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IT'S ALL ABOUT SOCIETY: GROWTH WHEN THE CONSUMPTION OF OTHERS ACTS AS A REFERENCE POINT

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Abstract

We model a standard OLG growth model in which agents are reference dependent and use the average consumption of the society as a reference point. In line with the standard literature in reference dependence, we model this by assuming that the utility function of each consumer is convex in an interval before the reference point, while it is concave everywhere else. (This functional form has an axiomatic foundation in Bogliacino et al. (2009)). We show that in this case the stable growth path of any society can have a wealth distribution of only two kinds: it is either polarized, with the rich separated from the poor by a gap in the distribution, or of perfect equality.

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1. Introduction

In recent years a sizable literature has documented empirically and modeled theoretically the role of reference points in human's behavior: agents are shown to compare every alternative to a reference point before a choice is made. The position of such reference point has been shown to have a profound effect on the agent's behavior, affecting her risk aversion and her choice in general.[1] The goal of this paper is to study the effects of such reference-dependent behavior in a standard growth model with overlapping generations. In particular, we study a model in which agents' reference point is determined by the behavior of the other members of the society: the reference point for consumption is a function of the consumption of the others, following the idea that the more others consume, the more our agent will want to consume herself. We shall call such reference point the "aspiration" of an agent. This terminology stems from our trying to capture the fact that if the agent consumes less than her peers, she feels a sense of loss, while if she consumes more, she has a sense of accomplishment. We will show that considering such feelings has relevant consequences on a standard growth model.

The role of such society-determined aspirations is widely discussed in the sociology and psychology literature. After the initial suggestions in Veblen (1934) and Simon (1955), a large literature in economics - mostly in macroeconomics - studies the case in which the agent utility depends on her relative standing in the society, a literature

[1]For empirical results, see among others, Tversky and Kahneman (1974), Kahneman and Tversky (1979), Tversky and Kahneman (1981), Camerer (1995). For theoretical behavioral models see Tversky and Kahneman (1991); Köszegi and Rabin (2006). For axiomatic models see Ok et al. (2009), Masatlioglu and Ok (2005, 2008), Ortoleva and Riella (2009), Diecidue and Van de Ven (2008). There is a sizable literature that tried to develop the original intuition of Simon (1955) of incorporating intrinsic motivation or aspirations rules into decision making, assuming different degrees of rationality, see Bendor et al. (2001), Heifetz and Minelli (2006), Benabou and Tirole (2003), Selten (1998) and Dalton and Ghosal (2009 (Forthcoming)).

that usually goes under the name of *keeping up with Joneses.*[2] A common feature of these papers is that the agent's utility has two arguments: her consumption and her status. Depending on how the impact of the latter is modeled, very different conclusions could be drawn,[3] while at the same time there seem to be no obvious way to choose one functional form over the other. We believe that these two element combined render rather difficult to apply such models. By constrast, in our model the agents' utility depend on her consumption and on her aspiration level, which in turns depends on the consumption of the other members of the society. While this is conceptually similar to status, it is formally different. Moreover, the functional form that we adopt has a strong microfoundation. First, it is in line with standard representations of reference dependence, which is in turn based on a large amount of empirical evidence. Second, it has a precise foundation in the axiomatic work of Ortoleva and Riella (2009), which implies that, potentially, it could be tested directly.[4]

In the theory literature, the case of interdependent preferences is studied in Robson (1992), who analyzes the characteristics of a utilty function that includes the role of the status, and it is studied axiomatically by Ok and Koçkesen (2000), Maccheroni et al. (2008), who analyze the preference over societies allowing for the possibility that an agent cares about her relative standing in it. Recently Ortoleva and Riella (2009) have developed an axiomatic model that analyzes the preferences of an agent over alternatives but that allow for the possibility that such preferences change with respect to what it is chosen by the other members of the society. As we mentioned, this model provides the theoretical foundation for our analysis.

The notion of aspirations and its implications in development economics are discussed in Ray (2006), the analysis in which has inspired our work. Mookherjee et al. (2009 (forthcoming)) present an OLG model of occupational choice in which parents choose the occupational level of their sons based on a peer-determined aspiration level. Their analysis is focused on the case in which agents look only at agent in their "neighboorhood" to form aspirations, and shows the consequences on wealth distribution of such behavior. This approach is very different from ours, since we study the case in which agent's aspirations are determined by the society as a whole, and not only by their immediate "neighbors." More importantly, our analysis is different since they model subjects who can always fulfill their aspirations if they want to, while most of our results are driven

[2]In this vast literature an analysis closer to the one in our work appears in Konrad (1992), Fershtman et al. (1996), Rauscher (1997), Corneo and Jeanne (2001), Cooper et al. (2001), Stark (2006), Hopkins and Kornienko (2006). Other works argue that people should care about their status not for an interest in the relative ranking per se', but because it gives access to goods traded outside standard markets, like marriage: see, for example, Cole et al. (1992) and Corneo and Jeanne (1998). Others study conspicuous consumption, like Bagwell and Bernheim (1996).

[3]One might contrast, for example, the results in Corneo and Jeanne (2001), according to which equality increases growth, with those in Stark (2006), where the opposite happens.

[4]Another work that has points of contacts with ours is Alonso-Carrera et al. (2007), which includes habits or aspirations into the utility function, where the former is based on past consumption, while the latter on consumption of antecessors. However, they use an additive formulation since they want to reach non-separability through time of the value function: this literature is rather interested in the issue of overaccumulation and it is less focussed on development issue.

by the fact that our agents might be unable to reach their aspirations – a condition that we define of "aspiration failure." Finally, Koszegi and Rabin (2009) and Bowman et al. (1999) analyze the consequence of reference-dependent behavior in a growth model, but they assume that the reference point is determined by the agent's past behavior and is irrespective of the behavior of others. By contrast, we model the corresponding case in which the reference point depends only on the behavior of others.

We study a standard OLG model in which special assumptions are made on the shape of the utility function of the agents. In particular, we assume that every agent has an aspiration level which is determined endogenously and we focus on the case in which this reference point is the average consumption of the society in the second of her two-period life. In line with the standard ways of modeling reference dependence, we assume that this utility function is convex in an interval that ends with the reference point, and it is concave everywhere else. We show that under general assumptions any economy of this kind can have only two types of wealth distribution in the long run: either it is polarized, that is the distribution has gap of positive measure, or is perfectly egalitarian. These clear cut predictions are in contrast with standard OLG models and suggest that aspirations can be an important driver of development success (or failure).

The remainder of the article is structured as follows. Section 2 introduces the theoretical model and enstablishes some basic existence and convergence results, discussing the implications in terms of wealth distribution and polarization and prove the main results of the paper. Section 3 concludes. The proofs appear in the appendix.

2. A Model of Growth with Aspirations

2.1 Formal Setup

The economy is populated by a continuum of size I of agents living for two periods.[5] Every individual generate offspring exogenously in her second period. Every agent is equipped with an initial endowment of human capital, measured in effective units, equal to a_i. This initial endowment is a function, equal for everyone, of the consumption in the second period of the previous generation. Part of this human capital can be used to acquire more human capital through the function $h(\cdot)$, which is increasing and concave and satisfies Inada conditions. Each agent can also buy capital, on which he receives the rental rate r_{t+1} at the end of the period. Access to the credit market is restricted (we are describing an underdeveloped country): for simplicity individual consumers cannot borrow. $\beta \leq 1$ is the discount factor. Let us call μ_t the distribution of endowments in every period.

[5]The presence of an uncountable number of agents is inessential for our results. In fact, it is routine to show that everything we prove would hold true with finitely many agents.

Every agents maximizes:

$$\begin{array}{c} \max_{c_{it},c_{it+1},e_{it},k_{i,t+1}} u(c_{it}) + \beta v(c_{i,t+1}) \\ \text{subject to} \\ c_{i,t} + k_{i,t+1} \leq w_t(a_{i,t} - e_{it}) \\ c_{i,t+1} \leq k_{i,t+1}(1 + r_{t+1}) + w_{t+1}h(e_{it}) \end{array} \tag{1}$$

together with:

$$a_{i,t+1} = a(c_{i,t+1})$$

We start by imposing standard restrictions.

Assumption 1. $u(\cdot)$ is increasing and concave at satisfies Inada conditions

Assumption 2. The production possibilities are resumed in the production function for the representative firm $F(K, H)$ increasing, concave, homogeneous of degree one and satisfying Inada conditions.

Assumption 3. The third derivatives of both u and v have the same sign and they either are always positive or always negative.

Assumption 4. $h(\cdot)$ is increasing and concave and satisfies Inada conditions.

All the requirement above are standard. In particular, agents have a standard utility function in the first period of their lives. We depart from the standard approach by imposing the following assumption.

Assumption 5. v is increasing and satisfies Inada consition, and there exist $\underline{c_i},\ \bar{c}_i \in \mathbb{R}_{++}$, $\underline{c_i} < \bar{c}_i$, such that $v''(x) > 0$ if $x \ \in \ [\underline{c_i},\ \bar{c}_i]$, and $v''(x) < 0$ otherwise.

The basic idea is that in our model agents have an *aspirations level* $\bar{c}_i$, which acts as a reference point in affecting their behavior. And following the standard literature in reference-dependent choice we model this as the presence of an area of convexity of the utility function right before the aspirations level.[6] The rationale is that agents might have a sense of disappointment, or failure, if they fall short of their expectations, which is captured by the convexity of the utility function. The interval $[\underline{c}, \bar{c}]$ is defined as "aspiration window" (from Ray (2006)). Notice that Assumptions 1 and 5 combined impose a very specific way on how the aspirations level affect agents behavior. In particular, since u is irrespective of the aspiration level, we are analyzing the case in which agents are reference dependent only in their second period, when they are "old," and about their bequest.[7] However, they are not reference dependent when they are young. This approach is motivated by the fact that people tend to set objectives for themselves to be accomplished when they have reached a certain age. At the same time, we would like to argue that this assumption is not crucial to our treatment: most of our results would hold true if we assumed that $u = v$.[8] Finally we remind that the agents take all the investment

[6]See, for example, Tversky and Kahneman (1974), Kahneman and Tversky (1979), Tversky and Kahneman (1981), Camerer (1995).

[7]Notice that, since the bequest agents leave to their children depends on their consumption in their second period, the reference point is indirectly affecting the bequest as well.

[8]Assuming $u = v$, however, would have its problems, since v includes the fact that part of the consumption in the second period will be left as a bequest.

decisions related with their future in the first period, thus setting the aspiration in the second period is precisely capturing the role of aspiration in accumulation of capital that Ray (2006) seems to suggest in his treatment of the phenomenon.

We now turn to impose a specific origin to the aspirations level: we impose that the aspirations level that every generation has for her consumption in their second period is equal to the average of the consumption of the other members of that generation in their second period. That is, agents want to consume at lest as much as the other members of their generations.

Assumption 6. For $i \in I$, $t \in T$, $\bar{c}_{i,t} = \frac{\int_I c_{i,t+1} \mathrm{d}i}{\int_I \mathrm{d}i}$.

Assumption 6 is clearly restricting our attention to a specific kind of reference-dependence: a society-determined reference point. In the following sections we relax this assumption and analyze the more general case. However we restrict the treatment to some examples. Notice, moreover, that Assumption 6 is not required for the next results on the existence of a steady state and the characterization of the optimal behavior. One of the reason to focus analytically on this case is that Ortoleva and Riella (2009) provide an axiomatic foundation for it.

Finally, we impose the standard assumption that the bequest evolves with respect to the consumption in the second period with a constant elasticity. (We shall impose it only when required.)

Assumption 7. $\frac{a'(c_{i,t+1})c_{i,t}}{a_{i,t}} = \epsilon$ for all $t \geq 0$.

2.2 Properties of the optimal behavior and existence of a steady state

Since we are analyzing non-standard preferences, we need to prove some general existence results.

Definition 1. A society converges to a balanced growth path if it converges to a distribution in which there is a constant growth rate $g \geq 0$ of physical and human capital.

Proposition 1. *Under Assumptions 1-5 there exists a balanced growth path with constant growth rate $g \geq 0$ of physical and human capital.*

Proposition 1 shows that the standard existence results follow through in this general case as well. Moreover, notice the following.

Observation 1. In a balanced growth path, the distribution of endowments μ is stable.

We now turn to analyze the properties of the optimal behavior of agents in this economy when a balanced growth path has been reached. Because of the convexity of the utility function, this behavior will be different from the standard one and therefore requires a separate treatment. Notice first of all that the wage per unit of efficient labour and the rental rate of capital are constant in a balanced growth path, respectively, at $f(\lambda) - f'(\lambda)\lambda$ and at $f'(\lambda)$, where λ is the long run K/H ratio and $f(\cdot)$ is the usual expression of the production function in term of efficiency units of labour. We can then rewrite the FOCs of the agents as:

$$-u'(c_{it}) + \beta(1 + r_{t+1})v'(c_{i,t+1}) = 0$$

$$-u'(c_{it})w_t + \beta w_{t+1}h'(e_{it})v'(c_{i,t+1}) = 0$$

Clearly, since agents are here heterogenous and credit constrained, corner solutions are possible without implying that r_{t+1} diverges: they will be found when the initial endowment is sufficiently low. Focusing on internal solutions, first of all we get $e_{it} = h'^{-1}(1 + r)$. Moreover, the interesting case is illustrated in Figure 1: in this case agent starts below the aspiration level if they made no capital investment (i.e. the case in which $w\ h(e^*) \leq \underline{c}$). From the figure one can see that there are at most three points that can satisfy first order conditions. It turns out that the optimal solution is always unique and, more importantly, always lies in the concave part of the utility function. [9].

To understand this result, go back to Figure 1. In this graph the increasing curve is $u'(\cdot)$ - it is increasing because we express it as a function of capital - while the other one is $\beta v'(\cdot)(1+r)$ - again as function of capital. As long as endowment grows, the agent passes from a corner solution to a solution in which the agent falls short of her aspirations – a solution that we call "aspiration failure." A further increase of the endowment generates three crossings, but we show that only the one with higher capital is the solution. This means that if we increase the capital the agent moves to a different solution in which she reaches her aspirations – a solution that we dub "aspiration reached." It is then clear that there is a threshold in terms of initial endowment that triggers the "jump" from a failure to a success in terms of reaching aspiration.

Notice that when the endowment is high enough, the agent simply starts above the aspiration level and thus the model behaves just as in a standard case. This facts suggests an important claim that will be key for our results on polarization. Excluding the eventual case of corner solutions, there are potentially three types of agents: those who "fail to reach their aspirations" and for this reason accumulate very little, those who are very rich and accumulate at regular pace, and finally those who can be called "jumpers." The latter ones climb the ladder of the aspiration windows with a strong effort in the first period.

We can sum up all these results in the following Proposition. We add some straightforward results on comparative statics, that can be deduced from Figure 1.

Proposition 2. *Under Assumptions 1-5 the following hold:*

1. *the optimal solution is always unique and is always on the concave part;*

[9]For the latter result, we use Assumption 3. Let us stress, at the same time, that we consider Assumption 3 not restrictive since it includes the counterintuitive case in which the third derivative is positive. Moreover, notice that it would hold even assuming $u(\cdot) = v(\cdot)$ (see Lemma 2 in the proof of Proposition 1). Unicity is just a simple implication of rationality and of the fact that the interest rate is positive.

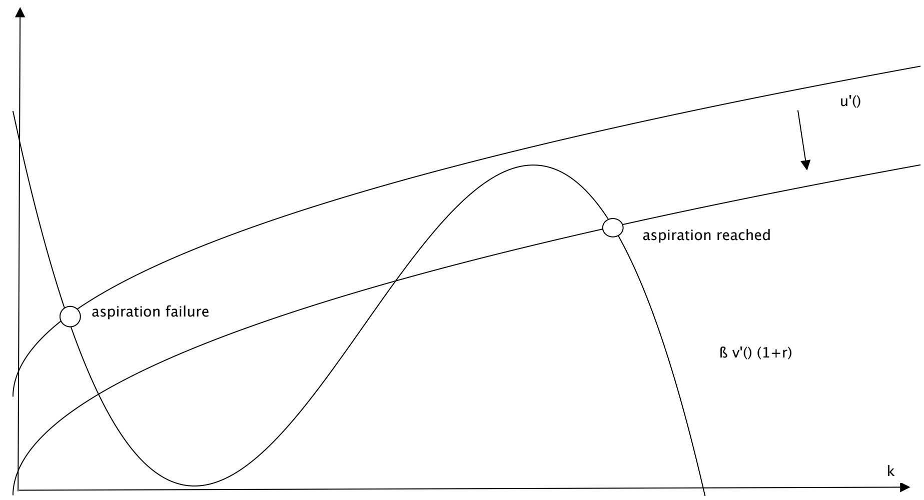

FIGURE 1 The cutoff point in terms of available resources.

2. *there is a threshold $\bar{a}_{i,t+1}$ of initial endowment that trigger the jump from an aspiration failure to aspiration realization solution for the individual agent;*

3. *the optimal c_{t+1} is non decreasing in $\underline{c}$;*

4. *in the aspiration realization solution the optimal c_{t+1} is non decreasing in $\bar{c}$;*

We move now to the case in which Aspiration are formed under Assumption 6.

2.3 Aspirations, Distribution and Frustration in the Long Run

2.3.1 Main Theorem We shall now evaluate the behavior of this economy in the steady state. In particular, we focus on the distribution of endowments μ.

Definition 2. A distribution μ on $\mathbb{R}$ is polarized if there exist $\underline{x}, \bar{x} \in \mathbb{R}$, $\underline{x} > \bar{x}$ such that:

1. $\mu(x) > 0$ and $\mu(x') > 0$ for some $x < \underline{x}$ and $x' > \bar{x}$;

2. $\mu(x) = 0$ for all $x \in [\underline{x}, \bar{x}]$.

A polarized distribution is a distribution that has a "gap" of positive measure. The idea is that on the one side of this "gap" we will find the rich, who meet their aspirations, while on the other we find the poor, who fail to meet it.

Definition 3. A distribution μ on $\mathbb{R}$ is of perfect equality if $\mu(x) = 1$ for some $x \in \mathbb{R}$.

It turns out that every balanced growth path of this economy must have a very specific distribution.

Theorem 1. *Consider an economy as described above that satisfies Assumptions 1-7. Then, if the economy is in a balanced growth path then its distribution of endowments μ is either polarized or of perfect equality.*

To analyze the meaning of the theorem, recall the standard result that, in the case in which the agents are standard agents with both u and v concave, any economy that started with a continuous and non-degenerate distribution of initial endowments would have a balanced growth path with a continuous and non-degenerate distribution of endowments. Theorem 1 therefore shows that the the presence of aspirations has a very strong impact on the type of balanced growth paths that are attainable. In particular, no matter what the initial distribution is, a continuous non-degenerate distribution is no longer possible in a balanced growth path. Either the poor get "left behind," failing to attain their aspirations, and the society is polarized between those that attain their aspirations and those that fail to. Or, everybody catches up with their aspirations, but this can happen only if that the distribution of endowments is of perfect equality.

2.3.2 Further characterizations We now turn to provide additional results on when either one of the possible distributions of a balanced growth path take place. Recall that we define ϵ the (constant) elasticity of bequest to the consumption in the second period. Also, recall that $\bar{a}_t$ is the threshold found in Proposition 2. Now, define by $\eta_t := \frac{\bar{a}'_{it}(\bar{c}_{it})\bar{c}_{it}}{\bar{a}_{it}}$ the elasticity of this threshold with respect to the aspirations level $\bar{c}_{i,t}$.

Proposition 3. *Consider an economy as described above that satisfies Assumptions 1-7, with initial distribution μ_0, and that has a balanced growth path with with distribution μ and growth rate g. Then:*

1. *if $\eta_t(x) \geq \epsilon$ for all x, then there exists $\gamma > 0$ such that:*
   (a) *if $\frac{\min_{i \in I: \mu(a_i)>0} a_i}{\int_{\mathbb{R}} d\mu} < \gamma$, then μ is polarized;*
   (b) *if $\frac{\min_{i \in I: \mu(a_i)>0} a_i}{\int_{\mathbb{R}} d\mu} \geq \gamma$, then μ is of perfect equality;*
2. *if there exists $\hat{x} \in \mathbb{R}$ such that for every $x > \hat{x}$ $\eta_t(x) < \epsilon$ and if $g > 0$, then μ is of perfect equality.*

2.4 Some extensions

In the previous analysis we have focused on the case in which the aspirations level of every member of the society is the average consumption in his generation. This implies, clearly, that every generation has the same reference point. We now turn to discuss the more general case in which individuals can have heterogeneous aspirations, and argue that this can generate a lot of interesting dynamics but we do not add any robust empirically testable prediction. For this reason we limit ourselves to some examples. For simplicity we consider the case of a countable number of agents (this is of course immaterial for the our claims).

For a given set of aspiration levels, we can always order agents according to them, and by Proposition 2 we know that the same ordering holds in terms of the bequest thresholds. In fact, the latter is now also, and $\bar{a}_{i,t+1}$ to denote it. We add a further Assumption.

Assumption 8. $\bar{c}_{i,t+1} = (1+g_c)\bar{c}_{it}$, where g_c is the average growth rate of consumption.

By Assumption 8 we are imposing that people update their aspiration at the rhythm at which society evolves. A similar process holds for $\underline{c_{it}}$. Define $T = \{i_1,\ i_2,\ ...\ i_n\ |\bar{a}_{i_1,t+1} \leq \bar{a}_{i_2,t+1} \leq\ ...\ \leq \bar{a}_{i_n,t+1}\}$ as the ordering of agents in terms of threshold. Finally define $D = \{j_1,\ j_2,\ ...\ j_n\ |a_{j_1,t+1} \leq a_{j_2,t+1} \leq\ ...\ \leq a_{j_n,t+1}\}$ as the ordering of agents in terms of endowment.

Now, notice that the rate of growth of threshold is

$$\log\left(\frac{\bar{a}_{i,t+1}}{\bar{a}_{i,t}}\right) \simeq \log\left(\frac{\bar{a}_{i,t} + \bar{a}'_{it}(\bar{c}_{it})(\bar{c}_{i,t+1} - \bar{c}_{it})}{\bar{a}_{i,t}}\right) \simeq \eta_t\ g_c \tag{2}$$

where we used a Taylor expansion and the standard approximation $\log(1+x) = x$ which holds when x is small. This is clearly the product between an elasticity and the average growth rate. We are able to characterize the elasticity. Notice that $\eta_t < w$. Moreover, since the derivative of threshold with respect to aspiration is 1/(1+r) (see (15))[10], then it is constant in the aspiration level. Then the elasticity varies along the distribution according to the term $\frac{\bar{c}_{it}}{\bar{a}_{it}}$. This term is always lower than $(1+r)$: $\bar{c}_{it}/[w(1+r)]$ would be the minimum value of the threshold necessary to reach the aspiration (i.e. the present value of aspiration, which cannot be optimal because it implies zero consumption in the first period). Simple algebra implies that the elasticity is lower than w. However since $\frac{d(\bar{c}_{it}/\bar{a}_{it})}{d\bar{c}_{it}} = \frac{\bar{a}_{it} - \bar{a}'_{it}(\bar{c}_{it})\bar{c}_{it}}{\bar{a}^2_{it}}$ we cannot conclude a priori if it is increasing or not. In a similar fashion we can define the rate of growth of bequest:

$$\log\left(\frac{a_{i,t+1}}{a_{i,t}}\right) \simeq \epsilon\ g_c \tag{3}$$

where we have used Assumption 7.

We can now discuss some examples.

Example 1. Assume that T and D are such $\epsilon_t < \eta_t(i_1)$, with the latter either constant or increasing. In this case the growth rate of aspiration of the less "ambitious" needs a growth rate of endowment which is higher than the growth rate of bequest of the richest. Then it should be obvious that society shows steady distribution and permanent failure of aspirations in the balanced growth path. We can call this society **Cien años de soledad**, as the famous village of Macondo in the novel by Marquez.

Example 2. Assume that T and D are such that $\epsilon_t > w$. Since, as we noted, $\eta_t < w$, then the rate of growth of endowment of all people in the society is stably higher than

[10] Clearly $\bar{c}$ is a stationary point of the first derivative and by definition the second derivative is equal to zero.

the rate of growth of threshold. This society converges to a steady state growth path in which everybody satisfies her aspiration. We can call this society **El Dorado**.

Example 3. Assume that $T = D$ and there exists $s \in [1,\ n)$ such that $\epsilon_t(j_s) = \eta_t(i_s)$. Assume for the sake of the argument that $w = 1$ in steady state (which implies that η_t is increasing in the aspiration level). This society is such that actual distribution and aspirations are ordered in the same way. There seems to be no source of conflict: everybody accepts "her position" in the society. This can be considered a sort of **Brave New World** in homage to Huxley famous book (where aspirations are genetically imprinted). The interesting point is that this society is counterintuitively unstable: the poor catch up with the s position and the rich are eventually frustrated in their increasing aspirations. Stability can be reached if we allow constancy of the $\eta_t = \epsilon$, with a polarized limit distribution.

Example 4. Assume that T and S are reversed, in the sense that $\forall k\ i_k = j_{n-k}$. Then if $w = 1$ assume that there exists an s such that $\forall i_k < i_s,\ \epsilon_t < \eta_t(i_k)$ and $\forall i_k \geq i_{s+1},\ \epsilon_t > \eta_t(i_k)$, while if η_t is constant just assume that $\eta_t = \epsilon_t$. In this case the society shows stable polarization. We can call this a **Bismarckian** society, where rich people are moderate in their aspirations and poor people should be looked behind because they are not able to decide their attainable targets.

3. Conclusion

In this paper we have presented an OLG model with human and physical capital, where preferences of the individual are reference dependent and the reference point is determined endogenously by the society. The presence of reference-dependence generates an area of convexity in the utility function, as standard in the behavioral literature.

After characterizing the general model, we consider the case in which the aspiration level is the average consumption of society. Our main result concern the distribution of society in a steady growth path: we show that under general conditions, a steady growth path can show a wealth distribution which is either polarized, or perfectly egalitarian. We also discuss, but only through examples, the more general case in which aspirations can be heterogeneous. Future research will study the case in which aspirations are formed mixing past private experience with society-level experience for further research.

Appendix

Appendix A. Proof of Proposition 1

We start by characterizing the optimal choice through First and Second Order Conditions. On the production side, since with constant return to scale the number of firms is indeterminate, we treat the production side at the aggregate level. The problem is standard and wage and rental ratio will be equal to:

$$\begin{aligned} w_t &= \frac{\partial F\left(\int_I k_{it}, \int_{i=1}^{n}(a_i - e_{it}) + \int_I h(e_{i,t-1})\right)}{\partial H} \\ r_{t+1} &= \frac{\partial F\left(\int_I k_{it+1}, \int_I (a_i - e_{it+1}) + \int_I h(e_{i,t})\right)}{\partial K} - \delta \end{aligned} \tag{4}$$

We start by looking at an interior solution, assuming it exists: as we will see this in not the case in general, because of restriction in the access to credit markets[11].

The problem can be seen as a problem in $e_{it},\ k_{it}$, leaving the two consumptions level determined by the constraints (which by rationality are satisfied with equality):

$$\max_{e_{it}, k_{it+1}} u(w_t(a_i - e_{it}) - k_{it+1}) + \beta v(k_{it+1}(1 + r_{t+1}) + w_{t+1}h(e_{it})) \tag{5}$$

The interior solution will be defined by the First Order Conditions:

$$-u'(c_{it}) + \beta(1 + r_{t+1})v'(c_{i,t+1}) = 0 \tag{6}$$

$$-u'(c_{it})w_t + \beta w_{t+1}h'(e_{it})v'(c_{i,t+1}) = 0 \tag{7}$$

and second order conditions:

$$u''(c_{it}) + \beta(1 + r_{t+1})^2 v''(c_{i,t+1}) < 0 \tag{8}$$

$$u''(c_{it})w_t^2 + \beta w_{t+1}h''(e_{it})v'(c_{i,t+1}) + \beta[w_{t+1}h'(e_{it})]^2 v''(c_{i,t+1}) < 0 \tag{9}$$

and

$$\begin{aligned} &[u''(c_{it})w_t]^2 + \beta u''(c_{it})w_t^2 h''(e_{it})(1 + r_{t+1})^2 v''(c_{t+1}) + \beta[w_{t+1}h'(e_{it})]^2 v''(c_{i,t+1}) + \\ &\beta u''(c_{it})v'(c_{i,t+1})w_{t+1}h''(e_{it}) + \beta^2 v'(c_{i,t+1})v''(c_{i,t+1})w_{t+1}(1 + r_{t+1})^2 h''(e_{it}) + \\ &\beta[w_{t+1}h'(e_{it})]^2 v''(c_{i,t+1})u''(c_{it}) + \beta^2[w_{t+1}h'(e_{it})]^2(1 + r_{t+1})^2[v''(c_{i,t+1})]^2 \\ &-[u''(c_{it})w_t]^2 - \beta^2[w_{t+1}h'(e_{it})]^2(1 + r_{t+1})^2[v''(c_{i,t+1})]^2 \\ &-2u''(c_{it})w_t]\beta w_{t+1}h'(e_{it})(1 + r_{t+1})[v''(c_{i,t+1})] > 0 \end{aligned} \tag{10}$$

Some remarks are in order

Remark1'. Replace (6) into (7) to get:

$$(1 + r_{t+1})w_t = w_{t+1}h'(e_{it}) \tag{11}$$

this equation tells us that in an interior solution the rate of return of investment in the two capital should be equalized. In the general solution, since we will see that capital investment can be zero, the

[11] Of course a solution does exist for the Weierstrass Theorem.

no arbitrage condition is with the inequality sign $(1 + r_{t+1})w_t \leq w_{t+1}h'(e_{it})$. In fact for 7 an internal solution exists thanks to Assumption 4.

Moreover, it tells us another thing. With perfect capital market, this equation determines the optimal individual choice as a function of market factor prices: this implies that the optimal choice would be equal through all agents.

Remark2'. (8) is necessary and sufficient to characterize the interior solution together with the FOCS. The former is straightforward. Let's have a look at sufficiency. Take Equation (9) and replace (11) into it, getting:

$$w_t^2[u''(c_{it}) + \beta(1 + r_{t+1})^2 v''(c_{i,t+1})] + \beta v'(c_{i,t+1})h''(e_i t)$$

the term into brackets in the first addend is Equation (8), since $h(\cdot)$ is concave, negativity of (8) implies (9)

Now let's make some algebra in (10), we can rewrite it as:

$$\beta u''(c_{it})v''(c_{i,t+1})[w_t^2(1 + r_{t+1})^2 - w_{t+1}^2 h'(e_{it})^2]+$$

$$-\beta u''(c_{it})v''(c_{i,t+1})[2w_t(1 + r_{t+1})w_{t+1}h'(e_{it})]+$$

$$+\beta w_{t+1}h''(e_{it})]v'(c_{i,t+1})[u''(c_{it}) + \beta(1 + r_{t+1})^2 v''(c_{i,t+1})] =$$

$$\beta u''(c_{it})v''(c_{i,t+1})[w_t(1 + r_{t+1}) - w_{t+1}h'(e_{it})]^2+$$

$$+\beta w_{t+1}h''(e_{it})]v'(c_{i,t+1})[u''(c_{it}) + \beta(1 + r_{t+1})^2 v''(c_{i,t+1})]$$

The first term into brackets $w_t(1 + r_{t+1}) - w_{t+1}h'(e_{it})$ is equal to zero by (11), since $h(\cdot)$ is concave (8) implies (10).

Remark3'. If $u(\cdot)$ is sufficiently steep, we can have an optimal solution on the convex part of $v(\cdot)$. For the concept of aspiration to make sense we need to exclude such a situation, and this is where Assumption 3 comes into play. We can prove the following Lemma.

Lemma 1. If the third derivatives of both function have always the same sign and they are always positive or negative then $v''(c_{t+1}) < 0$ in the optimum.

Proof. First of all, examine the case with $c_{it} > c_{i,t+1}$. A simple argument will convince you that this cannot be an optimum. Take $\beta = 1$, then if $c_{it} > c_{i,t+1}$ is feasible, it is also feasible to consume $c_{i,t+1}$ in the first period and $c'_{i,t+1} > c_{it}$ in the second period since interest rate is positive (this is certainly true at least in balanced growth path for the arbitrage condition and Inada condition on the $h(\cdot)$). Of course this new couple will give the agent an higher utility. For continuity we can always find a $\beta < 1$ for which the same argument applies. Thus $c_{it} > c_{i,t+1}$ cannot be a solution.

Secondly, since the function are equal outside the aspiration window, then it should be that $v'(c) > u'(c)\ \forall c \in [\underline{c},\ \bar{c}]$. By contradiction, assume that $v''(c_{t+1}) > 0$ in the optimum. Take as usual $\beta(1 + r) > 1$(β is irrelevant and the interest rate is positive in steady growth). Then it should be that $c_{it} < \bar{c}$ otherwise the first order condition would be violated. If $v'''(\cdot) < 0$ then:

$$v'(c_{it}) \leq v'(c_{i,t+1}) + v''(c_{i,t+1})(c_{it} - c_{i,t+1})$$

then

$$-u'(c_{it}) + \beta v'(c_{i,t+1})(1 + r_{t+1}) > -u'(c_{it}) + v'(c_{i,t+1}) \geq$$

$$v'(c_{it}) - u'(c_{it}) - v''(c_{i,t+1})(c_{it} - c_{i,t+1}) > 0$$

since functions are equal outside the windows and $c_{it} < c_{i,t+1}$. But this implies that the FOC is violated, so it cannot be a maximum, which is a contradiction.

Now take the case in which $v'''(\cdot) > 0$. By assumption the same holds for $u(\cdot)$. Then we can write

$$-u'(c_{i,t+1}) \leq u'(c_{it}) + u''(c_{it})(c_{i,t+1} - c_{it})$$

the rest is simple algebra:

$$-u'(c_{it}) + \beta v'(c_{i,t+1})(1 + r_{t+1}) > -u'(c_{it}) + v'(c_{i,t+1}) \geq$$

$$v'(c_{i,t+1}) - u'(c_{it+1}) - u''(c_{it})(c_{i,t+1} - c_{it}) > 0$$

which is again a contradiction. □

However, there is not guarantee that the solution is internal. Let's go back to the FOCs. Take for a second e_{it} as given. We can study $u'(w_t(a_i - e_{it}) - k_{i,t+1})$ and $\beta(1+r_{t+1})v'(k_{i,t+1}(1+r_{t+1}) + w_{t+1}h(e_{it}))$ as a function of capital. The former increase from $u(w_t(a_i - e_{it}))$ to infinite (when the agent put the consumption to zero). The latter has a behavior which depends on $w_{t+1}h(e_{it})$:

1. if it is greater than $\bar{c}_i$ it decreases from $\beta(1 + r_{t+1})v'(w_{t+1}h(e_{it}))$ to $\beta v'(w_t(a_i - e_{it})(1 + r_{t+1}) + w_{t+1}h(e_{it}))$
2. if it belongs to $[\underline{c_i},\ \bar{c}_i]$ it increases from $\beta(1+r_{t+1})v'(w_{t+1}h(e_{it}))$ to $\beta(1+r_{t+1})v'(\bar{c}_i)$ then decreases to $\beta(1 + r_{t+1})v'(w_t(a_i - e_{it})(1 + r_{t+1}) + w_{t+1}h(e_{it}))$
3. if it lower than $\underline{c_i}$ it decreases from $\beta(1 + r_{t+1})v'(w_{t+1}h(e_{it}))$ to $\beta(1 + r_{t+1})v'(\underline{c_i})$ then increases up to $\beta(1 + r_{t+1})v'(\bar{c}_i)$ and finally decreases to $\beta(1 + r_{t+1})v'(w_t(a_i - e_{it})(1 + r_{t+1}) + w_{t+1}h(e_{it}))$

If $w_t(a_i - e_{it})$ is sufficiently low, then an intersection between the two curves cannot exists and the optimal choice for capital is the corner solution at zero. If they intersect they can intersect at most three times (the argument is obvious): in case (1) they can intersect at most one (trivial); in case (2) they can intersect at most twice (one on the aspiration window and once above the aspiration level); finally in case three they can intersect zero times, or once (on the first concave part of $v()$ if the maximum capital investment is sufficiently low), or twice (on the first concave part and on the convex part), or three (once respectively on the first concave part, on the aspiration window and finally above the aspiration level). However we can see that the solution is unique under the Assumptions 3-4.

We can now prove the following Lemma, to state that it is without loss of generality to confine the discussion on aspiration to the second period.

Lemma 2. If $u(\cdot) = v(\cdot)$ and $u'''(\cdot)$ is either always positive or negative, then neither $u''(c_{it}) > 0$ nor $u''(c_{i,t+1}) > 0$ in the optimum.

Proof. Clearly, it is impossible that both $c_{i,t+1}$ and c_{it} are selected on the convex part, because it would violate SOCs. For the same reasoning as above, $c_{it} > c_{i,t+1}$. Assume $u'''(\cdot) > 0$ and $u''(c_{i,t+1}) > 0$ in the solution. By convexity, $u'(c_{it}) > u'(c_{i,t+1}) + u''(c_{i,t+1})(c_{it} - c_{i,t+1})$. But then, taking β sufficiently close to one (it is irrelevant in the model), we can write:

$$-u'(c_{it}) + u'(c_{i,t+1})\beta(1 + r_{t+1}) \geq -u'(c_{it}) + u'(c_{i,t+1}) >$$

$$> -u'(c_{it}) + u'(c_{it}) - u''(c_{i,t+1})(c_{it} - c_{i,t+1}) > 0$$

which violates the FOCs. Now consider the case in which $u'''(\cdot) > 0$ and $u''(c_{it}) > 0$ in the solution. Then $u'(c_{i,t+1}) > u'(c_{it}) + u''(c_{it})(c_{i,t+1} - c_{it})$. Again, we can write:

$$-u'(c_{it}) + u'(c_{i,t+1})\beta(1 + r_{t+1}) \geq -u'(c_{it}) + u'(c_{i,t+1}) >$$

$$> -u'(c_{it}) + u'(c_{it}) + u''(c_{it})(c_{i,t+1} - c_{it}) > 0$$

which again violates FOCs. Now change the sign of the third derivative, and assume that $u''(c_{i,t+1}) > 0$ in the solution. By concavity $-u'(c_{it}) > -u'(c_{i,t+1}) - u''(c_{i,t+1})(c_{it} - c_{i,t+1})$. Then we can write:

$$-u'(c_{it}) + u'(c_{i,t+1})\beta(1 + r_{t+1}) \geq -u'(c_{it}) + u'(c_{i,t+1}) >$$

$$> u'(c_{i,t+1}) - u'(c_{i,t+1}) - u''(c_{i,t+1})(c_{it} - c_{i,t+1}) > 0$$

violating FOCs. Finally assume that $u''(c_{it}) > 0$. Then $u'(c_{i,t+1}) < u'(c_{it}) + u''(c_{it})(c_{i,t+1} - c_{it})$, substituting, we get:

$$-u'(c_{it}) + u'(c_{i,t+1})\beta(1 + r_{t+1}) \geq -u'(c_{it}) + u'(c_{i,t+1}) >$$

$$> -u'(c_{it}) + u'(c_{it}) + u''(c_{it})(c_{i,t+1} - c_{it}) > 0$$

which again violates the FOC. □

We can prove the following Lemma:
Lemma 3. Under Assumptions 3 and 4 the optimal (e_{it}, k_{it+1}) is unique.

Proof. Take e_{it} as given. Since concavity and Inada conditions apply to $h(\cdot)$ by Assumption 4, if we can prove that the optimal solution for k_{it+1} is constant, then uniqueness will be guarantee also for e_{it}.

If there is no intersection, than unique best choice is trivially $k_{it+1} = 0$. If there are two intersection, by Lemma 1 the only interesting case is that on the concave part. The last case, that we have to check is when there are three intersection: when this fact occurs, the two curves cross once below the aspiration window and one above the aspiration level (the intersection on the convex part is eliminated by Lemma 1). Then we will have (c_t, c_{t+1}) and $(c'_t,\ c'_{t+1})$ that are candidate solutions, with $c_{t+1} \geq \bar{c}$ and $c'_{t+1} \leq \underline{c}$, and $c'_t > c_t$. Now we have to prove that:

$$u(c_t) + \beta v(c_{t+1}) > u(c'_t) + \beta v(c'_{t+1})$$

or

$$\beta\left(v(c_{t+1}) - v(c'_{t+1})\right) > u(c'_t) - u(c_t)$$

Individual rationality should then implies that $c'_t > c'_{t+1}$. But this cannot be a solution as proved in Lemma 2. □

Now we are ready to prove Proposition 1

Proof. $(e_{it}, k_{it+1}) = \phi(w_t, w_{t+1}, r_{t+1})$ is a function. Because of the assumptions on the production function there is a maximum ratio between physical and human capital (Acemoglu (2009): p. 240) so the optimum choice is picked up from a compact convex set. Berge's Maximum Theorem and uniqueness implies continuity (Berge (1997): Theorem 3 and Corollary). Continuity is preserved under summation. We remind that the $a_{i,t+1}$ depends continuously on w_t, r_{t+1}, and w_{t+1}. Define:

$$\lambda_{t+1} = \frac{\int_I k_{i,t+1}}{\int_I (a_{i,t+1} - e_{i,t+1}) + \int_I h(e_{it})} = q(w_t, w_{t+1}, r_{t+1}) \tag{12}$$

where $q(\cdot)$ is continuous. We can write

$$\lambda_{t+1} = q(f(\lambda_t) - f'(\lambda_t)\lambda_t, f(\lambda_{t+1}) - f'(\lambda_{t+1})\lambda_{t+1}, f'(\lambda_{t+1})) \tag{13}$$

where $f(\cdot)$ is the usual expression in term of efficiency units of labour.

A fixed point exists by Brouwer Fixed Point Theorem (Berge (1997): Corollary 1, p. 118). Thus both types of capital grow at constant rate $g \geq 0$.

□

Proof of Proposition 2

Proof. 1. See Lemmas 1 and 2 above.

2. From Figure 1 it is immediate to see that when the endowment grows the marginal cost of capital investment shifts downswards. Thus it is obvious that the trigger level is reached when the marginal utility of capital is greater than marginal cost for the capital that allow to consume $\bar{c}$ tomorrow. Define the required capital $\bar{k}$ to be:

$$\bar{c} = \bar{k}(1+r) + w\ h(h'^{-1}(1+r))$$

then the cutoff is defined by

$$\beta v'(\bar{c}) = u'\left(w(a_i - h'^{-1}(1+r))) - \bar{k}\right)$$

replacing we can define implicitly the level of a_i that triggers the aspiration catching up:

$$\beta v'(\bar{c}) = u'\left(w(a_i - h'^{-1}(1+r))) + \frac{w\ h(h'^{-1}(1+r)) - \bar{c}}{1+r}\right) \tag{14}$$

Applying the implicit function theorem, it is immediate to see that it is a monotonic function of the aspiration level $\bar{c}$:

$$\frac{\partial a^*}{\partial \bar{c}} = -\frac{\beta v''(\bar{c}) + u''\left(w(a^* - h'^{-1}(1+r))) + \frac{w\ h(h'^{-1}(1+r)) - \bar{c}}{1+r}\right)/(1+r)}{-u''\left(w(a^* - h'^{-1}(1+r))) + \frac{w\ h(h'^{-1}(1+r)) - \bar{c}}{1+r}\right)} > 0 \tag{15}$$

so the threshold is unique.

3. For $\underline{c}$, the comparative statics makes sense only in the interval $[0,\ \bar{c}]$. For an aspiration realization solution, no change occurs since the properties of the function above the aspiration don't change. In the aspiration failure case, moving $\underline{c}$ shifts the first concave part in the same direction and so the solution: it is just an implication of concavity, now the minimum $v'(\underline{c})$ is reached for an higher (lower) level of $\underline{c}$, so by concavity the previous solution is at the left (right) of the new one. since $w\ h(e^*)$ is fixed, the higher the capital the higher the consumption. For sufficiently low $\underline{c}$ the optimal capital is again the corner solution.

4. From (15) we know that *ceteris paribus*, if the endowment is below the threshold, increasing the $\bar{c}$ or decreasing it without reaching the threshold is not affecting the solution. When it decreases enough to reach the cutoff it jumps from the aspiration failure to aspiration reached. For the aspiration reached the optimal consumption is moving in the same direction as $\bar{c}$, for a similar argument as point 2) above. □

Proof of Theorem 1 and Proposition 3

Consider a steady state of the economy with distribution μ and growth rate g. Look at time t when the steady state has been reached and compute $\bar{a}_t$.

Claim 1. If there exists $i \in I$ such that $a_{i,t} < \bar{a}_t$, then the steady state is polarized.

Proof. For every $a \in \mathbb{R}$ define as c_a^R as the optimal solution of the agent's problem under the restriction that the consumption of the second period of her life is weakly above $\bar{c}_{t+1}$ (if feasible under the budget constraint); also, define define as c_a^F the solution to the consumption of the second period of her life is weakly below $\underline{c}_{t+1}$ (if feasible); define as c_a^{-1} the consumption of an agent that leaves a bequest equal to

a. Finally, define $g_a^R = \frac{c_a^R - c_a^{-1}}{c_a^{-1}}$ and $g_a^F = \frac{c_a^F - c_a^{-1}}{c_a^{-1}}$. Notice that g_a^F and g_a^R are also clearly continuous in a. Also, by construction we must have $g_a^R > g_a^F$ for every $a \in \mathbb{R}$ in which both c_a^R and c_a^R are defined. Notice also that, by construction of $\bar{a}_t$, c_a^F is the optimal behavior for every agent such that $a < \bar{a}_t$ and c_a^R is the optimal behavior of an agent with $a > \bar{a}_t$. Consider now $\bar{\epsilon} > 0$ and $\epsilon, \epsilon' \in (0, \bar{\epsilon})$. By continuity, we must have that, if $\bar{\epsilon}$ is small, $g_{a+\epsilon}^R > g_{a-\epsilon'}^F$. But since in a steady state the distribution is stable, then we cannot have that, for any ϵ, ϵ', we both have $\mu(a+\epsilon) > 0$ and $\mu(a-\epsilon') > 0$. Therefore, either $\mu(a+\epsilon) = 0$ for all $\epsilon \in (0, \bar{\epsilon})$, or $\mu(a-\epsilon) = 0$ for all $\epsilon \in (0, \bar{\epsilon})$, or both. In either case, since by assumption there exists $i \in I$ such that $a_{i,t} < \bar{a}_t$, and since by construction $\max_{i \in I} a_{i,t} > \bar{a}_t$, then the distribution must be polarized. □

Claim 2. If $a_{i,t} \geq \bar{a}_t$ for every $i \in I$, then every steady state is of perfect equality.

Proof. Consider a steady state in which $a_{i,t} \geq \bar{a}_t$ for every $i \in I$. By construction of $\bar{a}_t$, this is true if and only if $c_{i,t+1} \geq \bar{c}_{t+1}$. Since, however, $\bar{c}_{t+1}$ is also the average of $c_{i,t+1}$, then this can be true only if $c_{i,t} = \bar{c}_{t+1}$ for every $i \in I$, proving the claim. □

This concludes the proof of the Theorem. Proposition 3 is trivially proven by noticing which of the two cases above applies in each of the special cases presented. *Q.E.D.*

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