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Bargaining and equilibrium unemployment

Narrowing the gap between New Keynesian and 'disequilibrium' theories

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Wage and price formation are analyzed in a general equilibrium model combining New Keynesian features (wage bargaining and monopolistic competition) with quantity rationing due to stochastic demand and technological constraints. The alternative implications of 'efficient' and 'right-to-manage' models of bargaining are studied. The price–cost margin is less favorable to firms with efficient bargaining. A Phillips-like wage relationship obtains only in the right-to-manage case, although the interpretation of the role of unemployment is more complex than in standard models. Equilibrium unemployment results from the complementary interaction of agents' market power and of quantity constraints.

1. Introduction

Contemporary Keynesian macroeconomics has been for some time now based on the intuition that some form of noncompetitive but optimal price setting behavior must be at the root of any model trying to understand aggregate phenomena. Imperfect competition is used quite extensively in the literature, especially since the pathbreaking papers of Barro (1972), Benassy (1976), Dixit and Stiglitz (1977), and Hart (1982). The main idea is that if agents possess some degree of market power and set prices optimally at non-Walrasian levels, the economy may display some aggregate inefficiency which may not be relievable through 'competitive' mechanisms. Most of this

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literature, which for obvious reasons has been called New Keynesian, has focussed on models of price formation on the part of production firms. To formalize competition within large groups of firms, the framework of monopolistic competition in the goods market has proved most adequate [see Sneessens (1987), Blanchard ànd Kiyotaki (1987), Benassy (1990)]. It allows to integrate the notion of price setting and that of a reaction to demand pressures. Less attention seems to have been paid to the *wage formation* side, at least in a macroeconomic perspective, and to its interaction with price formation.

New Keynesian theorists have used efficiency wages, implicit contracts, insider–outsider theories, and bargaining models to analyze partial equilibrium issues [see Nickell (1990) for a survey]. A successful strand of literature has developed in the field of bargaining models which deals with labor markets in which workers are organized in trade unions [see Holmlund (1989) for a recent survey], but few results exist at the general equilibrium level. Those models which do exist have the drawback of considering prices as given to firms [as in Jacobsen and Schultz (1990)]. As a corollary, the models which analyze price formation *and* wage bargaining in a unified framework and with a view to aggregate issues are scanty. One of our purposes in the present paper is to provide a macroeconomic equilibrium model of the interdependence of price and wage fixation by combining institutional settings which seem plausible: monopolistic competition in the goods market, and firm–union bargaining in the labor market. Taking account of the interdependence implies interesting modifications with respect to existing price and wage models.

In addition, we wish to integrate into these market structures other characteristics which have received attention recently and which we believe to be relevant. They concern (1) firm-specific demand uncertainty, (2) idiosynchratic random technological shocks affecting each firm's productivity of factors, and (3) the existence of technological rigidities in the short run. These features are central to the most recent generation of so-called 'disequilibrium' models, as in Sneessens (1987), but they have up to now been used alongside *ad hoc* wage equations. Here we want to show how optimal price and wage setting behavior (from the point of view of individual agents) can be introduced in a framework with quantity constraints, or alternatively, how quantity constraints can be introduced in standard imperfect competition and bargaining models. In this sense, we hope to contribute to narrowing the gap between two strands of the macroeconomic literature.

Let us now state our main purpose in more specific terms. We want to see how the operation of an economy with price and wage setting agents is affected by firm-specific uncertainty in demand and technology, the existence of technological rigidities, and the choice of a firm–union bargaining framework. By operation of the economy, we mean essentially *price and wage* *setting rules* and *equilibrium unemployment*. There is thus a clear link between our preoccupations and those present in most Phillips curve and N.A.I.R.U.[1] models. We investigate the two classic bargaining frameworks, namely the 'efficient bargaining' model of McDonald and Solow (1981) and the 'right-to-manage' model of Nickell and Andrews (1983), for given assumptions about price formation, the structure of uncertainty, and technology.

Section 2 presents the behavioral assumptions and stresses the role of imperfect competition and firm-specific uncertainty. Section 3 derives firm-level wage and price equations in both bargaining models. In section 4, the equilibrium is computed with representative households and firms. Aggregate wage and price equations and equilibrium unemployment are derived and interpreted, and some salient properties of the macroeconomic general equilibrium model are analyzed. Section 5 summarizes the main results and concludes.

2. Behavior of agents

Households

We introduce the following assumptions.

(A1) There are three mutually exclusive types of households: wage-earners, unemployed workers, and agents living on capital income (shareholders). Let $\mathscr{E}$ be the set of wage-earners, $\mathscr{V}$ the set of unemployed workers and $\mathscr{S}$ the set of shareholders. The utility function is the same for all households, who differ only by the nature of their income. The total number of households is J. We will see in assumptions (A5) and (A6) that the determination of employment and unemployment depends on the realization of stochastic shocks faced by the firms in the productive sector. The fact that we distinguish types of households implies that we assume utility maximization to take place ex post, i.e., *after* the realization of these shocks.

(A2) The utility function U of a household j is:

$$U_j=\left(\frac{C_j}{\alpha}\right)^{\alpha}\left(\frac{M_j/P}{1-\alpha}\right)^{1-\alpha}, \qquad 0<\alpha<1, \tag{1}$$

with

[1] In this paper we are interested in wage level equations, in which the level of the (real) wage may or may not depend on the unemployment rate. We thus have a level version of the inflation-augmented Phillips curve with perfect foresight. But although we use the term 'Phillips curve,' we are in fact dealing with particular cases of a more general model formulated in terms of growth rates.

$$C_j = N^{1/(1-\varepsilon)} \left(\sum_{i=1}^{N} C_{ij}^{(\varepsilon-1)/\varepsilon} \right)^{\varepsilon/(\varepsilon-1)}, \qquad \varepsilon > 1.$$

C_j, the total consumption of household j, is a basket of N goods represented by a CES function of all goods, C_{ij}, which enter the utility function symmetrically. This implies a constant elasticity of substitution between goods, ε [see Dixit and Stiglitz (1977) and Blanchard and Kiyotaki (1987)]. M_j is the desired stock of money of household j and P is the price index. Since we allow for rationing, we will need to define various price indices depending on whether the weights are determined by 'notional' or 'true' consumption (see below). Real money balances enter the utility function directly, as is usual in static models of this type. It is a shortcut designed to take into account the utility of future consumption. We also assume that there is no utility associated with leisure in order to keep the model simple, with exogenous labour supply. This labour supply is firm-specific and is equal to the number of available workers (wage-earners plus unemployed workers). The changes implied by the introduction of a disutility of work are analyzed for a simple case in Appendix 1.

(*A3*) No household other than the shareholders has any capital income. The unemployed get no benefits. The budget constraint is thus

$$I_j = \sum_{i=1}^{N} p_i C_{ij} + M_j \tag{2}$$

with

$$I_j = M_{0j} + w_j, \quad \forall j \in \mathscr{E},$$

$$I_j = M_{0j}, \quad \forall j \in \mathscr{V},$$

$$I_j = M_{0j} + \sum_{i=1}^{N} \theta_{ij}(p_i Y_i - w_i L_i), \quad \forall j \in \mathscr{S}.$$

M_{0j} is the initial holding of money balances, which is the same for all households. The wage of worker j is w_j. $p_i Y_i - w_i L_i$ is the profit of firm i and θ_{ij} is the share of firm i in possession of shareholder j.

When expressing its demand, each household can face a quantity constraint $\bar{C}_i$ on each market i. The fact that this constraint is not indexed by j reflects an assumption of proportional rationing. The maximization problem is thus

$$\max_{C_{ij}, M_j} U_j \quad \text{subject to} \quad C_{ij} \leqq \bar{C}_i \quad \forall i.$$

When none of the $\bar{C}_i$ are binding, we obtain notional demands:

$$\begin{cases} \dfrac{M_j^*}{P^*} = (1-\alpha)\dfrac{I_j}{P^*}, \\ C_j^* = \alpha \dfrac{I^j}{P^*}, \\ C_{ij}^* = \left(\dfrac{p_i}{P^*}\right)^{-\varepsilon} \dfrac{C_j^*}{N}, \end{cases} \tag{3}$$

where

$$P^* = \sum_{i=1}^{N} \frac{C_{ij}^*}{C_j^*} p_i = \frac{1}{N}\left(\sum_{i=1}^{N} p_i^{1-\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}$$

is the 'notional' price index. Consumption is linear in wealth and a function of the good's relative price, with elasticity $-\varepsilon$. This elasticity is equal in absolute value to the elasticity of substitution between goods as given by the CES function in eq. (1).

Suppose now that the constraint is binding on some market i. Following the procedure initiated by Benassy (1975) and applied to the Dixit–Stiglitz framework by Licandro (1991), j's effective demand for good i is given by

$$\hat{C}_{ij} = \Lambda \left(\frac{P^*}{P}\right)^{1-\varepsilon} C_{ij}^*, \qquad \Lambda = \left(\frac{(1-\alpha)PC_j}{\alpha M}\right)^{-\varepsilon} \frac{PC_j}{\alpha I_j} \geqq 1, \tag{4}$$

where $\Lambda(P^*/P)^{1-\varepsilon}$ represents the spill-over effect induced by rationing (whose derivation is given in Appendix 2). The 'true' consumption of j is given by

$$C_j = \sum_{i=1}^{N} C_{ij} = \sum_{i=1}^{N} \min(\hat{C}_{ij}, \bar{C}_i)$$

and the associated 'true' price index is $P = \sum_{i=1}^{N}(C_{ij}/C_j)p_i$. Due to the symmetry property of our utility function, Λ is the same for all markets. It is larger than one because, knowing that they will be rationed, households overbid their notional magnitudes on all markets. Although this spill-over term is necessary in order to have a fully consistent equilibrium model, we can anticipate on our subsequent analysis by observing the following: Since Λ influences only aggregate demand (because it is not indexed by i) and since aggregate demand will turn out to be neutral, its presence does not have any impact on real magnitudes.

Firms

There are N identical firms. Each firm i produces a single good which is an imperfect substitute for the goods produced by its competitors. We make the following assumptions [see Sneessens (1987)]:

(*A4*) Each firm operates with the same Leontief technology. The technical coefficients are denoted A for labor and B for capital.

(*A5*) Each firm has the same fixed capital endowment KE. If it uses all this capital endowment, it produces its potential output, denoted YP_i. The use of capital is subject to a multiplicative stochastic shock ζ_i with a mean of 1. Thus

$$YP_i = \zeta_i BKE \tag{5}$$

and, in expected terms:

$$E(YP_i) = BKE.$$

(*A6*) Each firm faces the same fixed labor supply LS. If it uses all this available labor, it produces its full-employment output, denoted YS_i. The use of labor input is subject to a multiplicative stochastic shock τ_i with a mean of 1. Thus

$$YS_i = \tau_i ALS \tag{6}$$

and, in expected terms:

$$E(YS_i) = ALS.$$

The effective demand for each good i is of the Dixit–Stiglitz type and is obtained by aggregating eq. (4) over the three types of households:

$$\hat{C}_i = \left(\frac{p_i}{P}\right)^{-\varepsilon} \frac{\alpha A}{N} \left[\sum_{j \in \mathscr{E}} \frac{M_{0j} + w_j}{P} + \sum_{j \in \mathscr{V}} \frac{M_{0j}}{P} + \sum_{j \in \mathscr{S}} \frac{M_{0j} + \sum_i \theta_{ij}(p_i Y_i - w_i L_i)}{P} \right].$$

Denoting M the total initial stock of money, and Y total aggregate production, we get

$$\hat{C}_i = \left(\frac{p_i}{P}\right)^{-\varepsilon} \frac{\alpha A}{N} \left[\frac{M}{P} + Y \right].$$

(*A7*) We assume that each firm faces a stochastic demand curve, represented by a multiplicative stochastic shock δ_i with a mean of 1. We can write YD_i as the demand addressed to the firm:

$$YD_i = \delta_i \left(\frac{p_i}{P}\right)^{-\varepsilon} \frac{\alpha A}{N} \left[\frac{M}{P} + Y \right] \tag{7}$$

and, in expected terms:

$$E(YD_i)=\left(\frac{p_i}{P}\right)^{-\varepsilon}\frac{\alpha A}{N}\left[\frac{M}{P}+Y\right].$$

(A8) The stochastic shocks ζ_i, τ_i and δ_i have a joint lognormal distribution, which is assumed to be the same for all firms.
(A9) Price and wage decisions take place before the realizations of these stochastic shocks are known. Factor input decisions take place after the realizations of the stochastic shocks are known. Thus, since all firms are identical ex ante but not ex post, prices and wages will be the same for all firms, while output and employment will differ across them. Note that this sequence of decisions differs from that assumed for households in (A1). Firms optimize partly ex ante, while households optimize ex post.

Since labor supply, potential output and demand are stochastic, the firm's actual output Y_i is not known with certainty. However, we can obtain an expression for the expected output $E(Y_i)$. Using (A8), it can be shown[2] that expected output is a CES function of $E(YP_i)$, $E(YS_i)$ and $E(YD_i)$. We can then write expected output as

$$E(Y_i)=[E(YP_i)^{-\rho}+E(YS_i)^{-\rho}+E(YD_i)^{-\rho}]^{-1/\rho},\qquad \rho>0. \tag{8}$$

The parameter ρ is a function of the variance-covariance matrix of the stochastic terms affecting supply and demand constraints. In particular, when ρ goes to infinity, expected production is equal to the minimum of the three expected constraints. In this case, there is no more uncertainty and the model is reduced to the usual regime-switching model as in Benassy (1982). Eq. (8) allows us to define probabilities of the firm being constrained by demand, capital or labor [see Sneessens (1987)]:

$$\pi_{di}=\left(\frac{E(Y_i)}{E(YD_i)}\right)^{\rho},\quad \pi_{pi}=\left(\frac{E(Y_i)}{E(YP_i)}\right)^{\rho},\quad \text{and}\quad 1-\pi_{di}-\pi_{pi}=\left(\frac{E(Y_i)}{E(YS_i)}\right)^{\rho}. \tag{9}$$

Let us define L and K as the parts of LS and KE, respectively, used by the firm in production. From (A9), it follows that the firm can always determine its expected labor input as

$$E(L_i)=E(Y_i)/A. \tag{10}$$

[2]Lambert (1988) gives a proof using only two constraints. Sneessens (1983) extends the result to the three constraint case, using an additional assumption about the form of the variance-covariance matrix of the stochastic terms: He imposes the same variance for each shock and the same covariance between all shocks. For a discussion of this result, see Drèze (1987) and Sneessens (1990).

In the most general terms, the firm seeks to maximize its expected real profits subject to its technology and its stochastic labor supply, capital and demand constraints. In standard models, this maximization is carried out with respect to the price p_i to yield the usual markup pricing equation, given exogenous money wages. In our model, this is no longer the adequate way to formalize the problem. As we will see below, the way the problem is formalized depends on the bargaining framework.

Unions

In each firm, there is one trade union representing all households offering their labor services to the firm.
(*A10*) Since the indirect utility function of the households is linear in income, the utility function of the union is obtained by computing the expected income of the representative member. Using symmetry and (A9), and assuming that all workers (including unemployed) are union members, we can obtain an expected income function for the representative union member:

$$\tilde{V}_i = \frac{E(L_i)}{LS_i}\left(\frac{M_{0j}+w_j}{P}\right) + \left[1 - \frac{E(L_i)}{LS_i}\right]\frac{M_{0j}}{P}. \tag{11}$$

The presence of the expectations operator reflects assumptions (A5)–(A8) about firm-specific uncertainty. We thus suppose essentially that the union is aware of the stochastic nature of the firm's production and incorporates eqs. (8) and (10) in its calculations. The union has a utility function for real wages and employment, increasing in both arguments; as emphasized by Pencavel (1985), there are sensible reasons for supposing such a function, but we know little in general about its exact form. Here the functional form is derived directly from the characteristics of the households' utility function.

The bargaining game

We use the asymmetric Nash bargaining solution, which is familiar in the wage formation literature. It can be seen as the solution of a noncooperative, sequential bargaining process under the assumption [see Binmore, Rubinstein and Wolinsky (1986)] that both the union and the firm react very quickly to each other's proposals. We moreover introduce the following assumptions:
(*A11*) The union has a fall-back level corresponding to the utility of initial real balances:

$$\tilde{V}_i^0 = \frac{M_0}{P}.$$

This means that there are no outside incomes available to the workers: neither accumulated savings nor strike payments during the bargaining process [see Binmore, Rubinstein and Wolinsky (1986) and Sutton (1986) for extensive discussions of this implication]. The net gain of the representative union member is

$$\tilde{V}_i - \tilde{V}_i^0 = \frac{E(L_i)}{LS_i}\left(\frac{w_i}{P}\right).$$

(*A12*) The firm's fall-back profit level is zero.

The Nash product to be maximized is thus

$$\mathcal{N}_i = \left[\frac{E(Y_i)}{ALS_i}\left(\frac{w_i}{P}\right)\right]^{\beta}\left[\frac{p_i E(Y_i) - w_i E(Y_i)/A}{P}\right]^{1-\beta}. \tag{12}$$

Note that P is exogenous at the firm level. The fact that we deflate the firm's profits by P rather than by p_i can be rationalized by saying that the firm's shareholders are interested in the overall purchasing power of the dividends they earn.

The firm's real profit function and the union's utility function are both concave in w_i/P and $E(Y_i)$, ensuring a well-behaved bargaining set. The parameter β represents the union's (predetermined and exogenous) bargaining weight. In what follows we designate it succinctly by 'union power.' A central question is what $\mathcal{N}_i$ is maximized over. There are two possible models: the 'efficient bargaining' model, which uses a cooperative solution and thus leads to a Pareto-optimal outcome, and the 'right-to-manage' model, which relies on the solution of a noncooperative, sequential bargaining process. It corresponds to the usual 'battle of the mark-ups' framework. The two models yield very different results.

3. The bargaining outcomes

Efficient bargaining

In the existing literature, the efficient bargaining outcome is usually obtained by maximizing the Nash product with respect to w_i and L_i. Here, we use a somewhat different specification, which given assumption (A6) about the timing of decisions will yield equivalent results. We compute the first-order conditions for the firm's money wage w_i and the firm's price p_i. This gives us relationships which can be solved for π_{di}. Since $E(YS_i)$ and $E(YP_i)$ are exogenous, this yields $E(Y_i)$, and thus the expected labor input $E(L_i)$ from eq. (10).

The problem is to maximize (12) over p_i and w_i. Let us first look at the implied price equation. After some manipulations, the first-order condition for p_i leads to

$$p_i = \frac{\eta_{Y.p}}{\eta_{Y.p} + (1-\beta)} \frac{w_i}{A},$$

where $\eta_{Y.p}$ is the elasticity of the firm's *expected* output to the firm's price. From eqs. (5), (6) and (7), this elasticity can be computed as

$$\eta_{Y.p} = \pi_{di}\eta_{YD.p} = -\varepsilon\pi_{di} \tag{13}$$

so that the price equation is

$$p_i = \left[1 - \frac{1-\beta}{\varepsilon\pi_{di}}\right]^{-1} \frac{w_i}{A}. \tag{14}$$

The firm's price is a markup on marginal variable cost w_i/A, with the markup rate depending on union power and on the probability of a demand constraint. We see here that the introduction of capacity and labor-supply constraints allows to endogenize the mark-up rate, since it a function of the probability of a demand constraint. The second-order condition familiar to monopolistic competition models reads $\varepsilon\pi_{di} > 1-\beta$. Note that the Lerner index is not the same as in standard theory: the markup rate depends on demand conditions, but also on union power [see Arnsperger and de la Croix (1990) and Dowrick (1989)]; this leads to the following proposition:

Proposition 1. When the union and the monopolistically competitive firm bargain over wages and employment, the Lerner index is negatively affected by union power.

This can be interpreted in the following way: the efficient contract between the firm and the union contains an implicit clause about employment which forces the firm to reduce its output price in order to increase the demand for its good. The Lerner index is negatively affected by union power β: a 'powerful' union will extract some part of the pure monopoly profits, which amounts to lowering the firm's effective monopoly power. In the extreme case where $\beta = 1$, the union reaps all the surplus, since the wage share then equals one. On the other hand, if the firm has all the power ($\beta = 0$), its mark-up rate reduces to the expression $\varepsilon\pi_{di}/(\varepsilon\pi_{di} - 1)$, which is the same as the one we will use in the right-to-manage model. Thus, high union power is detrimental to the firm in terms of rent extraction.

Let us now turn to the wage equation. After some manipulations, we obtain the negotiated wage as

$$w_i = \beta A p_i. \tag{15}$$

The determination of the wage share w_i/Ap_i is guided by union power. The real product wage follows the firm's productivity.

Right-to-manage

In contrast with the efficient bargaining model, the right-to-manage outcome is obtained by maximizing the Nash product with respect to w_i, taking into account the optimal behavioral functions of the firm. In standard models with a price-taking firm, the only such behavioral function is labor demand. Here, since the firm is a monopolist on its segment of the market, it determines employment, but also the price as a function of the money wage. The employment function is given by (8) and (10).

The price equation is obtained by standard profit maximization with respect to p_i, taking the profit as it is written in the second term of the Nash product (12), and using (13):

$$p_i = \left[1 - \frac{1}{\varepsilon \pi_{di}}\right]^{-1} \frac{w_i}{A}. \tag{16}$$

This formula is subject to the second-order condition $\varepsilon\pi_{di} > 1$ which is more restrictive than in the efficient bargaining model. Eq. (16) simply says that price is a markup on marginal variable cost, with the markup depending on the firm's monopoly power.[3]

Given (16), the two parties maximize the Nash product with respect to w_i alone. This implies that the union, when formulating its wage demands, takes into account the effect on the firm's price (cost effect) and hence on demand and on employment. Thus, contrary to the efficient bargaining model, the union does not participate in the fixation of expected employment; it takes the firm's mark-up rule as given when entering the bargaining process.

The first-order condition of the Nash product for w_i leads to

$$w_i = \left[1 - (1-\beta)\frac{1-\eta_{p.w}}{1+\eta_{Y.w}}\right] A p_i,$$

where the two elasticities are self-explanatory. Using (13), the wage equation reduces to

[3]Note however that due to the structure of the model, the Lerner index depends on the probability of a constraint [see Sneessens (1987)]; without technical rigidities as defined in assumptions (A5) and (A6), we would have $\pi_{di} = 1$ and thus the standard markup result.

$$w_i = \left[1-(1-\beta)\frac{1-\eta_{p.w}}{1-\varepsilon\pi_{di}\eta_{p.w}}\right]Ap_i, \tag{17}$$

where, as shown in Appendix 3,

$$\eta_{p.w} = \left[1-\rho\left[1-\frac{\varepsilon-1}{\varepsilon\pi_{di}-1}\right]\right]^{-1}$$

is positive and below unity. We call $\eta_{p.w}$ the 'cost repercussion intensity'; it is a measure of the slope of the firm's labor demand curve, representing the extent to which wage increases may affect employment. We assume that this elasticity is small enough so that $1-\varepsilon\eta_{p.w}\pi_{di}>0$, implying a wage share between zero and one. Eq. (17) calls for the following comments.

(a) *Role of productivity*: Negotiated real wages follow average productivity.

(b) *Role of demand conditions*: Next to worker preferences, firm-level demand conditions – represented by the relative price elasticity and the probability of a demand constraint – come in as strong explanations. This reflects the fact that the union takes into account the effect of its wage demands on prices and thus on the firm's demand and its ability to employ workers. The role of the probability of a demand constraint is inferred from differentiation of (17) (see Appendix 4):

$$\operatorname{sgn}\frac{\partial(w_i/Ap_i)}{\partial\pi_{di}} = \operatorname{sgn}[(1-\beta)(\phi(1-\varepsilon\pi_{di})+\varepsilon\eta_{p.w}(\eta_{p.w}-1))], \qquad \phi>0.$$

The influence of demand constraints on the labor share is negative. This reflects an aspect of wage moderation: to counterbalance an expected demand-induced fall in employment, the union accepts a wage cut. This result will be used later on in Proposition 2.

(c) *Role of union power*: As can be seen from differentiation of (17), the influence of union power is

$$\operatorname{sgn}\frac{\partial(w_i/Ap_i)}{\partial\beta} = \operatorname{sgn}[(1-\eta_{p.w})(1-\varepsilon\eta_{p.w}\pi_{di})].$$

Since $\eta_{p.w}<1$ and $1-\varepsilon\eta_{p.w}\pi_{di}>0$, the optimal wage share is an increasing function of union power in this model. Let us now go on to the macroeconomic model.

4. The equilibrium

We now envisage the following system: There are N separate but identical unions, each bargaining with one of the N identical firms. We assume a representative firm and a representative union, the bargaining game being described as in section 1. From the property of a symmetric equilibrium, the wage and the price set in each firm are the same. This implies that the notional price index P^* is equal to the 'true' price index P and is equal to each individual price p_i.[4] As a consequence, the firm-level results of the preceding section can be used at the macroeconomic level. However, the model needs to be slightly modified to take into account the *aggregate* output relationship, which depends on aggregate demand and on aggregate capital and labor. We first sum over firms the demand function described by eq. (7), using the fact that the price is the same for all firms. Aggregate demand AD is

$$AD=\alpha\Lambda\left[\frac{M}{P}+Y\right], \tag{18}$$

where, using the fact that consumption equals output,

$$\Lambda=\left(\frac{(1-\alpha)PY}{\alpha M}\right)^{-\varepsilon}\frac{PY}{\alpha(M+PY)}.$$

$M=JM_0$ is the total exogenous money stock. Aggregate factor endowments are NLS and NKE. The resulting aggregate output relationship is non-stochastic, but because of the symmetry assumption has the same functional form as the one at the firm level [eq. (8)]:[5]

$$\begin{aligned} Y&=[YP^{-\rho}+YS^{-\rho}+YD^{-\rho}]^{-1/\rho}\\ &=[(BNKE)^{-\rho}+(ANLS)^{-\rho}+AD^{-\rho}]^{-1/\rho} \end{aligned} \tag{19}$$

and

$$\Pi_D=\left(\frac{Y}{AD}\right)^{\rho},\ \Pi_P=\left(\frac{Y}{YP}\right)^{\rho},\ \text{and } 1-\Pi_D-\Pi_P=\left(\frac{Y}{YS}\right)^{\rho}. \tag{20}$$

Aggregate output Y is a combination of aggregate demand, full-employment production and potential production. Note that $Y<AD$, $Y<YP$ and $Y<YS$ as long as ρ is finite. In this aggregate context, the magnitude of ρ measures the heterogeneity of situations across firms. The higher $1/\rho$, the more firms are either demand-, capacity- or labor supply-constrained after

[4] $P^*=P$ because although both indices sum the prices p_i with different weights (the differences flowing from the fact that there is rationing in some markets), all p_i are the same and the weights always sum to unity.

[5] Indeed, the assumption of symmetry allows to equate the (probability) distribution of regimes for a given firm and the (observed) distribution of all firms across the regimes. Thus the aggregate output relationship has the same functional form as the firm-level one, except with a non-stochastic specification.

the realizations of their idiosyncratic shocks. As $\rho \to \infty$, the aggregate distribution of firms constrained either by demand, potential output or labor supply becomes more and more one-sided, and all firms tend to be in the same situation.

Eq. (19) allows us to define in eq. (20) the *aggregate proportions of firms* facing a demand constraint or a factor constraint, in a similar way to our previous definitions of firm-level probabilities. Suppose the degree of diversity of individual situations (ρ) is given. The closer aggregate production is to aggregate demand, the more firms hit their demand constraint and the closer Π_D is to unity.

Using the definition of Π_D together with equations (18) and (19), we can rewrite aggregate demand as

$$AD = \frac{\alpha A}{1 - \alpha A \Pi_D^{1/\rho}} \left(\frac{M}{P} \right). \tag{21}$$

Note that we retrieve Blanchard and Kiyotaki's (1987) New Keynesian demand equation if $\Pi_D \to 1$ and $A \to 1$.

The efficient bargaining model

From the property of symmetry, in equilibrium prices and wages are the same in each firm. Denoting them by capital letters, we obtain the following equations:

$$P = \left[1 - \frac{1-\beta}{\varepsilon \Pi_D} \right]^{-1} \frac{W}{A}, \tag{22}$$

$$W = \beta A P. \tag{23}$$

The efficient bargaining model allows for a straightforward computation of the equilibrium proportion Π_D^*, obtained by a confrontation of (22) and (23), both of which give an expression for the aggregate wage share (W/AP).

$$\Pi_D^* = \frac{1}{\varepsilon}. \tag{24}$$

It can be shown [see Sneessens and Drèze (1986)] that the aggregate unemployment rate is a transformation of the aggregate proportion of labor-supply-constrained firms:

$$U = 1 - (1 - \Pi_D - \Pi_P)^{1/\rho}. \tag{25}$$

Clearly, Π_D is increasing in U. Eq. (24) yields the equilibrium unemployment rate in the efficient bargaining model:

$$U^* = 1 - \left[\frac{1-1/\varepsilon}{1+\left(\dfrac{ALS}{BKE}\right)^{\rho}}\right]^{1/\rho}. \tag{26}$$

Eq. (26) indicates that the equilibrium unemployment rate depends only on supply conditions – most notably the 'capital gap' $CG = 1 - BKE/ALS$, i.e. the shortage of production capacities relatively to the capacities needed to obtain full-employment – in addition to ε. The presence of the degree of heterogeneity, of the technical coefficients, and of the capital stock and labor supply is specific to our approach. They reflect the existence of heterogeneity ($\rho < \infty$) and of technological constraints. Notice that the effect on unemployment of New Keynesian parameters such as ε is more substantial the larger the value of some 'disequilibrium' parameters such as ρ. This illustrates the complementarity of these two strands of the macroeconomic literature.

The right-to-manage model

Again using the property of symmetry, from eq. (16) the aggregate price relationship is

$$P = \left[1 - \frac{1}{\varepsilon \Pi_D}\right]^{-1} \frac{W}{A}. \tag{27}$$

The wage equation is also a straightforward transposition of our above results [eq. (17)]:

$$W = \left[1 - (1-\beta)\frac{1-\eta_{P.W}}{1-\varepsilon \Pi_D \eta_{P.W}}\right] AP \tag{28}$$

$$\text{with} \quad \eta_{P.W} = \left[1 - \rho\left(1 - \frac{\varepsilon - 1}{\varepsilon \Pi_D - 1}\right)\right]^{-1}.$$

The qualitative discussion of the wage equation calls for much the same comments as those suggested for the firm model. However, an important point which cannot be adequately analyzed in a microeconomic framework is the role of unemployment in wage formation. In the efficient bargaining model, unemployment influences only the markup of prices on labor cost through relation (26) which links unemployment to Π_D. This is the standard effect of a reduction in monopoly power through a higher price elasticity of sales. Unemployment is not present in the structural wage equation, due to the assumption that the unions influence optimal price formation. For the right-to-manage model, by contrast, we get the following:

Proposition 2. In the right-to-manage model, a Phillips-type relationship arises between the real wage level and the unemployment level.

This is clear from eq. (25), which defines the link between unemployment and the proportion of sales-constrained firms and from the differentiation of the labor share with respect to Π_D presented in Appendix 4. This relation can be assimilated to an inflation-augmented Phillips curve in levels with perfect foresight. The magnitude of the unemployment effect depends on a complex expression involving union power, the relative price elasticity of demand, and the degree of firm heterogeneity. Our Phillips curve brings in unemployment as a general equilibrium reflection of demand and supply imbalances, rather than as a partial equilibrium labor market tension variable (as in more traditional interpretations).

Combining eqs. (27) and (28), we can now see that the equilibrium unemployment rate is determined in the tradition of 'battle of the markups' models [see Layard and Nickell (1987)]. To get this equilibrium rate we would first have to solve for the equilibrium value of Π_D. This is obtained by a confrontation of (27) and (28), both of which give an expression for the aggregate wage share (W/AP). The equilibrium value of Π_D^* is implicitly contained in the following equation:

$$\Pi_D^* = \frac{1}{\varepsilon(1+\beta(\eta_{PW}-1))}. \tag{29}$$

The equilibrium proportion of demand-constrained firms in the right-to-manage case depends on demand conditions, union power, worker preferences and the degree of mismatch:

$$\Pi_D^* = \Pi_D^*[\varepsilon, \beta, \rho].$$

Eq. (29) can be compared with eq. (24). In the efficient bargaining framework, Π_D^* is always smaller than in the right-to-manage case. As the unions have a say about the employment level in the efficient case, it is clear that this level will be higher, implying a smaller Π_D^*. Moreover, in eq. (24), Π_D^* is no longer a function of the degree of heterogeneity, ρ.

Unemployment also enters the price markup: Higher unemployment reflects a higher proportion of demand-constrained firms, implying lower monopoly power. Using eqs. (25) and (29), we can compute the equilibrium unemployment rate implied by the model:

$$U^* = 1 - \left[\frac{1 - \dfrac{1/\varepsilon}{1+\beta(\eta_{P.W}-1)}}{1+\left(\dfrac{ALS}{BKE}\right)^{\rho}} \right]^{1/\rho}. \tag{30}$$

The arguments of U^* include the ones already discussed for eq. (26); a new supply parameter is union power (β). Since we are in the right-to-manage case, moreover, there is also a new term involving the cost repercussion intensity $\eta_{P.W}$.

Macroeconomic analysis

Although the logic behind the two approaches to bargaining is different, the general structure of the models is the same: The confrontation of price and wage equations determines the proportion Π_D^* of firms facing a demand constraint. Using eq. (19), the price level is then determined in order to make demand compatible with the supply constraints (YP and YS) and with Π_D^*. We now analyze the general properties of our models (for convenience, the right-to-manage model will be denoted 'RTM,' and the efficient bargaining model 'EB'):

Proposition 3. Unemployment is higher in the RTM case than in the EB case. Moreover, it is an increasing function of union power in the RTM case.

The basic property of standard wage bargaining models, usually stated in partial-equilibrium frameworks, thus carries over to our general equilibrium model with price setting, in which goods market equilibrium is taken into account in the bargaining process. Since $\eta_{P.W} < 1$, it is clear that the unemployment rate defined in (30) is always larger that the one defined in (26):

$$U_{EB}^* = 1 - \left(\frac{1-1/\varepsilon}{1+(ALS/BKE)^{\rho}}\right)^{1/\rho},$$

$$U_{RTM}^* = 1 - \left[\frac{1 - \dfrac{1/\varepsilon}{1+\beta(\eta_{P.W}-1)}}{1+(ALS/BKE)^{\rho}}\right]^{1/\rho}.$$

The EB framework is more favorable for employment than the RTM one.

In addition, these equations indicate that unemployment is increasing in union power in the RTM case, while it is not affected by it in the EB case. Our conclusion could at first sight appear to be in line with one of the main results in Layard and Nickell (1990), who show that $U^*_{\mathrm{RTM}} > U^*_{\mathrm{EB}}$ when the elasticity of substitution between capital and labor is lower than one and that $U^*_{\mathrm{RTM}} = U^*_{\mathrm{EB}}$ when technology is Cobb–Douglas.[6] However, this is a pure coincidence because their result rests on an assumption on the union's fall-back utility which is very different from ours: Since their labour market is not segmented and since they think that the outside option is relevant for the fall-back level, they include both the unemployment rate and the outside wage in the union's fall-back. The fall-back thus differs across bargaining set-ups and is higher in the EB case; this implies that when Layard and Nickell move from RTM to EB, there is a negative effect on employment (not present in our model) linked with the rise in fall-back which may or may not compensate the positive effect of efficiency.

The fact that union power does not affect U^*_{EB} is due to the absence of workers' risk aversion (utilities are linear in income). If we allow for risk averse workers, unemployment is affected by union power also in the EB case, although with an indeterminate sign. The case of risk averse workers makes the model quite complex and is treated succinctly in Appendix 5.

The following proposition stresses another aspect of the difference between RTM and EB.

Proposition 4. Changes in firm heterogeneity affect unemployment in both models, but the proportions are modified only in the RTM case.

The lower the value of ρ, the more important the heterogeneity between individual firms and, ceteris paribus, the higher the unemployment rate [see eq. (25)].[7] However, a decrease in the value of ρ (which can be seen as an increase in the variance of the shocks at the firm level and as an increase in the mismatch at the economy level) changes the proportions of firms in each regime[8] only in the RTM case, as it is clear from eqs. (24) and (29):

$$(\Pi^*_D)_{EB} = \frac{1}{\varepsilon}, \quad (\Pi^*_D)_{RTM} = \frac{1}{\varepsilon(1+\beta(\eta_{P.W}-1))}.$$

In the EB case, the cooperative game has led to an agreement defining the

[6] We would retrieve their result if the cost repercussion intensity tended to unity.

[7] This is most easily understood by computing the unemployment rate for the case where YD, YP and YS are equal. The structural unemployment rate at a macroeconomic equilibrium, denoted $SURE$ [see Sneessens and Drèze (1986)], is $SURE = 1 - 3^{-1/\rho}$ and is a decreasing function of ρ.

[8] This change is important since it implies different values for the multipliers of the economy. See Lambert (1988).

labor share and the profit share as a function of β only [eq. (23)]. This agreement implies that the value of Π_D is kept constant at the level Π_D^* as defined in eq. (24). Facing a shock on ρ, each union–firm pair therefore changes its price (and wage) in order to have a new demand compatible with this fixed value of Π_D^*. This result, however, appears to be contingent on the simplicity of our specification of union utility.

In the RTM case, the degree of heterogeneity plays a role through the cost repercussion intensity: When the union and the firm make propositions about the wage level during the bargaining process, they incorporate the whole model in their calculations. As a result, the mismatch parameter intervenes because it changes the cost repercussion intensity (and therefore the cost in terms of employment of increasing the wage). This explains why the outcome of this noncooperative bargaining game, which can be represented by Π_D^*, is affected by a change in heterogeneity.

Let us now leave Proposition 4 and comment briefly on the role of demand in our model and on its implications for the spill-over term Λ. Looking at eqs. (26) and (30), we see clearly that the equilibrium unemployment rate is not a function of aggregate demand conditions. This is due to the fact that Π_D^* is determined outside the demand block by the confrontation of price and wage equations. Whatever the level of demand, the price level adjusts until this value of Π_D^* is obtained.

Concerning money neutrality, this result is similar to the one obtained by Blanchard and Kiyotaki (1987) in a model where prices *and* wages are set through monopolistic competition on both markets. In their model, as in ours, the introduction of imperfect competition does not by itself imply non-neutrality of money. We have replaced their monopolistic competition assumption in the labour market by another type of imperfect competition, bargaining, and added the possibility of technological constraints. All these features, however, impose absolutely no nominal wage and price rigidities, so that the neutrality result is not surprising.

Moreover, contrary to Blanchard and Kiyotaki (1987), we have an inelastic labour supply, implying a kind of vertical aggregate supply curve. In this case, even a rise in real aggregate demand (through e.g. a rise in the propensity to consume α) will have only inflationary effects. As a corollary, since with a CES utility function the spill-over term influences only aggregate demand, its presence does not have any impact on real magnitudes. It only influences the nominal variables P and W [see Licandro (1991)].

5. Summary and conclusions

In this paper we have constructed a general equilibrium macroeconomic model, in which we combine New Keynesian features (monopolistic competition and bargaining) with quantity rationing. Our aim has been to investigate the mutual contribution of New Keynesian and 'disequilibrium' theories in models of wage bargaining which up to now have been mainly discussed in a partial equilibrium framework or, at best, in general equilibrium with price-taking firms. The successive analysis of the efficient bargaining and of the right-to-manage approaches has allowed us to get insights into the influence of the bargaining setup on the macroeconomic equilibrium. Let us summarize the main results.

Price formation

With respect to price formation, the differences between the two models are striking. The RTM model uses, by construction, the markup equation derived by Sneessens (1987), in which the Lerner index is $1/(\varepsilon\Pi_D)$. In the EB model, union power enters the markup rate, because the union bargains also over expected employment and is thus interested in a lower price to boost expected demand. Accordingly, the effect of the union is to decrease the markup rate: The Lerner index becomes $(1-\beta)/(\varepsilon\Pi_D)$, corresponding to a lower power of rent extraction for the firm.

Wage formation: The role of unions

In the EB model, the structural-form wage share has a very simple expression. It depends only on union power. The dependence on union power is positive, which is in line with intuition. In the RTM model, the structural-form wage share depends on union power, but also on demand conditions. A crucial role is played by the elasticity of price to the wage, $\eta_{P.W}$, or what we have called the 'cost repercussion intensity,' which illustrates the importance of price-setting behavior in the RTM model.

Unemployment and wage formation

An important point this paper tries to analyze is the role of unemployment in wage formation, looking at the structural wage equations in isolation. The structure of the model implies that aggregate unemployment [see eq. (26)] is the reflection of demand and supply conditions in the aggregate (the proportions Π_D and Π_C) and of the diversity of situations at the level of individual firms (the coefficient $1/\rho$). Let us take the structure of the economy, i.e. the parameter ρ, as given. Then unemployment acts in wage formation through the proportion of demand-constrained and capacity-constrained firms. This has a straightforward empirical application: The usual Phillips curve term in wage equations, if any, may have to be replaced by a measure of the proportion Π_D.

In the EB model, unemployment influences only the markup of prices on labor cost. This is the standard effect of a reduction in monopoly power through a higher price elasticity of sales. Unemployment is not present in the structural wage equation, due to the assumption that the unions influence optimal price formation. In the RTM model, an inverse relationship arises. The magnitude of the effect depends on a complex expression involving union power, the relative price elasticity of demand, and the degree of mismatch.

The role of aggregate unemployment in our model is different from what it is in the usual Phillips curve equations. It is not a 'market pressure' variable in the same sense, because it reflects a complex configuration of market situations, rather than just pressures on an aggregate labor market. From the literature on wage bargaining, we know that the unemployment rate could play a role in other ways, too, more congenial to the standard Phillips-curve vision:

(1) Through the union's fallback utility level. We have assumed away this effect, because it is subject to some controversy in the literature on the game-theoretic foundations of bargaining models. As is clear from recent contributions [Binmore, Rubinstein and Wolinsky (1986), Sutton (1986), Fehr (1990)], a legitimate inclusion of unemployment in the fallback level is possible only under very strong assumptions about the nature and the course of the sequential bargaining process.

(2) Through the specification of the union's bargaining power parameter, β. It is unlikely, however, that unemployment has anything to do with this, since β reflects in fact relative characteristics (reaction speeds or probabilistic judgements) of the two parties during the bargaining process [Binmore, Rubinstein and Wolinsky (1986)]. Moreover, assuming β function of unemployment would imply that the union has a power on its own power, since it partly determines unemployment.

Unemployment and aggregate demand

The assumption of monopolistic competition does not lead to real effects of money in existing New Keynesian models. In our model, the additional introduction of technical rigidities and firm–union bargaining does not imply the nominal rigidities needed to bring about non-neutrality. Moreover, in the presence of an inelastic labour supply, real aggregate demand is neutral too. This implies that, since the demand spill-over term implied by the existence of quantity constraints influences only aggregate demand, its presence does not have any impact on real magnitudes. It only influences the nominal variables.

Equilibrium unemployment

In efficient bargaining, the equilibrium unemployment rate depends only on supply conditions (the capital gap and the degree of heterogeneity of firms) in addition to the degree of goods substitutability. The presence of the degree of heterogeneity, of the technical coefficients, and of the capital stock and labor supply is specific to the 'disequilibrium' approach. They reflect the existence of heterogeneity and of technological constraints. In the right-to-manage case, union power enters as an additional explanatory parameter.

In our analysis, the effect on unemployment of New Keynesian parameters such as the degree of goods substitutability is more substantial the larger the value of some 'disequilibrium' parameters such as the degree of heterogeneity. This illustrates the complementarity of these two strands of the macroeconomic literature.

Possible extensions

The model should be extended in three crucial directions. First, it would be relevant to study an open economy version, since in many countries wage settlements are closely linked with questions of competitiveness and indexation in the face of imported inflation. For a recent contribution in this field, see Rama (1990).

Second, it could be interesting to introduce asymmetric information between unions and firms in order to get sources of inefficiency other than monopoly of firms and unions. The introduction of asymmetric information might imply that, for instance, unions have little knowledge about the stochastic shocks, so that firms could extract an even higher rent than in our model.

Finally, in our model potential (capacity-determined) output is an important determinant of the equilibrium unemployment rate. We have assumed that it remains fixed. Closer attention should be paid to investment behavior and its link with wage bargaining. First approaches have been suggested by Anderson and Devereux (1988) and Van der Ploeg (1987), but using a partial equilibrium framework with a price-taking firm. Their results indicate that taking account of capital formation strongly affects the analysis because problems of long-term commitment and irreversibility are introduced. Similarly, capital–labour substitution should interact in a significant way with wage bargaining to explain unemployment.

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Appendix 1: Non-zero disutility of work in the EB case

We limit our presentation of the role of the disutility of work to the EB case because the RTM case does not lead to an explicit wage equation due to non-linearities.

In the case of non-zero disutility of work, households differ by the magnitude of their disutility of work which is infinite for the shareholders. The utility of household j is

$$U_j=\left(\frac{C_j}{\alpha}\right)^{\alpha}\left(\frac{M_j/P}{1-\alpha}\right)^{1-\alpha}-\phi_j L_{ij}, \qquad \begin{array}{l} 0<\alpha<1, \\ \phi_j=\phi\ \forall j\in\mathscr{E}\cup\mathscr{V}, \\ \phi_j=\infty\ \forall j\in\mathscr{S}. \end{array}$$

L_{ij} is the amount of work performed by household j in firm i and is assumed to be 0 or 1. It is zero for shareholders because their disutility of work is infinite. For the rest of the agents, we assume a constant disutility ϕ. Labour supply is firm-specific and is equal to the number of available workers if the real wage is above ϕ (wage-earners plus unemployed workers) and is zero otherwise.

The indirect utility net of the disutility of work of the agents is $((M_{0j}+w_j)/P)-\phi$ for wage-earners and M_{0j}/P for unemployed. The corresponding union utility is

$$\tilde{V}_i=\frac{E(L_i)}{LS_i}\left(\frac{M_{0j}+w_j}{P}-\phi\right)+\left[1-\frac{E(L_i)}{LS_i}\right]\frac{M_{0j}}{P}.$$

Implying a net utility of

$$\tilde{V}_i-\tilde{V}_i^0=\frac{E(L_i)}{LS_i}\left(\frac{w_i}{P}-\phi\right).$$

The Nash product to be maximized is thus

$$\mathscr{N}_i=\left[\frac{E(Y_i)}{ALS_i}\left(\frac{w_i}{P}-\phi\right)\right]^{\beta}\left[\frac{p_iE(Y_i)-w_iE(Y_i)/A}{P}\right]^{1-\beta}.$$

The corresponding wage equation in the EB case is

$$w_i=(1-\beta)\phi P+\beta A p_i.$$

The determination of the wage share w_i/Ap_i is thus guided by union power, by the ratio between labor disutility and labor productivity and by the ratio between aggregate price and firm's price.

Going to the aggregate level, the equilibrium proportion of demand constrained firms is

$$\Pi_D^* = \frac{1}{\varepsilon}\left[1 - \frac{\phi}{A}\right]^{-1}.$$

This yields the equilibrium unemployment rate:

$$U_{EB}^* = 1 - \left(\frac{1 - \frac{1}{\varepsilon}\left[1 - \frac{\phi}{A}\right]^{-1}}{1 + \left(\frac{ALS}{BKE}\right)^{\rho}} \right)^{1/\rho}.$$

Equilibrium unemployment is therefore positively affected by the ratio of the disutility of work to the productivity of labor.

Appendix 2: Computation of the spill-over term

The Lagrangean of the household is [see Licandro (1991)]

$$\mathcal{L}_j = \left(\frac{N^{1/(1-\varepsilon)}}{\alpha}\left(\sum_{i=1}^{N} C_{ij}^{(\varepsilon-1)/\varepsilon}\right)^{\varepsilon/(\varepsilon-1)}\right)^{\alpha}\left(\frac{M_j/P}{1-\alpha}\right)^{1-\alpha}$$
$$-\lambda\left(\sum_{i=1}^{N} p_i C_{ij} + M_j - I_j\right) - \sum_{i=1}^{N} \lambda_i (C_{ij} - \bar{C}_i),$$

whose first-order conditions are:

$$\begin{cases} C_{ij} = (\lambda p_i)^{-\varepsilon}\left(\dfrac{PC_j(1-\alpha)}{M_j\alpha}\right)^{-\varepsilon(1-\alpha)} \dfrac{C_j}{N} & \text{if } \lambda_i = 0, \\ \quad = \bar{C}_i & \text{if } \lambda_i > 0, \\ \lambda = \dfrac{1}{P}\left(\dfrac{PC_j(1-\alpha)}{M_j\alpha}\right)^{\alpha}, & \\ I_j = \displaystyle\sum_{i=1}^{N} p_i C_{ij} + M_j. & \end{cases}$$

Solving this system for C_{ij} when the constraint on market i is not binding, we obtain the effective demand $\hat{C}_{ij}$:

$$\hat{C}_{ij}=\left(\frac{(1-\alpha)PC_j}{\alpha M}\right)^{-\varepsilon}\frac{PC_j}{\alpha I_j}\left(\frac{P^*}{P}\right)^{1-\varepsilon}\left(\frac{p_i}{P^*}\right)^{-\varepsilon}\frac{\alpha I_j}{P^*N},$$

which can be rewritten

$$\hat{C}_{ij}=\Lambda\left(\frac{P^*}{P}\right)^{1-\varepsilon}C^*_{ij}$$

with

$$\Lambda=\left(\frac{(1-\alpha)PC_j}{\alpha M}\right)^{-\varepsilon}\frac{PC_j}{\alpha I_j}.$$

Appendix 3: Computation of $\eta_{p.w}$

The aim of this appendix is to derive the expression for the elasticity of the firm's price to the money wage. We discard the i subindices for notational convenience. From the markup equation (16), we get

$$\eta_{p.w}=1+\frac{\mu}{1+\mu}\eta_{\mu.w}, \quad \text{with} \quad \mu=\frac{1}{\varepsilon\pi_d-1}.$$

From the expression of the markup rate μ, we obtain $\eta_{\pi_d.w}=\rho(\eta_{Y.w}-\eta_{YD.w})$. From eq. (9), we see that $\eta_{\pi_d.w}=\rho(\eta_{Y.w}-\eta_{YD.w})$ and so $\eta_{\pi_d.w}=\rho\varepsilon(1-\pi_d)(1-\mu\eta_{\pi_d.w})$. This can be solved for the demand constraint elasticity, yielding

$$\eta_{\pi_d.w}=\frac{\rho\varepsilon(1-\pi_d)}{1+\rho\mu\varepsilon(1-\pi_d)}.$$

Putting all together, we finally arrive at

$$\eta_{p.w}=\frac{1}{1+\rho\mu\varepsilon(1-\pi_d)}=\left[1-\rho\left[1-\frac{\varepsilon-1}{\varepsilon\pi_d-1}\right]\right]^{-1}$$

from the definition of the mark-up rate. This is the equation in the text. The first of the two equalities shows that $0<\eta_{p.w}<1$ if the second-order condition is verified.

Appendix 4: Effect of π_d on the wage share in the RTM model

Here we also discard all subindices for convenience. From eq. (17) we can write the negotiated wage share as

$$\frac{w}{Ap}=\frac{\beta(1-\eta_{p.w})+(1-\varepsilon\pi_d)\eta_{p.w}}{1-\varepsilon\pi_d\eta_{p.w}}.$$

To sign the derivative with respect to π_d, we need only to find the sign of its numerator. Thus,

$$\operatorname{sgn}\frac{\partial(w/Ap)}{\partial\pi_d}=\operatorname{sgn}\left[\left((1-\beta)\frac{\partial\eta_{p.w}}{\partial\pi_d}-\varepsilon\eta_{p.w}-\varepsilon\pi_d\frac{\partial\eta_{p.w}}{\partial\pi_d}\right)(1-\varepsilon\pi_d\eta_{p.w})\right.$$
$$\left.-\left(-\varepsilon\eta_{p.w}-\varepsilon\pi_d\frac{\partial\eta_{p.w}}{\partial\pi_d}\right)(\beta(1-\eta_{p.w})+(1-\varepsilon\pi_d)\eta_{p.w})\right],$$

which, after some simplifications, becomes

$$\operatorname{sgn}\left[(1-\beta)\frac{\partial\eta_{p.w}}{\partial\pi_d}(1-\varepsilon\pi_{di})+(1-\beta)\varepsilon\eta_{p.w}(\eta_{p.w}-1)\right],$$

For notational convenience, let ϕ be the elasticity of $\eta_{p.w}$ with respect to π_d. We then get

$$\operatorname{sgn}\frac{\partial(w/pA)}{\partial\pi_d}=\operatorname{sgn}[(1-\beta)(\phi(1-\varepsilon\pi_d)+\varepsilon\eta_{p.w}(\eta_{p.w}-1))].$$

It can easily be shown that $\phi>0$, so that under the second-order condition for monopolistic competition, the sign is negative.

Appendix 5: Risk aversion in the EB model

If we allow for risk aversion for workers (and keeping capitalists risk neutral to preserve expected profit maximization) their utility function becomes

$$U_j=\frac{1}{v}C_j^{v\alpha}\left(\frac{M_j}{P}\right)^{v(1-\alpha)},$$

where the constant v measures risk aversion (more precisely, $1-v$ is relative risk aversion). In that case, the net utility function of the union is

$$\tilde{V}_i-\tilde{V}_i^0=\frac{1}{v}\frac{E(L_i)}{LS_i}\left[\left(\frac{M_0}{P}\right)^v-\left(\frac{M_0+w_i}{P}\right)^v\right].$$

Deriving the first-order condition of the Nash product for the case of efficient bargaining, we obtain the following wage equation:

$$\left\{\beta v+(1-\beta)\left[1-\left(\frac{M_0}{M_0+W}\right)^v\right]\right\}=\beta vAP+(1-\beta)\left[1-\left(\frac{M_0}{M_0+W}\right)^v\right]M_0.$$

The full model now becomes quite complex and cannot be solved analytically for the endogenous variables, since the wage equation is no longer linear. However, differentiation of the system shows that the elasticity of prices with respect to the money stock is unity. (The derivation of the elasticity of P to M involves solving a five-equation system with elasticities as unknowns. The computations are tedious and space-consuming, and are not reproduced here. They are available from the authors upon request.) The equilibrium proportion of firms in short demand becomes:

$$\Pi_D^* = \frac{1}{\varepsilon}\left(\frac{\beta v}{\Xi}+1-\beta\right) \quad \text{with} \quad \Xi = \frac{(M_0+W)^v - M_0^v}{(M_0+W)^{v-1}-W}.$$

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