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Ahmad Naimzada, Marina Pireddu

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A positional game for an overlapping generation economy

Ahmad Naimzada [a*], Marina Pireddu [b†]

[a] Dept. of Economics, Quantitative Methods and Management, University of Milano-Bicocca, Milan

[b] Dept. of Mathematics and Applications, University of Milano-Bicocca, Milan

Abstract

We develop a model with intra-generational consumption externalities, based on the overlapping generation version of Diamond (1965) model. More specifically, we consider a two-period lived overlapping generation economy, assuming that the utility of each consumer depends also on the average level of consumption by other consumers in the same generation. In this way we obtain a positional game embedded in an overlapping generation economy. We characterize the consumption and saving choices for the two periods in the Nash equilibrium path and we determine a dynamic equation for capital accumulation coherent with the agents' choices in the Nash equilibrium. Hence, also the behavior, both static and dynamic, described by the equation for the capital accumulation is coherent with the Nash equilibrium. For the associated dynamical system we find a unique positive steady state for capital, which is globally stable. Its position is decreasing with respect to positive variations in the degree of interaction in the first period, while the opposite relation holds in the second period. We then compare the steady states for capital with and without social interaction. In this respect we show that the steady state with social interaction is larger than the steady state in the absence of social interaction if and only if the degree of interaction in the second period exceeds the degree of interaction in the first period. In particular, if the degrees of interaction in the two periods coincide, the dynamical system is equivalent to the one without social interaction.

Keywords: Positional game; overlapping generations; consumption externalities; stability; comparative statics.

JEL classification: C720; D91; E210; O41.

*Mailing address: University of Milano-Bicocca, U7 Building, Via Bicocca degli Arcimboldi 8, 20126 Milano, Italy. Tel.: +39 0264485813; fax: +39 0264483085. E-mail address: ahmad.naimzada@unimib.it

†Corresponding author at: University of Milano-Bicocca, U5 Building, Via Cozzi 53, 20125 Milano, Italy. Tel.: +39 0264485729; fax: +39 0264485705. E-mail address: marina.pireddu@unimib.it

1 Introduction

The aim of the present paper is to analyze the role of the social dimension of consumption in an overlapping generation (OLG) model.
Traditional microeconomic accounts of consumption choices tend to characterize consumers in terms of a certain utility function that has to be maximized on the basis of the price structure and of the available budget; the possibility that preferences depend in turns on the consumption choices of others is admitted but generally it is not considered an essential feature of the model. However, especially in the past two decades, there has been an increasing interest in introducing the social dimension of consumption into the core of the state-of-the-art microeconomic theory (Frank, 2000, 2005). Introducing this element in the OLG framework amounts to something more than adding yet another element of dynamic complexity: it is a basic requisite for the consumption model to be realistic enough. In principle, introducing the social dimension of consumption could pave the way to both cooperative and competitive forms of interaction. The former includes, for instance, psychological benefits from the joint cultivation of common interests (e.g., sharing materials, information and emotions), and more generally, the so called relational goods (Uhlaner, 1989), i.e., goods whose enjoyment is enhanced by the simultaneous participation of others. The latter includes all kinds of positional competition, i.e., situations where the level of satisfaction deriving from the enjoyment of a given good is determined to some extent by the level of consumption of the same good by individuals belonging to a given social reference group (Frank, 1991). In this case, the social dimension, rather than being welfare-enhancing, easily becomes welfare destroying and is likely to be conducive to suboptimal over-consumption outcomes that closely replicate the social dynamics of arms races. The circumstances that cause the emergence of a cooperative or competitive social consumption attitude are generally complex and may be regarded as the outcome of a cultural evolution process acting on different motivational orientations (Menicucci and Sacco, 2009).
In this paper, we do not want to tackle the general problem of attitude selection, but rather to explore the implications of a given social mode of consumption. Specifically, we will focus here upon positional competition, i.e., on a form of social consumption that is potentially welfare destroying. Moreover, current forms of post-industrial consumption are very sensitive to the positional dimension (Goodwin et al., 1997), which is often invoked as an explicit motivational leverage for prospective buyers of goods and services, especially in the luxury segments of the consumption spectrum. The literature concerning positional consumption is mainly addressed towards static aspects of interdependent preferences (Duesenberry, 1949, Leibenstein, 1950, Hirsch, 1977), while there are a few papers concerning dynamical aspects. Rauscher (1992, 1993) in a dynamic setting show the possibility of complex dynamics and Antoci et al. (2010) and Naimzada et al. (2013) endogenize the social interaction coefficient.
Other approaches can be obtained by changing the kind of reference level of consump-

tion. For instance, De la Croix (1996) proposes an OLG model with production in which children inherit life standard aspirations from their parents, that is, the comparison reference level of consumption is given by parents' first period consumption level. Lahiri and Puhakka (1998) introduce subtractive habit persistence preferences into the standard pure exchange overlapping generation model. The reference level is here given by the agent's first period consumption level. Bunzel (2006) provides a complete characterization of the stationary and non-stationary monetary equilibria in a two-period pure exchange overlapping generation model with multiplicative habit persistence preferences. Also in this case the reference level is given by the agent's first period consumption level.

Using the overlapping generation version of Diamond (1965) model with productive capital, we develop a model with intra-generational consumption externalities. More specifically, we consider a two-period lived overlapping generation economy, assuming that the utility of a consumer in each generation depends not only on his own consumption, but also on the benchmark consumption given by the average level of consumption by other consumers in the same generation. In this way we obtain a positional game embedded in an overlapping generation economy, which displays strategic complementarity, i.e., each player increases his consumption strategy when the consumption strategies of other players increase.

We assume logarithmic utility functions and Cobb-Douglas production function. Our formalization crucially relies on two parameters describing the social interaction in the first and the second period, i.e., ρ_1 and ρ_2, respectively. The main goal of the paper is to analyze the dynamical system generated by the capital accumulation equation, in particular as concerns the stability of the positive steady state for capital and its position in dependence of variations in the parameters representing social interaction. We also compare the frameworks with and without social interaction.

The results we obtain are summarized hereinafter. We characterize the consumption and saving choices for the two periods in the Nash equilibrium path and we determine a dynamic equation for capital accumulation coherent with the agents' choices in the Nash equilibrium. Hence, also the behavior, both static and dynamic, described by the equation for the capital accumulation is coherent with the Nash equilibrium. For the associated dynamical system we find a unique positive steady state for capital, which is globally stable. Its position is decreasing with respect to positive variations in the degree of interaction in the first period, while the position is increasing with respect to positive variations in the degree of interaction in the second period. We then compare the steady states for capital with and without social interaction. In this respect we show that the steady state with social interaction is larger than the steady state in the absence of social interaction if and only if the degree of interaction in the second period exceeds the degree of interaction in the first period. In particular, if the degrees of interaction in the two periods coincide, the dynamical system is equivalent to the one without social interaction.

The remainder of the paper is organized as follows. In Section 2 we introduce the model and characterize the Nash equilibrium path. Section 3 contains our main results. Section 4 concludes.

2 The model

We consider a two-period lived overlapping generation economy, where in each period only two types of agents are alive, young and old. In their first period of life, when young, agents are endowed with one unit of labor, that they supply inelastically to firms. Their income is equal to the real wage, that they allocate between current consumption and savings, which are invested in the firms. In their second period of life, when old, they are retired. Their income comes from the return of the savings made in the first period of life. Agents are identical within each generation. Population is constant over time and each cohort is composed by N agents. The utility function of the representative agent i born at time t is given by

$$u_t^i = \log(c_{i,t} - \rho_1 \bar{c}^e_{-i,t}) + \beta \log(c_{i,t+1} - \rho_2 \bar{c}^e_{-i,t+1}) \tag{2.1}$$

where $\rho_1, \rho_2 \in [0,1]$ are the social interaction coefficients in the first and second periods, respectively; $\beta > 0$ is the given discount factor. Moreover, $c_{i,t}$ denotes consumption when agent i is young and $\bar{c}^e_{-i,t}$ denotes the average consumption by the other $N-1$ agents at the end of time t, expected at the beginning of the same period; similarly, $c_{i,t+1}$ denotes consumption when agent i is old and $\bar{c}^e_{-i,t+1}$ denotes the average consumption by the other $N-1$ agents at the end of time $t+1$, expected at the beginning of period t. In symbols, $\bar{c}^e_{-i,t} = \sum_{j\neq i} \frac{c^e_{ij,t}}{N-1}$, where $c^e_{ij,t}$ denotes the consumption by agent j at the end of time t, expected by agent i at the beginning of the same period; similarly, $\bar{c}^e_{-i,t+1} = \sum_{j\neq i} \frac{c^e_{ij,t+1}}{N-1}$, where $c^e_{ij,t+1}$ denotes the consumption by agent j at the end of time $t+1$, expected by agent i at the beginning of period t. Notice that when $\rho_1 = \rho_2 = 0$ we are in the case of an economy without social interaction, while when $\rho_1 = \rho_2 = 1$ we have an economy with the largest degree of interaction.

The budget constraints of consumers in the young and old ages are respectively given by

$$w_t = c_{i,t} + s_{i,t} \tag{2.2}$$

and

$$c_{i,t+1} = (1 + r^e_{i,t+1})(w_t - c_{i,t}), \tag{2.3}$$

where w_t is the real wage rate, $s_{i,t}$ is agent i saving and $r^e_{i,t+1}$ is the expected interest rate in period $t+1$. The agent born at the beginning of period t chooses $c_{i,t}$ and $c_{i,t+1}$ in order to maximize u_t^i subject to the lifetime budget constraints (2.2) and (2.3). We stress that, since all agents have identical strategy spaces $(0, w_t)^2 \ni (c_{i,t}, c_{i,t+1})$, for every t and i, and the payoff functions in (2.1) are symmetric, the decision problem

is a symmetric game.
The first order conditions for our maximization problem are

$$\frac{1}{c_{i,t} - \rho_1 \bar{c}^e_{-i,t}} = \lambda \tag{2.4}$$

and

$$\frac{\beta}{c_{i,t+1} - \rho_2 \bar{c}^e_{-i,t+1}} = \frac{\lambda}{1 + r^e_{i,t+1}}, \tag{2.5}$$

where $\lambda > 0$ is the Lagrange multiplier. Inserting λ from (2.4) into (2.5), we obtain

$$1 + r^e_{i,t+1} = \frac{c_{i,t+1} - \rho_2 \bar{c}^e_{-i,t+1}}{\beta(c_{i,t} - \rho_1 \bar{c}^e_{-i,t})} = \frac{c_{i,t+1} - \rho_2 \sum_{j \neq i} \frac{c^e_{ij,t+1}}{N-1}}{\beta\left(c_{i,t} - \rho_1 \sum_{j \neq i} \frac{c^e_{ij,t}}{N-1}\right)}.$$

Assuming perfect foresight for the agents, that is, $r^e_{i,t+1} = r_{t+1}$ and $c^e_{ij,t} = c_{j,t+1}$, for every t, every i and $j \neq i$, the expression above becomes

$$1 + r_{t+1} = \frac{c_{i,t+1} - \rho_2 \sum_{j \neq i} \frac{c_{j,t+1}}{N-1}}{\beta\left(c_{i,t} - \rho_1 \sum_{j \neq i} \frac{c_{j,t}}{N-1}\right)}. \tag{2.6}$$

and (2.3) becomes

$$c_{i,t+1} = (1 + r_{t+1})(w_t - c_{i,t}). \tag{2.7}$$

Inserting then $c_{i,t+1}$ from (2.7) into (2.6), we obtain

$$1 + r_{t+1} = \frac{(1 + r_{t+1})(w_t - c_{i,t}) - \rho_2 \sum_{j \neq i} \frac{(1+r_{t+1})(w_t - c_{j,t})}{N-1}}{\beta\left(c_{i,t} - \rho_1 \sum_{j \neq i} \frac{c_{j,t}}{N-1}\right)}.$$

Making $c_{i,t}$ explicit in the last equation, we obtain the best response function for agent i

$$c_{i,t} = \frac{w_t(1 - \rho_2) + \sum_{j \neq i} \frac{c_{j,t}}{N-1}[\beta\rho_1 + \rho_2]}{1 + \beta}. \tag{2.8}$$

We stress that, since for every t, for all i and $j \neq i$ it holds that

$$\frac{\partial c_{i,t}}{\partial c_{j,t}} = \frac{\beta\rho_1 + \rho_2}{(N-1)(1+\beta)} > 0,$$

the game we are considering displays strategic complementarity. Notice also that, as expected,

$$\frac{\partial c_{i,t}}{\partial \rho_1} = \sum_{j \neq i} \frac{\beta\, c_{j,t}}{(N-1)(1+\beta)} > 0$$

$$\frac{\partial c_{i,t}}{\partial \rho_2} = \frac{-w_t + \sum_{j \neq i} \frac{c_{j,t}}{N-1}}{\beta + 1} < \frac{-w_t + \sum_{j \neq i} \frac{w_t}{N-1}}{1 + \beta} = 0.$$

Due to the symmetry of the game, it follows that $c_{1,t} = \ldots = c_{N,t} = c_t$ and thus (2.8) becomes

$$c_t = \frac{w_t(1-\rho_2) + \sum_{j \neq i} \frac{c_t}{N-1}[\beta\rho_1 + \rho_2]}{1+\beta},$$

from which we get

$$c_t = \frac{w_t(1-\rho_2)}{1+\beta-\beta\rho_1-\rho_2}. \tag{2.9}$$

This is the symmetric Nash equilibrium for our game, which is dynamic in nature and depends on the real wage w_t, endogenously determined by the capital accumulation process.

From (2.2) and (2.9) we obtain the savings in the Nash equilibrium

$$s_t = w_t - c_t = \frac{\beta(1-\rho_1)w_t}{1+\beta-\beta\rho_1-\rho_2}. \tag{2.10}$$

Moreover, since the equilibrium condition in the good market reads as

$$k_{t+1} = s_t, \tag{2.11}$$

by (2.10) and (2.11) we get

$$k_{t+1} = \frac{\beta(1-\rho_1)w_t}{1+\beta-\beta\rho_1-\rho_2}. \tag{2.12}$$

Assuming a Cobb-Douglas production technology given, in intensive form, by

$$f(k_t) = Ak_t^\alpha,$$

with $A > 0$ and $0 < \alpha < 1$, then we find that the real wage is

$$w(k_t) = f(k_t) - k_t f'(k_t) = A(1-\alpha)k_t^\alpha.$$

Inserting this expression for $w(k_t)$ into (2.12), we finally obtain the following dynamic equation for the capital accumulation

$$k_{t+1} = \frac{A(1-\alpha)(1-\rho_1)\beta k_t^\alpha}{1+\beta-\beta\rho_1-\rho_2}. \tag{2.13}$$

We are going to study the main features of the dynamical system it generates in the next section.

3 Results

In this section we discuss the existence of steady states for capital in the presence and absence of social interaction and we compare their expressions. Then we analyze the stability of the system and we perform some comparative static exercises, in order to better understand the dependence of the globally stable steady state with respect to some crucial parameters.

In view of the subsequent analysis, it is expedient to introduce the map $F : \mathbb{R}_+ \to \mathbb{R}$ defined as

$$F(k) = \frac{A(1-\alpha)(1-\rho_1)\beta k^{\alpha}}{1+\beta-\beta\rho_1-\rho_2}, \tag{3.1}$$

associated to the dynamic equation in (2.13). Since for the denominator it holds that $1+\beta-\beta\rho_1-\rho_2 = 1-\rho_2+\beta(1-\rho_1)$, by our assumptions on ρ_1, ρ_2 and α, it follows that F is positive. Moreover, since $0 < \alpha < 1$, the map is increasing and concave. When we set $\rho_1 = \rho_2 = 0$ in (3.1), we find the classical increasing and concave function which describes the system in the absence of social interaction, i.e.,

$$F_0(k) = \frac{A(1-\alpha)\beta k^{\alpha}}{1+\beta}\,.$$

Notice that we obtain the same expression also when we set $\rho_1 = \rho_2 = \bar{\rho} \in (0,1]$ in F. This means that, if the degree of social interaction is the same in both periods, the dynamic behavior of the system coincides with that in the absence of social interaction.

Let us now show in the following result the existence of a unique interesting steady state for (2.13).

Proposition 3.1 *In addition to the origin, the dynamical system generated by the map F in* (3.1) *has the unique positive steady state*

$$k^* = \left(\frac{A(1-\alpha)(1-\rho_1)\beta}{1+\beta-\beta\rho_1-\rho_2}\right)^{\frac{1}{1-\alpha}}. \tag{3.2}$$

Proof. The expression for k^* immediately follows by solving the fixed point equation $F(k) = k$. □

Observe that, when $\rho_1 = \rho_2 = \bar{\rho} \in [0,1]$, the expression for the steady state in (3.2) becomes

$$k_0^* = \left(\frac{A(1-\alpha)\beta}{1+\beta}\right)^{\frac{1}{1-\alpha}}.$$

As stated in the next result, the precise relationship between k^* and k_0^* depends on the relative values of the parameters ρ_1 and ρ_2. Indeed we have the following:

Corollary 3.1 *It holds that $k^* > k_0^*$ if and only if $\rho_2 > \rho_1$.*

Proof. Notice at first that it is possible to rewrite k^* and k_0^* respectively as follows:

$$\begin{aligned} k^* &= \left(\tfrac{A(1-\alpha)(1-\rho_1)\beta}{1+\beta-\beta\rho_1-\rho_2\pm\rho_1}\right)^{\frac{1}{1-\alpha}} = \left(\tfrac{A(1-\alpha)(1-\rho_1)\beta}{1+\beta-\beta\rho_1-\rho_1+\rho_1-\rho_2}\right)^{\frac{1}{1-\alpha}} = \\ &= \left(\tfrac{A(1-\alpha)(1-\rho_1)\beta}{(1+\beta)(1-\rho_1)+\rho_1-\rho_2}\right)^{\frac{1}{1-\alpha}} \end{aligned}$$

and

$$k_0^* = \left(\frac{A(1-\alpha)(1-\rho_1)\beta}{(1-\rho_1)(1+\beta)}\right)^{\frac{1}{1-\alpha}}.$$

Hence, it is immediate to check that $k^* > k_0^*$ if and only if $\rho_2 > \rho_1$, as desired. $\square$

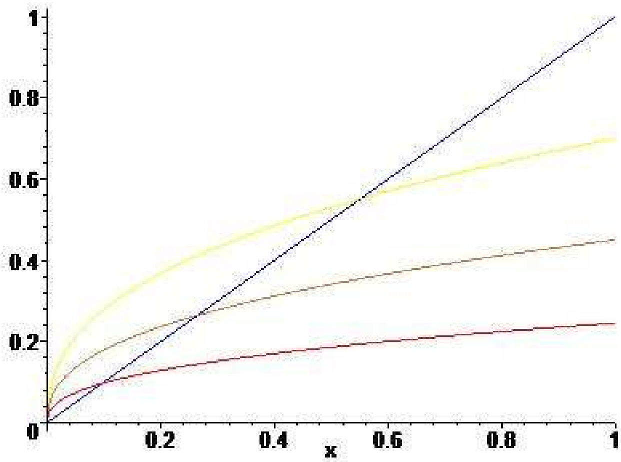

Figure 1: We represent in yellow the map F with $\rho_1 = 0.3$ and $\rho_2 = 0.7$, in brown the map F with $\rho_1 = \rho_2 = 0.5$ and in red the map F with $\rho_1 = 0.7$ and $\rho_2 = 0.3$. Moreover, for all three graphs, we have fixed $A = 2$, $\alpha = 0.4$ and $\beta = 0.6$.

A graphical illustration of Corollary 3.1 can be found in Figure 1, where we show that the value of steady state for capital increases with the increase of the difference between the social interaction coefficients in the second and in the first periods, i.e., of $\rho_2 - \rho_1$.
Since the relationship between the steady states for capital with and without social interaction has been clarified, in what follows we focus on the more general case of k^* only and on the dynamics generated by the map F.

Proposition 3.2 *The dynamical system generated by the map F in* (3.1) *is globally stable.*

Proof. We show that, for any starting point $\bar{k} > 0$, its forward F-trajectory tends to k^*. In fact, since $F(0) = 0$, F is strictly increasing and k^* is the unique positive fixed point of F, then, by continuity, $F(k) > k$, for every $0 < k < k^*$, and $F(k) < k$, for every $k > k^*$. Hence, if $0 < \bar{k} < k^*$, then $F^n(\bar{k})$ will tend increasingly towards k^* as $n \to \infty$, while if $\bar{k} > k^*$, then $F^n(\bar{k})$ will tend decreasingly towards k^* as $n \to \infty$. The proof is complete. □

Thanks to the global stability result shown in Proposition 3.2, the Nash equilibrium we found in (2.12) is dynamic in nature during the transient phase, while it becomes static in the long run.

We conclude the present section by performing some comparative static exercises. In particular, in the next result we analyze the dependence of the steady state for capital on the social interaction parameters ρ_1 and ρ_2.

Proposition 3.3 *It holds that* $\frac{\partial k^*}{\partial \rho_1} < 0$ *and* $\frac{\partial k^*}{\partial \rho_2} > 0$.

Proof. A direct computation shows that

$$\begin{aligned}\frac{\partial k^*}{\partial \rho_1} &= \frac{1}{1-\alpha}\left(\frac{A(1-\alpha)(1-\rho_1)\beta}{1+\beta-\beta\rho_1-\rho_2}\right)^{\frac{1}{1-\alpha}-1} \cdot \frac{A(1-\alpha)(\rho_2-1)\beta}{(1+\beta-\beta\rho_1-\rho_2)^2} = \\ &= \left(\frac{A(1-\alpha)(1-\rho_1)\beta}{1+\beta-\beta\rho_1-\rho_2}\right)^{\frac{\alpha}{1-\alpha}} \cdot \frac{A\beta(\rho_2-1)}{(1+\beta-\beta\rho_1-\rho_2)^2} < 0\end{aligned}$$

and

$$\begin{aligned}\frac{\partial k^*}{\partial \rho_2} &= \frac{1}{1-\alpha}\left(\frac{A(1-\alpha)(1-\rho_1)\beta}{1+\beta-\beta\rho_1-\rho_2}\right)^{\frac{1}{1-\alpha}-1} \cdot \frac{A(1-\alpha)(1-\rho_1)\beta}{(1+\beta-\beta\rho_1-\rho_2)^2} = \\ &= \left(\frac{A(1-\alpha)(1-\rho_1)\beta}{1+\beta-\beta\rho_1-\rho_2}\right)^{\frac{\alpha}{1-\alpha}} \cdot \frac{A(1-\rho_1)\beta}{(1+\beta-\beta\rho_1-\rho_2)^2} > 0.\end{aligned}$$

□

The result above is quite intuitive and allows a clear interpretation. In fact, an increasing interest towards the others' choices in the first period makes consumption in the first period increase and thus the accumulated capital decreases. Vice versa, an increasing interest towards the others' choices in the second period makes accumulated capital increase in order to have the possibility to increase consumption in the second period.

4 Conclusions

We have considered a two-period lived overlapping generation economy, with the utility of each consumer depending also on the average level of consumption by other consumers in the same generation. In this way we obtained a positional game embedded in an overlapping generation economy. We characterized the agents' choices along the Nash equilibrium path and the dynamic equation describing the capital accumulation. For the latter we found a unique positive steady state for capital, which is globally stable. Its position is decreasing with respect to positive variations in the degree of interaction in the first period, while the opposite relation holds in the

second period. We compared the steady states for capital with and without social interaction, showing that the steady state with social interaction is larger than the steady state in the absence of social interaction if and only if the degree of interaction in the second period exceeds the degree of interaction in the first period.
Future research should focus on the introduction of a further degree of heterogeneity, by assuming that the agents within a generation may have different social interaction coefficients. In such context one could investigate how consumption varies according to the value of those coefficients and also compare consumption for all kinds of agents with the consumption level in the absence of social interaction.

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