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Habit formation and resource dependence in dynastic economies[☆]

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ABSTRACT

This paper studies the consequences of habit formation in dynastic economies that exploit exhaustible resources. If the strength of habits is below a critical level, positive bequests generate Ramsey–Stiglitz equilibria: the altruism factor determines long-run growth and habits increase output levels by increasing capital accumulation and smoothing resource extraction during the transition. If the strength of habits is above the threshold, zero bequests induce Diamond–Mourmouras equilibria: the transitional effects become permanent and habits increase long-run growth. Results differ from those of capital–labor models because resource dependence implies that long-run growth is determined by the intergenerational distribution of wealth.

1. Introduction

A growing body of empirical evidence shows that preferences are time-dependent and influenced by aspirations. Economic agents form habits and tend to assess their present satisfaction on the basis of deviations from the standards of living enjoyed in the past (see e.g. Fuhrer, 2000). Theoretical models predict that habit formation generates reallocation effects that influence capital accumulation through saving decisions (Ryder and Heal, 1973) and affects long-term development if the economy displays endogenous growth (Carroll et al., 1997; Alvarez-Cuadrado et al., 2004). The aim of this paper is to analyze the consequences of habit formation for economic growth, income levels and welfare in overlapping-generations (OLG) models where production possibilities are constrained by resource scarcity: differently from the standard neoclassical model with capital and labor, we assume that output is obtained by combining man-made capital and labor with a third input, e.g. oil, extracted from a non-renewable stock of 'natural capital'.

The issue is relevant because the growth process of capital–resource economies differs from that arising in capital–labor economies. As a reference, consider a perfectly competitive economy with neoclassical technology exhibiting constant returns to scale at the aggregate level. It is well known that, if production only requires labor and man-made capital, the asymptotic growth rate of consumption is entirely determined by population and/or labor-efficiency growth: this *exogeneity result* holds in both versions of the model, i.e., the Ramsey variant with infinitely-lived agents and the OLG variant with selfish agents *à la* Diamond (1965). Introducing resource dependence in production modifies this conclusion: the sustainability literature pioneered by Dasgupta and Heal (1974) and Stiglitz (1974) shows that when both man-made capital and exhaustible resources are essential inputs, preference parameters determine the long-run growth rate.[1] This *endogeneity result* takes specific forms depending on the assumed demographic structure: with infinitely-lived agents, the long-run growth rate is negatively related to the social discount rate (Stiglitz, 1974). In OLG economies with selfish agents, the long-run growth rate depends on the technology and private-preference parameters determining the intergenerational distribution of wealth (Howarth and Norgaard, 1990; Mourmouras, 1991). These considerations suggest that habit formation has peculiar consequences for resource-using economies: since long-run growth is determined by the intergenerational distribution, the effects of habits on welfare and income levels may differ substantially from those predicted by capital–labor models. This paper tackles the issue by analyzing the

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[1] The presence of preference parameters in the reduced-form expression of the growth rate signals the endogenous determination of the growth rate (Solow, 2000, p. 119). In this respect, the capital–resource model of Dasgupta and Heal (1974) and Stiglitz (1974) differs from the Ramsey–Cass–Koopmans model because the long-run growth rate depends on preference parameters; at the same time, it differs from endogenous-growth models because the aggregate technology satisfies constant returns to scale.

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competitive equilibria of a resource-dependent dynastic economy: agents are potentially altruistic but habit formation contrasts their willingness to provide bequests to descendants.

The similarity with capital–labor models is twofold: the competitive economy approaches different equilibria depending on whether bequests are operative (Thibault, 2000), and the operativeness of bequests is linked to the strength of habits: transfers are positive (zero) if the degree of habit persistence is below (above) a critical threshold level (Alonso-Carrera et al., 2007; Schäfer and Valente, in press). The difference is that growth rates differ between the two equilibria due to resource dependence. Specifically, the present analysis demonstrates the following results.

If the strength of habits is below a critical level, bequests are operative, growth is determined by the altruism factor and habits yield permanent effects on output levels via transitional effects on growth rates and capital profitability: stronger habits induce a stronger willingness to accumulate capital in the short run, and the resulting input-substitution effect with natural resources reduces (increases) resource use in the short (long) run, smoothing the time profile of extraction. This *Ramsey-like equilibrium* satisfies present-value optimality (Pezzey and Withagen, 1998) and implies non-declining consumption levels only if resource-augmenting technical progress is strong enough to compensate for intergenerational discounting.

If the strength of habits is above the critical threshold, instead, the economy achieves a selfish equilibrium where all the transitional growth effects mentioned above become permanent: stronger habits increase the growth rate of output and incomes even in the long run via faster capital accumulation and a flatter time-profile of resource extraction. Notably, in this *Diamond-like equilibrium*, the growth rate is higher than in altruistic regimes because of habits. However, this result should be interpreted with care because the selfish economy does not satisfy present-value optimality.

The plan of the paper is as follows. Section 2 describes the model's assumptions. Sections 3 and 4 analyze altruistic and selfish equilibria. Section 5 describes the relation between habits and bequest operativeness. Section 6 discusses the robustness of the main results and compares them with those of the previous literature. Section 7 concludes. All lemmas and propositions are proved in Appendix.

2. The dynastic competitive economy

2.1. Assumptions

The analysis focuses on competitive dynastic economies where agents own the productive stocks, exhibit intergenerational altruism, and make intertemporal choices in order to maximize lifetime utility. The standard two-period OLG model is extended to include habit formation in consumption as in Alonso-Carrera et al. (2007) and Schäfer and Valente (in press). The aggregate technology is borrowed from capital–resource models with technical progress *à la* Stiglitz (1974).[2] The specific assumptions are as follows.

Demographic structure. Each household lives in two periods $(t, t+1)$ and the population in period t equals $N_t \equiv N_t^y + N_t^a$, where N_t^a and N_t^y respectively equal the number of adults and young agents. Each young generates $n \geq 1$ children at the end of the first period of life. Since $N_t^y = N_{t+1}^a$, the gross population growth rate is $N_{t+1}/N_t = N_{t+1}^y/N_t^y = N_{t+1}^a/N_t^a = n$.

Production sector. The production function reflects two basic features of capital–resource models. First, there is a positive rate of resource-augmenting technical progress, i.e., a dynamic process by which the productivity of extracted resources increases over time (Stiglitz, 1974). Second, man-made capital and extracted resources are both essential for production (Dasgupta and Heal, 1974). This last property can be captured by either a Cobb–Douglas function or by a CES function with a less-than-unity elasticity of input substitution (Di Maria and Valente, 2008). While the CES form appears empirically plausible,[3] we exploit the Cobb–Douglas specification for reasons of analytical tractability. We will later show (Section 6) that the central mechanism driving our results remains valid using CES technologies. Assuming that each young supplies inelastically one unit of labor, we posit

$$Y_t \equiv F(K_t, m_tX_t, N_t^y) = K_t^{\alpha_1}(m_tX_t)^{\alpha_2}(N_t^y)^{\alpha_3}, \quad (1)$$

where Y_t is final output, K_t is man-made capital, X_t is the flow of extracted resource, m_t is an index of resource efficiency in production, N_t^y is labor and parameters satisfy $\alpha_1 + \alpha_2 + \alpha_3 = 1$ with $\alpha_i \in (0, 1)$. The productivity index m_t develops according to

$$m_{t+1} = m_t(1+\gamma), \quad \gamma \geq 0, \quad (2)$$

where γ is the exogenous net rate of technical progress. Denoting by R_t, p_t^x, and w_t the marginal rewards for capital, resource use and labor, respectively, profit maximization requires

$$R_t = F_{K_t}, \qquad p_t^x = F_{X_t}, \qquad w_t = F_{N_t^y}, \quad (3)$$

where $F_{K_t} \equiv \partial F/\partial K_t$, $F_{N_t^y} \equiv \partial F/\partial N_t^y$, and F_{X_t} represents the chain derivative $\mathrm{d}F/\mathrm{d}X_t = m_t \cdot \partial F/\partial(m_tX_t)$.

Productive stocks. Man-made capital K_t is homogeneous with the consumption good, and is fully depreciated after one period. The accumulation constraint reads

$$\begin{aligned} K_{t+1} &= Y_t - N_t^y c_t - N_t^a e_t \\ &= F(K_t, m_tX_t, N_t^y) - N_t^y(c_t + e_t/n), \end{aligned} \quad (4)$$

where c_t and e_t respectively denote consumption levels of each young and each adult agent. The resource input X_t is extracted from a non-renewable stock Q_t. The physical transition law is

$$Q_{t+1} = Q_t - X_t. \quad (5)$$

All inputs are privately owned by households. The mechanism by which the resource is allocated across generations is purely market-based: at the beginning of period t, the whole stock Q_t is held by adults. The extracted flow X_t is used for (and destroyed in) production, while the remaining stock constitutes *resource assets*, A_t, that are sold to the currently young. We thus have $Q_t = A_t + X_t$ and, from (5), $Q_{t+1} = A_t$. Defining the per-adult variables $q_t \equiv Q_t/N_t^a$, $x_t \equiv X_t/N_t^a$, and $a_t \equiv A_t/N_t^a$, the resource constraints can expressed as

$$q_t = a_t + x_t \quad \text{and} \quad q_{t+1} = a_t/n = (q_t - x_t)/n. \quad (6)$$

Adults sell resource assets to the young at unit price p_t^a, and receive a marginal rent p_t^x for each unit of X_t supplied to firms.

Individual budget constraints. Following Thibault (2000), we assume that agents can make intergenerational transfers in the

[2] Capital-resource models have been extensively used in the more recent literature to address several issues regarding sustainability (e.g. Pezzey and Withagen, 1998). The Stiglitz (1974) variant has been extended to include endogenous technical progress (e.g. Barbier, 1999) and directed technical change (Di Maria and Valente, 2008).

[3] The available evidence suggests that oil-based energy and man-made capital are complements — i.e., an elasticity of input substitution below unity. See Di Maria and Valente (2008, pp. 710–711) and the references quoted therein — in particular, Van der Werf (2008).