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Consumption externality and indeterminacy under increasing returns to scale and endogenous capital depreciation☆

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ABSTRACT

This paper incorporates negative consumption externality embodying "jealousy" and "running away from the Joneses" into Guo and Lansing (2007)'s model with production externality and endogenous depreciation, and examines how consumption externality helps to generate equilibrium indeterminacy together with production externality. Specifically, the existence of consumption externality reduces the upper and lower bounds of production externality for local indeterminacy, and when the degree of consumption externality increases, the upper and lower bounds of production externalities for local indeterminacy are both reduced.

1. Introduction

Considerable progress has been made over the past two decades in understanding the conditions needed to generate equilibrium indeterminacy in real business cycle models with production externalities or monopolistic competition. In the original one-sector models of Benhabib and Farmer (1994) and Farmer and Guo (1994), local indeterminacy requires an implausible high degree of increasing returns-to-scale or externality in production. Subsequent research has shown that RBC models with multiple sectors of production (Benhabib and Farmer, 1996; Harrison, 2001; Perli, 1998; Weder, 2000) or endogenous capital depreciation (Guo and Lansing, 2007; Wen, 1998) can generate local indeterminacy with much lower degrees of increasing returns. Moreover, a combination model that incorporates both multiple production sectors and endogenous capital utilization may give rise to equilibrium indeterminacy only within an extremely narrow range of increasing returns (Guo and Harrison, 2001).

Another research line relates equilibrium indeterminacy to consumption externality. It has been shown that consumption externalities do not generate indeterminacy of the equilibrium path (1) when the labor supply is exogenous (Liu and Turnovsky, 2005); or (2) when the utility function has the restricted homotheticity (RH) property[1] (Guo, 1999; Weder, 2000) even if the labor supply is endogenous. However, indeterminacy can arise when consumption externalities modify the Frisch labor supply, which requires that the utility function is nonseparable between consumption and leisure (Alonso-Carrera and Raurich, 2008). However, there is no work on the interactions between consumption externality and production externality in determining equilibrium indeterminacy in the literature.

This paper develops a straightforward extension of the one-sector, increasing returns-to-scale, and endogenous capital depreciation model of Guo and Lansing (2007) by incorporating negative consumption externality in the sense of Dupor and Liu (2003) and Liu and Turnovsky (2005). The RH property exhibited by the utility function in Guo and Lansing (2007) due to the separability between consumption and leisure tells that consumption externality cannot generate indeterminacy alone without the existence of production externality. However, the paper shows that due to the existence of consumption externality, compared to Guo and Lansing (2007), the requirement for production externality to generate equilibrium indeterminacy can be further reduced.

In our model, households have separable utility on consumption and leisure. And the utility on consumption depends not only on private consumption but also on the average consumption of the society. For our purpose, the dependence of an individual's utility on the average consumption captures negative consumption externalities that reduce

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[1] The utility function satisfies the restricted homotheticity property when the MRS between an agent's consumption and consumption spillovers is constant along the equilibrium path.

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the felicity that each individual obtains from his or her own consumption and decrease the marginal rate of substitution between an agent's own consumption and leisure. That is, the individuals exhibit "jealousy" and "running away from the Joneses". Similar to Guo and Lansing (2007), firms make decisions about the amount of labor devoted to production, the level of expenditures devoted to investment and maintenance, and the utilization rate of the existing capital. The production technology employed by firms is subject to an external effect that depends on the economy-wide average levels of utilized capital and labor inputs. By utilizing the standard procedure of log-linearizing the equilibrium conditions around the steady state, we construct a two-dimension linearized system that depicts the stability properties of the steady state as a function of the externality parameters. It is shown that the existence of consumption externality reduces the upper and lower bounds of production externality for local indeterminacy; and when the degree of consumption externality increases, the upper and lower bounds of production externalities for local indeterminacy are both decreased. The intuition for why consumption externality can make equilibrium indeterminacy easier to obtain is that more effective adjustments of private consumption due to consumption externality promote agents' optimistic expectations as a self-fulfilling equilibrium driven by production externalities.

The rest of this paper is organized as follows. Section **2** describes the model set-up including both consumption externality in households' behaviors and production externality in firms' behaviors. Section **3** solves competitive equilibrium and the two-dimension dynamic system. Section **4** discusses the relationship between externalities and local indeterminacy. And the concluding remarks are summarized in Section **5**.

2. The model

We introduce consumption externality into Guo and Lansing's (2007) local indeterminacy RBC model with production externality and maintenance expenditures. In the decentralized economy, a representative household supplies labor by taking the real wage as given, and its utility function is separable between consumption and leisure and displays negative consumption externality exhibiting "jealousy" and "running away from the Joneses". The household is the owner of a representative firm that makes decisions about production, investment, maintenance and capital utilization, and the firm's production technology displays increasing return to scale due to positive production externality.

2.1. Households

The economy is populated by a large number of identical, infinitely-lived households, each endowed with one unit of time, who choose sequences of consumption c_t and total hours worked n_t to maximize:

$$E_0\sum_{t=0}^{\infty}\beta^t u(c_t,\bar{c}_t,n_t), \tag{1}$$

subject to the budget constraint

$$c_t = w_t n_t + \pi_t, \tag{2}$$

where $\beta\in(0,1)$ is the discount factor, w_t is the real wage, and π_t represents profits paid out by the firm in the form of dividends. It is assumed that the utility function of a representative household depends not only on his own consumption c and labor (leisure) n separably, but also on the average per capita consumption level, $\bar{c}$, namely, $u(c_t,\bar{c}_t,n_t)=\frac{(c_t\bar{c}_t^{\epsilon})^{1-\sigma}-1}{1-\sigma}-\frac{An_t^{1+\gamma}}{1+\gamma}$, where $A>0$, $\sigma\in[0,1)$, and $\gamma\geq 0$ are the inverses of the elasticity of intertemporal substitution in consumption and labor supply, respectively, and $\epsilon<0$. The specification of preference implies (1) "jealousy" (i.e., $u_{\bar{c}}=\epsilon(c_t\bar{c}_t^{\epsilon})^{1-\sigma}\bar{c}_t^{-1}<0$), and (2) "running away from the Joneses" (i.e., $d\left(\frac{u_n}{u_c}\right)/d\bar{c}=A\epsilon(1-\sigma)n_t^{\gamma}c_t^{\sigma}\bar{c}_t^{-\epsilon(1-\sigma)-1}<0$), which together exhibits negative consumption externality extensively examined by Dupor and Liu (2003) and Liu and Turnovsky (2005).

The first-order condition for the household's optimization problem is given by

$$Ac_t n_t^{\gamma} = w_t\left(c_t\bar{c}_t^{\epsilon}\right)^{1-\sigma}, \tag{3}$$

which equates the household's marginal rate of substitution between consumption and leisure to the real wage.

2.2. Firms

The firms' behaviors are very similar to Guo and Lansing (2007). It is assumed that the labor market is perfectly competitive and a large number of identical competitive firms acting in the best interests of the household-owners maximize a discounted stream of profits. By taking $\{w_t\}$ as given and choosing the sequences of $\{n_t,u_t,m_t,k_{t+1}\}$, the firm maximizes the following discounted stream of expected profits:

$$\max_{\{n_t,u_t,m_t,k_{t+1}\}} E_0\left\{\sum_{t=0}^{\infty}\beta^t\left[(c_t\bar{c}_t^{\epsilon})^{-\sigma}\bar{c}_t^{\epsilon}\right]\underbrace{(y_t-w_tn_t-i_t-m_t)}_{\pi_t}\right\},$$

subject to the firm's production function

$$y_t=\bar{e}_t(u_tk_t)^{\alpha}n_t^{1-\alpha},\quad 0<\alpha<1. \tag{4}$$

Its capital accumulation equation

$$k_{t+1}=(1-\delta_t)k_t+i_t,\quad k_0 \text{ is given}. \tag{5}$$

The symbol $\bar{e}_t$ represents a productive externality that takes the form

$$\bar{e}_t=\left(\bar{u}_t\bar{k}_t\right)^{\alpha\eta}\bar{n}_t^{(1-\alpha)\eta},\quad \eta\geq 0, \tag{6}$$

where $\left(\bar{u}_t\bar{k}_t\right)$ and $(\bar{n}_t)$ are the economy-wide averages levels of utilized capital and production labor inputs; the rate of endogenous capital depreciation $\delta_t\in(0,1)$ is postulated to follow the following rule of evolutions

$$\delta_t=\tau\frac{u_t^{\theta}}{(m_t/k_t)^{\phi}},\quad \tau>0,\ \theta>1,\ \text{and}\ \phi\geq 0, \tag{7}$$

where u_t is the endogenous rate of capital utilization, m_t represents goods expenditures on maintenance, m_t/k_t is the "maintenance cost rate" (Licandro and Puch (2000)), θ and ϕ are the elasticities of the depreciation rate with respect to the capital utilization rate and the maintenance cost rate, respectively. Eq. (7) implies that an increase in the capital utilization rate u_t serves to accelerate the depreciation rate. However, an increase in maintenance serves to slow the depreciation rate. Firms act in the best interests of households such that realized profits in period t are valued using the household's marginal utility of consumption, given by $\frac{\partial u_t}{\partial c_t}=\left(c_t\bar{c}_t^{\epsilon}\right)^{-\sigma}\bar{c}_t^{\epsilon}$.

The firm's first-order conditions with respect to the indicated variables are

$$n_t:(1-\alpha)\frac{y_t}{n_t}=w_t, \tag{8}$$

$$u_t:\frac{\alpha}{\theta}\frac{y_t}{k_t}=\delta_t, \tag{9}$$

$$m_t:1=\phi\frac{\delta_tk_t}{m_t}, \tag{10}$$

$$k_{t+1}:(c_t\bar{c}_t^{\epsilon})^{-\sigma}\bar{c}_t^{\epsilon}=\beta E_t\left\{(c_{t+1}\bar{c}_{t+1}^{\epsilon})^{-\sigma}\bar{c}_{t+1}^{\epsilon}\left[\alpha\frac{y_{t+1}}{k_{t+1}}+1-(1+\phi)\delta_{t+1}\right]\right\}, \tag{11}$$