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Macroeconomic (in)stability and endogenous market structure with productive government expenditure

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Abstract: We consider the congestion effect of productive government spending in a monopolistic competition model with endogenous entry, and analyze the possibility of local indeterminacy. Some main findings emerge from the analysis. First, the indeterminacy condition is independent of the monopoly power. Second, productive government expenditure can be a source of local indeterminacy, while a higher degree of public goods congestion lessens the beneficial effect of productive government expenditure, and therefore reduces the possibility of indeterminacy. Third, a higher degree of internal returns to scale is associated with a lower possibility for the emergence of indeterminacy when production externalities are present.

Keywords: congestion; endogenous market structure; internal returns to scale; local indeterminacy; productive government expenditure.

JEL classification: E30; E32.

1 Introduction

The issue of local indeterminacy or belief-driven fluctuations has been studied extensively in the field of macroeconomics. In their pioneering work, Benhabib and Farmer (1994) propose that production externalities play an important role in governing local indeterminacy. They also further show that local indeterminacy requires a sufficiently high degree of increasing returns in production or sufficiently strong monopoly power.

As pointed out by both Burnside (1996) and Basu and Fernald (1997), the empirical evidence suggests that private production externalities at the aggregate level are much smaller.[1] Subsequent studies support their efforts to establish different models to match the local indeterminacy conditions for empirically plausible values. Wen (1998) incorporates endogenous capital utilization into the Benhabib and Farmer (1994) model and shows that the increasing returns required for local indeterminacy can be substantially reduced. Meng and Yip (2008) show that, with separable preferences, local indeterminacy can arise even if negative capital externalities are present. Chang, Hung, and Huang (2011) introduce endogenous entry under monopolistic competition and find that local indeterminacy can occur with an empirically plausible degree of increasing returns provided that the degree of monopoly power is large (less competition). In addition to the one-sector model mentioned above, Benhabib and Farmer (1996), Harrison and Weder (2000), and

1 Burnside (1996) finds that the feature of increasing returns to scale is insignificant in the US economy. The Basu and Fernald (1997) estimate reports that the degree of increasing returns to scale in production in the US economy is in the range between 1.03 and 1.18. Obviously, the empirically observed values are much smaller than the required degree of increasing returns (i.e. 1.5) to satisfy the Benhabib-Farmer condition for local indeterminacy. See also Chang, Hung, and Huang (2011).

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Gokan (2013), respectively develop their real business cycle model featuring two sectors. A common finding in these studies is that indeterminacy is consistent with plausible values of sector-specific externalities.

However, all of the above studies seem to downplay the role of government expenditure in governing the dynamic behavior of the economy. By considering a one-sector general equilibrium model with perfectly competitive markets and constant returns-to-scale social technology, Schmitt-Grohé and Uribe (1997) point out that indeterminacy may occur when the government implements a balanced-budget rule with a constant level of government expenditure. Following the spirit of Aschauer (1989),[2] Palivos, Yip, and Zhang (2003) reexamine the interrelations between the stability of equilibria and a balanced-budget rule when government spending provides productive services. They show that the economy may exhibit indeterminacy and sunspots under a balanced-budget rule that consists of fixed income tax rates. The main reason is that public spending provides a positive externality in private production.

As claimed by Thompson (1974) and Barro and Sala-i-Martin (1992), all services provided by the public sector, like transport, public utilities and possibly national defense, are characterized by some degree of congestion. When confronted with such an observation, it is a natural extension to consider the congestion effect of public goods when assessing the effect of government spending on the private sector. In recent years, by setting up an endogenous growth model, a number of studies, including Barro and Sala-i-Martin (1992), Turnovsky (1996), Ott and Turnovsky (2006), and Agénor (2008), among others, have discussed the congestion effect. Accordingly, this paper considers public goods congestion when analyzing the effect of productive government spending on the private sector.

In their previous papers, Dos Santos Ferreira and Lloyd-Braga (2008) and Lewis (2009) document that the competitive behavior of firms regarding an entry and exit decision may serve as a driving force behind the business cycle. In other words, the economy may suffer from higher macroeconomic volatility in the presence of demand and supply disturbances when the market structure is endogenous (measured by the free entry and exit of firms in the market).[3] To capture this phenomenon in a formal setting, in this paper the endogenous market structure (EMS) is brought into the picture.[4] With such a consideration, we show that the endogenous entry of firms plays an important role in determining the possibility of local indeterminacy.

Moreover, in their well-cited paper, Benhabib and Farmer (1994) introduce internal increasing returns at the level of the intermediate goods firm in a monopolistic competition market structure without free entry. Their analysis indicates that the condition for local indeterminacy crucially depends upon the extent of the monopoly power. Recently, Chang, Hung, and Huang (2011) have considered endogenous entry under monopolistic competition and have found that local indeterminacy can occur with an empirically plausible degree of increasing returns provided that the degree of monopoly power is large. However, their conclusions are based on the assumption that there is no difference between returns to production specialization and monopoly power. By making a distinction between these two factors and allowing for endogenous entry, this paper reexamines how the possibility for the emergence of local determinacy is related to each of these two factors.

The remainder of this paper is organized as follows. Section 2 describes the model economy. Section 3 deals with local dynamic properties. Section 4 concludes our discussion.

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2 By using US data from 1949 to 1985, Aschauer (1989) estimates the output elasticity of public capital to be in the range from 0.39 to 0.56.

3 See, for example, Chang, Hung, and Huang (2011), Gómez and Sequeira (2012) and Pavlov and Weder (2012).

4 Some existing studies, for example, Peretto (1996, 1999), De Santis and Stahler (2004), Etro and Colciago (2010) and Etro (2014), set up imperfectly competitive macroeconomic models with an endogenous market structure, which is characterized by endogenous entry as well as strategic interactions. Under strategic interactions, firms must take into account the strategies used by the others when making their optimal decisions, and this therefore gives rise to a competition effect on the markups. To highlight strategic interactions between competitive firms, these existing studies set up their models with Cournot competition, Bertrand competition, or Stackelberg competition. To compare our results with the findings in the existing indeterminacy literature and, to simplify our discussion, the analysis in this paper does not involve strategic interactions between firms. We thank an anonymous referee for pointing this out.

2 The model

The economy in our model consists of three types of agents: firms, households, and a government. The production environment consists of two sectors: a perfectly competitive final goods sector, and a monopolistically competitive intermediate goods sector. The intermediate goods sector is composed of a variety of industries. Final firms buy differentiated industry goods to produce a final good. The households derive utility from both the consumption of the final good and leisure, and they accumulate capital as an instrument for saving. Moreover, government spending provides productive services to private production but is subject to congestion. In what follows, we in turn describe the structure of the economy.

2.1 Firms

There are N kinds of differentiated industry goods y_i, $i\in[0, N]$, which are used by a perfectly competitive firm to produce a final good Y.[5] In line with Bénassy (1996) final output is produced with the following technology:

$$Y=N^{1-\frac{1}{\lambda}}\left(\int_0^N y_i^{\lambda}di\right)^{\frac{1}{\lambda}};\quad 0<\lambda<1. \tag{1}$$

Two points related to the specification of Eq. (1) should be mentioned here. First, if all industry goods are used in the same quantities, namely, y, the production of final output is given by $Y=Ny$. Thus, the production of final output exhibits constant returns to an expansion of variety, while holding the quantity employed of each industry's goods fixed. This implies that production specialization is absent, and hence the degree of the returns to production specialization is zero.[6] Second, given that in Eq. (1) the parameter λ reflects the degree of monopoly power and the extent of the returns to production specialization is restricted to zero, it is quite obvious that our analysis makes a distinction between returns to production specialization and monopoly power.

Assuming that the final good is the numéraire and that p_i is the price of the industry goods i (in terms of the final good), the profit-maximization problem for the final good firm is expressed as:

$$\underset{y_i}{\text{Max}}\quad \pi^f=Y-\int_0^N p_i y_i di.$$

The first-order condition leads to the following expression:

$$y_i=p_i^{\frac{1}{\lambda-1}}N^{-1}Y. \tag{2}$$

Equation (2) is the demand function for the ith industry goods which is characterized by a constant price elasticity $1/(1–\lambda)$. A higher value of λ implies a higher price elasticity of demand and indicates that the intermediate goods sector is more competitive.

There is a variety of intermediate goods producers operating in a monopolistically competitive market. Each of them uses capital and labor to produce differentiated industry goods and sells them to the final good sector. In line with the viewpoint proposed by Aschauer (1989) and Barro (1990), government infrastructure

5 As stated by Kim (2004), heterogeneous outputs need to be aggregated from a macroeconomic point of view. A conventional specification is introducing an aggregator, such as a firm producing a final good, in the economy. See also Lewis and Roth (2016).
6 It should be noted that our analytical results are qualitatively valid once production specialization is present. Since it is not qualitatively relevant to our main result, we omit this specification. The detailed mathematical derivations are available from the authors upon request.

provides a positive externality in relation to private production. Thus, the production technology for the ith intermediate goods can be described as:[7]

$$y_i = (k_i^a h_i^{1-a})^\gamma g_i^\chi - \phi; \quad 0<a<1, \quad \gamma>0, \quad \chi\geq 0, \tag{3}$$

where k_i and h_i, respectively denote capital and labor hired by the ith intermediate producer, g_i refers to the public goods available to each firm, $\phi(>0)$ is an overhead cost, a measures the capital share, χ captures the extent of the production externality arising from public goods,[8] and γ represents the degree of internal returns to scale. In particular, the production function exhibits internal increasing returns to scale when $\gamma>1$, while exhibiting internal decreasing returns to scale when $\gamma<1$.

In our analysis, when assessing available public goods g_i, we would like to consider the possibility that public goods are subject to either absolute or relative congestion. As in Eicher and Turnovsky (2000), absolute congestion refers to the scenario where the level of public goods available to the individual firm is inversely related to the aggregate capital stock. Relative congestion refers to the scenario where the level of available public goods depends on the individual firm's usage of its own private capital stock relative to the aggregate capital stock.

As a consequence, public goods available to each firm are given by:

$$g_i = G\left(\frac{1}{K}\right)^A \left(\frac{k_i}{K}\right)^R, \quad 0\leq A\leq 1, \quad 0\leq R\leq 1, \tag{4}$$

where G is aggregate government spending and K is the aggregate capital stock.

The economic reasoning behind Eq. (4) can be well understood by analyzing the following three scenarios. The first scenario concerns the situation where the provision of public services is treated as a pure public good, i.e. $A=R=0$ and hence $g_i=G$. As noted by Thompson (1974) and Barro and Sala-i-Martin (1992), all services provided by the public sector are characterized by some degree of congestion. As a consequence, the scenario featuring the pure public goods could be viewed as the benchmark situation.

The second scenario in association with $A=0$ and $R>0$ is referred to as purely relative congestion.[9] With relative congestion the firm can derive a constant level of public services (g_i) from the aggregate government spending (G) if and only if the ratio of its individual capital stock and the aggregate capital stock remains constant. A typical example of relative congestion, as pointed out by Eicher and Turnovsky (2000) and Pintea and Turnovsky (2006), might be highway traffic.[10]

The third scenario in association with $A>0$ and $R=0$ is referred to as purely aggregate (absolute) congestion.[11] In this case, congestion increases with the aggregate capital stock in the economy provided that public services remain unchanged. A plausible example of absolute congestion might be police protection or fire protection as pointed out by Eicher and Turnovsky (2000) and Gómez (2008).[12]

7 Hornstein (1993), Devereux, Head, and Lapham (1996), Xiao (2008) and Brito and Dixon (2013) provide a similar specification in the intermediate goods production, while their analysis downplays the role of the public good externality, i.e. $\chi=0$. The generalized production function was brought to our attention by an anonymous referee, to whom we are grateful.

8 By using data for OECD countries, Ford and Poret (1991) find that the public expenditure-output elasticity ranges from 0.29 to 0.77. In addition, Wylie (1996) estimates the output elasticity of public expenditure to be around 0.5 for the Canadian economy.

9 Turnovsky (1996), Ott and Turnovsky (2006) and Dioikitopoulos and Kalyvitis (2008) adopt the specification of relative congestion in their models.

10 In the special case where $A=0$ and $R=1$, public services available to the individual firm are subject to proportional relative congestion, and public goods resemble private goods in that the firm receives its proportional share of public services, $g_i=G/N$ since $K=Nk_i$ [see Eicher and Turnovsky (2000)].

11 This specification is introduced in Barro and Sala-i-Martin (1992) and Agénor (2008).

12 In the special case where $R=0$ and $A=1$, public services available to the agent, $g_i=G/K$, are subject to proportional absolute congestion. Under such a situation, the agent can maintain a constant level of public services g_i if and only if the aggregate government spending grows in proportion to the level of the aggregate capital stock.

Let π_i^m denote the profit of the ith intermediate goods firm, and w and r, respectively denote the market wage and capital rental rate. Based on the demand function in Eq. (2) and the production function in Eq. (3), the decision problem of the ith intermediate goods producer can be expressed as:

$$\underset{h_i\ k_i}{\text{Max}} \quad \pi_i^m = p_i y_i - w h_i - r k_i, \tag{5}$$

$$s.t. \quad y_i = (k_i^a h_i^{1-a})^{\gamma} g_i^{\chi} - \phi \text{ and } y_i = p_i^{\frac{1}{\lambda-1}} N^{-1} Y.$$

The first-order conditions with respect to h_i and k_i are:

$$w = \frac{\lambda(1-a)\gamma p_i(y_i+\phi)}{h_i}, \tag{6}$$

$$r = \frac{\lambda(a\gamma+\chi R)p_i(y_i+\phi)}{k_i}. \tag{7}$$

Then, substituting Eqs. (6) and (7) into (5) allows us to derive the profit of the ith intermediate goods producer:

$$\pi_i^m = p_i\{[1-\lambda(\gamma+\chi R)]y_i - \lambda(\gamma+\chi R)\phi\}. \tag{8}$$

We confine the analysis to a symmetric equilibrium under which $p_i=p$, $y_i=y$, $k_i=k=K/N$, and $h_i=h=H/N$ for all i, where H denotes the aggregate labor hired by the intermediate firms. From the zero-profit condition for the final good sector, we obtain:

$$p=1. \tag{9}$$

Moreover, free entry guarantees zero profits for each intermediate goods producer and, as a result, the quantity of each intermediate good produced in equilibrium is given by:

$$y = \frac{\lambda(\gamma+\chi R)\phi}{1-\lambda(\gamma+\chi R)}. \tag{10}$$

Based on Eq. (10), the following condition should be imposed to ensure that an individual firm's output is positive in equilibrium:

Condition PIFO [the Positive Individual Firm's Output Condition].

$$1-\lambda(\gamma+\chi R)>0. \tag{11}$$

By substituting Eqs. (3) and (4) into (10), we can derive the variety of intermediate goods in equilibrium:

$$N = \left[\frac{1-\lambda(\gamma+\chi R)}{\phi}\right]^{\frac{1}{\gamma+\chi R}} [K^{a\gamma-\chi A} H^{(1-a)\gamma} G^{\chi}]^{\frac{1}{\gamma+\chi R}}. \tag{12}$$

By inserting Eqs. (10) and (12) into (1), we can obtain:

$$Y = \lambda(\gamma+\chi R)\left[\frac{1-\lambda(\gamma+\chi R)}{\phi}\right]^{\frac{1-\gamma-\chi R}{\gamma+\chi R}} [K^{a\gamma-\chi A} H^{(1-a)\gamma} G^{\chi}]^{\frac{1}{\gamma+\chi R}}. \tag{13}$$

2.2 Households

The economy is populated by a unit measure of identical and infinitely-lived households. The representative household derives utility from consumption C and incurs disutility from labor supply H. The lifetime utility of the representative household U can be expressed as:

$$U=\int_0^{\infty}[\ln C_t-\xi H_t]e^{-\rho t}dt, \tag{14}$$

where $\rho(>0)$ represents the constant rate of time preference, and t is the time index. As stressed by Hansen (1985) and Rogerson (1988), the households can work either a fixed number of hours or not at all. Accordingly, we adopt the characterization of indivisible labor in the analysis.[13]

The representative household faces the following budget constraint:[14]

$$\dot{K}_t=(1-\tau)(w_tH_t+r_tK_t+\Pi_t)-C_t, \tag{15}$$

where $\Pi_t\left(=\int_0^{N_t}\pi_{it}^m di\right)$ is the distributed aggregate profits from firms, and τ is the proportional income tax rate imposed by the government. For notational simplicity, in what follows the time subscript "t" is omitted unless the analysis requires it.

The household maximizes the discounted sum of future utility (14) subject to the budget constraint (15) and the initial capital stock K_0. Performing the optimization problem leads to the first-order conditions:

$$\frac{1}{C}=\mu, \tag{16}$$

$$\xi=\mu(1-\tau)w, \tag{17}$$

$$\mu(1-\tau)r=-\dot{\mu}+\mu\rho, \tag{18}$$

together with Eq. (15) and the transversality condition $\lim_{t\to\infty}\mu Ke^{-\rho t}=0$, where μ is the shadow price of capital.

Combining Eq. (16) with (18) yields the standard Keynes-Ramsey rule:

$$\dot{C}=[(1-\tau)r-\rho]C. \tag{19}$$

2.3 The government

At any point in time, the government levies an income tax with a proportional rate to finance its public expenditure. Accordingly, the government's budget constraint can be expressed as:

$$G=\tau(wH+rK+\Pi). \tag{20}$$

2.4 The competitive equilibrium

In equilibrium, individual and aggregate capital stocks are related by $k_i=k=K/N$, so public services available to the individual firm can be expressed as:

$$g=G\left(\frac{1}{K}\right)^{A}\left(\frac{1}{N}\right)^{R}. \tag{4a}$$

One point concerning Eq. (4a) should be mentioned. As can be seen, the mechanism of endogenous entry (N) plays an important role in determining the efficiency of the level of public services available to the individual firm via the relative congestion, and therefore affects the possibility for the emergence of local indeterminacy.

13 The existing studies in the real business cycle (RBC) literature, including Schmitt-Grohé and Uribe (1997), Harrison and Weder (2000) and Ljungqvist and Uhlig (2000), adopt the same specification.

14 For simplicity and without loss of generality, the depreciation rate of capital is set to zero.

The aggregate consistency condition refers to:[15]

$$w=\frac{(1-a)\gamma Y}{(\gamma+\chi R)H}, \tag{21}$$

$$r=\frac{(a\gamma+\chi R)Y}{(\gamma+\chi R)K}. \tag{22}$$

By substituting Eqs. (8), (20), (21) and (22) into (13), the aggregate production function can be expressed in the following form:

$$Y=\psi[K^{a\gamma-\chi A}H^{(1-a)\gamma}]^{\frac{1}{\gamma-(1-R)\chi}}, \tag{23}$$

where $\psi=\tau^{\frac{\chi}{\gamma-(1-R)\chi}}[\lambda(\gamma+\chi R)]^{\frac{\gamma+\chi R}{\gamma-(1-R)\chi}}[(1-\lambda(\gamma+\chi R))/\phi]^{\frac{1-\gamma-\chi R}{\gamma-(1-R)\chi}}$.

Based on Eq. (23), the following conditions should be imposed to ensure a positive marginal productivity of labor as well as capital:

Condition PMPL [the Positive Marginal Productivity of Labor Condition].

$$\gamma-(1-R)\chi>0. \tag{24a}$$

Condition PMPC [the Positive Marginal Productivity of Capital Condition].

$$a\gamma-\chi A>0. \tag{24b}$$

Moreover, we impose the following condition that the externality is not sufficiently strong to generate sustained growth:

Condition NSG [the Non-Sustained Growth Condition].

$$\gamma-(1-R)\chi>a\gamma-\chi A. \tag{24c}$$

By putting Eqs. (24a), (24b) and (24c) together, we can further infer the result $\gamma-(1-R)\chi>a\gamma-\chi A>0$.

By substituting Eqs. (8), (20), (21) and (22) into (15), we can obtain the economy-wide resource constraint:

$$\dot{K}=Y-C-G. \tag{25}$$

In addition, from Eqs. (16), (17), (21) and (23), we can solve employment for the instantaneous relationship:

$$H=H(K, C), \tag{26}$$

where $H_K(=\partial H/\partial K)=\frac{-(a\gamma-\chi A)H}{\Omega K}$, $H_C(=\partial H/\partial C)=\frac{[\gamma-(1-R)\chi]H}{\Omega C}$, and $\Omega=(1-R)\chi-a\gamma$.

Before ending this section, one point deserves special mention. Based on the aggregate production function reported in Eq. (23), it is quite easy to infer that the output elasticity with respect to capital ε_K and the output elasticity with respect to labor ε_H are respectively given by:

$$\varepsilon_K=\frac{a\gamma-\chi A}{\gamma-(1-R)\chi}, \tag{27a}$$

$$\varepsilon_H=\frac{(1-a)\gamma}{\gamma-(1-R)\chi}. \tag{27b}$$

15 To see this result, note first that the aggregate consistency condition requires that $Y=Ny$, $K=Nk$ and $H=Nh$ in equilibrium. Then, substituting these conditions together with Eqs. (9) and (10) into (6) and (7) yields the expressions above. See Chang et al. (2007) for a similar statement. For details on the aggregate consistency condition, see Barro (1997, p. 168).

As reported in Eqs. (27a) and (27b), the crucial factors in determining both ε_K and ε_H are the capital share a, the degree of internal returns to scale γ, the extent of the production externality arising from public services χ, the extent of absolute congestion A, and the extent of relative congestion R.

In their previous studies, Bernanke and Parkinson (1991) and Burnside, Eichenbaum, and Rebero (1995) point out that the estimated output elasticity of capital is close to zero and the estimated output elasticity of labor is close to one. Besides, empirical observations (e.g. OECD 2003) document that the estimated output elasticity of capital is per se different from the capital share in national accounts statistics, and is roughly between 0.1 and 0.4 across models. By using data from 36 countries over the period 1985–1993, Dewan and Kraemer (2000) estimate that the output elasticity of labor ranges from 0.823 to 0.955 for developed countries. Mittal and Nault (2009) use time-series data from 1948 to 2000 for the US manufacturing industries, finding that the output elasticity of labor is about 0.7. In sum, the empirical observations reveal that the output elasticity of capital is roughly between 0 and 0.4, and the output elasticity of labor is roughly between 0.7 and 1.

To gain insights concerning the plausible values of ε_K and ε_H, we offer a quantitative assessment by resorting to a numerical analysis. The parameters we set are adopted from commonly-used values in the existing RBC literature or obtained from the empirical research. The capital share is set to a=0.3, as used by Benhabib and Farmer (1996), Wen (1998), Dos Santos Ferreira and Lloyd-Braga (2008) and Chang, Hung, and Huang (2011). By using the data for a wide range of industries in the United States and three European countries (France, Germany and the Netherlands), Inkaar (2007) finds that the returns to scale vary widely across industries. They can be as high as 1.32 when estimated based on France's non-durable manufacturing industry, but they can also be as low as 0.74 when estimated based on US non-manufacturing industry. According to Inkaar's (2007) estimation, we set γ=1.03, the average value of 0.74 and 1.32. As documented by Getachew and Turnovsky (2015), the output elasticity of public goods lies within the range from 0.2 to 0.4, which covers most of the plausible values parameterized by Eden and Kraay (2014). Thus, in line with Eden and Kraay (2014) and Getachew and Turnovsky (2015), the production externality arising from public goods is set to χ=0.3, which is the average value of 0.2 and 0.4. There are fewer estimates for the degree of congestion of public goods. Thus, following Eicher and Turnovsky (2000) and Pintea and Turnovsky (2006), the degree of both absolute and relative congestions is varied from 0 to 1 to highlight its importance, i.e. we set A=0, 0.5, 1 and R=0, 0.5, 1. A summary of these parameter values is reported in Table 1.

Table 2 reports the values of the output elasticity with respect to capital/labor in association with the parameter values in Table 1. Some interesting findings emerge from Table 2. First, as exhibited in Table 2, the output elasticity with respect to capital is roughly between 0 and 0.4 and the output elasticity with respect to labor is roughly between 0.7 and 1, depending upon the degree of congestion. As is evident, this result is somewhat consistent with the above-mentioned empirical estimates. Second, in association with a higher degree of absolute congestion, the output elasticity of capital will decrease in response, while the output elasticity of labor remains intact. This is because, as indicated in Eq. (27a), $a\gamma-\chi A$ will decrease in response

Table 1: Parameter values.

Parameter	a	γ	χ	A	R
Value	0.3	1.03	0.3	0, 0.5, 1	0, 0.5, 1

Table 2: The output elasticities.

		A					
		0		0.5		1	
		ε_K	ε_H	ε_K	ε_H	ε_K	ε_H
R	0	0.423	0.988	0.218	0.988	0.012	0.988
	0.5	0.351	0.819	0.181	0.819	0.010	0.819
	1	0.300	0.700	0.154	0.700	0.009	0.700

as A increases. This leads to a decrease in ε_K. Third, in association with a higher degree of relative congestion, both the output elasticity of capital and the output elasticity of labor will decrease in response.

3 Macroeconomic (in)stability

Substituting Eqs. (22) and (23) into (19) and (25), the dynamic system of the economy can be expressed as:

$$\dot{K}=(1-\tau)\psi K^{\frac{a\gamma-\chi A}{\gamma-(1-R)\chi}}H^{\frac{(1-a)\gamma}{\gamma-(1-R)\chi}}-C, \tag{28}$$

$$\dot{C}=\left[\frac{(1-\tau)(a\gamma+\chi R)\psi}{(\gamma+\chi R)}K^{\frac{a\gamma-\chi A}{\gamma-(1-R)\chi}-1}H^{\frac{(1-a)\gamma}{\gamma-(1-R)\chi}}-\rho\right]C, \tag{29}$$

where H is given by Eq. (26).

Let $\tilde{K}$ and $\tilde{C}$ be the stationary values of K and C. Then, linearizing Eqs. (28) and (29) around the steady-state equilibrium yields:

$$\begin{bmatrix}\dot{K}\\ \dot{C}\end{bmatrix}=\begin{bmatrix}J_{11} & J_{12}\\ J_{21} & J_{22}\end{bmatrix}\begin{bmatrix}K-\tilde{K}\\ C-\tilde{C}\end{bmatrix}, \tag{30}$$

where $J_{11}=\frac{-(1-\tau)(a\gamma-\chi A)\tilde{Y}}{\Omega\tilde{K}}$, $J_{12}=\frac{\gamma-(1-R)\chi}{\Omega}$, $J_{21}=\frac{-(1-\tau)(1-A-R)(a\gamma+\chi R)\chi\tilde{C}\tilde{Y}}{(\gamma+\chi R)\Omega\tilde{K}^2}$ and $J_{22}=\frac{(1-\tau)(a\gamma+\chi R)(1-a)\gamma\tilde{Y}}{(\gamma+\chi R)\Omega\tilde{K}}$.

From Eq. (30), we can derive the trace and determinant of the Jacobian:

$$Tr(J)=\frac{(1-\tau)[(1-a)\gamma(a\gamma+\chi R)-(\gamma+\chi R)(a\gamma-\chi A)]\tilde{Y}}{\Omega(\gamma+\chi R)\tilde{K}}, \tag{31}$$

$$Det(J)=\frac{(1-\tau)(a\gamma+\chi R)[(1-a)\gamma-(1-A-R)\chi]\tilde{C}\tilde{Y}}{\Omega(\gamma+\chi R)\tilde{K}^2}. \tag{32}$$

We can infer that $(1-a)\gamma-(1-A-R)\chi>0$ by using Condition NSG. Thus, the numerator of $Det(J)$ is positive. It turns out that $Det(J)>0$ (<0) if and only if $\Omega=(1-R)\chi-a\gamma>0$ (<0).

3.1 The condition for (in)stability

We are now in a position to explore how the parameters of interest affect the equilibrium (in)stability. As addressed in the literature on dynamic rational expectations models [see, for example, Burmeister (1980), Buiter (1984) and Turnovsky (2000)], for the dynamic system there exists a unique perfect foresight equilibrium solution if the number of unstable roots with a positive real part equals the number of jump variables. Since C is the only jump variable in this dynamic system, the steady-state equilibrium is locally determinate if only one of the real parts of the roots is negative in the system and this implies that the value of the determinant of the Jacobian is negative (i.e. $Det(J)<0$), which leads to the formulation of the following constraint:

$$\Omega=(1-R)\chi-a\gamma<0. \tag{33}$$

Besides, as argued by Benhabib and Farmer (1994), there exists a continuum of equilibrium paths converging to the steady state if the dynamic system has two real negative roots, i.e. $Det(J)>0>Tr(J)$. Therefore, a necessary and sufficient condition for local indeterminacy is that the real part of both roots is negative. Accordingly, we formulate the following constraint for equilibrium indeterminacy:

$$\Omega=(1-R)\chi-a\gamma>0 \quad \text{and } (1-a)\gamma(a\gamma+\chi R)<(\gamma+\chi R)(a\gamma-\chi A). \tag{34}$$

However, the dynamic system becomes a totally unstable source if the real part of both roots is positive in the system (i.e. $Det(J)>0$ and $Tr(J)>0$), which results in the following constraint:

$$\Omega=(1-R)\chi-a\gamma>0 \quad \text{and } (1-a)\gamma(a\gamma+\chi R)>(\gamma+\chi R)(a\gamma-\chi A). \tag{35}$$

The above discussion can be summarized by the following proposition:

Proposition 1. *Under Condition NSG,*
i. *the economy exhibits saddle-point stability and equilibrium uniqueness if and only if* $\Omega=(1-R)\chi-a\gamma<0$;
ii. *the economy displays an indeterminate steady state (a sink) if and only if* $\Omega=(1-R)\chi-a\gamma>0$ *and* $(1-a)\gamma(a\gamma+\chi R)<(\gamma+\chi R)(a\gamma-\chi A)$;
iii. *the steady state becomes an unstable source if and only if* $\Omega=(1-R)\chi-a\gamma>0$ *and* $(1-a)\gamma(a\gamma+\chi R)>(\gamma+\chi R)(a\gamma-\chi A)$.

It is clear that the condition for equilibrium (in)stability is totally unrelated to the extent of the monopoly power λ. However, it is closely related to the following factors: the capital share a, the degree of internal returns to scale γ, the extent of the production externality arising from public services χ, the extent of absolute congestion A, and the extent of relative congestion R. We then in turn examine how the possibility of equilibrium (in)stability is related to each of these factors.

3.2 Economic intuition for (in)determinacy

We first discuss the linkage between the possibility of equilibrium (in)determinacy and the extent of the monopoly power. In an earlier paper, Benhabib and Farmer (1994) incorporate internal increasing returns at the level of the intermediate firm in a monopolistically competitive market structure without free entry. Their analysis indicates that the indeterminacy condition crucially depends upon the extent of the monopoly power. In addition, Chang, Hung, and Huang (2011) consider endogenous entry under monopolistic competition and conclude that local indeterminacy can occur with an empirically plausible degree of increasing returns provided that the degree of monopoly power is large. Departing from their analysis, our study allows for endogenous entry and distinguishes returns to specialization from monopoly power. With this specification, we find that the necessary and sufficient condition for local indeterminacy is independent of the monopoly power.

The independent result between the monopoly power and the indeterminacy condition can be explained intuitively. It is well known in the literature on imperfect competition, see, e.g. Coto-Martínez (2006), that a higher degree of monopoly power tends to generate more monopoly profits for firms and hence increases the lifetime income of households.[16] By way of this so-called feedback effect from monopoly profits to the household's behavior, the degree of monopoly power can govern the transitional dynamics of the economy. Once a firm's free entry is allowed, it will result in zero profits in equilibrium, implying that the feedback effect from monopoly profits on the household's behavior is cut off. As a consequence, the condition for local indeterminacy is independent of the monopoly power.[17]

The above discussion leads to the following proposition:

Proposition 2. *In a one-sector RBC model with monopolistic competition and free entry, the necessary and sufficient condition for equilibrium indeterminacy is independent of the monopoly power.*

16 In their static model with imperfect competition, Dixon (1987) and Startz (1989) also show that a higher degree of monopoly power is associated with more monopoly profits for firms, thereby leading to a rise in the disposable income of households.
17 This is also the reason why Startz (1989) concludes that the long-run output effect is independent of the monopoly power. Similarly, Bénassy (1996) draws the conclusion that output persistence is independent of the monopoly power. See also, for example, Pavlov and Weder (2012).

We then deal with the interrelation between the degree of relative congestion R and the magnitude of the production externalities in relation to government spending χ in equilibrium (in)determinacy. As mentioned above, the steady-state equilibrium could be a saddle, a sink or a source, depending on the values of a, γ, χ, A and R. Thus, it is not easy to theoretically derive analytical results for local indeterminacy, and so we resort to numerical analysis. Figure 1 is drawn to highlight the effect of both R and χ on the likelihood of equilibrium (in)determinacy. To compare our results with those of existing studies, we assume that the degree of internal returns to scale is one and absolute congestion is absent (i.e. $\gamma=1$ and $A=0$). As in Benhabib and Farmer (1996), Chang, Hung, and Huang (2011) and many previous studies in the RBC literature, the capital share is set to $a=0.3$. In line with Baxter and King (1993), we set the upper bound of the degree of production externalities in relation to government spending χ to 0.4, which is regarded as the highest possible value of the empirical observation [see Eden and Kraay (2014) and Getachew and Turnovsky (2015)]. We also vary the degree of relative congestion R from 0 to 1 to highlight its importance [see Eicher and Turnovsky (2000) and Pintea and Turnovsky (2006)]. As can be seen, the R–χ space in Figure 1 is divided into "Saddle" (i.e. $Det(J)<0$) and "Sink" [i.e. $Det(J)>0>Tr(J)$] regions. It is obvious from Figure 1 that the economy exhibits a locally unique equilibrium for $\chi<0.3$, while it is more susceptible to indeterminacy for $\chi>0.3$, provided that the degree of relative congestion is relatively small (i.e. $R<0.25$).[18]

The emergence of local indeterminacy in this scenario can be explained as follows. Substituting $\gamma=1$ and $R=0$ into the local indeterminacy condition yields:[19]

$$\Omega(\gamma=1,\ R=0)=\chi-a. \tag{36}$$

Equation (36) reveals the main finding in Palivos, Yip, and Zhang (2003): when government spending is financed with a fixed income tax rate, the economy displays equilibrium indeterminacy if the production externalities in relation to government expenditure are sufficiently large (i.e. $\chi>a$).[20] Furthermore, this finding supports the assertion made by Benhabib and Farmer (1996) who stressed that local indeterminacy can easily occur in real business cycle models that have been extended to include elements of production externalities or increasing returns.

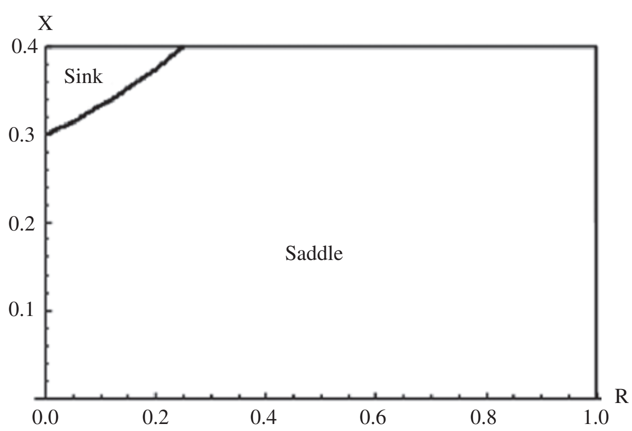

Figure 1: The case of $\gamma=1$, $A=0$ and $a=0.3$.

18 The possibility for the emergence of local indeterminacy qualitatively holds even if we set $\gamma=1.03$, which is the value used in the previous analysis. To be more precise, given that $\gamma=1.03$, the economy exhibits an indeterminate steady state when $\chi>0.309$, provided that the degree of relative congestion is relatively small (i.e. $R<0.2275$).

19 In this scenario a totally unstable source would definitely not occur in the steady state in the range $0\leq\chi\leq0.4$ and $0\leq R\leq1$, so we omit the discussion concerning the sign of $Tr(J)$.

20 In their paper, Palivos, Yip, and Zhang (2003) specify that the production function takes the following form: $y=Ak^{\alpha}h^{1-\alpha}g^{1-\alpha}$, where the degree of productive government spending and the labor share are characterized by the same parameter.

In addition, the endogenously-determined number of firms also governs the impacts of productive government expenditure on private production in the presence of relative congestion. To be more precise, a rise in the number of firms weakens the production externalities in relation to government expenditure via the relative congestion effect, which gives rise to an unfavorable effect on private production. Therefore, in the presence of relative congestion the feature of a firm's free entry would cause the production externalities available to each firm to become of trifling importance and hence the economy is less likely to result in local indeterminacy.

We summarize the findings discussed above with the following result:

Result 1. *When $\chi<0.3$, the economy always displays saddle-point stability and equilibrium uniqueness. When $\chi>0.3$, the economy may exhibit local indeterminacy, provided that the degree of relative congestion is relatively small.*

We in turn deal with the quantitative interrelation between the degree of absolute congestion A and the magnitude of the production externalities in relation to government spending χ in equilibrium (in)determinacy. To this end, Figure 2 depicts the local stability properties of our model as a function of A and χ given that $\gamma=1$, $R=0$ and $a=0.3$. Similarly, we vary the degree of absolute congestion from 0 to 1 to highlight its importance. Then, the A–χ space is divided into "Saddle", "Sink" and "Source" (i.e. $Det(J)>0$ and $Tr(J)>0$) regions.[21] It is clear from Figure 2 that the economy exhibits a locally unique equilibrium for $\chi<0.3$. However, local indeterminacy occurs for $\chi>0.3$, provided that the degree of absolute congestion is relatively small, while the steady state turns into a source if the degree of absolute congestion is relatively large.

The emergence of the local indeterminacy result is straightforward. As mentioned above, a relatively high degree of production externalities in relation to government spending tends to raise the possibility of the emergence of local indeterminacy. However, the presence of absolute congestion reduces the contribution of productive government expenditure to private production, thereby mitigating the possibility of local indeterminacy. As a consequence, the economy is more susceptible to local indeterminacy when the magnitude of the production externalities in relation to government spending χ is relatively large and the degree of absolute congestion A is relatively small.

The following result summarizes the above discussions:

Result 2. *When $\chi<0.3$, the economy always displays saddle-point stability and equilibrium uniqueness. When $\chi>0.3$, the steady state turns into a sink if the degree of absolute congestion is relatively small, while the steady state turns into a source if the degree of absolute congestion is relatively large.*

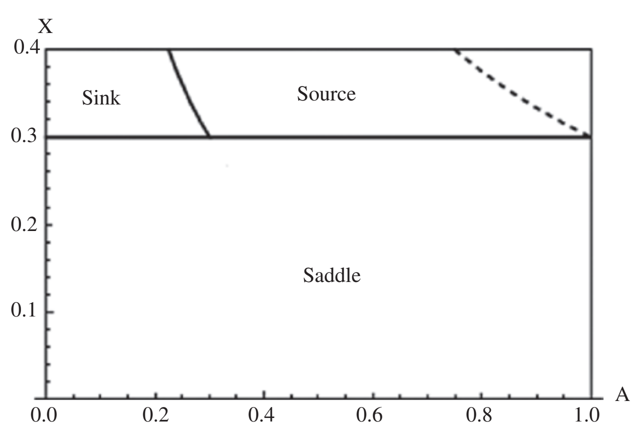

Figure 2: The case of $\gamma=1$, $R=0$ and $a=0.3$.

21 Notice that the points on the right-hand side of the dotted line are not feasible as they do not satisfy Condition PMPC.

Finally, we deal with how the possibility of equilibrium (in)determinacy is related to the internal returns to scale γ in the presence of production externalities χ. To this end, Figure 3 depicts the local stability properties of our model as a function of γ and χ for $A=R=0$ and $a=0.3$. As documented by Inkaar (2007), the extent of the returns to scale varies widely across industries. As already mentioned, they can be as high as 1.32, while they can also be as low as 0.74. Thus, we set $\gamma\in[0.7, 1.3]$. It is clear from Figure 3 that the threshold degree of production externalities in relation to government expenditure, denoted as $\chi^{\min}$, that leads to saddle-point stability is monotonically increasing with respect to the degree of internal returns to scale, i.e. $\partial\chi^{\min}/\partial\gamma>0$, which runs in sharp contrast to the Benhabib and Farmer (1994) result.

Our intuitive explanation for this result is borrowed from Chang, Hung, and Huang (2011). For ease of presentation, the Keynes-Ramsey rule reported in Eq. (29) can be expressed in the following discrete-time form:

$$\frac{C_{t+1}}{C_t}=\frac{(1-\tau)(a\gamma+\chi R)\psi[K_{t+1}^{(a\gamma-\chi A)}H_{t+1}^{(1-a)\gamma}]^{1/[\gamma-(1-R)\chi]}}{(\gamma+\chi R)K_{t+1}}-\rho. \tag{37}$$

When the households generate optimistic expectations regarding having a higher future return on capital, they will tend to reduce consumption and increase their investment today. This in turn will induce a rise in the capital stock in the next period (K_{t+1}). Given that labor and capital are complements in production, labor supply in the next period (H_{t+1}) will increase, too. As a result, future consumption (C_{t+1}) will rise in response. A higher value of future consumption (C_{t+1}) together with a lower value of current consumption (C_t) will cause the left-hand side of Eq. (37) to increase.

With a rise in C_{t+1} and a fall in C_t, it is clear from Eq. (37) that a self-fulfilling equilibrium driven by the agents' optimistic expectations can emerge only when the right-hand side of Eq. (37) increases. As described above, when agents become optimistic, H_{t+1} will rise in response. As such, when faced with a higher degree of internal returns to scale (γ), two conflicting effects will be at work. First, a higher value of γ increases the labor productivity, which is reflected by the term $(1-a)\gamma$ on the right-hand side of Eq. (37). Second, due to the fact that agents' optimistic expectations create more future consumption demand (C_{t+1}), the number of firms in the next period (N_{t+1}) will increase in response. An increase in the number of firms, on the one hand, will cut down factor inputs in the individual firm production and, on the other hand, intensify the relative congestion, thereby reducing the positive effect stemming from productive government spending. This negative induced effect arising from free entry is reflected by the term $1/[\gamma-(1-R)\chi]$ on the right-hand side of Eq. (37). In equilibrium, the second effect due to free entry dominates the first effect and, as a result, a higher value of γ is more likely to lead to a fall in the right-hand side of Eq. (37), indicating that a higher value of γ is less likely to result in local indeterminacy.

It should be noted that in Benhabib and Farmer (1994) the number of firms is exogenous, and hence the second effect is excluded. Accordingly, their analysis proposes that a higher value of γ more easily results

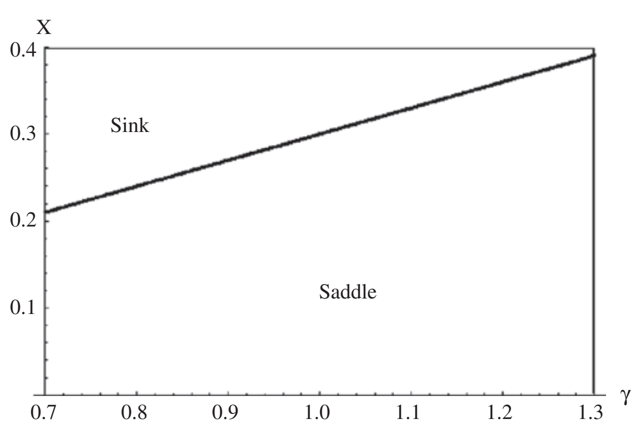

Figure 3: The case of $A=R=0$ and $a=0.3$.

in local indeterminacy. This is the reason why our result runs in sharp contrast to the Benhabib and Farmer (1994) assertion.

The following result summarizes the above discussions:

Result 3. *The threshold degree of production externalities in relation to government spending, denoted as* $\chi^{\min}$, *that leads to saddle-point stability is monotonically increasing with respect to the extent of the internal returns to scale, i.e.* $\partial\chi^{\min}/\partial\gamma>0$.

4 Conclusion

In this paper, we have considered the congestion effect of productive government spending in a monopolistic competition model with endogenous entry. In particular, the production function of individual firms displays a generalized form of internal increasing (or decreasing) returns to scale. Equipped with these features, this paper has focused on the linkage between the possibility of local (in)determinacy and endogenous entry.

Several main results are obtained from the analysis. First, by making a distinction between returns to production specialization and monopoly power, the indeterminacy condition is independent of the monopoly power. Second, a higher magnitude of the production externalities in relation to government spending tends to increase the possibility of the emergence of local indeterminacy, while a higher degree of congestion lessens the beneficial effect of productive government expenditure, and therefore reduces the possibility for indeterminacy. Third, a higher degree of internal returns to scale is associated with a lower possibility for the emergence of indeterminacy when production externalities are present. If a firm's endogenous entry and exit is excluded, the reverse result is true.

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