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Demography and pollution ☆

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ABSTRACT

In this paper, we consider an OG model with endogenous fertility and pollution externalities. We assume that pollution lowers the productivity. In the long run, under dominant income (substitution) effects, a raise in the cost of rearing children, increases (decreases) consumption and decreases (increases) pollution. In the short run, under dominant income effects, a sufficiently low pollution elasticity of labor productivity promotes deterministic cycles through a Hopf bifurcation jointly with expectations-driven fluctuations.

1. Introduction

In this paper, we consider the dynamic interplay between demography and pollution. On the one hand, pollution affects the productivity of workers because of its impact on health. On the other hand, demography changes the supply of labor, its impact on growth and pollution in turn. We consider short and long run effects, but the novelty of the paper mainly rests on the analysis of equilibrium multiplicity.

The dynamic aspects of pollution have been considered either in economies à la Ramsey or in OG models. Our paper contributes to the OG literature, pioneered by John and Pecchenino (1994) where the issue of sustainability of economic growth was addressed.

In OG framework à la Diamond (1965) (with capital accumulation), Seegmuller and Verchère (2004) and Schumacher and Zou (2008) prove that, when the consumer chooses between consumption and environmental quality, endogenous business cycles may appear in a neighborhood of the steady state. Seegmuller and Verchère (2007) study an OG economy where households arbitrate between leisure, consumption and environmental quality. Considering pollution as a flow, these authors find that the elasticity of labor supply plays a role for equilibrium indeterminacy and the concavity of preferences promotes the emergence of sunspot equilibria.

One can raise the question whether technology or preferences matter more in the occurrence of such endogenous fluctuations. Even if the debate is not ended, Azariadis (1981) stresses the role of technology in promoting equilibrium multiplicity. In this respect, Grandmont et al. (1998) focus on the degree of capital-labor substitution and Cazzavillan et al. (1998) on the increasing returns to scale to demonstrate the existence of sunspot equilibria. Conversely, the level of gross substitutability between consumption and labor seems to play a little role to explain the equilibrium indeterminacy in OG economies without pollution.

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To rule out any misleading interference from capital accumulation, we consider a simple monetary model à la Samuelson (1958) where money represents households' savings. In addition, we consider labor supply in terms of endogenous fertility *à la* Galor and Weil (1996) with an environmental dimension. In contrast to Seegmuller and Verchère (2007), pollution does not enter household utility, but simply lowers labor productivity. Moreover, we treat pollution as a stock instead of a flow, that is as a predetermined variable, and, in this sense, we remain close to John and Pecchenino (1994). In this context, we study the long-run effects of pollution and demography on consumption. In the short run, we find that, under dominant income effects, a lower pollution elasticity of labor productivity may promote the emergence of sunspot equilibria through a Hopf bifurcation. In this sense, the joint effect of technology (through the externalities of pollution) and preferences (through the elasticity of intertemporal substitution) seems to play a role for the occurrence of endogenous fluctuations.

The paper is organized as follow. In the next section, we present the model. The market clearing conditions are given in Section 3. In Sections 4 and 5, we study the steady state and the stability properties of equilibrium. In addition, we provide an interpretation for the effects of pollution in the long run and the occurrence of fluctuations in the short run. Section 6 concludes.

2. The model

The economy consists of an infinite sequence of overlapping generations living three periods: childhood, adulthood and the old age. Time is discrete and is indexed by $t=0,1,\ldots$ Agents self-replicate and divide their income between consumption and the number of children desired. They derive no satisfaction in childhood, they have children in adulthood and consume in the old age. In this economy, a single consumption good is produced using a technology with labor as single input. Without capital market, the agents transfer income from adulthood to the old age gaining currency. In addition, production generates pollution that reduces labor productivity.

2.1. Producers

There are q firms with no market power (let m be sufficiently large) that transform a unique input l_{jt} (labor demand) in a unique output y_{jt} with $j=1,\ldots,q$. Technology is represented by a linear function:

$$y_{jt}=A_t l_{jt}$$

The firm j maximizes the profit:

$$\pi_{jt}\equiv p_t y_{jt}-w_t l_{jt}=p_t A_t l_{jt}-w_t l_{jt}$$

Let ω_t denote the real wage: $\omega_t\equiv w_t/p_t$. Profit maximization implies at equilibrium that the real wage is equal to the productivity of labor:

$$\omega_t=A_t$$

The aggregate production Y_t is given by

$$Y_t\equiv\sum_{j=1}^{q} y_{jt}=A_t\sum_{j=1}^{q} l_{jt}\equiv A_t L_t \tag{1}$$

and depends linearly on the aggregate labor demand L_t.

2.2. Consumers

The economy is populated by individuals who live for three periods. Consider an individual born at time $t-1$.

During childhood (period $t-1$), he neither works nor consumes. The introduction of childhood does not matter in the model, but allows us to justify that an individual makes children only in his adult period.

In the working age (period t), he supplies labor at a nominal wage rate w_t, makes n_t children and saves through nominal balances m_{t+1} without consuming. For simplicity, we assume that an individual can generate n_t children alone. Rearing children takes time: z is the constant leisure-time needed per child. So, the opportunity cost of rearing children is given by $w_t z n_t$. We normalize to one the endowment of leisure time in the adult period. The individual labor supply turns out to be endogenous as a result of the endogenous fertility: $l_t=1-zn_t$.

At the end of his life-cycle (period $t+1$), the individual consumes the quantity c_{t+1} using the monetary savings.

Money is the numeraire and the budget constraints of second and third period become

$$m_{t+1}\le w_t(1-zn_t) \tag{2}$$

$$p_{t+1}c_{t+1}\le m_{t+1} \tag{3}$$

In addition, we require $n_t\le 1/z$.