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Abstract

We take into account that envy (relative consumption concerns) is more pronounced in the present than in the future. We consider a Ramsey-type model in which agents differ only in their initial capital endowments but are identical in their exogenous parameters. Agents' preferences exhibit present-biased envy: agents are naive and care about how their consumption levels compare to that of others in the current period. Our results suggest that present-biased envy affects both the level of inequality and the income level in an economy. First, present-biased envy generates the Matthew effect (the relatively rich get richer while the relatively poor get poorer), leading to a highly unequal long-run distribution of wealth. After some finite time, only those agents who were the wealthiest from the outset own the entire capital stock. All other agents are in the maximum borrowing state and spend their wages to repay the debt. Second, present-biased envy makes agents effectively more impatient, lowering the long-run capital stock and the aggregate income level compared to those in an economy without envy.

JEL-Codes: D150, D310, D500, D910, O400.

Keywords: relative consumption, envy, time inconsistency, sliding equilibrium, perfect foresight, wealth distribution.

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1 Introduction

This paper examines the effects of present-biased envy on consumption, savings, and the wealth distribution in a general equilibrium version of the Ramsey model. Empirical evidence overwhelmingly demonstrates that people are engaged in social comparisons and are subject to *positional concerns*: individuals care about their relative position within a social or economic hierarchy (see, e.g., Johansson-Stenman et al., 2002; Ferrer-i-Carbonell, 2005; Luttmer, 2005; Solnick and Hemenway, 2005). Moreover, there is robust empirical evidence of *relative consumption concerns*: individuals compare their consumption level to that of those around them (see, e.g., Alpizar et al., 2005; Johansson-Stenman and Martinsson, 2006; Carlsson et al., 2007; Wendner and Goulder, 2008; Petach and Tavani, 2021). In a seminal contribution, Duesenberry (1949) suggests that people make decisions based not on absolute income but on relative income. In order to rationalize the Duesenberry approach, the prior literature considers individuals whose preferences exhibit *envy*, that is, negative dependence on average consumption. A typical result is that envy may lead to a higher degree of inequality in consumption and capital than would prevail in an economy without relative consumption concerns (see, e.g., Koyuncu and Turnovsky, 2010; Alvarez-Cuadrado and Long, 2012).

However, the existing literature assumes that envy is permanent: individuals are envious at the decision date and know that they will be envious in all future periods. At the same time, it is empirically well-documented that individuals are *present-biased*: people treat the present qualitatively differently than other periods (see, e.g., DellaVigna, 2009; Ericson and Laibson, 2019). This observation is even more natural with respect to envy: as pointed out by Aristotle, "We envy those who are near us in time, place, age or reputation ... we do not compete with men who lived a hundred centuries ago, or those not yet born" (Rhetoric, II, 10). Furthermore, recent research in psychology and economics acknowledges that people are *naive*: they revise and change the previously chosen course of action (see, e.g., DellaVigna and Malmendier, 2006; Hey and Lotito, 2009).

In this paper we take into account these ubiquitous behavioral patterns and study *present-biased envy*: relative consumption concerns which are more pronounced right now than in the future. We show that present-biased envy significantly impacts both the level of inequality and the income level in an economy. First, present-biased envy under complete financial markets leads to a highly unequal distribution of wealth in the long run: eventually only agents who are the wealthiest from the outset own the entire capital stock, while all other agents are in the maximum borrowing state. This result suggests that present-biased envy has a much more considerable impact on increasing inequality than permanent envy and even leads to a division of society into two classes. Second, present-biased envy reduces the effective discount factors of agents, making them more impatient. As a result, the long-run capital stock and aggregate income are lower in the presence of present-biased envy compared to an economy without relative consumption concerns.

From a behavioral point of view, present-biased envy is similar to what is discussed in the psychology literature as *episodic envy* (see, e.g., Smith, 2004; Cohen-Charash, 2009; Crusius et al., 2020). Social psychologists distinguish between *dispositional* envy (a general, stable, and chronic sense of inferiority with respect to others) and *episodic* envy (temporary and situation-specific feeling limited to a particular experience).[1] Cohen-Charash (2009) provides experimental evidence that episodic envy, unlike dispositional envy, is characterized by a social comparison component (a desire to have what others have), and it is this comparison component that is responsible for behavioral reactions aimed at reducing the gap between the envious and the envied. Hence present-biased (episodic) envy is especially relevant in the context of relative consumption concerns.

From a theoretical point of view, present-biased envy resembles the idea of quasi-hyperbolic (β–δ) discounting where an individual is excessively impatient only in the current period. Both specifications reflect the empirical observation that decision makers are very sensitive to outcomes received right now and relatively less sensitive to outcomes received later. As O'Donoghue and Rabin (2015, p. 274, emphasis in original) put it, "the β, δ functional form better captures the underlying psychology — that the vast majority of the action (relative to time consistency) is biased toward *now*".

Specifically, this paper studies a Ramsey-type model with agents who are identical in their exogenous parameters and differ only in their initial capital endowments. In each period agents maximize their discounted infinite horizon utility subject to a lifetime budget constraint, and their preferences exhibit present-biased envy. The agents care about how their consumption level compares to that of others only in the *current* period, while starting from the subsequent period their consumption is not subject to envy.

As suggested by empirical evidence, we assume that agents are naive. Agents are envious only in the current period, and they do not take into account that in the subsequent period timing will restart and they will become envious again.

[1]Imagine a scenario where a young student notices at school that most of their classmates have a new and expensive electronic device or personal accessory. At home, the student requests their parents to purchase the same item. This is the type of envy that we consider in our model.

As a consequence, agents revise their consumption decisions in each period. A natural concept to describe the behavior of naive agents in a market economy is a *sliding equilibrium path under perfect foresight* applied by Barro (1999) and formalized by Borissov et al. (2022). On a sliding equilibrium path under perfect foresight the agents (incorrectly) believe that in the future they will behave in a manner consistent with their long-run preferences but (correctly) expect that all other agents will recalculate their plans to satisfy their present-biased envy. As a result, in each period agents revise their consumption paths (which is an indication of naivete) but correctly anticipate interest and wage rates that occur on the resulting sliding equilibrium path (which is precisely the sense in which "the market knows best" in a model with time-inconsistent preferences).

We prove that there exists a sliding equilibrium path under perfect foresight in our model and study its properties. We show that after a finite time society splits into two unequal classes: the rich and the poor. Only agents who were the wealthiest from the outset belong to the rich: they own the entire capital stock and have positive consumption levels in all periods. All other agents are poor: they consume nothing and are in the maximum borrowing state.[2] We reveal the intuition for this result by considering the mechanism of transition to this degenerate long-run distribution of wealth.

The transitional dynamics are governed by relative consumption concerns and are characterized by a *Matthew effect*: the relatively rich get richer, and the relatively poor get poorer.[3] In each period, an agent whose previous period savings are higher than average improves their relative position, and their relative savings increase (the relatively rich gets richer). On the contrary, an agent whose relative savings are less than average further decreases their relative savings (the relatively poor gets poorer). The desire to keep up with the Joneses in each current period forces this agent to consume today more, gradually eroding their savings. After some finite time, this process ends: being too poor to achieve their reference level of consumption in the current period, an agent becomes absolutely impatient and spends their total expected lifetime income on current consumption, reaching the maximum borrowing state. From this moment on, this agent consumes zero and spends their wages to repay the debt.

Ultimately, all agents, except for those who were initially the wealthiest, end up in this situation. Even the second wealthiest individuals in society whose relative

[2] Like in Bewley (1982), in our model agents can sustain themselves and continue providing labor services even when they have zero consumption after a finite time.

[3] The Matthew effect is sometimes loosely expressed as "the rich get richer and the poor get poorer". However, in our framework poverty is relative, in line with the Duesenberry (1949) approach. Perhaps, it is more accurate to refer to this effect as the "relative Matthew effect".

savings at first might have increased, eventually become relatively poor. As long as there is someone relatively wealthier than them, their present-biased envy will inevitably lead them into debt. Only the agents who were the wealthiest from the outset accumulate capital and enjoy the highest consumption level. Nevertheless, the wealthiest agents are also affected by the present-biased envy. We show that the long-run capital stock under present-biased envy is lower than in the case without envy. Intuitively, present-biased envy reduces the effective discount factor of agents, making them more impatient and forcing them to save less.

The contribution of this paper is threefold. First, our paper contributes to the literature on the relative income hypothesis proposed by Duesenberry (1949) and developed further by Schlicht (1975); Bourguignon (1981); Frank (1985; 2007).[4] The relative income hypothesis argues that individuals base their decisions on their relative position within their reference group and, in particular, compare their consumption level to that of those around them. A natural way to rationalize the Duesenberry approach is to take into account that individuals are envious and are subject to relative consumption concerns: an agent cares not only about their absolute consumption level but also about how their consumption level compares to that of others. Relative consumption concerns are studied, among others, by Alvarez-Cuadrado and Long (2012); Borissov (2016) in the OLG setting, and by Alonso-Carrera et al. (2004); Garcia-Peñalosa and Turnovsky (2008); Dioikitopoulos et al. (2020) in the neoclassical growth setting.

However, the existing literature focuses on permanent (dispositional) envy which is present and foreseen throughout the whole life of an individual. As a result, within the neoclassical framework, previous models either consider symmetric equilibria in which consumption levels of all agents are identical (as in Alonso-Carrera et al., 2004) or obtain aggregate dynamics which do not depend on the distribution of wealth and are identical to those obtained in the model with homogeneous agents under a symmetric equilibrium (as in Garcia-Peñalosa and Turnovsky, 2008). By contrast, our study investigates the impact of episodic envy on the wealth distribution. Heuristically, we assume that agents care about their consumption relative to others but only in the current period. Specific emphasis on present-biased envy leads to drastically different conclusions about the role of envy in the dynamics of capital accumulation and increasing inequality.

Second, our paper contributes to the literature on present-focused preferences (see Ericson and Laibson, 2019, for a survey). These preferences reflect the empirical observation that people place greater emphasis on immediate outcomes than

[4] See also Borissov (2013), who considers a growth model with endogenous time preferences where agents' discount factors depend on their relative income.

to long-term consequences. Models with present-focused preferences imply that agents exhibit greater impatience when making choices for the present compared to when they make decisions for the future and capture such effects as present bias (quasi-hyperbolic discounting), temptation or psychometric distortions.

Our contribution here lies in showing that present-biased envy produces effects similar to that of quasi-hyperbolic discounting by shifting agents' consumption toward the present. In particular, we show that present-biased envy reduces the effective discount factor of agents, making them more impatient. However, the important difference is that short-run impatience of quasi-hyperbolic discounting is fully exogenous: agents consume more today because they are assumed *ex ante* to have present bias. By contrast, short-run impatience of present-biased envy is endogenous: agents consume more today because they are relatively poor and are keeping up with the Joneses. In a sense, present-biased envy can be considered as a manifestation of a present bias not directly related to discounting, which highlights an additional psychological mechanism generating present bias.

Third, our paper contributes to the discussion of the long-run income and wealth distribution in a complete market economy. Our results are similar to those of Bewley (1982) who studied an infinite horizon general equilibrium model with agents who are heterogeneous in their discount factors. Bewley showed that in any equilibrium (and thus Pareto-optimal) allocation only the most patient agents have positive consumption in all periods, while consumption of all other, less patient agents, converges to zero or becomes zero after some finite time. This property of a long-run equilibrium is referred to in the literature as the *Ramsey conjecture* (see also Becker, 2006, for a review). In the Bewley model, it is ultimately differences in exogenous discount factors that drive the distribution of income and wealth. Agents' heterogeneity under complete financial markets results in a degenerate distribution of wealth in the long run: all the less patient agents are indebted and spend their wages on interest payments, while the most patient agents own the entire capital stock together with all the debts of all other agents.

By contrast to Bewley (1982), our agents are identical in their discount factors and in any other exogenous parameters; they differ only in their initial capital endowments. Nevertheless, we also obtain a degenerate long-run distribution, solely as a consequence of present-biased envy. By a similar mechanism, present-biased envy under complete financial markets leads to a highly unequal distribution of wealth and allows agents who are the wealthiest from the outset to improve their relative position and eventually own all capital.[5] Our results imply that even the

[5] This mechanism is well in line with recent findings of Banuri and Nguyen (2023), who show in a lab experiment that envy and access to credit increase consumption and amplify inequality.

slightest difference in initial endowments, whose role is typically overlooked in growth models, reinforces over time and eventually amplifies inequality.

The rest of the paper is organized as follows. Section 2 describes the model and defines a sliding equilibrium path under perfect foresight. Section 3 proves its existence and characterizes its properties. Section 4 concludes. All the proofs and important derivations are relegated to the Appendix.

2 The model

2.1 Production and consumption

In this section we describe the main building blocks of our model. Every period the economy produces a single good that may be consumed or invested. The production side is characterized by a neoclassical production function $F(K, N)$, where K is the stock of physical capital, N is the labor input, and function F is homogeneous of degree one. The production function in intensive form, f, is given by $f(k) = F(K/N, 1)$, where $k = K/N$. Capital is the only variable factor, and it is assumed to depreciate completely within one period. The production function $f(k)$ satisfies the standard assumptions: $f(0) = 0$, $f'(k) > 0$, $f''(k) < 0$, $\lim_{k\to 0} f'(k) = +\infty$, and $\lim_{k\to\infty} f'(k) = 0$.

In each period t, producers take as given the interest rate r_t and solve the following profit maximization problem:

$$\max_{k_t \geq 0} \quad f(k_t) - (1 + r_t)k_t \, .$$

On the consumption side, there are N agents. Without loss of generality, we assume that the initial savings of agents, $\left(s_{-1}^{j*}\right)_{j=1}^{N}$, are such that

$$s_{-1}^{1*} \; = \; \ldots \; = \; s_{-1}^{L*} \; > \; s_{-1}^{(L+1)*} \; \geq \; \ldots \; \geq \; s_{-1}^{N*} \; > \; 0 \, ,$$

that is, there are L $(1 \leq L \leq N)$ wealthiest agents in the initial distribution.

Consider any agent $j \in \{1, \ldots, N\}$. Their preferences in period τ are given by the following utility function:[6]

$$U_\tau(\{c_t\}_{t=\tau}^{\infty}) = \begin{cases} c_\tau - \gamma\bar{c}_\tau, & c_\tau \leq \gamma\bar{c}_\tau \\ \exp\left[\ln(c_\tau - \gamma\bar{c}_\tau) + \delta \ln c_{\tau+1} + \delta^2 \ln c_{\tau+2} + \ldots\right], & c_\tau > \gamma\bar{c}_\tau \end{cases} . \quad (1)$$

[6] In the following discussion we omit index j for consumption sequences to simplify the notation. Since agents are identical in their exogenous parameters, they have identical preferences.

Here $0 < \delta < 1$ is the discount factor, $0 \leq \gamma < 1$ is the degree of envy and $\overline{c}_\tau$ is the average level of consumption in period τ taken as given by the agent. The agent takes the current average level of consumption in society as a reference point and derives current period utility from the convex combination of their own consumption and their consumption compared to the reference point, with the degree of envy being the weight of the latter term: $(1-\gamma)c_\tau + \gamma(c_\tau - \overline{c}_\tau)$.

Let us comment on this utility function. Note that for the sequences $\{c_t\}_{t=\tau}^{\infty}$ such that $c_\tau > \gamma\overline{c}_\tau$, it is equivalent to the standard logarithmic utility function

$$\ln\left(c_\tau - \gamma\overline{c}_\tau\right) + \delta \ln c_{\tau+1} + \delta^2 \ln c_{\tau+2} + \dots .$$

If in equilibrium for any agent j for all τ we had $c_\tau^j > \gamma\overline{c}_\tau$, then we could have limited our consideration to this function.

However, as we shall see in what follows, the above condition in equilibrium holds only in the degenerate case where all agents have the same initial savings. To analyze the general case, it is necessary to extend the preferences of agents to the set of all non-negative sequences in such a way that they remain quasi-concave. The *unique way* to do this is to consider the following preference relation $\succcurlyeq_\tau$: for $C = \{c_t\}_{t=\tau}^{\infty}$ and $C' = \{c'_t\}_{t=\tau}^{\infty}$ we have $C \succcurlyeq_\tau C'$ if

- $c_\tau \geq c'_\tau\,, \quad$ when $\quad 0 \leq c'_\tau \leq \gamma\overline{c}_\tau;$

- $c_\tau > \gamma\overline{c}_\tau \quad$ and

$$\ln(c_\tau - \gamma\overline{c}_\tau) + \sum_{t=1}^{\infty} \delta^t \ln c_{\tau+t} \;\geq\; \ln(c'_\tau - \gamma\overline{c}_\tau) + \sum_{t=1}^{\infty} \delta^t \ln c'_{\tau+t}\,, \quad \text{when} \quad c'_\tau > \gamma\overline{c}_\tau\,.$$

The utility function given by (1) represents these preferences. When agents consider consumption sequences in which current period consumption is less than $\gamma\overline{c}_\tau$, they are absolutely impatient and ignore the future.

In each period τ, given previous period savings $s_{\tau-1}^j$, agent j solves the following problem:

$$\begin{aligned} \max_{\{c_t\}_{t=\tau}^{\infty}} \quad U_\tau(\{c_t\}_{t=\tau}^{\infty}) \qquad \text{s. t.} \;\; & c_\tau + \frac{c_{\tau+1}}{1+r_{\tau+1}} + \frac{c_{\tau+2}}{(1+r_{\tau+1})(1+r_{\tau+2})} + \dots \\ \leq \;\; & (1+r_\tau)s_{\tau-1}^j + w_\tau + \frac{w_{\tau+1}}{1+r_{\tau+1}} + \frac{w_{\tau+2}}{(1+r_{\tau+1})(1+r_{\tau+2})} + \dots\,, \end{aligned} \tag{2}$$

where the sequences of interest rates $\{r_t\}_{t=\tau}^{\infty}$ and wage rates $\{w_t\}_{t=\tau}^{\infty}$ are taken as given by the agent.

2.2 Sliding equilibrium

In this section we introduce a sliding equilibrium path under perfect foresight (perfect sliding equilibrium, PSE) for our model. In each period τ, each agent maximizes their utility. The agents correctly anticipate the sequences of interest and wage rates that will prevail in the economy, and take as given the equilibrium average level of consumption in period τ. The capital supply in period τ is the sum of current period savings of all agents at equilibrium prices. Producers maximize profit and determine the required capital stock. Interest and wage rates are given by the respective marginal products. An equilibrium occurs when the output and capital markets clear in each period, that is, aggregate savings are equal to the capital stock. Formally, we define a PSE as follows.

Definition 1. *A sequence* $\left\{ \left(c_t^{j*}\right)_{j=1}^N, \left(s_t^{j*}\right)_{j=1}^N, k_{t+1}^*, r_t^*, w_t^* \right\}_{t=0}^{\infty}$ *is a* sliding equilibrium path under perfect foresight *starting from* $\left(s_{-1}^{j*}\right)_{j=1}^N$, *if in each period* $\tau \geq 0$,

1. *Consumption of each agent* j *is obtained from the solution to problem* (2) *for*
$$\bar{c}_\tau = \frac{\sum_{i=1}^N c_\tau^{i*}}{N}, \tag{3}$$
at $s_{\tau-1}^{j*}$ *and given* $\{r_t^*\}_{t=\tau}^{\infty}$ *and* $\{w_t^*\}_{t=\tau}^{\infty}$*;*

2. *Savings of each agent* j *are determined recursively by*
$$s_\tau^{j*} = (1 + r_\tau^*)s_{\tau-1}^{j*} + w_\tau^* - c_\tau^{j*}\,; \tag{4}$$

3. *Prices are equal to marginal products:*
$$1 + r_\tau^* = f'(k_\tau^*) \qquad \textit{and} \qquad w_\tau^* = f(k_\tau^*) - f'(k_\tau^*)k_\tau^*\,; \tag{5}$$

4. *Aggregate savings are equal to the stock of capital:*
$$k_\tau^* = \frac{\sum_{i=1}^N s_{\tau-1}^{i*}}{N}.$$

This definition deserves several comments. First, a PSE is associated with infinitely many optimization problems of the form (2). In each period τ each agent solves the corresponding problem and implements only the first step. Agents are naive about their present-biased envy and revise their consumption paths in each period. At the same time, agents correctly anticipate sliding equilibrium prices and never recalculate the expected interest and wage rates. This is exactly what perfect foresight means under time-inconsistent preferences: agents' expectations about prices are model-consistent and are correct from the sliding perspective.

Second, the idea of a PSE can be traced to Barro (1999). He considers a Ramsey model with hyperbolic discounting where in equilibrium an agent revises their consumption path in each period but does not revise their expectations. Hence Barro in fact considers a naive agent who correctly anticipates prices taking into account that the equilibrium itself will change, and studies a PSE in our terms. As Barro (1999, p. 1127) puts it, "Consumers ... are impatient about consuming right now, but they need not be shortsighted in the sense of failing to take account of long-term consequences". The formal definition and discussion of a PSE in a Ramsey model with quasi-hyperbolic discounting and naive agents are provided by Borissov et al. (2022). Note also that when $\gamma = 0$, a PSE coincides with an equilibrium path in the standard Ramsey model where N agents share the same discount factor δ.

Third, due to log-utility, a PSE admits a simple characterization. Let

$$W_\tau^{j*} \;=\; (1+r_\tau^*)s_{\tau-1}^{j*} + w_\tau^* + \frac{w_{\tau+1}^*}{1+r_{\tau+1}^*} + \frac{w_{\tau+2}^*}{(1+r_{\tau+1}^*)(1+r_{\tau+2}^*)} + \dots\,, \tag{6}$$

be the present (period-τ) value of the equilibrium period-τ lifetime income of agent j. By (4), in a PSE lifetime incomes of agent j in different periods are linked as follows: for all $\tau \geq 0$,

$$W_{\tau+1}^{j*} \;=\; (1+r_{\tau+1}^*)(W_\tau^{j*} - c_\tau^{j*})\,. \tag{7}$$

Moreover, in each period τ, consumption level of agent j in a PSE is given by

$$c_\tau^{j*} \;=\; \begin{cases} W_\tau^{j*}, & W_\tau^{j*} \;\leq\; \gamma\overline{c}_\tau \\ (1-\delta)W_\tau^{j*} + \delta\gamma\overline{c}_\tau, & W_\tau^{j*} \;\geq\; \gamma\overline{c}_\tau \end{cases}, \tag{8}$$

where $\overline{c}_\tau$ satisfies (3) (for the derivation, see Appendix A). Equation (8) has a very natural interpretation: if in period τ an agent is too poor to obtain $\gamma\overline{c}_\tau$, the agent becomes absolutely impatient and spends their total wealth on current consumption.[7] Therefore, the following proposition holds.

Proposition 1. *A sequence* $\left\{ \left(c_t^{j*}\right)_{j=1}^N, \left(s_t^{j*}\right)_{j=1}^N, k_{t+1}^*, r_t^*, w_t^* \right\}_{t=0}^\infty$ *is a PSE starting*

[7] While this scenario might seem rather implausible, there are real world examples of such an impatient and myopic behavior. For instance, in 2022 some Argentinians depleted their savings accounts, sold houses and spent their parental college savings just in order to visit the FIFA World Cup (see, among others, The Sun, 2022).

from $\left(s_{-1}^{j*}\right)_{j=1}^{N}$ *if and only if in each period* $\tau \geq 0$*, for* $\bar{c}_\tau$ *given by* (3) *and* W_τ^{j*} *given by* (6)*, the following holds:*

1. *Consumption of each agent* j*,* c_τ^{j*}*, is given by* (8)*;*

2. *Lifetime income of each agent* j*,* $W_{\tau+1}^{j*}$*, satisfies* (7)*;*

3. *The capital stock is given by* $k_{\tau+1}^* = f(k_\tau^*) - \bar{c}_\tau$*;*

4. *Savings of each agent* j *are given by* (4)*, and prices are given by* (5)*.*

Finally, a stationary sliding equilibrium under perfect foresight (stationary perfect sliding equilibrium, SPSE) for our model is defined in a natural way.

Definition 2. *A tuple* $\left\{(c^{j*})_{j=1}^{N}, (s^{j*})_{j=1}^{N}, k^*, r^*, w^*\right\}$ *is a* stationary sliding equilibrium under perfect foresight *if the sequence* $\left\{\left(c_t^{j*}\right)_{j=1}^{N}, \left(s_t^{j*}\right)_{j=1}^{N}, k_{t+1}^*, r_t^*, w_t^*\right\}_{t=0}^{\infty}$ *is a sliding equilibrium path under perfect foresight starting from* $(s^{j*})_{j=1}^{N}$*, where for each* $t \geq 0$*,* $c_t^{j*} = c^{j*}$*,* $s_t^{j*} = s^{j*}$ *for all* j*,* $k_{t+1}^* = k^*$*,* $r_t^* = r^*$*, and* $w_t^* = w^*$*.*

3 Main results

In this section we characterize the properties of a PSE in our model. We begin by the following theorem which shows that a PSE is well-defined and establishes its existence.

Theorem 1. *There exists a sliding equilibrium path under perfect foresight starting from any* $\left(s_{-1}^{j*}\right)_{j=1}^{N}$*.*

Proof. See Appendix B. ■

The dynamics of a PSE are given as follows. In each period, those agents whose savings are higher than average (among all agents whose consumption level is positive) improve their relative position. On the contrary, the agents whose savings are less than average further decrease their relative savings and relative lifetime income. All agents (except for those L agents who are the wealthiest from the outset) eventually find themselves in a situation where their savings are less than average. For each of those $N - L$ agents there is a period of time (different for different agents) when they become too poor to consume their reference level in this period. As is clear from (8), in this period they are forced to spend all of their lifetime income on current consumption and reach the maximum borrowing state. From this period on, they consume nothing and spend their wages to repay the debt. Thus, in the long run, only L agents who were the wealthiest from the outset have positive consumption and savings. All other, initially relatively poorer agents, drive their consumption level to zero after some finite time. The following theorem characterizes the dynamics of a PSE.

Theorem 2. *Let* $\left\{ \left(c_t^{j*}\right)_{j=1}^{N}, \left(s_t^{j*}\right)_{j=1}^{N}, k_{t+1}^*, r_t^*, w_t^* \right\}_{t=0}^{\infty}$ *be a sliding equilibrium path under perfect foresight starting from* $\left(s_{-1}^{j*}\right)_{j=1}^{N}$.

1. *Let* M_τ *be the number of agents for whom* $W_\tau^{j*} > 0$. *In each period* τ*, for each agent* $j = 1, \ldots, M_\tau$*,*

$$\frac{s_{\tau-1}^{j*}}{\sum_{i=1}^{M_\tau} s_{\tau-1}^{i*}} \ \underset{>}{\overset{<}{=}} \ \frac{1}{M_\tau} \qquad \Longrightarrow \qquad \frac{W_{\tau+1}^{j*}}{\overline{W}_{\tau+1}} \ \underset{>}{\overset{<}{=}} \ \frac{W_\tau^{j*}}{\overline{W}_\tau},$$

where $\overline{W}_\tau = \frac{\sum_{i=1}^{N} W_\tau^{i*}}{N}$.

2. *There is* T *such that for* $j = L+1, \ldots, N$*, we have* $c_t^{j*} = 0$ *and* $W_t^{j*} = 0$ *for all* $t \geq T$.

Proof. See Appendix C. ∎

Theorem 2 implies that starting from some period T, only L agents who were the wealthiest from the outset will accumulate capital. Since these agents are identical both in their exogenous parameters and in their initial savings, they make identical decisions every period. Moreover, from period T on, the dynamics of the model are identical to that of the standard Ramsey model: consumption and savings decisions made by the wealthiest agents under present-biased envy coincide with those of a representative agent in the standard Ramsey model for some effective discount factor δ^*. We show that this effective discount factor is given by

$$\delta^* = \frac{\delta - \frac{L}{N}\delta\gamma}{1 - \frac{L}{N}\delta\gamma}, \tag{9}$$

and is monotonically decreasing in γ. Therefore, the long-run effect of present-biased envy is to decrease the effective discount factor of the wealthiest agents. It follows that the long-run capital stock under present-biased envy (given by the modified golden rule for discount factor δ^*) is lower than in the case with $\gamma = 0$. The following proposition characterizes the long-run distribution of consumption and capital in the resulting stationary perfect sliding equilibrium.[8]

[8] This result also implies that if all agents have identical initial savings, a PSE is *observationally equivalent* to an optimal path in the standard Ramsey model: there is a constant discount factor

Proposition 2. *Every sliding equilibrium path under perfect foresight starting from* $\left(s_{-1}^{j*}\right)_{j=1}^{N}$ *converges to the stationary sliding equilibrium under perfect foresight* $\left\{\left(c^{j*}\right)_{j=1}^{N}, \left(s^{j*}\right)_{j=1}^{N}, k^*, r^*, w^*\right\}$*, which is given by*

$$k^* = (f')^{-1}\left(\frac{1}{\delta^*}\right), \qquad 1 + r^* = \frac{1}{\delta^*}, \qquad w^* = f(k^*) - f'(k^*)k^*,$$

$$c^{j*} = \frac{N}{L}\left(f(k^*) - k^*\right), \qquad s^{j*} = \frac{N}{L}k^* + \frac{N-L}{L}\frac{w^*}{r^*}, \qquad j = 1, \dots, L,$$

$$c^{j*} = 0, \qquad s^{j*} = -\frac{w^*}{r^*}, \qquad j = L+1, \dots, N,$$

where the effective discount factor δ^* *is given by* (9) *and is decreasing in* γ*.*

Proof. See Appendix D. ■

Let us discuss our results. First, Proposition 2 essentially provides the same result as that in Bewley (1982). Formally, a SPSE in a model with present-biased envy coincides with a stationary equilibrium in the Bewley model with L most patient agents whose discount factor is equal to δ^*. In the long run, both models predict a division of society into two unequal classes. The rich (the most patient agents in the Bewley model and the wealthiest agents from the outset in our model) own the entire capital stock and have positive consumption. The poor (all other agents in both cases) are indebted and consume nothing. However, the important difference between the Bewley model and ours is that in our case agents are identical in all exogenous parameters, including the discount factors. Our results are not driven by the fact that agents are heterogeneous, which underscores the potency of the psychological mechanism of present-biased envy.

Moreover, the effective discount factor δ^* under present-biased envy is lower than the actual discount factor of agents δ. Hence, present-biased envy affects the observable time preference of agents, making them effectively more impatient. As a result, the long-run capital stock and aggregate income are decreasing in the degree of envy. Note also that the effective discount factor δ^* is decreasing in the share of the wealthiest agents in the initial distribution, L/N. Therefore, we observe a growth-inequality trade-off in our model. As L/N increases, the degree of inequality in the SPSE decreases, but simultaneously, the long-run capital stock decreases. Intuitively, higher L/N implies that more people belong to the rich in the long run, which reduces inequality. At the same time, higher L/N means

δ^* such that the sequence of consumption and capital in a PSE coincides with the optimal path in the standard Ramsey model for discount factor δ^*. When all agents have identical initial savings, the effective discount factor is given by (9) with $L = N$.

that envied individuals on average consume more, which forces envious agents to increase consumption and to save even less.

Second, when $\gamma = 0$, a SPSE coincides with a stationary equilibrium in the standard Ramsey model where N agents have the same discount factor δ. As is well known, the stationary equilibrium in the Ramsey model with agents sharing the same discount factor is *egalitarian*: all agents have the same level of consumption and identical positive savings. Thus, the very presence of present-biased envy drastically changes the qualitative properties of the model. Society without envy is characterized by perfect income and wealth equality in the long run, while society with even a very low degree of envy splits into two classes and is characterized by a highly unequal distribution of wealth.

Third, it is instructive to compare Proposition 2 with the results from the models which study permanent envy (e.g., Garcia-Peñalosa and Turnovsky, 2008), where agents care about how their consumption level compares to that of others in every period. While it is acknowledged that permanent envy typically results in higher inequality in consumption and capital than in an economy without envy (cf. Alvarez-Cuadrado and Long, 2012), this type of models leads to neither a degenerate distribution of wealth nor to a two-class society. The reason is that permanent envy has only *short-run effects* on consumption, while present-biased envy has both short-run and *long-run effects*.

Indeed, it is easily seen that under permanent envy the growth rate of consumption compared to the reference level $(c_\tau - \gamma \bar{c}_\tau)$ is the same for all agents and is determined by their discount factor (as in the standard Ramsey model). At the same time, under present-biased envy the growth rate of consumption compared to the reference level depends on an agent's lifetime income, and hence is determined by the initial distribution of savings and is different for different agents. Intuitively, permanent envy implies that agents know they will be envious in all future periods. Because of this stability and predictability, permanent envy affects only the levels of consumption of different agents, and the natural situation where the consumption level of one agent is increasing while the consumption level of another agent is decreasing is impossible. On the contrary, present-biased envy implies that agents revise their consumption decisions in each period, and because of their naivete both the consumption level and the consumption growth rate in the short run turn out to depend on their initial endowments. This observation highlights that relative income effects play a significant role under naivete.

4 Conclusion

In this paper we take seriously two empirically well-documented behavioral patterns: people care about relative consumption; and people are naive and revise their decisions. We introduce the assumption of *present-biased envy* — relative consumption concerns which are more pronounced right now than in the future. We analyze the effects of present-biased envy on levels of income and inequality in a Ramsey-type model where agents differ only in their initial capital endowments.

We show that present-biased envy affects both the distribution of wealth and capital accumulation. First, present-biased envy results in splitting society into two classes, the rich and the poor. In the long run only agents who were the wealthiest from the outset own the entire capital stock, while all other agents consume nothing and spend their wages to repay the debt. Present-biased envy gives rise to the Matthew effect: the relatively rich get richer while the relatively poor get poorer, and the effect of inequality in initial endowments increases over time, leading to a degenerate long-run distribution of wealth. Second, present-biased envy reduces the effective discount factor of agents, making them more impatient. In the long run, the capital stock and aggregate income are lower under present-biased envy than in an economy without relative consumption concerns.

There are several open questions to be addressed by future studies. A possible direction of future research is to consider an economy with borrowing constraints in the spirit of Becker (1980). If agents can sell or accumulate capital but cannot borrow, then no one has zero consumption, because the relatively poorer agents always consume at least a part of their labor income. It is reasonable to conjecture that, under additional assumptions on technology and for a sufficiently high degree of envy, the introduction of incomplete financial markets would lead to results similar to those presented in this study. In the long run, society would split into two unequal classes: the entire capital stock is owned by agents who were the wealthiest from the outset, while all other agents have zero capital and consume their wages.

Another research question relates to policy implications under present-biased envy. An open question is whether redistributive fiscal policy is able to address over-consumption and under-saving by agents. Optimal policy design here is not straightforward. This is partly due to the fact that welfare criteria under time inconsistency are not clearly defined. Additionally, the growth-inequality trade-off concerning the share of the wealthiest agents further complicates matters. Nevertheless, we hope that our discussion of present-biased envy will contribute to further understanding the effects of time-inconsistent decision making.

Appendix

A Characterization of a PSE

Consider problem (2) for some agent j. Suppose that c_τ is known. Then the remaining consumption decisions are determined as a solution to the following problem:

$$\max_{\{c_t\}_{t=\tau+1}^{\infty}} \sum_{t=1}^{\infty} \delta^t \ln c_{\tau+t} \qquad \text{s. t.} \quad c_{\tau+1} + \frac{c_{\tau+2}}{1+r_{\tau+2}} + \ldots \;=\; W_{\tau+1}^j \,, \tag{A.1}$$

where the value of the expected period-$\tau+1$ lifetime income is given by $W_{\tau+1}^j = (1+r_{\tau+1})(W_\tau^j - c_\tau)$. It is easily checked that the solution to (A.1) is given by

$$c_{\tau+1} \;=\; (1-\delta)W_{\tau+1}^j, \qquad c_{t+1} \;=\; \delta(1+r_{t+1})c_t, \quad t \geq \tau+1.$$

The optimal value of problem (A.1) is given by

$$\begin{aligned}\sum_{t=1}^{\infty} \delta^t \ln c_{\tau+t} \;&=\; \delta \ln\big((1-\delta)W_{\tau+1}^j\big) \\ &\quad + \delta^2 \ln\big(\delta(1-\delta)(1+r_{\tau+2})W_{\tau+1}^j\big) + \ldots \;=\; \frac{\delta}{1-\delta} \ln W_{\tau+1}^j + A \,,\end{aligned}$$

where A does not depend on c_τ and $W_{\tau+1}^j$,

$$A \;=\; \delta \ln(1-\delta)\left[1 + \delta \ln\left(\delta(1+r_{\tau+1})\right) + \delta^2 \ln\big(\delta^2(1+r_{\tau+1})(1+r_{\tau+2})\big) + \ldots\right] .$$

Then the period-τ decision from problem (2) can be found as the solution to the following problem:

$$\begin{aligned} &\max \quad u_\tau(c_\tau - \gamma\bar{c}_\tau, W_{\tau+1}^j) \\ &\text{s. t.} \;\; c_\tau + \frac{1}{1+r_{\tau+1}} W_{\tau+1}^j \;\leq\; W_\tau^j, \quad c_\tau \;\geq\; 0, \quad W_{\tau+1}^j \geq 0 \,, \end{aligned} \tag{A.2}$$

with

$$u_\tau(c_\tau - \gamma\bar{c}_\tau, W_{\tau+1}^j) = \begin{cases} c_\tau - \gamma\bar{c}_\tau, & c_\tau < \gamma\bar{c}_\tau \\ \exp\left[\ln(c_\tau - \gamma\bar{c}_\tau) + \frac{\delta}{1-\delta}\ln W_{\tau+1}^j + A\right], & c_\tau \geq \gamma\bar{c}_\tau \end{cases} .$$

Therefore, for any agent j, c^j_τ is given as follows:

$$c^j_\tau = \begin{cases} W^j_\tau, & W^j_\tau \le \gamma \bar{c}_\tau \\ (1-\delta)W^j_\tau + \delta\gamma\bar{c}_\tau, & W^j_\tau \ge \gamma\bar{c}_\tau \end{cases} .$$

B Proof of Theorem 1

Let $s^j_{-1} \ge 0$, $j = 1, \dots, N$, be given and $k_0 = \frac{\sum_{j=1}^N s^j_{-1}}{N} > 0$. It follows from Proposition 1 that in a PSE, for each agent j the initial period-0 lifetime income can be written as $W^j_0(X^*)$ where

$$W^j_0(X) \;=\; (1+r_0)s^j_{-1} + w_0 + X\,, \tag{B.1}$$

and

$$X^* \;=\; \frac{w^*_1}{1+r^*_1} + \frac{w^*_2}{(1+r^*_1)(1+r^*_2)} + \dots\,.$$

Since lifetime incomes in a PSE in all future periods are determined by (7), a PSE is essentially determined by the value X^*. Let us show that such X^* exists.

Let $W^j_0(X)$ be defined by (B.1), and let also $k_0(X) \equiv k_0$ and $s^j_{-1}(X) \equiv s^j_{-1}$ for all j. Let us recursively define for all $j = 1, \dots, N$, and for all $t \ge 0$, the following functions of X: $c^j_t(X)$, $s^j_t(X)$, $W^j_{t+1}(X)$, $\bar{c}_t(X)$, $k_{t+1}(X)$, $r_t(X)$, $w_t(X)$. Specifically, we define

$$\begin{aligned} s^j_t(X) &= (1+r_t(X))s^j_{t-1}(X) + w_t(X) - c^j_t(X)\,, \\ k_{t+1}(X) &= \max\{f(k_t(X)) - \bar{c}_t(X), 0\}\,, \\ r_t(X) = f'(k_t(X)), &\qquad w_t(X) = f(k_t(X)) - f'(k_t(X))k_t(X)\,, \\ W^j_{t+1}(X) &= (1+r_{t+1}(X))(W^j_t(X) - c^j_t(X))\,, \end{aligned}$$

where the functions $c^j_t(X)$ and $\bar{c}_t(X)$ are recursively constructed as follows.

Suppose that in period τ we are given $W^j_\tau(X)$ for all j, and define the functions

$$\tilde{c}^j_\tau(X, c) = \begin{cases} W^j_\tau(X), & W^j_\tau(X) \le \gamma c \\ (1-\delta)W^j_\tau(X) + \delta\gamma c, & W^j_\tau(X) \ge \gamma c \end{cases} .$$

We have

$$\frac{\sum_{j=1}^N \tilde{c}^j_\tau(X, 0)}{N} \;=\; (1-\delta)\frac{\sum_{j=1}^N W^j_\tau(X)}{N} > 0\,,$$

and

$$\frac{\sum_{j=1}^{N} \tilde{c}_\tau^j(X,\infty)}{N} \;=\; \frac{\sum_{j=1}^{N} W_\tau^j(X)}{N} < \infty\,.$$

Since for a given X, $\frac{\sum_{j=1}^{N} \tilde{c}_\tau^j(X,c)}{N}$ is a non-decreasing piecewise-linear function of c, the following equation in c:

$$\frac{\sum_{j=1}^{N} \tilde{c}_\tau^j(X,c)}{N} \;=\; c\,.$$

has a unique solution. We set $\overline{c}_\tau(X)$ equal to this solution and determine $c_\tau^j(X)$ as follows:

$$c_\tau^j(X) = \begin{cases} W_\tau^j(X), & W_\tau^j(X) \le \gamma\overline{c}_\tau(X) \\ (1-\delta)W_\tau^j(X) + \delta\gamma\overline{c}_\tau(X), & W_\tau^j(X) \ge \gamma\overline{c}_\tau(X) \end{cases}.$$

Now let the function $\Phi(X)$ be given by

$$\Phi(X) \;=\; \frac{w_1(X)}{1+r_1(X)} + \frac{w_2(X)}{(1+r_1(X))(1+r_2(X))} + \dots\,.$$

Clearly, if $k_t(X)=0$, then $r_t(X)=+\infty$ and $w_t(X)=0$, so that $\Phi(X)=0$.

Observe that $\Phi(X)$ is continuous and that $\Phi(0)>0$ and $\Phi(X)=0$ for sufficiently large X. Therefore, there exists a solution X^* to the following equation in X: $\Phi(X)=X$. It follows from Proposition 1 that, by construction, the sequence $\left\{\left(c_t^{j*}\right)_{j=1}^N, \left(s_t^{j*}\right)_{j=1}^N, k_{t+1}^*, r_t^*, w_t^*\right\}_{t=0}^{\infty}$, in each period $\tau \ge 0$ given by

$$\begin{aligned} c_\tau^{j*} &= c_\tau^j(X^*), \qquad s_\tau^{j*} = s_\tau^j(X^*), \quad j=1,\dots,N, \\ k_{\tau+1}^* &= k_\tau(X^*), \qquad r_\tau^* = r_\tau(X^*), \qquad w_\tau^* = w_\tau(X^*)\,, \end{aligned}$$

is a PSE.

C Proof of Theorem 2

It is clear that, in a PSE, for all $t \ge 0$,

$$W_t^{1*} \;=\; \dots \;=\; W_t^{L*} \;>\; W_t^{(L+1)*} \;\ge\; \dots \;\ge\; W_t^{N*} \ge 0\,.$$

Furthermore, if $W_\tau^{j*} \le \gamma\overline{c}_\tau$, then $W_t^{k*}=0$ and $c_t^{k*}=0$ for $k=j,j+1,\dots,N$, and for all $t \ge \tau+1$.

Let M_τ be the number of agents with positive lifetime income in period τ:

$$W_\tau^{j*} \;>\; 0\,, \quad j = 1, \ldots, M_\tau; \qquad W_\tau^{j*} \;=\; 0, \quad j = M_\tau + 1, \ldots, N\,.$$

Note that $M_0 = N$.

It follows from (8) that for all $j \leq M_\tau$, we have

$$c_\tau^{j*} \;=\; (1-\delta)W_\tau^{j*} + \delta\gamma\overline{c}_\tau\,. \tag{C.1}$$

Therefore,

$$\sum_{j=1}^{M_\tau} c_\tau^{j*} \;=\; (1-\delta)\sum_{j=1}^{M_\tau} W_\tau^{j*} + M_\tau\delta\gamma\overline{c}_\tau\,,$$

and hence

$$\overline{c}_\tau \;=\; (1-\delta)\overline{W}_\tau + \frac{M_\tau}{N}\delta\gamma\overline{c}_\tau\,.$$

It follows that in any period τ,

$$\overline{c}_\tau \;=\; \lambda_\tau\overline{W}_\tau\,, \tag{C.2}$$

where

$$\lambda_\tau \;=\; \frac{1-\delta}{1-\frac{M_\tau}{N}\delta\gamma}\,. \tag{C.3}$$

It is easily seen that $1-\delta < \lambda_\tau < 1$.

It follows from (7) that

$$\overline{W}_{\tau+1} \;=\; (1+r_{\tau+1}^*)(\overline{W}_\tau - \overline{c}_\tau)\,.$$

For $j = 1, \ldots, M_\tau$, we get

$$\frac{W_{\tau+1}^{j*}}{\overline{W}_{\tau+1}} = \frac{(1+r_{\tau+1}^*)(W_\tau^{j*} - c_\tau^{j*})}{(1+r_{\tau+1}^*)(\overline{W}_\tau - \overline{c}_\tau)} = \frac{W_\tau^{j*} - c_\tau^{j*}}{\overline{W}_\tau - \overline{c}_\tau}\,.$$

Taking into account (C.1) and (C.2), we get

$$\frac{W_{\tau+1}^{j*}}{\overline{W}_{\tau+1}} = \frac{W_\tau^{j*} - (1-\delta)W_\tau^{j*} - \delta\gamma\overline{c}_\tau}{(1-\lambda_\tau)\overline{W}_\tau} = \frac{\delta W_\tau^{j*} - \delta\gamma\lambda_\tau\overline{W}_\tau}{(1-\lambda_\tau)\overline{W}_\tau} = \frac{\delta}{1-\lambda_\tau}\left(\frac{W_\tau^{j*}}{\overline{W}_\tau} - \gamma\lambda_\tau\right)\,.$$

Now, using (C.3) and (6), it is easily seen that for each $j = 1, \ldots, M_\tau$,

$$\frac{W_{\tau+1}^{j*}}{\overline{W}_{\tau+1}} \lesseqgtr \frac{W_\tau^{j*}}{\overline{W}_\tau} \iff \frac{W_\tau^{j*}}{\overline{W}_\tau} \lesseqgtr \frac{\delta\gamma\lambda_\tau}{\delta + \lambda_\tau - 1} \iff \frac{W_\tau^{j*}}{\overline{W}_\tau} \lesseqgtr \frac{N}{M_\tau} \iff$$
$$\frac{(1+r_\tau^*)s_{\tau-1}^{j*} + w_\tau^* + X^*}{(1+r_\tau^*)\sum_{i=1}^{M_\tau} s_{\tau-1}^{i*} + M_\tau w_\tau^* + M_\tau X^*} \lesseqgtr \frac{1}{M_\tau} \iff \frac{s_{\tau-1}^{j*}}{\sum_{i=1}^{M_\tau} s_{\tau-1}^{i*}} \lesseqgtr \frac{1}{M_\tau}.$$

Therefore, for all $t \geq \tau$ such that $M_t = M_\tau$, the relative lifetime incomes of agents j whose savings in period τ were less than average (among all agents whose consumption level is positive) are strictly decreasing. Clearly, they decrease until some τ' at which $W_{\tau'}^{j*} = 0$ for at least one such j. Starting from this τ', we would have $M_{\tau'+1} = M_\tau - 1$, and the described above process repeats.

This process ends in some finite period T after which $M_t = L$ for all $t \geq T$. Indeed, since all agents $j = 1, \ldots, L$ are identical even in their initial savings, for all $t \geq T$ we would have

$$\frac{s_{t-1}^{j*}}{\sum_{i=1}^{L} s_{t-1}^{i*}} = \frac{1}{L} \qquad \text{and} \qquad \frac{W_t^{j*}}{\overline{W}_t} = \frac{N}{L}.$$

Therefore, starting from this T,

$$W_t^{j*} = 0 \qquad \text{and} \qquad c_t^{j*} = 0, \qquad j = L+1, L+2, \ldots, N, \quad t \geq T.$$

D Proof of Proposition 2

Consider the economy starting from period T defined in Theorem 2. Then all agents who have non-negative savings are completely identical: $s_\tau^{1*} = \ldots = s_\tau^{L*}$ for all $\tau \geq -1$. Moreover, for any agent $j = 1, \ldots, L$ for all $\tau \geq T$, $c_\tau^{j*} = \frac{N}{L}\overline{c}_\tau$ and $W_\tau^{j*} = \frac{N}{L}\overline{W}_\tau$. It follows from (C.2) that

$$c_\tau^{j*} = \frac{1-\delta}{1 - \frac{L}{N}\delta\gamma} W_\tau^{j*}.$$

At the same time, it is well known that in the standard Ramsey model for an agent with exponential discounting who has a constant discount factor δ^* and logarithmic utility, the optimal period-τ consumption is given by

$$c_\tau^* = (1-\delta^*)\, W_\tau^{j*}.$$

Therefore, the dynamics of consumption and savings of the wealthiest agents in a PSE are observationally equivalent to the optimal path in the standard Ramsey model for the effective discount factor δ^* given by (9). It is easily seen that δ^* is monotonically decreasing in γ. It now follows from the standard results about the Ramsey model that the long-run capital stock is given by the modified golden rule for discount factor δ^*.

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