the top wealth quartile is only half of the drop in consumption for the bottom wealth quartile but both drops are individually significant at high levels of confidence. Nevertheless, at least the variation in the hump shape could be explained by other theoretical explanations, such as hyperbolic discounting and illiquid savings, as proposed by Laibson et al. (2012), an incomplete planning horizon, as proposed by Park (2011), and overconfidence, as proposed by Caliendo and Huang (2008). Given this wealth of explanations, I will now highlight several additional news-utility predictions for consumption, which are new and testable comparative statics.

First, I explain the agent's consumption function, equation (9), in detail to highlight some subtle predictions about how the marginal propensity to consume varies with the realization of the permanent and transitory shocks and the agent's horizon. To explain the consumption function, I assume that the agent's horizon $T-t$ is large, such that the annuitization factor $a(T-t) \approx \frac{1}{1+r}$. Then, in each period t, the agent consumes the interest payments of his last period's asset holdings rA_{t-1}, his entire permanent income $P_{t-1}+s_t^P$, and the per-period value of his temporary shock $\frac{r}{1+r}s_t^T$. In addition, optimal consumption depends on the function Λ_t, which captures the agent's patience compared to the market, his precautionary savings, and his marginal gain-loss utility. In the event of a negative shock, Λ_t is low and the agent consumes more out of his end-of-period asset holdings, and thus, spreads the consumption adjustment to his entire future. The function Λ_t varies more with the permanent shock than with the transitory shock because marginal gain-loss utility varies with the distribution function of consumption $F_{C_t}^{t-1}(C_t)$, which varies little with the transitory shock as the agent consumes only the per-period value of the transitory shock $\frac{r}{1+r}s_t^T$ and $\frac{r}{1+r}$ is small. This observation constitutes the first novel prediction of the news-utility model: consumption is more excessively sensitive for permanent shocks than for transitory shocks in an environment with permanent shocks. This prediction is seen in Figure 1. However, in an environment with transitory shocks alone, news-utility consumption is excessively sensitive with respect to transitory shocks. This prediction could be tested empirically by comparing the consumption responses of individuals who are exposed mainly to transitory shocks, such as cab drivers or waiters, and those who are exposed to transitory and permanent shocks, such as white-collar workers. News utility would predict that cab drivers exhibit excessively smooth consumption in response to transitory income shocks, as shown by Crawford and Meng (2011), while white-collar workers do not. This prediction is different from the prediction of borrowing constraints, which does not differentiate between permanent or transitory shocks. Moreover, it is not necessarily predicted by inattention, as proposed by Reis (2006), adjustment costs, as proposed by Chetty and Szeidl (2010), or incomplete consumption insurance, as proposed by Attanasio and Pavoni (2011).

A second prediction is that any bell-shaped shock distribution induces bounded variation in the function determining optimal consumption Λ_t, and thus, the agent's excess sensitivity. If the agent is affected by a tail realization, the actual value of the low-probability shock matters less because neighboring states have very low probability; thus, the variation in Λ_t is bounded. A third prediction is that consumption is more excessively smooth when the agent's horizon increases for two reasons: first, the marginal propensity to consume out of permanent shocks declines when the precautionary-savings motive accumulates, and second, the annuitization factor $a(T-t)$ is increasing in the agent's horizon $T-t$. In contrast, excess sensitivity is not proportional to $a(T-t)$, such that consumption is relatively less excessively sensitive when the agent's horizon increases.

The last prediction can be tested empirically by comparing the excess smoothness and sensitivity in consumption of young and old households, which is done in Section 2.3.2. A young household's consumption should be excessively smooth but not too excessively sensitive. An old household's consumption should be somewhat excessively smooth and excessively sensitive. If young households are more borrowing constrained, then, such empirical evidence can distinguish between news utility, borrowing constraints, inattention, adjustment costs, and consumption insurance.

Another easily testable prediction is that the degree of excess smoothness and sensitivity is decreasing in permanent income uncertainty, σ_P. If σ_P is small, the agent's beliefs change more rapidly relative to the change in the realization of the shock; hence, the consumption function is flatter for realizations around the expected value of the permanent income shock, μ_P. This prediction could actually result in the consumption function being flat over some range if permanent income uncertainty σ_p is small.[29] To formally describe this result about flat consumption, I return to the two-period, one-shock model of Section 2.2.1. Suppose that the realization of the income shock, s^P_{T-1}, increases; then, holding consumption C_{T-1} constant, the marginal value of savings declines and the agent's first-order condition implies that present consumption should increase. However, the value of the cumulative distribution of the income shock $F_P(s^P_{T-1})$ also increases, and marginal gain-loss utility is lower, such that current optimal consumption should decrease. Suppose that the realization of the income shock, s^P_{T-1}, increases marginally but $F_P(s^P_{T-1})$ increases sharply, which could occur if F_P is a very narrow distribution. In this case, the lower marginal gain-loss utility that decreases consumption dominates the increase in savings that increases consumption, such that the first-order condition predicts decreasing consumption over some range in the neighborhood of the expected value μ_P, where the distribution function F_P increases most sharply if F_P is bell shaped. However, a decreasing consumption function cannot be an equilibrium because the agent would unnecessarily experience gain-loss utility over the decreasing part of consumption, which, in turn, decreases expected utility as losses are overweighted. Thus, the agent could increase expected utility by choosing a flat consumption function instead of a decreasing consumption function to not experience any gain-loss utility in that region. In such a situation, he does not respond to shocks at all, that is, his consumption is perfectly excessively smooth and sensitive, which resembles borrowing constraints or adjustment costs to consumption. Moreover, the agent may choose a credible consumption plan with a flat section, which induces less overconsumption than the original plan. Suppose the agent chooses a flat consumption level for realizations of the income shock s^P_{T-1} in some range $\underline{s}$ and $\overline{s}$. Then, $\overline{s}$ is chosen where the original consumption function just stops decreasing, which corresponds to the lowest possible level of the flat section of consumption $\overline{C}_{T-1}$, which I explicitly describe in Appendix B.5.1. Moreover, in Appendix B.5.1, I show that the agent's consistency constraint for not increasing consumption beyond $\overline{C}_{T-1}$ for any realization of the income shock $s^P_{T-1} \in [\underline{s}, \overline{s}]$ always holds. Thus, I can conclude

[29]This prediction about flat consumption is also highlighted by Heidhues and Koszegi (2008).

that flat consumption results in less overconsumption than the baseline equilibrium. To empirically distinguish this prediction from borrowing constraints, inattention, or adjustment costs, one could check whether households with little income uncertainty, such as tenure-track academics, seem to have flat consumption and suffer less from overconsumption problems despite a lack of borrowing constraints.

Empirically, there is abundant laboratory and field evidence for time-inconsistent overconsumption, preference reversals, and demand for commitment devices.[30] In addition, theoretically, the hyperbolic-discounting model of Laibson et al. (2012) is very successful in explaining life-cycle consumption. While hyperbolic-discounting preferences do not generate excess smoothness and sensitivity in consumption per se, they induce borrowing constraints to bind much more often. However, the news-utility time inconsistency is observationally distinguishable from hyperbolic-discounting preferences. First, news utility introduces an additional precautionary-savings motive that is absent in the hyperbolic-discounting model. Second, because of this precautionary-savings motive, the news-utility agent does not have a universal desire to pre-commit himself to the standard agent's consumption path, in contrast to hyperbolic-discounting preferences. Third, news utility predicts that the agent's degree of present bias is reference dependent and lower in bad times. Intuitively, increasing consumption in bad times is a best response. Fourth, the news-utility agent's degree of present bias depends on the uncertainty he faces. In the absence of uncertainty, the agent's present bias is absent so long as the prospective gain-loss discount factor is weakly larger than the inverse of the coefficient of loss aversion $\gamma \geq \frac{1}{\lambda}$, as explained in Section 2.2.3. In the presence of small or discrete uncertainty, the agent's degree of present bias is less than in the presence of large and dispersed uncertainty. The third and fourth prediction could be tested empirically or in the laboratory with on-the-spot consumption as in Pagel and Zeppenfeld (2014).

2.3. **Quantitative predictions about consumption.** In the following subsection, I assess whether the model's quantitative predictions match the empirical evidence. To demonstrate that all of the predictions hold in model environments that are commonly assumed in the life-cycle consumption literature, I present the numerical implications of a power-utility model, that is, $u(C) = \frac{C^{1-\theta}}{1-\theta}$ with θ being the coefficient of constant relative risk aversion.[31] In Section 2.3.1, I first outline the power-utility model. In Section 2.3.2, I then structurally estimate the power-utility model's parameters, compare my estimates with those in the microeconomic literature, and show that my estimates generate the degree of excess sensitivity and smoothness found in aggregate data.

2.3.1. *The power-utility model.*

[30] See, for example, DellaVigna (2009), Frederick et al. (2002), or Angeletos et al. (2001) for a survey of the theory and empirical evidence.

[31] The power-utility model cannot be solved analytically, but it can be solved by numerical backward induction, as shown by Gourinchas and Parker (2002) or Carroll (2001), among others. The numerical solution is illustrated in greater depth in Appendix B.6.4.

The income processes and model environment. I follow Carroll (1997) and Gourinchas and Parker (2002), who specify income Y_t to be log-normal and characterized by deterministic permanent income growth G_t, permanent shocks N_t^P, and transitory shocks N_t^T, which allow for a low probability p of unemployment or illness

$$Y_t = P_t N_t^T = P_{t-1} G_t N_t^P N_t^T$$

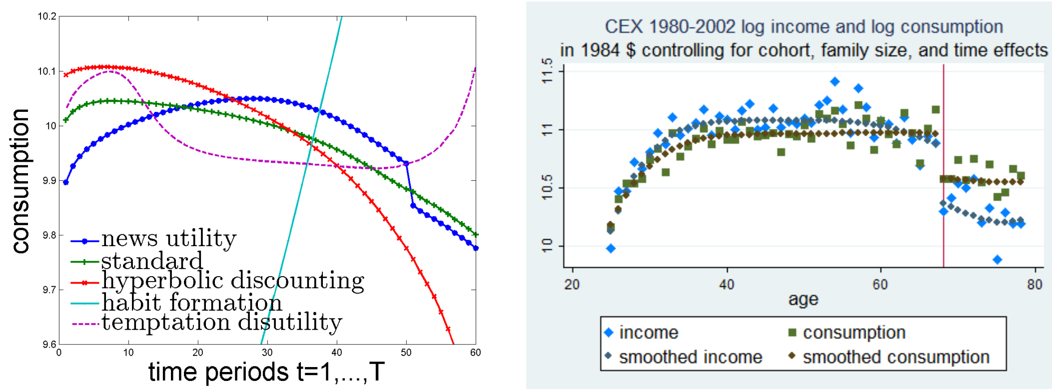
$$N_t^T = \left\{ \begin{array}{cc} e^{s_t^T} & \text{with probability } 1-p \text{ and } s_t^T \sim N(\mu_T, \sigma_T^2) \\ 0 & \text{with probability } p \end{array} \right\} N_t^P = e^{s_t^P} \; s_t^P \sim N(\mu_P, \sigma_P^2).$$

The life-cycle literature suggests fairly tight ranges for the parameters of the log-normal income process, which are approximately $\mu_T = \mu_P = 0$, $\sigma_T = \sigma_P = 0.1$, and $p = 0.01$. G_t typically implies a hump-shaped income profile. Nevertheless, I initially assume that income is flat, that is, $G_t = 1$ for all t, to highlight the model's predictions in an environment that does not simply generate a hump-shaped consumption profile via a hump-shaped income profile. In addition to the standard and hyperbolic agents, I display results for internal, multiplicative habit-formation preferences, as assumed in Michaelides (2002), and temptation-disutility preferences, as developed by Gul and Pesendorfer (2004), following the specification of Bucciol (2012). The utility specifications can be found in Appendix B.1. For the habit-formation agent, I roughly follow Michaelides (2002) and choose a habit-forming parameter $h = 0.45$, which matches the excess-smoothness evidence. The tempted agent's additional preference parameter $\tau = \frac{\lambda^{td}}{1+\lambda^{td}} = 0.1$ is chosen according to the estimates of Bucciol (2012).[32]

Comparison of life-cycle consumption profiles. Figure 3 contrasts the five agents' consumption paths with the empirical consumption and income profiles, which I explain in Section 2.3.2. The habit-formation agent's consumption profile is shown only in part because he engages in extremely high wealth accumulation owing to his high effective risk aversion, even if I choose a lower value for the habit-forming parameter h than the one that fits the excess-sensitivity evidence.[33] Hyperbolic-discounting preferences tilt the consumption profile upward at the beginning and downward at the end of life. Temptation disutility causes severe overconsumption at the beginning of life, which then reduces when consumption opportunities become depleted. Standard, hyperbolic-discounting, and news-utility preferences all generate a hump-shaped consumption profile. The consumption path of the standard and hyperbolic agents is increasing at the beginning of life because power utility renders them unwilling to borrow; however, the agents are also sufficiently impatient, such that

[32] For the news-utility parameters, I use the same calibration as in Section 2.2.1.
[33] This result about wealth accumulation confirms a finding by Michaelides (2002).

FIGURE 3. **LIFE-CYCLE PROFILES AND CEX CONSUMPTION AND INCOME DATA**



This figure contrasts the five agents' consumption paths with the average CEX consumption and income data. The parameter values are $\mu_T = \mu_P = 0$, $\sigma_T = \sigma_P = 0.1$, $p = 0.01$, and $G_t = 1$ for all t. The preference parameters are $\beta = 0.97$, $r = 1\%$, $\theta = 2$, $\eta = 1$, $\lambda = 3$, $\gamma = 0.8$, the hyperbolic discounting parameter is 0.8, the habit-forming parameter is $h = 0.45$, and the temptation-disutility parameter is $\tau = 0.1$. The unit of consumption and income is the log of 1984 dollars controlling for cohort, family size, and time effects.

consumption eventually decreases.[34] Nevertheless, at first glance, the news-utility agent's hump looks more similar than the other agents' humps to the empirical consumption profile with slowly increasing consumption at the beginning of life and decreasing consumption shortly before retirement. Moreover, the news-utility hump is a more robust result than the standard and hyperbolic humps to alternative assumptions about the discount factor, interest rate, and income profile. For instance, in a model with only transitory shocks and no unemployment, the standard agent's consumption is basically flat and the hyperbolic agent's consumption is decreasing throughout because the precautionary-savings motive is very weak; in contrast, the news-utility model generates a hump-shaped consumption profile. Obviously, in partial equilibrium, it is trivial to match the hump shape as preference and environmental parameters are jointly calibrated; thus, I confirm in a simple real-business-cycle model that news-utility generates realistic moments with the preference parameters that I assume in this study.

Moreover, Figure 3 shows a substantial drop in consumption at retirement for both the news-utility consumption profile and the Consumer Expenditure Survey (CEX) consumption data. Thus, I conclude that the news-utility agent's lifetime consumption profile looks very similar to the average consumption profile from the CEX data, which I explain in greater detail in the next subsection.

2.3.2. *Structural estimation.*

[34]Because power utility eliminates the possibility of negative or zero consumption and because of the small possibility of zero income in all future periods, the agents will never find it optimal to borrow. Moreover, power utility implies prudence such that all agents have a standard precautionary-savings motive. However, this motive is rather weak because the standard agent's consumption begins to decrease rather early in life, which has been criticized by Attanasio (1999) among others.

Data, estimation procedure, identification, and results. I use data from the CEX for 1980 to 2002. Because the CEX does not survey households consecutively, I generate a pseudo panel that averages each household's consumption and income at each age. To control for cohort, family size, and time effects, I employ average cohort techniques, which are explained in detail in Appendix 2.3.2. Figure 3 displays the average empirical income and average empirical consumption profiles. Then, I structurally estimate the news-utility parameters using a methods-of-simulated-moments procedure following Gourinchas and Parker (2002) among others. The procedure has two stages. In the first stage, I estimate the structural parameters governing the environment using standard techniques and obtain results perfectly in line with the literature. Given the first-stage estimates, I estimate the preference parameters by matching the simulated and empirical average life-cycle consumption profiles in the second stage. The estimation procedure is explained in greater detail in Appendix 2.3.2. Moreover, I describe the identification of all preference parameters in Appendix 2.3.2.

I employ a two-stage method-of-simulated-moments procedure. In the first stage, I estimate all of the structural parameters governing the environment $\hat{\mu}_P$, $\hat{\sigma}_P$, $\hat{\mu}_T$, $\hat{\sigma}_T$, $\hat{p}$, $\hat{G}$, $\hat{r}$, $\hat{a}_0$, $\hat{R}$, and $\hat{T}$. The parameters $\hat{\mu}_P = -0.002$, $\hat{\mu}_T = -0.0031$, $\hat{\sigma}_P = 0.18$, $\hat{\sigma}_T = 0.16$, and $\hat{p} = 0.0031$ turn out in accordance with the literature. The mean of Moody's municipal bond index is $\hat{r} = 3.1\%$. Moreover, because 25 years is chosen as the beginning of life by Gourinchas and Parker (2002), I choose the retirement period $\hat{R} = 11$ years and the working life span $\hat{T} = 54$ years in accordance with the average retirement age in the US according to the OECD and the average life expectancy in the US according to the UN. At age 25 years, I estimate the mean ratio of liquid wealth to income as 0.0096 under the assumption that initial permanent income equals one $P_0 = 1$.

I estimate the preference parameters β, θ, η, λ, and γ and obtain $\hat{\theta} = 0.79$, $\hat{\beta} = 0.97$, $\hat{\eta} = 1.1$, $\hat{\lambda} = 2.4$, and $\hat{\gamma} = 0.53$. I display all first- and second-stage structural parameter estimates, as well as their standard errors, in Table 1.[35] The second-stage standard errors are adjusted for first-stage uncertainty and the sampling correction; while the former increases the standard errors considerably, the latter has very little effect, as noted by Laibson et al. (2012). The preference parameters are estimated very tightly, and I cannot reject the overidentification test, which is a surprisingly positive result given the number of moments T and the number of parameters, which is only five. In contrast, for the standard model, the standard errors are considerably larger and I reject the overidentification test, as do Gourinchas and Parker (2002). Finally, I obtain suggestive evidence for one of the new comparative statics generated by news utility; the excess-smoothness ratio in the CEX data increases from 0.68 at age 25 years to 0.82 at the start of retirement.

[35] Alternatively, I use a more complex set of moments to estimate the preference parameters, namely the degree of excess smoothness in consumption, the extent of the drop in consumption at retirement, and four other points of the life-cycle consumption profile. The resulting estimates and their standard errors are quantitatively very similar to the original ones.

TABLE 1. **FIRST-STAGE PARAMETER ESTIMATION RESULTS**

	$\hat{\mu}_P$	$\hat{\sigma}_P$	$\hat{\mu}_T$	$\hat{\sigma}_T$	$\hat{p}$	$\hat{G}_t$	$\hat{r}$	P_0	$\frac{\hat{A}_0}{\hat{P}_0}$	$\hat{R}$	$\hat{T}$
estimate	0	0.19	0	0.15	0.0031	$e^{Y_{t+1}-Y_t}$	3.1%	1	0.0096	11	54
st. error		(0.004)		(0.006)	(0.001)	$(\hat{\Omega}_{\hat{G}})$	(0.003)		(0.005)		

SECOND-STAGE PARAMETER ESTIMATION RESULTS

	news-utility model					standard model	
	$\hat{\beta}$	$\hat{\theta}$	$\hat{\eta}$	$\hat{\lambda}$	$\hat{\gamma}$	$\hat{\beta}$	$\hat{\theta}$
estimate	0.97	0.77	0.97	2.33	0.59	0.9	2.01
standard error	(0.001)	(0.011)	(0.068)	(0.018)	(0.021)	(0.029)	(0.091)
$\chi(\cdot)$			43.3			101.2	

This table displays all first- and second-stage structural parameter estimates as well as their standard errors. The overidentification test's critical value at 5% is 67.5.

Discussion of the estimated preference parameters. I now show that my estimates are perfectly in line with the micro literature, generate reasonable attitudes towards small and large wealth gambles, and match the empirical evidence for excess smoothness and sensitivity in aggregate data. I refer to the literature for the standard preference parameter estimates of the exponential discount factor $\beta \approx 1$ and the coefficient of risk aversion $\theta \approx 1$ but discuss the news-utility parameter estimates, that is, η, λ, and γ, in greater detail. In particular, I demonstrate that my estimates are consistent with existing micro evidence on risk and time preferences. In Table 3 in Appendix A, I illustrate the risk preferences over gambles with various stakes of the news-utility, standard, and habit-formation agents. In particular, I calculate the required gain G for a range of losses L to make each agent indifferent between accepting or rejecting a 50-50 win G or lose L gamble at a wealth level of \$300,000, in accordance with Rabin (2001) and Chetty and Szeidl (2007).

First, I aim to demonstrate that my estimates match risk attitudes towards gambles about immediate consumption, which are determined solely by the weight of gain-loss versus consumption utility η and the coefficient of loss aversion λ because it can be reasonably assumed that utility over immediate consumption is linear. $\eta(\lambda-1) \approx 2$ implies that the equivalent Kahneman and Tversky (1979) coefficient of loss aversion is around 2, because the news-utility agent experiences consumption and news utility, whereas classical prospect theory effectively consists of news utility only, and consumption utility works in favor of any small-scale gamble. In Table 3, it can be seen that the news-utility agent's contemporaneous gain-loss utility generates reasonable attitudes towards small and large gambles over immediate consumption. Moreover, the parameters are consistent with the laboratory evidence on loss aversion over immediate consumption, that is, the endowment effect literature.[36] In contrast, since I assume linear utility over immediate consump-

[36]For illustration, I take a concrete example from Kahneman et al. (1990), in which the authors distribute a good (mugs or pens) to half of their subjects and ask those who received the good about their willingness to accept (WTA) and those who did not receive it about their willingness to pay (WTP) if they traded the good. The median WTA is \$5.25, whereas the median WTP is \$2.75. Accordingly, I infer $(1+\eta)u(mug) = (1+\eta\lambda)2.25$ and $(1+\eta\lambda)u(mug) = (1+\eta)5.25$, which implies that $\lambda \approx 3$ when $\eta \approx 1$. I obtain a similar result for the pen experiment.

TABLE 2. **EXCESS-SMOOTHNESS AND SENSITIVITY REGRESSION RESULTS**

Model	news-utility		habit		standard		hyperbolic		tempted	
	β_1	β_2	β_1^h	β_2^h	β_1^s	β_2^s	β_1^b	β_2^b	β_1^{td}	β_2^{td}
coefficient	0.67	0.27	0.69	0.38	0.93	0.01	0.94	0.01	1.01	-0.01
t-statistic	86.7	34.2	141	76.3	187	1.32	205	1.33	135	-1.76
e-s ratio	0.74		0.80		0.95		0.96		1.04	

This table displays the aggregate regression results of 1,000 individuals with $N = 200$ simulated data points.

tion, the standard and habit-formation agents are risk neutral. Second, I elicit the agents' risk attitudes by assuming that each of them is presented with the gamble after all consumption in the current period has taken place. The news-utility agent will experience only prospective gain-loss utility over the gamble's outcome, which is determined by the prospective gain-loss discount factor γ. $\gamma < 1$ implies similar attitudes towards intertemporal consumption tradeoffs as a hyperbolic-discounting parameter of the same value. Empirical estimates for the hyperbolic-discounting parameter model typically range between 0.7 and 0.8 (e.g., Laibson et al. (2012)) such that the experimental and field evidence on peoples' attitudes towards intertemporal consumption trade-offs dictates a choice of the prospective gain-loss discount factor around 0.7, $\gamma \approx 0.7$, when the exponential discount factor is around one, $\beta \approx 1$, which is roughly in line with my estimate. Table 3 shows that the news-utility agent's risk attitudes take reasonable values for small, medium, and large stakes. The habit-formation agent is risk neutral for small and medium stakes and somewhat more risk averse for large stakes than the standard agent, who exhibits reasonable risk attitudes for very large stakes only.

Excess smoothness and excess sensitivity in aggregate data. Finally, I now demonstrate that my estimates are not only consistent with those found in the micro literature but generate the degree of excess smoothness found in macro data. I simulate 200 consumption and income data points of 1,000 individuals, and then, aggregate their consumption and income and run the regression

$$\Delta log(\bar{C}_{t+1}) = \alpha + \beta_1 \Delta log(\bar{Y}_{t+1}) + \beta_2 \Delta log(\bar{Y}_t) + \varepsilon_{t+1}$$

following Campbell and Deaton (1989).[37] The results are displayed in Table 2. In the news-utility model, I obtain a regression coefficient $\beta_2 \approx 0.27$ and the excess smoothness ratio, that is, $\frac{\sigma(\Delta log(\bar{C}_t))}{\sigma(\Delta log(\bar{Y}_t))}$ as defined in Deaton (1986), is 0.74, whereas in the standard model, I obtain $\beta_2^s \approx 0.01$ and 0.95.[38] Regressing consumption growth on lagged labor income growth in aggregate data, I

[37]The regression results are similar for different assumptions about the number of data points, the number of citizens, their wealth levels, and their time horizons. I simulate data for each individual at normalized wealth level $\frac{A_0}{P_0} = 1$ and age 40.

[38]All consumption adjustment takes place after a single period because the agent's preferences are characterized by full belief updating. However, the variation in consumption adjusts via end-of-period asset holdings and is thereby spread out over the entire future. Empirically, Fuhrer (2000) and Reis (2006) find that consumption peaks one year af-

obtain a regression estimate for β_2 of approximately 0.23 and an excess-smoothness ratio of approximately 0.68.[39] Unsurprisingly, temptation disutility does not generate excess smoothness and sensitivity, while habit formation does. However, habit formation appears to generate too little excess smoothness and too much excess sensitivity and has unrealistic implications for the life-cycle consumption profile, which I explored in Section 2.3.1. I conclude that the estimates obtained from CEX consumption data simultaneously match the degree of excess smoothness and sensitivity found in aggregate data.

3. Conclusion

This study demonstrates that expectations-based reference-dependent preferences cannot only explain micro evidence, such as the endowment effect or cab-driver labor supply, but also offer a unified explanation for major life-cycle consumption facts. Excess smoothness and sensitivity in consumption, two widely analyzed macro consumption puzzles, are explained by loss aversion, a robust risk preference analyzed in experimental research and a popular explanation for the equity premium puzzle. Intuitively, the agent wants to allow his expectations-based reference point to decrease or increase prior to adjusting consumption. Moreover, a hump-shaped consumption profile and a drop in consumption at retirement are explained by the interplay of news-utility risk and time preferences. A hump-shaped consumption profile results from the net effect of two preference features. The news-utility agent's consumption path is steeper at the beginning of life because loss aversion generates an additional precautionary-savings motive, which accumulates more rapidly than the standard precautionary-savings motive in the agent's horizon. However, the news-utility agent's consumption path declines toward the end of life because the expectations-based reference point introduces time-inconsistent overconsumption. However, once the agent retires, overconsumption is associated with a certain loss in future consumption. Thus, the agent is suddenly able to behave himself, and his consumption drops at retirement. I explore the intuition for the model's results in depth by solving an exponential-utility model in closed form. Moreover, assuming power utility as standard in the literature, I structurally estimate the preference parameters, obtain estimates that are in line with the existing micro evidence, and generate the degree of excess smoothness found in aggregate data.

Finally, I draw potentially important welfare conclusions that can be derived from the analysis of the monotone-pre-committed equilibrium that maximizes expected utility and is described in Appendix B.3. The result that excess smoothness is an optimal response is in contrast to the welfare implications of borrowing constraints, the potentially most popular alternative explanation for excess smoothness. Instead, the hump-shaped life-cycle consumption profile and consumption drop at retirement is welfare decreasing, which is more in line with alternative explanations.

ter the shock and that the consumption response dies out briefly after the first year.

[39] I follow Ludvigson and Michaelides (2001) and use NIPA deflated total, nondurable, or services consumption and total disposable labor income for the years 1947 to 2011.

REFERENCES

Abeler, J., A. Falk, L. Goette, and D. Huffman (2012). Reference Points and Effort Provision. *American Economic Review 3939*.

Aguiar, M. and E. Hurst (2005). Consumption versus Expenditure. *Journal of Political Economy 113*(5), 919–948.

Ameriks, J., A. Caplin, and J. Leahy (2007). Retirement Consumption: Insights from a Survey. *Review of Economics and Statistics 89*(2), 265–274.

Angeletos, G. M., D. Laibson, A. Repetto, and S. Weinberg (2001). The Hyperbolic Consumption Model: Calibration, Simulation, and Empirical Evaluation. *Journal of Economic Perspectives 15*(3), 47.

Angner, E. and G. Loewenstein (fthc). Behavioral Economics. *Handbook of Philosophy and Science*.

Attanasio, . and N. Pavoni (2011). Risk Sharing in Private Information Models with Asset Accumulation: Explaining the Excess Smoothness of Consumption. *Econometrica 79*(4), 1027–1068.

Attanasio, O. (1998). Cohort Analysis of Saving Behavior by U.S. Households. *Journal of Human Resources 33*(3), 575–609.

Attanasio, O. (1999). Consumption. *Handbook of Macroeconomics, Edited by J.B. Taylor and M. Woodford 1*, 741–812.

Attanasio, O. and G. Weber (2010). Consumption and Saving: Models of Intertemporal Allocation and Their Implications for Public Policy. *Journal of Economic Literature 48*, 693–751.

Banks, J., R. Blundell, and S. Tanner (1998). Is There a Retirement-Savings Puzzle? *American Economic Review 88*(4), 769–788.

Barberis, N. (2013). Thirty Years of Prospect Theory in Economics: A Review and Assessment. *Journal of Economic Perspectives 27*(1), 173–196.

Barberis, N., M. Huang, and T. Santos (2001). Prospect Theory and Asset Prices. *Quarterly Journal of Economics 116*(1).

Battistin, E., A. Brugiavini, E. Rettore, and G. Weber (2009). The Retirement Consumption Puzzle: Evidence from a Regression Discontinuity Approach. *American Economic Review 99*(5), 2209–26.

Benartzi, B. and R. Thaler (1995). Myopic Loss Aversion and the Equity Premium Puzzle. *Quarterly Journal of Economics 110*, 73–92.

Bernheim, D., J. Skinner, and S. Weinberg (2001). What Accounts for the Variation in Retirement Wealth Among U.S. Households? *American Economic Review 91*(4), 832–857.

Bowman, D., D. Minehart, and M. Rabin (1999). Loss Aversion in a Consumption-Savings Model. *Journal of Economic Behavior and Organization 38*, 155–178.

Bucciol, A. (2012). Measuring Self-Control Problems: A Structural Estimation. *Journal of the European Economic Association*.

Bullard, J. and J. Feigenbaum (2007). A Leisurely Reading of the Life-cycle Consumption Data. *Journal of Monetary Economics 54*, 2305–2320.

Caballero, R. (1995). Near-Rationality, Heterogeneity and Aggregate Consumption. *Journal of Money, Credit and Banking 27*, 29–48.

Caliendo, F. and K. Huang (2007). Short-Term Planning and the Life-Cycle Consumption Puzzle. *Journal of Economic Dynamics and Control 31*, 1392–1415.

Caliendo, F. and K. Huang (2008). Overconfidence and Consumption over the Life Cycle. *Journal of Macroeconomics 30*, 1347–1369.

Caliendo, F. and K. Huang (2011). Rationalizing Multiple Consumption-Saving Puzzles in a Unified Framework. *Frontiers of Economics in China 6*(3), 359–388.

Campbell, J. and A. Deaton (1989). Why is Consumption So Smooth? *Review of Economic Studies 56*(3), 357–373.

Carroll, C. (2001). Theoretical Foundations of Buffer Stock Saving. *Working Paper Johns Hopkins University*.

Carroll, C. (2011). Theoretical Foundations of Buffer Stock Saving. *Working Paper Johns Hopkins University*.

Carroll, C. D. (1997). Buffer Stock Saving and the Life Cycle/Permanent Income Hypothesis. *Quarterly Journal of Economics CXII*, 1–56.

Chetty, R. and A. Szeidl (2007). Consumption Commitments and Risk Preferences. *Quarterly Journal of Economics 122*(2), 831–877.

Chetty, R. and A. Szeidl (2010). Consumption Commitments: A Foundation for Reference-Dependent Preferences and Habit Formation. *Working Paper*.

Crawford, V. P. and J. Meng (2011). New York City Cabdrivers' Labor Supply Revisited: Reference-Dependence Preferences with Rational-Expectations Targets for Hours and Income. *American Economic Review 101*(5).

Deaton, A. (1985). Panel Data from Time Series of Cross-Sections. *Journal of Econometrics 30*, 109–126.

Deaton, A. (1986). Life-Cycle Models of Consumption: Is the Evidence consistent with the Theory? *NBER Working Paper 1910*.

Deaton, A. (1991). Saving and Liquidity Constraints. *Econometrica 59*, 1221–1248.

DellaVigna, S. (2009). Psychology and Economics: Evidence from the Field. *Journal of Economic Literature 47*(2), 315–372.

Disney, R. (1996). Can we Afford to Grow Old? *Cambridge, MA, MIT Press*.

Ericson, K. and A. Fuster (2011). Expectations as Endowments: Evidence on Reference-Dependent Preferences from Exchange and Valuation Experiments. *Quarterly Journal of Economics 126*(4), 1879–1907.

Feigenbaum, J. (2008). Can Mortality Risk Explain the Consumption Hump? *Journal of Macroeconomics 30*, 844–872.

Fernandez-Villaverde, J. and D. Krueger (2007). Consumption over the Life Cycle: Facts from Consumer Expenditure Survey Data. *Review of Economics and Statistics 89*(3), 552–565.

Flavin, M. (1981). The Adjustment of Consumption to Changing Expectations about Future Income. *Journal of Political Economy 89*, 974–1009.

Flavin, M. (1985). Excess Sensitivity of Consumption to Current Income: Liquidity Constraints or Myopia? *Canadian Journal of Economics 18*(1), 117–136.

Flavin, M. and S. Nakagawa (2008). A Model of Housing in the Presence of Adjustment Costs: A Structural Interpretation of Habit Persistence. *American Economic Review 98*(1), 474–495.

Frederick, S., G. Loewenstein, and T. O'Donoghue (2002). Time Discounting and Time Preference: A Critical Review. *Journal of Economic Literature 40*(2), 351–401.

Fuhrer, J. (2000). Habit Formation in Consumption and Its Implications for Monetary-Policy Models. *American Economic Review 90*(3), 367–390.

Gabaix, X. and D. Laibson (2002). The 6D Bias and the Equity-Premium Puzzle. *NBER Macroeconomics Annual 16*, 257–312.

Gill, D. and V. Prowse (2012). A Structural Analysis of Disappointment Aversion in a Real Effort Competition. *American Economic Review 102*(1), 469–503.

Gourinchas, P.-O. and J. A. Parker (2002). Consumption over the Life Cycle. *Econometrica LXX*, 47–89.

Gul, F. and W. Pesendorfer (2004). Self-Control and the Theory of Consumption. *Econometrica 72*(4), 119–158.

Haider, S. and M. Stephens (2007). Is There a Retirement-Consumption Puzzle? Evidence Using Subjective Retirement Expectations. *Review of Economics and Statistics 89*(2), 247–264.

Hansen, G. and S. Imrohoroglu (2008). Consumption over the Life Cycle: The Role of Annuities. *Review of Economic Dynamics 11*, 566–583.

Harris, C. and D. Laibson (2002). Hyperbolic Discounting and Consumption. *Advances in Economics and Econometrics: Theory and Applications 1*, 258–298.

Harris, E. and J. Sabelhaus (2001). Consumer Expenditure Survey - Family-Level Extracts, 1980:1 -1998:2. *Congressional Budget Office, Washington, D.C. 20515.*.

Heckman, J. (1974). Life Cycle Consumption and Labor Supply: An Explanation of the Relationship Between Income and Consumption Over the Life Cycle. *American Economic Review 64*, 188–194.

Heffetz, O. and J. A. List (2011). Is the Endowment Effect a Reference Effect? *NBER Working Paper 16715*.

Heidhues, P. and B. Koszegi (2008). Competition and Price Variation when Consumers are Loss Averse. *American Economic Review 98*(4), 1245–1268.

Heidhues, P. and B. Koszegi (2014). Regular Prices and Sales. *Theoretical Economics 9*, 217–251.

Herweg, F. and K. Mierendorff (2012). Uncertain Demand, Consumer Loss Aversion, and Flat-Rate Tariffs. *Journal of the European Economic Association*.

Herweg, F., D. Mï¿œller, and P. Weinschenk (2010). Binary Payment Schemes: Moral Hazard and Loss Aversion. *American Economic Review 100*(5), 2451–2477.

Hurd, M. (1989). Mortality Risk and Bequests. *Econometrica 57*(4), 779–813.

Hurd, M. and S. Rohwedder (2003). The Retirement-Consumption Puzzle: Anticipated and Actual Declines in Spending at Retirement. *NBER Working Paper 9586*.

Jappelli, T. and L. Pistaferri (2010). The Consumption Response to Income Changes. *Annual Review of Economics 2*, 479–506.

Kahneman, D., J. Knetsch, and R. Thaler (1990). Experimental Tests of the Endowment Effect and the Coase Theorem. *Journal of Political Economy 98*(6), 1325–1348.

Kahneman, D. and A. Tversky (1979). Prospect Theory: An Analysis of Decision under Risk. *Econometrica*, 263–291.

Koszegi, B. and M. Rabin (2006). A Model of Reference-Dependent Preferences. *Quarterly Journal of Economics 121*(4), 1133–1166.

Koszegi, B. and M. Rabin (2007). Reference-Dependent Risk Attitiudes. *American Economic Review 97*(4), 1047–1073.

Koszegi, B. and M. Rabin (2009). Reference-Dependent Consumption Plans. *American Economic Review 99*(3), 909–936.

Krueger, D. and F. Perri (2011). How do Households Respond to Income Shocks? *Working Paper*.

Laibson, D. (1997). Golden Eggs and Hyperbolic Discounting. *Quarterly Journal of Economics 112*(2), 443–477.

Laibson, D., A. Repetto, and J. Tobacman (2012). Estimating Discount Functions with Consumption Choices over the Lifecycle. *American Economic Review*.

Ludvigson, S. and A. Michaelides (2001). Does Buffer-Stock Saving Explain the Smoothness and

Excess Sensitivity of Consumption? *American Economic Review 91*(3), 631–647.
Meng, J. (2013). Can Prospect Theory Explain the Disposition Effect? A New Perspective on Reference Points. *Working Paper*.
Michaelides, A. (2002). Buffer Stock Saving and Habit Formation. *LSE and CEPR Working Paper*.
Nardi, M., E.ï¿œFrench, and J.ï¿œJones (2011). Why Do the Elderly Save? The Role of Medical Expenses. *Journal of Political Economy 118*(1), 39–75.
Pagel, M. (fthc). Expectations-based Reference-Dependent Preferences and Asset Pricing. *Journal of the European Economic Association*.
Pagel, M. and C. Zeppenfeld (2014). Expectations-Based Reference-Dependent Consumption and Portfolio Choice – Evidence from the Lab. *Unpublished Paper*.
Park, H. (2011). Bounded Rationality and Lifecycle Consumption. *Unpublished paper*.
Pope, D. G. and M. E. Schweitzer (2011). Is Tiger Woods Loss Averse? Persistent Bias in the Face of Experience, Competition, and High Stakes. *American Economic Review 101*, 129–157.
Rabin, M. (2001). Risk Aversion and Expected-Utility Theory: A Calibration Theorem. *Econometrica 68*(5), 1281–1292.
Reis, R. (2006). Inattentive Consumers. *Journal of Monetary Economics 53*, 1761–1800.
Schwerdt, G. (2005). Why does Consumption fall at Retirement? Evidence from Germany. *Economics Letters 89*, 300–305.
Shea, J. (1995). Union Contracts and the Life-Cycle/Permanent-Income Hypothesis. *American Economic Review 85*(1), 186–200.
Sims, C. (2003). Implications of Rational Inattention. *Journal of Monetary Economics 50*(3), 665–690.
Sprenger, C. (2010). An Endowment Effect for Risk: Experimental Tests of Stochastic Reference Points. *Working Paper*.
Sydnor, J. (2010). (Over)insuring Modest Risks. *American Economic Journal: Applied Economics 2*, 177–199.
Tutoni, A. (2010). Rationally Inattentive Consumption Choices. *Review of Economic Dynamics 16*, 421–439.
Verbeek, M. (2007). Pseudo Panels and Repeated Cross-Sections. *The Econometrics of Panel Data: Fundamentals and Recent Developments in Theory and Practice*.

Appendix A. More Figures and Tables

Table 3.
Risk Attitudes over Small and Large Wealth Gambles

	standard	news-utility		habit-formation
Loss (L)		contemp.	prospective	
10	10	15	22	10
200	200	300	435	200
1000	1000	1500	2166	1000
5000	5000	7500	10719	5000
50000	50291	75000	105487	52502
100000	100406	150000	2066770	112040

For each loss L, the table's entries show the required gain G to make each agent indifferent between accepting and rejecting a 50-50 gamble win G or lose L at a wealth level of 300,000 and a permanent income of 100,000 (power-utility model).

Appendix B. Derivations and Proofs

B.1. **Summary of utility functions under consideration.** I briefly summarize the lifetime utility of all preference specifications that I consider. I define the "news-utility" agent's lifetime utility in each period $t = \{0, ..., T\}$ as

$$u(C_t) + n(C_t, F_{C_t}^{t-1}) + \gamma \sum_{\tau=1}^{T-t} \beta^{\tau} \boldsymbol{n}(F_{C_{t+\tau}}^{t,t-1}) + E_t[\sum_{\tau=1}^{T-t} \beta^{\tau} U_{t+\tau}]$$

with $\beta \in [0,1]$, $u(\cdot)$ a HARA[40] utility function, $\eta \in (0,\infty)$, $\lambda \in (1,\infty)$, and $\gamma \in [0,1]$. Additionally, I first consider standard preferences as analyzed by Carroll (2001), Gourinchas and Parker (2002), and Deaton (1991), among many others. The "standard" agent's lifetime utility is given by

$$u(C_t^s) + E_t[\sum_{\tau=1}^{T-t} \beta^{\tau} u(C_{t+\tau}^s)].$$

Second, I consider internal, multiplicative habit-formation preferences as assumed in Michaelides (2002). The "habit-forming" agent's lifetime utility is given by

$$u(C_t^h) - hu(C_{t-1}^h) + E_t[\sum_{\tau=1}^{T-t} \beta^{\tau} (u(C_{t+\tau}^h) - hu(C_{t+\tau-1}^h))]$$

with $h \in [0,1]$.

Third, I consider $\beta\delta-$ or hyperbolic-discounting preferences as developed by Laibson (1997). The "$\beta\delta-$" or "hyperbolic-discounting" agent's lifetime utility is given by

$$u(C_t^b) + bE_t[\sum_{\tau=1}^{T-t} \beta^{\tau} u(C_{t+\tau}^b)]$$

[40] A utility function $u(c)$ is said to exhibit hyperbolic absolute risk aversion (HARA) if the level of risk tolerance, $-\frac{u''(c)}{u'(c)}$ is a linear function of c.

with $b \in [0,1]$ corresponding to the $\beta\delta-$agent's β.

Fourth, I consider temptation-disutility preferences as developed by Gul and Pesendorfer (2004) following the specification of Bucciol (2012). The "tempted" agent's lifetime utility is given by

$$u(C_t^{td}) - \lambda^{td}(u(\tilde{C}_t^{td}) - u(C_t^{td})) + E_t[\sum_{\tau=1}^{T-t} \beta^\tau (u(C_{t+\tau}^{td}) - \lambda^{td}(u(\tilde{C}_{t+\tau}^{td}) - u(C_{t+\tau}^{td})))]$$

with $\tilde{C}_t^{td}$ being the most tempting alternative consumption level and $\lambda^{td} \in [0,\infty)$.

B.2. **Derivation of the exponential-utility model.**

B.2.1. *The finite-horizon model.* A simple derivation of the second-to-last period can be found in the text. The exponential-utility model can be solved through backward induction. In the following, I outline the model's solution for period $T-i$ in which the agent chooses how much to consume C_{T-i} and how much to invest in the risk-free asset A_{T-i}. I guess and verify the model's consumption function

$$C_{T-i} = \frac{(1+r)^i}{f(i)}(1+r)A_{T-i-1} + P_{T-i-1} + \bar{s}_{T-i} - \frac{f(i-1)}{f(i)}\Lambda_{T-i}$$

with $\bar{s}_{T-i} = s_{T-i}^P + (1 - \frac{f(i-1)}{f(i)})s_{T-i}^T$ and $f(i) = \sum_{j=0}^{i}(1+r)^j = (1+r)^i \frac{1+r-(\frac{1}{1+r})^i}{r}$ (in the text I defined $a(i) = \frac{f(i-1)}{f(i)}$)

$$\Lambda_{T-i} = \frac{1}{\theta} log(\frac{(1+r)^i}{f(i-1)} \frac{\psi_{T-i} + \gamma Q_{T-i}\eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_t))}).$$

with $F_{\bar{S}}(\bar{s}_t) = Pr(S_t^P + (1 - \frac{f(i-1)}{f(i)})S_t^T < \bar{s}_t)$. Then, the budget constraint $A_{T-i} = (1+r)A_{T-i-1} + Y_{T-i} - C_{T-i}$ determining end-of-period asset holdings

$$A_{T-i} = \frac{f(i-1)}{f(i)}(1+r)A_{T-i-1} + \frac{f(i-1)}{f(i)} s_{T-i}^T + \frac{f(i-1)}{f(i)}\Lambda_{T-i}.$$

Λ_{T-i} is a function independent of A_{T-i-1} and P_{T-i-1} but dependent on s_{T-i}^P and s_{T-i}^T. In the last period the agent consumes everything such that $\Lambda_T = 0$. As a first step to verify the solution guess, I sum up the expectation of the discounted consumption function utilities from period $T-i$ to T

$$\beta E_{T-i-1}[\sum_{\tau=0}^{i} \beta^\tau u(C_{T-i+\tau})] = u(P_{T-i-1} + \frac{(1+r)^i}{f(i)}(1+r)A_{T-i-1})Q_{T-i-1}$$

$$= -\frac{1}{\theta} exp\{-\theta(P_{T-i-1} + \frac{(1+r)^i}{f(i)}(1+r)A_{T-i-1})\}Q_{T-i-1},$$

with Q_{T-i-1} given by

$$Q_{T-i-1} = \beta E_{T-i-1}[exp\{-\theta(\bar{s}_{T-i} - \frac{f(i-1)}{f(i)}\Lambda_{T-i})\} + exp\{-\theta(\bar{s}_{T-i} + \frac{(1+r)^i}{f(i)}\Lambda_{T-i})\}Q_{T-i}]$$

Q_{T-i-1} is a constant if Λ_{T-i} depends only on s_{T-i}^P and s_{T-i}^T. To derive the above sum, I simply plug in the asset-holding function into each future consumption function. For instance, C_{T-i+1} is given by

$$C_{T-i+1} = \frac{(1+r)^{i-1}}{f(i-1)}(1+r)A_{T-i} + P_{T-i} + \bar{s}_{T-i+1} - \frac{f(i-2)}{f(i-1)}\Lambda_{T-i+1}$$

$$= \frac{(1+r)^i}{f(i)}(1+r)A_{T-i-1} + \bar{s}_{T-i} + \frac{(1+r)^i}{f(i)}\Lambda_{T-i} + P_{T-i-1} + \bar{s}_{T-i+1} - \frac{f(i-2)}{f(i-1)}\Lambda_{T-i+1}.$$

The consumption function and it's sum allows me to write down the agent's continuation utility in period $T-i-1$ as follows

$$u(P_{T-i-1} + \frac{(1+r)^i}{f(i)}(1+r)A_{T-i-1})\psi_{T-i-1} = -\frac{1}{\theta}exp\{-\theta(P_{T-i-1} + \frac{(1+r)^i}{f(i)}(1+r)A_{T-i-1})\}\psi_{T-i-1}$$

with ψ_{T-i-1} given by

$$\psi_{T-i-1} = \beta E_{T-i-1}[exp\{-\theta(\bar{s}_{T-i} - \frac{f(i-1)}{f(i)}\Lambda_{T-i})\} + \omega(exp\{-\theta(\bar{s}_{T-i} - \frac{f(i-1)}{f(i)}\Lambda_{T-i})\})$$

$$+\gamma Q_{T-i}\omega(exp\{-\theta(\bar{s}_{T-i} + \frac{(1+r)^i}{f(i)}\Lambda_{T-i})\}) + exp\{-\theta(\bar{s}_{T-i} + \frac{(1+r)^i}{f(i)}\Lambda_{T-i})\}]\psi_{T-i}$$

and $\omega(x)$ for any random variable $X \sim F_X$, where the realization is denoted by x, is

$$\omega(x) = \eta\int_{-\infty}^{x}(x-y)dF_X(y) + \eta\lambda\int_{x}^{\infty}(x-y)dF_X(y).$$

The above expression for ψ_{T-i-1} can be easily inferred from the agent's utility function. The first component in ψ_{T-i-1} corresponds to the expectation of consumption utility in period $T-i$, the second to contemporaneous gain-loss in period $T-i$, the third to prospective gain-loss in period $T-i$ that depends on the sum of future consumption utilities Q_{T-i}, and the last to the agent's continuation value. Moreover, for any random variable $Y \sim F_Y = F_X$ note that

$$\int_{-\infty}^{\infty}\omega(g(x))dF_X(x) = \int_{-\infty}^{\infty}\{\eta\int_{-\infty}^{x}\underbrace{(g(x)-g(y))}_{<0 \text{ if } g'(\cdot)<0}dF_Y(y) + \eta\lambda\int_{x}^{\infty}\underbrace{(g(x)-g(y))}_{>0 \text{ if } g'(\cdot)<0}dF_Y(y)\}dF_X(x) > 0$$

$$\int_{-\infty}^{\infty}\{\eta\int_{-\infty}^{x}\underbrace{(g(x)-g(y))}_{<0 \text{ if } g'(\cdot)<0}dF_Y(y) + \eta\int_{x}^{\infty}\underbrace{(g(x)-g(y))}_{>0 \text{ if } g'(\cdot)<0}dF_Y(y) + \eta(\lambda-1)\int_{x}^{\infty}\underbrace{(g(x)-g(y))}_{>0 \text{ if } g'(\cdot)<0}dF_Y(y)\}dF_X(x) > 0$$

$$= \int_{-\infty}^{\infty}\{\eta(\lambda-1)\int_{x}^{\infty}\underbrace{(g(x)-g(y))}_{>0 \text{ if } g'(\cdot)<0}dF_Y(y)\}dF_X(x) > 0$$

if $\lambda > 1$, $\eta > 0$, and $g'(\cdot) < 0$. The above consideration implies that $\psi_{T-i-1} > Q_{T-i-1}$ necessarily if $\theta > 0$ such that $u(\cdot)$ is concave. Now, I turn to the agent's maximization problem in period $T-i$, which is given by

$$u(C_{T-i}) + n(C_{T-i}, F_{C_{T-i}}^{T-i-1}) + \gamma\sum_{\tau=1}^{i}\beta^{\tau}\boldsymbol{n}(F_{C_{T-i+\tau}}^{T-i,T-i-1}) + u(P_{T-i} + \frac{(1+r)^{i-1}}{f(i-1)}A_{T-i})\psi_{T-i}.$$

I want to find the agent's first-order condition. I begin by explaining the first derivative of contemporaneous gain-loss utility $n(C_{T-i}, F_{C_{T-i}}^{T-i-1})$. The agent takes his beliefs about period $T-i$ consumption $F_{C_{T-i}}^{T-i-1}$ as given such that

$$\frac{\partial n(C_{T-i}, F_{C_{T-i}}^{T-i-1})}{\partial C_{T-i}} = \frac{\partial(\eta\int_{-\infty}^{C_{T-i}}(u(C_{T-i})-u(c))dF_{C_{T-i}}^{T-i-1}(c)) + \eta\lambda\int_{C_{T-i}}^{\infty}(u(C_{T-i})-u(c))dF_{C_{T-i}}^{T-i-1}(c))}{\partial C_{T-i}}$$

$$= u'(C_{T-i})(\eta F_{C_{T-i}}^{T-i-1}(C_{T-i}) + \eta\lambda(1-F_{C_{T-i}}^{T-i-1}(C_{T-i}))) = u'(C_{T-i})(\eta F_{\bar{S}}(\bar{s}_{T-i}) + \eta\lambda(1-F_{\bar{S}}(\bar{s}_{T-i})))$$

$$= u'(C_{T-i})\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))$$

the last step results from the guessed consumption function and the assumption that admissible consumption functions are increasing in both shocks. The first derivative of the agent's prospective gain-loss utility $\sum_{\tau=1}^{i}\beta^{\tau}\boldsymbol{n}(F_{C_{T-i+\tau}}^{T-i,T-i-1})$ over the entire stream of future consumption utilities $u(P_{T-i}+\frac{(1+r)^i}{f(i-1)}A_{T-i})Q_{T-i}$ can be inferred in a similar manner. Recall that Q_{T-i} is a constant under the guessed consumption function; thus, the agent only experiences gain-loss utility over the realized uncertainty in period $T-i$, i.e.,

$$\frac{\partial\sum_{\tau=1}^{\infty}\beta^{\tau}\boldsymbol{n}(F_{C_{T-i+\tau}}^{T-i-1,T-i})}{\partial A_{T-i}}=\sum_{\tau=1}^{\infty}\beta^{\tau}\frac{\partial}{\partial A_{T-i}}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\mu(u(c)-u(r))dF_{C_{T-i+\tau}}^{T-i-1,T-i}(c,r)$$

$$=\frac{\partial}{\partial A_{T-i}}\int_{-\infty}^{\infty}\mu(u(P_{T-i}+\frac{(1+r)^i}{f(i-1)}A_{T-i})Q_{T-i}-u(x)Q_{T-i})dF^{T-i-1}_{P_{T-i}+\frac{(1+r)^i}{f(i-1)}A_{T-i}}(x)$$

$$=\frac{(1+r)^i}{f(i-1)}exp\{-\theta(P_{T-i}+\frac{(1+r)^i}{f(i-1)}A_{T-i})\}Q_{T-i}\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))$$

and again, $F_{\bar{S}}(\bar{s}_{T-i})=Pr(S_{T-i}^{P}+\frac{(1+r)^i}{f(i)}S_{T-i}^{T}<\bar{s}_{T-i})$ results from the solution guess for A_{T-i} times $\frac{(1+r)^i}{f(i-1)}$ and the fact that future consumption is increasing in both shocks. The derivative of the agent's continuation utility with respect to A_{T-i} is simply given by

$$\frac{(1+r)^i}{f(i-1)}exp\{-\theta\frac{(1+r)^i}{f(i-1)}A_{T-i}\}\psi_{T-i}.$$

In turn, in any period $T-i$ the news-utility agent's first-order condition (normalized by P_{T-i}) is given by

$$exp\{\underbrace{-\theta((1+r)A_{T-i-1}+s_{T-i}^{T}-A_{T-i})}_{=-\theta(C_{T-i}-P_{T-i})\text{ budget constraint}}\}(1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i})))$$

$$=\frac{(1+r)^i}{f(i-1)}exp\{-\theta\frac{(1+r)^i}{f(i-1)}A_{T-i}\}(\psi_{T-i}+\gamma Q_{T-i}\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i})).$$

The first-order condition can be rewritten to obtain the optimal consumption and end-of-period asset holdings functions and the function Λ_{T-i}

$$\Lambda_{T-i}=\frac{1}{\theta}log(\frac{(1+r)^i}{f(i-1)}\frac{\psi_{T-i}+\gamma Q_{T-i}\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))})$$

and the guessed consumption function can be verified.

B.2.2. *The infinite-horizon model.* Suppose $\sigma_{Pt}=\sigma_P$ and $\sigma_{Tt}=\sigma_T$ for all t and $T,i\rightarrow\infty$. I use a simple guess and verify procedure to find the infinite-horizon recursive equilibrium; alternatively, the solution can be obtained by simple backward induction taking T and i to infinity. I guess and verify that the infinite-horizon model consumption and asset-holding functions are given by

$$C_t=Y_t+rA_{t-1}-\frac{1}{1+r}s_t^T-\frac{1}{1+r}\Lambda_t=P_{t-1}+\bar{s}_t+rA_{t-1}-\frac{1}{1+r}\Lambda_t$$

where $\bar{s}_t=s_t^P+\frac{r}{1+r}s_t^T$ and with the budget constraint $A_t=(1+r)A_{t-1}+Y_t-C_t$ determining end-of-period asset holdings

$$A_t=A_{t-1}+\frac{1}{1+r}s_t^T+\frac{1}{1+r}\Lambda_t$$

and the function Λ_t being i.i.d. in the infinite-horizon model and given by

$$\Lambda_t = \frac{1}{\theta} log(r \frac{\psi + \gamma Q \eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))}{1 + \eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))}).$$

The function Λ_t results from the first-order condition that is derived analogously to the finite horizon model and normalized by P_t. First, marginal consumption and contemporaneous gain-loss utility, i.e.,

$$exp\{\underbrace{-\theta(1+r)A_{t-1} - \theta s_t^T + \theta A_t}_{=-\theta(C_t - P_t) \text{ (budget constraint)}}\}(1 + \eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))),$$

is equalized with the agent's marginal continuation utility captured by ψ (the infinite sum of future consumption and gain-loss utility) and Q (the infinite sum of future consumption utility) with the latter multiplied by marginal prospective gain-loss utility

$$= rexp\{-\theta r A_t\}(\psi + \gamma Q \eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))).$$

To understand the first-order condition, take the guessed consumption function and note that consumption in period $t+1$ is $C_{t+1} = P_t + \bar{s}_{t+1} + rA_t - \frac{1}{1+r}\Lambda_{t+1}$ and thus depends on the end-of-period asset holdings A_t. Similarly, consumption in period $t+2$ can be iterated back to A_t and P_t, i.e.,

$$C_{t+2} = P_{t+1} + \bar{s}_{t+2} + r(A_t + \frac{1}{1+r}s_{t+1}^T + \frac{1}{1+r}\Lambda_{t+1}) - \frac{1}{1+r}\Lambda_{t+2} = P_t + \bar{s}_{t+1} + rA_t + \frac{r}{1+r}\Lambda_{t+1} + \bar{s}_{t+2} - \frac{1}{1+r}\Lambda_{t+2}.$$

These two equations for C_{t+1} and C_{t+2} help to understand the continuation utility terms in the first-order condition. Let Q be the infinite discounted sum of marginal consumption utility excluding rA_t and P_t, which is determined by C_{t+1}, C_{t+2}, and so forth using the following recursion

$$Q = \beta E_t[exp\{-\theta(\bar{s}_{t+1} - \frac{1}{1+r}\Lambda_{t+1})\} + exp\{-\theta(\bar{s}_{t+1} + \frac{r}{1+r}\Lambda_{t+1})\}Q].$$

More specifically the agent's infinite discounted sum of marginal future consumption utilities normalized by P_t is (as in the first-order condition)

$$rexp\{-\theta r A_t\}Q \text{ with } Q = \frac{\beta E_t[exp\{-\theta(\bar{s}_{t+1} - \frac{1}{1+r}\Lambda_{t+1})\}]}{1 - \beta E_t[exp\{-\theta(\bar{s}_{t+1} + \frac{r}{1+r}\Lambda_{t+1})\}]}$$

in turn, this term gets multiplied by marginal prospective gain-loss utility $\gamma\eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))$. Now, I move on to the second continuation utility term that is the infinite discounted sum of marginal consumption and gain-loss utility ψ, which is determined analogously to Q, but simply includes gain-loss in addition to consumption utility

$$\psi = \frac{\beta E_t[exp\{-\theta(\bar{s}_{t+1} - \frac{1}{1+r}\Lambda_{t+1})\} + \omega(exp\{-\theta(\bar{s}_{t+1} - \frac{1}{1+r}\Lambda_{t+1})\}) + \gamma Q \omega(exp\{-\theta(\bar{s}_{t+1} + \frac{r}{1+r}\Lambda_{t+1})\})]}{1 - \beta E_t[exp\{-\theta(\bar{s}_{t+1} + \frac{r}{1+r}\Lambda_{t+1})\}]}.$$

Thus, the agent's marginal continuation value of end-of-period asset holdings (normalized by P_t) is determined by $rexp\{-\theta r A_t\}\psi$.

Solving the first-order condition for optimal end-of-period asset holdings A_t yields

$$A_t = A_{t-1} + \frac{1}{1+r}s_t^T + \frac{1}{1+r}\underbrace{\frac{1}{\theta}log(r\frac{\psi + \gamma Q \eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))}{1 + \eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))})}_{=\Lambda_t}$$

which verifies the expression for A_t and Λ_t above. In turn, consumption can be verified by the budget constraint

$$C_t = Y_t + rA_{t-1} - \frac{1}{1+r}s_t^T - \frac{1}{1+r}\Lambda_t = P_{t-1} + \bar{s}_t + rA_{t-1} - \frac{1}{1+r}\Lambda_t.$$

B.3. **Comparison to the agent's pre-committed equilibrium.** In order to assess the preferences' welfare implications, I briefly explain the consumption implications of the monotone-pre-committed equilibrium. The monotone-personal equilibrium maximizes the agent's utility in each period t when he takes his beliefs as given. However, if the agent could pre-commit to his consumption in each possible contingency, he would choose a different consumption path. I define this path as the model's "monotone-pre-committed" equilibrium in the spirit of the choice-acclimating equilibrium concept, as defined by Koszegi and Rabin (2007), but within the outlined environment and admissible consumption function as follows.

Definition 8. The family of admissible consumption functions, $C_t = g_t(X_t, Z_t, s_t)$ for each period t, is a monotone-pre-committed equilibrium for the news-utility agent, if, in any contingency, $C_t = g_t(X_t, Z_t, s_t)$ maximizes (4) subject to (2) and (1) under the assumption that all future consumption corresponds to $C_{t+\tau} = g_{t+\tau}(X_{t+\tau}, Z_{t+\tau}, s_{t+\tau})$. In each period t, the agent's maximization problem determines both his beliefs $\{F^{t-1}_{C_{t+\tau}}\}_{\tau=0}^{T-t}$ and consumption $\{C_{t+\tau}\}_{\tau=0}^{T-t}$.

I derive the equilibrium consumption function under the premise that the agent can pre-commit to an optimal, history-dependent consumption path for each possible future contingency and thus jointly optimizes over consumption and beliefs. This equilibrium is not time consistent because the agent would deviate if he were to take his beliefs as given and optimize over consumption alone. In the next proposition, I formalize how the consumption implications differ in the monotone-pre-committed equilibrium if one exists. Then, I explain beliefs-based present bias in detail and show how it differs from hyperbolic discounting.

Proposition 6. *Comparison to the monotone-pre-committed equilibrium.*
1. If income uncertainty $\sigma_{Pt} > 0$ for any period t, then the monotone-pre-committed consumption path does not correspond to the monotone-personal equilibrium consumption path.
2. The news-utility agent's monotone-pre-committed consumption is excessively smooth and sensitive.
3. News-utility preferences introduce a first-order precautionary-savings motive in the monotone-pre-committed equilibrium, monotone-pre-committed consumption is lower $C^c_{T-1} < C_{T-1}$, and the gap increases in the event of good income realizations $\frac{\partial(C^c_{T-1} - C_{T-1})}{\partial s^P_{T-1}} > 0$.
5. The news-utility agent's monotone-pre-committed consumption path is not necessarily characterized by a hump-shaped consumption profile and consumption does not drop at retirement.

The proof can be found in Appendix B.5.9. Suppose that the agent can pre-commit to an optimal, history-dependent consumption path for each possible future contingency. Then, the agent's marginal gain-loss utility is no longer solely composed of the sensation of increasing consumption in one particular contingency; additionally, the agent considers that he will experience fewer sensations of gains and more feelings of loss in all other contingencies. Thus, marginal gain-loss utility has a second component, $-u'(C_{T-1})(\eta(1-F_{C_t}^{t-1}(C_t))+\eta\lambda F_{C_t}^{t-1}(C_t))$, which is negative such that the pre-committed agent consumes less. Moreover, this negative component dominates if the realization is above the median, i.e., $F_{C_t}^{t-1}(C_t)>0.5$. Thus, in the event of good income realizations, pre-committed marginal gain-loss utility is negative. In contrast, non-pre-committed marginal gain-loss utility is always positive because the agent enjoys the sensation of increasing consumption in any contingency. Therefore, the degree of present bias is reference dependent and less strong in the event of bad income realizations, when increasing consumption is the optimal response even on the pre-committed path. Moreover, this negative component implies additional variation in marginal gain-loss utility such that pre-committed consumption is more excessively smooth and sensitive. From the above consideration it can be easily inferred that the optimal pre-committed consumption function in the exponential-utility model is thus given by

$$\Lambda_{T-i}^{c}=\frac{1}{\theta}log(\frac{(1+r)^{i}}{f(i-1)}\frac{\psi_{T-i}^{c}+\gamma Q_{T-i}^{c}\eta(\lambda-1)(1-2F_{\bar{S}}(\bar{s}_{T-i}))}{1+\eta(\lambda-1)(1-2F_{\bar{S}}(\bar{s}_{T-i}))})$$

with

$$Q_{T-i-1}^{c}=E_{T-i-1}[\beta exp\{-\theta(\bar{s}_{T-i}-\frac{f(i-1)}{f(i)}\Lambda_{T-i}^{c})\}+\beta exp\{-\theta(\bar{s}_{T-i}+\frac{(1+r)^{i}}{f(i)}\Lambda_{T-i}^{c})\}Q_{T-i}^{c}]$$

and

$$\psi_{T-i-1}^{c}=\beta E_{T-i-1}[exp\{-\theta(\bar{s}_{T-i}-\frac{f(i-1)}{f(i)}\Lambda_{T-i}^{c})\}+\omega(exp(-\theta(\bar{s}_{T-i}-\frac{f(i-1)}{f(i)}\Lambda_{T-i}^{c})\})$$
$$+\gamma Q_{T-i}^{c}\omega(exp\{-\theta(\bar{s}_{T-i}+\frac{(1+r)^{i}}{f(i)}\Lambda_{T-i}^{c})\})+\frac{1}{\theta}exp\{-\theta(\bar{s}_{T-i}+\frac{(1+r)^{i}}{f(i)}\Lambda_{T-i}^{c})\}\psi_{T-i}^{c}.$$

B.4. **The other agent's exponential-utility consumption functions.** By the same arguments as for the derivation of the news-utility model, the "standard" agent's consumption function in period $T-i$ is

$$A_{T-i}^{s}=\frac{f(i-1)}{f(i)}(1+r)A_{T-i-1}^{s}+\frac{f(i-1)}{f(i)}s_{T-i}^{T}+\frac{f(i-1)}{f(i)}\Lambda_{T-i}^{s}$$
$$C_{T-i}^{s}=\frac{(1+r)^{i}}{f(i)}(1+r)A_{T-i-1}^{s}+P_{T-i-1}+\bar{s}_{T-i}-\frac{f(i-1)}{f(i)}\Lambda_{T-i}^{s}$$
$$\Lambda_{T-i}^{s}=\frac{1}{\theta}log(\frac{(1+r)^{i}}{f(i-1)}Q_{T-i}^{s})$$
$$Q_{T-i-1}^{s}=\beta E_{T-i-1}[exp\{-\theta(\bar{s}_{T-i}-\frac{f(i-1)}{f(i)}\Lambda_{T-i}^{s})\}+\beta exp\{-\theta(\bar{s}_{T-i}+\frac{(1+r)^{i}}{f(i)}\Lambda_{T-i}^{s})\}Q_{T-i}^{s}].$$

The "hyperbolic-discounting" agent's consumption in period $T-i$ is

$$A_{T-i}^{b}=\frac{f(i-1)}{f(i)}(1+r)A_{T-i-1}^{b}+\frac{f(i-1)}{f(i)}s_{T-i}^{T}+\frac{f(i-1)}{f(i)}\Lambda_{T-i}^{b}$$
$$C_{T-i}^{b}=\frac{(1+r)^{i}}{f(i)}(1+r)A_{T-i-1}^{b}+P_{T-i-1}+\bar{s}_{T-i}-\frac{f(i-1)}{f(i)}\Lambda_{T-i}^{b}$$

$$\Lambda^b_{T-i} = \frac{1}{\theta} log(\frac{(1+r)^i}{f(i-1)} b Q^b_{T-i})$$

$$Q^b_{T-i-1} = \beta E_{T-i-1}[exp\{-\theta(\bar{s}_{T-i} - \frac{f(i-1)}{f(i)}\Lambda^b_{T-i})\} + \beta exp\{-\theta(\bar{s}_{T-i} + \frac{(1+r)^i}{f(i)}\Lambda^b_{T-i})\} Q^b_{T-i}].$$

The "tempted" agent's maximization problem is given by

$$max_{C^{td}_t}\{u(C^{td}_t) - \lambda^{td}(u(\tilde{C}^{td}_t) - u(C^{td}_t)) + E_t[\sum_{\tau=1}^{T-t}\beta^\tau(u(C^{td}_{t+\tau}) - \lambda^{td}(u(\tilde{C}^{td}_{t+\tau}) - u(C^{td}_{t+\tau})))]\}$$

with $\tilde{C}^{td}_{t+\tau}$ being the most tempting alternative. To explain temptation disutility in greater detail, I also outline the agent's optimization in periods T, $T-1$, and $T-2$. I In period T as the agent cannot die in debt the most tempting alternative is $\tilde{C}^{td}_T = X^{td}_T$ but the agent will consume X_T anyway thus temptation disutility is zero and $Q^{td}_{T-1} = Q^s_{T-1}$. In period $T-1$ the agent's consumption is then given by

$$A^{td}_{T-1} = \frac{1+r}{2+r}A^{td}_{T-2} + \frac{1}{2+r}s^T_{T-1} + \frac{1}{2+r}\Lambda^{td}_{T-1}$$

$$C^{td}_{T-1} = \frac{1+r}{2+r}(1+r)A^{td}_{T-2} + P_{T-2} + \bar{s}_{T-1} - \frac{1}{2+r}\Lambda^{td}_{T-1}$$

with $\Lambda^{td}_{T-1} = \frac{1}{\theta}log((1+r)\frac{1}{1+\lambda^{td}}Q^{td}_{T-1})$ and $Q^{td}_{T-1} = \beta E_{T-1}[exp\{-\theta(\bar{s}_T)\}]$.

What's the agent's most tempting alternative in period $T-1$? The value of cash-on-hand is X^{td}_{T-1} but the most tempting alternative is $\tilde{C}^{td}_T \to \infty$ as consumption could be negative in the last period $C_T \to -\infty$, which would yield $lim_{C^{td}_T \to -\infty} u(C^{td}_T) = lim_{C^{td}_T \to -\infty} - \frac{1}{\theta}e^{-\theta C^{td}_T} \to -\infty$. Accordingly, Q^{td}_{T-2} enters $lim_{\tilde{C}^{td}_T \to -\infty} u'(\tilde{C}^{td}_T) = lim_{\tilde{C}^{td}_T \to -\infty} e^{-\theta\tilde{C}^{td}_T} \to 0$

$$Q^{td}_{T-2} = \beta E_{T-2}[exp\{-\theta(\bar{s}_{T-1} - \frac{1}{2+r}\Lambda^{td}_{T-1})\} - \lambda^{td}(exp\{-\theta(\bar{s}_{T-1} - \frac{1}{2+r}\Lambda^{td}_{T-1})\}$$
$$\underbrace{-exp\{\theta\frac{1+r}{2+r}(1+r)A^{td}_{T-2} - \theta\tilde{C}^{td}_T\}}_{\to 0}) + exp\{-\theta(\bar{s}_{T-1} + \frac{1+r}{2+r}\Lambda^{td}_{T-1})\}Q^{td}_{T-1}]$$

$$Q^{td}_{T-2} = E_{T-2}[\beta exp\{-\theta(\bar{s}_{T-1} - \frac{1}{2+r}\Lambda^{td}_{T-1})\}(1-\lambda^{td}) + \beta exp\{-\theta(\bar{s}_{T-1} + \frac{1+r}{2+r}\Lambda^{td}_{T-1})\}Q^{td}_{T-1}].$$

And in period $T-i$

$$A^{td}_{T-i} = \frac{f(i-1)}{f(i)}(1+r)A^{td}_{T-i-1} + \frac{f(i-1)}{f(i)}s^T_{T-i} + \frac{f(i-1)}{f(i)}\Lambda^{td}_{T-i}$$

$$C^{td}_{T-i} = \frac{(1+r)^i}{f(i)}(1+r)A^{td}_{T-i-1} + P_{T-i-1} + \bar{s}_{T-i} - \frac{f(i-1)}{f(i)}\Lambda^{td}_{T-i}$$

$$\Lambda^{td}_{T-i} = \frac{1}{\theta}log(\frac{(1+r)^i}{f(i-1)}\frac{1}{1+\lambda^{td}}Q^{td}_{T-i})$$

$$Q^{td}_{T-i-1} = \beta E_{T-i-1}[exp\{-\theta(\bar{s}_{T-i} - \frac{f(i-1)}{f(i)}\Lambda^{td}_{T-i})\}(1-\lambda^{td}) + \beta exp\{-\theta(\bar{s}_{T-i} + \frac{(1+r)^i}{f(i)}\Lambda^{td}_{T-i})\}Q^{td}_{T-i}].$$

B.5. **Proofs of Section 2.2:**

B.5.1. *Proof of Proposition 1.* If the consumption function derived in Section B.2.1 belongs to the class of admissible consumption functions then the equilibrium exists and is unique as the equilibrium solution is obtained by maximizing the agent's objective function, which is globally concave, and there is a finite period that uniquely determines the equilibrium. Please refer to Section B.2.1 for the derivation of the consumption function. σ_t^* is implicitly defined by the two admissible consumption function restrictions $\frac{\partial C_{T-i}}{\partial s^P_{T-i}} > 0$ and $\frac{\partial C_{T-i}}{\partial s^T_{T-i}} > 0$ as

$$C_{T-i} = \frac{(1+r)^i}{f(i)}(1+r)A_{T-i-1} + P_{T-i-1} + \bar{s}_{T-i} - a(i)\Lambda_{T-i}$$

the restrictions are equivalent to $\frac{\partial a(i)\Lambda_{T-i}}{\partial s^P_{T-i}} < 1$ and $\frac{\partial a(i)\Lambda_{T-i}}{\partial s^T_{T-i}} < 1 - a(i)$ as $\frac{\partial \Lambda_{T-i}}{\partial s^P_{T-i}}, \frac{\partial \Lambda_{T-i}}{\partial s^T_{T-i}} > 0$ (since $\psi_{T-i} > \gamma Q_{T-i}$ (for any concave utility function which I have shown in Section B.2)). Recall that $a(i) = 1 - \frac{(1+r)^i}{f(i)} = \frac{f(i-1)}{f(i)}$. Then, σ^*_{T-i} is implicitly defined by the two restrictions

$$\frac{\partial a(i)\Lambda_{T-i}}{\partial s^P_{T-i}} = \frac{a(i)}{\theta(\frac{1-a(i)}{a(i)})} \frac{\frac{(\psi_{T-i}-\gamma Q_{T-i})\eta f_{\bar{S}}(\bar{s}_{T-i})(\lambda-1)}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))}}{\psi_{T-i} + \gamma Q_{T-i}\eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))} < 1$$

and

$$\frac{\partial a(i)\Lambda_{T-i}}{\partial s^T_{T-i}} = \frac{a(i)}{\theta(\frac{1-a(i)}{a(i)})} \frac{\frac{(\psi_{T-i}-\gamma Q_{T-i})\eta f_{\bar{S}}(\bar{s}_{T-i})(\lambda-1)}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))}}{\psi_{T-i} + \gamma Q_{T-i}\eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))} < 1 - a(i).$$

Here, the normal pdf of any random variably X is denoted by f_X. Increasing σ_{Pt} and σ_{Tt} unambiguously decreases $f_{\bar{S}}(\bar{s}_{T-i})$ and thereby $\frac{\partial a(i)\Lambda_{T-i}}{\partial s^P_{T-i}}$ and $\frac{\partial a(i)\Lambda_{T-i}}{\partial s^T_{T-i}}$. Thus, there exists a condition $\sigma^2_{Pt} + (\frac{(1+r)^i}{f(i)})^2\sigma^2_{Tt} \geq \sigma^*_t$ for all t which ensures that an admissible consumption function exists that uniquely determines the equilibrium (given the admissible consumption functions in each future period until the final period) because the optimization problem is globally concave.

If uncertainty is small then the consumption function may be decreasing over some range, i.e., $\frac{\partial C_{T-i}}{\partial s^P_{T-i}} < 0$ or $\frac{\partial C_{T-i}}{\partial s^T_{T-i}} < 0$. I now show that the agent would pick a consumption function that is instead of decreasing flat and thus weakly increasing in the shock realizations, i.e., $\frac{\partial C_{T-i}}{\partial s^P_{T-i}} \geq 0$ or $\frac{\partial C_{T-i}}{\partial s^T_{T-i}} \geq 0$. To discuss this result in a simple framework, I return to the two-period, one-shock model. Suppose that the absolute level of the shock increases; then, holding C_{T-1} constant, the marginal value of savings declines and the agent's first-order condition implies that consumption should increase. However, $F_P(s^P_{T-1})$ also increases, and marginal gain-loss utility is lower, such that the agent's optimal consumption should decrease. Suppose that s^P_{T-1} increases marginally but $F_P(s^P_{T-1})$ increases sharply, which could occur if F_P is a very narrow distribution. In this case, the lower marginal gain-loss utility that decreases consumption dominates such that the first-order condition predicts decreasing consumption over some range in the neighborhood of the expected value μ_P where F_P increases most sharply if F_P is bell shaped. However, a decreasing consumption function cannot be an equilibrium because the agent would unnecessarily experience gain-loss utility over the decreasing part of consumption, which decreases expected utility unnecessarily. In the decreasing-consumption function region, the agent could choose a flat consumption function instead. In the following I show that the agent may choose a credible consumption plan with a flat section. Suppose the agent chooses a flat consumption level for realizations of s^P_{T-1} in $\underline{s}^P$ and

$\bar{s}^P$. Then, $\bar{s}^P$ is chosen where the original consumption function just stops decreasing, which corresponds to the lowest possible level of the flat section of consumption $\overline{C}_{T-1}$. In that is then determined by

$$u'(\overline{C}_{T-1}) = (1+r)u'((\bar{s}^P - \overline{C}_{T-1})(1+r) + \bar{s}^P)\frac{\psi_{T-1} + \gamma Q_{T-1}\eta(\lambda - (\lambda-1)F_P(\bar{s}^P))}{1+\eta(\lambda - (\lambda-1)F_P(\bar{s}^P))}$$

in which case $\underline{s}$ is determined by

$$u'(\overline{C}_{T-1}) = (1+r)u'((\underline{s}^P - \overline{C}_{T-1})(1+r) + \underline{s}^P)\frac{\psi_{T-1} + \gamma Q_{T-1}\eta(\lambda - (\lambda-1)F_P(\underline{s}^P))}{1+\eta(\lambda - (\lambda-1)F_P(\underline{s}^P))}.$$

The agent's consistency constraint for not increasing consumption beyond $\overline{C}_{T-1}$ for any $s^P_{T-1} \in [\underline{s}^P, \bar{s}^P]$ is given by

$$u'(\overline{C}_{T-1}) < (1+r)u'((s^P_{T-1} - \overline{C}_{T-1})(1+r) + s^P_{T-1})\frac{\psi_{T-1} + \gamma Q_{T-1}\eta(\lambda - (\lambda-1)F_P(s^P_{T-1}))}{1+\eta(\lambda - (\lambda-1)F_P(\bar{s}^P))}$$

and always holds as can be easily inferred. This result can be easily generalized to any horizon, thus, if the consumption function is decreasing over some range, the agent can credibly replace the decreasing part with a flat section as described above.

B.5.2. *Proof of Proposition 2.* Please refer to the derivation of the exponential-utility model Section B.2 for a detailed derivation of Λ_{T-i}. According to Definition 4 consumption is excessively smooth if $\frac{\partial C_t}{\partial s^P_t} < 1$ and excessively sensitive if $\frac{\partial \Delta C_{t+1}}{\partial s^P_t} > 0$. Consumption growth is

$$\Delta C_{T-i} = \bar{s}_{T-i} - a(i)\Lambda_{T-i} + \Lambda_{T-i-1}$$

so that $\frac{\partial C_{T-i}}{\partial s^P_{T-i}} < 1$ iff $\frac{\partial \Lambda_{T-i}}{\partial s^P_{T-i}} > 0$ and $\frac{\partial \Delta C_{T-i}}{\partial s^P_{T-i-1}} > 0$ iff $\frac{\partial \Lambda_{T-i-1}}{\partial s^P_{T-i-1}} > 0$. Since $\psi_{T-i} > \gamma Q_{T-i}$ (for any concave utility function which I have shown in Section B.2) it can be easily seen that $\frac{\partial \Lambda_{T-i}}{\partial s^P_{T-i}} > 0$, i.e.

$$\frac{\partial \Lambda_{T-i}}{\partial s^P_{T-i}} = \frac{1}{\theta(\frac{1-a(i)}{a(i)})}\frac{\frac{(\psi_{T-i} - \gamma Q_{T-i})\eta f_{\bar{S}}(\bar{s}_{T-i})(\lambda-1)}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))}}{\psi_{T-i} + \gamma Q_{T-i}\eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))} > 0.$$

The same holds true for the infinite-horizon model

$$\Delta C_t = \bar{s}_t - \Lambda_t + (1+r)\Lambda_{t-1}$$

as Λ_t is increasing in the permanent shock

$$\frac{\partial \Lambda_t}{\partial s^P_t} = \frac{1}{\theta(1+r)r}\frac{\frac{(\psi - \gamma Q)\eta f_{\bar{S}}(\bar{s}_t)(\lambda-1)}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_t))}}{\psi + \gamma Q\eta(\lambda - (\lambda-1)F_{\bar{S}}(\bar{s}_t))} > 0.$$

Accordingly, $\frac{\partial \Lambda_t}{\partial s^P_t} > 0$ as $\psi > \gamma Q$. Thus, if $s^P_t \uparrow$ then $\Lambda_t \uparrow$ and the shock induced change in consumption is less than one and the period t shock induced change in one-period ahead consumption ΔC_{t+1} is larger than zero.

The difference to the standard, tempted, and quasi-hyperbolic discounting agents is that $\frac{\partial \Lambda^{s,t,b}_t}{\partial s^P_t} = 0$ for all t such that consumption is neither excessively sensitive nor excessively smooth.

B.5.3. *Proof of Lemma 1.* I start with the first part of the lemma, the precautionary-savings motive. In the second-to-last period of the simple model outlined in the text, the first-order condition is given by

$$u'(C_{T-1})+u'(C_{T-1})\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))$$
$$=(1+r)u'((s^P_{T-1}-C_{T-1})(1+r)+s^P_{T-1})\gamma\underbrace{\beta E_{T-1}[u'(S^P_T)]}_{Q_{T-1}}\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))$$

$$+(1+r)u'((s^P_{T-1}-C_{T-1})(1+r)+s^P_{T-1})\underbrace{\beta E_{T-1}[u'(S^P_T)+\eta(\lambda-1)\int_{S^P_T}^{\infty}(u'(S^P_T)-u'(y))dF_P(y)]}_{\psi_{T-1}}.$$

From Section B.2 I know that $\psi_{T-1}>Q_{T-1}$ because for any two random variables $X\sim F_X$ and $Y\sim F_Y$ with $F_X=F_Y$ in equilibrium

$$\int_{-\infty}^{\infty}\{\eta\int_{-\infty}^{x}\underbrace{(g(x)-g(y))}_{<0\text{ if }g'(\cdot)<0}dF_Y(y)+\eta\lambda\int_{x}^{\infty}\underbrace{(g(x)-g(y))}_{>0\text{ if }g'(\cdot)<0}dF_Y(y)\}dF_X(x)>0$$

if $\lambda>1$, $\eta>0$, and $g'(\cdot)<0$. Thus, $\beta E_{T-1}[\eta(\lambda-1)\int_{S^P_T}^{\infty}(u'(S^P_T)-u'(y))dF_P(y)]>0$ if $u''(\cdot)>0$ the agent is risk averse or $u(\cdot)$ is concave. Moreover, it can be seen that $\frac{\partial\beta E_{T-1}[\eta(\lambda-1)\int_{S^P_T}^{\infty}(u'(S^P_T)-u'(y))dF_P(y)]}{\partial\eta}>0$ and $\frac{\partial\beta E_{T-1}[\eta(\lambda-1)\int_{S^P_T}^{\infty}(u'(S^P_T)-u'(y))dF_P(y)]}{\partial\lambda}>0$. Then, for any value of savings $A_{T-1}=s^P_{T-1}-C_{T-1}$ the right hand side of the first-order condition is increased by the presence of expected gain-loss disutility if $\sigma_P>0$ whereas if $\sigma_P=0$ then $\psi_{T-1}=Q_{T-1}$. The increase of the agent's marginal value of savings by the presence of expected gain-loss disutility depends on $\sigma_P>0$, but does not go to zero as $\sigma_P\to 0$ so that the additional precautionary savings motive is first-order $\frac{\partial(s^P_{T-1}-C_{T-1})}{\partial\sigma_P}|_{\sigma_P=0}>0$ as can be easily shown for any normally distribution random variable $X\sim F_X=N(\mu,\sigma^2)$

$$E_{T-1}[\eta(\lambda-1)\int_X^{\infty}(u'(X)-u'(y))dF_X(y)]$$
$$=e^{-\theta\mu}\int_{-\infty}^{\infty}(\eta\int_{-\infty}^{z}(e^{-\theta\sigma z}-e^{-\theta\sigma\varepsilon})dF_{01}(\varepsilon)+\eta\lambda\int_z^{\infty}(e^{-\theta\sigma z}-e^{-\theta\sigma\varepsilon})dF_{01}(\varepsilon))dF_{01}(z)\text{ with }z,\varepsilon\sim F_{01}=N(0,1)$$
$$=e^{-\theta\mu}\eta(\lambda-1)\int_z^{\infty}(e^{-\theta\sigma z}-e^{-\theta\sigma\varepsilon})dF_{01}(\varepsilon))dF_{01}(z)$$
$$=e^{-\theta\mu}\eta(\lambda-1)\int_{-\infty}^{\infty}\{(1-F_{01}(z))e^{-\theta\sigma z}-e^{\frac{1}{2}\theta^2\sigma^2}F_{01}(-\theta\sigma-z)\}dF_{01}(z)$$
$$\frac{\partial(\cdot)}{\partial\sigma}|_{\sigma=0}=e^{-\theta\mu}\eta(\lambda-1)\int_{-\infty}^{\infty}\{-\theta z(1-F_{01}(z))e^{-\theta\sigma z}-\theta\sigma e^{\frac{1}{2}\theta^2\sigma^2}F_{01}(-\theta\sigma-z)+\theta e^{\frac{1}{2}\theta^2\sigma^2}F_{01}(-\theta\sigma-z)\}dF_{01}(z)|_{\sigma=0}$$
$$=e^{-\theta\mu}\theta\eta(\lambda-1)\int_{-\infty}^{\infty}\{-z+zF_{01}(z)+F_{01}(-z)\}dF_{01}(z)\approx e^{-\theta\mu}\theta\eta(\lambda-1)0.7832>0.$$

Thus, news-utility introduces a first-order precautionary-savings motive.

In the second part of the lemma the implications for consumption can be immediately seen by comparing the agents' first-order conditions. The standard agent's first-order condition in period $T-1$ is given by

$$u'(C_{T-1})=Ru'((s^P_{T-1}-C_{T-1})R+s^P_{T-1})Q_{T-1}.$$

The difference to the news-utility model can be seen easily: First, $\frac{\psi_{T-1}}{Q_{T-1}}>1$ implies that

$$\frac{\frac{\psi_{T-1}}{Q_{T-1}}+\gamma\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))}{1+\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))}>1$$

for γ high enough such that the news-utility agent consumes less than the standard agent if he does not discount prospective gain-loss utility very highly. Moreover, as $\frac{\psi_{T-1}}{Q_{T-1}}$ is increasing in σ_P the threshold value for γ, i.e., $\bar{\gamma}$, in each comparison is decreasing in σ_P.

B.5.4. *Proof of Proposition 3.* The agent optimally chooses consumption and asset holdings in periods $T-i=1,...,T$ for any horizon T. I defined a hump-shaped consumption profile as characterized by increasing consumption and asset holdings in the beginning of life $C_1<C_2$ and decreasing consumption in the end of life $C_T<C_{T-1}$ (note that, I derive the thresholds $\underline{\sigma_P}$ and $\overline{\sigma_P}$ for $s^P_t=0$ and $s^T_t=0$ in all periods, since Λ_{T-i} is skewed this is not exactly the average consumption path but the difference is minor). The first characteristic requires $C_1<C_2$ which implies that

$$\frac{(1+r)^{T-1}}{f(T-1)}(1+r)A_0+P_0-\frac{f(T-2)}{f(T-1)}\Lambda_1<\frac{(1+r)^{T-2}}{f(T-2)}(1+r)A_1+P_0-\frac{f(T-3)}{f(T-2)}\Lambda_2$$

so that $\Lambda_1>\frac{f(T-3)}{f(T-2)}\Lambda_2$ and since $\frac{f(T-3)}{f(T-2)}<1$ this holds always if $\Lambda_1>0$ as T becomes large since in the limit $\Lambda_1=\Lambda_2$. Recall that if $\lambda>1$ and $\eta>0$ then $\psi_{T-i}>Q_{T-i}$, $\psi_{T-i}>\psi_{T-i+1}$ and $Q_{T-i}>Q_{T-i+1}$ and $\psi_{T-i}-Q_{T-i}>\psi_{T-i+1}-Q_{T-i+1}$ for all i and $\frac{\psi_{T-i}}{Q_{T-i}}$ approaches it's limit $\frac{\psi}{Q}$ as i and T become large. $\underline{\sigma_P}$ is then implicitly defined by the requirement $\Lambda_1>0$ which is equivalent to

$$\frac{(1+r)^{T-1}}{f(T-2)}\frac{\psi_1+\gamma Q_1\eta\frac{1}{2}(1+\lambda)}{1+\eta\frac{1}{2}(1+\lambda)}=\frac{r}{1-(\frac{1}{1+r})^{T-1}}\frac{\psi_1+\gamma Q_1\eta\frac{1}{2}(1+\lambda)}{1+\eta\frac{1}{2}(1+\lambda)}>1.$$

Accordingly, if $\frac{\psi_1}{Q_1}$ (which is determined by expected marginal gain-loss utility) is large enough relative to γ the agent chooses an increasing consumption path. For $T\rightarrow\infty$ the condition boils down to

$$r\frac{\psi+\gamma Q\eta\frac{1}{2}(1+\lambda)}{1+\eta\frac{1}{2}(1+\lambda)}>1\Rightarrow r(\psi+\gamma Q\eta\frac{1}{2}(1+\lambda))>1+\eta\frac{1}{2}(1+\lambda)$$

for which a sufficient condition is $\gamma Q>\frac{1}{r}$.

The second characteristic requires $C_T<C_{T-1}$ which implies that

$$(1+r)A_{T-1}<\frac{1+r}{2+r}(1+r)A_{T-2}-\frac{1}{2+r}\Lambda_{T-1}$$

and is equivalent to $\Lambda_{T-1}<0$. Thus, $\overline{\sigma_P}$ is implicitly defined by $\Lambda_{T-1}<0$

$$\frac{1}{\theta}log((1+r)\frac{\psi_{T-1}+\gamma Q_{T-1}\eta\frac{1}{2}(1+\lambda)}{1+\eta\frac{1}{2}(1+\lambda)})<0\Rightarrow(1+r)\frac{\psi_{T-1}+\gamma Q_{T-1}\eta\frac{1}{2}(1+\lambda)}{1+\eta\frac{1}{2}(1+\lambda)}<1.$$

Note that, because $\beta(1+r)\approx1$ the standard agent will choose an almost flat consumption path such that $(1+r)Q_{T-1}\approx1$. Thus, the news-utility agent chooses a mean falling consumption path in the end of life as long as $\frac{\psi_{T-1}}{Q_{T-1}}$ is not too large or γ is not too close to one.

B.5.5. *Proof of Proposition 4.* In the deterministic setting, $s^P_t=s^T_t=0$ for all t such that the news-utility agent will not experience actual news utility in a subgame-perfect equilibrium because he cannot fool himself and thus $\psi_t=Q_t$ for all t. Thus, the expected-utility maximizing path corresponds to the standard agent's one which is determined in any period $T-i$ by the following first-order condition

$$exp\{-\theta(1+r)A_{T-i-1}+\theta A_{T-i}\} = \frac{(1+r)^i}{f(i-1)}exp\{-\theta\frac{(1+r)^i}{f(i-1)}A_{T-i}\}Q^s_{T-i}.$$

If the agent believes he follows the above path then the consistency constraint (increasing consumption is not preferred) has to hold

$$exp\{-\theta(1+r)A_{T-i-1}+\theta A_{T-i}\}(1+\eta) < \frac{(1+r)^i}{f(i-1)}exp\{-\theta\frac{(1+r)^i}{f(i-1)}A_{T-i}\}Q^s_{T-i}(1+\gamma\eta\lambda).$$

Thus, if $\eta < \gamma\eta\lambda \Rightarrow \gamma > \frac{1}{\lambda}$ the agent follows the expected-utility maximizing path. Whereas for $\gamma \leq \frac{1}{\lambda}$ news-utility consumption is characterized by equality of the consistency constraint, because the agent will choose the lowest consumption level that just satisfies it. Then, the first-order condition becomes equivalent to a $\beta\delta-$agent's first-order condition with $b = \frac{1+\gamma\eta\lambda}{1+\eta} < 1$.

In the infinite-horizon model, a simple perturbation argument gives the following consistency constraint

$$exp(-\theta(1+r)A_{t-1}+\theta A_t)(1+\eta) < rexp(-\theta rA_t)Q(1+\gamma\eta\lambda),$$

because $\psi = Q$. However, if $\gamma > \frac{1}{\lambda}$ the news-utility agent finds it optimal to follow the expected-utility-maximizing standard agent's path

$$exp(-\theta(1+r)A_{t-1}+\theta A_t) = rexp(-\theta rA_t)Q^s \Rightarrow A_t = A_{t-1}+\Lambda^s \Rightarrow C_t = rA_{t-1}+Y_t-\Lambda^s$$

$$\Lambda^s = \frac{1}{\theta(1+r)}log(rQ^s) \text{ with } Q^s = \frac{\beta exp(-\theta(-\Lambda^s))}{1-\beta exp(-\theta r\Lambda^s)}.$$

Whereas for $\gamma \leq \frac{1}{\lambda}$ news-utility consumption will choose the lowest consumption level that just satisfies his consistency constraint. Then, the first-order condition becomes equivalent to a $\beta\delta-$agent's first-order condition with $b = \frac{1+\gamma\eta\lambda}{1+\eta} < 1$.

B.5.6. *Proof of Proposition 5.* I say that the news-utility agent's consumption path features a drop in consumption at retirement, if consumption growth after the start of retirement is negative and smaller than it is at the start of retirement, i.e., ΔC_{T-R} is negative and smaller than ΔC_{T-R+1}. In general, after the start of retirement the news-utility agent's consumption growth follows the standard model or the hyperbolic-discounting model. Thus, the news-utility agent's implied hyperbolic-discount factor after retirement is $b^R \in \{\frac{1+\gamma\eta\lambda}{1+\eta}, 1\}$, which is larger than the news-utility agent's implied hyperbolic-discount factor before retirement. In period $T-R-1$ the weight on future marginal value versus current marginal consumption is between $\{\frac{1+\gamma\eta\lambda}{1+\eta\lambda}, \frac{1+\gamma\eta}{1+\eta}\}$ and since $\frac{1+\gamma\eta\lambda}{1+\eta\lambda} < \frac{1+\gamma\eta}{1+\eta} < \frac{1+\gamma\eta\lambda}{1+\eta} < 1$ the hyperbolic-discount factor implied by at-retirement consumption growth ΔC_{T-R} is necessarily lower than the hyperbolic-discount factor implied by post-retirement consumption growth ΔC_{T-R+1}. Thus, consumption growth at retirement will necessarily be less than consumption growth after retirement. Moreover, if consumption growth after retirement is approximately zero, because $log((1+r)\beta) \in [-\triangle, \triangle]$ with $\triangle$ small then consumption growth at retirement will be negative.

Let me formalize the agent's consumption growth at and after retirement. After retirement the news-utility agent's consumption growth is $\Delta C_{T-R+1} = C_{T-R+1} - C_{T-R} = -a(R-1)\Lambda_{T-R+1} + \Lambda_{T-R}$ and will correspond to a hyperbolic-discounting agent's consumption with $b \in \{\frac{1+\eta\gamma\lambda}{1+\eta}, 1\}$ such that the agent's continuation utilities in period $T-R$ and $T-R+1$ (which determine Λ_{T-R} and Λ_{T-R+1}) correspond to

$$Q_{T-R} = \psi_{T-R} = Q^b_{T-R} \text{ and } Q_{T-R+1} = \psi_{T-R+1} = Q^b_{T-R+1}$$

such that

$$\Lambda_{T-R} = \frac{1}{\theta}log(\frac{(1+r)^R}{f(R-1)}bQ^b_{T-R}) \text{ and } \Lambda_{T-R+1} = \frac{1}{\theta}log(\frac{(1+r)^{R-1}}{f(R-2)}bQ^b_{T-R+1})$$

thus if $log((1+r)\beta) \in [-\triangle, \triangle]$ with $\triangle$ small then consumption growth after retirement will be approximately zero (if $b = 1$ and the news-utility agent follows the standard agent's path) or negative if $b < 1$ (if the news-utility agent follows a hyperbolic-discounting path but $log((1+r)\beta) \approx 0$)). Consumption growth at retirement is $\Delta C_{T-R} = C_{T-R} - C_{T-R-1} = -a(R)\Lambda_{T-R} + \Lambda_{T-R-1}$. Λ_{T-R} will correspond to a hyperbolic-discounting agent's value with $b \in \{\frac{1+\eta\gamma\lambda}{1+\eta}, 1\}$ as above. But, Λ_{T-R-1} will correspond to a hyperbolic-discounting agent's value with $b \in \{\frac{1+\gamma\eta\lambda}{1+\eta\lambda}, \frac{1+\gamma\eta}{1+\eta}\}$ and it can be easily seen that $\frac{1+\gamma\eta\lambda}{1+\eta\lambda} < \frac{1+\gamma\eta}{1+\eta} < \frac{1+\gamma\eta\lambda}{1+\eta} < 1$. Thus, from above

$$\Lambda_{T-R} = \frac{1}{\theta}log(\frac{(1+r)^R}{f(R-1)}bQ^b_{T-R})$$

and if the news-utility agent would continue this hyperbolic path implied by the past retirement $b \in \{\frac{1+\eta\gamma\lambda}{1+\eta}, 1\}$ then

$$\Lambda^b_{T-R-1} = \frac{1}{\theta}log(\frac{(1+r)^{R+1}}{f(R)}bQ^b_{T-R-1})$$

whereas in fact his Λ_{T-R-1} is given by

$$\Lambda_{T-R-1} = \frac{1}{\theta}log(\frac{(1+r)^{R+1}}{f(R)}\frac{\psi_{T-R-1} + \gamma Q_{T-R-1}\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-R-1}))}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-R-1}))})$$

with $\psi_{T-R-1} = Q_{T-R-1} = Q^b_{T-R-1}$ because there is no uncertainty from period $T-R$ on. As can be easily seen iff $\gamma < 1$ then $\Lambda_{T-R-1} < \Lambda^b_{T-R-1}$ because

$$\frac{Q^b_{T-R-1} + \gamma Q^b_{T-R-1}\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-R-1}))}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-R-1}))} < Q^b_{T-R-1}$$

for instance, if $F(\cdot) = 0.5$ then $\frac{1+\gamma\frac{1}{2}\eta(1+\lambda)}{1+\frac{1}{2}\eta(1+\lambda)} < 1$ iff $\gamma < 1$. Thus, news-utility consumption growth is smaller at retirement than after retirement. Moreover, it is negative because it is either approximately zero after retirement (if $b^R = 1$) or negative after retirement (if $b^R = \frac{1+\gamma\eta\lambda}{1+\eta} < 1$).

B.5.7. *Proof of Corollary 1.* After retirement the news-utility agent's consumption from period $T-R$ on will correspond to a hyperbolic-discounting agent's consumption with $b \in \{\frac{1+\eta\gamma\lambda}{1+\eta}, 1\}$ such that the agent's continuation utilities correspond to

$$Q_{T-R-1} = \psi_{T-R-1} = Q^b_{T-R-1}$$

thus Λ_{T-R-1} is given by

$$\Lambda_{T-R-1} = \frac{1}{\theta}log(\frac{(1+r)^{R+1}}{f(R)}\frac{\psi_{T-R-1} + \gamma Q_{T-R-1}\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-R-1}))}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-R-1}))})$$

as can be easily seen iff $\gamma < 1$ then $\frac{\partial \Lambda_{T-R-1}}{\partial s^P_{T-R-1}} > 0$ and consumption is excessively smooth and sensitive in the pre-retirement period.

B.5.8. *Proofs of the new predictions about consumption (Section 2.2.4).* The new predictions can be easily inferred from the above considerations.

(1) Consumption is more excessively sensitive for permanent than for transitory shocks in an environment with permanent shocks. In an environment with transitory shocks only, however, news-utility consumption is excessively sensitive with respect to transitory shocks. Λ_t varies more with the permanent shock than with the transitory shock, because the agent is consuming only the per-period value $\frac{r}{1+r}s_t^T$ of the period t transitory shock, such that $F_{C_t}^{t-1}(C_t)$ varies little with s_t^T. However, in the absence of permanent shocks Λ_t would vary with $F_{S_{T-i}^T}(s_{T-i}^T)$ which fully determines $F_{C_t}^{t-1}(C_t)$ even though consumption itself will increase only by the per-period value $\frac{r}{1+r}s_t^T$ of the transitory shock. Thus, consumption is excessively sensitive for transitory shocks when permanent shocks are absent. With permanent shocks, however, consumption is excessively sensitive for transitory shocks only when the horizon is very short or the permanent shock has very little variance such that the transitory shock actually moves $F_{\bar{S}}(\bar{s}_{T-i})$ despite the fact that it is discounted by $\frac{(1+r)^i}{f(i)}$.

(2) The degree of excess smoothness and sensitivity is decreasing in the amount of economic uncertainty σ_P. If σ_P is small, the agent's beliefs change more quickly relative to the change in the realization of the shock; hence, the consumption function is more flat for realizations around μ_P. The consumption function C_{T-i} is less increasing in the realizations of the shocks s_{T-i}^P if $\frac{\partial \Lambda_{T-i}}{\partial s_{T-i}^P}$ is relatively high. As can be seen easily, $\frac{\partial \Lambda_{T-i}}{\partial s_{T-i}^P}$ is increasing in $f_P(s_{T-i}^P)$ which is high if $f_P(s_{T-i}^P)$ is very high at $s_{T-i}^P = \mu_P$ which happens if $f_P(s_{T-i}^P)$ is a very narrow distribution, i.e., σ_P is small.

(3) Any bell-shaped shock distribution induces the variation in Λ_{T-i} and thereby the amount of excess sensitivity to be bounded. If the agent is hit by an extreme shock, the actual value of the low probability realization matters less because neighboring states have very low probability. The expression $\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))$ is bounded if the two shocks' distributions are bell shaped. Thus, the variation in Λ_{T-i} is bounded.

(4) Consumption is more excessively sensitive and excessively smooth when the agent's horizon increases, because the marginal propensity to consume out of permanent shocks declines when the additional precautionary-savings motive accumulates. $\frac{\psi_{T-i}}{Q_{T-i}}$ is increasing in i and approaches a constant $\frac{\psi}{Q}$ when $T \rightarrow \infty$ and $i \rightarrow \infty$. Then, the variation in Λ_{T-i} is increasing in i. And since consumption growth ΔC_{T-i} is determined by $-a(i)\Lambda_{T-i}+\Lambda_{T-i-1}$ on average the larger variation in Λ_{T-i} translates into a higher coefficient in the OLS regression. This can be seen by looking at $\frac{\partial \Lambda_{T-i}}{\partial s_{T-i}^P}$, i.e.,

$$\frac{\partial a(i)\Lambda_{T-i}}{\partial s_{T-i}^P} = \frac{a(i)}{\theta(\frac{1-a(i)}{a(i)})}\frac{\frac{(\psi_{T-i}-Q_{T-i})\eta f_{\bar{S}}(\bar{s}_{T-i})(\lambda-1)}{1+\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))}}{\psi_{T-i}+Q_{T-i}\eta(\lambda-(\lambda-1)F_{\bar{S}}(\bar{s}_{T-i}))} > 0.$$

As $a(i) = \frac{f(i-1)}{f(i)}$ is increasing in i because $f(i) = \sum_{j=0}^{i}(1+r)^j$ and thus $\frac{(a(i))^2}{1-a(i)}$ is increasing in i and approaching a constant and $\frac{\psi_{T-i}}{Q_{T-i}}$ is increasing in i and approaching a constant it can be easily seen that $\frac{\partial a(i)\Lambda_{T-i}}{\partial s_{T-i}^P}$ is increasing in i which means that consumption becomes more excessively smooth as the agent's horizon increases. Moreover, as $\frac{a(i)}{1-a(i)}$ is increasing in i too $\frac{\partial \Lambda_{T-i}}{\partial s^P_{T-i}}$ is increasing in i which means that consumption becomes more excessively sensitive as the agent's horizon increases.

B.5.9. *Proof of Proposition 6.* In the following, I assume that the following parameter condition (which ensures that the agent's maximization problem is globally concave) holds $\eta(\lambda-1)<1$. All of the following proofs are direct applications of the prior proofs for the monotone-personal equilibrium just using Λ^c_{T-i} instead of Λ_{T-i}. Thus, I make the exposition somewhat shorter.

(1) The personal and pre-committed consumption functions are different in each period as can be seen in Section B.2. But, if there's no uncertainty and $\gamma > \frac{1}{\lambda}$ then the personal and pre-committed consumption functions both correspond to the standard agent's consumption function as shown in the proof of Proposition 4.

(2) Please refer to the derivation of the exponential-utility pre-committed model in Section B.2 for a detailed derivation of Λ^c_{T-i}. According to Definition 4 consumption is excessively smooth if $\frac{\partial C^c_{t+1}}{\partial s^P_{t+1}} < 1$ and excessively sensitive if $\frac{\partial \Delta C^c_{t+1}}{\partial s^P_t} > 0$. Consumption growth is

$$\Delta C^c_{T-i} = s^P_{T-i} + (1-a(i))s^T_{T-i} - a(i)\Lambda^c_{T-i} + \Lambda^c_{T-i-1}$$

so that $\frac{\partial C^c_{T-i}}{\partial s^P_{T-i}} < 1$ iff $\frac{\partial \Lambda^c_{T-i}}{\partial s^P_{T-i}} > 0$ and $\frac{\partial \Delta C^c_{T-i}}{\partial s^P_{T-i-1}} > 0$ iff $\frac{\partial \Lambda^c_{T-i-1}}{\partial s^P_{T-i-1}} > 0$. Since $\psi^c_{T-i} > \gamma Q^c_{T-i}$ it can be easily seen that $\frac{\partial \Lambda^c_{T-i}}{\partial s^P_{T-i}} > 0$, i.e.

$$\frac{\partial \Lambda^c_{T-i}}{\partial s^P_{T-i}} = \frac{1}{\theta(\frac{1-a(i)}{a(i)})} \frac{\frac{(\psi_{T-i}-\gamma Q_{T-i})\eta(\lambda-1)2f_{\bar{S}}(\bar{s}_{T-i})}{1+\eta(\lambda-1)(1-2F_{\bar{S}}(\bar{s}_{T-i}))}}{\psi^c_{T-i} + \gamma Q^c_{T-i}\eta(\lambda-1)(1-2F_{\bar{S}}(\bar{s}_{T-i}))} > 0.$$

Thus, optimal pre-committed consumption is excessively smooth and sensitive.

(3) The first-order condition of the second-to-last period in the exemplified model of the text is

$$u'(C^c_{T-1}) = (1+r)u'((s^P_{T-1} - C^c_{T-1})(1+r) + s^P_{T-1}) \frac{\psi_{T-1} + \gamma Q_{T-1}\eta(\lambda-1)(1-2F_P(s^P_{T-1}))}{1+\eta(\lambda-1)(1-2F_P(s^P_{T-1})))}.$$

By the exact same argument as above $\psi_{T-1} > Q_{T-1}$ such that news utility introduces a first-order precautionary-savings motive in the pre-committed equilibrium. Compare the above first-order condition with the one for personal-monotone consumption C_{T-1}, i.e.,

$$u'(C_{T-1}) = (1+r)u'((s^P_{T-1} - C_{T-1})(1+r) + s^P_{T-1}) \frac{\psi_{T-1} + \gamma Q_{T-1}\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))}{1+\eta(\lambda-(\lambda-1)F_P(s^P_{T-1}))}.$$

Because $\eta(\lambda-(\lambda-1)F_P(s^P_{T-1})) > \eta(\lambda-1)(1-2F_P(s^P_{T-1}))$ for all s^P_{T-1} and $\psi_{T-1} > \gamma Q_{T-1}$ monotone personal consumption is higher $C_{T-1} > C^c_{T-1}$ than pre-committed consumption. Moreover, the difference $\eta(\lambda-(\lambda-1)F_P(s^P_{T-1})) - \eta(\lambda-1)(1-2F_P(s^P_{T-1})) = \eta(1-F_P(s^P_{T-1})) + \eta\lambda F_P(s^P_{T-1})$ is increasing in s^P_{T-1} such that the difference in consumption $C_{T-1} - C^c_{T-1}$ is increasing in s^P_{T-1}.

(4) Consider the pre-committed first-order conditions before and after retirement. After retirement the news-utility agent's consumption from period $T-R$ on will correspond to the standard agent's one, i.e.,

$$Q_{T-R-1} = \psi_{T-R-1} = Q^s_{T-R-1}$$

thus Λ_{T-R-1} is given by

$$\Lambda_{T-R-1} = \frac{1}{\theta} log(\frac{(1+r)^{R+1}}{f(R)} \frac{\psi_{T-R-1} + \gamma Q_{T-R-1}\eta(\lambda-1)(1-2F_{\bar{S}}(\bar{s}_{T-R-1}))}{1+\eta(\lambda-1)(1-2F_{\bar{S}}(\bar{s}_{T-R-1}))})$$

it can be easily seen that

$$\frac{\partial \Lambda_{T-R-1}}{\partial \gamma} < 0 \text{ only if } F_{\bar{S}}(\bar{s}_{T-R-1}) < 0.5.$$

Thus, $\gamma < 1$ does not necessarily increase or decrease Λ_{T-R-1} and thereby consumption growth at retirement is not necessarily negative and smaller than consumption growth after retirement. There is no systematic underweighting of marginal utility before or after retirement and there does not occur a drop in consumption at retirement for $\gamma < 1$. The same argument that $\gamma < 1$ does not necessarily lead to a reduction in consumption growth even in the end of life when ψ_{T-i} and Q_{T-i} are small implies that the pre-committed consumption path is not necessarily hump shaped.

B.6. **Derivation and estimation of the power-utility model.** In the following, I outline the numerical derivation of the model with a power-utility specification $u(C_t) = \frac{C_t^{1-\theta}}{1-\theta}$. I start with the standard model to then explain the news-utility model in detail.

B.6.1. *The standard model.* The standard agent's maximization problem in any period $T-i$ is

$$max\{u(C_{T-i}) + \sum_{\tau=1}^{i} \beta^{\tau} E_{T-i}[u(C_{T-i+\tau})]\}$$

$$\text{subject to } X_t = (X_{t-1} - C_{t-1})R + Y_t \text{ and } Y_t = P_{t-1}G_t e^{s_t^P} e^{s_t^T} = P_t e^{s_t^T}.$$

The maximization problem can be normalized by $P_{T-i}^{1-\theta}$ and then becomes in normalized terms ($X_t = P_t x_t$ for instance)

$$max\{u(c_{T-i}) + \sum_{\tau=1}^{i} \beta^{\tau} E_{T-i}[\prod_{j=1}^{\tau} (G_{T-i+j} e^{s^P_{T-i+j}})^{1-\theta} u(c_{T-i+\tau})]\}$$

$$\text{subject to } x_t = (x_{t-1} - c_{t-1}) \frac{R}{G_t e^{s_t^P}} + y_t \text{ and } y_t = e^{s_t^T}.$$

The model can be solved by numerical backward induction as done by Gourinchas and Parker (2002) and Carroll (2001). The standard agent's first-order condition is

$$u'(c_{T-i}) = \Phi'_{T-i} = \beta R E_{T-i}[\frac{\partial c_{T-i+\tau}}{\partial x_{T-i+1}} (G_{T-i+1} e^{s^P_{T-i+1}})^{-\theta} u'(c_{T-i+\tau}) + (1 - \frac{\partial c_{T-i+1}}{\partial x_{T-i+1}})(G_{T-i+1} e^{s^P_{T-i+1}})^{-\theta} \Phi'_{T-i-1}]$$

with his continuation value

$$\Phi'_{T-i-1} = \beta R E_{T-i-1}[\frac{\partial c_{T-i}}{\partial x_{T-i}} (G_{T-i} e^{S^P_{T-i}})^{-\theta} u'(c_{T-i}) + (1 - \frac{\partial c_{T-i}}{\partial x_{T-i}})(G_{T-i} e^{S^P_{T-i}})^{-\theta} \Phi'_{T-i}]$$

where it can be easily noted that

$$P_{T-i}\Phi'_{T-i} = E_{T-i}[\frac{\partial X_{T-i+1}}{\partial A_{T-i}} \frac{\partial \sum_{\tau=1}^{i} \beta^{\tau} u(C_{T-i+\tau})}{\partial X_{T-i+1}}] = E_{T-i}[\frac{\partial X_{T-i+1}}{\partial A_{T-i}} (\frac{\partial \beta u(C_{T-i+\tau})}{\partial X_{T-i+1}} + \frac{\partial \sum_{\tau=1}^{i} \beta^{\tau+1} u(C_{T-i+1+\tau})}{\partial X_{T-i+1}})]$$

$$= E_{T-i}[\frac{\partial X_{T-i+1}}{\partial A_{T-i}}\frac{\partial \beta u(C_{T-i+\tau})}{\partial X_{T-i+1}} + \frac{\partial X_{T-i+1}}{\partial A_{T-i}}\frac{\partial X_{T-i+2}}{\partial X_{T-i+1}}\frac{\partial X_{T-i+1}}{\partial X_{T-i+2}}\frac{\partial \sum_{\tau=1}^{i}\beta^{\tau+1}u(C_{T-i+1+\tau})}{\partial X_{T-i+1}}]$$

$$= E_{T-i}[\frac{\partial X_{T-i+1}}{\partial A_{T-i}}\frac{\partial \beta u(C_{T-i+\tau})}{\partial X_{T-i+1}} + \frac{\partial X_{T-i+1}}{\partial A_{T-i}}\frac{\partial X_{T-i+2}}{\partial X_{T-i+1}}\frac{\partial \sum_{\tau=1}^{i}\beta^{\tau+1}u(C_{T-i+1+\tau})}{\partial X_{T-i+2}}]$$

$$= \beta R E_{T-i}[\frac{\partial u(C_{T-i+\tau})}{\partial X_{T-i+1}} + \frac{\partial X_{T-i+2}}{\partial X_{T-i+1}}\frac{\partial \sum_{\tau=1}^{i}\beta^{\tau}u(C_{T-i+1+\tau})}{\partial X_{T-i+2}}]$$

$$= \beta R E_{T-i}[\frac{\partial u(C_{T-i+\tau})}{\partial X_{T-i+1}} + \frac{\partial A_{T-i+1}}{\partial X_{T-i+1}}\underbrace{E_{T-i+1}[\frac{\partial X_{T-i+2}}{\partial A_{T-i+1}}\frac{\partial \sum_{\tau=1}^{i}\beta^{\tau}u(C_{T-i+1+\tau})}{\partial X_{T-i+2}}]}_{P_{T-i+1}\Phi'_{T-i-1}}]$$

$$= \beta R E_{T-i}[\frac{\partial u(C_{T-i+\tau})}{\partial X_{T-i+1}} + \frac{\partial (X_{T-i+1} - C_{T-i+1})}{\partial X_{T-i+1}}P_{T-i+1}\Phi'_{T-i-1}] = \beta R E_{T-i}[\frac{\partial u(C_{T-i+\tau})}{\partial X_{T-i+1}} + (1 - \frac{\partial C_{T-i+1}}{\partial X_{T-i+1}})P_{T-i+1}\Phi'_{T-i-1}].$$

${\Phi'}_{T-i}$ is a function of savings a_{T-i} thus I can solve for each optimal consumption level c^*_{T-i} on a grid of savings a_{T-i} as $c^*_{T-i} = (\Phi'_{T-i-1})^{-\frac{1}{\theta}} = (f^{\Phi'}(a_{T-i}))^{-\frac{1}{\theta}}$ to then find each optimal level of consumption for each value of the normalized cash-on-hand grid x_{T-i} by interpolation. This endogenous-grid method has been developed by Carroll (2001). Alternatively, I could use the Euler equation instead of the agent's continuation value but this solution illustrates the upcoming solution of the news-utility model of which it is a simple case.

B.6.2. *Habit formation.* Consider an agent with internal, multiplicative habit formation preferences $u(C_t, H_t) = \frac{(\frac{C_t}{H_t^h})^{1-\theta}}{1-\theta}$ with $H_t = H_{t-1} + \vartheta(C_{t-1} - H_{t-1})$ and $\vartheta \in [0,1]$ (Michaelides (2002)). Assume $\vartheta = 1$ such that $H_t = C_{t-1}$. For illustration, in the second-to-last period his maximization problem is

$$u(C_{T-1}, H_{T-1}) + \beta E_{T-1}[u(R(X_{T-1} - C_{T-1}) + Y_T, H_T)]$$
$$= \frac{(\frac{C_{T-1}}{H_{T-1}^h})^{1-\theta}}{1-\theta} + \beta E_{T-1}[\frac{1}{1-\theta}(\frac{R(X_{T-1} - C_{T-1}) + Y_T}{H_T^h})^{1-\theta}]$$

which can be normalized by $P_T^{(1-\theta)(1-h)}$ (then $C_T = P_T c_T$ for instance) and the maximization problem becomes

$$\frac{P_{T-1}^{(1-\theta)(1-h)}(\frac{c_{T-1}}{h_{T-1}^h})^{1-\theta}}{1-\theta} + \beta P_{T-1}^{(1-\theta)(1-h)} E_{T-1}[\frac{1}{1-\theta}(G_T e^{s_T^P})^{(1-\theta)(1-h)}(\frac{(x_{T-1} - c_{T-1})\frac{R}{G_T e^{s_T^P}} + y_T}{h_T^h})^{1-\theta}]$$

which results in the following first-order condition

$$c_{T-1}^{-\theta} = h_{T-1}^{-\theta h + h}\beta E_{T-1}[(G_T e^{s_T^P})^{-\theta(1-h)}(\frac{c_T}{h_T^h})^{-\theta}(R + \frac{c_T}{h_T}h)] = \Phi'_{T-1}$$

with Φ'_{T-1} being a function of savings $x_{T-1} - c_{T-1}$ and habit h_T. The first-order condition can be solved very robustly by iterating on a grid of savings a_{T-1} assuming $c^*_{T-1} = (\Phi'_{T-1})^{-\frac{1}{\theta}} = (f^{\Phi'}(a_{T-1}, h_T))^{-\frac{1}{\theta}}$ and $h_T = c^*_{T-1}\frac{1}{G_T e^{s_T^P}}$ until a fixed point of consumption and habit has been found. The normalized habit-forming agent's first-order condition in any period $T-i$ is given by

$$c_{T-i}^{-\theta} = h_{T-i}^{-\theta h+h}\Phi_{T-i}^{\prime} = h_{T-i}^{-\theta h+h}\beta E_{T-i}[(G_{T-i+1}e^{S_{T-i+1}^{P}})^{-\theta(1-h)}(\frac{c_{T-i+1}}{h_{T-i+1}^{h}})^{-\theta}(R\frac{dc_{T-i+1}}{dx_{T-i+1}}+\frac{c_{T-i+1}}{h_{T-i+1}}h)$$
$$+(1-\frac{dc_{T-i+1}}{dx_{T-i+1}})(G_{T-i+1}e^{S_{T-i+1}^{P}})^{-\theta(1-h)}\Phi_{T-1}^{\prime}].$$

B.6.3. *The monotone-personal equilibrium in the second-to-last period.* Before starting with the fully-fledged problem, I outline the second-to-last period for the case of power utility. In the second-to-last period the agent allocates his cash-on-hand X_{T-1} between contemporaneous consumption C_{T-1} and future consumption C_T, knowing that in the last period he will consume whatever he saved in addition to last period's income shock $C_T = X_T = (X_{T-1}-C_{T-1})R+Y_T$. According to the monotone-personal equilibrium solution concept, in period $T-1$ the agent takes the beliefs about contemporaneous and future consumption he entered the period with $\{F_{C_{T-1}}^{T-2}, F_{C_T}^{T-2}\}$ as given and maximizes

$$u(C_{T-1})+n(C_{T-1},F_{C_{T-1}}^{T-2})+\gamma\beta \boldsymbol{n}(F_{C_T}^{T-1,T-2})+\beta E_{T-1}[u(C_T)+n(C_T,F_{C_T}^{T-1})]$$

which can be rewritten as

$$u(C_{T-1})+\eta\int_{-\infty}^{C_{T-1}}(u(C_{T-1})-u(c))F_{C_{T-1}}^{T-2}(c)+\eta\lambda\int_{C_{T-1}}^{\infty}(u(C_{T-1})-u(c))F_{C_{T-1}}^{T-2}(c)$$
$$+\gamma\beta\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}(u(c)-u(r))F_{C_T}^{T-1,T-2}(c,r)+\beta E_{T-1}[u(C_T)+\eta(\lambda-1)\int_{C_T}^{\infty}(u(C_T)-u(c))F_{C_T}^{T-1}(c)].$$

To gain intuition for the model's predictions, I explain the derivation of the first-order condition

$$u'(C_{T-1})(1+\eta F_{C_{T-1}}^{T-2}(C_{T-1})+\eta\lambda(1-F_{C_{T-1}}^{T-2}(C_{T-1})))=\gamma\beta RE_{T-1}[u'(C_T)]\eta(\lambda-(\lambda-1)F_{A_{T-1}}^{T-2}(A_{T-1}))$$
$$+\beta RE_{T-1}[u'(C_T)+\eta(\lambda-1)\int_{C_T}^{\infty}(u'(C_T)-u'(c))F_{C_T}^{T-1}(c)].$$

The first two terms in the first-order condition represent marginal consumption utility and gain-loss utility over contemporaneous consumption in period $T-1$. As the agent takes his beliefs $\{F_{C_{T-1}}^{T-2}, F_{C_T}^{T-2}\}$ as given in the optimization, I apply Leibniz's rule for differentiation under the integral sign. This results in marginal gain-loss utility being the sum of states that would have promised less consumption $F_{C_{T-1}}^{T-2}(C_{T-1})$, weighted by η, or more consumption $1-F_{C_{T-1}}^{T-2}(C_{T-1})$, weighted by $\eta\lambda$,

$$\frac{\partial n(C_{T-1},F_{C_{T-1}}^{T-2})}{\partial C_{T-1}} = u'(C_{T-1})\eta(\lambda-(\lambda-1)F_{C_{T-1}}^{T-2}(C_{T-1})).$$

Note that, if contemporaneous consumption is increasing in the realization of cash-on-hand then I can simplify $F_{C_{T-1}}^{T-2}(C_{T-1}) = F_{X_{T-1}}^{T-2}(X_{T-1})$. Returning to the maximization problem the third term represents prospective gain-loss utility over future consumption C_T experienced in $T-1$. As before, marginal gain-loss utility is given by the weighted sum of states $u'(C_T)\eta(\lambda-(\lambda-1)F_{A_{T-1}}^{T-2}(A_{T-1}))$. Note that $F_{C_T}^{T-2}(c)$ is defined as the probability $Pr(C_T<c|I_{T-2})$. Applying a logic similar to the law of iterated expectation

$$Pr(C_T<c|I_{T-2}) = Pr(A_{T-1}R+Y_T<c|I_{T-2}) = Pr(A_{T-1}<\frac{c-Y_T}{R}|I_{T-2})$$

thus if savings are increasing in the realization of cash-on-hand then I can simplify $F_{A_{T-1}}^{T-2}(A_{T-1}) = F_{X_{T-1}}^{T-2}(X_{T-1})$.

The last term in the maximization problem represents consumption and gain-loss utility over future consumption C_T in the last period T, i.e., the first derivative of the agent's continuation value with respect to consumption or the marginal value of savings. Expected marginal gain-loss utility $\eta(\lambda-1)\int_{C_T}^{\infty}(u'(C_T)-u'(c))F_{C_T}^{T-1}(c)$ is positive for any concave utility function such that

$$\Psi'_{T-1} = \beta R E_{T-1}[u'(C_T)+\eta(\lambda-1)\int_{C_T}^{\infty}(u'(C_T)-u'(c))F_{C_T}^{T-1}(c)] > \beta R E_{T-1}[u'(C_T)] = \Phi'_{T-1}.$$

As expected marginal gain-loss disutility is positive, increasing in σ_Y, absent if $\sigma_Y = 0$, and increases the marginal value of savings, I say that news-utility introduces an "additional precautionary-savings motive". The first-order condition can now be rewritten as

$$u'(C_{T-1}) = \frac{\Psi'_{T-1} + \gamma\Phi'_{T-1}\eta(\lambda-(\lambda-1)F_{X_{T-1}}^{T-2}(X_{T-1}))}{1+\eta(\lambda-(\lambda-1)F_{X_{T-1}}^{T-2}(X_{T-1}))}.$$

Beyond the additional precautionary-savings motive $\Psi'_{T-1} > \Phi'_{T-1}$ implies that an increase in $F_{X_{T-1}}^{T-2}(X_{T-1})$ decreases

$$\frac{\frac{\Psi'_{T-1}}{\Phi'_{T-1}} + \gamma\eta(\lambda-(\lambda-1)F_{X_{T-1}}^{T-2}(X_{T-1}))}{1+\eta(\lambda-(\lambda-1)F_{X_{T-1}}^{T-2}(X_{T-1}))},$$

i.e., the terms in the first-order condition vary with the income realization X_{T-1} so that consumption is excessively smooth and sensitive.

B.6.4. *The monotone-personal equilibrium path in all prior periods.* The news-utility agent's maximization problem in any period $T-i$ is given by

$$u(C_{T-i}) + n(C_{T-i}, F_{C_{T-i}}^{T-i-1}) + \gamma\sum_{\tau=1}^{i}\beta^{\tau}\boldsymbol{n}(F_{C_{T-i+\tau}}^{T-i,T-i-1}) + \sum_{\tau=1}^{i}\beta^{\tau}E_{T-i}[U(C_{T-i+\tau})]$$

again, the maximization problem can be normalized by $P_{T-i}^{1-\theta}$ as all terms are proportional to consumption utility $u(\cdot)$. In normalized terms, the news-utility agent's first-order condition in any period $T-i$ is given by

$$u'(c_{T-i}) = \frac{\Psi'_{T-i} + \gamma\Phi'_{T-i}\eta(\lambda-(\lambda-1)F_{c_{T-i}}^{T-i-1}(c_{T-i}))}{1+\eta(\lambda-(\lambda-1)F_{a_{T-i}}^{T-i-1}(a_{T-i}))}$$

I solve for each optimal value of c^*_{T-i} for a grid of savings a_{T-i}, as Ψ'_{T-i} and Φ'_{T-i} are functions of a_{T-i} until I find a fixed point of c^*_{T-i}, a_{T-i}, $F_{a_{T-i}}^{T-i-1}(a_{T-i})$, and $F_{c_{T-i}}^{T-i-1}(c_{T-i})$. The latter two can be inferred from the observation that each $c_{T-i} + a_{T-i} = x_{T-i}$ has a certain probability given the value of savings a_{T-i-1} I am currently iterating on. However, this probability varies with the realization of permanent income $e^{s_{T-i}^P}$ thus I cannot fully normalize the problem but have to find the right consumption grid for each value of $e^{s_{T-i}^P}$ rather than just one. The first-order condition can be slightly modified as follows

$$u'(e^{s^P_{T-i}}c_{T-i}) = \frac{e^{s^P_{T-i}}\Psi'_{T-i} + \gamma e^{s^P_{T-i}}\Phi'_{T-i}\eta(\lambda-(\lambda-1)F^{T-i-1}_{c_{T-i}}(c_{T-i}))}{1+\eta(\lambda-(\lambda-1)F^{T-i-1}_{a_{T-i}}(a_{T-i}))}$$

to find each corresponding grid value. Note that, the resulting two-dimensional grid for c_{T-i} will be the normalized grid for each realization of s^T_t and s^P_t, because I multiply both sides of the first-order conditions with $e^{s^P_{T-i}}$. Thus, the agent's consumption utility continuation value is

$$\Phi'_{T-i-1} = \beta R E_{T-i-1}[\frac{\partial c_{T-i}}{\partial x_{T-i}}(G_{T-i}e^{S^P_{T-i}})^{-\theta}u'(c_{T-i}) + (1-\frac{\partial c_{T-i}}{\partial x_{T-i}})(G_{T-i}e^{S^P_{T-i}})^{-\theta}\Phi'_{T-i}].$$

The agent's news-utility continuation value is given by

$$P^{-\theta}_{T-i-1}\Psi'_{T-i-1} = \beta R E_{T-i-1}[\frac{dC_{T-i}}{dX_{T-i}}u'(C_{T-i}) + \eta(\lambda-1)\int\limits_{C_{T-i}<C^{T-i-1}_{T-i}}(\frac{dC_{T-i}}{dX_{T-i}}u'(C_{T-i})-x)dF^{T-i-1}_{\frac{dC_{T-i}}{dX_{T-i}}u'(C_{T-i})}(x)$$

$$+\gamma\eta(\lambda-1)\int\limits_{C_{T-i}<C^{T-i-1}_{T-i}}(\frac{dA_{T-i}}{dX_{T-i}}P^{-\theta}_{T-i}\Phi'_{T-i}-x)dF^{T-i-1}_{\frac{dA_{T-i}}{dX_{T-i}}P^{-\theta}_{T-i}\Phi'_{T-i}}(x) + (1-\frac{dC_{T-i}}{dX_{T-i}})P^{-\theta}_{T-i}\Psi'_{T-i}]$$

(here, $\int\limits_{C_{T-i}<C^{T-i-1}_{T-i}}$ means the integral over the loss domain) or in normalized terms

$$\Psi'_{T-i-1} = \beta R E_{T-i-1}[\frac{dc_{T-i}}{dx_{T-i}}u'(c_{T-i})(G_{T-i}e^{s^P_{T-i}})^{-\theta}$$

$$+\eta(\lambda-1)\int\limits_{c_{T-i}<c^{T-i-1}_{T-i}}(\frac{dc_{T-i}}{dx_{T-i}}u'(c_{T-i})(G_{T-i}e^{S^P_{T-i}})^{-\theta}-x)dF^{T-i-1}_{\frac{dc_{T-i}}{dx_{T-i}}u'(c_{T-i})(G_{T-i}e^{S^P_{T-i}})^{-\theta}}(x)$$

$$+\gamma\eta(\lambda-1)\int\limits_{c_{T-i}<c^{T-i-1}_{T-i}}(\frac{da_{T-i}}{dx_{T-i}}\Phi'_{T-i}(G_{T-i}e^{S^P_{T-i}})^{-\theta}-x)dF^{T-i-1}_{\frac{da_{T-i}}{dx_{T-i}}\Phi'_{T-i}(G_{T-i}e^{S^P_{T-i}})^{-\theta}}(x) + (1-\frac{dc_{T-i}}{dx_{T-i}})(G_{T-i}e^{S^P_{T-i}})^{-\theta}\Psi'_{T-i}].$$

B.6.5. *Details of the estimation procedure.* I use data from the Consumer Expenditure Survey (CEX) for the years 1980 to 2002 as provided by the NBER.[41] The CEX is conducted by the Bureau of Labor Statistics and surveys a large sample of the US population to collect data on consumption expenditures, demographics, income, and assets. As suggested by Harris and Sabelhaus (2001), consumption expenditures consists of food, tobacco, alcohol, amusement, clothing, personal care, housing, house operations such as furniture and housesupplies, personal business, transportation such as autos and gas, recreational activities such as books and recreational sports, and charity expenditures; alternatively, I could consider non-durable consumption only. Income consists of wages, business income, farm income, rents, dividends, interest, pension, social security, supplemental security, unemployment benefits, worker's compensation, public assistance, foodstamps, and scholarships. The data is deflated to 1984 dollars.

Because the CEX does not survey households consecutively, I generate a pseudo panel that av-

[41]This data set extraction effort is initiated by John Sabelhaus and continued by Ed Harris, both of the Congressional Budget Office. The data set links the four quarterly interviews for each respondent household and collapses all the spending, income, and wealth categories into a consistent set of categories across all years under consideration.

erages each household's consumption and income at each age. I only consider non-student households that meet the BLS complete income reporter requirement and complete all four quarterly interviews. Furthermore, I only consider households that are older than 25 years; that are retired after age 68, the average retirement age in the US according to the OECD; and that are younger than 78, the average life expectancy in the US according to the UN list.

To control for cohort, family size, and time effects, I employ average cohort techniques (see, e.g., Verbeek (2007), Attanasio (1998), and Deaton (1985)). More precisely, as I lack access to the micro consumption data for each household i at each age a, I pool all observations and estimate $log(C_{i,a}) = \xi_0 + \alpha_a + \gamma_c + f_s + X_{i,a}^{'}\beta^{ia} + \varepsilon_{i,a}$. Here, ξ_0 is a constant, α_a is a full set of age dummies, γ_c is a full set of cohort dummies, and f_s is a full set of family size and number of earners dummies. Essentially, these sets of dummies allow me to consider the sample means of my repeated cross-section $C_{c,a}^{*} = E[log(C_{i,a})|c,a]$ and $X_{c,a}^{*} = E[X_{i,a}^{*}|c,a]$ for each cohort c at age a. Using the sample means brings about an errors-in-variables problem, which, however, does not appear to make a difference in practice as the sample size of each cohort-age cell is large. Because age α_a and cohort γ_c effects are not separately identifiable from time effects, I proxy time effects by including the regional unemployment rate as an additional variable in $X_{i,a}^{*}$ beyond a dummy for retirement following Gourinchas and Parker (2002). As an alternative to a full set of dummies, I use fifth-order polynomials in order to obtain a smooth consumption profile. After running the pooled regression, I back out the consumption data uncontaminated by cohort, time, family size, and number of earners effects and construct the average empirical life-cycle profile by averaging the data across households at each age. The same exercise is done for income. Figure 3 displays the average empirical income and average empirical consumption profiles.

I structurally estimate the news-utility parameters using a methods-of-simulated-moments procedure following Gourinchas and Parker (2002), Laibson et al. (2012), and Bucciol (2012). The procedure has two stages. In the first stage, I estimate the structural parameters governing the environment $\Xi = (\mu_P, \sigma_P, \mu_T, \sigma_T, p, G, r, a_0, R, T)$ using standard techniques and obtain results perfectly in line with the literature. Given the first-stage estimates $\hat{\Xi}$ and their associated variances $\hat{\Omega}_{\Xi}$, in the second stage, I estimate the preference parameters $\boldsymbol{\theta} = (\eta, \lambda, \gamma, \beta, \theta)$ by matching the simulated and empirical average life-cycle consumption profiles. The empirical life-cycle consumption profile is the average consumption at each age $a \in [1,T]$ across all household observations i. More precisely, it is $ln\bar{C}_a = \frac{1}{n_a}\sum_{i=1}^{n_a} ln(\bar{C}_{i,a})$ with $ln(\bar{C}_{i,a})$ being the household i's log consumption at age a of which n_a are observed. The theoretical population analogue to $ln\bar{C}_a$ is denoted by $lnC_a(\theta,\Xi)$ and the simulated approximation is denoted by $ln\hat{C}_a(\boldsymbol{\theta},\Xi)$. Moreover, I define $g(\boldsymbol{\theta},\Xi) = lnC_a(\boldsymbol{\theta},\Xi) - ln\bar{C}_a$ and

$$\hat{g}(\boldsymbol{\theta},\Xi) = ln\hat{C}_a(\boldsymbol{\theta},\Xi) - ln\bar{C}_a.$$

In turn, if the estimated preference and environment parameter vectors $\boldsymbol{\theta}_0$ and Ξ_0 are the true vectors, the procedure's moment conditions imply that $E[g(\theta_0,\Xi_0)] = E[lnC_a(\theta,\Xi) - ln\bar{C}_a] = 0$. In turn, let W denote a positive definite weighting matrix then

$$q(\boldsymbol{\theta},\Xi) = \hat{g}(\boldsymbol{\theta},\Xi)W^{-1}\hat{g}(\boldsymbol{\theta},\Xi)'$$

is the weighted sum of squared deviations of the simulated from their corresponding empirical moments. I assume that W is a robust weighting matrix rather than the optimal weighting matrix to avoid small-sample bias. More precisely, I assume that W corresponds to the inverse of the variance-covariance matrix of each point of the average log consumption at age a $ln\bar{C}_a$, which I denote by Ω_g^{-1} and consistently estimate from the sample data. Taking the first-stage estimates $\hat{\Xi}$ as given, I minimize the weighted sum of squared deviations of the simulated from their corresponding empirical moments $q(\boldsymbol{\theta},\hat{\Xi})$ with respect to the vector of preference parameters $\boldsymbol{\theta}$ to obtain $\hat{\boldsymbol{\theta}}$ the consistent estimator of $\boldsymbol{\theta}$ that is asymptotically normally distributed with standard errors

$$\Omega_\theta = (G_\theta^{'}WG_\theta)^{-1}G_\theta^{'}W[\Omega_g + \Omega_g^s + G_\Xi\Omega_\Xi G_\Xi^{'}]WG_\theta(G_\theta^{'}WG_\theta)^{-1}.$$

Here, G_θ and G_Ξ denote the derivatives of the moment functions $\frac{\partial g(\boldsymbol{\theta}_0,\Xi_0)}{\partial \boldsymbol{\theta}}$ and $\frac{\partial g(\boldsymbol{\theta}_0,\Xi_0)}{\partial \Xi}$, Ω_g denotes the variance-covariance matrix of the second-stage moments as above that corresponds to $E[g(\boldsymbol{\theta}_0,\Xi_0)g(\boldsymbol{\theta}_0,\Xi_0)']$, and $\Omega_g^s = \frac{n_a}{n_s}\Omega_g$ denotes the sample correction with n_s being the number of simulated observations at each age a. As Ω_g, I can estimate Ω_Ξ directly and consistently from sample data. For the minimization, I employ a Nelder-Mead algorithm. For the standard errors, I numerically estimate the gradient of the moment function at its optimum. If I omit the first-stage correction and simulation correction the expression becomes $\Omega_\theta = (G_\theta^{'}\Omega_g^{-1}G_\theta)^{-1}$. Finally, I can test for overidentification by comparing the minimized weighted sum of squared deviations of the simulated from their corresponding empirical moments $\hat{g}(\hat{\theta},\hat{\Xi})$ to a chi-squared distribution with $T-5$ degrees of freedom.

Theoretically, the functional form of the function determining optimal consumption Λ_t, or the agent's first-order condition in the power-utility model, imply that news utility introduces such specific variation in consumption growth that all preference parameters are identified in the finite-horizon model because the Jacobian has full rank.[42] Roughly speaking, the shape of the consumption profile identifies the exponential discounting parameter β and the coefficient of risk aversion θ. Because consumption tracks income too closely and peaks too early in the standard model, the weight of gain-loss versus consumption utility being larger than zero $\eta > 0$ and the coefficient of loss aversion being larger than one $\lambda > 1$ can be identified. Finally, the drop in consumption at retirement identifies the prospective gain-loss discount factor $\gamma < 1$. More precisely, as explained in Appendix B.6.4, the agent's consumption is determined by the following first-order condition

[42] Numerically, I confirm this result in a Monte Carlo simulation and estimation exercise. Moreover, because previous studies cannot separately identify the weight of gain-loss versus consumption utility η and the coefficient of loss aversion λ, I confirm that I obtain similar estimates when I assume $\eta = 1$ and only estimate the other parameters.

$u'(c_{T-i}) = \frac{\Psi'_{T-i}+\gamma\Phi'_{T-i}(\eta F^{T-i-1}_{c_{T-i}}(c_{T-i})+\eta\lambda(1-F^{T-i-1}_{c_{T-i}}(c_{T-i})))}{1+\eta F^{T-i-1}_{a_{T-i}}(a_{T-i})+\eta\lambda(1-F^{T-i-1}_{a_{T-i}}(a_{T-i}))}$ of which I observe the inverse and log average of all households. Φ'_{T-i} represents future marginal consumption utility, as in the standard model, and is determined by the exponential discounting parameter β and the coefficient of risk aversion θ, which can be separately identified in a finite-horizon model. Ψ'_{T-i} represents future marginal consumption and news utility and is thus determined by something akin of weight of gain-loss versus consumption utility times the coefficient of loss aversion $\eta(\lambda-1)$. $\eta F^{T-i-1}_{a_{T-i}}(a_{T-i}) + \eta\lambda(1-F^{T-i-1}_{a_{T-i}}(a_{T-i}))$ and $\eta F^{T-i-1}_{c_{T-i}}(c_{T-i}) + \eta\lambda(1-F^{T-i-1}_{c_{T-i}}(c_{T-i}))$ represents the weighted sum of the cumulative distribution function of savings, a_{T-i}, and consumption, c_{T-i}, of which merely the average determined by $\eta 0.5(1+\lambda)$ is observed. Thus, I have two equations in two unknowns and can separately identify weight of gain-loss versus consumption utility η and the coefficient of loss aversion λ. Finally, the prospective gain-loss discount factor γ enters the first-order condition distinctly from all other parameters.

B.6.6. *Risk attitudes over small and large stakes.* First, I suppose the agent is offered a gamble about immediate consumption in period t after that period's uncertainty has resolved and that period's original consumption has taken place. I assume that utility over immediate consumption is linear. Then, the agent is indifferent between accepting or rejecting a 50-50 win G or lose L gamble if$0.5G-0.5L+0.5\eta G-0.5\eta\lambda L=0$. Second, I suppose the agent is offered a monetary gamble or wealth bet that concerns future consumption. Suppose $T\to\infty$. I assume that his initial wealth level is $A_t = 100,000$ and $P_t = 300,000$. Let $f^{\Psi}(A)$ and $f^{\Phi}(A)$ be the agent's continuation value as a function of the agent's savings A_t. Then, the agent is indifferent between accepting or rejecting a 50-50 win G or lose L gamble if

$$0.5\eta(f^{\Phi}(A_t+G)-f^{\Phi}(A_t))+0.5\eta\lambda(f^{\Phi}(A_t-L)-f^{\Phi}(A_t))+0.5f^{\Psi}(A_t+G)+0.5f^{\Psi}(A_t-L)=f^{\Psi}(A_t-L).$$