The new version of the model (with consumption and other minor improvements)

(Preliminary Version, 9/16/2014)

1 The utility function and the choice of the consumption basket

The utility function, here, has two additive components: the utility of consumption, and a component related with a negative utility of effort. This second component is modeled in a way to reflect the assumption that workers are less willing to make effort if the firm gives them an unfair treatment than if the treatment is fair.[1] A third alternative, a generous treatment, is not analyzed because the rationing for it is similar and, therefore, the model would become unnecessarily more complicated. Therefore, the utility obtained by a worker *j* in period *t*, v_{jt}, is

$v_{jt} = C_{jt} - (\phi_1 + z_{jt}\phi_2)A_t e_{jt}$
with $z_{jt} = 1$ if $W_{jt} < W_{Ft}$, and 0 otherwise, ${}_te_{jt}$ is zero or one,
$\phi_1, \phi_2 > 0$, and $\phi_1 + \phi_2 < (\eta - 1)/\eta$, , (1)

where C_{jt} is the utility of consumption, defined in equations (2), ϕ_1 is a parameter associated with the negative utility of effort, ϕ_2 is a parameter reflecting the utility of retaliating an unfair wage, A_t is the productivity level of all firms in the economy, and there are two binary (zero or one) variables: z_{jt}, which is equal to one when the worker believes that the wage that he/she receives is unfair, and zero otherwise, and e_{jt}, representing a worker's effort level.[2] Regarding the inequalities, W_{jt} is the nominal wage received by *j*, W_{Ft} is the fair wage, and η is the elasticity of

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[1] The discussion about mixing retribution with a shirking model was already discussed in the

[2] Of course it is not necessary that productivity with low effort be zero—it is enough that productivity with high effort less productivity with low effort be higher than the increase in the wage necessary to induce workers not to shirk. Therefore, the zero-one effort assumption is just a normalization to simplify the model.

substitution (in the utility of consumption) between goods. Productivity multiplies ϕ_1 and ϕ_2 in a simplified way to model that leisure and the desire to reciprocate are not inferior goods.

The term $z_{jt}\phi_2 A_t e_{jt}$ translates reciprocity into a utility function framework, through the stylized fact that workers are more prone to reduce effort when the wage is unfair. Alternatively, parameter ϕ_2 could be seen as capturing not only this direct preference for reciprocating an unfair treatment, but, in addition, also a peer effect—in this latter case, the worker would pay the price (in terms of disutility) of their peers' disapprobation when his effort is e_{jt} =1 while others is zero (the wage and the reference of his peers are the same as his).

In this analysis, money does not enter in the utility function. It enters indirectly in the model through the assumption that the central bank controls the nominal aggregate demand. The reason is that the paper intends to compare the cost of reciprocity (in terms of utility) with the utility of the consumption basket bough with the real wage, not with the utility of this basket plus the utility of money.

Agents are either workers, or owners of a firm. Each firm has one agent as owner, owners are not simultaneously workers, and both workers and firm owners have the same function for their utility of consumption, C_{jt},, given by

$$C_{jt} = K^{1/(1-\eta)}(\textstyle\sum_{k=1}^{K} C_{kj}^{(\eta-1)/\eta})^{\eta/(\eta-1)}, \tag{2}$$

where K is the number of firms, each of them producing a single diferenciable good, and C_{kj}, is the quantity of the good k consumed by worker j. As mentioned above, η is the elasticity of substitution between goods.

The budget constraint of agent j is

$\sum_{k=1}^{K} P_{kt}C_{kj} = P_tY_{jt}$

$P_tY_{jt},\ = W_{jt}$ if he is an employed worker, $P_tY_{jt},\ = B_t$ if he is an unemployed worker,

and $P_tY_{jt},\ = V_{kt} - \{(N - L_t)/K\}\ B_t,$ if he is the owner of one of the firms in the economy, (3)

with Y_{jt}, being worker's j real income P_{kt} being the price of good k, W_{jt} being worker's nominal wage, and B_t being the unemployment benefit also in nominal terms, V_k
being the profit of firm k, B_t is the social benefit received by an unemployed worker, $\{(N - L_t)B_t$ is the total amount of the unemployment benefit in the economy in period t, that the government takes from the profits of the firms through a transference. Finally, variables without subscripts j or k indicate the average value in the economy, such as P_t, the general price level, given by

$$P_t = \{(1/\mathrm{K})\sum_{k=1}^{K} P_{kt}^{\;1-\eta})^{1/(1-\eta)} \qquad (4)$$

Maximizing utility with the budgetary restriction gives the demand for each good by worker j:

$$C_{kjt} = (P_{kt}/P_t)^{-\eta} Y_{jt}/K,\ 0 < \eta < 1, \qquad (5)$$

2 Firms and price setting

The production of firm k's differentiable good in period t, S_{kt}**,**$= Y_{kt}$. its demand, D_{kt}, $= Y_{kt}$., and total real aggregate demand, Y_t, are, respectively

$$S_{kt} = Y_{kt}. = A_t e_{kt} L_{kt}, = e = 0 \text{ or } 1, \qquad (6)$$

$$D_{kt} = Y_{kt}. = \sum_{j=1}^{N+K} C_{kjt} \qquad (7)$$

$$Y_t = \sum_{k=1}^{K} D_{kt} = \sum_{k=1}^{K} Y_{kt}.. \qquad (8)$$

Using (5) and (8), equation (7) becomes

$$D_{kt} = Y_{kt}.= (P_{kt}/P_t)^{-\eta} Y_t/K. \qquad (7')$$

Firm profit in nominal terms, V_{kt},, is

$$V_{kt} = D_{kt}P_{kt} - L_{kt}W_{kt} = Y_{kt}P_{kt} - (Y_{kt}/A_t)W_{kt} \qquad (9)$$

where L_{kt} is the number of workers in firm k, and W_{kt} is the nominal wage it pays.

As usual I monopolistic competition, setting prices to maximize profits (equation (9)), with the restriction of (7'), leads to a markup rule that, in this case, is given by

$$P_{kt} = \eta/(\eta - 1)(W_{kt}/A_t) = \eta/(\eta - 1)(W_t/A_t) ==> W_t = E_{t-1}[P_t]E_{t-1}[A_t](\eta - 1)/\eta \qquad (10)$$

3 From the utility function to the intertemporal value functions of being employed and unemployed

Like in DH, the representative worker considers a wage unfair when the nominal wage readjustment he receives is lower than the readjustments of others, and, here, past inflation is the primary reference for that. More specifically, the paper considers annual readjustments, and, therefore, the reference for nominal wage readjustments is the inflation rate of the past twelve moths.[3] However, the paper (again like in DH) studies the case in which retaliating an unfair wage is not advantageous if the cost of this retaliation is high (in terms of the risk of loosing expected income). Besides, coherently with the first phrase stated in this paragraph, once this situation becomes the same for all representative workers, a wage readjustment below the primary reference under an adverse conjuncture will no longer be considered unfair. Finally, the model assumes rational expectations and, therefore, workers anticipate this binary condition: inflation inertia with full employment versus disinflation with recession.

Therefore, there is an interaction between the expected cost of getting unemployed and the judgment about what is a fair wage readjustment. This interaction is modeled in a second step (in the subsequent subsections), after the definition of a utility function taking into account solely the references, not the interaction. This first step utility function is denominated v_{Rjt}, and its expected value, $E_{t-1}[\mathrm{v}_{Rjkt}]$, is given by

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[3] In another context, Cachon and Camerer (1996) denominated "loss avoidance" the case where subjects believe that others may have a tendency of avoiding strategies that result in losses.

$$E_{t-1}[\text{v}_{Rjt}] = (E_{t-1}[C_{kjt}]) - \{(\phi_1 + z_{Rt}\phi_2)E_{t-1}[A_t]e_t$$

$$z_{Rt} = 1 \text{ if } dw_{kt} < dw_{Rt}, \text{ and 0 otherwise,} \tag{11}$$

w_t is the natural log of W_t, dw_t is a first difference of w_t and dw_{Rt} corresponds to the assessment about the average fair wage readjustment in period t with a judgment made in t–1 based solely on social norms and salient information under the frame[4] of t–1. Conversely, there is a W_{Rt} reference wage.

To simplify the notation, it is useful to define β_t

$$\beta_t = (\phi_1 + z_{Rt}\phi_2), \tag{12}$$

Using the budgetary restriction, the definition of the price index, and (12), equation (11) becomes

$$E_{t-1}[\text{v}_{Rjt}] = (W_{jt}/E_{t-1}[P_t]) - \beta_t E_{t-1}[A_t]e_t\,, \tag{11'}$$

which is used in the intertemporal value function of the employed worker to derive the no-shirking condition. Using (11'), this intertemporal expected value of being employed and not shirking, $E_{t-1}[V_{Nt}]$, is

$$E_{t-1}[V_{Nt}] = (W_t/E_{t-1}[P_t]) - \beta_t\, E_{t-1}[A_t]e_t$$

$$+ (1 + r)^{-1}\{bE_{t-1}[V_{Ut+1}] + (1 - b)E_{t-1}[V_{Nt+1}])\}, \tag{13}$$

where r is the intertemporal discount rate, b is a constant exogenous exit rate (the percentage of employees that are fired regardless of their effort level), q is the additional probability of being fired when shirking in period t and V_{Ut} is the value of being unemployed. $E_{t-1}[V_{Nt}]$ is given by

[4] A frame is the way agents receive information, reflecting the information that is salient. It influences the determination of agents' references and expectations about the references of others and defines how salient those references are. See, e.g., Tversky and Kahneman (1981).

(11') plus the discounted sum of the expected values of being employed and unemployed in t+1 weighted by the probabilities of each of these states. Since the agents and fims are all symmetrical, from now onward, I simplify the notation no longer using the subscripts identifying firm and worker.

Similarly, the equation giving the intertemporal expected value of being employed and shirking, V_{St}, is

$$E_{t-1}[V_{St}] = (W_t/E_{t-1}[P_t]) + (1 + r)^{-1}\{(b + q)E_{t-1}[V_{Ut+1}]$$

$$+ (1 - (b + q))E_{t-1}[V_{St+1}])\}, \qquad (14).$$

Where q is the probability of being caught shirking.

These equations represent the assumptions that workers care about receiving a fair treatment but that they also care about the consequences of being fired if they are caught exerting a low level of effort (therefore, q is included in equation (14)). In other words, it is expected that reciprocating firms that do not respect norms with a reduction in effort have a positive effect on utility, but it is also expected that workers take into account the consequences of this preference, including the consequences on the labor market cycles.

Finally, it is necessary to define the intertemporal value of being unemployed. The utility of being unemployed is

$$v_{Ut} = v(B_{jt}) = A_t\theta, \qquad (15)$$

with B_{jt} as in equation (3), and $A_t\theta$ being the utility of leisure in working days of unemployed workers, plus the unemployment compensation measured in relation with the utility of $(W_t/E_{t-1}[P_t])$.

The job finding rate,[5] a_t, is defined by the relation

$$a_t[N - L_t] \equiv bL_t + (L_t - L_{t-1}), \tag{16}$$

where the total number of workers in the economy, N, is assumed constant and normalized to 1, and L_t is the share of employed workers.

Therefore, the expected value function of being unemployed, $E_{t-1}[V_{Ut}]$, is

$$E_{t-1}[V_{Ut}] = A_t\theta + (1 + r)^{-1}\{a_tE_{t-1}[V_{Ut+1}]$$

$$+ (1 - a_t)E_{t-1}[V_{Ut+1}])\}, \quad (17).$$

4 The no-shirking condition with references

Workers simply choose an effort level when they are employed, and firms choose the wage that induces them not to shirk, the no-shirking wage, W_N. I assume that wages set this way are always within the wage bargaining set (the set of wages that do not induce either workers or the firm to disrupt the work contract).

The expected wage that induces workers not to shirk is obtained in a way analogous to Kimball (1994) dynamic model with shirking. Equating $E_{t-1}[V^S_t]$ ad $E_{t-1}[V^N_t]$, and the equations that define them, gives:

$$E_{t-1}[V^U_{t+1}] = E_{t-1}[V^N_{t+1}] - ((1+\mathrm{r})/\mathrm{q})\beta_tE_{t-1}[A_t]. \tag{18}$$

leading to the result that β_t influences the difference between $E_{t-1}[V^N_{t+1}]$ and $E_{t-1}[V^U_{t+1}]$. Substituting (18) and (10) in (13):

$$E_{t-1}[V^N_t] = ((\eta - 1)/\eta)E_{t-1}[A_t] - \beta_tE_{t-1}[A_t]$$

$$+ b(1 + r)^{-1}\{E_{t-1}[V^N_{t+1}] - ((1 + r)/q)\beta_tE_{t-1}[A_t]\}$$

$$+ (1 - b)(1 + r)^{-1}E_{t-1}[V^N_{t+1}]$$

[5] Also called the job acquisition rate; therefore, we keep the notation a_t used by Shapiro and Stiglitz (1984).

$$= ((\eta - 1)/\eta)E_{t-1}[A_t] - (1 + b/q)\beta_t E_{t-1}[A_t] + (1 + r)^{-1}E1_{t-1}[V^N_{t+1}]. \quad (13')$$

Substituting (18) and (13') in (17):

$$E_{t-1}[V^N_t] = ((1 + r)/q)\beta_{t-1}E_{t-2}[A_{t-1}] + \theta E_{t-1}[A_t] + (1 + r)^{-1}E_{t-1}[a_t(V^N_{t+1})]$$

$$+ (1 - E_{t-1}[a_t])(1 + r)^{-1}\{E_{t-1}[V^N_{t+1}] - ((1+\mathrm{r})/q)\beta_t E_{t-1}[A_t]\}$$

$$= ((1+ r)/q)\beta_{t-1}E_{t-2}[A_{t-1}] + \theta E_{t-1}[A_t] + (1 + r)^{-1}E_{t-1}[V^N_{t+1}] - (1 - E_{t-1}[a_t])/q)\beta_t E_{t-1}[A_t]. \quad (17')$$

Equating (13') and (17'):

$$((\eta - 1)/\eta)E_{t-1}[A_t] - (1 + b/q)\beta_t E_{t-1}[A_t] + (1 + r)^{-1}E_{t-1}[V^N_{t+1}]$$

$$= ((1+ r)/q)\beta_{t-1}E_{t-2}[A_{t-1}] + \theta E_{t-1}[A_t] + (1 + r)^{-1}E_{t-1}[V^N_{t+1}] - (1 - E_{t-1}[a_t])/q)\beta_t E_{t-1}[A_t]$$

$$==> ((\eta - 1)/\eta) = \theta + (1 + b/q)\beta_t + ((1+ r)/q)\beta_{t-1}(E_{t-2}[A_{t-1}]/E_{t-1}[A_t]) - (1 - E_{t-1}[a_t])/q)\beta_t$$

$$==> ((\eta - 1)/\eta) = \theta + \{(1 + (b + E_{t-1}[a_t] - 1)/q)\beta_t + ((1+ r)/q)\beta_{t-1}(E_{t-2}[A_{t-1}]/E_{t-1}[A_t]) \quad (19)$$

Multiplying both sides of (19) by $E_{t-1}[A_t]$ and using (10):

$$\frac{W_t}{E_{t-1}[P_t]} = \frac{W_{Nt}}{E_{t-1}[P_t]} = E_{t-1}[A_t]\{\theta + \{(1 + \frac{E_{t-1}[a_t] + b - 1}{q})\beta_t + (\frac{1 + r}{q})\beta_{t-1}E_{t-2}[A_{t-1}]\}. \quad (20)$$

The term $\beta_{t-1}E_{t-2}[A_{t-1}]$ in (20) comes from the fact that, in this model, a worker who is caught shirking in period t receives the wage in this period and goes to the unemployed workers' pool only at t+1.

Notice that when $E_{t-1}[W_{Nt}] \geq W_{Rt}$ and $E_{t-2}[W_{Nt-1}] \geq W_{Rt}$ (that is, when $E_{t-1}[W_{Nt}]$ and $E_{t-1}[W_{Nt-1}]$ are both not considered unfair in the purely norm-based assessments made respectively in t–1 and t–2), $z_{Rt} = z_{Rt-1} = 0$, so the outcome is analogous to that in Shapiro and Stiglitz (1984).

Let us, then, analyze what happens when the reference is a problem. Given equation (10), $W_t / E_{t-1}[P_t]$ is always equal to $E_{t-1}[A_t](\eta - 1)/\eta$. Therefore, equation (20) implies that when β_t is higher than in steady state, $E_{t-1}[a_t]$ will be lower than its steady state level. In this case, $W_t < W_{Rt}$, but effort is $e_t = 1$ because $E_{t-1}[a_t]$ is low. This means that with a passive monetary policy, nominal wages (and prices) are high and the job finding rate is at its long-run level, while with a (fully anticipated) contractionary monetary policy, like in a (credible) disinflation, lower nominal wages (and prices) are obtained at the cost of a (fully anticipated) lower job finding rate. This implies a kind of short run Phillips curve (derived and discussed below) without errors in expectations, with the economy always in equilibrium.

5 Equilibrium at the steady state

In this model, expectations are "rational" in the sense that they are always consistent with an expected Nash equilibrium—each firm and agent action is the best response given the choices of the others. In the steady state, it also happens that (i) references are adjusted as in the long run, so they are determined fully by the fundamentals (and, thus, they don't matter), and (ii) unexpected shocks are zero. Therefore, $W_{Rt} = P_t A_t(\eta - 1)/\eta$, where P_t is determined below. So, the steady-state equilibrium equations do not bring anything new; they are used simply to study how the short-run equilibrium equations of the model deviate from them.

Rearranging equation (19), it is possible to obtain the job finding rate at the steady-state rate a_{ss}:

$$a_{ss} = \left\{\left(\frac{\eta - 1}{\eta} - \theta\right)\frac{q}{\gamma} - (q + b)\right\} - \{(1 + r)/(1 + g) - 1\}, \tag{21}$$

where g is the steady-state productivity growth rate.

The rate of unemployment at the steady state u_{nat} is

$$u_{nat} = \frac{b}{b + a_{ss}} = \frac{b}{b + (q/\gamma)((\eta - 1)/\eta - \theta) - \{(1 + r)/(1 + g) - 1\}}. \tag{22}$$

The "natural" real output in period t, Y_{natt}, and L_{nat}, the employment level compatible with the natural unemployment rate (u_{nat},), are

$Y_{natt} = A_t L_{nat} = A_t(1 - b/(b + a_{ss})) =$

$$= A_t[1 - b/[b + (q/\gamma)((\eta - 1)/\eta - \theta) - \{(1 + r)/(1 + g) - 1\}]. \quad (23)$$

Finally, the general price level is determined by assuming that the central bank controls nominal aggregate demand, denominated M_t

$$P_t Y_t = M_t, \quad (24)$$

which implies that

$$P_{natt} = \frac{M_t}{A_t/(1 - b/(b + a_{ss}))}$$

$$= \frac{M_t}{A_t}[1 - b/[b + (q/\gamma)((\eta - 1)/\eta - \theta) - \{(1 + r)/(1 + g) - 1\}]. \quad (25)$$

6 Short-run equilibrium and the Phillips curve with references

This subsection discusses what happens in times when the economy can be in or out of the steady state and compares the model's Phillips curve with the Phillips curve proposed in DH and with the Friedman–Phelps Phillips curve, as in Phelps (1968). The contrast with the NKPC will be clear in the comparison of the simulations with the results obtained in the literature.

In this model, judgments of fairness (with this condition anticipated in $t - 1$) that allow $W_{Rt} > E_{t-1}[P_{nat\,t}]E_{t-1}[A_t](\eta - 1)/\eta$ (implying $z_{Rt} = 1$ and, therefore, a β higher than its steady-state value) bring the economy out of the steady state. Formally

$$z_{Rt} = 1 \text{ if } W_{Rt} > E_{t-1}[P_{nat\,t}]E_{t-1}[A_t](\eta - 1)/\eta, \quad (26)$$

that is

$z_{Rt} = 1,$

if $W_{Rt} > E_{t-1}[M_t]((\eta - 1)/\eta)[1 - b/[b + (q/\gamma)((\eta - 1)/\eta - \theta) - \{(1 + r)/(1 + g) - 1\}]$. (24′)

This implies that

$$z_{Rt} - z_{Rt-1} = 1 \text{ if } dw_{Rt} > E_{t-1}[dm_t], \tag{27}$$

with $dw_{Rt} = \log(W_{Rt}) - \log(W_{t-1})$ and $dm_t = \log(M_t) - \log(M_{t-1})$. This implies that, if z_{Rt} is zero initially, it becomes 1 only if $dw_{Rt} > E_{t-1}[dm_t]$ (if the fair wage readjustment is higher than what would be given by fundaments).

Rearranging equation (19), it is possible to obtain the expected job finding rate

$$E_{t-1}[a_t] = \left(\frac{\eta - 1}{\eta} - \theta\right) \frac{q}{\beta_t} - (q + b)\} - \{(1 + r)\frac{E_{t-2}[A_{t-1}]\beta_{t-1}}{E_{t-1}[A_t]\beta_t} - 1\}, \tag{28}$$

and the difference between it and its steady-state value

$$E_{t-1}[a_t] - a_{ss} = \{\frac{\eta - 1}{\eta}\left(\frac{q}{\beta_t} - \frac{q}{\gamma}\right)\} - \{(1 + r)\frac{E_{t-2}[A_{t-1}]\beta_{t-1}}{E_{t-1}[A_t]\beta_t} - \frac{(1 + r)}{(1 + g)}\}, \tag{29}$$

where the origin of the negative effect of β_{t-1} was commented on immediately after equation (20) was introduced.

Since $\beta_t = (\phi_1 + z_{Rt}\,\phi_2)$, and $z_{Rt} = \{1 \text{ if } dw_{kt} < dw_{Rt}, \text{ and } 0 \text{ otherwise}\}$, equation (28) implies that the expected job finding rate, $E_{t-1}[a_t]$, is a function of $(dw_t - dw_{Rt})$ and of $(dw_{t-1} - dw_{Rt-1})/(dw_t - dw_{Rt})$:

$$E_{t-1}[a_t] = g(dw_t - dw_{Rt}, \{(dw_t - dw_{Rt})/(dw_{t-1} - dw_{Rt-1})\}), \tag{30}$$

with $\partial g/\partial(dw_t - dw_{Rt}) > 0$, $\partial g/\partial\{(dw_t - dw_{Rt})/(dw_{t-1} - dw_{Rt-1})\} < 0$.

The function (30), simply expresses that equation (28) is a the variant of the Phillips curve, as summarily proposed immediately after equation (20) was presented. It is a relation between $(dw_t - dw_{Rt})$ (the actual nominal wage readjustment less the norm-based readjustment), implicit in β_t, and $E_{t-1}[a_t]$, the expected job finding rate.

Let us first compare this result with DH, followed by a comparison with the Friedman–Phelps Phillips curve. The DH model shows a range of unemployment rates with the same inflation rate (a flat portion of a Phillips curve). Similarly, in the model presented here, there is a range of job finding rates with the same inflation rate, and equation (28) implies that the central bank has to keep the job finding rate below this range to obtain a disinflation. The range is given by the set of job finding rates between a_{ss} and the $E_{t-1}[a_t]$ when β_t is above its long-run level. Looking at the definition of β_t in equation (12), $\beta_t = \phi_1$ in steady state (ϕ_1 = the disutility of effort when the wage is fair)), while the level of $E_{t-1}[a_t]$ at the other extreme of the range is obtained with $\beta_t = \phi_1 + \phi_2$ (the expected disutility of effort when the wage is unfair). Therefore, the "Philips curve" developed here is close to the one in DH, with the main difference being that, here, the job finding rate replaces the unemployment rate.

The differences between this modified Phillips curve and the Friedman–Phelps Phillips curve are i) $dw_t - dw_{Rt}$ replaces the difference between wage readjustments and expected inflation, ii) (again) the job finding rate replaces the unemployment rate (because it represents more appropriately the opportunity cost of losing a job), and iii) the tradeoff conceded by the Friedman–Phelps Phillips curve is associated with out-of-equilibrium situations, while here there is a tradeoff even with the economy in equilibrium, although not in steady state.

The fact that the model can generate a kind of Phillips curve tradeoff with the economy always in equilibrium constitutes an advance in the theory, because the notion that the economy operates in a out-of-equilibrium condition along the Phillips curve, while the Phillips curve prevails in reality, is often considered a puzzle.[6]

[6] See, e.g., the discussion in Mankiw (2001).

7. The complete set of equations defining the short run equilibrium and the monetary policy overshooting in disinflation

The exogenous variables of the system are simply the implicitly or explicitly targeted inflation rate and the exogenous shocks (in this work, they are represented only by the aggregate productivity shock). Given the targeted inflation rate, equation (10) (the markup rule equation) implies that there is an implicitly targeted nominal wage readjustment. With it, $E_{t-1}[a_t]$ is obtained with equation (28). With it, the values of $E_{t-1}[L_t]$, $E_{t-1}[Y_t]$, $E_{t-1}[P_t]$ and W_t are

$$E_{t-1}[L_t] = (E_{t-1}[a_t]N + L_{t-1})/(1 + \mathrm{b} + E_{t-1}[a_t]), \tag{31}$$

$$E_{t-1}[Y_t] = E_{t-1}[A_t]E_{t-1}[L_t],\ E_{t-1}[L_t] \text{ given by (25)}, \tag{32}$$

$$E_{t-1}[P_t] = E_{t-1}[M_t]/E_{t-1}[Y_t],\ E_{t-1}[Y_t] \text{ given by (26)}, \tag{33}$$

$$\begin{aligned} W_t &= (E_{t-1}[A_t](\eta - 1)/\eta)\, E_{t-1}[P_t] = (E_{t-1}[A_t](\eta - 1)/\eta)\{E_{t-1}[M_t]/(E_{t-1}[A_t]E_{t-1}[L_t])\} \\ &= ((\eta - 1)/\eta)E_{t-1}[M_t]/E_{t-1}[L_t] \\ &= ((\eta - 1)/\eta)E_{t-1}[M_t]/E_{t-1}[((\{q((\eta - 1)/\eta)/\beta_t - (q + b)\} \\ &\quad - \{(1 + r)(\beta_{t-1}/\beta_t) - 1\})\mathrm{N} + L_{t-1})/(1 + \mathrm{b} + \{q((\eta - 1)/\eta)/\beta_t - (q + b)\} \\ &\quad - \{(1 + r)(\beta_{t-1}/\beta_t) - 1\})]. \end{aligned} \tag{34}$$

This implies that

$$dw_t = log(E_{t-1}[M_t]) - log(E_{t-2}[M_{t-1}])\} - \{log(E_{t-1}[L_t]) - log(E_{t-2}[L_{t-1}])\}, \tag{34′}$$

or

$$dw_t + \{log(E_{t-1}[L_t]) - log(E_{t-2}[L_{t-1}])\}= log(E_{t-1}[M_t]) - log(E_{t-2}[M_{t-1}])\}. \tag{34″}$$

Although (34″) is just an equilibrium equation, there is also an important insight behind it. In the model, causality runs from β_t to the other variables, and when β_t increases from its steady-state level to a condition in which the targeted dw_t is lower than dw_{Rt}, the job finding rate decreases, so $\{log(E_{t-1}[L_t]) - log(E_{t-2}[L_{t-1}])\}$ becomes negative. This implies that, in this case, $log(E_{t-1}[M_t]) - log(E_{t-2}[M_{t-1}])\}$ must be lower than dw_t, which is equivalent to saying that the central bank must target a nominal aggregate demand increase lower than the nominal wage increase it desires, generating a recession (real output growing less than productivity, with the size of the labor force constant in the model). Without this recession, dw_t would be equal to dw_{Rt}. Accordingly, at the periods when β_t returns to its long-run level, there is a recovery (once more induced by the monetary policy) with $L_t - L_{t-1} > 0$ and, therefore, output growth above productivity growth. This is shown in Figures 1 and 2, discussed in the next section.

Finally, the actual values of P_t, Y_t and L_t are easy to compute. With W_t and A_t, P_t is obtained directly with equation (10) (the markup equation). Using (10) in (24),

$$Y_t = \frac{M_t}{P_t} = \frac{A_t M_t}{(\eta/(\eta-1))W_t}, \qquad (35)$$

and, aggregating equation (6), L_t is Y_t divided by A_t, implying

$$L_t = \frac{Y_t}{A_t} = \frac{M_t}{(\eta/(\eta-1))W_t}. \qquad (36)$$

8 Staggered wage readjustments

The introduction of staggering in wage readjustments in the model is made in the simplest possible way, with more complex specifications being left for future related work. I first assume that each firm readjusts the wages of all its employees in the same period, although the timing of the readjustments of the firms in the economy is distributed uniformly. For yearly contracts and quarterly series, the average wage paid in period t is

$$W_t = (\Sigma_{\mathrm{r}=0}{}^{3} X_{t-\mathrm{r}})/4, \tag{37}$$

X_t being the wage contracts set in $t-1$ to prevail from t to $t+3$.

Define $dx_t \equiv log(X_t) - log(X_{t-4})$ and $\beta_{\underline{x}t}$ as the β taken into account by the respective firms when X_t is set. $\beta_{\underline{x}t}$ is then given by an equation analogous to (12), but referring to expected reciprocity in each of the periods in which the readjustment set in $t-1$ prevails. We examine two cases: when the old reference has the same strength in the four periods (equation 38), and the case where employees with wage readjustments awarded in $t-1$ consider this readjustment fair from $t+1$ up to the end of the implicit contract regardless of the unemployment rate as long as it was shared with all other employees with concomitant readjustments (equation (39)). Any other case lies between these two. The simulations in this paper use the second one, which is the simpler. Meanwhile, the assumption that workers are willing to pay the price of reciprocity during the minimum amount of time (one quarter) is, at least in this sense, the weakest assumption to deal with staggering.

Equation (12), in the first and in the second case becomes, then, respectively

$$\beta_{\underline{x}t+s} = \phi_1 + E_{t-1}[z_{Rt+s}]E_{t-1}[\phi_{2t+s}],\ 0 \leq \mathrm{s} \leq 3, \tag{38}$$

$$\beta_{\underline{x}t} = \phi_1 + E_{t-1}[z_{Rt}]E_{t-1}[\phi_{2t}], \text{ and } \beta^{-}_{\underline{x}t+s} = \phi_1,\ 1 \leq \mathrm{s} \leq 3, \tag{39}$$

within each of these cases, the job finding rate is given by

$$E_{t-1}[a_{t+\mathrm{s}}] = \left\{\left(\frac{\eta - 1}{\eta} - \theta\right) \frac{q}{\beta_{\underline{x}t+s}} - (q+b)\right\} - \left\{(1+r)\frac{E_{t-2}[A_{t-1}]\beta_{\underline{x}t+\mathrm{s}}}{E_{t-1}[A_t]\,\beta_{\underline{x}t+s}} - 1\right\}, \quad 0 \leq \mathrm{s} \leq 3 \tag{40}$$

$$E_{t-1}[a_t] = \left\{\left(\frac{\eta - 1}{\eta} - \theta\right) \frac{q}{\beta_{\underline{x}t}} - (q+b)\right\} - \left\{(1+r)\frac{E_{t-2}[A_{t-1}]\beta^{x}{}_{t-1}}{E_{t-1}[A_t]\beta_{\underline{x}t}} - 1\right\}. \tag{41}$$

And the equation analogous to (34′) is

$$dw_t \equiv log(W_t) - log(W_{t-1}) = dx_t/4 \equiv (log(X_t) - log(X_{t-4}))/4$$

$$=\{log(E_{\mathrm{t}-1}[M_t]) - log(E_{t-2}[M_{t-1}])\} - \{log(E_{t-1}[L_t]) - log(E_{t-2}[L_{t-1}])\}. \quad (42)$$