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THE CYCLICAL BEHAVIOUR OF WAGES AND PROFITS UNDER IMPERFECT COMPETITION

Emanuela Cardia[1] and Steve Ambler[2]

1 Département de sciences économiques and Centre de recherche et développement en économique (C.R.D.E.), Université de Montréal.

2 Centre de recherches sur l'emploi et les fluctuations économiques, Université du Québec à Montréal.

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C.P. 6128, succursale A
Montréal (Québec)
H3C 3J7

Télécopieur (FAX): (514) 343-5831
Courrier électronique (E-Mail): econo@tornade.ERE.Umontreal.CA

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RÉSUMÉ

Nous construisons un modèle dynamique d'une économie où les biens sont produits pa des firmes en concurrence monopolistique et analysons l'état stationnaire de ce modèle et se propriétés dynamiques. Étant donné des hypothèses simples quant aux entrées et sorties de firmes du marché, le modèle capte certains des faits importants qui caractérisent le cycle économique. Entre autres, le modèle prédit les mouvements contre-cycliques de la part des salaires dans le revenu national, les mouvements procycliques de la part des profits et le comportement cyclique de la création des firmes et des faillites.

Mots clés : cycles économiques, concurrence monopolistique, modèles dynamiques.

ABSTRACT

We build a dynamic model of an economy with a collection of monopolistically competitive firms. We analyze its steady state and dynamic properties. Given simple assumptions concerning firm entry and exit, we show that it is able to reproduce some of the key stylized facts of the business cycle. These include the cyclical behaviour of the shares of labour income and profits in aggregate income, the volatilities of those shares, and the cyclical behaviour of firm creation and bankruptcy.

Key words : business cycles, imperfect competition, dynamic models
Jel classification codes : E32, E62

1. Introduction

We build a dynamic model of an economy with a collection of monopolistically competitive firms. We analyse the steady state properties of the model and its response to shocks to production technology and government purchases. We show that, with simple assumptions concerning firm entry and exit, it can reproduce some of the key stylised facts of the business cycle. These include the countercyclical behaviour of the share of labour income and the procyclicality of the share of profits in aggregate income, the volatilities of these shares, and the cyclical pattern of firm creation and bankruptcies.

Although these comovements are important characteristics of the business cycle, little attention has been paid to them in the literature. The real business cycle (RBC) approach places much emphasis on reproducing the comovements observed in the data, and the school has devoted much attention to the cyclical behaviour of wages and productivity, but the cyclical behaviour of wage and profit shares has been almost completely ignored. The nearly exclusive use of perfectly competitive models with aggregate Cobb-Douglas production technologies in the RBC literature may explain this phenomenon; if factors are paid their marginal products then, under these assumptions, factor shares are constant. There are two important exceptions to this lack of attention. Gomme and Greenwood (forthcoming) use a perfectly competitive model with Cobb-Douglas technology, but introduce long-term labour contracts so that factor payments are divorced from marginal products. They are able to generate both an acyclical real wage and countercyclical movements in labour's share of total income. Hornstein (1993) uses a model of monopolistic competition with a fixed number of firms. He is able to reproduce cyclical movements in the share of profits, but not the cyclical pattern of firm creation and bankruptcies. In contrast, we generate cyclical movements labor and profit shares and in net firm creation while retaining an allocative role for real wages by assuming that labour markets are spot markets.

Our model builds on previous work on general equilibrium models of monopolistic competition in a static framework, notably Hart (1982), Blanchard and Kiyotaki (1987), Mankiw (1988) and Startz (1989). Our model is explicitly dynamic, with private agents maximising an intertemporal utility function and facing a tradeoff between labour and leisure. It also draws inspiration from the dynamic models of imperfect competition of Bénassy (1990, 1991, 1993). His use of an overlapping generations framework with a life cycle of two periods makes his models inappropriate to analyse comovements at business cycle frequencies. Svensson (1986) also uses a model with monopolistic competition, which is used as a device to model optimal price setting by firms and the effects of monetary policy when firms must set prices before learning the value of monetary shocks.[1]

Other recent papers have analysed the importance of imperfect competition for business cycles, but have emphasised a different set of stylised facts from the ones considered here. In papers by Hornstein (1991), Devereux, Head and Lapham (1992) and Rotemberg and Woodford (1991, 1992a, 1992b), the focus is on the importance of aggregate technology shocks in accounting for cyclical fluctuations and on the properties of the Solow residual when there are increasing returns to scale.[2]

The paper is structured as follows. In the following section, we present the maximization problems of consumers and firms, show how to derive aggregate demand and supply relationships from the optimal behaviour of individual consumers and firms, and give the market clearing conditions for general equilibrium. In the third section, we analyse the behaviour of the economy in the steady state, including the effects of a change in the steady-state level of government purchases. In the fourth section, we study the stochastic properties of the model's endogenous variables for given assumptions about the variance-covariance matrix of exogenous shocks and about the entry and exit behaviour of firms, and compare them with the properties of the corresponding U.S. time series. A brief appendix describes the sources and construction of our data series.

2. The Model

The model is closely patterned after Startz (1989), but is dynamic. Consumers maximize expected utility subject to an intertemporal budget constraint. In order to simplify the analysis,

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1 Production technology in his model is particularly simple; firms face exogenous capacity constraints.

2 Devereux, Head and Lapham do analyse the predictions of their model concerning firm creation and bankruptcies, but assume instantaneous entry and exit so that their model does not generate fluctuations in the shares of wages and profits in total income. Murphy, Shleifer and Vishny (1989) use a model of external increasing returns and competitive markets to generate endogenous procyclical fluctuations in labour productivity in response to demand shocks.

we abstract from capital accumulation so that the maximization of profits by firms is a static problem.

A. *The Representative Consumer's Problem*

Each consumer is endowed with time l^* per period. Consumers own an equal share of each firm and receive an equal share of aggregate profits. Abstracting from equity markets in this fashion simplifies the analysis considerably. The instantaneous utility function of an individual of at time t is given by:

$$U_t = \alpha_c \ln(c_t) + \alpha_g \ln(g_t) + (1 - \alpha_c - \alpha_g)\ln(l^* - l_t), \tag{1}$$

where c_t is the individual's purchase of the composite private consumption good, g_t is her consumption of the composite government good, and l_t is the individual's labour supply. The composite government and private consumption goods are defined as follows:

$$c_t \equiv (n_t)^{1/(1-\sigma)}\left(\sum_{i=1}^{n_t}\left(c_{it}\right)^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)}, \tag{2a}$$

$$g_t \equiv \left(n_t^g\right)^{1/(1-\sigma)}\left(\sum_{i=1}^{n_t^g}\left(g_{it}\right)^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)}, \tag{2b}$$

where n_t is the total number of private good types available in time t and n_t^g is the total number of government consumption good types.

As is standard in this literature,[3] the consumer's problem can be broken down into a two-stage problem. In the first stage, a given amount of consumption expenditure is allocated among the individual types of private consumption goods. In the second stage, the consumer makes her consumption and labour supply decision using a utility function in terms of composite goods of the form of equation (1). It can be shown that solving the individual's problem of

[3] See Dixit and Stiglitz (1977).

allocating expenditure among the individual good types yields the following conditional demand functions:

$$c_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\sigma} \frac{c_t}{n_t}, \tag{3}$$

where

$$p_t = \left(\frac{1}{n_t} \sum_{i=1}^{n_t} p_{it}^{(1-\sigma)}\right)^{1/(1-\sigma)}, \tag{4}$$

so that p_i is the price of individual good i at time t and p_t is a price index for the composite private consumption good. We do not analyse the individual's optimal demand for individual government consumption goods, since by assumption these goods are furnished by the government. We do assume that the government minimizes the costs of satisfying a given level of private agents' utility. This ensures that the government's conditional demand for individual consumption good types is of the same form as equation (3) and that the price index for government consumption goods is of the same form as equation (4). Aggregating across individuals gives the following demand functions for the i[th] individual good type:

$$C_{it} = \left(\frac{p_{it}}{p_t}\right)^{-\sigma} \frac{C_t}{n_t}, \tag{5}$$

where C_t is aggregate consumption of the composite private good.

The individual's expected utility function can then be written in terms of the composite goods as follows:

$$U = E_t\left[\sum_{i=0}^{\infty} \beta^i \left(\alpha c \ln(c_{t+i}) + \alpha g \ln(g_{t+i}) + (1 - \alpha c - \alpha g)\ln(l^* - l_{t+i})\right)\right] \quad , (6)$$

where E_t is the mathematical expectations operator conditional on information available at time t and β is the individual's subjective discount factor. The individual's one-period budget constraint is given by:

$$c_t + b_t + t_t = w_t l_t + \pi_t + (1 + r_t) b_{t-1}, \tag{7}$$

where b_t is the individual's holdings of indexed government debt, t_t denotes the individual's lump-sum tax liabilities, π_t is the individual's share of aggregate profits, r_t is the real interest rate, and w_t is the real wage rate.

The Lagrangian for the maximization of the individual's expected utility at time t is:

$$\Im_t = E_t\left[\sum_{i=0}^{\infty} \beta^i \left(\alpha c \ln(c_{t+i}) + \alpha g \ln(g_{t+i}) + (1 - \alpha c - \alpha g)\ln(l^* - l_{t+i})\right)\right]$$

$$+E_t\left[\sum_{i=0}^{\infty} \lambda_{t+i}\left(\left(1 + r_{t+i}\right) b_{t+i-1} + w_{t+i} l_{t+i} + \pi_{t+i} - t_{t+i} - c_{t+i} - b_{t+i}\right)\right], \tag{8}$$

where λ_{t+} are Lagrange multipliers whose interpretation is the marginal value of wealth at time t+i. From the first order conditions for a maximum, we get the following optimality condition relating the individual's private consumption expenditures to her labour supply at time t:

$$w_t(l^* - l_t) = \frac{\left(1 - \alpha c - \alpha g\right)}{\alpha c} c_t, \tag{9}$$

Both leisure and consumption are linearly related to the individual's current wealth, which implies that they are linearly related according to equation (9). This gives the following relationship between aggregate labour supply and aggregate consumption:

$$w_t(L^* - L_t) = \frac{\left(1 - \alpha c - \alpha g\right)}{\alpha c} C_t \tag{10}$$

B. *The Representative Firm's Problem*

There are n_t varieties of private consumption goods and n_t varieties of goods purchased by the government. In the short run, n_t and n_t are taken to be exogenous, but we allow entry and exit of firms in the long run so that there are no profits and the number of firms is endogenous. Each individual good is produced by a single firm. The production function of each firm is given by:

$$X_{it} = \gamma_1 L_{it} - \gamma_0, \tag{11}$$

where X_i is the firm's production of either a private consumption good type C_i or a government good type G_i, and L_i is the firm's labour input at time t. Marginal productivity of labour is constant, but the fixed cost γ means that there are increasing returns to scale. Each firm maximizes its profits subject to the individual product demand function, given by equation (5) above. We abstract from capital and we assume that there are no costs of adjusting the firm's labour inputs, so that the profit maximization problem is static. As noted above, we assume that the government allocates its spending among varieties of goods in order to minimize its expenditure for a given level of the representative consumer's subutility function g, and furthermore we assume that the government ignores its monopsony power, so that the problem of profit maximization is the same for firms in the public goods sector as in the private goods sector. We consider explicitly only the latter.

The inverse demand function for the i[th] firm follows from equation (5) and can be written as:

$$p_{it} = p_t \left(\frac{C_t}{C_{it} n_t} \right)^{1/\sigma} . \tag{12}$$

The nominal profit function of the i[th] firm in the private goods sector is given by:

$$\pi_{it} = p_{it} C_{it} - W_t L_{it} \quad , \tag{13}$$

where we use W_t to denote the nominal wage. We assume that the labour market operates in a perfectly competitive manner so that the firm takes the nominal wage rate as given. Substituting out p_i using the inverse demand function and differentiating the profit function with respect to labour input gives:

$$p_t(C_t/n_t)^{1/\sigma}(1-1/\sigma)\frac{\partial C_{it}}{\partial L_{it}}\left(C_{it}\right)^{-1/\sigma} = W_t. \qquad (14)$$

In turn, this gives the following pricing rule:

$$p_{it} = \mu\left(W_t/\gamma_1\right), \qquad (15)$$

where $\mu = (1-1/\sigma)^{-1}$. This is a standard formula for monopoly pricing as a markup over marginal unit costs. The output rule is:

$$C_{it} = \left(\frac{C_t}{n_t}\right)\left(\frac{\mu}{\gamma_1}\right)^{-\sigma} w_t^{-\sigma}, \qquad (16)$$

where the real wage w_t, is defined as W_t/p_c. Optimal output is proportional to aggregate private goods demand and depends negatively on the real wage. The firm's labour demand is given by:

$$L_{it} = \left(\frac{C_t}{n_t}\right)\mu^{-\sigma}\left(\gamma_1\right)^{(\sigma-1)} w_t^{-\sigma} + \frac{\gamma_0}{\gamma_1}. \qquad (17)$$

Total labour demand by private consumer goods firms is given by summing the labour demands of the n_t individual firms:

$$L_t^c = \sum_{i=1}^{n_t}\left(\left(\frac{C_t}{n_t}\right)\mu^{-\sigma}\left(\gamma_1\right)^{(\sigma-1)} w_t^{-\sigma} + \frac{\gamma_0}{\gamma_1}\right) \quad , \qquad (18)$$

or:

$$L_t^c = C_t \mu^{-\sigma} \left(\gamma_1\right)^{(\sigma-1)} w_t^{-\sigma} + \left(\frac{\gamma_0}{\gamma_1}\right) n_t, \tag{19}$$

where L_t^c is defined as total labour demand by consumer goods firms. Similarly, labour demand by public goods firms can be shown to be equal to:

$$L_t^g = G_t \mu^{-\sigma} \left(\gamma_1\right)^{(\sigma-1)} \left(\frac{W_t}{p_t^g}\right)^{-\sigma} + \left(\frac{\gamma_0}{\gamma_1}\right) n_t^g \tag{20}$$

where G_t is total demand by the government for the composite public good. We therefore have the following equation for aggregate labour demand by all firms in the economy:

$$L_t = \left(C_t + G_t \left(\frac{p_t}{p_t^g}\right)\right) \mu^{-\sigma} \left(\gamma_1\right)^{(\sigma-1)} w_t^{-\sigma} + \left(n_t + n_t^g\right) \left(\frac{\gamma_0}{\gamma_1}\right). \tag{21}$$

From the pricing rule (15), since there is one aggregate labour market and since firms in the private goods sector and the public goods sector have identical production functions, we must have that $p_{it} = p_{it}^g = p_t = p_t^g$, so that equation (21) simplifies to:

$$L_t = (C_t + G_t) \mu^{-\sigma} \left(\gamma_1\right)^{(\sigma-1)} w_t^{-\sigma} + \left(n_t + n_t^g\right) \left(\frac{\gamma_0}{\gamma_1}\right). \tag{22}$$

Aggregate output is then given by the following relation:

$$Y_t = \gamma_1 L_t - \gamma_0 \left(n_t + n_t^g\right) \tag{23}$$

C *General Equilibrium*

The following set of equations jointly determines the general equilibrium of the economy at time t:

$$w_t(L^* - L_t) = \frac{\left(1-\alpha_c-\alpha_g\right)}{\alpha_c} C_t, \tag{24}$$

$$w_t = \frac{\gamma_1}{\mu}, \tag{25}$$

$$Y_t = \gamma_1 L_t - \gamma_0 \left(n_t + n_t^g\right), \tag{26}$$

$$C_t + G_t = Y_t, \tag{27}$$

$$Y_t = \Pi_t + w_t L, \tag{28}$$

where Π_t denotes aggregate profits.

Equations (24) and (25) give equilibrium labour supply and the equilibrium real wage rate. Equation (26) gives output supply, equation (27) is the goods market equilibrium condition, and equation (28) gives national income as the sum of aggregate labour income and aggregate profits. In the short run, the number of firms in the economy is fixed and the system determines the equilibrium levels of Y_t, L_t, w_t, C_t and Π_t. In the long run, as a result of firm entry and exit, pure profits are reduced to zero and the total number of firms, $\left(n_t + n_t^g\right)$, is determined endogenously. Our assumptions concerning entry and exit are made explicit in the fourth section of the paper.

We also have the following government flow budget constraint and private sector flow budget constraint:

$$B_t + T_t = (1 + r_t)B_{t-1} + G_t, \tag{29}$$

$$C_t + B_t + T_t = w_t L_t + \Pi_t + (1 + r_t)B_t, \tag{30}$$

where B_t denotes aggregate holdings of indexed government debt. The full solution to the representative agent's utility maximization problem gives consumption as a linear function of total wealth, which aggregates to:

$$C_t = (1-\beta)(B_t + H_t). \tag{31}$$

Aggregate wealth other than government bonds, H_t, is a forward-looking variable which evolves according to the following difference equation:

$$H_t = (1+r_t)H_{t-1} - w_t L_t - \Pi_t + T_t. \tag{32}$$

Because of Ricardian equivalence and the absence of capital accumulation, the system is recursive and the equilibrium values of output, employment, profits, and intratemporal relative prices do not depend on future expected variables.[4] As long as we are not interested in the stochastic properties of interest rates and private sector wealth, we do not have to specify a rule for how the government finances its expenditures, other than to assume that the usual transversality condition concerning the government's real debt to the private sector is respected.

3. Steady State Analysis

In the steady state, in the absence of exogenous shocks and once firm entry or exit has taken place, aggregate pure profits are equal to zero. Equations (24) through (28) can then be solved for the following reduced form solutions for the endogenous variables of the model:

$$L_t = \frac{\alpha c}{\left(1-\alpha g\right)} L^* + \frac{\left(1-\alpha c-\alpha g\right)}{\left(1-\alpha g\right)} \left(\frac{\mu}{\gamma_1}\right) G_t, \tag{33}$$

$$Y_t = \frac{\gamma_1 \alpha c}{\mu\left(1-\alpha g\right)} L^* + \frac{\left(1-\alpha c-\alpha g\right)}{\left(1-\alpha g\right)} G_t, \tag{34}$$

$$C_t = \frac{\gamma_1 \alpha c}{\mu\left(1-\alpha g\right)} L^* - \frac{\alpha c}{\left(1-\alpha g\right)} G_t \quad , \tag{35}$$

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[4] This result is just a special case of the result derived in Barro and King (1984).

$$w_t = \frac{\gamma_1}{\mu}, \tag{36}$$

$$\left(n_t + n_t^g\right) = \frac{(\mu-1)}{\gamma_0} Y_t \tag{37}$$

Several important implications follow immediately from these equations. In the long run, the number of firms is perfectly correlated with output. All variations in output are due to firm entry and exit; the long run level of output per firm depends only on the degree of substitutability across types of goods and on the fixed cost parameter in the production function. The real wage is perfectly correlated with labour productivity. Employment and output are perfectly correlated in response to government expenditure shocks, but labour productivity shocks (movements in γ) will cause inverse comovements between employment and output. Government spending shocks cause an inverse comovement between hours and consumption.

We can also study the implications of the model for the welfare of the representative private agent in the steady state. It is clear from the instantaneous utility function of the representative private agent that, as the steady state level of government expenditure increases, utility derived from private consumption and from leisure decreases. There is an optimal steady state level of government expenditure which equates the marginal benefit of government goods with the marginal cost of the reduction in private consumption and leisure. Figure 1 below shows the effects on instantaneous utility and output, private consumption and work effort of varying steady state levels of government expenditure, for the base case parameter values given in Table 1 and discussed in the next section.

4. Calibration and Simulation

In order to carry out numerical simulations, we need to derive the short run response of the economy when the number of firms remains fixed, to make some assumptions about the entry and exit behaviour of firms, and to specify stochastic processes for the model's exogenous shocks.

A. *Short Run Responses*

Solving equations (24) through (29) for a given number of firms and with the level of profits taken to be endogenously determined gives the following reduced form solutions for the various endogenous variables:

$$L_t = \frac{\alpha c}{\alpha c+\mu\left(1-\alpha c-\alpha g\right)}L^* + \frac{\left(1-\alpha c-\alpha g\right)}{\alpha c+\mu\left(1-\alpha c-\alpha g\right)}\left(\frac{\mu}{\gamma_1}\right)\left(G_t+\gamma_0\left(n_t+n_t^g\right)\right) \tag{38}$$

$$Y_t = \gamma_1\frac{\alpha c}{\alpha c+\mu\left(1-\alpha c-\alpha g\right)}L^* + \mu\frac{\left(1-\alpha c-\alpha g\right)}{\alpha c+\mu\left(1-\alpha c-\alpha g\right)}G_t - \gamma_0\frac{\alpha c}{\alpha c+\mu\left(1-\alpha c-\alpha g\right)}\left(n_t+n_t^g\right)$$

(39)

$$C_t = \gamma_1\frac{\alpha c}{\alpha c+\mu\left(1-\alpha c-\alpha g\right)}L^* - \frac{\alpha c}{\alpha c+\mu\left(1-\alpha c-\alpha g\right)}\left(G_t+\gamma_0\left(n_t+n_t^g\right)\right) \tag{40}$$

$$w_t = \frac{\gamma_1}{\mu} \tag{41}$$

$$\Pi_t = Y_t - w_t L_t \tag{42}$$

It is possible to talk meaningfully about short run multiplier effects of government expenditure shocks in our model. We can write the difference between the short term (with the number of firms held constant) and long term (with profits equal to zero) impact effects of government spending as:

$$\frac{\partial Y_t}{\partial G_t}\Big|_{short\ term} - \frac{\partial Y_t}{\partial G_t}\Big|_{long\ term} = \frac{\left(1-\alpha c-\alpha g\right)}{\left(\frac{1}{\mu}-1\right)\alpha c+\left(1-\alpha g\right)} - \frac{\left(1-\alpha c-\alpha g\right)}{\left(1-\alpha g\right)}$$

(43)

The difference is clearly positive and depends on the degree of imperfect competition in the economy. As the markup μ tends to one, the difference tends to zero. The economic intuition of this difference is straightforward. An increase in government expenditures increases both aggregate demand and profits. The profits are distributed to households, and this leads to an increase in wealth and therefore to an increase in the demand for private consumption goods. This second-round increase in aggregate demand also leads to an increase in profits, which in turn leads to a third-round increase in aggregate demand and so on.

B. *Firm Entry and Exit*

Since we assume that firms distribute their profits to private agents within the period, and since we do not observe negative dividend payments, we allow immediate exit of firms in response to shocks that would make profits negative. There is thus no distinction between the long run and the short run in response to negative shocks that would tend to drive profits below zero. In response to shocks that generate positive profits, we assume that firms face a one-period entry delay, which operates as follows. We assume that there is a large pool of potential entrants. In response to a positive shock, the number of firms that would reduce aggregate profits to zero given the current levels of government spending and labour productivity decide to enter the market. This is the number of firms in existence at the beginning of the following period.

These assumptions concerning entry and exit are fairly simplistic, but they allow us to treat the representative firm's profit maximisation problem as static. The explicit introduction of sunk costs would give rise to an option value of being in the market, so that firms would have to solve a complex dynamic problem. In any case, our results are robust to small changes in these assumptions. For example, Rotemberg and Woodford (1992a) report simulation results from a model in which the number of firms is assumed to follow an error correction process. Imposing a similar assumption in our model would not substantially change the results.

C. *Calibration*

The parameter values used for numerical simulations are given in Table 1. The discount rate rate is equal to .99, which is compatible with a real interest rate of four percent in the steady state and is comparable to values used in the real business cycle (RBC) literature. We normalized the representative agent's time endowment to equal one. The substitutability parameter σ was set equal to 6.075, which gives a markup ratio equal to that found by Morrison (1990) for total manufacturing.[5] Other parameter values were chosen to reproduce some features of the U.S. data. We chose values such that, in the steady state, the representative private agent devotes one third of her time to labour market activities. Once again, this is standard in the RBC literature. We also restricted parameters so that, in the steady state, the ratio of consumption to total income reproduced the average value observed in the U.S. data.[6] We assumed that the steady state level of government spending is optimal in the sense that it maximizes the instantaneous utility function of the representative private agent. This gave us three relationships which we used to solve for the two parameters α_C and α and the steady state level of government spending G, conditional on the values of the two remaining free parameters in the model, γ and γ. We report results for the base case parameter values reported in Table 1, but we conducted extensive sensitivity analysis to changes in the production function parameter values. The main moment properties of the model did not depend on these parameter values.

We consider the response of the model to two main types of shocks, labour productivity shocks and government expenditure shocks. We specified AR(1) processes for the logarithms of both exogenous shocks, with autoregressive coefficients equal to .95 in each case. This means that persistence in the model comes, aside from the delay that we impose on firm entry, mainly from the persistence of the forcing variables of the model. This is potentially a drawback, but Cogley and Nason (1992) show that even neoclassical growth models with capital accumulation suffer from the absence of strong endogenous propagation mechanisms. Because of the absence of propagation mechanisms, we focus on the contemporaneous correlations of variables and on their relative volatilities; these statistics do not depend on the absolute size of the exogenous shocks. Also, the absence of capital from our model makes it difficult to parameterize the volatilities of the shocks. We report results for productivity shocks only, for expenditure shocks only, and for a case in which the standard deviations of the productivity shocks and the expenditure shocks are equal. The model's predictions concerning the main moments in which we

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5 The same value is used by Devereux, Head and Lapham (1992) for their numerical simulations.

6 Since there is neither investment nor foreign trade in our model, total income in the data was measured as consumption plus total government expenditures.

are interested (the procyclicity and relative volatility of labour and profit shares) do not depend on the relative volatilities of the shocks. Some of the model's predictions are sensitive to the mix of shocks; this will be noted below.

D. *Simulation Results*

The main results of the numerical simulations are reported in Table 2. For each scenario, we used 500 replications. The standard error of each comovement statistic across the 500 replications is reported in parentheses to give an idea of the degree of precision of the model's predictions. The sample length was chosen to match that of the data with which the model's predictions are being compared. For each replication, we initialized all variables at their steady state levels, generated a sample twenty periods longer than the sample length of our data, and truncated the first twenty observations so that the results do not depend on initial conditions.

The data were rendered stationary by using the Hodrick-Prescott filter, which is standard practice in the real business cycle literature.[7] The simulated data series are stationary, but these were also passed through the Hodrick-Prescott filter. This has the effect of removing low-frequency fluctuations in the generated series, and is also standard practice. For purposes of comparison with the U.S. time series, we used series of the same length as our data sample.[8]

The most important predictions of the model concern the cyclical behaviour of profits and labour income. The simulation results indicate that labour's share of total income is significantly countercyclical. This result is qualitatively compatible with the stylized facts of the U.S. economy, although the correlation between labour's share and income is more than two standard deviations too small in absolute value. It is interesting to note that labour's share is countercyclical in response to both fiscal spending shocks and productivity shocks as well as a combination of the two types of shocks. Profit's share of income is significantly procyclical. Once again, this result is independent of the relative importance of shocks, and the predicted correlation, although of the right sign, is smaller than the one in the data.

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7 We used a Lagrange multiplier equal to 1600, which is also standard practice when dealing with quarterly data.

8 We generated our simulated data using a sample length of 164 observations, and discarded the first twenty observations so that the results do not depend on initial conditions.

Gomme and Greenwood (1992) also formulate a model in which labour's share of income is significantly countercyclical. Their model is one of perfect competition, and they obtain their result by eliminating the allocative role of the real wage. Markets are incomplete in their model, and wages are merely installment payments of a long term contract. If labour was paid its marginal product in their model, its share of income would be constant. Their assumptions imply that the real wage is smoothed over the cycle, so that workers are paid more than their marginal product in bad times (with negative productivity shocks) and less than their marginal product in good times. This makes labour's share countercyclical.

The model predicts that labour's share of income should be less volatile than output and that the profit share should be more volatile than output. These predictions are in qualitative agreement with the stylised facts of the U.S. economy, although quantitatively the model underpredicts the relative volatility of labour's share and overpredicts the relative volatility of the profit share. Once again, the model's predictions concerning these relative volatilities are robust to the relative importance of the two types of exogenous shocks that we consider.

The model's prediction concerning the procyclicality of net firm creation is quite close to what we observe in the data, although the predicted correlation is too small by more than two standard errors. As noted above, in the long run with zero profits the output of each firm is constant, and output changes are perfectly correlated with the number of firms. It is interesting to note that our simple assumption of a one-period delay to firm entry is sufficient to reduce the correlation between net entries and output from one to 0.441. The model predicts that net entries should be more volatile than output, which is in qualitative agreement with the data, although the predicted volatility of net entries is too high. Once again, these predictions are robust to the relative volatilities of the two types of exogenous shocks in the model.

When the standard deviations of the productivity shocks and fiscal spending shocks are equal, Table 2 indicates that the comovement statistics are dominated by the effects of productivity shocks. The model does well in capturing the procyclicity of consumption spending.[9] The model's greatest shortcoming is in some of its predicitons concerning the labour market. It overpredicts the relative volatility of average labour productivity, both with respect to total hours

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9 Note, however, that fiscal spending shocks by themselves partially crowd out private consumption spending and result in highly countercyclical movements in private consumption.

worked and to output fluctuations. It predicts, counterfactually, that total hours should move countercyclically, and it overpredicts the correlation of average labour productivity with output. This shortcoming can be attributed primarily to the lack of capital in the model, which reduces the incentives of agents to engage in intertemporal substitution, dampening the response of both employment and output to productivity shocks. This phenomenon is also responsible for the negative correlation between productivity and hours: the primary effect of a positive productivity shock on labour supply is a wealth effect that leads agents to consume more leisure and reduce their labour supply.

With both shocks operating, the model predicts a correlation between government spending and ouptut that is compatible with the data, and it matches the data in terms of the relative volatilites of government spending and output. We do not emphasise these results, however, since these predictions are highly sensitive to the mix of shocks operating in the economy.

7. Conclusions

Our model can be considered a first attempt at setting up and simulating a dynamic model of imperfect competition which is appropriate to study comovements in the data at business cycle frequencies. Some authors have concluded that the introduction of imperfect competition into equilibrium business cycle models adds little to their ability to their ability to explain the stylized facts of the business cycle.[10] We think that we have demonstrated here that when a broader range of stylized facts is considered, notably the cyclical behaviour of labour income and profits and the cyclical properties of bankruptcies and firm creation, models of imperfect competition yield strong testable predictions, so that imperfect competition may be important for explaining some aspects of the business cycle.

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[10] Ambler, Cardia and Phaneuf (1992) find that introducing imperfect competition into an encompassing model of the business cycle (which includes real business cycle models as a special case) has no effect on standard comovements including the relative volatilities of output, employment and productivity and correlations among these variables. Hornstein (1991) finds that introducing monopolistic competition increases the impact of productivity shocks on output fluctuations but that with his specification, the volatility of employment is decreased.

Adding capital accumulation would make the model more directly comparable to standard models in the literature on real business cycles. We are confident that the model's predictions concerning income shares and net firm creation will survive such an extension, and that it will bring the model's predictions concerning labour market more into line with the stylised facts.

In its present form, the model does make predictions concerning the cyclical nature of profits and of bankruptcies. The assumptions concerning the entry and exit decisions of firms are extremely simplistic. It would be interesting to study the implications of more realistic assumptions about entry costs. The addition of sunk costs would render firms' value maximization problems dynamic even without capital in the model.

Our specification of preferences implies that consumers do not have a preference for variety per se. In an economy with permanent technological change, this assumption may have important consequences for the creation and destruction of firms in the face of technological innovation. The sensitivity of the model's dynamics to the specification of preferences warrants further study.

All of these extensions are on our research agenda for future work.

Appendix: Data Sources

The data are U.S quarterly data, seasonally adjusted, 1954:01-1989:04, unless specified otherwise.

- *population*: population aged 16 and older. Citibase data bank (P16). Monthly series, not seasonally adjusted. Quarterly series generated by taking middle month of quarter.
- y: national income per capita in 1982 dollars. Citibase data bank (GY82/P16).
- c: personal consumption expenditure per capita in 1982 dollars. Citibase data bank (GC82/P16).
- g: government expenditures per capita in 1982 dollars. Citibase data bank (GGE82/P16).
- wl/y: labour share of national income. Citibase data bank (GCOMXY).
- π/y: profit share of national income before taxes. Citibase data bank (GPBT/GY).
- l: total manhours employed, all workers, all industries, per week, per capita. Citibase data bank (LHOURS/P16). Monthly series. Quarterly series for hours generated by multiplying weekly figure by four and summing across months in each quarter.
- Δn: net business formation per capita (number of new business incorporations, INC, minus number of business failures, FAILN, divided by population P16). Citibase data bank (INC).

Dunn & Bradstreet Record of Business Closing, Economic Analysis Department, monthly 1968:01-1989:04 (FAILN).

- w: real compensation per hour in the business sector. Citibase data bank (LBCP7).

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Table 1

Base Case Parameter Values

δ	l^*	σ	γ_0	γ_1	α_c	α_g
0.990	1.000	6.075	0.100	1.000	0.252	0.081

Table 2

Stochastic Properties of the Model

Moment	Productivity Shocks Only	Expenditure Shocks Only	Both Shocks	U.S. Data
$\sigma(lw/y,y)$	-0.360 (.049)	-0.371 (.056)	-.354 (.053)	-0.668
$\sigma(\pi,y)$	0.363 (.049)	0.372 (.055)	0.358 (.052)	0.771
$\sigma(l,y)$	-0.979 (.003)	0.997 (.001)	-0.567 (.105)	0.887
$\sigma(c,y)$	0.999 (.000)	-0.997 (.001)	0.956 (.014)	0.787
$\sigma(y/l,y)$	0.999 (.000)	0.371 (.056)	0.977 (.008)	0.715
$\sigma(w,y)$	1.000 (.000)	-0.001 (.112)	0.977 (.008)	0.365
$\sigma(g,y)$	0.002 (.106)	0.999 (.001)	0.221 (.147)	0.078
$\sigma(\Delta n,y)$	0.446 (.044)	0.445 (.043)	0.441 (.044)	0.578
$\sigma(y/l,l)$	-0.986 (.002)	0.301 (.054)	-0.727 (.074)	0.287
$\sigma_{wl/y}/\sigma_y$	0.077 (.008)	0.078 (.009)	0.076 (.008)	0.475
$\sigma_{w/y}/\sigma_y$	6.281 (.654)	7.411 (.814)	6.230 (.668)	4.000
σ_l/σ_y	0.238 (.008)	0.973 (.006)	0.311 (.042)	0.610
σ_c/σ_y	1.322 (.011)	0.487 (.006)	1.294 (.061)	0.608
$\sigma_{y/l}/\sigma_y$	1.234 (.008)	0.078 (.009)	1.204 (.040)	0.505
$\sigma_{y/l}/\sigma_l$	5.181 (.136)	0.080 (.009)	3.922 (.447)	0.506
$\sigma_{\Delta n}/\sigma_y$	6.455 (.634)	6.229 (.580)	6.401 (.617)	2.330
σ_g/σ_y	0.000 (.000)	5.613 (.155)	1.195 (.186)	1.192

For variable definitions and data sources, see the appendix to the paper.

Figure 1a

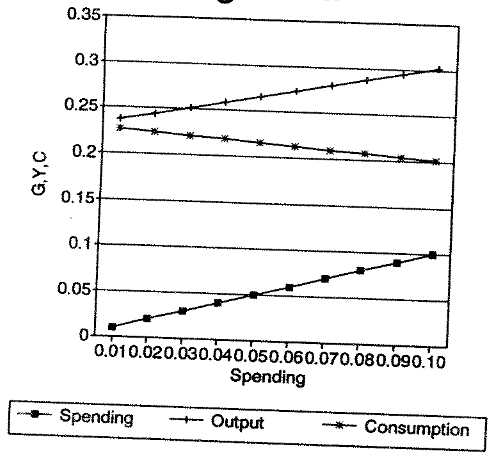
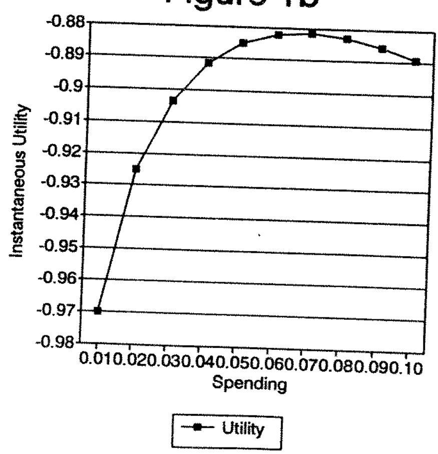


Figure 1b



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