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NON-WALRASIAN UNEMPLOYMENT FLUCTUATIONS

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ABSTRACT

We modify the standard real business cycle model by assuming that wages are set by a monopoly union at the firm level. In the context of such a model, we introduce a measure of unemployment and analyze its equilibrium behavior. We show that a calibrated version of the model is capable of generating both a procyclical labor supply and a countercyclical unemployment rate, in a way qualitatively consistent with the evidence. The model stresses the role of countercyclical markups in the goods market as a key mechanism underlying the countercyclical behavior of unemployment.

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1. Introduction

Dynamic stochastic general equilibrium models (henceforth, DSGE models) have become in recent years the central paradigm for the analysis and understanding of macroeconomic fluctuations. Though early applications were generally restricted to model economies for which technology shocks were the only source of fluctuations, and where built-in classical assumptions guaranteed the optimality of equilibrium allocations (thus leaving no room for any meaningful welfare or policy analysis), the flexibility of that paradigm has been illustrated by the growing number of examples of DSGE economies found in the literature and which are characterized by non-classical features [1] and/or alternative sources of fluctuations.[2] In contrast with earlier applications, many of the recent models yield equilibrium allocations that are inefficient, and thus provide a rationale for corrective policies.

Despite the previous effort to enrich the basic framework in order to improve

[1]Examples include models with productive externalities (e.g., Baxter and King (1991)), imperfect competition (e.g., Chaterjee and Cooper (1993), Rotemberg and Woodford (1992)), policy distortions (Greenwood and Huffman (1991),Galí (1994)), and cash-in-advance constraints (e.g., Cooley and Hansen (1989)), among other non-classical assumptions.

[2]Including shocks to government spending (e.g., Christiano and Eichenbaum (1992)), distortionary tax shocks (e.g., Braun (1994)), and even sunspots (e.g., Farmer and Guo (1994), Galí (1994)).

its empirical relevance and performance, most existing models–classical and non-classical–embed the assumption of continuously clearing, perfectly competitive labor market, thus effectively ruling out the possibility of unemployment.[3] That feature flies in the face of actual market economies' experience, which–to a degree that varies both across countries and historical periods–are characterized by significant levels of unemployment, as well as large and persistent fluctuations in that variable. From the viewpoint of many societies, the magnitude of the unemployment problem, its social repercussions, and the central role it plays in the policy debate make the notion of "macroeconomics without unemployment" seems almost a contradiction in terms.[4]

On the other hand, the traditional macroeconomic literature on unemployment[5], though rich and full of insights, has been largely restricted to static and/or par-

[3]That statement applies to models with divisible labor (e.g., Kydland and Prescott (1982)) as well as models with indivisible labor (Hansen (1985)). In the latter, some agents are not working at any point in time, as a result of the outcome of a lottery in which they have chosen the "probability of working" in a perfectly competitive manner, taking the wage schedule as given. "Unemployment" in that context is equated to the (random) optimal consumption of leisure, a characterization which we do not view as a plausible theoretical explanation of the bulk of unemployment observed in actual economies.

[4]Even though unemployment is often viewed by economists and commentators as a European disease, its cyclical variations have historically played a major role in American politics and election outcomes. In fact, Americans' concerns about unemployment seem to show fluctuations as large as unemployment itself. Over the period 1981-1992, the percentage of respondents to the Gallup Poll who ranked unemployment as the most important problem facing the United States fluctuated between 3 % (1990) to 53 % (1983). The difference in unemployment rates between those two years was of about 2 percentage points.

[5]See, e.g., Layard et al. (1991) and chapter 9 of Blanchard and Fischer (1989) for a review of that literature. Bean (1994) discusses its relevance to the European case.

tial equilibrium models, thus falling short of adopting the explicitly dynamic, optimizing, general equilibrium framework that has proved so useful in modelling other aspects of economic fluctuations. Unemployment models in that tradition include models with unions (e.g., Hart (1982)), efficiency wages (e.g., Shapiro and Stiglitz (1984)), as well as models with insider-outsiders (e.g., Lindbeck and Snower (1988)), among others. A common theme of those models is the absence of a perfectly competitive labor market, with wages being instead *set* (by firms, workers, or both) at some level above the perfectly competitive level. That feature generally becomes a source of unemployment, manifested in the inability of (some) individual workers to sell as much labor services as they would wish to supply, given the prevailing wages (and other market conditions). In those models unemployment is thus a consequence of a non-Walrasian wage-setting mechanism, which prevents the wage from adjusting in order to match the opportunity cost of work.[6]

[6] A different strand of the literature on unemployment is given by search models. The concept and sources of unemployment in those models differs from the one emphasized in the traditional literature. In search models unemployment results from a *technological constraint*, usually in the form of a matching function (Mortensen (1990), Pissarides (1990)) or a time cost for job reallocation (e.g., Lucas and Prescott (1974), Jovanovic (1987), Greenwood et al. (1994)), which prevents those who lose or quit their job from immediately finding employment somewhere else. In that context, unemployment is associated with time allocated to search activities. In many search models unemployment can be viewed as voluntary, in the sense that it is consistent with a (privately) optimal decision by workers to quit their current jobs (given the wage and opportunity cost of remaining in the job). In other models unemployment results from exogenous separations, that occur independently of the wage.

In the present paper we try to bridge the gap between recent business cycle modelling strategies–based on the use of DSGE models–and the traditional models of unemployment with imperfect competition in labor markets. Specifically, we develop and analyze a DSGE model that is consistent (at least qualitatively) with a number of stylized facts regarding the cyclical behavior of the labor market, in addition to other features of their business cycles. In particular, we want to account for the fact that (a) employment is highly procyclical and almost as variable as GNP, (b) the labor force is mildly procyclical and substantially less volatile than GNP and employment, and (c) the unemployment rate is highly countercyclical and roughly half as variable as GNP. The three previous observations are illustrated in Figures 1, 2, and 3 (respectively) and Table 1. The dashed line in each figure corresponds to the HP-filtered time series for (log) GNP. The solid lines plot, respectively, the HP-filtered logs of measures of employment, the labor force, and unemployment. A description of the data and sources can be found in section 5.4 . Though (a) is well known and frequently reported, (b) and (c) have generally been ignored by the recent business cycle literature.

In order to focus on the mechanisms that bring about unemployment and to compare our results with those of other researchers we choose to depart as little as possible from the standard RBC paradigm. In particular, we assume that technology shocks are the only source of fluctuations, and we maintain the fiction of a representative household. Depending on whether the household is viewed as consisting of a single individual (allocating his time between work and leisure) or a continuum of individuals (a fraction of which work a fixed amount of hours), the resulting unemployment will take place at either the "intensive" or "extensive" margins.[7] In either case, we define unemployment in our model economy as the difference between (a) the quantity of labor services employed and (b) the quantity of labor services that an individual household wishes to supply *given the actual law of motion for wages* (and interest rates).[8] We interpret (b) as a well defined theoretical counterpart to the survey-based measures of the labor force used in the construction of unemployment rate figures.[9] In our model the existence of a gap between (a) and (b) is a consequence of the exercise of market power by *insid-*

[7]As illustrated by the measures of unemployment constructed and discussed below, both margins seem to be important in actual economies. Here we are not trying to give a literal interpretation to the type of unemployment generated by the model, but rather view it as a shortcut– associated with the use of a representative household device–to the modelling of unemployment at both margins.

[8]This concept of unemployment has a familiar static counterpart in the gap between the perfectly competitive labor demand and labor supply schedules, given a wage above their intersection. In our dynamic framework, both curves keep being shifted around, as a result of random technology shocks and household investment decisions, which affect firms' marginal revenue product of labor and households' competitive choice of labor supplied.

[9]The conventional unemployment rate measure (known as U-5 in the BLS terminology) is defined as the total number of persons not working, but available for and seeking work (in the past for weeks), as a percent of the civilian labor force (which in addition includes the number of persons working). The so called U-6 measure contains an adjustment of the previous measure aimed at counting as partially unemployed those workers who are involuntarily on part-time schedules for economic reasons (Sorrentino (1993)).

ers (i.e., incumbent workers insulated from competition by the existence of labor turnover costs) who manage to bring the wage above its competitive market clearing level. Furthermore, the cyclical variations in that gap predicted by the model (and which mirror the observed cyclicality of unemployment rates) are shown to be associated with the cyclical variations in workers' degree of market power that result from our assumptions on technology and market structure. We want to stress, however, that neither the notion of unemployment nor the methodology to compute the equilibrium unemployment rate introduced in this paper hinge on the specific mechanism that is assumed to generate unemployment in our model, and could be easily applied to other dynamic models with non-Walrasian wage-setting mechanisms.[10]

In contrast with much of the literature on non-Walrasian labor markets–which typically treats capital as either a fixed or irreversible factor–we follow recent business cycle models in assuming the existence of a competitive capital rental market, which allows any individual firm to adjust its capital input level at any time. In that context, and given the assumed homogeneity properties of technology, the presence of imperfect competition in the goods market is a *necessary* condition

[10]See Galí (1995) for a discussion of a general framework for the analysis of unemployment fluctuations in DSGE models.

for workers' at the firm level to have any market power and thus for unemployment (as defined above) to exist. Furthermore, under our (standard) assumptions on preferences and technology, we show that the existence of *fluctuations* in the unemployment rate requires cyclical variations in the degree of market power–reflected in countercyclical markups and resulting (in our model) from the entry and exit of firms. [11]

We approximate the equilibrium of our model economy in a neighborhood of the steady state using the log-linearization technique described in Campbell (1994). Once we determine the equilibrium law of motion for quantities and prices, we proceed to construct the corresponding equilibrium process for the unemployment rate. Given our definition, that involves solving a (partial equilibrium) dynamic optimization problem for a household who chooses his optimal labor supply while taking as given the law of motion for factor prices that characterizes the equilibrium of the imperfectly competitive economy. Interestingly, the Campbell solution method can also be used to solve for the optimal labor supply rule of the competitive agent in terms of the economy-wide state variables. The law of motion for equilibrium unemployment is then easily obtained by combining

[11] Rotember and Woodford (1991), among others, provide some empirical evidence for the presence of such countercyclical markups in U.S. data.

the competitive labor supply decision rule and the equilibrium law of motion for employment.

The present paper has a clear precedent in the work of Danthine and Donaldson (1990,1992), who have examined the implications of introducing a variety of non-Walrasian labor market features in an otherwise standard RBC model. Such features include efficiency wages (Danthine and Donaldson (1990), as well as risk-sharing arrangements, minimum wages and unemployment subsidies (Danthine and Donaldson (1992)). As is well known, some of those elements can lead to wages above their competitive market-clearing level and, thus, generate unemployment as in the present paper. Yet, and in contrast with the framework developed here, Danthine and Donaldson do not allow for a labor-leisure choice by households, assuming instead an inelastic labor supply. In their model unemployment is simply given by the difference between the quantity of labor demanded and an *exogenous* aggregate labor endowment. By construction such a structure cannot account for the cyclical fluctuations in the labor force, a feature of the data present in most market economies.[12] By allowing for variations in the quantitiy of labor that individual households wish to supply in response to changes in the environment, the framework proposed here has the potential to account also for that aspect

[12]See, e.g., Elmeskov and Pichelmann (1993).

of labor market fluctuations. Furthermore, our framework becomes more readily comparable to standard business cycle models found in the literature (which do allow for a labor-leisure choice), thus making it possible to isolate the role of labor market imperfections.

The plan of the paper is as follows. Section 2 presents the model. Section 3 analyzes its equilibrium. Section 4 defines unemployment. Section 5 describes the solution method and the statistical properties of a number of calibrated versions of the model. Section 6 concludes and points to some possible extensions.

2. The Model

The production side of the economy consists of two sectors which turn out, respectively, a single final good and a continuum of intermediate inputs. Next we describe the market structure and technology in some detail.

2.1. Final Good

The final good is produced by a perfectly competitive representative firm. That firm has access to a constant returns technology that transforms intermediate inputs into the final good, and which is represented by the CES production function

$$Y = \left(\int_0^1 X(z)^{\frac{\epsilon-1}{\epsilon}} dz \right)^{\frac{\epsilon}{\epsilon-1}} \tag{2.1}$$

where Y denotes the output of the final good, $X(z)$ is the quantity of input $z \in [0,1]$, and $\epsilon > 1$ is the elasticity of substitution among intermediate inputs. The representative firm maximizes its profits at each point in time

$$\pi_y \equiv \max\ Y - \int_0^1 p(z)\ X(z)\ dz$$

subject to (2.1), where $p(z)$ denotes the price of input z in terms of the final good (which is taken as the numéraire). The first order conditions for the problem above take the form of a set of demand functions for intermediate inputs

$$X(z) = \left(\frac{p(z)}{P} \right)^{-\epsilon} \left(\frac{I}{P} \right), \qquad z \in [0,1] \tag{2.2}$$

where $I \equiv \int_0^1 p(z)\ X(z)\ dz$, and $P \equiv \left(\int_0^1 p(z)^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}$. It is easily checked that for an equilibrium with positive production to exist it must be the case that $P = 1$, which in turn implies $Y = I$, and $\pi_y = 0$.

2.2. Intermediate goods

The intermediate sector is made up of a continuum of industries represented by the unit interval. Each industry, indexed by $z \in [0,1]$, consists of a finite number of firms producing a homogeneous intermediate good that is sold to the final goods sector. A typical firm (say, firm j) in a given industry has access to a production function

$$X_{jt} = \exp(\phi_t)\ (K_{jt} - \upsilon\ \gamma^t\ )^\alpha\ (\gamma^t\ L_{jt})^{1-\alpha} \tag{2.3}$$

X_{jt}, K_{jt} and L_{jt} denote, respectively, the level of output and the quantities of capital and labor services employed by firm j in period t.[13] Each firm has an overhead capital requirement $\upsilon\ \gamma^t$, which grows at an exogenous gross rate γ, which also corresponds to the rate of growth of labor-augmenting technology.[14] $\{\phi_t\}$ denotes the stochastic component of technology which follow the first-order autoregressive process

$$\phi_t = \rho\ \phi_{t-1} + e_t \tag{2.4}$$

[13]In order to lighten the notation and given the symmetry across industries embedded in the model we omit the industry index z whenever there is no risk of confusion.

[14]That assumption is needed for a balanced growth path with positive growth to exist.

with $|\rho| < 1$, $Ee_t e_{t-j} = 0$, for $j \neq 0$, and $Ee_t^2 = s^2$, $t = 0, 1, 2, ...$ Parameters υ and γ, as well as the realizations of $\{\phi_t\}$ are assumed to be common to all industries and firms.

Each intermediate firm rents labor and capital services from consumers, taking the wage W_j and the rental cost of capital q as given. Thus, the (static) profit maximization problem faced by an intermediate firm each period can be formalized as follows:

$$\pi_{jt} \equiv \max \ p_{jt} \ X_{jt} - W_{jt} \ L_{jt} - q_t \ K_{jt}$$

subject to (2.3) and the inverse demand schedule (derived from (2.2))

$$p_t = \left[\frac{(m_t - 1) \ \overline{X}_{-jt} + X_{jt}}{Y_t} \right]^{-\frac{1}{\epsilon}} \tag{2.5}$$

where m denotes the number of active firms in the industry, $\overline{X}_{-j}$ is the average output for the $(m-1)$ firms in the industry (other than firm j) . We assume Cournot competition at the industry level, with each firm taking aggregate demand Y_t, the quantities produced by other firms in the industry $\overline{X}_{-jt}$, and the number of firms in the industry m as given.

The associated first order conditions equate each factor's marginal revenue product to its rental cost, and are given by

$$p_t \left(1 - \frac{1}{\xi_{jt}}\right)\left(\frac{\partial X_{jt}}{\partial K_{jt}}\right) = q_t \tag{2.6}$$

$$p_t \left(1 - \frac{1}{\xi_{jt}}\right)\left(\frac{\partial X_{jt}}{\partial L_{jt}}\right) = W_{jt} \tag{2.7}$$

where $\xi_j = \epsilon \left(1 + \frac{(m-1)\,\overline{X}_{-j}}{X_j}\right)$ is the price-elasticity associated with firm j's demand schedule.

Letting $w_{jt} \equiv \frac{W_{jt}}{\gamma^t}$, the quantity of labor employed by the firm (L_{jt}) is (implicitly) determined by

$$J(L_{jt}, w_{jt}, \theta_{jt}) = 0 \tag{2.8}$$

where $\theta_{jt} \equiv [\phi_t, q_t, \overline{x}_{-jt}, m_t, y_t]$, with $\overline{x}_{-jt} \equiv \frac{\overline{X}_{-jt}}{\gamma^t}$ and $y_t \equiv \frac{Y_t}{\gamma^t}$, and where $J : \Re^7 \rightarrow \Re$ is a continuously differentiable function formally derived in the appendix. θ_{jt} is a vector of variables taken as given by each individual firm when maximizing profits (and which will also be taken parametrically by its workers in the wage-setting process, as we will see below). We note that (2.8) already embeds the firm's optimal choice of capital, as well as its price-setting decision.

We focus on a symmetric equilibrium in which all firms in all industries produce the same quantities and employ the same levels of inputs. In that case we have $p_t = 1$, $\overline{X}_{-jt} = X_{jt}, \xi_{jt} = \epsilon\ m_t$, and $K_{jt} = \frac{K_t}{m_t}$, for $j = 1, 2, ...m$, where K_t denotes the aggregate capital stock.

Conditions (2.6) and (2.7) can be used to derive an expression for an individual firm's profits in a symmetric equilibrium:

$$\pi_{jt} = X_{jt} \left[\frac{1}{\epsilon\ m_t} - \alpha \left(1 - \frac{1}{\epsilon\ m_t}\right)\left(\frac{m_t\ v}{k_t - m_t\ v}\right)\right] \tag{2.9}$$

where $k_t \equiv \frac{K_t}{\gamma^t}$.

Under the assumption of free entry and zero profits we can solve for the number of firms as a function of the aggregate capital stock

$$m(k_t) = \left(\frac{1-\alpha}{2\alpha\epsilon}\right)\left(\sqrt{1 + \Psi\ \left(\frac{k_t}{v}\right)} - 1\right) \tag{2.10}$$

where $\Psi \equiv \frac{4\alpha\epsilon}{(1-\alpha)^2}$. The previous result, combined with the symmetric equilibrium condition $y_t = m_t x_{jt}$, (where $x_{jt} \equiv \frac{X_{jt}}{\gamma^t}$ and $y_t \equiv \frac{Y_t}{\gamma^t}$) allows us to derive the following reduced-form aggregate production function

$$y_t = \exp(\phi_t)\ \varphi(k_t)^\alpha\ {L_t}^{1-\alpha} \tag{2.11}$$

where $\varphi(k_t) \equiv k_t - m(k_t)\upsilon$ and $L_t \equiv m(k_t)\ L_{jt}$.

Furthermore, using (2.10) we can derive an expression for the wage-elasticity of a firm's labor demand $\eta_{jt} \equiv \frac{\left(\frac{\partial J_{jt}}{\partial w_{jt}}\right)}{\left(\frac{\partial J_{jt}}{\partial L_{jt}}\right)} \frac{w_{jt}}{L_{jt}}$ evaluated at the symmetric equilibrium, as a function of the aggregate capital stock

$$\eta(k_t) = \alpha + (1-\alpha) \left(\frac{(\epsilon\ m(k_t) - 1)\ \epsilon\ m(k_t)}{2\ \epsilon\ m(k_t) - (1+\epsilon)} \right) \tag{2.12}$$

Henceforth we assume that $\eta > 1$ and $\eta'(k) > 0$. Sufficient conditions to guarantee that the previous inequalities hold (at least in a neighborhood of the steady state) are very weak and will generally hold for any reasonable set of parameter values.[15] In that case the wage elasticity of labor demand η is positively related to the price elasticity of the demand for the intermediate good $\xi = \epsilon\ m(k_t)$, which in turn is increasing in the aggregate capital stock. The intuition for that result is as follows: in the face of an idiosyncratic wage increase, the firm's optimal response involves (a) an increase in the capital/labor ratio and (b) a reduction in output (with the consequent price increase). Both (a) and (b) work in the direction of reducing employment. The size of the downward adjustment in employment will

[15] It is easy to check that $\eta' > 0$ will hold if $m > \frac{(1+\epsilon)+\sqrt{\epsilon^2-1}}{2\ \epsilon}$. Using 2.10 we can see that such an inequality will be satisfied as long as the steady state capital stock is above a certain threshold. That condition was easily satisfied in all the simulations reported below.

depend on the optimal reduction in output, and the latter will be greater the higher is the price-elasticity of demand.[16] In the limiting case of perfect competition in the goods market (as implied, say, by $\varepsilon \to \infty$), the individual firm's labor demand schedule becomes perfectly flat (i.e., $\eta \to \infty$) and, as a result, workers become *de facto* wage takers.[17]

2.3. Households

We assumes a continuum of identical households indexed by $i \in [0,1]$. Household preferences are represented by the utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\log c_{it} - \chi \, \sigma \, n_{it}^{\frac{1}{\sigma}} \right) \tag{2.13}$$

where c_{it} is (normalized) consumption, $\beta \in (0,1)$ is the discount factor, and $\sigma \in (0,1)$ determines the curvature of labor disutility. n_{it} denotes the quantity of labor services sold by household i. Its units depend on how we interpret what a household means in our model. If we view the household as consisting of a

[16] The existence of a connection between goods markets competitiveness and the the degree of workers' market power is a standard result in the wage bargaining literature (see, e.g., chapter 2 in Layard et al. (1991)).

[17] In other words, in that case the wage is pinned down by the factor price frontier, given the rental cost of capital. That result follows from technology's homogeneity of degree one assumption combined with the absence of a "predetermined" input.

single agent, n_{it} has the natural interpretation of hours of work. At the other extreme we can think as being made up of a continuum of individuals, in which case n_{it} would represent a measure of the subset of household members that are employed (working a fixed number of hours). Intermediate interpretations are also possible as long as we are willing to accept that the two margins ("intensive" and "extensive") for increasing the total quantity of labor services sold by the household are perfect substitutes from the latter's viewpoint.

Household i's dynamic budget constraint is given by

$$\gamma\ k_{i,t+1} = R_t\ k_{it} + w_{jt}\ n_{it} - c_{it} \tag{2.14}$$

where $R_t \equiv ((1-\delta) + q_t)$, δ is the depreciation rate, and w_{jt} is the wage paid by the firm (j, say) where household i works.

Let us now turn to the wage setting and employment decisions. The assumed structure aims at capturing in a stylized (and admittedly ad-hoc) manner some of the labor market rigidities that may be at the root of any market power enjoyed by workers in actual economies. At the beginning of period t, firm j enters a labor contract with a set of households with (uniform) measure τ_{jt}. Upon drawing the contract, those households become "insiders" to the firm, in a sense to be explained below. Labor contracts last one period. Contracts (a) entitle workers to set the wage rate unilaterally (after observing the technology shock), and (b) give the firm the right to choose its desired level of employment (i.e., the number of man-hours or workers, depending on the interpretation of n), given that wage.[18] The monopoly power enjoyed by a firm's "insiders" results from two implicit assumptions. First, early termination of the contract by the firm is effectively ruled out by the existence of (sufficiently large) firing costs. Second, we assume that either de iuris (because of closed-shop like restrictions) or de facto (because of incumbent workers' threat not to cooperate or to harass any new hires) the firm is prevented from extending the contract (or drawing a new one) with any additional households (which we refer to as "outsiders" *to that firm*) once the shock has been observed, and before the beginning of the following period. Thus, each firm's insiders effectively hold the monopoly on the supply of labor services to that firm. In particular, and because of the labor turnover costs suggested above, they cannot be underbid by outsiders, even though that would be benefit both the firm and the underbidders. Accordingly, the total quantity of labor services $L_{jt} = \tau_{jt}\, n_{it}$ (measure of households $\times$ labor service units per household),

[18]The assumed wage setting structure corresponds to models of "monopoly union with right-to-manage". As discussed in McDonald and Solow (1981), those contracts are known to be inefficient in general (i.e., both workers and firms could be better off if they could bargain over both wages and employment).

demanded by firm j in period t is given implicitly by

$$J(\tau_{jt}\ n_{it}, w_{jt}, \theta_{jt}) = 0 \tag{2.15}$$

As will become clear below, the symmetry embedded in our model implies that a firm's insiders effectively face an identical problem. They also have an obvious incentive to exploit to the full extent their market power, manifested in their recognition that they face a downward sloping demand schedule (2.15). That leads them to jointly determine the wage, consumption and savings consistent with the maximization of (2.13) subject to the dynamic budget constraint (2.14) and the labor demand schedule (2.15), while taking as given the equilibrium process for the economy-wide and industry-wide variables θ_{jt}.

The optimality conditions for that problem are given by

$$w_{jt} = \lambda_{jt}\ \chi\ c_{it}\ n_{it}^{\frac{1-\sigma}{\sigma}} \tag{2.16}$$

$$\beta\gamma^{-1}\ E_t\ \left\{\left(\frac{c_{it}}{c_{i,t+1}}\right)\ R_{t+1}\right\} = 1 \tag{2.17}$$

$$\lim_{T\to\infty} E_t\, \beta^T \left(\frac{k_{iT}}{c_{iT}}\right) = 0 \tag{2.18}$$

for $t = 0, 1, 2, 3...$ where $\lambda_{jt} \equiv \frac{\eta_{jt}}{\eta_{jt}-1}$ (with η_{jt} defined as above) is the wedge between the wage and the marginal relation of substitution between consumption and labor, resulting from the market power enjoyed by workers, and which we refer to as the *wage markup.* In a symmetric equilibrium, it follows from (2.12) that the wage markup will be common to all firms and given by $\lambda(k_t) \equiv \frac{\eta(k_t)}{\eta(k_t)-1}$. Notice also that in a such an equilibrium $\tau_{jt} = \tau_t = \frac{1}{m(k_t)}$, and $L_{jt} = \tau_t\, n_t = \frac{n_t}{m(k_t)}$, for all j.

3. Equilibrium

We define a (symmetric) equilibrium of our model economy as a stochastic sequence $\{k_t, y_t, c_t,\ n_t, w_t, R_t\}_{t=0}^{\infty}$, satisfying

$$\gamma\, k_{t+1} = (1-\delta)\, k_t + y_t - c_t \tag{3.1}$$

$$y_t = \exp(\phi_t)\ \varphi(k_t)^{\alpha}\ n_t^{\,1-\alpha} \tag{3.2}$$

$$\beta\gamma^{-1}\ E_t\ \left\{\left(\frac{c_t}{c_{t+1}}\right)\ R_{t+1}\right\} = 1 \tag{3.3}$$

$$w_t = \lambda(k_t)\ \chi\ c_t\ n_t^{\frac{1-\sigma}{\sigma}} \tag{3.4}$$

$$w_t = \left(\frac{1}{\mu(k_t)}\right)(1-\alpha\ )\exp(\phi_t)\ \left(\frac{\varphi(k_t)}{n_t}\right)^{\alpha} \tag{3.5}$$

$$R_t = (1-\delta) + \left(\frac{1}{\mu(k_t)}\right)\alpha\ \exp(\phi_t)\ \left(\frac{\varphi(k_t)}{n_t}\right)^{-(1-\alpha)} \tag{3.6}$$

$$\lim_{T\to\infty} E_t\ \beta^T\ \left(\frac{k_T}{c_T}\right) = 0 \tag{3.7}$$

together with (2.4), and where $\mu(k_t) \equiv \frac{\epsilon\ m(k_t)}{\epsilon\ m(k_t)-1}$ is the price markup. Under our assumptions, $\mu' < 0$ and $\lambda' < 0$, reflecting the fact that as the aggregate capital stock accumulates, entry of new firms leads to a reduction in equilibrium markups, for both prices and wages.

Given the recursive structure of the model, the equilibrium process $\{k_t, y_t, c_t, n_t, w_t, R_t\}_{t=0}^{\infty}$ can be in general represented as a first-order difference equation for the vector of aggregate state variables $[k_t, \phi_t]' = f([k_{t-1}, \phi_{t-1}]', e_t)$, together with a set of equilibrium conditions linking each aggregate variable with the contemporaneous values of the two state variables, i.e., $y_t = y(k_t, \phi_t)$, $c_t = c(k_t, \phi_t)$, $n_t = n(k_t, \phi_t)$, $w_t = w(k_t, \phi_t)$, and $R_t = R(k_t, \phi_t)$.[19] Unfortunately, the nonlinear nature of equilibrium conditions (3.1)-(3.7) does not allow us to obtain an exact solution for the equilibrium functions but, as described below, we can approximate their behavior in a neighborhood of a steady state by means of the log-linearization method of Campbell (1994).

4. Unemployment

We define *unemployment* as the difference between (a) the quantity of labor services that the representative household wishes to supply *taking as given the equilibrium law of motion for wages and interest rates generated by the imperfectly competitive economy*, and (b) the actual quantity of labor services employed in that economy.

Given the law of motion for employment implied by (3.1)-(3.7), determining the equilibrium process for unemployment requires solving the partial equilibrium

[19] Notice that we are we are implicitly assuming that the equilibrium is unique, at least locally around a steady state. That property cannot be guaranteed, since local indeterminacy and thus stationary sunspot equilibria (Woodford (1986)) cannot be ruled out in general in the presence of imperfect competition. Yet, for all the calibrated versions of the model considered here the steady state exhibits saddle-point stability, which guarantees the local uniqueness of equilibrium.

dynamic optimization problem faced by an individual household who behaves as wage taker, believing (incorrectly, given the restrictions on hiring and firing described above) that it will be able to sell as much labor as it wishes to supply at those wages, and whose decisions have a negligible impact on the economy. Formally, this involves maximizing

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\log c_t^* - \chi \ \sigma \ n_t^{* \frac{1}{\sigma}} \right)$$

subject to

$$\gamma \ k_{t+1}^* = R(k_t, \phi_t) \ k_t^* + w(k_t, \phi_t) \ n_t^* - c_t^* \tag{4.1}$$

and the equilibrium laws of motion

$$[k_t, \phi_t]' = f([k_{t-1}, \phi_{t-1}]', \ e_t)$$

where we let variables with a '*' superscript denote the (normalized) choice variables of the perfectly competitive household. The optimality conditions associated with that problem are given by

$$\beta \gamma^{-1} \ E_t \ \left\{ \left(\frac{c_t^*}{c_{t+1}^*} \right) \ R_{t+1} \right\} = 1 \tag{4.2}$$

$$w_t = \chi \;\; c_t^* \; n_t^{*\frac{1-\sigma}{\sigma}} \tag{4.3}$$

and the transversality condition $\lim_{T\to\infty} E_t \, \beta^T \, \left(\frac{k_T}{c_T}\right) = 0$.

The optimal labor supply choice for the wage-taking consumer can be written as a function of the two aggregate state variables k_t and ϕ_t and the individual state variable k_t^*

$$n_t^* = n^*(k_t^*, k_t, \phi_t)$$

Given our definition, the *unemployment rate* u is determined by the following function of the aggregate state variables (k_t, ϕ_t):

$$u_t = u(k_t, \phi_t) \equiv \log \left(\frac{n^*(k_t, k_t, \phi_t)}{n(k_t, \phi_t)} \right) \tag{4.4}$$

where the symmetry assumption $k_t^* = k_t$ is imposed so that n_t^* can be interpreted as the labor supply choice of the representative household at any given period t if it did not face any restrictions on the quantity of labor services it could sell to any firm (and, in particular, to the firms with respect to which he is an outsider), at the prevailing wage. Unemployment thus defined can be interpreted as *involuntary* in the following sense: *in the absence of labor market rigidities* restricting the hiring of outsiders, an *individual* household would choose to employ some of its unemployed members and/or work longer hours (depending on the interpretation), for a wage no greater than the current wage, and any firm would be willing to hire his services.

5. Approximate Equilibrium Dynamics

In order to solve for the laws of motion describing the economy's equilibrium behavior, we apply the method of undetermined coefficients to a log-linear approximation of (3.1)-(3.7) around the associated perfect foresight steady state.[20] Interestingly, the same method can be applied to derive a log-linear approximation to the competitive labor supply policy rule $n^*(k_t^*, k_t, \phi_t)$, a result which can then be used to approximate the equilibrium unemployment function $u(k_t, \phi_t)$.

5.1. Steady State

Setting $\phi_t = 0$, all t, and dropping all time subscripts (and the expectation operator) in (3.1)-(3.6) we obtain a system of equations implicitly determining the (perfect foresight) steady state vector $\{k, y, c, n, w, R\}$:

[20]See Campbell (1994) for an exposition of that solution method.

$$R = \frac{\gamma}{\beta} \tag{5.1}$$

$$c = \left(\frac{r+\delta}{\alpha}\right) \mu(k)\ \varphi(k)\ - (\gamma - 1 + \delta)\ k \tag{5.2}$$

$$\varphi(k) = n\ \left(\frac{\alpha}{(r+\delta)\ \mu(k)}\right)^{\frac{1}{1-\alpha}} \tag{5.3}$$

$$n = \left(\frac{(1-\alpha)\ (r+\delta)\ \varphi(k)}{\alpha\ \chi\ c\ \ \lambda(k)}\right)^{\sigma} \tag{5.4}$$

$$y = \varphi(k)^{\alpha}\ n^{1-\alpha} \tag{5.5}$$

$$w = \left(\frac{1}{\mu(k)}\right) (1-\alpha)\ \left(\frac{\varphi(k)}{n}\right)^{\alpha} \tag{5.6}$$

where $r \equiv R - 1$.

5.2. Log-Linearized Equilibrium Conditions

Letting $\widehat{x}_t \equiv \log(\frac{x_t}{x})$, for $x = k,\ y,\ c,\ n,\ w, R$...we can derive a first order vector-autoregressive representation for the vector of state variables law of motion

$$\begin{bmatrix} \widehat{k}_t \\ \phi_t \end{bmatrix} = A \begin{bmatrix} \widehat{k}_{t-1} \\ \phi_{t-1} \end{bmatrix} + \begin{pmatrix} 0 \\ e_t \end{pmatrix}$$

where A is a (2x2) upper-triangular matrix . We can also derive the linearized equilibrium relationships

$$\widehat{z}_t = b_{zk}\ \widehat{k}_t + b_{z\phi}\ \phi_t$$

for $z = y,\ c,\ n,\ w,\ R$,...

Finally, we can also approximate the optimal rules for the perfectly competitive consumer-worker. Letting $\widehat{k}^*_t \equiv \log(\frac{k^*_t}{k})$, $\widehat{c}^*_t \equiv \log(\frac{c^*_t}{c})$,and $\widehat{n}^*_t \equiv \log(\frac{n^*_t}{n})$ denote the latter's optimal choices of capital holdings, consumption, and labor supply as percent deviations from the economy's steady state values k, c, and n, we have

$$\widehat{c}^*_t = a_{c0} + a_{ck^*}\ \widehat{k}^*_t + a_{ck}\ \widehat{k}_t + a_{c\phi}\ \phi_t$$

$$\widehat{n}_t^* = a_{n0} + a_{nk^*} \ \widehat{k}_t^* + a_{nk} \ \widehat{k}_t + a_{n\phi} \ \phi_t$$

The function mapping the economy state variables into the unemployment rate can thus be approximated as

$$\begin{aligned} u_t &\simeq (\widehat{n}_t^* - \widehat{n}_t) \mid_{\widehat{k}_t^* = \widehat{k}_t} \\ &= a_{n0} + (a_{nk^*} + a_{nk} \ - b_{nk}) \ \widehat{k}_t + (a_{n\phi} - b_{n\phi}) \ \phi_t \end{aligned}$$

In order to get some intuition on the mechanism underlying unemployment fluctuations in our model it is useful to combine (2.16), (4.3) and (4.4) to obtain (after taking logs):

$$u_t = \left(\frac{\sigma}{1-\sigma}\right) \ (\ \log \ \lambda_t + \widehat{c}_t - \widehat{c}_t^*) \tag{5.7}$$

Thus we see that *fluctuations* in the rate of unemployment are associated with changes over time in (a) the wage markup λ, and (b) the gap between equilibrium consumption and the optimal consumption choice of the hypothetical perfectly competitive household. On the other hand, the *steady state* unemployment rate is given by

$$u = \left(\frac{\sigma}{1-\sigma}\right) \left(\log \ \lambda(k) - a_{c0}\right)$$

Notice that the quantitative effect of (a) and (b) on both the steady state level and the size of fluctuations in the unemployment rate is positively related to the labor supply elasticity $\frac{\sigma}{1-\sigma}$.

In the absence of entry and exit, both price and wage markups are constant. Furthermore, it is possible to show analytically that $\widehat{c}_t^* = \widehat{c}_t + a_{c0}$ for all t in that case, i.e. the competitive agent's desired consumption increase after a shock hits the economy is proportional to the actual increase in consumption.[21] It follows from (5.7) that the unemployment rate will be constant over time and given by $u_t = u = \left(\frac{\sigma}{1-\sigma}\right)$ $(\log \ \lambda - a_{c0})$, all t. Such a result is presumably not a robust one, but a consequence of the homogenity properties of preferences and technology, which are required for the existence of a balanced growth path.

[21] We omit the (long) proof here in order to save space and since the basic result is illustrated by the simulations of the "constant markups" model below.

5.3. Calibration

The ultimate goal of this section is to compute and study the statistical properties of different macroeconomic aggregates implied by a number of calibrated versions of our model economy. We start by discussing the calibration of the model's parameters

We choose parameter values that make the model's steady state predictions roughly match certain features of the US economy in the postwar period. We set $\gamma = (1.01)^{0.25}$, which corresponds to the average (gross) quarterly rate of productivity growth. Given the previous value for γ,we choose $\beta = \left(\frac{1.01}{1.04}\right)^{0.25}$ thus implying a steady state gross interest rate $R = (1.04)^{0.25}$. We let $\alpha = 0.36$, which is approximately one minus the average labor income share. Even though the latter correspondence holds exactly only when the goods market is characterized by perfect competition, it is a reasonable approximation whenever the average markup is close to one, as is the case in all simulations [22]. The previous values for γ, β,and α were used in all the calibrated models that we analyzed. In addition, we choose $\sigma = 0.5$ as a benchmark setting, implying a labor supply elasticity $\frac{\sigma}{1-\sigma}$ equal to one, a value often used in the literature. We set $\rho = 0.95$,

[22]When $\mu \neq 1$ it can be shown that $\alpha = 1 - \mu\ s_n$, where s_n is the labor income share (Hall (1988)). The steady state markup in all our simulations lies between 1 and 1.2 .

a conventional setting in RBC models. Given the difficulties in measuring the technology parameter and estimating its variability we just normalize $s^2 = 1$ and report only volatility measures relative to output for a number of variables. The remaining three parameters–the elasticity of substitution ϵ, the overhead parameter υ and the labor disutility parameter–interact in a complicated way as determinants of the steady state share of overhead capital, number of firms, markup level, employment and unemployment rate. We choose $\chi = 1$, $\epsilon = 1.5$ and $\nu = 0.38$ as benchmark values, though we experiment with alternative settings. The previous choice implies steady state values of 1.06 for the price-markup, 1.18 for the wage markup, as well as a 9 % unemployment rate. The latter number corresponds approximately to the average value of our (adjusted) unemployment rate measure, which is described below.

5.4. Statistical Properties

Table 1 reports a number of basic statistical properties for some key U.S. macroeconomic aggregates in the postwar period. We use quarterly, seasonally adjusted data, covering the sample period 1960:1 - 1993:4 and drawn from the CITIBASE data bank. y, c, and i correspond to the logarithms of the standard measures of GNP, consumption and gross fixed investment in the national income accounts.

Our wage measure w is the log of average hourly earnings of production workers in the private, nonagricultural sector. Our measure of employment n corresponds to the logarithm of the number of *full-time equivalent workers*, a measure constructed by assigning part-time workers a weight of $\frac{1}{2}$. We stress the difference between full-time and part-time workers, since we want to include a share of the latter (namely, those who would rather work full-time) in our adjusted unemployment measure. The quantitative significance of "part-time unemployment" is illustrated in Figure 4, which plots the share of total employment accounted for by involuntary part-time workers, where the latter are identified with the number of workers that report to be working part time "for economic reasons"[23] The countercyclical pattern of that variable, as well as its significant long-run upward trend (similar to that of conventional unemployment rate measures), is clearly apparent in the figure.[24] Furthermore, a comparison between the average value for the previous variable (4.2 % in our sample) and that of conventional measure of unemployment, suggests that the latter significantly understates the magnitude of unemployment, by ignoring the existence of significant rationing at the

[23]Part time employment is defined in the U.S. as employment involving less than 35 hour of work per week. Part time employment *for economic reasons* is almost entirely accounted for by workers who reported "slack work" or "inability to find full time work" as the main reason for working part time.

[24]Shaded areas correspond to NBER-dated recessions.

"intensive" margin.[25]

Our full-time equivalent labor supply measure n^* was obtained as the (log) weighted sum of the number of full-time workers (F), part-time workers for economic reasons (EP), part-time workers for non economic reasons (NP), and the (fully) unemployed (U).[26] Weights are meant to approximate relative labor supplies. Thus, the first two categories are assigned a unit weight. Part time workers for non economic reasons are assigned a weight of $\frac{1}{2}$. Finally, the unemployed are given a weight $\frac{F+\ EP\ +\ 0.5\ NP}{F+\ EP+\ NP}$, which implicitly assumes that the distribution of preferences regarding part time vs. full time work among the unemployed is the same as among employed workers.We interpret the resulting measure as a *rough* empirical counterpart to the model's competitive labor supply.[27]

Our measure of unemployment u is defined, in a way consistent with our

[25]Using the data reported in Sorrentino (1993), one can derive the 1989 values of the *part time employment for economic reasons/total employment* ratio for a number of countries: U.S. (4.1%), Canada (4 %), Japan (1.6 %), Sweden (3.3 %), France (1.7 %), Germany (0.95 %), Italy (3.5 %), Netherlands (7 %), and U.K. (1.9 %). No obvious correlation between the previous variable and conventional unemployment rates seems to be present.

[26]Our measure of "involuntary" part-time workers corresponds to workers who claim to be working part-time (i.e., less than 35 hours per week) for economic reasons, mostly because of slack work and/or because they can only find part-time work. "Voluntary" part time workers are workers who claim to be working part-time for noneconomic reasons (e.g., they do not want to work full-time, too busy with housework, vacation,...).

[27]That interpretation is subject to a number of caveats, which we view as unavoidable given the limitations of the data. First, it does not account for the unemployed who drop out of the labor force because of the difficulty of finding a job ("discouraged workers"). Second, it does not reflect a possible gap between actual and desired hours worked among full-time or part-time workers which is the result in most cases from the existence of workweek indivisibilities.

theoretical model, as the difference between the (log) labor supply (n^*) and (log) employment (n). Figure 5 plots the time series for the unemployment rate thus constructed. Its average value over our sample is 9 %.

All the statistics reported in Table 1 correspond to time series detrended with the HP-filter (with the smoothing parameter set at 1600). For each time series we report the standard deviation relative to GNP, the contemporaneous correlation with GNP, and the first-order autocorrelation. Though similar statistical properties of output,consumption, investment, wages, and employment have been reported in a number of papers, our table quantifies two usually unreported business cycle facts: (a) the labor force is mildly procyclical and substantially less volatile than GNP and employment, and (b) the unemployment rate is highly countercyclical and roughly half as variable as GNP.

Table 2 reports the equilibrium statistical properties of the same macro variables implied by a perfectly competitive version of our model economy, with constant returns to scale ($\upsilon = 0$) and price/wage taking behavior by firms and workers ($\lambda_t = \mu_t = 1$,all t). That particular case of our model corresponds to the basic RBC framework[28], for which the unemployment rate is (trivially) zero in all periods. As is well known, that model is capable of matching, at least qualitatively,

[28]See, e.g., Prescott (1986) and King, Plosser, and Rebelo (1988).

most of the basic properties observed in the data. Among its familiar shortcomings (leaving aside the unemployment predictions) lie its inability to account for the large volatility of employment (relative to output) given reasonable values for the labor elasticity parameter. It is also known to generate too much wage variability, as well as too high a correlation between wages and output.

Table 3 reports similar statistics for a model with imperfectly competitive goods and labor markets, but *constant* markups (resulting from the assumption of a constant number of firms). The number of firms is adjusted so that steady state profits are zero, given the benchmark parameter settings. The latter are such that the steady state unemployment rate is 9 %, the average value for our empirical counterpart. The resulting model is similar to one of the models analyzed in Hornstein (1993), with the exception that a non competitive wage setting process (and the ensuing unemployment) is assumed here. As discussed above, under the assumption of constant markups, changes in the labor supply brought about by a technology shock are *proportional* to the implied changes in employment so that, as a result, the unemployment rate is unchanged. Thus, even though the model is capable of generating positive unemployment, it cannot account for the strongly countercyclical behavior of the unemployment rate.

Table 4 reports the statistical properties of economic aggregates generated by our "benchmark" model, with imperfect competition in both goods and labor markets, and variable markups. Again, the parameter settings are consistent with a steady state unemployment rate of 9%. We note that our benchmark model roughly matches the performance of the standard RBC model in terms of its ability to replicate the properties of output, consumption, investment, wages and employment. In addition, however, it is also capable of accounting for the presence of unemployment and, at least qualitatively, the countercyclical behavior of the unemployment rate. As in the data, the labor supply is positively correlated with output but less so than employment. The relative variability of the labor supply also seems to be in accordance with the data. The variability of employment implied by the model, though greater than the labor supply's, falls short of the variability observed in the data. Given $\sigma(n^*)$, that result implies too small fluctuations in the unemployment rate: the standard deviation of the unemployment rate in the model is only 7 % that of GNP, about ten times smaller than the (relative) variability observed in the data. The "immediate" source of that anomaly appears clear in the table: roughly speaking, changes in employment seems to track changes in the labor force too closely in the model.

Figure 6 displays the dynamic responses of a number of variables to a unit shock to technology. The response of output, consumption, investment, wages, and consumption is, qualitatively, similar to that generated by a standard RBC model with the same preference and technology parameters. The figure emphasizes, however, the key feature at work in our model: higher investment (and, hence, positive capital accumulation) leads to entry of new firms, a reduction in both the price and wage markups, and a persistent decline in the unemployment rate. The quantitative impact on the unemployment rate is small (a maximum decline of about 0.06 percentage points around the fifth year after the shock), even though the parallel increase in output is substantial (1.7 percentage points at impact). The dynamic response of unemployment essentially traces the path of the wage markup, with the latter's decline never going beyond one-tenth of a percentage point. An even smaller percent decline is obtained for the price markup, despite a sizable relative increase in the number of firms (close to 6 %). Notice that the consumption gap $\widehat{c}_t - \widehat{c}_t^*$ increases in response to a positive shock, which tends to offset (marginally) the effect of lower wage markups. In fact, since the wage markup remains unchanged at impact, the previous effect leads to a small short lived positive blip in the unemployment rate after the shock.[29]

[29]The impulse responses (as well as the computed correlations) also make it clear that countercyclical wage markups can easily coexist with procyclical real wages, since the opportunity cost of work is procyclical. Yet, we expect countercyclical wage markups to partly offset the opportunity cost effect and thus smooth the fluctuations in wages. Our simulation results suggest that such a smoothing effect is quantitatively very small.

Tables 5-7 report the results for three alternative calibrations. Each of them involves a change in a single parameter setting relative to the benchmark model. Table 5 examines the effects of an increase in the labor supply elasticity, by setting $\sigma = 0.9$. The implied labor supply elasticity is admittedly too high (9). Though that change manages to raise the variability of unemployment to a level close to that observed in the data, that calibration yields a number of counterfactual predictions. Thus, the average steady state unemployment rate goes up to 18 %, well above the observed average rate. In addition, the correlation between labor supply and output becomes (slightly) negative, whereas that correlation is positive in the data.[30] Finally, the labor supply appears to be more variable than employment, also counterfactually.

In Table 6 we report the properties of an economy with a lower elasticity of substitution between intermediate goods (we set $\epsilon = 1.1$, down from 1.5) and, as a consequence, with a greater degree of market power (for a given number of firms). Nevertheless, the steady state markup (1.07) is not significantly different from that of the benchmark model (1.06), for the lower price elasticity of *industry level* demand turns out to be largely offset by further entry within each industry.

[30]Even though a favorable technolgy shock leads to a short-term increase in the labor supply, that effect is reversed after a few quarters, and the labor supply remains persistently below its steady state level, while output is above its steady state level.

Overall, the impact of a lower ϵ on the predicted variability measures of employment, labor supply, and unemployment is very small, with none of the anomalies of the benchmark calibration being solved.

Finally, Table 7 reports the results associated with an increase of the size of the overhead component (we set $\upsilon = 1$, up from $\upsilon = 0.38$). A direct effect of that change is a reduction in the number of active firms and, as a by-product, lower competition in both the goods and labor markets, and a resulting increase in the unemployment rate well above the observed mean unemployment rate. In contrast with the high σ experiment, the higher unemployment rate is not accompanied here by a significantly greater variability in either employment or the unemployment rate, whose relative standard deviations thus remain far below their empirical counterparts.

5.5. Some Evidence on Wage Markups and Unemployment

In our calibrated models with variable markups the simulations point to a dominant role of countercyclical variations in the wage markup as a source of a countercyclical unemployment rate and an almost perfect positive correlation between those two variables. If the wage markup was observable we could assess the empirical significance of that prediction of the model. Interestingly, and given a value for σ , (3.4) allows us to recover (up to a constant) a measure of the implicit wage markup using data on wages, consumption, and hours of work. In logs,

$$\log \lambda_t = \log w_t - \log c_t - \left(\frac{1-\sigma}{\sigma}\right) \log n_t + const \tag{5.8}$$

An HP-filtered measure of $\log \lambda_t$ obtained using (5.8) with $\sigma = 0.5$ is displayed in Figure 7 together with our (HP-filtered) time series for the unemployment rate. Clearly, the positive correlation between the two time series is positive and very high. Furthermore, the variability of the two series is similar (slightly greater for the markup) in a way roughly consistent with equilibrium condition (5.7) given the $\sigma = 0.5$ setting. Though alternative interpretations are possible,[31] we view the previous evidence as encouraging for our model and, more generally, for models of unemployment dynamics driven by (time varying) wedge between the wage and the marginal rate of substitution between consumption and leisure.

6. Concluding Remarks

In this paper we have developed and analyzed a real business cycle model in which both goods and labor markets are characterized by imperfect competition. In par-

[31] Hall (1994) interprets a similar measure as a time varying exogenous preference parameter that shifts around the MRS between consumption and leisure.

ticular, the monopoly power enjoyed (and exercised) by each firm's *insiders,* and which results from exogenous hiring and firing restrictions, leads to wages being set in equilibrium above the social opportunity cost of work. That feature allows us to develop a well defined measure of unemployment which can be viewed as the dynamic counterpart to the traditional measures of the gap between labor supply and labor demand curves in static models of the labor market. Our analysis of the model's equilibrium has emphasized the role of imperfect competition and countercyclical markups in the *goods* market as an important factor underlying fluctuations in the unemployment rate. Finally, we have shown that a calibrated version of the model, despite its stylized nature, is capable of accounting for *both* a procyclical labor supply and a countercyclical unemployment rate, even though it fails to generate suffient variability in the latter variable for plausible parameter values. Our analysis of the results points to an insufficient variability in employment as the basic source of that quantitative mismatch, an observation which should guide and motivate future extensions of this work. Among those possible extensions, we could study the implications of introducing labor indivisibilities and labor contracts with lotteries (as in Hansen (1985) and Rogerson (1988)), while maintaining the current non-Walrasian structure of the labor market, with insiders colluding in setting wages and employment probabilities.[32] Other possible extensions of our basic model could involve the introduction of additional sources of fluctuations (shocks to government spending, sunspots) as well as departures from the current monopoly union plus right to manage setup that could allow for wage bargaining between workers and firms and/or efficient contracts.

[32]The introduction of indivisibilities in the standard RBC framework is known to lead to a substantial increases in the volatility of employment, without the need to assume implausibly high labor supply elasticities at the individual level.

A. Derivation of the Firm's Labor Demand Schedule

Let $w_{jt} \equiv \frac{W_{jt}}{\gamma^t}$, $x_{jt} \equiv \frac{X_{jt}}{\gamma^t}$, $\overline{x}_{-jt} \equiv \frac{\overline{X}_{-jt}}{\gamma^t}$,and $y_t \equiv \frac{Y_t}{\gamma^t}$. Combining 2.3 ,2.6, and 2.7 we have

$$x_{jt} = \alpha^{\alpha}(1-\alpha)^{-\alpha}\exp(\phi_t)\left(\frac{w_{jt}}{q_t}\right)^{\alpha} L_{jt} \tag{A.1}$$

On the other hand, 2.7 and 2.5 imply

$$\left[\frac{(m_t-1)\,\overline{x}_{-jt}+x_{jt}}{y_t}\right]^{-\frac{1}{\epsilon}}\left[1-\frac{1}{\epsilon\,\left(1+(m_t-1)\,\left(\frac{\overline{x}_{-jt}}{x_{jt}}\right)\right)}\right]\left[\frac{(1-\alpha)\,x_{jt}}{L_{jt}}\right]-w_{jt}=0$$

Replacing x_{jt} in the expression above with A.1 we obtain the (implicit) labor demand schedule of the form

$$J(w_{jt}, L_{jt}, \theta_{jt}) = 0$$

where $\theta_{jt} \equiv [\phi_t, q_t, \overline{x}_{-jt}, m_t, y_t]$.

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Table 1: U.S. Data

		$\frac{\sigma_x}{\sigma_y}$	$\rho(x,y)$	$\rho_1(x)$
y		1.62	1.00	0.85
c	0.64	0.76	0.88	0.85
i	0.15	3.47	0.90	0.89
w	0.64	0.78	0.60	0.78
n		0.75	0.87	0.91
n^*		0.23	0.44	0.76
u	9 %	0.67	-0.90	0.89

Table 2: Perfect Competition

	SS	$\frac{\sigma_x}{\sigma_y}$	$\rho(x,y)$	$\rho_1(x)$
y	3.50	1.00	1.00	0.97
c	0.72	0.74	0.91	0.99
i	0.28	1.97	0.92	0.93
w	0.64	0.85	0.98	0.98
n	0.94	0.22	0.72	0.91
n^*	0.94	0.22	0.72	0.91
u	0.00	0.00	0.00	0.00

Table 3: Constant Markups

	SS	$\frac{\sigma_x}{\sigma_y}$	$\rho(x,y)$	$\rho_1(x)$
y	3.08	1.00	1.00	0.97
c	0.69	0.79	0.92	0.99
i	0.31	1.75	0.92	0.93
w	0.60	0.87	0.98	0.98
n	0.86	0.21	0.66	0.91
n^*	0.93	0.21	0.66	0.91
u	9 %	0.00	0.00	0.00

Table 4: Benchmark Model

	SS	$\frac{\sigma_x}{\sigma_y}$	$\rho(x,y)$	$\rho_1(x)$
y	3.08	1.00	1.00	0.97
c	0.69	0.77	0.91	0.99
i	0.31	1.79	0.92	0.94
w	0.60	0.84	0.99	0.98
n	0.86	0.23	0.85	0.93
n^*	0.93	0.21	0.63	0.91
u	9 %	0.08	-0.76	0.99

Table 5: High σ model

	SS	$\frac{\sigma_x}{\sigma_y}$	$\rho(x,y)$	$\rho_1(x)$
y	2.71	1.00	1.00	0.97
c	0.69	0.74	0.90	0.99
i	0.31	1.86	0.92	0.93
w	0.60	0.69	0.94	0.99
n	0.75	0.43	0.86	0.92
n^*	0.88	0.68	-0.09	0.95
u	18.3 %	0.63	-0.69	0.99

Table 6: Low ϵ model

	SS	$\frac{\sigma_x}{\sigma_y}$	$\rho(x,y)$	$\rho_1(x)$
y	3.03	1.00	1.00	0.97
c	0.69	0.77	0.92	0.99
i	0.31	1.76	0.92	0.94
w	0.60	0.83	0.99	0.98
n	0.84	0.23	0.87	0.93
n^*	0.93	0.21	0.60	0.91
u	10.8 %	0.09	-0.76	0.99

Table 7: **High v model**

	SS	$\frac{\sigma_x}{\sigma_y}$	$\rho(x,y)$	$\rho_1(x)$
y	2.84	1.00	1.00	0.97
c	0.67	0.78	0.92	0.99
i	0.33	1.69	0.93	0.94
w	0.58	0.83	0.99	0.98
n	0.81	0.23	0.91	0.94
n^*	0.93	0.21	0.55	0.92
u	15.5 %	0.13	-0.77	0.99

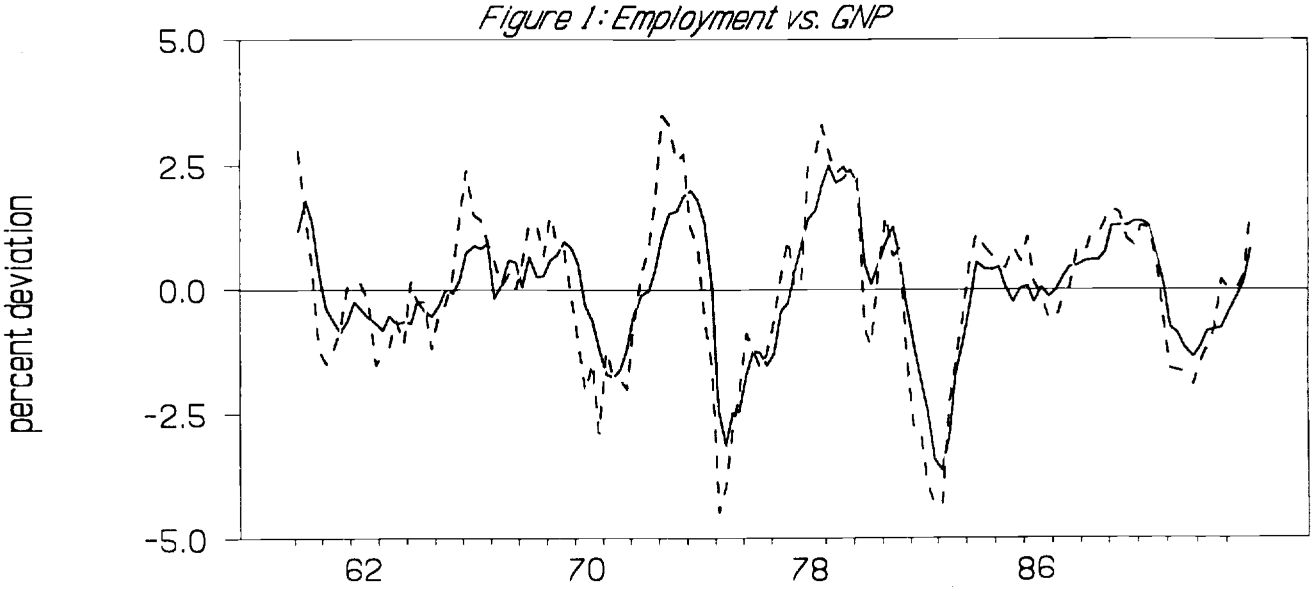
Figure 1: Employment vs. GNP
5.0
2.5
0.0
-2.5
-5.0
percent deviation
62
70
78
86

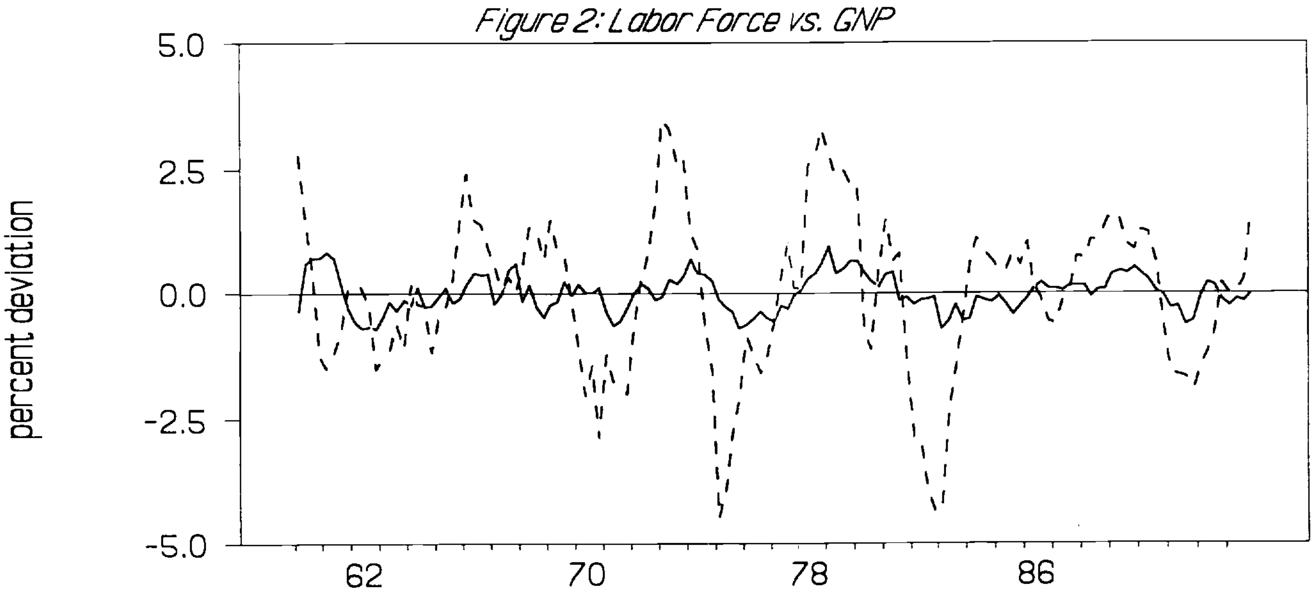
Figure 2: Labor Force vs. GNP
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2.5
0.0
-2.5
-5.0
percent deviation
62
70
78
86

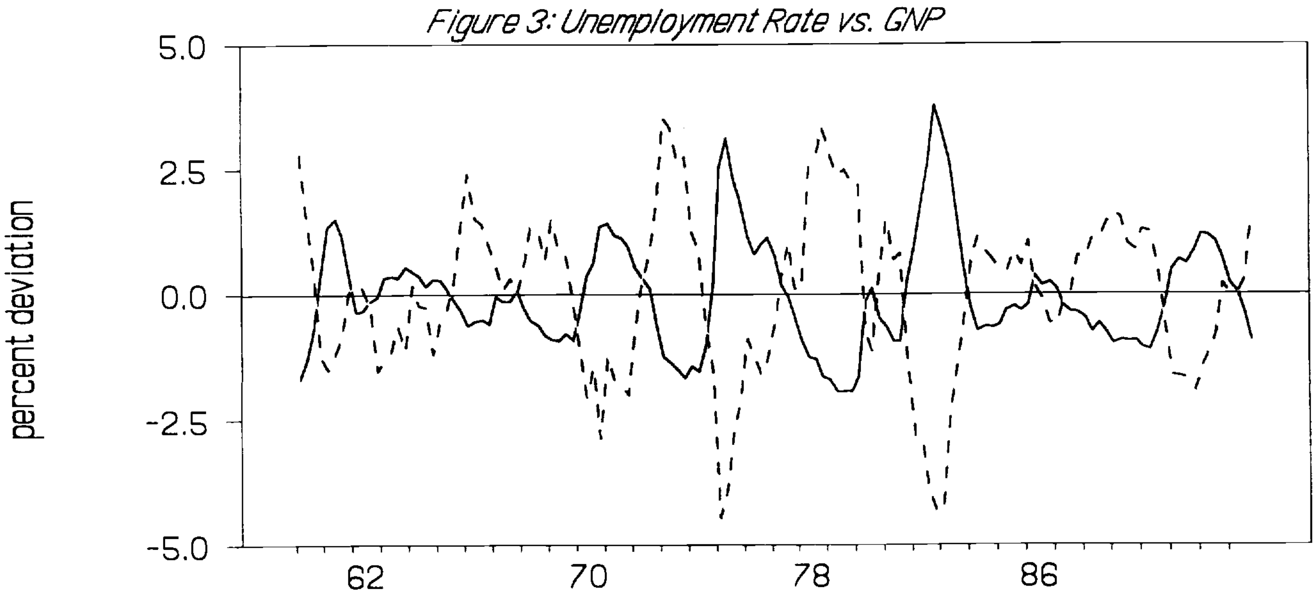
Figure 3: Unemployment Rate vs. GNP
5.0
2.5
0.0
-2.5
-5.0
percent deviation
62
70
78
86

Figure 4: Involuntary Part-Time Employment / Total Employment

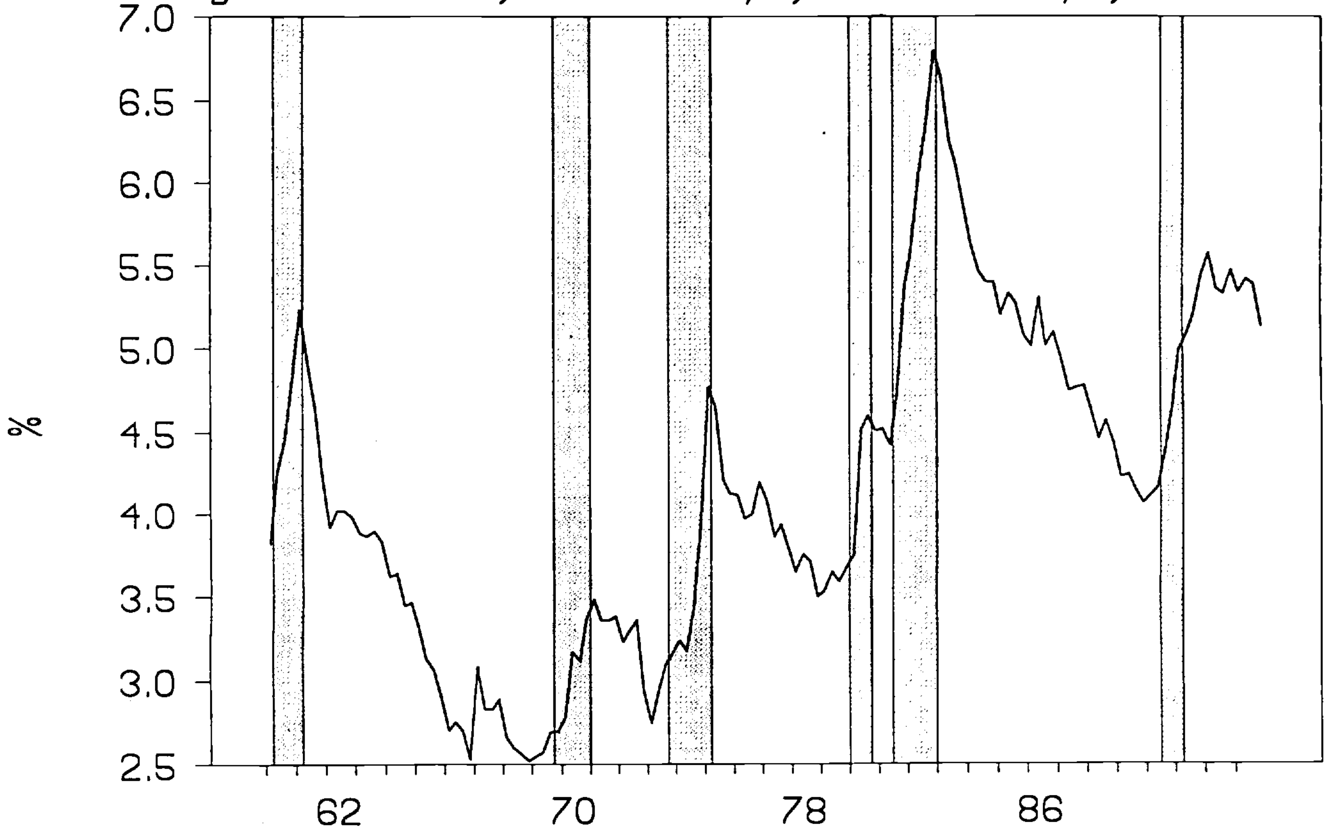

Figure 5: Adjusted Unemployment Rate

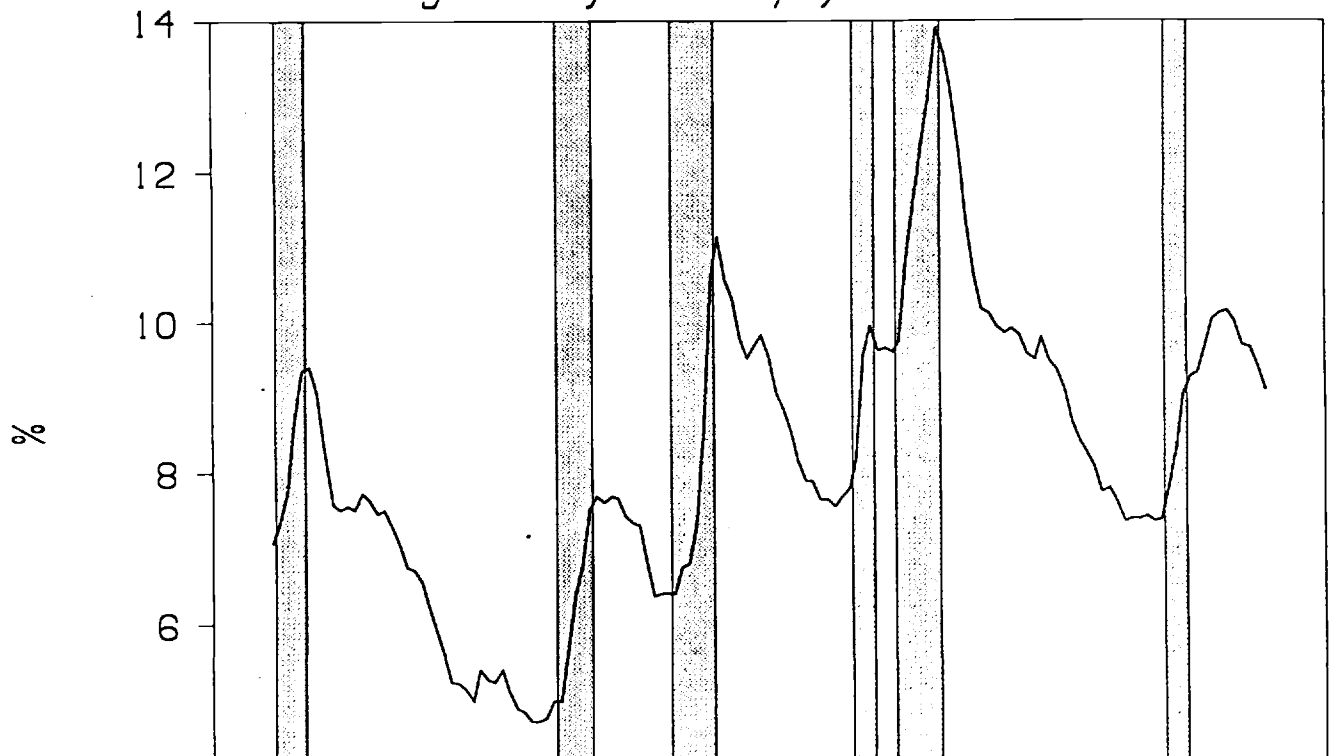

Figure 6: Impulse Responses (Benchmark)

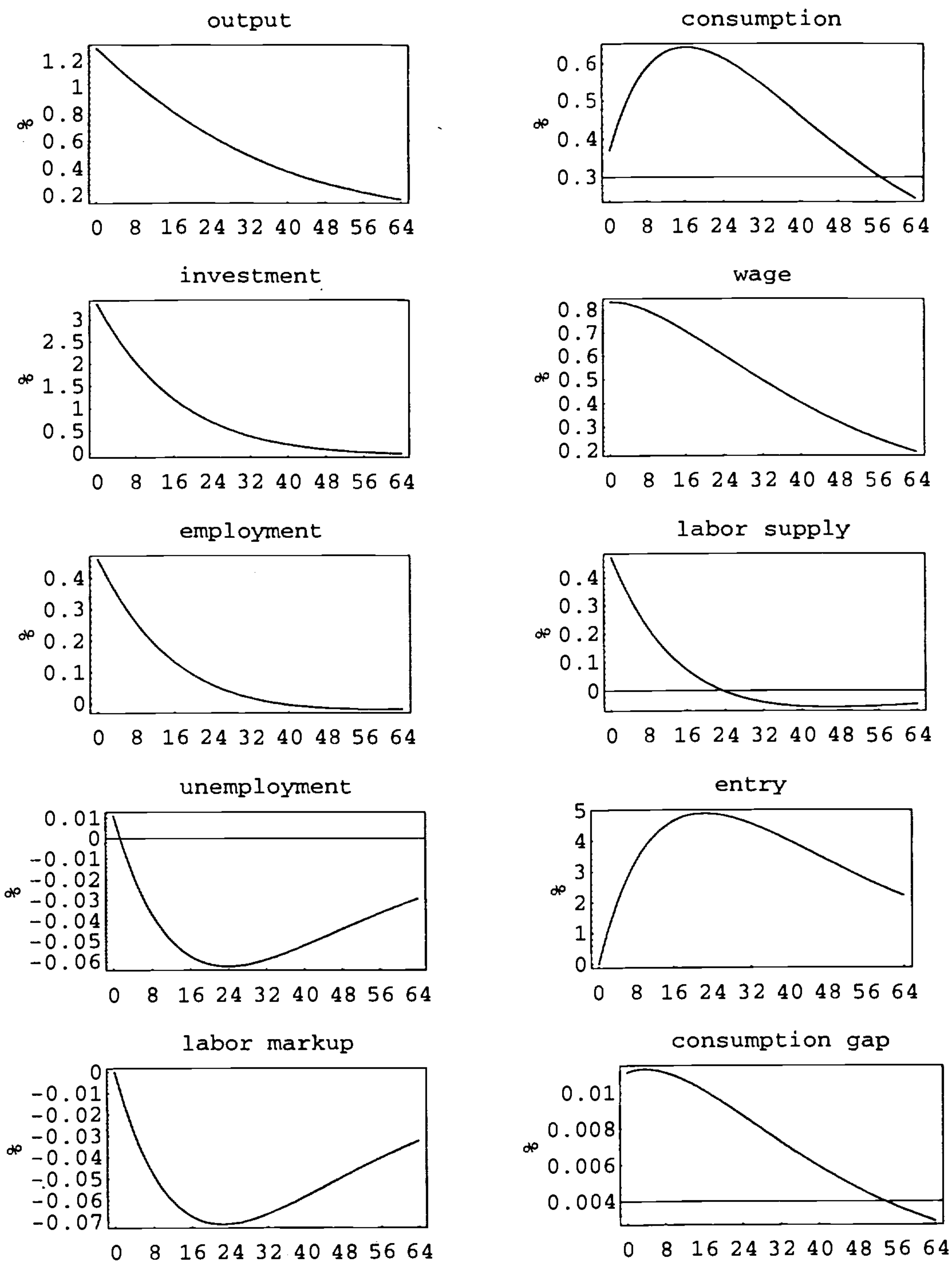

Figure 7: Unemployment and the Wage Markup