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Monopolistic Competition, Increasing Returns, and the Effects of Government Spending

IN THE LAST DECADE, a large literature has explored the effects of government spending in dynamic general equilibrium environments. Most papers in this area are based on the one-sector neoclassical growth model with constant returns to scale. For example, Aiyagari, Christiano, and Eichenbaum (1992) and Baxter and King (1993) explore the responses of economic aggregates to temporary and permanent changes in government spending in this model, extending the earlier work of Barro (1981, 1989) and Hall (1980). In these studies, the effects of government spending stem mainly from its negative wealth effects. In response to a temporary increase in government spending, employment and output rise while both real wages and consumption fall. In addition, as Barro and King (1984) show, in a model with constant returns and time separable utility, government spending shocks generate a negative relationship between consumption and hours worked. These findings have been seen as difficult to reconcile with observed co-movements in aggregate variables. For example, it has been recognized since Dunlop (1938) and Tarshis (1939) that the negative relationship between real wages and employment is not present in the data. Also, it is a well-documented observation that consumption and employment move together over the business cycle.

This paper explores the effects of government spending in a model with increasing returns and monopolistic competition. We find that changes in government spending may have markedly different effects in this economy than in the neoclassi-

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cal model with constant returns. Our findings stem mainly from the fact that in our economy an increase in the level of government spending results in an endogenous increase in total factor productivity in spite of the fact that the spending itself is entirely wasteful. If this increase in productivity is great enough, a government spending shock may result in simultaneous increases in output, employment, wages, and consumption. Motivation for a link between government spending and total factor productivity in the United States has been provided by Evans (1992) and Hall (1990). Both of these studies have found that a standard measure of total factor productivity, the Solow residual, is not invariant to changes in the level of government spending. Similar results have been found for France and the United Kingdom by Ravn (1992).

In our model monopolistically competitive firms supply intermediate goods under conditions of free entry. Intermediate goods are used to produce a single final good. The productivity of any one intermediate good depends positively on the total number of intermediates in use. This specification reflects a type of “increasing returns to specialization” commonly used in international trade theory and endogenous growth theory. In the presence of returns to specialization, fluctuations in government demand for the final good generate movements in total factor productivity by changing the equilibrium number of firms operating in the intermediate goods industry. This is a simple way of capturing the spirit of a “thick market” effect as described by Diamond (1982) and Hall (1992). In the model, periods of high output coincide with entry of new firms and high productivity, whereas when output is low, firms exit, and productivity is low. In addition, the procyclical behavior of net entry of new firms is a noted business cycle feature in the U.S. economy (for example, Audretsch and Acs 1992 and Chatterjee, Cooper, and Ravikumar 1993). Davis and Haltiwanger (1990) also show that firm entry and exit have significant impact on labor fluctuations. For the period 1972–86 they estimate that annually 25 percent of gross job destruction and 20 percent of gross job creation in U.S. manufacturing can be attributed to establishment deaths and births, respectively.

We consider the effects of both permanent (steady-state) changes in the share of government spending in aggregate output and temporary shocks to the level of government spending in a neighborhood of the steady state. The results depend critically on the magnitude of the markup of price over marginal cost, which in our model determines the degree of returns to specialization. Since we are interested in the qualitative effects of increasing returns on the effects of government spending shocks in equilibrium, we perform our analysis for a range of markups.

We find that a steady-state change in the share of government spending in output has substantially different effects in the presence of returns to specialization than in the standard model. In particular, the steady-state real wage is increasing in the share of government in output for *any* degree of increasing returns. In addition, if labor supply is sufficiently elastic, then steady-state consumption is also positively related to the share of government in output in the presence of increasing returns. Thus government spending will crowd in long-run private consumption. In contrast,

under constant returns the real wage is invariant to changes in the steady-state share of government spending in output, and private consumption is nonincreasing in this share. Qualitatively, these results depend only on the existence of returns to specialization, not on their magnitude.

We also compute the dynamic responses of the economy to temporary government spending shocks for a range of values of returns to specialization. If increasing returns are sufficiently large, then even a purely transitory shock to government spending can lead to simultaneous increases in output, consumption, investment, and the real wage. With lesser degrees of returns to specialization, the impact of government spending will be to increase output, investment, and the real wage, but to reduce aggregate consumption. These findings contrast with the case of constant returns, in which government spending shocks must be very persistent if they are to produce increases in investment on impact, and in which no degree of persistence is sufficient to produce an increase in consumption or the real wage.

Our results are driven by the endogenous response of total factor productivity to a change in government spending. An expansion in government spending leads to an increase in labor supply at given factor prices. Holding the number of intermediate goods producers fixed, this would lead to a fall in the real wage and a rise in profitability for each firm. With free entry, however, enhanced profit opportunities precipitate the entry of a new group of intermediate producers, increasing the productivity of all intermediate goods. If this effect is strong enough, both employment and the real wage will rise. Moreover, in this case consumption and employment can move in the same direction in response to an aggregate demand shock alone. Because total factor productivity increases in response to the shock, the increase in the real wage facing each worker can lead to a substitution out of leisure and into consumption. The crucial issue is that the effects of the aggregate demand shock on productivity must be strong enough to produce a sufficient increase in the real wage.

The model then is capable of producing positive co-movements between real wages and hours worked and between consumption and hours worked, in an environment with only demand shocks. For these implications, however, the required markups are quite high. While not strong enough to generate either multiple equilibria or endogenous growth, they are larger than recent empirical evidence suggests are realistic for U.S. manufacturing. In addition, they require that the quantitative response of output to a government spending shock be higher than suggested by empirical evidence. With smaller returns to specialization (associated with markups that fall within the range of the recent estimates), however, the effects of government spending shocks on both output and real wages differ from those predicted by the standard model with constant returns and are more in line with those found in recent empirical studies.

This paper is related to a growing literature on the presence of increasing returns and imperfect competition in dynamic general equilibrium models. Baxter and King (1991) develop a real business cycle model in which the presence of spillovers at the aggregate level generate increasing returns in a Marshallian sense. They explore the

response of the aggregate economy to taste shocks. Rotemberg and Woodford (1993) examine the impact of government spending shocks in an imperfectly competitive general equilibrium economy without free entry.

The rest of the paper is organized as follows. The economy is described in section 1. Section 2 characterizes the deterministic steady state. Section 3 analyzes the model's dynamics in a neighborhood of the steady state and considers the effects of temporary shocks to government spending. Section 4 concludes.

1. THE ECONOMY

There is a single final good that can be consumed or invested, as in the standard neoclassical model. It is produced through the use of a range of differentiated intermediate inputs. Let m_{it} be the quantity of input i used in production of the final good. The final good production technology is given by

$$Y_t = \left[\int_0^{N_t} m_{it}^\rho di \right]^{1/\rho} \quad \rho \in (0, 1) \quad (1)$$

where N_t represents the measure of intermediate inputs produced at time t . The two-sector representation follows Hornstein (1993) with the modification that the variety of intermediate goods is not assumed to be constant. Note that if all intermediates are hired in the same quantity, m , then final output is given by $Y = N^{1/\rho}m$. Thus, there are constant returns to the quantity employed of a fixed variety of intermediate goods, but increasing returns to an expansion of variety, holding fixed the quantity employed of each intermediate. We refer to this type of increasing return as returns to specialization. The degree of returns to specialization is equal to $1/\rho$, where the parameter ρ governs the elasticity of substitution between any two intermediate inputs in final goods production. This form of increasing returns has been employed in a variety of settings, for example in international trade theory by Ethier (1982) and Krugman (1979) and in the theory of endogenous growth by Romer (1987).

Each intermediate input is produced by a monopolist using a symmetric technology:¹

$$\forall i \in [0, N_t], \quad m_{it} = zk_{it}^\alpha h_{it}^{1-\alpha} - \phi, \quad \alpha \in (0, 1), \quad \phi > 0. \quad (2)$$

Here k_{it} and h_{it} represent the capital and labor hired by intermediate producer i , and z is a constant technology parameter. Here ϕ is an amount which must be produced

1. The model could alternatively be reinterpreted as one in which each monopolist produces a differentiated final good, and consumption and investment are "composites" represented by aggregators over the differentiated final goods. Rotemberg and Woodford (1993) take that interpretation in their model (without entry or exit). Under this reinterpretation, final output would be $\int_0^{N_t} p_{it} m_{it} di$. From the results below, it can easily be shown that in a symmetric equilibrium, this definition of final output is equivalent to (1).

to cover a fixed cost of production, before any sales are made to the final goods sector.

Capital is accumulated by means of a standard intertemporal technology. The law of motion for the aggregate capital stock, K , is given by

$$K_{t+1} = (1 - \delta) K_t + X_t \quad (3)$$

where δ is the depreciation rate and X_t denotes investment in units of final good at time t .

There is a unit measure of identical households in the economy. A representative household has period preferences over individual consumption, \tilde{c}_t , and leisure, $L - \tilde{h}_t$, given by

$$U(\tilde{c}_t, L - \tilde{h}_t) = \log \tilde{c}_t + V(L - \tilde{h}_t) , \quad (4)$$

where a $\tilde{\cdot}$ (tilde) denotes a per capita quantity. Here L is the fixed endowment of time, \tilde{h}_t is hours worked, and the function V satisfies $V'(\cdot) > 0$, and $V''(\cdot) \leq 0$. Lifetime utility of a representative household is then given by

$$E_t \sum_{t=0}^{\infty} \beta^t U(\tilde{c}_t, L - \tilde{h}_t) \quad \beta \in (0, 1) . \quad (5)$$

The government is assumed to purchase an amount G_t of the final good in each period. G will follow a first-order autoregressive process,

$$G_t = (1 - \gamma) \tilde{G} + \gamma G_{t-1} + \epsilon_t \quad \gamma \in (0, 1) , \quad (6)$$

where ϵ_t is an iid shock. Government spending will be financed solely with a lump sum tax, τ_t , and we assume without loss of generality that $G_t = \tau_t$ for all t . Since our intention is to isolate the impact of changes in the level of government spending, we abstract from all issues associated with alternative means of government financing.

We consider a symmetric recursive equilibrium. The aggregate state variables for the economy are the aggregate capital stock, K , and level of government consumption, G . Households rent capital and labor to intermediate goods producers in competitive factor markets. Intermediate goods producers sell their differentiated products to an arbitrary number of identical final goods producers under conditions of monopolistic competition with free entry. Final goods producers sell output competitively to households, which make a dynamic consumption-investment decision. To characterize the equilibrium we proceed as follows. First, the conditions for static profit maximization on the part of final and intermediate goods producers, factor market clearing conditions, and the free entry condition for intermediate goods producers are used to derive equilibrium factor prices and the measure of intermediates as functions of the aggregate state and choice variables. These relationships, togeth-

er with the equilibrium requirement that aggregate behavior be consistent with individual household choices, are then imposed on the solution of the household intertemporal utility maximization problem to obtain the equilibrium.

Since both final and intermediate goods producers face static profit maximization problems, time subscripts are suppressed whenever possible in the following discussion. The final goods producer is a competitive price taker, with a cost function given by

$$C_Y(Y, \mathbf{p}) = Y \left[\int_0^N p_i^{\rho/(\rho-1)} di \right]^{(\rho-1)/\rho}, \quad (7)$$

where \mathbf{p} is the exact input price index. At the optimum, price must equal unit cost. Choosing the final good as the numeraire, in equilibrium we have

$$1 = \left[\int_0^N p_i^{\rho/(\rho-1)} di \right]^{(\rho-1)/\rho}. \quad (8)$$

The cost function for a representative intermediate producer is

$$C_m(w, r, m) = Ar^\alpha w^{1-\alpha} \frac{(m + \phi)}{z} \quad (9)$$

where $A = (1 - \alpha)^{-(1-\alpha)} \alpha^{-\alpha}$. Given (8), each intermediate good firm faces a demand curve with constant elasticity $1/(1 - \rho)$. Profit maximization implies the constant mark-up rule

$$p = \left(\frac{1}{\rho} \right) \left(\frac{Ar^\alpha w^{1-\alpha}}{z} \right). \quad (10)$$

Conditional factor demands of a representative intermediate producer are given by

$$k = A\alpha(r/w)^{\alpha-1} \frac{(m + \phi)}{z} \quad (11)$$

and

$$h = A(1 - \alpha)(r/w)^\alpha \frac{(m + \phi)}{z}. \quad (12)$$

Finally, free entry into the intermediate sector forces profits to be zero in each period,

$$pm = Ar^\alpha w^{1-\alpha} \frac{(m + \phi)}{z}. \quad (13)$$

Since all intermediate goods are produced with identical technologies and enter the final goods technology symmetrically, we focus only on a symmetric equilibrium in which intermediate firms have identical pricing policies. Under symmetry, (8) implies

$$p = N^{(1-\rho)/\rho} . \quad (14)$$

If K and H denote the aggregate capital stock and aggregate labor supply respectively, then factor market clearing requires $K = Nk$ and $H = Nh$. Using these, along with (10)–(14), we may solve for equilibrium w , r , and N , as functions of K and H :

$$w(K, H) = (1 - \alpha) \Delta z^{1/\rho} K^{\alpha/\rho} H^{((1-\alpha)/\rho)-1} \quad (15)$$

$$r(K, H) = \alpha \Delta z^{1/\rho} K^{(\alpha/\rho)-1} H^{(1-\alpha)/\rho} \quad (16)$$

$$N(K, H) = \frac{z(1 - \rho) K^\alpha H^{1-\alpha}}{\Phi} , \quad (17)$$

where $\Delta = \rho \left(\frac{1 - \rho}{\Phi} \right)^{(1-\rho)/\rho}$. With our specification, all variation in aggregate output is due to entry and exit, as output per firm is unaffected by changes in the aggregate state.² Note also, that neither factor prices nor the equilibrium number of varieties (or intermediate goods prices) are affected by the level of government spending except through its effect on the aggregate capital stock and level of employment. Since in equilibrium aggregate employment will be a function of the aggregate state, (14)–(17) give factor prices and varieties as functions of the aggregate state.

Equations (15) and (16) depict relationships between factor prices and factor employment that satisfy factor market clearing and zero profits in the intermediate industry, whereas equations (11) and (12) represent factor demand curves for a single firm. It is important to note that (15) and (16) are not merely aggregated versions of (11) and (12). In particular if we aggregate (12) with N fixed, combine the result with (2), (10), and (14), and rearrange, we can write

$$w_N(K, H; N) = \rho(1 - \alpha) N^{(1-\rho)/\rho} z K^\alpha H^{-\alpha} . \quad (18)$$

Given N , we can consider (18) an aggregate labor demand function and compare it to (15) which represents a locus of equilibrium combinations of w and H , incorporating the equilibrium condition that the number of intermediate goods give rise to zero profits. First note that the two equations differ for $\rho < 1$, but become identical as $\rho \rightarrow 1$. Recall that $1/\rho$ is the degree of returns to specialization. While the

2. This implication is, of course, at odds with the fact that output per firm does vary over time. It could be weakened by allowing investment goods and consumption goods to be produced with different technologies, as does Gali (1994). This modification would not affect the qualitative relationship between the overall degree of returns to specialization and the effects of government spending.

“labor demand” function (18) will always be downward sloping, the wage-hours locus (15) will have a lesser slope (in absolute value) when $\rho < 1$ and will be upward sloping if the degree of increasing returns is high enough, that is, if $\rho < 1 - \alpha$. The explanation for the divergence of (15) from (18) lies in the fact that firm entry in the presence of increasing returns to specialization results in an endogenous increase in total factor productivity. For any one firm, labor demand is downward sloping, as the firm does not choose N . But for the sector as a whole, increased employment (through entry) raises the productivity of labor. This raises the relative price of the good facing each firm through the variety effect, as can be seen from (14). Both of these effects shift the individual labor demand curves outward, and may cause equilibrium wages and employment to be positively related.

To better understand the endogenous productivity effect that drives these results, note that using (1) and (18), final output in equilibrium may be written as

$$Y = \rho N^{(1-\rho)/\rho} (zK^\alpha H^{1-\alpha}) = \Delta (zK^\alpha H^{1-\alpha})^{1/\rho} . \quad (19)$$

The first equality indicates that, at the aggregate level, $N^{(1-\rho)/\rho}$ may be treated as a productivity measure. Output is a constant returns function of primary factors, for a given measure of intermediates. Movements in the number of firms, however, shift the relationship between equilibrium output and primary factor employment and may be thought of as an endogenous productivity response to any impulse that causes the number of firms to change.³ Changes in government spending will provoke fluctuations in the number of firms as variations in aggregate demand create opportunities for profits or losses, causing firms to enter or exit, respectively.

The implications for the relationship between wages and hours can be clarified with labor market diagrams analogous to those used by Rotemberg and Woodford (1991), Hansen and Wright (1992), and others. We define the labor supply function as the schedule that relates hours to the real wage holding consumption constant. Figure 1a illustrates the case of constant returns. In this case, the aggregate labor demand function and the wage-hours locus coincide. A rise in government spending will reduce consumption, shift out the labor supply function, and cause wages to fall, while hours rise. Therefore, demand shocks will lead to a negative relationship between hours and wages. Figure 1b illustrates equilibrium effects in the presence of a relatively small markup ($1 - \alpha < \rho < 1$). In this case, the aggregate labor demand schedule given by equation (18) is steeper than the wage-hours locus given by equation (15). In response to the endogenous increase in productivity resulting from entry, each firm’s labor demand schedule shifts out. But, as in the model without increasing returns, wages and hours will be negatively related, although wages fall by less than in an economy with constant returns.

Figures 1c and 1d illustrate the case of large markups ($\rho < 1 - \alpha$). In both figures, the aggregate wage-hours locus is upward sloping. As the figures suggest, de-

3. Baxter and King (1991) examine a model in which there are increasing returns to scale due to external spillovers across perfectly competitive firms. In their model, taste shocks also generate an endogenous productivity movement.

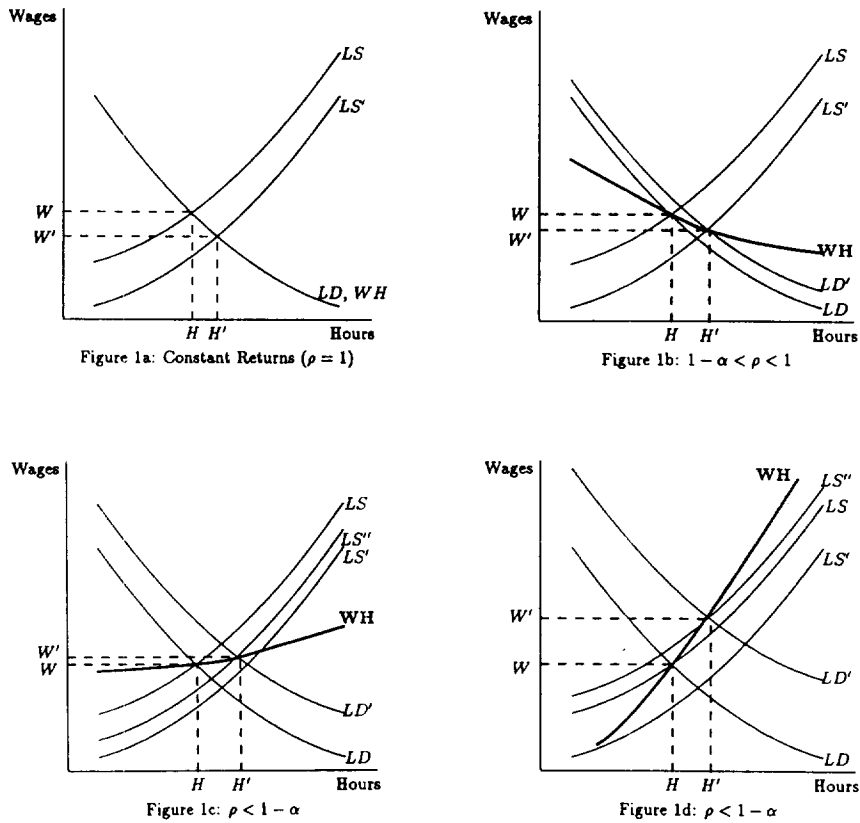


FIG. 1. The Labor Market

pending on preferences and the degree of increasing returns, the wage-hours locus may intersect the labor supply function from above or from below. In the former case (Figure 1c), an outward shift in the labor supply curve leads to increases in both employment and the real wage. In the latter case (Figure 1d), an expansion in government spending also raises private consumption. Effectively, the labor supply curve shifts leftward (to LS''). This also leads to a rise in employment and the real wage. This phenomenon is further discussed in section 3 below.⁴

While our discussion has focused on the aggregate labor demand schedule, equation (14), returns to specialization also affect the aggregate capital demand sched-

4. Benhabib and Farmer (1992) emphasize the relationship between a wage-hours locus (14) which cuts the labor supply curve from below and multiplicity of equilibria. They show that in this case there may be multiple rational expectations equilibrium paths—the linear approximate dynamic system is a sink rather than a saddle. To maintain comparability to the standard neoclassical model, we restrict attention to cases where the linear approximate solution to the model is a saddle path, and therefore, the issue of indeterminacy does not arise.

ule. For this locus to be upward sloping, however, we would have to have much larger increasing returns, ($\rho < \alpha$). With increasing returns of this magnitude, there would be more than constant returns to the factor that could be accumulated (that is, capital) resulting in endogenous growth (see Romer 1987). In this study, we focus on increasing returns that are “small” in the theoretical sense that they are not sufficient to generate endogenous growth. Thus we require $\rho > \alpha$.

We now consider the utility maximization problem of the representative household. Taking prices as given, the household maximizes utility through the choice of consumption, capital accumulation, and hours worked subject to its budget constraint and the laws of motion of the household state variables. The household's state includes the aggregate state variables, K_t and G_t , and its household capital, \bar{k}_t . The household's Bellman equation can be written:

$$v(K_t, G_t, \bar{k}_t) = \max_{\bar{c}_t, \bar{h}_t, \bar{x}_t} \{U(\bar{c}_t, \bar{h}_t) + \beta E v(K_{t+1}, G_{t+1}, \bar{k}_{t+1})\}$$

subject to

$$\bar{c}_t + \bar{x}_t = w(K_t, H_t)\bar{h}_t + r(K_t, H_t)\bar{k}_t - G_t$$

$$\bar{k}_{t+1} = (1 - \delta)\bar{k}_t + \bar{x}_t$$

$$K_{t+1} = (1 - \delta)K_t + X_t$$

$$H_t = H(K_t, G_t)$$

$$X_t = X(K_t, G_t)$$

$$G_{t+1} = \gamma G_t + (1 - \gamma)\bar{G} + \epsilon_{t+1},$$

where $w(K_t, H_t)$ and $r(K_t, H_t)$ are given by (15) and (16), respectively.

A symmetric recursive equilibrium is a collection of individual policy functions, $\bar{c}(K_t, G_t, \bar{k}_t)$, $\bar{h}(K_t, G_t, \bar{k}_t)$, $\bar{x}(K_t, G_t, \bar{k}_t)$; aggregate policy functions, $C(K_t, G_t)$, $H(K_t, G_t)$, $X(K_t, G_t)$; and a value function, $v(K_t, G_t, \bar{k}_t)$, such that:

- i. $v(K_t, G_t, \bar{k}_t)$, $C(K_t, G_t)$, $H(K_t, G_t)$, and $X(K_t, G_t)$ solve the dynamic programming problem with $\bar{c}(K_t, G_t, \bar{k}_t)$, $\bar{h}(K_t, G_t, \bar{k}_t)$, and $\bar{x}(K_t, G_t, \bar{k}_t)$ the associated policy functions.
- ii. $C(K_t, G_t) = \bar{c}(K_t, G_t, K_t)$
 $H(K_t, G_t) = \bar{h}(K_t, G_t, K_t)$
 $X(K_t, G_t) = \bar{x}(K_t, G_t, K_t)$

The first-order conditions for the household utility maximization, together with equilibrium condition ii give rise to the following nonlinear dynamic system in aggregate variables:

$$w(K_t, H_t) = V'(L - H_t)C_t; \quad (20)$$

$$C_t^{-1} = \beta E_t C_{t+1}^{-1} [r(K_{t+1}, H_{t+1}) + 1 - \delta]; \quad (21)$$

$$C_t + K_{t+1} - (1 - \delta)K_t + G_t = \Delta (zK_t^\alpha H_t^{1-\alpha})^{1/\rho}. \quad (22)$$

This system of nonlinear stochastic difference equations cannot be solved analytically. The solution is characterized using standard numerical techniques in section 3.

2. THE DETERMINISTIC STEADY STATE

We begin by deriving the deterministic steady state for the economy. This analysis serves two purposes. First it enables us to analyze the long-run effects of permanent changes in the level of government spending. Second, it is necessary for the derivation of the economy's dynamic responses to temporary government spending shocks, which are considered in the next section.

To facilitate the exposition of this section, let government purchases in the deterministic steady state be governed by the following rule:

$$\bar{G} = \theta \bar{Y}. \quad (23)$$

We may then write the deterministic steady-state interest rate as

$$\bar{r} = \frac{1}{\beta} - (1 - \delta). \quad (24)$$

The following steady-state relationships may then be derived:

$$\frac{\bar{Y}}{\bar{K}} = \frac{\bar{r}}{\alpha} \quad (25)$$

$$\frac{\bar{C}}{\bar{Y}} = 1 - \theta - \frac{\alpha \delta}{\bar{r}} \quad (26)$$

$$V'(L - \bar{H}) = \frac{(1 - \alpha)}{\bar{H}[1 - \theta - (\alpha \delta)/\bar{r}]}. \quad (27)$$

Thus the interest rate, the capital-output ratio, and the consumption-output ratio are determined by preference and technology parameters and the steady-state share of government expenditure in output, θ . Equation (27) implicitly determines \bar{H} , the steady-state level of hours worked. Given \bar{H} , the steady-state capital stock can be calculated using (24) and (25). The steady-state wage and consumption are then calculated using (15) and (26).

We now consider the impact on the steady state of a permanent change in the share of government spending, θ . From (27), we see that the impact of a permanent rise in θ on steady-state labor supply in our economy is

$$\frac{d \log \bar{H}}{d \log \theta} = \frac{\theta}{(1 - \theta - \alpha \delta / \bar{r}) \left[1 + \sigma \frac{\bar{H}}{L - \bar{H}} \right]} > 0, \quad (28)$$

where $\sigma \equiv \left(\frac{-V''}{V'} \right) (L - \bar{H}) \geq 0$. Note that the permanent response of hours to changes in the share of government spending in GNP is independent of the markup parameter, ρ . The response is exactly the same in this economy as in one with constant returns. This equivalence does not carry over to the non-steady-state analysis conducted in the next section.

Using (15), (25), and (26), we derive the impact of a change in θ on steady-state values for the capital stock, output, the wage, and consumption.

$$\frac{d \log \bar{K}}{d \log \theta} = \left[\frac{1 - \alpha}{\rho - \alpha} \right] \frac{d \log \bar{H}}{d \log \theta} > 0; \quad (29)$$

$$\frac{d \log \bar{Y}}{d \log \theta} = \left[\frac{1 - \alpha}{\rho - \alpha} \right] \frac{d \log \bar{H}}{d \log \theta} > 0; \quad (30)$$

$$\frac{d \log \bar{W}}{d \log \theta} = \left[\frac{1 - \rho}{\rho - \alpha} \right] \frac{d \log \bar{H}}{d \log \theta} \geq 0; \quad (31)$$

$$\frac{d \log \bar{C}}{d \log \theta} = \left[\frac{1 - \alpha}{\rho - \alpha} - 1 - \frac{\sigma \bar{H}}{L - \bar{H}} \right] \frac{d \log \bar{H}}{d \log \theta}. \quad (32)$$

Consider first (29) and (30). Since $\rho > \alpha$, it is apparent that both the long-run capital stock and output will rise in response to an increase in the share of government. Furthermore, with $\rho < 1$, the response of both the capital stock and output will be more than proportional to the response of hours worked. Intuitively, with the marginal product of capital constant in the long run [cf. (24)], a steady-state increase in hours must be accompanied by an increase in the capital stock. When $\rho < 1$, the rise in the endogenous component of productivity requires a greater than proportional increase of the capital stock to keep the return to capital constant. Since the "crowding in" of capital is greater than the increase in hours, the long-run real wage must increase for *any* value of ρ less than unity. As can be seen from (31), this contrasts with the case of constant returns ($\rho = 1$) in which the long-run real wage is *invariant* to changes in θ .

Equation (32) describes the impact of government spending on long-run consumption. Note that this relationship depends not only on the markup, but also on the parameter σ , which governs the labor supply elasticity. When $\rho = 1$, and σ is positive and finite, steady-state consumption is negatively related to the share of

government in output. With $\rho < 1$, however, this may be reversed, for σ sufficiently small. Thus, if labor supply is sufficiently elastic, an increase in the steady-state share of government in output will crowd in private consumption.

3. LOCAL DYNAMICS AND TEMPORARY CHANGES IN GOVERNMENT SPENDING

In this section we describe the model's local dynamics and analyze the response of the economy to government spending shocks in a neighborhood of the deterministic steady state. As the model does not admit an analytical solution for the full dynamic path, the approximate linear solution is derived using the method of King, Plosser, and Rebelo (1988). This solution is derived by linearizing the system (20)–(22) in a neighborhood of the deterministic steady state. The linearized system has a unique rational expectations solution so long as the dynamics satisfy the saddle-path condition. In an economy with constant returns, this property will always hold, since the equilibrium is equivalent to a social planning solution. But with increasing returns, the saddle-path condition is no longer guaranteed and must be checked for each parameterization (see footnote 4).

The effects of temporary shocks to government spending in a neighborhood of the deterministic steady state are illustrated in a series of computational experiments. We consider the responses of aggregate output, consumption, investment, real wages, and interest rates to a one-time government spending shock equal to 1 percent of total output.

Insight into the dynamic properties of the model can be gained by considering (20) in linearized form.

$$\hat{H} = \frac{1}{\Omega} \left[\frac{\alpha}{\rho} \hat{K} - \hat{C} \right], \quad (33)$$

where

$$\Omega \equiv \left[1 + \sigma \frac{\hat{H}}{L - \bar{H}} - \frac{1 - \alpha}{\rho} \right],$$

and $\hat{Z} \equiv (Z - \bar{Z})/\bar{Z}$ denotes the percentage deviation of the variable Z from its steady-state value. The response of hours to capital and consumption movements along a dynamic path is governed by the sign of Ω . With constant returns to specialization, ($\rho = 1$), $\Omega > 0$, and the model has the general implication that holding capital and the technology process constant, consumption and hours are negatively related. This point was emphasized by Barro and King (1984) for a general class of dynamic models with intertemporal separability in preferences. It is possible, however, to have $\Omega < 0$ and consumption and hours *positively* related when increasing returns are sufficiently large. For $\sigma = 0$, (totally elastic labor supply) the requirement that $\Omega < 0$ is that $\rho < 1 - \alpha$. The case in which $\Omega < 0$ corresponds to Figure 1d in which the wage-hours locus intersects the labor supply curve from below. In

this case, the negative wealth effects of tax increases arising from the increase in government spending are dominated by the positive wealth effects of the rise in productivity and wages due to increasing returns. With less-elastic labor supply ($\sigma > 0$), a larger degree of returns to specialization is required for government spending to crowd in consumption in the short run. Thus for a given degree of returns to specialization, the labor supply elasticity can determine whether Figure 1c or Figure 1d is relevant for analysis of the effect of a temporary government spending shock.

To conduct computational experiments it is necessary to choose values for the model's parameters. We do not interpret this as a calibration exercise because the simplifying assumptions we have made make it very difficult to match our model exactly to empirical studies that have estimated the degree of returns to specialization, $1/\rho$. We have used simple technologies, and have also chosen a particular two-sector representation of the economy because we feel it facilitates exposition.⁵ Rather than attempting to calibrate the model fully, we consider a range of markups and illustrate the relationship between returns to specialization and the qualitative effects of temporary shocks to government spending in equilibrium. Our markups are taken from the low (that is, zero), middle, and upper ranges of those estimated in the empirical literature. Parameters other than the markup ratio are taken from previous studies in the real business cycle literature to facilitate comparisons.

Three parameters are taken directly from previous studies. We interpret a period in our model as one year, and so we set $\beta = .96$ and $\delta = .1$, as these are the annualized equivalents of the values used throughout the real business cycle literature (for example, Hansen 1985). For the labor share parameter, $(1 - \alpha)$, we choose .71, following Greenwood, Hercowitz, and Huffman (1988).⁶ We choose the indivisible labor formulation of Hansen (1985) and Rogerson (1988). This corresponds to the following functional form for $V(\cdot)$:

$$V(L - \bar{h}) = \eta(L - \bar{h}) . \quad (34)$$

Following Hansen (1985) we set $\eta = 3.78$ so that households devote 30 percent of their time endowment to working in the deterministic steady state. The fixed cost ϕ plays no role in the dynamics of the model, so it is set to unity.⁷

Another category of parameters to be chosen determines the level and dynamic path of government spending. Following Baxter and King (1993), we set the ratio of government spending to output in the steady state at 20 percent, that is, $\theta = .2$, as this coincides with the average share of government purchases in U.S. GNP for the

5. For example, it is our assumption that final goods are produced using only intermediate inputs that causes the markup ratio to be equal to the degree of returns to specialization. (See also footnote 1.)

6. The choice of this parameter makes a difference in our results, since the wage-hours locus (14) is upward sloping for cases in which $\rho < 1 - \alpha$. If this parameter were set to .64 following, for example, Hansen (1985), then this restriction would not be satisfied for any of the markups that we consider. Our high markup would have to be increased slightly to illustrate the relationships that we want to highlight. For illustrative purposes, we find it easier to use the value from Greenwood, Hercowitz, and Huffman (1988).

7. Were we to exclude entry and exit in the model, the fixed costs would be important for the dynamics of the economy. See Rotemberg and Woodford (1993).

period 1960–89. Our temporary shocks are modeled as one-time innovations to a first-order autoregressive process, that is, equation (6). It has been shown [for example, by Aiyagari, Christiano, and Eichenbaum (1992)] that the aggregate effects of temporary government spending shocks in a model with constant returns are strongly affected by the persistence of the shock. We therefore consider two possibilities for the persistence of a disturbance to government spending. First we consider a case in which $\gamma = .6$, to capture the effects of a change in government spending that is relatively short lived. Then we consider the case of $\gamma = .95$, the estimate reported from U.S. data by Christiano and Eichenbaum (1992).

In our economy, the degree of returns to specialization is equal to the markup. There is a large literature on the estimation of markups, and the estimates have ranged widely. Hall (1990) estimates markup rates ranging from 1.5 to 4. More recent estimates by Basu and Fernald (1993) have corrected Hall's estimates for the bias inherent in using value-added data. Using gross output data, they report a much lower range of markups, ranging from 1.15 to 1.23. Morrison (1990) also estimates markups for U.S. total manufacturing and for seventeen two-digit manufacturing industries using gross output data. Her estimate for total U.S. manufacturing is 1.197, and her estimates for the two-digit industries range from 1.186 to 1.695. Domowitz, Hubbard, and Peterson (1988) also estimate markups for nineteen two-digit U.S. manufacturing industries, reporting estimates ranging from 1.198 to 1.513. Finally, a recent study by Chirinko and Fazzari (1994), estimates markups using firm-level data in eleven four-digit U.S. manufacturing industries. Their estimates of the average markup range from 1 to 1.45.

As noted above, none of these studies can be used directly to calibrate the markup in our model since the estimated markups in all of them depend on particular assumptions about technologies and market structure, none of which are exactly replicated in our environment. Therefore, we report results for a range of markup values. We consider three markup levels we consider: a zero markup ($\rho = 1$); a "small" markup ($\rho = .83$, markup ratio approximately 1.2); and a "large" markup ($\rho = .66$, markup ratio approximately 1.5). The "small" markup corresponds roughly to those estimated by Basu and Fernald (1993) and Morrison (1990) for U.S. manufacturing. In this case, there are increasing returns to specialization, but since $\rho > 1 - \alpha$, the equilibrium wage-hours locus remains downward sloping. This corresponds to Figure 1b. Our large markup remains in the range estimated for two and four-digit U.S. industries in the studies cited above. In this case $\rho < 1 - \alpha$, so the wage-hours locus is upward sloping. Furthermore, given the indivisible labor formulation, the labor supply curve cuts the wage-hours locus from below. This corresponds to Figure 1d.

Figure 2 presents the dynamic responses of aggregates to a shock to government spending equal to 1 percent of GNP in the low persistence ($\gamma = .6$) case. Each panel of the figure illustrates the impulse response of a given variable for each of the three markups considered. The zero markup case may be interpreted as a benchmark, against which the effects of increasing returns can be compared. The results for this case are familiar from the literature. Government spending shocks lead to a fall in

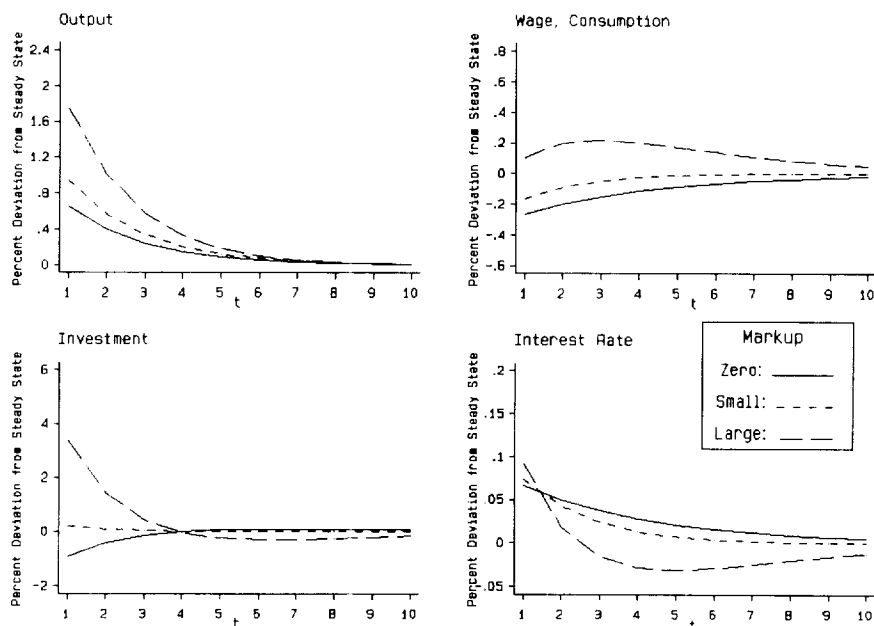


FIG. 2. Response to a Temporary Shock: Low Persistence

consumption, which shifts the labor supply curve outward, increasing employment and reducing the real wage.⁸ The expansion in employment raises output. The behavior of investment depends upon both the response of the interest rate and of expected future employment. Some intuition is provided by considering the equation that governs the initial response of investment to a fiscal spending shock (at time t) in the linear approximation:

$$\hat{I}_t = \frac{1}{(1 - \alpha/\rho)(1 - \beta(1 - \delta))} E_t \left[\frac{1 - \alpha}{\rho} \hat{H}_{t+1} - \hat{R}_{t+1} \right] \quad (35)$$

where \hat{R}_{t+1} is the percentage deviation of the interest rate from its deterministic steady-state value. As Figure 2 illustrates, both the interest rate and employment increase following the government spending shock, and so the direction of the investment response is ambiguous. In the constant returns benchmark, the effect of the interest rate dominates, and investment falls (Figure 2c).

Increasing the degree of returns to specialization strengthens the expansionary impact of the spending shock on output. With a markup of 1.2, consumption falls by less and both hours worked and output rise by more in response to the shock.

8. Note that the percentage responses of consumption and the real wage are the same in the indivisible labor model.

Returning to Figure 1b, with the “small” markup, the economy moves along a WH locus which is flatter than the labor demand curve. The effect of the outward shift in the labor supply curve due to the wealth effect of government spending is partially counteracted by an endogenous increase in productivity that results from entry of intermediate goods producers. Thus employment rises by more than it does under constant returns in spite of the fact that the wage falls by less. Since consumption falls on impact and is everywhere growing during the transition, the interest rate converges monotonically to the steady state from above.

In the small markup case, investment responds positively to the shock. Returning to (35), the relatively large response of hours worked now dominates the rise in the interest rate, and investment increases. Since this result hinges on the size of the employment response, it is clear that the labor supply elasticity plays a crucial role. Returning to (33), we see that *ceteris paribus* an increase in σ will reduce the response of hours worked to a spending shock. Therefore, the indivisible labor formulation considered here provides an upper bound of this response for a given degree of returns to specialization. With a sufficiently small labor supply elasticity, a markup of 1.2 would not be sufficient to generate a positive investment response. In this case, the responses of output, employment, consumption, wages, and interest rates would all be unchanged in direction relative to the constant returns benchmark. The only effects of returns to specialization would be quantitative: the positive responses of output, employment, and the interest rate would all be accentuated, while the negative responses of wages and consumption would be muted.

With a markup of 1.5, the expansionary effect of the shock on output becomes sufficiently large to change several features of the impulse responses. The output response is more than twice as large as in the constant returns model, and as a result, both consumption and the real wage *rise* immediately following the shock. Intuitively, the negative wealth effect of increased taxation on households is now more than offset by the extent of the endogenous increase in total factor productivity coming from the entry of new firms following the spending increase. Households consume more, and, due to the rise in the real wage, substitute out of leisure. The extent of the increase in hours worked leads to a sharp increase in investment. The response of the real interest rate is also affected, reflecting the different response of consumption. While the real interest rate initially rises, it falls quickly due to the sharp increase in investment and drops *below* its steady-state level after three periods. With sufficiently strong returns to specialization, consumption peaks after a few periods and then *falls* through time back to its steady-state. Falling consumption is associated with an interest rate below its steady state level.

Overall, with returns to specialization of sufficient magnitude, a fiscal spending shock can lead to a simultaneous expansion in output, consumption, investment, the real wage, and employment. Thus, the qualitative effects of aggregate demand disturbances on the economy may be changed considerably by the presence of returns to specialization. How large increasing returns must be to cause these changes again depends in part on the elasticity of labor supply. The Hansen-Rogerson case gives us a lower bound on the degree of increasing returns needed for a shock of particular

duration to generate these effects. With less-elastic labor supply, increasing returns of this magnitude result in an increase in output, employment, and the real wage, but a fall in both consumption and investment.⁹ This would correspond to the case of Figure 1c.

We now consider a highly persistent increase in government spending in the presence of returns to specialization ($\gamma = .95$). The results are presented in Figure 3. With a zero markup, the negative wealth effect on consumption leads to a substantial rise in employment, which generates a *rise* in investment. Moreover, for any markup, the output response is both higher and more persistent than before. This is in accordance with the findings of Aiyagari, Christiano, and Eichenbaum (1992) who show that as the persistence of government spending shocks is increased, the expansionary effects of a given shock increase markedly. The negative wealth effect of the tax rises with the persistence of the shock. Thus, labor supply responds by more, causing a larger fall in the real wage. With sufficient persistence, a positive response of investment results.

In our small markup case, while investment responds positively, consumption and the wage initially fall. The gradual increase in the capital stock, however, leads both consumption and the real wage to rise above their initial steady-state level during the transition. Thus, even for relatively modest returns to specialization, a persistent government spending increase may raise the real wage and crowd in consumption. This effect, however, will occur with a lag, not in the same period as the spending shock.

With large markups, the responses of output are similar to those depicted in Figure 2a, with the only difference being that the response of output is significantly stronger than before. Both consumption and the real wage now rise *immediately*. Throughout Figure 3, the dynamic responses in the high markup case are qualitatively similar to the corresponding responses in Figure 2. Evidently the increase in persistence has only quantitative effects. In fact, the qualitative properties of these impulse responses are independent of the degree of persistence in the government spending shock. Even if the shock is purely transitory ($\gamma = 0$), a government spending shock still stimulates a simultaneous increase in output, investment, consumption, and employment.

This experiment illustrates that returns to specialization reduce the degree of persistence required to generate an increase in investment in response to a government spending shock. Indeed, if markups are large, then *no* persistence is required. Again, however, these findings are affected by the quantitative response of employment to the shock, and so depend on other parameters. In particular, as the labor supply elasticity decreases, a given markup generates a smaller response of employment and output than it does with indivisible labor.

Overall these experiments illustrate that increasing returns to specialization may have important implications for the role of aggregate demand shocks in producing

9. That these effects will occur for lower labor elasticities with a given degree of returns to specialization is clear from (33) and (35) respectively.

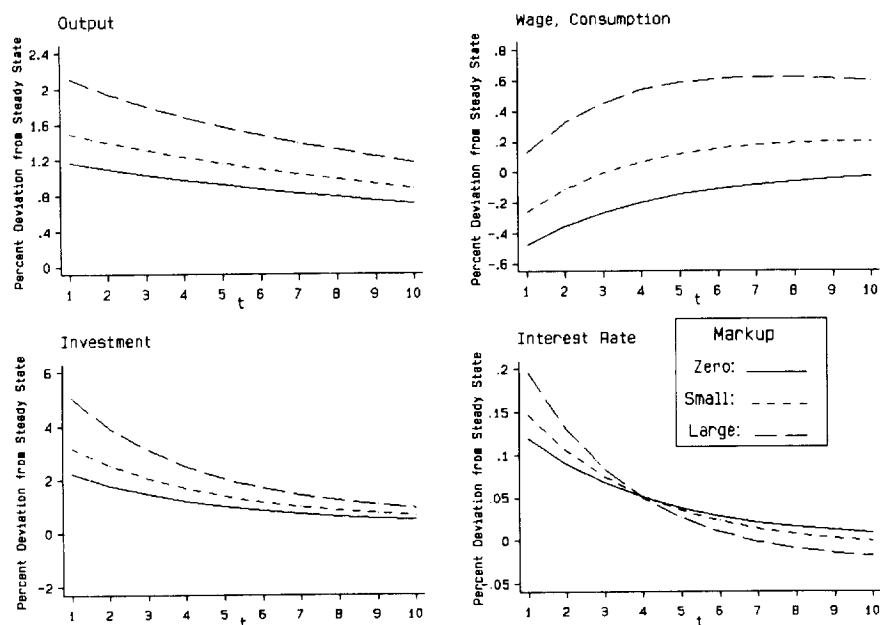


FIG. 3. Response to a Temporary Shock: High Persistence

aggregate fluctuations. Traditional Keynesian analysis accords a large role to aggregate demand shocks as sources of business cycle fluctuations. In the standard neoclassical model, however, aggregate demand shocks generate negative correlations of both real wages and consumption with employment. Neither of these correlations is consistent with the data, and in principle, our model can address both of these issues. Although the model contains no exogenous technology shocks, real wages and consumption may be positively correlated with employment. These effects stem from an endogenous response of total factor productivity that occurs when firms enter and exit in response to shocks to aggregate demand. This effect is similar to that of the aggregate demand externality that has been discussed in the recent literature (for example, Diamond 1982 and Blanchard and Kiyotaki 1987).

It is clear, however, that these relationships are somewhat sensitive to the degree of returns to specialization. Recent empirical estimates of markup levels (for example, Basu and Fernald 1993) have typically been substantially lower than those required to generate a positive response of consumption to a temporary government spending shock in our model. Another issue to consider is the relationship between the qualitative responses of consumption, wages, and investment and the quantitative response of output to a government spending shock (that is, the multiplier). With markups sufficient to produce positive responses of both output, consumption, and investment to a temporary government spending shock, the response of output to the shock is higher than may be plausible given the empirical evidence. Hall

(1986) estimates that the multiplier effect of military purchases in U.S. data is about unity. Rotemberg and Woodford (1992) confirm this estimate using an independently constructed measure of military purchases. These estimates are considerably smaller than suggested by the case of large markups above. For example, in the case depicted in Figure 3a, the multiplier is close to two. The case of the relatively small markup ($1/\rho = 1.2$) does, however, accord with both Rotemberg and Woodford's estimate of the multiplier, and with their finding of a positive response of the real wage to innovations in military purchases. Thus, the lower markup case may be more in accord with the empirical evidence.

4. CONCLUSION

This paper has shown that the effects of fiscal spending shocks in a dynamic general equilibrium model with imperfect competition and increasing returns can be substantially different from those in the standard constant returns model. With increasing returns the wage may rise rather than fall in response to a government spending shock, and the impact of government spending on consumption may be positive rather than negative. Furthermore a government spending shock may crowd in investment, even if the shock is purely transitory. Our results suggest that increasing returns increase the role of government spending shocks (and presumably other types of demand shocks) in dynamic general equilibrium models and thus may be very useful for understanding the impact of fiscal policy on macroeconomic aggregates.

Several issues remain to be considered. For example, in order to isolate the effects of *spending* on the economy, we abstracted from all issues regarding government financing. Also, we have modeled government spending as purely wasteful, and abstracted from direct impacts of government spending on productivity. If government spending directly augmented total factor productivity, say, because some or all of it was used to augment a stock of public capital [as in Baxter and King (1993)], then the effects of government spending in our economy could be substantially enhanced.

LITERATURE CITED

- Aiyagari, S. Rao, Lawrence J. Christiano, and Martin Eichenbaum. "The Output, Employment, and Interest Rate Effects of Government Consumption." *Journal of Monetary Economics* (30)1 (October 1992), 73–86.
- Audretsch, David B., and Zoltan J. Acs. "Entrepreneurial Activity, Innovation, and Macroeconomic Fluctuations." Manuscript, April 1992.
- Barro, Robert J. "Output Effects of Government Purchases." *Journal of Political Economy* 89(6) (December 1981), 1086–1121.
- . "The Neoclassical Approach to Fiscal Policy." In *Modern Business Cycle Theory*, edited by Robert J. Barro, pp. 178–235. Cambridge, Mass.: Harvard University Press, 1989.

- Barro, Robert J., and Robert G. King. "Time-Separable Preferences and Intertemporal-Substitution Models of Business Cycles." *Quarterly Journal of Economics* 99(4) (November 1984), 817–39.
- Basu, Susanto, and John G. Fernald. "Constant Returns and Small Markups in U.S. Manufacturing." Working Paper Number 93–19, University of Michigan, April 1993.
- Baxter, Marianne, and Robert G. King. "Productive Externalities and Business Cycles." Discussion Paper Number 53, Institute for Empirical Macroeconomics, December 1991.
- . "Fiscal Policy in General Equilibrium." *American Economic Review* 83(3) (June 1993), 315–34.
- Benhabib, Jess, and Roger E.A. Farmer. "Indeterminacy and Increasing Returns." Manuscript, University of California–Los Angeles, 1992.
- Blanchard, Olivier J., and Nobuhiro Kiyotaki. "Monopolistic Competition and the Effects of Aggregate Demand." *American Economic Review* 77(4) (September 1987), 647–66.
- Caballero, Ricardo J., and Richard K. Lyons. "External Effects in U.S. Pro-cyclical Productivity." *Journal of Monetary Economics* 29(2) (April 1992), 209–25.
- Chatterjee, Satayit, Russell W. Cooper, and B. Ravikumar. "Strategic Complementarity in Business Formation: Aggregate Fluctuations and Sunspot Equilibria." *Review of Economic Studies* 60(4) (October 1993), 795–812.
- Chirinko, R. S., and S. M. Fazzari. "Economic Fluctuations, Market Power, and Returns to Scale: Evidence from Firm-Level Data." *Journal of Applied Econometrics* 9(1) (January–March 1994), 47–70.
- Davis, Steven J., and John C. Haltiwanger, Jr. "Gross Job Creation and Destruction: Microeconomic Evidence and Macroeconomic Implications." *National Bureau of Economic Research Macroeconomics Annual* (1990), 126–68.
- Diamond, Peter A. "Aggregate Demand in Search Equilibrium." *Journal of Political Economy* (90)5 (October 1982), 881–94.
- Domowitz, Ian, R. Glenn Hubbard, and Bruce C. Petersen. "Market Structure and Cyclical Fluctuations in U.S. Manufacturing." *Review of Economics and Statistics* 70 (February 1988), 55–66.
- Dunlop, John T. "The Movement in Real and Money Wage Rates." *Economic Journal* 18 (1938), 413–34.
- Ethier, Wilfred J. "National and International Returns to Scale in the Modern Theory of International Trade." *American Economic Review* 72(3) (June 1982), 389–405.
- Evans, Charles L. "Productivity Shocks and Real Business Cycles." *Journal of Monetary Economics* 29(2) (April 1992), 173–90.
- Gali, Jordi. "Monopolistic Competition, Business Cycles, and the Composition of Aggregate Demand." *Journal of Economic Theory* 63(1) (June 1994), 73–96.
- Greenwood, Jeremy, Zvi Hercowitz, and Gregory W. Huffman. "Investment, Capacity Utilization, and the Real Business Cycle." *American Economic Review* 78(3) (June 1988), 402–17.
- Hall, Robert E. "Labor Supply and Aggregate Fluctuations." *Carnegie Rochester Conference Series on Public Policy* 12 (1980), 7–33.
- . "Market Structure and Macroeconomic Fluctuations." *Brookings Papers on Economic Activity* 2 (1986), 285–322.
- . "Invariance Properties of Solow's Productivity Residual." In *Growth, Productivity, Unemployment*, edited by Peter A. Diamond, pp. 71–112. Cambridge Mass.: MIT Press, 1990.
- . *Booms and Recessions in a Noisy Economy*. New Haven: Yale University Press, 1992.

- Hansen, Gary D. "Indivisible Labor and the Business Cycle." *Journal of Monetary Economics* 16(3) (November 1985), 309–27.
- Hansen, Gary D., and Randall Wright. "The Labor Market in Real Business Cycle Theory." Federal Reserve Bank of Minneapolis *Quarterly Review* (Spring 1992), 2–12.
- Hornstein, Andreas. "Monopolistic Competition, Increasing Returns to Scale, and the Importance of Productivity Shocks." *Journal of Monetary Economics* 31(3) (June 1993), 299–316.
- King, Robert G., Charles I. Plosser, and Sergio T. Rebelo. "Production, Growth, and Business Cycles I: The Basic Neoclassical Model." *Journal of Monetary Economics* 21(2/3) (March/May 1988), 195–232.
- Krugman, Paul R. "Monopolistic Competition, Increasing Returns, and International Trade." *Journal of International Economics* 9 (1979), 469–79.
- Kydland, Finn E., and Edward C. Prescott. "Time to Build and Aggregate Fluctuations." *Econometrica* 50(6) (November 1982), 1345–70.
- Morrison, Catherine. "Market Power, Economic Profitability and Productivity Growth Measurement: An Integrated Structural Approach." Working Paper Number 3355, National Bureau of Economic Research, May 1990.
- Ravn, Morten O. "Testing Exogeneity of the Solow Residuals: Empirical Evidence for Three European Economies." Manuscript, Institute of Economics, University of Aarhus, June 1992.
- Rogerson, Richard. "Indivisible Labor, Lotteries, and Equilibrium." *Journal of Monetary Economics* 21(1) (January 1988), 3–16.
- Romer, Paul M. "Growth Based on Increasing Returns Due to Specialization." *American Economic Review* 77(2) (May 1987), 56–62.
- Rotemberg, Julio J., and Michael Woodford. "Markups and the Business Cycle." *National Bureau of Economic Research Macroeconomics Annual* (1991), 65–129.
- . "Oligopolistic Pricing and the Effects of Aggregate Demand on Economic Activity." *Journal of Political Economy* 100(6) (December 1992), 1153–1207.
- . "Dynamic General Equilibrium Models with Imperfectly Competitive Product Markets." Working Paper Number 4502, National Bureau of Economic Research, September 1993.
- Tarshis, Lorie. "Changes in Real and Money Wage Rates." *Economic Journal* 19 (1939), 150–54.