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Profits, markups and entry: fiscal policy in an open economy

Javier Coto-Martínez[a], Huw Dixon[b,c,*]

[a] *University of East Anglia, Norwich, NR4 7TJ, UK*
[b] *CESifo, Poschingerst 5, 81697 Munich, Germany*
[c] *University of York, York YO10 5DD, UK*

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Abstract

In this paper, we develop a general model of an imperfectly competitive small open economy. There is a traded and non-traded sector, whose outputs are combined in order to produce a single final good that can be either consumed or invested. We make general assumptions about preferences and technology, and analyze the impact of fiscal policy on the economy. We find that the fiscal multiplier is between zero and one, and provide sufficient conditions for it to be increasing in the degree of imperfect competition. We also are able to compare the multiplier under free-entry and with a fixed number of firms and welfare. A simple graphical representation of the model is developed.

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1. Introduction

This paper focuses on the relationship between markups, profits and entry in an open economy. There is now a well established literature which explores the effects of imperfect competition in output markets on fiscal policy

* Corresponding author. University of York, York, YO10 5DD, UK.
E-mail addresses: j.coto-martinez@uea.ac.uk (J. Coto-Martínez), hdd1@york.ac.uk (H. Dixon).

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in a closed economy.[1] With perfectly competitive labor markets, the key result is that the presence of imperfect competition in the product market leads to a *profit multiplier*, by which an initial increase in output generates a positive feed-back onto consumption via profits which is stronger with larger markups. As Startz (1989) argued, this effect will be absent when free-entry drives profits down to zero or in a Walrasian model with constant returns when profits are zero anyway. This paper seeks to extend this analysis to a dynamic small open economy model, developing the Walrasian framework of Turnovsky et al.[2] by explicitly introducing monopolistic competition and entry into the model. We keep the traditional Ramsey assumption of a single final output which can be used for consumption, investment or government expenditure, with the traded and non-traded goods as intermediates. There are two factors or production (capital and labor). The Ramsey household holds two assets, capital and an international bond and solves the standard intertemporal optimization problem giving rise to the dynamics of the economy.

The main innovation in the paper is the inclusion of monopolistic competition in the output market: we retain perfect competition in the labor market.[3] We are able to provide a simple graphical analysis of the steady-state effects of fiscal policy and consider the relationship between the multiplier and the markup. We are able to show that whenever there is imperfect competition, the multiplier is larger when there is a fixed number of firms as opposed to the free-entry case. The multiplier is increasing in the degree of imperfect competition when preferences and technology are Cobb–Douglas. Throughout, the *profit effect* of imperfect competition without free-entry is vital for understanding the multiplier and resultant welfare effects. A crucial feature in the dynamic case is that we need to consider changes in the net present value of profits: in particular we find that variations in profit along the path to equilibrium influence the steady-state equilibrium through their impact on household wealth.

Our setup differs in certain key respects from other papers. We allow for a general non-separable utility function over consumption and leisure (in many papers, either there is no disutility of work—e.g. Dornbusch, 1983; Turnovsky, 1991; or it is additive—e.g. Sen and Turnovsky, 1991). Whilst it is standard in RBC models to have leisure in utility, it usually takes

[1] Dixon (1987), Mankiw (1988), Startz (1989), Dixon and Lawler (1996) and more recently in dynamic closed economy models Rotemberg and Woodford (1995), Heijdra (1998), Dixon (1998).

[2] Sen and Turnovsky (1990, 1991), Brock and Turnovsky (1994), Turnovsky (1991). Other papers that have looked at this issue in an essentially dynamic context include Ghosh (1992), Mendoza (1995), Obstfeld (1982, 1989), Serven (1995), van Wincoop (1993) inter alia (see Obstfeld and Rogoff, 1995a for more references).

[3] For closed economy, Ramsey models with a unionized labor market, see Hansen (1999) and Dixon (2000).

specific functional forms (e.g. Backus et al., 1995). We also specify technology in terms of homothetic functions: this enables us to understand which results are due to specific forms (Cobb–Douglas or *CES*) and which are more general.

The paper is organized as follows. Section 2 describes the disaggregated microlevel in the final output market, the two intermediate sectors and the factor markets, where the relationships are primarily *intra*temporal. In Section 3 we analyze the aggregate level with a representative Ramsey consumer which captures the *inter*temporal relationships and the portfolio behavior which yields the dynamic equilibrium of the economy. The steady state and dynamic properties of the equilibrium are described in Section 4 and given graphical expression. The impact of imperfect competition on the multiplier and welfare is analyzed in Section 5, and we conclude in Section 6. All proofs are in Appendix A.

2. Output and factor markets

There are two sectors in the small non-monetary open economy: a perfectly competitive sector producing the traded good at a given international price and an imperfectly competitive non-traded sector.[4] The traded and the non-traded sector outputs are combined[5] to produce a single final output Y which can be consumed C, invested I or used as government expenditure G

$$Y = C + I + G.$$

The non-traded sector is monopolistic with a composite aggregate y_{N} derived from the production of n monopolistic firms' outputs y_j $(j = 1 \ldots n)$. The constant returns technology for the final output is represented by the separable unit-cost function $P = P(p_{\mathrm{N}}, p_{\mathrm{T}})$ where $p_{\mathrm{T}} = 1$ is the price of the traded good (the numeraire), and p_{N} is the unit cost of the non-traded composite which depends on the n-vector $\mathbf{p}$ of monopolistic prices p_j, $p_{\mathrm{N}} = p_{\mathrm{N}}(\mathbf{p})$. Since we will be allowing for entry, n may vary. We assume that for any n, if all prices are the same $p_j = p$, then $p_{\mathrm{N}} = p$. This is a useful normalization, but importantly it rules out any *Ethier effect* or *love of variety* (the range of

[4] The assumption that the non-traded sector is imperfectly competitive reflects the view that it is not open to foreign competition. For UK, '... the average markup tends to be higher in service industries than in manufacturing, which could reflect the greater tradeability of manufacturing', Small (1997, p.13).

[5] The combination can be seen equivalently *either* as occurring due to production (the traded and non-traded good are intermediate products) *or* through preferences (a sub-utility function). For the formal structure of the paper, we will adopt the former 'physical' interpretation.

inputs has no implication for unit cost).[6] By Shephard's lemma we have the following conditional input demands for the traded good X_T and the composite non-traded good X_N:

$$X_\mathrm{N} = \alpha(p_\mathrm{N})\frac{P(C+I+G)}{p_\mathrm{N}}, \tag{1}$$

$$X_\mathrm{T} = [1 - \alpha(p_\mathrm{N})]P(C+I+G), \tag{2}$$

where $\alpha(p_\mathrm{N})$ is the factor share of the non-traded sector composite good. Along with the standard properties of a cost function, we also assume that $1 > \alpha(p_\mathrm{N}) > 0$ for all $p_\mathrm{N} > 0$, (this rules out corner solutions where only one good is used to produce Y).[7] The demands for the individual monopolist $j's$ output comes by Shephard's lemma from the cost function $p_\mathrm{N}(\mathbf{p})$:

$$x_j = \frac{\partial p_\mathrm{N}}{\partial p_j}X_\mathrm{N} = \bar{\alpha}_j(\mathbf{p})\frac{p_\mathrm{N}X_\mathrm{N}}{p_j}, \tag{3}$$

where $\bar{\alpha}$ $(\mathbf{p})$ is the factor-share for input j, which is homogeneous to degree zero in $\mathbf{p}$. From the demand for firm j (3) we can derive the elasticity of demand $\varepsilon_j(\mathbf{p})$ which is homogeneous of degree zero in $\mathbf{p}$.[8] In particular, if all prices are the same, then the elasticity of demand is $\varepsilon^* = \varepsilon_j(\mathbf{1})$ for all j. The only restrictions on demand are that $\varepsilon^* > 1$ and the elasticity ε_j is non-decreasing in own-price.[9] We also assume that ε^* is unaffected by n (as in the assumption of no Ethier effect).

The demand for the traded good is satisfied through the net export from abroad and the domestic production. The traded sector is perfectly competitive, firms produce output by combining capital and labor with constant returns technology $y_\mathrm{T} = L_\mathrm{T} f_\mathrm{N}(k_\mathrm{T})$, where k_T is the capital labor ratio, f_T the factor intensive production function and L_T is employment in the traded sector. There is capital and labor mobility across sectors, so firms in both sectors pay the same wage w, and the same rental on capital r_K. The unit cost function is $C^\mathrm{T}(w, r_K)$, and under perfect competition price equals unit cost, $1 = C^\mathrm{T}(w, r_K)$. Factor demands in the traded sector are given by Shephard's lemma, $L_\mathrm{T} = C^\mathrm{T}_w y_\mathrm{T}$ and $K_\mathrm{T} = C^\mathrm{T}_{r_K} y_\mathrm{T}$.

[6] In the context of imperfect competition with entry see, for example, Heijdra (1998) and Heijdra and Van Der Ploeg (1996) where the Ethier effect is considered in detail. We exclude it only because our focus is elsewhere and we want to keep the model as simple as possible.

[7] In terms of the primal production function for Y, this means that the isoquants in input space do not cut the axes.

[8] The elasticity of demand is $\varepsilon_j(\mathbf{p}) = (p_j/x_j)\partial x_j/\partial p_j$. Since x_j is homogeneous of degree 1 in $\mathbf{p}$, it follows that $\varepsilon_j(\mathbf{p})$ is homogeneous of degree 0. See Dixon (1998).

[9] We require that $\varepsilon^* > 1$ from the first order an interior optimum with strictly positive costs. ε_j being non-decreasing in p_j is sufficient to ensure that marginal revenue is decreasing and the second-order conditions are satisfied.

2.1. The monopolistic sector and the markup

Each firm j employs capital and labor to produce its output y_j. The increasing returns technology takes the form $y_j = L_j f_N(k_j) - F$, k_j is the capital–labor ratio and L_j employment in firm j and $F > 0$ is a fixed overhead in terms of output. The resulting cost function [10] takes the form $C^N(w, r_K)(y_j + F)$, where $C^N(w, r_K)$ is the constant marginal cost of output, variable cost is $y_j C^N$ and fixed cost is FC^N. Firm j chooses its price p_j to maximize profits treating the price index p_N and factor prices $\{w, r_K\}$ as given, subject to the product demand (3)

$$\max_{p_j} (p_j - C^N(w, r_K))x_j - C^N(w, r_K)F,$$

which yields the condition that marginal revenue equals marginal cost. Under symmetry, $p_j = p_N$ and $\varepsilon_j = \varepsilon^*$. Defining the markup as the *Lerner index* of monopoly $\mu \equiv (p_N - C^N)/p_N = 1/\varepsilon^* > 0$ we have price-cost equation

$$p_N(1 - \mu) = C^N(w, r_K).$$

Under symmetry total non-traded output, employment and capital are $y_N = ny_j$, $L_N = nL_j, K_N = L_N k_N$. Factor demands in the monopolistic sector are $L_N = C^N_w[y_N + nF]$ and $K_N = C^N_{r_K}[y_N + nF]$. Hence total profits are $\Pi = y_N(p_N - C^N) - C^N nF$. With free-entry, the number of firms is determined by the zero profit condition, which also ties down output per firm

$$n^e = \frac{\mu}{1 - \mu} \frac{y_N}{F}. \tag{4}$$

2.2. Intra-temporal equilibrium

We can now specify the equilibrium in factor and output markets at any time t conditional on the parameter μ, and the variables $\{K, L, p_N\}$ which are to be determined when we introduce the intertemporal optimization of the household. We have four equations. The first two price-cost equations (5a) and (5b) for traded and non-traded sector relate factor prices to the price of the non-traded good. The other two Eqs. (5c) and (5d) are the factor market clearing conditions: the demands for labor and capital in each sector need to add up to the total supply of K and L.

$$1 = C^T(w, r_K), \tag{5a}$$

$$p_N(1 - \mu) = C^N(w, r_k), \tag{5b}$$

[10] Clearly, we can think of a constant returns production function in terms of notional *gross* output, $y_j + F = L_j f_N(k_j)$: then C^N is the unit/marginal cost of gross output. In terms of *actual* output y_j unit cost is decreasing and marginal cost is constant and equal to C^N.

$$C^{\mathrm{N}}_{w}(y_{\mathrm{N}}+nF)+C^{\mathrm{T}}_{w}y_{\mathrm{T}}=L, \tag{5c}$$

$$C^{\mathrm{N}}_{r_K}(y_{\mathrm{N}}+nF)+C^{\mathrm{T}}_{r_K}y_{\mathrm{T}}=K. \tag{5d}$$

If there is free entry in the non-traded sector, then we can impose (4) on the last two equations.

First, the price-cost equations (5a) and (5b) can be solved for $\{w, r_K\}$ as a function of (p_{N}, μ) [11]

$$r_k(\underset{-}{p_{\mathrm{N}}}, \underset{+}{\mu}), \qquad w(\underset{+}{p_{\mathrm{N}}}, \underset{-}{\mu}).$$

From this we can define sectoral the capital–labor ratios $\{k_{\mathrm{N}}, k_{\mathrm{T}}\}$ in terms of the derivatives of the cost-functions evaluated at $\{w(p_{\mathrm{N}},\mu), r_K(p_{\mathrm{N}},\mu)\}$

$$k_{\mathrm{N}}(p_{\mathrm{N}},\mu)=\frac{C^{\mathrm{N}}_{r}}{C^{\mathrm{N}}_{w}}, \qquad k_{\mathrm{T}}(p_{\mathrm{N}},\mu)=\frac{C^{\mathrm{T}}_{r}}{C^{\mathrm{T}}_{w}}.$$

Throughout this paper, we will be considering the case where the traded sector is more capital intensive than the non-traded sector: $k_{\mathrm{T}} > k_{\mathrm{N}}$. This assumption is standard in the literature (e.g. Obstfeld, 1989; Mendoza, 1995; Rebelo, 1997; Rebelo and Vegh, 1995) and empirically justified: '*International evidence seems generally to support the assumption that non-traded goods, taken as an aggregate, are labor-intensive relative to tradeables*' (Obstfeld, 1989, p. 446; see also Kravis et al., 1983; pp. 206–207).

Second, using (5c) and (5d) we can state the sectoral employment and output levels in terms of aggregate capital, employment, the sectoral capital–labor ratios and the number of firms (and imposing (4) with free-entry)

$$L_{\mathrm{T}}=\frac{K-Lk_{\mathrm{N}}}{k_{\mathrm{T}}-k_{\mathrm{N}}}, \qquad y_{\mathrm{T}}=L_{\mathrm{T}}f_{\mathrm{T}}(k_{\mathrm{T}}), \tag{6a}$$

$$L_{\mathrm{N}}=\frac{Lk_{\mathrm{T}}-K}{k_{\mathrm{T}}-k_{\mathrm{N}}}, \tag{6b}$$

$$y_{\mathrm{N}}=\begin{cases} L_{\mathrm{N}}f_{\mathrm{N}}(k_{\mathrm{N}})-nF & \text{fixed } n,\\ L_{\mathrm{N}}f_{\mathrm{N}}(k_{\mathrm{N}})(1-\mu) & \text{free-entry.}\end{cases} \tag{6c}$$

Note that the Rybcznysnki effect implies an increase in K reduces non-traded output and increases traded output, the opposite holding true for L.

The presence of monopolistic competition in the non-traded sector leads to an inefficient allocation of capital and labor: the fact that the marginal cost in the non-traded sector is less than price means that the value of the

[11] For reference, note that $\mathrm{d}w/\mathrm{d}p_{\mathrm{N}}=(1-\mu)k_{\mathrm{T}}f_{\mathrm{N}}/(k_{\mathrm{T}}-k_{\mathrm{N}})>0>-(1-\mu)f_{\mathrm{N}}/(k_{\mathrm{T}}-k_{\mathrm{N}})=\mathrm{d}r_K/\mathrm{d}p_{\mathrm{N}}$.

marginal product of capital and labor are higher in the non-traded sector than in the traded sector. For example, taking the case of capital, note that $C^{\mathrm{N}} = r_K/f'(k_{\mathrm{N}})$ and $C^{\mathrm{T}} = r_K/f'(k_{\mathrm{T}})$, so (5a) and (5b) imply

$$p_{\mathrm{N}} f'_{\mathrm{N}}(k_{\mathrm{N}}) > f'_{\mathrm{T}}(k_{\mathrm{T}}).$$

In this paper, we analyze equilibrium and the fiscal multiplier under two market structures for the non-traded sector: monopolistic competition with and without free entry. In both cases, the price is higher than the marginal cost in the non-traded sector, the markup being the same in both cases. Therefore, the economy is not efficient and it is possible (given K and L) to increase the aggregate income by increasing output in the non-traded sector relative to the traded sector.

With a fixed number of firms, firms can earn profits/losses that are distributed to the household and influence consumption and labor supply decisions: as consequence the effects of fiscal policy are going to depend on the evolution of profits. In the case of free entry, the entry/exit of firms drives profits to zero. Hence when comparing the effect of fiscal policy with and without free entry, the variation in profits without entry will be crucial. Lastly, no Walrasian equilibrium exists: since $F > 0$, increasing returns in the non-traded sector implies non-existence of a perfectly competitive equilibrium. However, the Walrasian case of $\mu = F = 0$ is a limiting case of our economy: for any $F > 0$, the Walrasian economy is the limit as $\mu \to 0$.

3. The Ramsey household

In this section we turn to the aggregate level and the intertemporal structure of the economy. First, we consider the household's intertemporal optimization. Second, we combine the household's behavior with the micro-structure in order to derive the fundamental dynamic equations describing the economy. In the next section we will examine the steady state and linearized dynamics of the economy.

There is a representative household which owns all capital, supplies all labor, owns the net foreign (real) assets b, receives all of the profits from the domestic firm and pays (lumpsum) taxes which equal in each instant government expenditure G.[12] Lifetime utility is

$$\int_0^\infty U(C, 1-L)\mathrm{e}^{-\rho t}\,\mathrm{d}t,$$

where $U(C, 1-L)$ gives the flow of utility from current consumption C and leisure $l = 1 - L$: the household has one unit of leisure-endowment per instant

[12] The timing of taxation is irrelevant so long as the present values are equivalent since Ricardian equivalence holds.

and works for L of this. The discount rate ρ is assumed equal to the world interest rate r. This is a strong assumption, but one that is common in the literature: see for example Turnovsky (1997, pp. 23–24) for a discussion. For this paper, we assume that U is strictly concave in $(C, 1-L)$ and twice continuously differentiable, with both consumption and leisure being normal goods.

The household's budget constraint is

$$\dot{b} = rb + wL + r_K K + \Pi - P(C + I + G). \tag{7}$$

The current-value Hamiltonian for the household's optimization is

$$H = U(C, 1-L) + \lambda[rb + wL + r_K K + \Pi - P(C + I + G)] + qI. \tag{8}$$

From the first order conditions we have

$$U_c = \lambda P, \tag{9a}$$

$$U_L = -\lambda w, \tag{9b}$$

$$\dot{\lambda} = \lambda(r - \rho) = 0, \tag{9c}$$

$$\dot{P} = rP - r_k \tag{9d}$$

with the initial conditions $b(0) = b_0$, $K(0) = K_0$ and transversality conditions:

$$\lim_{t\to\infty} \lambda b \mathrm{e}^{-\rho t} = \lim_{t\to\infty} \lambda PK \mathrm{e}^{-\rho t} = 0. \tag{10}$$

From (9c) the marginal utility of wealth λ is constant along time, $\lambda(t) = \lambda^*$. This results from the assumption the discount rate and world interest rate are the same, $r = \rho$. If $r \neq \rho$ then no (interior) steady state would exist, with the trajectory of consumption being either increasing $(r < \rho)$ or decreasing $(r > \rho)$. Secondly, the two Eqs. (9a) and (9b) yield C and L conditional on (λ, P, w), the Frisch demands:[13]

$$C = C(\lambda, P, w), \tag{11a}$$

$$L = L(\lambda, P, w). \tag{11b}$$

We assume that consumption and leisure are normal goods so $L_\lambda > 0$ and $C_\lambda > 0$. An increase in the marginal utility of wealth reduces consumption and increase labor supply. An increase in the wages has a positive effect on labor supply, $L_w > 0$ and negative effect on consumption $C_w > 0$. Also, an increase in the aggregate prices P reduces the consumption $C_P < 0$ and labor supply $L_P < 0$. The real wage w/P defines the *income-expansion path* (*IEP*) in consumption-leisure space, λP the position on the path. Eq. (9d) is the arbitrage equation equating the return on capital and bonds.

[13] See Cornes (1992, pp. 163–165).

4. Macroeconomic equilibrium

In this section, we represent the equilibrium as a dynamic system in $\{p_{\mathrm{N}}, K, b\}$ and analyze the dynamics of the linearized system around the steady state. Since the dynamics are similar with and without entry, we present the no entry case entry as the baseline, pointing out the situations where free-entry affects the analysis as necessary.

First, since λ is constant at its steady-state value, the evolution of consumption and labor supply (Eqs. (11a) and (11b)) is determined only by the price level and wages, which are functions of p_{N}: $P = P(p_{\mathrm{N}})$; $w = w(p_{\mathrm{N}}, \mu)$. The equilibrium in the capital market requires that the arbitrage condition (9d) is satisfied, combining this equation with the rental price of capital $r_k(p_{\mathrm{N}}, \mu)$, we obtain a differential equation in p_{N}

$$\dot{p}_{\mathrm{N}} = \frac{p_{\mathrm{N}}\,[rP(p_{\mathrm{N}}) - r_k(p_{\mathrm{N}}, \mu)]}{\alpha(p_{\mathrm{N}})P(p_{\mathrm{N}})} \equiv \Gamma(p_{\mathrm{N}}). \tag{12}$$

This equation yields a stationary point $p_{\mathrm{N}}^*(\mu)$, satisfying $rP(p_{\mathrm{N}}^*) = r_k(p_{\mathrm{N}}^*, \mu)$: the solution must be unique (because of strict monotonicity of P and r_K in p_{N}) and is strictly increasing in μ ($\mathrm{d}p_{\mathrm{N}}^*/\mathrm{d}\mu > 0$). Thus, steady-state prices P and wages w are determined by the markup:[14] $P^*(\mu) = P(p_{\mathrm{N}}^*(\mu))$, $w = w(p_{\mathrm{N}}^*(\mu), \mu)$, $\mathrm{d}P/\mathrm{d}\mu > 0 > \mathrm{d}w/\mathrm{d}\mu$. An increase in the markup raises the price of non-tradables p_{N}, leading to an increase in the price level P and a reduction in wages w. Moreover, since steady-state wages and prices are exclusively determined by (12), they are not affected by changes in fiscal policy.

Secondly, the dynamic equation for capital can be obtained from the non-traded good market clearing condition,[15] equating supply (6c) with demand (2).With a fixed n we have

$$L_{\mathrm{N}} f_{\mathrm{N}}(k_{\mathrm{N}}) - nF = \frac{\alpha(p_{\mathrm{N}})P(p_{\mathrm{N}})}{p_{\mathrm{N}}}[C + G + \dot{K}],$$

whilst with free entry the *LHS* is $(1-\mu)L_{\mathrm{N}} f_{\mathrm{N}}(k_{\mathrm{N}})$. Hence:

$$\dot{K} = \frac{p_{\mathrm{N}}}{\alpha(p_{\mathrm{N}})P}\left[\frac{Lk_{\mathrm{T}} - K}{k_{\mathrm{T}} - k_{\mathrm{N}}} f_{\mathrm{N}} - nF\right] - C - G \equiv \Phi(K, p_{\mathrm{N}}). \tag{13}$$

Finally, the evolution of bonds b is determined by the balance of payments that comprises the trade balance: the difference between the demand to the

[14] The international interest rate also determines these variables: however, since it is presumed exogenous throughout, we suppress this in the notation.

[15] We are assuming that capital itself is not traded: for a discussion of this assumption, see Turnovsky (1997, pp. 123–125).

traded sector, (1), and domestic supply, (6a), plus the interest payment on the existing assets, rb.

$$\dot{b} = rb + \frac{K - Lk_N}{k_T - k_N} f_T - [1 - \alpha(p_N)]P(C + \dot{K} + G). \tag{14}$$

Substituting (13), we obtain a differential equation that describes the evolution of bonds

$$\dot{b} = rb + \frac{K - Lk_N}{k_T - k_N} f_T - \left[\frac{1-\alpha}{\alpha}\right] p_N \frac{Lk_T - K}{k_T - k_N} f_N \equiv \Psi(K, p_N, b). \tag{15}$$

The dynamic equilibrium for the economy can be represented by the three differential equations for $\{K, b, p_N\}$ along with the transversality conditions (10). We first consider the dynamics of the linearized system. Following Brock and Turnovsky (1994), we linearize the dynamic system (equations Γ, Φ and Ψ), around the steady state defined by $\dot{p}_N = \dot{K} = \dot{b} = 0$ treating the steady-state value λ^* as given (since it is constant, it does not influence the dynamics):

$$\begin{bmatrix} \dot{p}_N \\ \dot{K} \\ \dot{b} \end{bmatrix} = \begin{bmatrix} \Gamma_p(p_N^*) & 0 & 0 \\ \Phi_p(p_N^*, K^*) & \Phi_K(p_N^*, K^*) & 0 \\ \Psi_p(p_N^*, K^*, b^*) & \Psi_K(p_N^*, K^*, b^*) & r \end{bmatrix} \begin{bmatrix} p_N - p_N^* \\ K - K^* \\ b - b^* \end{bmatrix}. \tag{16}$$

This system can be solved recursively: we first solve the system composed by Γ and Φ, then solve for level of bonds b. The sub-system in $\{K, p_N\}$ possesses two eigenvalues: one negative (Φ_K) and one positive (Γ_{p_N}), implying that the dynamics are saddle path stable

$$\Gamma_{p_N} = \frac{p_N}{\alpha P}\left(\frac{\partial P(p_N)}{\partial p_N} - \frac{\partial r_k(p_N)}{\partial p_N}\right) > 0 \quad \text{and} \quad \Phi_K = \frac{p_N}{\alpha P}\frac{-f_N}{k_T - k_N} < 0,$$

where Φ_K refers to derivative of equation Φ with respect to capital in the case of fixed n. In the case of free-entry, $\Phi_K^e = (1-\mu)\Phi_K$. The derivatives Γ_{p_N} and Φ_K are evaluated at the steady state. Their sign is determined by the fact that the traded sector is capital intensive $k_T > k_N$. In general, the stable solution takes the following form

$$p_N(t) = p_N^*, \tag{17a}$$

$$K(t) = K^* + (K_0 - K^*)e^{\Phi_K t}, \tag{17b}$$

$$b(t) = b^* + \Omega(K_0 - K^*)e^{\Phi_K t}, \quad \text{where } \Omega = \frac{\Psi_K}{\Phi_K - r} < 0. \tag{17c}$$

Given that the arbitrage equation is unstable ($\Gamma_{P_N}(p_N^*) > 0$), the relative price of non-traded good is constant at its steady-state value $p_N^* = p_N(\mu)$, as are wages and the price level: $w(t) = w(\mu)$ and $P(t) = P(\mu)$. Since $\{P, w, \lambda\}$ are immediately set at their steady-state values, so are $C(t) = C^*$ and $L(t) = L^*$ for all $t \in [0, \infty)$. The evolution of bonds is determined by investment: since Ω is negative, an increase in capital produces a deficit in the current account. This is a common feature of other intertemporal models (see e.g., Turnovsky, 1997; Obstfeld and Rogoff, 1996). As will be seen, this relationship between the balance of payments and capital accumulation is affected by the existence of imperfect competition in the economy. As capital is accumulated there is a *sectoral reallocation* of labor and capital towards the traded sector via the Rybczynski effect (6), which reduces and eventually eliminates the current account deficit. The role of profits is crucial here when there is a fixed number of firms. Profits are the sole source of income variation over time, as is revealed in Proposition 1:

Proposition 1. The relationship between the current account and the level of investment, Ω.

- *Free-entry*: $\Omega = -P$,
- *fixed n*: $\Omega = -P - \left[\dfrac{\mu P_{\mathrm{N}}}{\Phi_K - r} \dfrac{f_{\mathrm{N}}}{k_{\mathrm{T}} - k_{\mathrm{N}}} \right]$.

In the case of free-entry, as in the case of perfect competition, there are no profits. The arbitrage equation equating the returns of capital and bonds means that although bond income and capital rental may vary individually over time, the total value of assets is constant as is the fixed world interest rate r, so that the flow of combined income from bonds and capital is also constant: $r(b(t) + PK(t)) = r(b_0 + PK_0)$. For this to be the case, the change in the value of bonds and capital must be equal and opposite in sign in terms of the numeraire: hence $\Omega = -P$. When there is a fixed number of firms, there is an additional effect on the net present value of profits: this is captured by the term in square brackets which equals $\Omega + P > 0$. Since consumption and all items of income other than profit are constant, the variation in profit is reflected in the stock of bonds (see 20 below).

Turning to the steady-state, as we have explained output and factor prices $\{P, p_{\mathrm{N}}, w, r_k\}$ are determined by international interest rate and markup. Using (13), we obtain the steady-state capital stock K^* corresponding to the steady-state level of employment and consumption and steady-state profits with non-entry

$$K^* = \frac{1}{\Phi_K}(C^* + G) + k_{\mathrm{T}} L^*, \tag{18}$$

$$\Pi^* = \mu p_{\mathrm{N}} \left[\frac{L^* k_{\mathrm{T}} - K^*}{k_{\mathrm{T}} - k_{\mathrm{N}}} f_{\mathrm{N}} - nF \right]. \tag{19}$$

The steady-state level of bonds b^* is determined by evaluating (17c) at $t=0$

$$b^* = b_0 - \Omega(K_0 - K^*). \tag{20}$$

Finally, we compute the marginal utility of wealth at the steady state λ^*. We use the fact that the level of consumption and labor supply satisfy the intratemporal optimality conditions given $\{P, w\}$: $C(\lambda) = C(\lambda, P(\mu), w(\mu))$, $L = L(\lambda, P(\mu), w(\mu))$. Hence, we can represent the household's lifetime budget constraint (*LTBC*) in steady state, derived from (7), setting $\dot{b} = \dot{K} = 0$

$$C(\lambda) = r\left(\frac{b^*}{P(\mu)} + K^*\right) + \frac{w(\mu)}{P(\mu)} L(\lambda) + \frac{\Pi^*}{P(\mu)} - G. \tag{21}$$

This gives us a system of three equations $\{21, 20, 18\}$ with three unknowns $\{K^*, \lambda^*, b^*\}$, which define the steady state. We next evaluate the steady state and develop a graphical representation of equilibrium in consumption and leisure space for the two cases (entry, no-entry), which allows a simple and intuitive analysis of fiscal policy in Section 5.

In the case of free-entry, as with perfect competition, there are no profits and $\Omega = -P$, so the *LTBC* (21) can be written in the form:[16]

$$C = \frac{rb_0}{P} + rK_0 + \frac{w}{P} L - G \equiv J^e(L, \mu) - G. \tag{22}$$

With a fixed number of firms, we have to take into account the variation in the *NPV* of profits caused by investment (given by $\Omega + P > 0$). The reason is that the wealth of consumer depends on the present value of profits. The net present value of profits can be decomposed into two parts: steady state and deviations therefrom

$$\int_0^\infty \Pi(t) e^{-rt} dt = \frac{\Pi^*}{r} - (\Omega + P)(K_0 - K^*). \tag{23}$$

The output in the non-traded sector and hence profits are governed by the evolution of the capital stock, (17b): if $K_0 < K^*$, the profit flow will exceed the steady state and then diminish as capital is accumulated, and vice versa. We can represent the steady state *LTBC* (21) in terms of $J^e(L, \mu)$ and the *NPV* of profits (23)

$$C + G = J^e(L, \mu) + \frac{\Pi^*}{P} - r\left(\frac{\Omega + P}{P}\right)(K_0 - K^*) \equiv J(L, \mu, n), \tag{24}$$

where Π^* and K^* are given by (18) and (19). The key point to note is that the slope of $J(L, n, \mu)$ in consumption-leisure space is greater than w/P since it includes the additional effect on steady-state profits when L increases (see (19)):

[16] Since the initial stocks of bonds are given, we omit them from J^e. Clearly, changes in initial wealth will result in shifts in (22) in $\{C, L\}$ space.

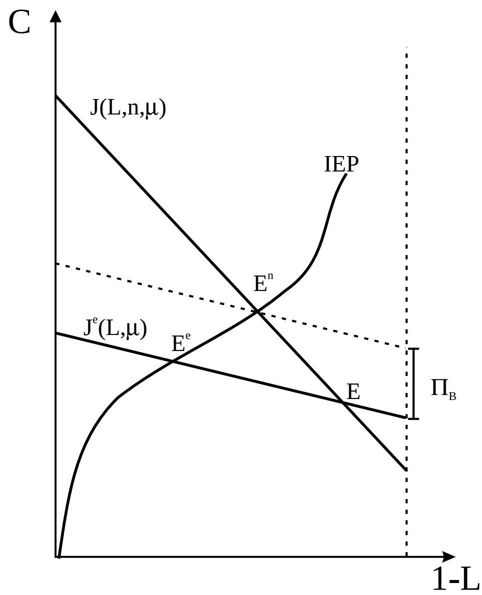

Fig. 1. Free-entry and fixed n compared with $\mu > 0$.

Proposition 2. Consider the case of n fixed the steady-state relationship between consumption and employment $J(L,n,\mu)$ is given by

$$J(L,n,\mu) = A + BL,$$

where $B > w/P$ and $A = A_0 - A_1 n$, with $A_0 > r(b_0/P + K_0)$ and $A_1 > 0$.

The steady state is presented by intersection of the *IEP*, which represents the optimal consumption and labor for any level of income given the real wage $w(\mu)/P(\mu)$, and the life-time budget constraint *LTBC*.

In Fig. 1, we depict equilibria with free-entry and with fixed-n. The *IEP* is common to both cases since wages and price are the same in both cases. With free-entry, there are no profits and the *LTBC* is $J^e(L,\mu)$, (22): in consumption-leisure space this has a slope $-w/P$. with the resultant equilibrium at E^e. The intercept term $L = 0$ represents non-labor income less tax: $r(b_0/P + K_0) - G$.

When firms obtain profits, the *LTBC* is $J(L,\mu,n)$ with equilibrium at point E^n. It is worth emphasizing that when the consumer decides the consumption and labor supply it takes the level of profits as given: the *intra*temporal budget constraint has slope $-w/P$ and is represented by the dotted line. The flow value of profits (losses) is represented by the vertical distance above (below) the point where the free-entry budget line $J^e(L,\mu)$ intersects the

$L=0$ line, Π_B. Moreover, the intercept term $J(0,\mu,n)$ falls as the number of firms n increases. At point E, where $J(L,n,\mu)=J^e(L,\mu)$, the fixed number of firms n happens to equal the free-entry number n^e: at points to the left of E, $n<n^e$ and profits are positive; to the right $n>n^e$ leading to losses. If we alter the number of firms, there is a vertical shift in $J(L,n,\mu)$. Hence, at the equilibrium depicted, E^n, the number of firms is less than the free-entry equilibrium E^e.

An increase in μ has two effects: firstly, the *IEP* shifts to the right/down: an increase in μ reduces the real wage and means that the household will substitute leisure for consumption. Secondly, the *LTBC* will be rotated anti-clockwise (as the real wage falls) and the absolute value of the intercept will fall when $b_0 \neq 0$ (since $b_0/P(\mu)$ falls).

It is important to note that expected variations in profits, even in the distant future, affect the present level of consumption. Hence, the effect of the fiscal policy on consumption and labor will depend not only on variation in current or steady-state profits, but also on the variation in profits along the transition to new steady state. Static models do not consider this effect because they do not introduce the intertemporal budget constraint. In dynamic closed economy models (e.g. Heijdra, 1998; Rotemberg and Woodford, 1995), the consumer can only use domestic savings to accumulate capital and consumption varies with investment. In our model, variations in profits affect the current account and stock of bonds, whilst consumption is perfectly smoothed.

5. Fiscal policy

We consider the effects of a permanent but unanticipated change in total government expenditure financed by a lump-sum tax. Let us first turn to the steady-state effects. We will be considering the output [17] and employment multipliers in particular. Since government expenditure does not affect the equilibrium prices, there is a pure wealth effect on consumption and leisure (a *resource withdrawal effect* in Turnovsky's terminology). Hence

Proposition 3. Independently of the market structure that we consider

$$0<\frac{\mathrm{d}Y^*}{\mathrm{d}G}<1, \quad \frac{\mathrm{d}L^*}{\mathrm{d}G}>0, \quad \frac{\mathrm{d}K^*}{\mathrm{d}G}>0, \quad \frac{\mathrm{d}b^*}{\mathrm{d}G}<0.$$

This is depicted in consumption-leisure space, Fig. 2. In all three cases, there is a linear *LTBC*. An increase in G merely results in a vertical shift

[17] Y is related to national income (measured in terms of the numeraire) by the following identities: $GDP=PY-rb+\dot{b}$ and $GNP=GDP+rb$. In steady state, since $\dot{b}=0$, we have $GNP=PY$.

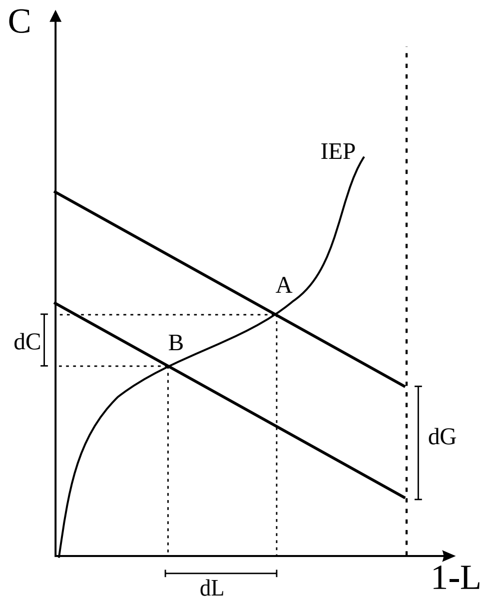

Fig. 2. The multiplier and resource withdrawal effect.

downwards in the *LTBC*, shifting the equilibrium from *A* to *B*. The increase in tax is allocated between consumption and leisure according to the *slopes* of the *IEP* and the *LTBC*. In the limiting case where leisure has an infinite marginal utility (vertical *IEP*), then there would be 100% crowding out and zero multipliers for employment output and capital. Conversely, with zero marginal utility of leisure (*IEP* Horizontal) there is no crowding out. Likewise, the flatter the *LTBC*, the greater the reduction in consumption and smaller reduction in Leisure. Hence, the comparison of multipliers depends crucially on comparison of the slopes of the *IEP* and *LTBC*.

We firstly compare the multiplier under free-entry and for a fixed-n. Assuming that we start off from an initial position with zero-profits ($n = n^e$, a point like *A* in Fig. 3).

Proposition 4. If either (a) *for general preferences with* $n = n^e$, *or* (b) *for any* n *with* $U(C, 1-L)$ *homothetic*

$$\left.\frac{\mathrm{d}Y^*}{\mathrm{d}G}\right|_n > \left.\frac{\mathrm{d}Y^*}{\mathrm{d}G}\right|_e \quad \textit{and} \quad \left.\frac{\mathrm{d}L^*}{\mathrm{d}G}\right|_e > \left.\frac{\mathrm{d}L^*}{\mathrm{d}G}\right|_n .$$

In Fig. 3, we depict the new equilibria after the increase in G from the initial equilibrium at A. If there was no change in Leisure, then the new

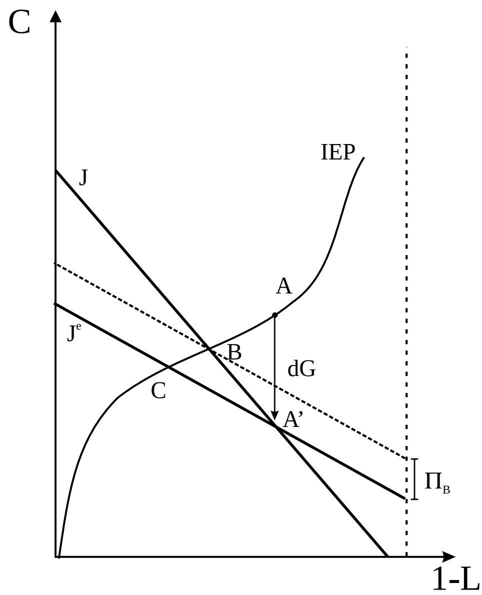

Fig. 3. The multiplier under free entry and with a fixed number of firms.

equilibrium would be at A'. However, the household chooses to allocate the increase in taxes by working harder, to be on its *IEP* (which is the same in both cases). The only difference between free entry and fixed-n is that the *LTBC* is flatter with free-entry. With free-entry, the new equilibrium is at C; with fixed-n the new equilibrium is at B (the dotted line passing through B is the households steady-state budget constraint). Clearly, the reduction in consumption is smaller in the case of fixed-n than with free-entry. The reason is that with a fixed number of firms an increase in output is achieved more efficiently (since the level of fixed costs is constant), the efficiency being reflected in the additional steady-state profit income Π_B. Note that Proposition 4 could be reversed if we allow for a strong enough Ethier effect. This requires the reduction in costs as a result of new products to outweigh the extra fixed costs (see, for example, Heijdra, 1998). This argument applies to general preferences, only relying on the upward slope of the *IEP*, but requires the starting position to be the same ($n = n^e$) so that the slope is the same. In the case of homothetic preferences, the *IEP* is linear with constant slope so that the proposition does not rely on the same initial condition for n.

We now contrast the *impact* effect with the steady-state effects. On impact, the stock of capital and bonds are unchanged by dG. Clearly, since price is also unaffected by changes in G, and $\{\lambda, C, L\}$ jump to their steady-state values immediately, we need only look at $\{Y, y_{\mathrm{N}}, y_{\mathrm{T}}\}$. The impact effects of a

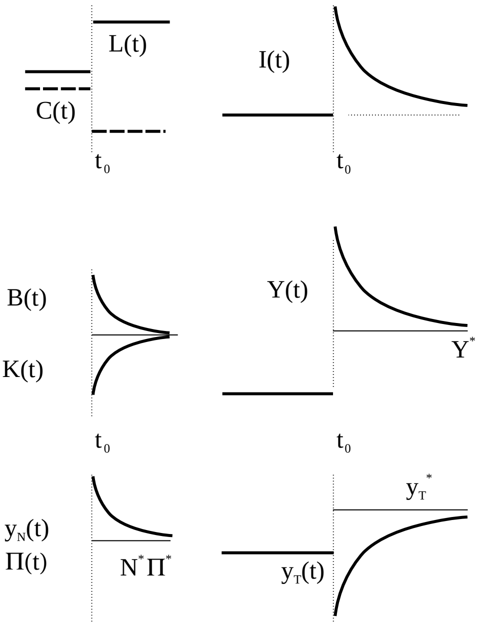

Fig. 4. Dynamic responses to a permanent increase in G at time t_0.

permanent increase in government expenditure obey the following inequalities

$$\frac{\mathrm{d}Y(0)}{\mathrm{d}G} > \frac{\mathrm{d}Y^*}{\mathrm{d}G} > 0, \qquad \frac{\mathrm{d}y_{\mathrm{N}}(0)}{\mathrm{d}G} > \frac{\mathrm{d}y_{\mathrm{N}}^*}{\mathrm{d}G} > 0,$$

$$\frac{\mathrm{d}y_{\mathrm{T}}^*}{\mathrm{d}G} > 0 > \frac{\mathrm{d}y_{\mathrm{T}}(0)}{\mathrm{d}G}, \qquad \frac{\mathrm{d}\dot{b}(0)}{\mathrm{d}G} < 0.$$

The Rybczynski effect determines the effect on sectoral outputs: an increase in labor with a constant capital stock decreases the output of the capital intensive traded sector from (6c), whilst increasing the output in the labor intensive non-traded sector. This means that on impact there is a balance of payments deficit (bonds are decumulated). As we move towards steady state, capital is accumulated: output in the traded sector increases, and decreases in the non-traded. If we look at aggregate output, the initial jump is higher than the steady-state change, reflecting the investment that occurs. In the case of fixed-n, the time path of profits follows that of the NT sector: on impact there is overshooting and then decline towards the new higher steady state. The time-paths of variables are depicted in Fig. 4, where the unanticipated increase in G occurs at t_0.

5.1. The markup, the multiplier and welfare

Having considered the effect of fiscal policy for a given markup μ, we can now explore the effect of variations in μ. In general, we cannot say what the effect of μ is on the multiplier. The intuitive reason for this is that an increase in μ tends to make *both* the *IEP* and the *LTBC* flatter: the first increases the multiplier and the second reduces it. First, the reduction in the real wage means that the households substitutes from consumption to leisure—the *IEP* shifts to the right/down. This will tend to increase the multiplier: the response to reduced wealth falls more heavily on the labor supply than consumption. Second, the slope of the *LTBC* is reduced, representing the increased inefficiency in the economy: this effect tends to lead to a greater decrease in both consumption and leisure. Which effect dominates will depend very much on functional forms (see Dixon and Lawler, 1996, for the static closed economy case). In particular, when the *IEP* is non-linear, no obvious connection can be made between the shift in the *IEP* and the slope at the equilibrium point.

We are able to make some general statements for Cobb–Douglas (*C–D*) preferences and/or technology

$$U(C,L)=\frac{1}{1-\sigma}(C^{v}(1-L)^{1-v})^{1-\sigma}, \quad \text{preferences},$$

$$f_{\mathrm{N}}(k_{\mathrm{N}})=(k_{\mathrm{N}})^{\delta},\ f_{\mathrm{T}}(k_{\mathrm{T}})=(k_{\mathrm{T}})^{\beta},\ P=(p_{\mathrm{N}})^{\alpha}, \quad \text{technology}.$$

Proposition 5. The markup and the multiplier in a Cobb–Douglas economy
(*a*) *Free-entry, C–D technology and preferences*: $\mathrm{d}Y^*/\mathrm{d}G=1-v$.
(*b*) *Fixed n, C–D Preferences and technology* : $\mathrm{d}^2Y^*/\mathrm{d}G\,\mathrm{d}\mu>0$.
(*c*) *Fixed n, C–D preferences*: $\mathrm{d}Y^*/\mathrm{d}G|_{\mu>0} > \mathrm{d}Y^*/\mathrm{d}G|_{\mu=0}$.

In the case of free-entry with *C–D* preferences and technology, the markup has no effect on the multiplier. This is a useful reference point. In the case of a fixed number of firms, there is an additional profit effect: as output in the non-traded sector increases, so does profit. This profit effect is larger when there is a larger markup. This effect is similar to the results in static models (Dixon, 1987; Mankiw, 1988): however, in a dynamic economy the profit effect takes in the net present value of profits, including profits earned along the path to equilibrium. With *C–D* technology and preferences, the multiplier is increasing in μ: with *C–D* preferences and general technology, the multiplier with any positive $\mu>0$ is greater than the limiting Walrasian case. This last result also indicates that the multiplier is increasing in μ for μ small enough (by continuity).

Lastly, we can determine the welfare effects of fiscal policy. Since we are treating G as waste, the resource withdrawal effect reduces utility. Defining lifetime utility as $\bar{U}=\int_0^{\infty}U(C,1-L)\exp[-rt]\,\mathrm{d}t$, we find that

Proposition 6. The effect of public expenditure on lifetime utility.
(*a*) *Free-entry* $\mathrm{d}\bar{U}/\mathrm{d}G = -\,U_c/r < 0$.
(*b*) *Non-entry*

$$\frac{\mathrm{d}\bar{U}}{\mathrm{d}G} = -\frac{U_c}{r} + \frac{U_c}{r}\left[\frac{1}{P}\frac{\mathrm{d}\Pi^*}{\mathrm{d}G}\frac{\Phi_K}{(\Phi_K - r)}\right] < 0.$$

Under free-entry, the reduction in utility is equal to the reduction in consumption due to higher taxes $(-U_c/r)$. This is the result that would be obtained in economy with perfect competition (e.g. Sen and Turnovsky, 1991).[18] In the case of monopolistic competition with non-entry, we have an additional positive effect on welfare: the increase in the present value of profits. The term in square brackets in part (b) is precisely the increase in the net present value of profits caused by an increase in G. The effect of profits is as crucial in determining welfare effects as it is the output multiplier.

6. Conclusion

In this paper, we have attempted to develop a general yet tractable framework with which to analyse the conduct of fiscal policy in the context of a small open economy with an imperfectly competitive non-traded sector. The approach does not rely on special assumptions about the functional forms of preferences or technology, yet is able to yield some clear results. In addition, we have developed a diagrammatic approach to the analysis of fiscal policy to complement the mathematical analysis. This general approach can be developed. For some applications, it might be desirable to have imperfect competition in the traded sector in addition to or instead of the non-traded sector. The existing modelling framework can also be extended by introducing other features: distortionary taxes and tariffs, Ethier and other productivity effects, public infrastructure effects and different types of imperfect competition.

Acknowledgements

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[18] In the model the marginal rate of substitution between consumption and leisure is equal to real wage. Hence, since the wage is constant the marginal utility of labor can be expressed in terms of the marginal utility of consumption and the variation in welfare can be represented solely by the change in consumption as consequence of the variation in public expenditure (see Appendix A).

Small Open Economy. This paper has been presented at the ASSET meeting 1998, EEA 1998 meeting (Berlin), the RES meeting 1999 (Nottingham), the 8th World Congress of the Econometric Society 2000 (Seattle) and seminars at The Bank of England, Barcelona (UAB), Copenhagen, Hull, Lisbon (ISEG), Manchester, Oslo, Paris-1 and York. We would like to thank seminar participants for their valuable comments, along with the referees. Special thanks also to Mary Carmen García-Alonso. Huw Dixon wrote this paper whilst an ESRC Research Fellow. Javier Coto would like to acknowledge the financial support from the Spanish government (FPI program), Generalitat de Catalunya and Fundación Caixa Galicia. Faults remain our own.

Appendix A.

Proof of Proposition 1. (a) *Fixed n*. To simplify Ω note that from the budget constraint, the value of the sum of the increase in output in both sectors as a result of a higher capital stock is equal to the rental price of capital plus the increase in profits.

$$\frac{\partial y_{\mathrm{T}}}{\partial K} + p_{\mathrm{N}}\frac{\partial y_{\mathrm{N}}}{\partial K} = rP + \frac{\mathrm{d}\Pi}{\mathrm{d}K}. \tag{A.1}$$

From (15), using Φ_K and (A.1) we have $\Psi_K = P(r - \Phi_K) + \mathrm{d}\Pi/\mathrm{d}K$. Hence, Ω becomes

$$\Omega = \frac{(r-\Phi_K)P + (\mathrm{d}\Pi/\mathrm{d}K)}{\Phi_K - r} = -P - \frac{\mu P_{\mathrm{N}}}{\Phi_K - r}\frac{f_{\mathrm{N}}}{k_{\mathrm{T}} - k_{\mathrm{N}}} < 0. \tag{A.2}$$

(b) *Free entry*. The proof is as in (a) except that there is no profit income. Hence,

$$\Psi_K = \frac{\partial y_{\mathrm{T}}}{\partial K} - P\Phi_K^e + p_n\frac{\partial y_{\mathrm{N}}}{\partial K} = P(r - \Phi_K^e). \qquad \square$$

Proof of Proposition 2. The relationship between expenditure and income in steady state is given by (21). Noting that $\Pi = \mu\alpha(p_{\mathrm{N}})(PC + G)$, using (18), (20) and Proposition 1 we obtain

$$C + G = \left(\frac{\Phi_K \alpha\mu f_{\mathrm{T}}}{P(\Phi_K(1-\mu\alpha(p_{\mathrm{N}})) - r)} + \frac{w}{P}\right)L + rK_0$$

$$+ \left(\frac{\Phi_K - r}{\Phi_K(1-\mu\alpha(p_{\mathrm{N}})) - r}\right)\frac{rb_0}{P},$$

where

$$\frac{\Phi_K \alpha \mu f_{\mathrm{T}}}{P(\Phi_K(1-\mu\alpha(p_{\mathrm{N}}))-r)} > 0$$

and

$$\frac{\Phi_K - r}{\Phi_K(1-\mu\alpha(p_{\mathrm{N}}))-r} > 1. \qquad \square$$

Proof of Proposition 3. From the market clearing condition in the steady state, (18) and the budget constraints in the steady state (21), we compute the derivative of the marginal utility of wealth λ^* and the capital stock K^* with respect to public expenditure G.

The derivatives of the marginal utility of wealth with respect to public expenditure are equal to

$$\textit{Free-entry}: \frac{\partial \lambda^e}{\partial G} = \frac{P}{l_\lambda w - PC_\lambda}$$

$$\textit{Fixed } n: \frac{\partial \lambda^n}{\partial G} = \frac{P - (p_{\mathrm{N}}\mu/(\Phi_K - r))\partial y_{\mathrm{N}}/\partial K}{l_\lambda w - PC_\lambda + (l_\lambda r k_{\mathrm{T}} + C_\lambda)(p_{\mathrm{N}}\mu/(\Phi_K - r))\partial y_{\mathrm{N}}/\partial K}. \tag{A.3}$$

Hence

$$\frac{\partial C^*}{\partial G} = C_\lambda \frac{\partial \lambda^*}{\partial G} < 0$$

and

$$\frac{\partial L^*}{\partial G} = L_\lambda \frac{\partial \lambda^*}{\partial G} > 0.$$

The derivatives of capital stock with respect to public expenditure are

$$\frac{\partial K^e}{\partial G} = \frac{l_\lambda P((\alpha/p_{\mathrm{N}})k_{\mathrm{N}} f_{\mathrm{T}} + (1-\alpha(p_{\mathrm{N}}))k_{\mathrm{T}}(1-\mu)f_{\mathrm{N}})}{(1-\mu)f_{\mathrm{N}}(l_\lambda w - PC_\lambda)} > 0,$$

$$\frac{\partial K^n}{\partial G} = \frac{l_\lambda P((\alpha/p_{\mathrm{N}})k_{\mathrm{N}} f_{\mathrm{T}} + (1-\alpha)k_{\mathrm{T}} f_{\mathrm{N}})}{f_{\mathrm{N}}[l_\lambda w - PC_\lambda + (l_\lambda r k_{\mathrm{T}} + C_\lambda)p_{\mathrm{N}}\mu(\partial y_{\mathrm{N}}/\partial K)/(\Phi_K - r)]} > 0.$$

$\square$

Proof of Proposition 4. (a) If we start from long-run equilibrium, then all derivatives are evaluated from the same initial position. In order to prove that the fiscal multiplier is higher in the case of imperfect competition with non-entry than the case of entry, we need to prove that

$$\frac{\partial \lambda^n}{\partial G} < \frac{\partial \lambda^e}{\partial G}.$$

From (A.3), we obtain the equivalent condition:

$$(-l_\lambda w)\frac{p_N \mu \partial y_N/\partial K}{\Phi_K - r} < P(l_\lambda r k_T)\frac{p_N \mu \partial y_N/\partial K}{\Phi_K - r},$$

$$-w < Prk_T \tag{A.4}$$

since $p_N \mu \partial y_N/\partial K/(\Phi_K - r) > 0$ and $l_\lambda > 0$. Inequality (A.4) is always satisfied, establishing the result.

(b) With homothetic preferences, l_λ, C_λ do not vary with λ. Hence, the derivation given in part (a) is valid irrespective of the initial position. □

Proof of Proposition 5. (a) With Cobb–Douglas preferences and technology we have for fixed n

$$\frac{\partial C}{\partial G} = \frac{-\upsilon(1-\beta+\alpha(\beta-\delta)-\alpha\mu(1-\delta))}{1-\beta+\alpha(\beta-\delta)+\mu\alpha(\delta-\upsilon)} \tag{A.5}$$

which is decreasing in μ. Since $\mathrm{d}Y^2/\mathrm{d}G\,\mathrm{d}\mu = -\,\mathrm{d}C^2/\mathrm{d}G\,\mathrm{d}\mu$, we have the result.

(b) With Cobb–Douglas preferences and a general technology, the derivative of consumption with respect to public expenditure in the case of perfect competition and free entry are equal

$$\frac{\partial C}{\partial G} = -\,\upsilon. \tag{A.6}$$

In the case of fixed n, we have

$$\frac{\partial C^*}{\partial G} = \frac{-\upsilon(1 - \dfrac{1}{P}\dfrac{p_N\mu}{(\Phi_K - r)}\dfrac{\partial y_N}{\partial K})}{(1 - \dfrac{1}{P}\dfrac{p_N\mu}{(\Phi_K - r)}\dfrac{\partial N}{\partial K}) + \dfrac{1}{P}(\dfrac{(1-\upsilon)f_T}{w})\dfrac{p_N\mu}{(\Phi_K - r)}\dfrac{\partial y_N}{\partial K}}. \tag{A.7}$$

Now, we compare the case of monopolistic competition with respect to the case of perfect competition

$$\frac{-\upsilon(1 - \dfrac{1}{P}\dfrac{p_N\mu}{(\Phi_K - r)}\dfrac{\partial y_N}{\partial K})}{(1 - \dfrac{1}{P}\dfrac{p_N\mu}{(\Phi_K - r)}\dfrac{\partial y_N}{\partial K}) + \dfrac{1}{P}(\dfrac{(1-\upsilon)f_T}{w})\dfrac{p_N\mu}{(\Phi_K - r)}\dfrac{\partial y_N}{\partial K}} > -\,\upsilon. \tag{A.8}$$

This inequality is always satisfied since

$$\upsilon\frac{1}{P}\frac{(1-\upsilon)f_{\mathrm{T}}}{w}\frac{p_{\mathrm{N}}\mu}{\Phi_K - r}\frac{\partial y_{\mathrm{N}}}{\partial K} > 0. \tag{A.9}$$

(c) In the free-entry case the effect of G on C^* is given by (A.5) setting $\mu = 0$. □

Proof of Propositions 6. The derivative of the lifetime utility of the consumer with respect to public expenditure

$$\frac{\mathrm{d}\bar{U}}{\mathrm{d}G} = \frac{1}{r}\left(U_c\frac{\mathrm{d}C}{\mathrm{d}G} - U_L\frac{\mathrm{d}L}{\mathrm{d}C}\right) = \frac{U_c}{r}\left(\frac{\mathrm{d}C}{\mathrm{d}G} - \frac{w}{P}\frac{\mathrm{d}L}{\mathrm{d}G}\right). \tag{A.10}$$

Differentiating (7) with respect to public expenditure and re-arranging terms yields

$$\frac{\mathrm{d}C}{\mathrm{d}G} = \frac{1}{P}\left(-\frac{\mathrm{d}\dot{b}(t)}{\mathrm{d}G} + r\frac{\mathrm{d}b(t)}{\mathrm{d}G} + w\frac{\mathrm{d}L}{\mathrm{d}G} + rP\frac{K(t)}{\mathrm{d}G} + \frac{\mathrm{d}\Pi(t)}{\mathrm{d}G} - P\frac{\mathrm{d}I}{\mathrm{d}G} - P\right).$$

We substitute the above expression into (A.10), noting that bonds and capital accumulation are related through Ω to obtain the variation in lifetime welfare

$$\frac{\mathrm{d}\bar{U}}{\mathrm{d}G} = \frac{U_c}{r}\left(-\frac{1}{P}\Omega\frac{\dot{K(t)}}{\mathrm{d}G} + \frac{1}{P}r\Omega\frac{K(t)}{\mathrm{d}G} + r\frac{K(t)}{\mathrm{d}G} + \frac{1}{P}\frac{\mathrm{d}\Pi(t)}{\mathrm{d}G} - \frac{\dot{K(t)}}{\mathrm{d}G} - 1\right). \tag{A.11}$$

Note that, in the case of free-entry there is no profits and $\Omega = -P$, so that (A.11) becomes $\mathrm{d}\bar{U}/\mathrm{d}G = -U_c/r$.

In the case of fixed n, in order to compute the effect of the fiscal policy on consumer welfare, we substitute (A.2) into (A.11)

$$\frac{\mathrm{d}\bar{U}}{\mathrm{d}G} = \frac{U_c}{rP}\left(\left(\frac{r}{\Phi_K - r}\right)\frac{\mathrm{d}\Pi^*}{\mathrm{d}G} + \frac{\mathrm{d}\Pi^*}{\mathrm{d}G}\exp\Phi_K t + \frac{\mathrm{d}\Pi(t)}{\mathrm{d}G} - P\right). \tag{A.12}$$

We compute the derivative of profits with respect to G,

$$\frac{\mathrm{d}\Pi(t)}{\mathrm{d}G} = \frac{\mathrm{d}\Pi^*}{\mathrm{d}G} - \frac{\mathrm{d}\Pi}{\mathrm{d}K}\frac{\mathrm{d}K^*}{\mathrm{d}G}\exp\Phi_K t = \frac{\mathrm{d}\Pi^*}{\mathrm{d}G}(1 - \exp\Phi_K t). \tag{A.13}$$

Together (A.12) and (A.13) imply

$$\frac{\mathrm{d}\bar{U}}{\mathrm{d}G} = \frac{U_c}{r}\left(\frac{1}{P}\frac{\mathrm{d}\Pi^*}{\mathrm{d}G}\left(\frac{\Phi_K}{\Phi_K - r}\right) - 1\right) < 0,$$

the desired result. □

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