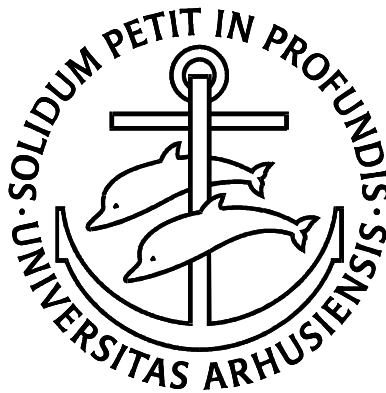


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Rejuveniles and Growth

Richard C. Barnett and Joydeep Bhattacharya



UNIVERSITY OF AARHUS

BUILDING 1322 - 8000 AARHUS C - DENMARK ☎ +45 8942 1133

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RICHARD C. BARNETT*
VILLANOVA UNIVERSITY

JOYDEEP BHATTACHARYA†
IOWA STATE UNIVERSITY

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ABSTRACT. *Rejuveniles are “people who cultivate tastes and mind-sets traditionally associated with those younger than themselves.” (Noxon, 2006) In this paper, we study a standard AK growth model of overlapping generations populated by rejuveniles. For our purposes, rejuveniles are old agents who derive utility from “keeping up” their consumption with that of the current young. We find that such cross-generational keeping up is capable of generating interesting equilibrium growth dynamics, including growth cycles. No such growth dynamics is possible either in the baseline model, one where no such generational consumption externality exists, or for almost any other form of keeping up. Steady-state growth in a world with rejuveniles may be higher than that obtained in the baseline model.*

Keywords: Growth cycles, keeping up preferences, consumption externality

JEL Classifications: E 13, E 32

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*Corresponding author: Richard C. Barnett, Department of Economics, Bartley Hall Rm 3008, 800 Lancaster Avenue, Villanova, PA 19085; Ph: (610) 519-6321; Email address: Richard.Barnett@villanova.edu

†Department of Economics, Iowa State University, Ames IA 50011-1070. Phone: (515) 294 5886; E-mail: joydeep@iastate.edu

“Life can only be understood backwards, but it must be lived forward”

— *Soren Kierkegaard*

1. INTRODUCTION

There was a time when “children were seen but not heard”. Nowadays, not only are they seen and heard – they are emulated. Rejuvenile is a term coined by Christopher Noxon (2006) to describe “adults dedicated to indulging their inner child.” In her review in the *Wall Street Journal*, Gurdon (2006) goes further to describe rejuveniles as “[This] curious modern hybrid, adult in physique yet deliberately madcap and childlike in tastes, habits,...”¹ In this paper, we study a neoclassical world populated by overlapping generations of rejuveniles and seek to understand the impact of such preferences on economic growth. For our purposes, rejuveniles are old agents who derive utility from “keeping up” their consumption with that of the current young.²

Lately there has been some interest in dynamic macroeconomic models featuring “extended” preferences that deviate from the standard additive, time-separable, homothetic utility – the most notable being those that incorporate a minimum consumption requirement, habit persistence, or ‘keeping up with the Joneses’.³ This paper fits into this larger literature because it explores a consumption externality similar in spirit to the aforementioned, except for the fact that the externality studied here is *cross generational*. In fact, one can reinterpret the preferences studied in this paper as representing minimum consumption requirements imposed by the consumption patterns of generations other than

¹Noxon (2003) provides more context. “Evidence of their presence is widespread. According to Nielsen Media research, more adults 18 to 49 watch the Cartoon Network than watch CNN. More than 35 million people have caught up with long-lost school pals on the Web site Classmates.com. (“There’s something about signing on to Classmates.com that makes you feel 16 again,” the “60 Minutes II” correspondent Vicki Mabrey reported.) Fuzzy pajamas with attached feet come in adult sizes at Target, along with Scoobie Doo underpants. The average age of video game players is now 29, up from 18 in 1990, according to the Entertainment Software Association. Hello Kitty’s cartoon face graces toasters. Sea Monkeys come in an executive set....And then there is Harry Potter, whose cross-generational popularity prompted the British publisher Bloomsbury to release an edition of the books with so-called grown-up covers.”

²Then there are people who match their consumption with that of the young by association. For example, there are 60 million grandparents in the United States – 72% of everyone over 50 in the US is a grandparent. Grandparents spend time and money with their grandchildren – over \$30 billion in annual spending. Research shows that going out to a restaurant and watching television together are the activities grandparents and grandkids do most.

³Alvarez-Cuadado, Monteiro, and Turnovsky (2004) contain a nice discussion of the empirical underpinnings of departures from time-separability.

one's own, a keeping up with the senior and junior Joneses, if you will.

More generally, we assume that an agent wishes to “keep up” her consumption with the rest of the population that is alive at the time, young and old alike. Within this “peer group”, we allow some members to have more influence than others. For example, it may be that when young, the agent wishes to keep her consumption more closely paced with members of her own cohort, rather than cohorts of the previous generation. When old, her consumption may be more heavily influenced by cohorts of the current, young generation (in which case, she would exhibit strong rejuvenile behavior).⁴

In Section 2, we embed these extended preferences into a standard *AK* model of growth. In Section 3, we find that the long run growth rate is higher in the presence of rejuveniles when compared to the benchmark economy (one with no minimum consumption requirements of any kind). Intuitively, for the old to keep up with the consumption of the young, the old would have had to save adequately in the past, and it is this forward-looking thriftiness that fosters growth. We also find that keeping up when young hurts growth.

Curiously enough, we also find that the model with rejuveniles has the potential to generate interesting dynamics in the growth rate, including *growth cycles*. The presence of the agent's own cohort in her peer group does not seem to matter much here – what does matter, and what sets our formulation apart from other papers looking at minimum consumption requirements, is the fact that we allow another generation to influence the agent's consumption decision – in this case, the old (when the agent is young) and youth (when the agent is old). Indeed, in the absence of rejuveniles, the economy at hand does not generate any growth fluctuations. The upshot is that rejuveniles raise the long run growth rate but their presence may also expose the economy to endogenous growth fluctuations.

In Section 4, we go on to study several other ways of introducing minimum consumption

⁴After reading footnote 1 - especially the example of the pajamas - one may come away with the impression that rejuvenile behavior in grown-ups is more a story of the type of consumption, not the amount (as is modeled in this paper). While the consumption of certain types of goods may be useful in identifying rejuveniles, the essential ingredient of this behavior is the influence of youth consumption on the consumption decisions of older members of society, which is captured in our one-good economy model. Moreover, it is not at all clear that a distinction between type versus quantity makes much of a difference here. It is possible to construct a simple alternative model to ours with two goods, one of which is considered a ‘youth good’ simply by the fact that adults consume it only to satisfy the desire to keep up with youth consumption. If the cost of producing this youth good (in terms of the other good) is constant, most of our results - especially those regarding economic growth - will hold up under this alternative framework. Alternatively, one can reinterpret the pajama example as one where grown-ups have their own (traditional) pajamas, but choose to acquire *additional* units of fuzzy pajamas with attached feet. What really matters is the *consumption externality* that exists between the generations.

requirements, such as: a) minimum consumption requirements that keep up with the level of development of the economy, b) keeping up with one's own past consumption (aka, habit persistence), and c) keeping up with one's parents consumption at parallel points in the lifecycle (bequeathed tastes). Interestingly, *none* of these preferences can generate any form of endogenous growth fluctuations within our *AK* model framework.⁵

Our work is in line with the recent paper by Alvarez-Cuadado, Monteiro, and Turnovsky (2004) who study alternative preference formulations (habit formation, keeping up with the Joneses) within the context of a continuous time, infinitely-lived agent framework with a neoclassical production function. Our results are not strictly comparable given our overlapping generations structure; especially, their framework is not suited to study the cross generational keeping up preferences that is our focus. Additionally, while the generation of growth cycles is our focus, it is not theirs.⁶

Our paper also relates to a part of a larger literature studying growth cycles (as opposed to periodicity in levels) in real neoclassical economies. To the best of our knowledge, all models to date that generate growth cycles are *technology* not preference driven (see, for example, Matsuyama (1999) or Walde (2005)). Our result on the existence of periodic growth equilibria is of some independent interest. There is a vast literature studying the possibility of periodic (even chaotic) equilibria in general equilibrium growth models, especially in overlapping generations models. Most of that literature is concerned with studying *nominal* cycles (i.e., fluctuations in price *levels*).⁷ The rest of the literature has focused on studying real cycles in the levels of the capital stock or output. As is well-known in that literature, complex dynamics (such as periodic equilibria) can emerge under assumptions such as limited market participation, imperfect competition, and multiple sectors. Additionally, as discussed in Azariadis (1993), a sufficiently strong income effect can cause savings to decline with an increase in the interest rate, creating a “backward-

⁵This last point deserves further attention. de la Croix and Michel (1999, 2002) show that endogenous cycles in output *levels* are possible in a standard overlapping generations growth model with bequeathed tastes. Their result turns on the fact that the spillover effect from the old to the young has two components, one based on the production process which displays diminishing returns to the capital stock, the other on inherited standard-of-living aspirations, or bequeathed tastes, which has constant returns. As we show in Section 4, this result fails to carry over to cycles in growth rates in our framework, due to the *AK* technology.

⁶Alonso-Carrera, Caballé, and Raurich (2005) study the efficiency properties of the steady state in the standard infinitely-lived neoclassical model under alternative formulations of habit formation.

⁷See Grandmont (1985), Smith (1991), Bhattacharya and Russell (2003), or more recently, Bunzel (2006) and Koskela and Puhakka (2006).

bending” savings function that can produce complex dynamics in overlapping generations models. In our model, periodic equilibria in the *real growth rate* emerge in a relatively standard economy; indeed, absent our assumptions on preferences (especially the presence of juveniles), our model economy would not produce endogenous fluctuations of any kind. Thus, ours is not *yet* another paper demonstrating the presence of complex dynamics in overlapping generation growth models. Our novelty lies in our ability to a) generate real growth cycles that are preference not technology driven, and b) to show that such growth cycles are not possible with almost any other kind of keeping up preferences.

2. The Model

We analyze a production economy inhabited by an infinite sequence of two-period lived overlapping generations, plus an initial old generation. At each date, $t = 1, 2, 3, \dots$, a new generation is born, consisting of a continuum of agents with mass 1. Each agent is endowed with one unit of time when young and is retired when old. Agents do not value leisure, so the allocation of work-time equals the time endowment of 1. In addition, each initial old agent is endowed with $k_1 > 0$ units of capital.

There is a single final good produced using a production function $F(K_t, L_t)$ where K_t denotes the capital input and L_t denotes the labor input at t . Let $k_t \equiv K_t/L_t$ denote the capital-labor ratio (capital per young agent). Output per young agent at time t may be expressed as $f(k_t)$ where $f(k_t) \equiv F(K_t/L_t, 1)$ is the intensive production function. The final good can either be consumed in the period it is produced, or it can be stored to yield capital the following period. For reasons of analytical tractability, capital is assumed to depreciate 100% between periods.

We assume a standard Ak model with a Romer-style externality, where $\alpha(1-\alpha)$ denotes capital’s (labor’s) share of output. Specifically, we assume $Y_t^i = A\bar{K}_t^\beta (K_t^i)^\alpha (L_t^i)^{1-\alpha}$ where i indexes a firm among a continuum of firms of unit measure, and $\bar{K}$ denotes the average of all K^i s. Firms in the economy are competitive and factors are paid their marginal product. Let w denote the wage and R denote the gross interest rate. If one assumes that firms are all identical, $L_t^i = 1$, and $\beta = 1 - \alpha$, then it follows that

$$w(k) = (1 - \alpha)Ak$$

and

$$R = \alpha A.$$

We now define cross-generational keeping-up preferences. We assume that agents have preferences represented by the atemporal utility function $U(c_t, x_t)$ defined as

$$U(c_t, x_t) \equiv \frac{(c_t - \theta_t)^{1-\sigma}}{1-\sigma} + \frac{\beta (x_t - \delta_t)^{1-\sigma}}{1-\sigma}, \quad \sigma > 0, \theta_t \geq 0, \delta_t \geq 0, t \geq 1 \quad (1)$$

where c_t (x_t) is the consumption of an agent of generation t when young (old) and θ_t (δ_t) represents the minimum consumption requirement the agent faces when young (old). Peeking inside the consumption floors θ and δ , we posit that

$$\theta_t \equiv (\theta_y \bar{c}_t + \theta_o \bar{x}_{t-1}),$$

and

$$\delta_t \equiv (\delta_y \bar{c}_{t+1} + \delta_o \bar{x}_t).$$

Here, variables with “bars” represent average levels of consumption, taken as parametric by the agent. For example, $\bar{c}_t$ represents the average level of consumption of the agent’s generational cohorts when she is young. [Of course, in equilibrium, $c_t = \bar{c}_t$ and $x_t = \bar{x}_t$ will hold]. θ_y and θ_o represent scalars capturing the strength of the influence of the current youth and current old’s consumption, respectively, on the minimum consumption requirement of the agent when young. Similarly, δ_y and δ_o represent scalars capturing the strength of the influence of the current youth and current old’s consumption, respectively, on the minimum consumption requirement of the agent when old. Within the context of these preferences, rejuvenile-like behavior is associated with $\delta_y > 0$.

What sets our formulation apart from other papers looking at minimum consumption requirements is the fact that we allow a generation other than one’s own to influence the agent’s consumption decision – in this case, the old (when the agent is young) and youth (when the agent is old), and this pattern of influence may change over the agent’s life. For example, consumption in an economy is dominantly “youth driven” if both $\theta_y > \theta_o$ and $\delta_y > \delta_o$.

From our specification in (1), it is clear we must assume that

$$c_t \geq \theta_t \tag{2}$$

and

$$x_t \geq \delta_t. \tag{3}$$

holds in what follows.

Given the capital stock k_t and taking everyone else's consumption as given, the agent's choices for c_t , x_t , and k_{t+1} conform to the following budget constraints:

$$c_t + k_{t+1} \leq (1 - \alpha)Ak_t \tag{4}$$

$$x_t \leq \alpha Ak_{t+1}, \tag{5}$$

where we have incorporated in (4) and (5) the assumption that date t output $y_t = Ak_t$. An agent's problem is to maximize (1) subject to (4) and (5). Furthermore, her optimal choices for c_t , x_t , and k_{t+1} all have to be positive.

The first-order conditions for the agent's optimization problem are summarized by the following equation:

$$\frac{x_t - \delta_t}{c_t - \theta_t} = z, \tag{6}$$

where $z \equiv (\beta\alpha A)^{1/\sigma}$.

In the benchmark case, we set $\delta_t = \theta_t = 0$. Employing the two budget constraints (4) and (5) with equality, we can rewrite (6) as

$$\frac{\alpha Ak_{t+1}}{(1 - \alpha) Ak_t - k_{t+1}} = z.$$

Dividing the numerator and denominator of the left-hand side by k_t , we have:

$$\frac{\alpha A \gamma_t}{(1 - \alpha) A - \gamma_t} = z, \tag{7}$$

where $\gamma_t \equiv y_{t+1}/y_t = k_{t+1}/k_t$ is the growth rate in output at date t . Solving for γ_t , we obtain our benchmark growth rate, γ_{bm} :

$$\gamma_{bm} = \frac{(1 - \alpha) Az}{\alpha A + z}. \tag{8}$$

Equation (6) for our specific formulation of minimum consumption requirements is

$$\frac{x_t - (\delta_y \bar{c}_{t+1} + \delta_o) \bar{x}_t}{c_t - (\theta_y \bar{c}_t + \theta_o \bar{x}_{t-1})} = z,$$

which after incorporating the definitions of the variables with bars, may be rewritten as

$$\frac{(1 - \delta_o) x_t - \delta_y c_{t+1}}{(1 - \theta_y) c_t - \theta_o x_{t-1}} = z. \quad (9)$$

From the budget constraints (4) and (5), and (9), we write for $t \geq 1$,

$$\frac{(1 - \delta_o) \alpha A k_{t+1} - \delta_y ((1 - \alpha) A k_{t+1} - k_{t+2})}{(1 - \theta_y) ((1 - \alpha) A k_t - k_{t+1}) - \theta_o \alpha A k_t} = z. \quad (10)$$

where we have incorporated the budget constraint for the initial old, $x_0 = \alpha A k_1$, in (9) for $t = 1$. As is evident, this is a second-order nonlinear difference equation in k with a single initial condition k_1 .

Dividing the numerator and denominator by k_t , we express this condition, for $t \geq 1$, in growth rates:

$$\frac{\gamma_t [(1 - \delta_o) \alpha A - \delta_y ((1 - \alpha) A - \gamma_{t+1})]}{(1 - \theta_y) ((1 - \alpha) A - \gamma_t) - \theta_o \alpha A} = z. \quad (11)$$

What is interesting about (11) is the presence of the future growth rate γ_{t+1} . The agent's belief about the consumption decisions of the future generation impact on consumption and saving decisions of the agent when young. It is by this mechanism that 'keeping up' has the potential to generate equilibrium cycles in *growth rates*. Note that if youth has no influence on the agent's consumption decision when old ($\delta_y = 0$), i.e., no one is a rejuvenile, the future growth rate drops out of (11), and has no impact on the current growth rate γ_t . More generally, it is the presence of rejuveniles that generates transitional dynamics in this model.

Solving (11) for γ_{t+1} (assuming $\delta_y > 0$) yields the difference equation, for $t \geq 1$,

$$\gamma_{t+1} = \frac{z [(1 - \theta_y) (1 - \alpha) A - \theta_o \alpha A] + \gamma_t [\delta_y (1 - \alpha) A - (1 - \delta_o) \alpha A - z (1 - \theta_y)]}{\delta_y \gamma_t}. \quad (12)$$

A dynamic growth equilibrium for this economy is represented by a sequence of positive growth rates given by $\{\gamma_t\}_{t=1}^{\infty}$, $\gamma_t \geq 0$, which satisfies (12). Any equilibrium path is indexed by an initial growth rate γ_1 which is not pinned down by the model, consistent with the fact that (10) is a second-order difference equation in k with only one initial condition k_1 .

3. Characterizing Equilibria

3.1. Existence. Our minimum consumption requirements (2) and (3) place restrictions on the magnitude of the primitives of the model. These are summarized by

Assumption 1 $(1 - \alpha)(1 - \theta_y) > \alpha\theta_o$.

Assumption 2 $(1 - \delta_o)(1 - \theta_y) > \delta_y\theta_o$.

Note both assumptions place the restriction that the influence on the consumption decision of an agent's own peer group cannot be too great, i.e., $\theta_y, \delta_o < 1$.

The constraint (2) requires

$$\begin{aligned} (1 - \theta_y) c_t &\geq \theta_o \bar{x}_{t-1} \Leftrightarrow (1 - \theta_y) ((1 - \alpha) A k_t - k_{t+1}) \geq \theta_o \alpha A k_t \\ &\Leftrightarrow [(1 - \theta_y)(1 - \alpha) - \alpha\theta_o] A k_t \geq (1 - \theta_y) k_{t+1} \end{aligned}$$

and since $k_{t+1} > 0$, we require Assumption 1. This assumption also restricts the growth rate, in the first instance, to be no greater than $\bar{\gamma}$, where $\bar{\gamma} \equiv (1 - \alpha) A - \frac{\alpha A \theta_o}{1 - \theta_y}$.

Examining (11), we see the model also places the restriction that the growth rate must be greater than $\underline{\gamma}$, where $\underline{\gamma} \equiv \max \{0, (1 - \alpha) A - \alpha A (1 - \delta_o) / \delta_y\}$, for otherwise, the numerator in (11) is negative while the denominator is positive. (This condition also follows from (3)). Assumption 2 ensures $\underline{\gamma} < \bar{\gamma}$. Hence, a valid equilibrium growth sequence $\{\gamma_t\}_{t=1}^{\infty}$ defined by (12) additionally requires $\underline{\gamma} < \gamma_t < \bar{\gamma}$ for $t \geq 1$.

Let $h(\gamma_t)$ denote the function described by the right-hand side of (12). Given Assumptions 1 and 2, $h(\cdot)$ has the following properties:⁸

P-1 $h'(\gamma_t) < 0$ and $h''(\gamma_t) > 0$ over the interval $(\underline{\gamma}, \bar{\gamma})$.

P-2 $h(\underline{\gamma}) > \underline{\gamma}$ and $h(\bar{\gamma}) < \bar{\gamma}$.

Together, P-1 and P-2 ensure a *unique steady-state* growth rate (denoted γ^*) exists for all dates $t \geq 1$. It is easy to verify using (12) that at a steady state γ^* ,

$$\gamma^* = \frac{a}{\gamma^*} + b \tag{13}$$

⁸Condition P-1 can be verified directly by inspection of the right-hand side of (12). Condition P-2 is verified in the Appendix.

holds where

$$\begin{aligned} a &\equiv \frac{z[(1-\theta_y)(1-\alpha)A - \theta_o\alpha A]}{\delta_y} \\ b &\equiv \frac{[\delta_y(1-\alpha)A - (1-\delta_o)\alpha A - z(1-\theta_y)]}{\delta_y}. \end{aligned} \quad (14)$$

Solving (13) yields $\gamma^* = \frac{1}{2}b \pm \frac{1}{2}\sqrt{4a+b^2}$ where the root, $\frac{1}{2}b - \frac{1}{2}\sqrt{4a+b^2}$, is negative and hence economically invalid.

Properties P-1 and P-2 are not sufficient, however, to ensure $h(\cdot)$ maps into $[\underline{\gamma}, \bar{\gamma}]$, whereby a valid equilibrium sequence $\{\gamma_t\}_{t=1}^{\infty}$ obtains for *any* initial $\gamma_1 \in [\underline{\gamma}, \bar{\gamma}]$. This requires

Assumption 3 $(\delta_y(1-\alpha) - \alpha(1-\delta_o))A \geq (1-\theta_y)z$.

Note that Assumption 3 implies $\underline{\gamma} = (1-\alpha)A - \alpha A(1-\delta_o)/\delta_y$. These assumptions also yield the properties

P-3 $0 > h'(\gamma^*) \geq -1$

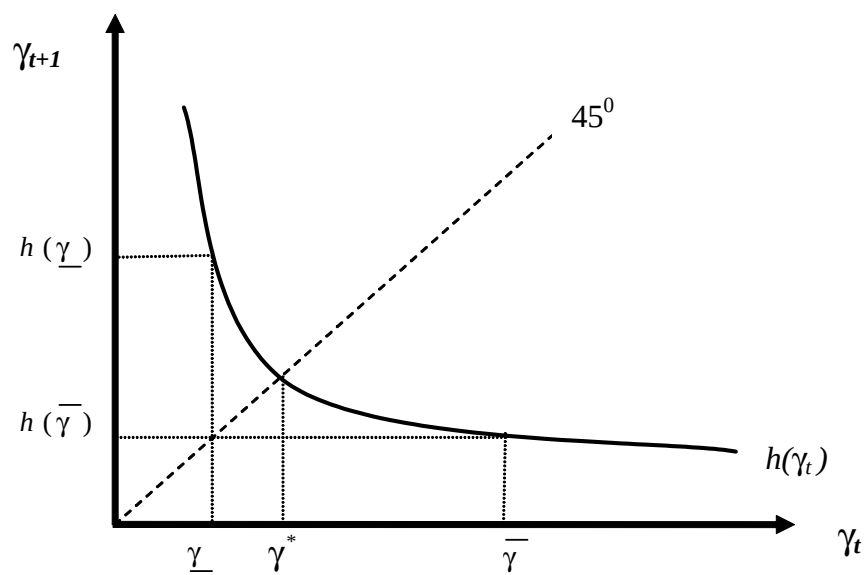
P-4 $\underline{\gamma} \leq h(\bar{\gamma})$ and $h(\underline{\gamma}) \leq \bar{\gamma}$,

which ensures $h(\cdot)$ maps into $[\underline{\gamma}, \bar{\gamma}]$.⁹

The above discussion is summarized pictorially in Figure 1 below. The upshot is that under Assumptions 1-3, the law of motion for the equilibrium growth rate is downward sloping and that there is a unique stationary growth rate. When $0 > h'(\gamma^*) > -1$ holds, the system displays indeterminacy since numerous equilibrium growth paths starting from any valid γ_1 oscillate but eventually converge to γ^* .

3.2. Comparative Statics. In this subsection, we address two related issues: i) how does ‘keeping up’ affect the steady-state growth rate, and ii) how steady-state growth in this model compares with the benchmark growth rate γ_{bm} , that is, growth in a model where $\theta_t = \delta_t = 0$.

⁹It is important to note here that if Assumption 3 is violated, Property 3 does not obtain and then a) periodic orbits are not possible, and b) there may be undamped oscillation in γ that eventually takes it beyond the valid interval $[\underline{\gamma}, \bar{\gamma}]$.

Figure 1: The mapping $h(\cdot)$

Proposition 1 *‘Keeping up’ when young lowers the steady-state growth rate; ‘keeping up’ when old raises the growth rate.*

A formal proof of Proposition 1, provided in the Appendix, involves describing how the curve in Figure 1 will shift with a change in one of the four keeping up parameters, θ_i, δ_i , $i = y, o$. The intuition behind this proposition, however, is simple. A greater value for either keeping up parameter (θ_y or θ_o) requires the agent, when young, to devote more of her wage income to current consumption and less to saving. This in turn leads to a lower growth rate. On the other hand, the greater the keeping up parameters δ_y, δ_o , the more the agent saves in order to meet the greater consumption commitment when old, which increases the growth rate. Rejuvenile behavior actually contributes to greater economic growth; after all, for the old to keep up with the consumption of the young, the old would have had to save adequately in the past and it is this forward-looking thriftiness that fosters growth.

Given the ambiguous way in which keeping up, in general, affects growth, it would seem that the steady-state growth rate in this model may be either greater or less than the benchmark growth γ_{bm} . However, with Assumption 3, we have:

Proposition 2 *If $\theta_y < \delta_o$, the steady-state growth rate in this model is greater than in the benchmark case, $(1 - \alpha)Az / (\alpha A + z)$.*

The condition $\theta_y < \delta_o$, along with Assumption 3, implies $\gamma_{bm} < h(\bar{\gamma})$. Since $h(\gamma_t) > h(\bar{\gamma})$ for all $\gamma_t \in [\underline{\gamma}, \bar{\gamma}]$, the proposition is true.

Having explored the properties of the steady state growth rate, we now move on to study the dynamics of the growth rate. We are particularly interested in the possibility that the growth rate may exhibit endogenous cyclical fluctuations. From P-1, we know that in the presence of rejuveniles ($\delta_y > 0$), the law of motion $h(\cdot)$ is negatively sloped everywhere suggesting the possibility of such fluctuations near the steady state. We address this potential next.

3.3. Cycles. Heuristically, we can describe the possibility of growth cycles as follows. Suppose the young at date t believe that when they are old, the young at $t + 1$ will have fairly low levels of consumption (i.e., they save a lot and the growth rate γ_{t+1} is high).

This will imply ‘keeping up’ with the young at $t + 1$ will not require a large amount of savings on the part of the young at date t – hence they consume more when young and the growth rate γ_t is low. But what makes the young choose to save more at $t + 1$? If the young at date $t + 2$ face a similar prospective future as the young at t , they will choose a high level of consumption, thereby making ‘keeping up’ more difficult for the old at $t + 2$ (the young at $t + 1$), which is countered by greater saving by the young at date $t + 1$.

It is convenient, for our purposes here, to rewrite the law-of-motion (12). Let γ^* denote the steady-state of (12), and let $\Gamma \equiv h'(\gamma^*) < 0$ (see P-2). We can then write (see the Appendix)

$$\gamma_{t+1} = (1 + \Gamma) \gamma^* - \frac{(\gamma^*)^2 \Gamma}{\gamma_t}. \quad (15)$$

Equation (15) can be used to characterize 2-period flip cycles.

Let γ_o (γ_e) denote the growth rate at odd (even) dates, respectively. In a 2-period cycle, we then have

$$\begin{aligned} \gamma_e \gamma_o &= (1 + \Gamma) \gamma^* \gamma_o - (\gamma^*)^2 \Gamma \\ \gamma_e \gamma_o &= (1 + \Gamma) \gamma^* \gamma_e - (\gamma^*)^2 \Gamma \end{aligned} \quad (16)$$

A trivial solution to (16), of course, is $\gamma_e = \gamma_o = \gamma^*$, the 1-cycle or the steady state. However, we seek solutions to (16) with $\gamma_o \neq \gamma_e$.

Proposition 3 *Any 2 period cycle must satisfy $\Gamma = -1$.*

We provide two examples of 2-period cycles below.

Example 1 *Let $\alpha = 1/3$, $\beta = 1$, $\sigma = 2/3$, $A = 3$, $\theta_y = 2/3$, $\theta_o = 0$, $\delta_y = 1/3$, $\delta_o = 2/3$.*

In this case, the steady-state growth rate $\gamma^ = \sqrt{2}$. An example of an equilibrium with 2-cycles is summarized by the pair $(\gamma_o, \gamma_e) = (5/3, 1.20)$.*

Example 2 (Youth Driven Consumption) *Retain the same parameter values as above except for δ_y and δ_o . Let $\delta_y = 1/2$ and $\delta_o = 1/3$. The steady-state growth rate $\gamma^* = 2/\sqrt{3}$. An example of a 2-cycle equilibrium pair is $(\gamma_o, \gamma_e) = (4/3, 1)$.*

Examining (12) and (15) reveals that $\Gamma = -1$ when b , in (14), equals zero. This in turn implies 2-period flip cycles are possible whenever the parameters δ_y , δ_o , and θ_y satisfy

$$\delta_y (1 - \alpha) A - (1 - \delta_o) \alpha A = z (1 - \theta_y). \quad (17)$$

The parameter values of the two examples above were selected to conform to this condition.

By a similar construction, using (15), it is easy to show that cycles of higher periodicity are not possible. These results are summarized in the following proposition.

Proposition 4 *Cycles exist only in the case where $\Gamma = -1$ (see (17)) and in that instance, the only out of steady state equilibria that exist, exhibit cycles of periodicity two.*

4. ALTERNATIVE FORMS OF ‘KEEPING UP’ PREFERENCES

Part of our interest in studying these preferences was to identify whether endogenous fluctuations in growth rates could arise purely from preferences. Recall that a necessary condition for any kind of volatility in growth rates is that the law of motion for growth not be positively sloped everywhere. One thing we know for sure is that the benchmark model (with $\theta = \delta = 0$) will not deliver growth cycles. We also now know that in the presence of juveniles, flip growth cycles are possible. Phrased differently, then, our issue becomes: can alternative reasonable specifications of keeping up preferences produce a (somewhere) negatively sloped law of motion?

We identify three popular alternatives found in the literature: i) keeping up with a consumption minimum defined as a function of current output (used most recently in Alvarez and Diaz, 2005), ii) keeping up with a standard of living established by one’s parents (also known as generational keeping up, used in de la Croix and Michel, 2002), and iii) keeping up with one’s past consumption (also known, simply as habit formation, used for example in Alessei and Lusardi, 1997, or Bunzel, 2006). We discuss briefly how each of these alternatives would work in our current framework.

4.1. Consumption Minimum as a Function of Current Output. One popular form of ‘keeping up’, intended to mimic a ‘keeping up with the Joneses’ argument assumes that agents desire to keep up with a consumption minimum defined as a function of current output. Often this consumption minimum is interpreted as a time-evolving poverty line.

In this formulation, $\theta_t = \theta y_t$ and $\delta_t = \delta y_{t+1}$, with $1 - \alpha > \theta$ and $\alpha > \delta$. Constraints (2) and (3) are replaced with

$$\begin{aligned} c_t &\geq \theta y_t \\ x_t &\geq \delta y_{t+1} \end{aligned}$$

The marginal conditions for the agent's problem, with the changes indicated above, can be summarized by (6). The counterpart to (11) is

$$\frac{\alpha A k_{t+1} - \delta A k_{t+1}}{((1 - \alpha) A k_t - k_{t+1}) - \theta A k_t} = z,$$

which reduces to

$$\frac{(\alpha - \delta) A \gamma_t}{(1 - \alpha) A - \gamma_t - \theta A} = z. \quad (18)$$

Solving for the growth rate, one gets

$$\gamma_t = \frac{Az(1 - \alpha - \theta)}{(\alpha - \delta)A + z},$$

for all $t \geq 1$ and hence it is clear that no fluctuations in growth rates are possible here. Here too the stationary growth rate may be greater or less than baseline γ_{bm} ; the difference, $\gamma_t - \gamma_{bm}$ is

$$-\frac{zA[(\alpha A + z)\theta - \delta(1 - \alpha)A]}{(\alpha A + z)((\alpha - \delta)A + z)},$$

which is greater than or less than 0 depending on whether $\delta(1 - \alpha)A \gtrless (\alpha A + z)\theta$.

4.2. Bequeathed tastes. The overlapping generations framework allows us to consider the possibility that parents may, in part, shape the consumption decisions of their offspring. de la Croix and Michel (2002) consider such ‘keeping up’ effects in a neoclassical growth model. These sorts of preferences can generate cycles in *levels*. We briefly describe here how they would work in a model with Ak technology and *growth rates*.¹⁰

We assume the agent's utility depends on how much her own consumption differs from the consumption of her parents (denoted c_{t-1} and x_{t-1} above and taken as given by the

¹⁰Our discussion here is somewhat broader as we allow the parent's consumption when young and old to affect the child's utility both when young *and* old, while de la Croix and Michel (2002) assume the parent's consumption directly only affects the child's utility when young.

agent) at *parallel* points in their life. The parameters θ and δ determine how much weight the agent places on ‘keeping up’ in each stage in life. We replace (2) and (3) with

$$\begin{aligned} c_t &\geq \theta c_{t-1} \\ x_t &\geq \delta x_{t-1} \end{aligned}$$

Like our framework with juveniles, bequeathed tastes introduce a time dynamic in the equation for the equilibrium growth rate. The first order conditions for the agents’ problem for dates $t \geq 1$ can be summarized by (6), with $\theta_t = \theta c_{t-1}$ and $\delta_t = \delta x_{t-1}$. The counterpart to (11) for dates $t \geq 2$ is

$$\frac{\alpha A k_{t+1} - \delta \alpha A k_t}{(1 - \alpha) A k_t - k_{t+1} - \theta [(1 - \alpha) A k_{t-1} - k_t]} = z,$$

which readily reduces to

$$\frac{\alpha A \gamma_t \gamma_{t-1} - \delta \alpha A \gamma_{t-1}}{(1 - \alpha) A \gamma_{t-1} - \gamma_t \gamma_{t-1} - \theta [(1 - \alpha) A - \gamma_{t-1}]} = z. \quad (19)$$

This yields the law-of-motion for the growth rate γ_t for dates $t \geq 2$ as follows:

$$\gamma_t = \gamma_{bm} + \frac{\delta \alpha A + \theta z}{\alpha A + z} - \frac{\theta (1 - \alpha) A z}{(\alpha A + z) \gamma_{t-1}} \equiv H(\gamma_{t-1}) \quad (20)$$

A quick examination of equation (20) reveals that $H'(\gamma_{t-1}) \geq 0$ implying that bequeathed tastes cannot generate endogenous fluctuations in the growth rate.

Unlike in the juvenile formulation above, however, the initial growth rate γ_1 is not indeterminate. For date $t = 1$, the marginal conditions can be summarized by

$$\frac{\alpha A k_2 - \delta \alpha A k_1}{(1 - \alpha) A k_1 - k_2 - \theta c_0} = z,$$

where k_1 and c_0 are given. Dividing the numerator and denominator by k_1 yields

$$\gamma_1 = \frac{\delta \alpha A + (1 - \alpha) A z - z \theta c_0 / k_1}{\alpha A + z}$$

or

$$\gamma_1 = \gamma_{bm} + \frac{\delta \alpha A - z \theta c_0 / k_1}{\alpha A + z}$$

Although c_0 and k_1 are given at date 1, they presumably are selected together and satisfy a budget constraint similar to (4) and (5). Let $c_0 = (1 - \alpha) A k_0 - k_1$, where k_0 is

given. Substituting in expression above, and dividing the numerator and denominator by k_1 , we have

$$\gamma_1 = \gamma_{bm} + \frac{\delta \alpha A + z \theta}{\alpha A + z} - \frac{\theta (1 - \alpha) A z}{(\alpha A + z) \gamma_0}.$$

which is of the same form as (20).

4.3. Habit Formation. In this formulation, we set $\theta_t = 0$ in (2) and replace δ_t in (3) with

$$x_t \geq \delta c_t.$$

Unlike the form of ‘keeping up’ presented in the previous sections and the other two alternatives listed above, the agent, when young, will *internalize* this minimum requirement when selecting c_t . The counterpart to (6) in this case is:

$$\frac{(x_t - \delta c_t)}{c_t} = \tilde{z}, \quad (21)$$

where $\tilde{z} \equiv (\beta (\alpha A + \delta))^{1/\sigma}$. Incorporating the budget constraints (4) and (5) into this expression, we derive the counterpoint to (11) as

$$\frac{(\alpha A k_{t+1} - \delta ((1 - \alpha) A k_t - k_{t+1}))}{(1 - \alpha) A k_t - k_{t+1}} = \tilde{z},$$

which reduces to

$$\frac{(\alpha A \gamma_t - \delta ((1 - \alpha) A - \gamma_t))}{(1 - \alpha) A - \gamma_t} = \tilde{z}. \quad (22)$$

The growth rate in this economy is constant for all $t \geq 1$ (hence no possibility of endogenous fluctuations) and satisfies:

$$\gamma_t = \frac{\tilde{z} (1 - \alpha) A}{\alpha A + \tilde{z}}.$$

Comparing this solution with the baseline growth rate γ_{bm} is easy since it is in a form similar to the baseline with $\tilde{z}$ replacing z . Since the baseline is increasing in z , and since $\tilde{z} > z$, it follows that the growth rate here is greater than baseline. This of course makes perfect sense and is consistent with the general finding in our ‘keeping up’ formulation: the habit formation parameter motivates the agent to find ways to increase her consumption when old - the way to do this is increase saving when young, which leads to a higher growth rate.

5. CONCLUSION

Real growth cycles (cycles in the growth rate of real per capita income) are observed in almost every country around the world. Economists have sought to generate these cycles within the neoclassical paradigm. Toward that end, they have relied on changing the formulation of technology away from the usual neoclassical textbook specifications. In this note, we ask the question: Can a simple change in preferences deliver growth cycles? The only preference structure that seems to have the potential to generate such cycles is one where agents face minimum consumption requirements imposed by the consumption patterns of generations other than one's own. We define juveniles as old agents who derive utility from "keeping up" their consumption with some measure of the consumption of the current young. We show that juveniles raise the long run growth rate but their presence may also expose the economy to endogenous growth fluctuations that were impossible in their absence.

Two important sets of issues deserve at least a mention here. First, in a recent paper by Carrera et.al (2007), it is shown that while habit formation style preferences reduce the likelihood of an operative bequest motive, a consumption externality from parents to children (a keeping up with one's parents style "aspirational" preference) increases the same likelihood. As Carrera et.al (2007) point out, operative bequests are associated with Ricardian equivalence since generations that receive tax cuts with no change in government spending will leave adequate bequests to neutralize the effects of an eventual tax hike on their progeny. It appears to be a non-trivial extension to our current setup to include a bequest motive that operates alongside the cross generational consumption externalities already present. In such an environment, one can conjecture that the old may find it more onerous to keep up with a generation of young whose standard of living has been raised by inheritances from the old themselves! If this is true, then it seems plausible that the likelihood of an operative bequest motive would go down, raising the possibility that tax cuts would not stay generationally neutral.

Second, in an important paper by Artige et.al (2004), an effort is made to develop a theory of endogenous growth with alternating primacy and decline consistent with the historical experience of many countries and based on the notion of a consumption externality from parents to children. Operating in tandem with these aspiration-driven preferences

is a warm glow that parents feel from incurring education expenses on their children. As the authors articulate so clearly: “At some point in a development process, the young generation of the richer region develops living standards that are incompatible with the necessary investment in knowledge to remain the leader. This reduces the growth rate in comparison with the other region.” In this vein, one can ask if our setup with rejuvenile preferences has anything to add to this literature. In particular, an interesting question for future research would be to figure out parameter restrictions on the size of the cross generational externalities which generate or rule out the patterns of overtaking, alternating primacy, irreversible decline, and monotonic convergence.

Appendix

1. Proof of P-2 Suppose $\underline{\gamma} = (1 - \alpha) A - \alpha A (1 - \delta_o) / \delta_y$. The difference $h(\underline{\gamma}) - \underline{\gamma}$ can be written as:

$$h(\underline{\gamma}) - \underline{\gamma} = \frac{\alpha z [(1 - \theta_y) - (1 - \theta_y) \delta_o - \theta_o \delta_y]}{\delta_y [(1 - \alpha) \delta_y + \alpha \delta_o - \alpha]}.$$

The numerator of this difference is positive, by Assumption 2. The assumption that $(1 - \alpha) A - \alpha A (1 - \delta_o) / \delta_y > 0$ ensures that the denominator is also positive; hence, $h(\underline{\gamma}) > \underline{\gamma}$.

If $(1 - \alpha) A - \alpha A (1 - \delta_o) / \delta_y < 0$, $\underline{\gamma} = 0$. Since $\lim_{\gamma \rightarrow 0} h(\gamma) = \infty$, the result $h(\underline{\gamma}) > \underline{\gamma}$ holds.

At $\gamma = \bar{\gamma}$,

$$\bar{\gamma} - h(\bar{\gamma}) = \frac{\alpha A [(1 - \theta_y) (1 - \delta_o) - \delta_y \theta_o]}{\delta_y (1 - \theta_y)},$$

which is positive, by Assumption 2.

2. Proof of P-3 We have:

$$h'(\gamma_t) = \frac{-[A(1 - \theta_y)(1 - \alpha) - \alpha A \theta_o] z}{\delta_y \gamma_t^2},$$

which can be written as

$$h'(\gamma_t) = \frac{-a}{\gamma_t^2}$$

where a is defined in (14). When Assumption 3 holds with equality, b , in (14), equals zero and $\gamma^* = \sqrt{a}$, so $h'(\gamma^*) = -1$. When Assumption 3 holds with strict inequality, $b > 0$ and $\gamma^* > \sqrt{a}$, hence $h'(\gamma^*) > -1$.

3. Proof of P-4 First, $\underline{\gamma} = [\delta_y (1 - \alpha) - \alpha (1 - \delta_o)]A/\delta_y > 0$, by Assumption 3.

The difference $h(\bar{\gamma}) - \underline{\gamma} = 0$. The difference $\bar{\gamma} - h(\underline{\gamma})$ equals

$$\bar{\gamma} - h(\underline{\gamma}) = \frac{\alpha [(1 - \theta_y)(1 - \delta_o) - \delta_y \theta_o] [A(\delta_y (1 - \alpha) - \alpha (1 - \delta_o)) - (1 - \theta_y)z]}{\delta_y (1 - \theta_y) [\delta_y (1 - \alpha) - \alpha (1 - \delta_o)]}.$$

Assumption 3 ensures $\delta_y (1 - \alpha) > \alpha (1 - \delta_o)$. Assumption 2 and Assumption 3 ensure the numerator above is positive.

4. Proof Proposition 1 We analyze below the impact on $h(\gamma_t)$ (12) of a marginal change in each of the keeping up parameters. These indicate how the curve in Figure 1 will shift for a change in each of these variables; the result of the proposition then follows.

- a. $\frac{\partial \gamma_{t+1}}{\partial \theta_y} = \frac{-((1-\alpha)A-\gamma_t)z}{\delta_y \gamma_t} < 0$.
- b. $\frac{\partial \gamma_{t+1}}{\partial \theta_o} = \frac{-\alpha A z}{\delta_y \gamma_t} < 0$.
- c. $\frac{\partial \gamma_{t+1}}{\partial \delta_y} = \frac{\alpha A}{\delta_y} > 0$.
- d. $\frac{z(1-\theta_y)\gamma_t + A[-(1-\alpha)(1-\theta_y)z + \alpha(1-\delta_o)\gamma_t + \alpha\theta_o z]}{\delta_y \gamma_t}$.

In last case, the numerator is increasing in γ_t . Evaluated at $\gamma_t = \underline{\gamma}$, the numerator equals

$$\alpha A (1 - \delta_o) [A(\delta_y (1 - \alpha) - \alpha (1 - \delta_o)) - (1 - \theta_y)z] + \delta_y \theta_o \alpha A z,$$

which is positive by Assumption 3.

5. Proof Proposition 2 Form the difference

$$h(\bar{\gamma}) - \gamma_{bm} h(\bar{\gamma}) - \gamma_{bm} = \frac{\alpha A [A(\delta_y (1 - \alpha) - \alpha (1 - \delta_o)) - (1 - \delta_o)z]}{\delta_y (\alpha A + z)}.$$

From Assumption 3, $A(\delta_y (1 - \alpha) - \alpha (1 - \delta_o)) > (1 - \theta_y)z$, which is greater than $(1 - \delta_o)z$ if $\theta_y < \delta_o$.

6. Derivation of (15) By definition, $\Gamma \equiv \frac{-z[(1-\theta_y)(1-\alpha)A - \theta_o \alpha A]}{\delta_y (\gamma^*)^2}$. We can then write

(12) as

$$\gamma_{t+1} = \frac{-\Gamma (\gamma^*)^2}{\gamma_t} + \frac{[\delta_y (1 - \alpha) A - (1 - \delta_o) \alpha A - z (1 - \theta_y)]}{\delta_y}.$$

Evaluating this expression at the steady-state ($\gamma_t = \gamma_{t+1} = \gamma^*$), we have: $\gamma^* = -\Gamma\gamma^* + \frac{[\delta_y(1-\alpha)A - (1-\delta_o)\alpha A - z(1-\theta_y)]}{\delta_y}$, or

$$\frac{[\delta_y(1-\alpha)A - (1-\delta_o)\alpha A - z(1-\theta_y)]}{\delta_y} = (1+\Gamma)\gamma^*.$$

We can then write (12) as

$$\gamma_{t+1} = (1+\Gamma)\gamma^* - \frac{\Gamma(\gamma^*)^2}{\gamma_t}.$$

7. Proof of Proposition 3 Any 2-period cycle will have the following property: $h(\gamma_e) = \gamma_o$ and $h(\gamma_o) = \gamma_e$. This implies

$$h(\gamma_o) - h(\gamma_e) = \gamma_e - \gamma_o$$

must hold. Without loss of generality, let $\gamma_e > \gamma_o$. then, using (15), it follows that

$$h(\gamma_o) - h(\gamma_e) = \frac{(\gamma^*)^2 \Gamma}{\gamma_e} - \frac{(\gamma^*)^2 \Gamma}{\gamma_o}.$$

So a 2-period cycle must satisfy

$$\frac{(\gamma^*)^2 \Gamma}{\gamma_e} - \frac{(\gamma^*)^2 \Gamma}{\gamma_o} = \gamma_e - \gamma_o$$

A solution to this equation is $\gamma_e = \gamma_o$, the steady state; the other solution is

$$\gamma_e = -\frac{(\gamma^*)^2 \Gamma}{\gamma_o}.$$

Since $h(\gamma_e) = \gamma_o$, using the above solution, we must have

$$\gamma_o = (1+\Gamma)\gamma^* - \frac{(\gamma^*)^2 \Gamma}{\gamma_e} = (1+\Gamma)\gamma^* + \gamma_o$$

which can only hold if $\Gamma = -1$.

Proof of Proposition 4 The proof of the first part of the proposition follows from the observation that the law of motion is monotonically declining everywhere in the

interval $[\underline{\gamma}, \overline{\gamma}]$. As for the second part, notice that (12) evaluated at $\Gamma = -1$ reduces to

$$\gamma_{t+1} = \frac{(\gamma^*)^2}{\gamma_t}.$$

Hence for any $\gamma_1 \neq \gamma^*$, it follows that $\gamma_2 = \frac{(\gamma^*)^2}{\gamma_1}$ and $\gamma_3 = \gamma_1$.

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