Unemployment and the open economy wage-price spiral.*

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Abstract

We present a dynamic model of real wages in the open economy that encapsulates the well known "competing claims model" or "incomplete competition model" of real wage determination. In general, the model determines the development of inflation, real wages and the real exchange rate for any given rate of unemployment. Inflation, rather than unemployment is the "conflict solver" in the unrestricted model. However, a supply side determined equilibrium rate of unemployment is subsumed as a special case. A re-appraisal of the empirical literature shows that there is little evidence in support of the "natural rate" restrictions.

Keywords: inflation, real-wages, natural-rate,nominal rigidities, real wage resistance.

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1 Introduction

Unlike the Phillips curve framework that anchored macro economics in the 1970's, modern models of unemployment and real wages recognize the importance of imperfect competition and incomplete information on both product and labour markets, see Layard and Nickell (1986), Layard et al. (1991), Layard et al. (1994), Lindbeck (1993) and Andersen (1994). Although the new standard model is incontestably linked to Layard and Nickell and their coauthors, we prefer to use the more neutral term Imperfect Competition Model—ICM hereafter—following e.g., the acclaimed textbook presentation in Carlin and Soskice (1990).

The ICM literature has been dominated by models that are static in nature: The equilibrium level of real wages is determined simultaneously with the equilibrium unemployment rate, assuming a constant level of inflation. The lack of explicit dynamics in existing models is surprising, since most authors refer to the wage-price spiral—a truly dynamic phenomenon—as a motivation for the ICM wage and price setting equations, see e.g. (Layard et al., 1994, Chapter 3). As a supplement to the existing literature, this paper sets out an open economy ICM that is genuinely *dynamic* in nature. This enables us to determine nominal wage and price adjustments, inflation and the implied real wage in a consistent manner.

In order to derive a dynamic ICM, we only need a few simple building blocks. The first step is to re-interpret the static wage and price equations of the ICM as long-run relationships that are not necessarily achieved by agents in each calendar period. The second step is to combine these long-run equations with error-correction equations. The resulting model is a system of difference equations that can be solved for the real wage, the real exchange rate and the rates of wage and price inflation. The model can be interpreted as an extension of Haavelmo's conflict model of inflation, see Qvigstad (1975), or models of the wage-price spiral, cf. Blanchard (1987), thus elucidating the close relation between the ICM and the earlier literature on inflation and wage-price dynamics.

A key property of the model is that the rate of inflation itself reconciles conflicting real wage claims, so that an equilibrium results at a constant rate of inflation and at any *given* rate of unemployment. Hence, the model brings out that inflation has a double role in the wage-price spiral. On the one hand, the change in inflation is a short-run disequilibrium phenomenon. This aspect is focused by the standard ICM, see (Layard et al., 1994, p. 17). However, in the dynamic ICM, inflation also has an equilibrating function, namely in reconciling competing claims. Conversely, in the static ICM, the only effective equilibrating mechanism is the rate of unemployment (and the real exchange rate in the open economy version), whereas in the dynamic model, also the rate of inflation acts as an arbiter.

Perhaps the most noteworthy implication of modelling the dynamics explicitly, is that the equilibrium rate of unemployment is undetermined under more general assumptions than the standard ICM will have us believe. For example, dynamic homogeneity and a so-called "no wedge" restriction are shown to be necessary but not sufficient conditions for the existence of a supply side determined equilibrium unemployment rate. However, we do encompass the static ICM as a special case, and we identify the parameter restrictions that are necessary and sufficient for a unique equilibrium rate of unemployment in an open economy.

The rest of the paper is organized as follows: Section 2 sets out the model and derive two different solutions: One stable and one unstable. In the unstable solution, the real exchange rate is a unit root process even though the rate of inflation and real wages remain stable process. Whether the system in characterized by the stability or not, is shown to hinge on the presence or otherwise of real wage resistance in the form a wedge term in wage formation. Section 3 addresses a number of issues of interpretation and discusses some important special cases, including the ICM version of the natural rate hypothesis. Section 4 briefly mentions how a simple extension of the model allows us to derive an equilibrium (though not invariant) rate of unemployment under more general assumptions. Section 5 re-appraises the existing evidence conveyed by econometric wage equations, in order to evaluate the empirical relevance of the notion of a supply side determined equilibrium rate of unemployment. Section 6 concludes the paper.

2 A dynamic wage-price system

To concentrate on the main issues, we keep the analytical framework simple. Throughout we use the presentation in Carlin and Soskice (1990) as our reference to the standard ICM. We use lower case Latin letters to denote logarithms of the raw variables. Hence, for example, the producer real wage $w_{q,t}$ is defined as

$$w_{q,t} = w_t - q_t = \log(W_t/Q_t), \tag{1}$$

where w_t is the nominal wage and q_t is the producer price of domestic products. A simple model of workers' real wage claim $w_{q,t}^w$ is given by

$$w_{q,t}^w \;=\; m_w + \omega(p_t - q_t) - \varpi\, u_t, \qquad 0 \leq \omega \leq 1,\ \varpi \geq 0. \tag{2}$$

which captures that workers' real wage claims might be adjusted upward if unemployment (u_t) falls, or if consumer prices p_t increase relative to producer prices q_t. The term $(p_t - q_t)$ is frequently referred to as the wedge. A related concept is real wage resistance, which describes the situation when a deterioration in workers' costs of living leads to an increase in firms' labour costs, i.e. the case with $\omega > 0$.

In equation (2), we abstract from tax-rates and all other exogenous real variables that might affect real wage ambitions. The conspicuous absence of expectation variables in (2) anticipates that (by construction) $w_{q,t}^w$ will appear with a lag in the system determining wages and prices. Below, expectations are considered for the contemporaneous variables in that system.

Firms' real wage plan $w^f_{q,t}$ is also tied to the level of economic activity. For simplicity, we follow e.g. (Layard et al., 1994, p. 19), and assume that movements in the mark-up on labour costs are proxied by the rate of unemployment

$$(3) \qquad w^f_{q,t} = m_q + \vartheta u_t. \quad \vartheta \geq 0.$$

Since we are looking at an open economy, it might be reasonable that the mark-up also depends on the level of competitiveness, as in e.g. (Layard et al., 1991, p. 385) and (Carlin and Soskice, 1990, p. 255). However, the inclusion of a separate competitiveness term in (3) will complicate the notation without altering the general behaviour of the system. The reason is that in the present model, real wages become dependent on competitiveness via the wedge term in the wage claim equation and the definitional equation for consumer prices. However, we note below the particular instances where the exact formulation in (3) is important for the results.

Although equations (2) and (3) have been introduced as claim-equations, they have other interpretations as well. For example, (2) is consistent with the broad implications of theories of wage bargaining, see e.g. Nickell and Andrews (1983), Hoel and Nymoen (1988): If w^*_t denotes the predicted bargained nominal wage level, we can define the real wage plan as $w^w_{q,t} = w^*_t - q_t$. Similarly, if q^*_t is the price level following from pricing under monopolistic competition, assuming e.g. constant demand elasticities, then $w^f_{q,t}$ in (3) can be defined as $w^f_{q,t} = w_t - q^*_t$. For reference, we note that (2) corresponds to the concept of the "bargained real wage equation" in the textbook presentation by Carlin and Soskice (1990).[1] On the firm side, $w^f_{q,t}$ is similar to Carlin and Soskice's concept of the "price determined real wage".[2]

In the standard ICM, the model is solved by equating the two static equations (2) and (3) for the bargained real wage (w^w_q) and the price determined real wage (w^f_q), i.e. $w^w_q = w^f_q$. In the case with real wage resistance, $\omega > 0$, the static system determines a real exchange rate that equates the two real wage claims for any given level of unemployment, as in (Carlin and Soskice, 1990, Chapter 11.2), (Layard et al., 1991, Chapter 8.5) and Wright (1992). In general therefore, a trade balance constraint is needed to pin down a unique "sustainable equilibrium rate". However, in the absence of real wage resistance, $\omega = 0$, the static model determines a unique equilibrium rate of unemployment that reconciles the conflicting real wage aims captured by (2) and (3), see (Layard et al., 1991, pp. 390-91). Below, we show that in the dynamic ICM, the "no wedge" condition, $\omega = 0$, is no longer sufficient to ensure

[1] See (Carlin and Soskice, 1990, pp. 139 and 254). In Carlin and Soskice's notation: $w^B = W/P^e = b(U)$, where w^B is the bargained real wage, W is the nominal wage and P^e is the expected domestic price level.

[2] i.e. w^P in their notation, see (Carlin and Soskice, 1990, pp 143 and 255).

a supply-side determined equilibrium unemployment rate. Further restrictions on the dynamics are required.

The primary motivation for considering dynamic formulations of the ICM, is the observation that the model consisting of (2), (3) and an equilibrium condition $w_q^w = w_q^f$, abstracts from short-run nominal rigidities in wage and price setting that are well documented empirically and theoretically, see e.g. Andersen (1994). Below, we show that nominal rigidities imply dynamic effects that turn out to be essential, as endogenous inflation mitigates the conflict between firms and workers. The role of inflation as an arbiter of conflicting claims was brought out in Haavelmo's conflict model of inflation (see Qvigstad (1975)), which serves as a reminder of the fact that additional equilibrating mechanisms may be at work alongside unemployment.

The natural way to incorporate nominal rigidities in the ICM is to assume that workers' real wage aim feed into nominal wage growth, as captured by

$$\begin{aligned}\Delta w_t &= \theta_w(w_{q,t-1}^w - w_{q,t-1}) + \psi_{wp}\Delta p_t^e + \psi_{wq}\Delta q_t^e - \varphi u_{t-1} + c_w, \\ &\quad 0 \le \psi_{wp} + \psi_{wq} \le 1, \quad \varphi \ge 0, \quad \theta_w \ge 0.\end{aligned} \tag{4}$$

In this equation, nominal wage growth depends on last period's deviation from the planned real wage level, on the expected inflation rates Δp_t^e and Δq_t^e and on labour-market pressure captured by u_{t-1}. Equivalently, using $w_{q,t-1}^w = w_{t-1}^* - q_{t-1}$, (4) can be rewritten with wage-inflation reacting to last period's deviation from the desired nominal wage level w_t^*.

Price formation is modelled along the same lines:

$$\begin{aligned}\Delta q_t &= -\theta_q(w_{q,t-1}^f - w_{q,t-1}) + \psi_q\Delta w_t^e - \varsigma u_{t-1} + c_q, \\ &\quad 0 \le \psi_q \le 1, \quad 0 \le \theta_q, \quad \varsigma \ge 0.\end{aligned} \tag{5}$$

The use of the dynamic adjustment equations of the type (4) and (5) goes back to conflict models of inflation, e.g. Sargan (1964), Sargan (1980) and Qvigstad (1975). They reappear in modern theories of the wage-price spiral, see Blanchard (1987).

Equations (2) and (4) yield

$$\begin{aligned}\Delta w_t &= (c_w + \theta_w m_w) + \psi_{wp}\Delta p_t^e + \psi_{wq}\Delta q_t^e - \mu_w u_{t-1} \\ &\quad +\theta_w\omega(p_{t-1} - q_{t-1}) - \theta_w w_{q,t-1},\end{aligned} \tag{6}$$

where we choose to define μ_w as

$$\mu_w = \theta_w\varpi \text{ or } \mu_w = \varphi, \tag{7}$$

since either ϖ or φ (but not both) would be identifiable in an econometric version of (6). In equation (6), long-run price homogeneity is ensured in the form of the two lagged level-terms $(p_{t-1} - q_{t-1})$—the wedge—and the real wage $w_{q,t-1} = w_{t-1} - q_{t-1}$. Initially, there is no presumption about short-run price homogeneity, (since

$\psi_{wp} + \psi_{wq} \leq 1$), although we will consider the implications of dynamic homogeneity ($\psi_{wp} + \psi_{wq} = 1$) in due course.

For product prices, equations (3) and (5) yield a dynamic equation of the cost mark-up type which is commonplace in empirical models.

$$\Delta q_t = (c_q - \theta_q m_q) + \psi_q \Delta w_t^e - \mu_q u_{t-1} + \theta_q w_{q,t-1}, \tag{8}$$

where

$$\mu_q = \theta_q \vartheta \text{ or } \mu_q = \varsigma. \tag{9}$$

Finally, we make use of the fact that in an open economy the consumer price depends on the price q_t of domestic products, with weight ϕ, and import price b_t, with weight $(1 - \phi)$:

$$p_t = \phi q_t + (1 - \phi) b_t, \quad 0 < \phi < 1. \tag{10}$$

The import price b_t is in domestic currency. We treat it as exogenous here, as implied by a fixed exchange-rate regime. Equation (10) implies that expected inflation in (6) behaves according to

$$\Delta p_t^e = \phi \Delta q_t^e + (1 - \phi) \Delta b_t^e. \tag{11}$$

We solve the above wage-price system for the case of $\Delta w_t^e = \Delta w_t$, $\Delta q_t^e = \Delta q_t$ and $\Delta b_t^e = \Delta b_t$, This corresponds to a usual technique in applied work, namely of invoking rational expectations, replacing expectations with realized values and estimating each equation by an instrumental variables or maximum likelihood method. The properties of the (stable) solution presented below are robust for most types of backward looking expectations, but the dynamics will be more involved (i.e. the reduced form difference equations will be of second order or higher, with more than two potentially unstable roots).

The reduced form equation for the product real wage $w_{q,t}$ is

$$\begin{aligned} w_{q,t} &= \delta + \xi \Delta b_t + \kappa w_{q,t-1} + \lambda b_{q,t-1} - \eta u_{t-1}, \\ & \quad 0 \leq \xi \leq 1, \quad 0 \leq \kappa \leq 1, \quad 0 \leq \lambda, \end{aligned} \tag{12}$$

which is seen to include a variable $b_{q,t}$ defined by

$$b_{q,t} = b_t - q_t, \tag{13}$$

i.e. price competitiveness or the real-exchange rate. The reduced form coefficients in (12) amalgamate the parameters of the structural equations

$$\begin{aligned} \delta &= \left[(c_w + \theta_w m_w)(1 - \psi_q) - (c_q - \theta_q m_q)(1 - \psi_{wq} - \psi_{wp}\phi) \right] / \chi, \\ \xi &= \psi_{wp}(1 - \psi_q)(1 - \phi)/\chi, \\ \lambda &= \theta_w \omega (1 - \psi_q)(1 - \phi)/\chi, \\ \kappa &= 1 - \left[\theta_w (1 - \psi_q) + \theta_q (1 - \psi_{wq} - \psi_{wp}\phi) \right] / \chi, \\ \eta &= [\mu_w (1 - \psi_q) - \mu_q (1 - \psi_{wq} - \psi_{wp}\phi)]/\chi, \end{aligned} \tag{14}$$

where the denominator is given by

$$\chi = (1 - \psi_q(\psi_{wq} + \psi_{wp}\phi)). \tag{15}$$

Note that η, the coefficient of unemployment in the real wage equation (12), is unsigned in general, reflecting that unemployment potentially affects both wage and price adjustments alike. However, if the wage side reacts sufficiently quick relative to price setters, as captured by $\mu_w(1-\psi_q) > \mu_q(1-\psi_{wq}-\psi_{wp}\phi)$, then $\eta > 0$, implying a negative relationship between the level of unemployment and real wages.[3]

The corresponding reduced form equation for competitiveness $b_{q,t}$ can be written as

$$\begin{aligned} b_{q,t} &= -d + e\Delta b_t - kw_{q,t-1} + lb_{q,t-1} + nu_{t-1}, \\ & \quad 0 \le e \le 1, \quad l \le 1, \quad 0 \le n, \end{aligned} \tag{16}$$

where the parameters are given by

$$\begin{aligned} d &= (c_q - \theta_q m_q) + (c_w + \theta_w m_w)\psi_q/\chi, \\ e &= 1 - \left[\psi_q \psi_{wp}(1-\phi)/\chi\right], \\ l &= 1 - \left[\psi_q \theta_w \omega(1-\phi)/\chi\right], \\ k &= (\theta_q - \psi_q \theta_w)/\chi, \\ n &= (\mu_w \psi_q + \mu_q)/\chi. \end{aligned} \tag{17}$$

Equations (12) and (16) constitute a system of first-order difference equations that determines the real wage $w_{q,t}$ and the real exchange rate $b_{q,t}$ at each point in time. Once we have obtained the solutions for $w_{q,t}$ and $b_{q,t}$, the time paths for Δw_t, Δp_t and Δq_t can be found by backward substitution. The benefits of working with dynamic equations become obvious at this stage, as we obtain a consistent model of the real wage level *and* of inflation. The conventional static ICM yields a theory of the real wage level only, but says little about how inflation is determined in real time.

To investigate the long-run or steady-state behaviour of the system, assume that import price growth is constant, $\Delta b_t = \Delta b$, and that the level of unemployment is fixed, $u_t = u$. The roots of the system are

$$r = \frac{1}{2}\left[(\kappa + l) \pm \sqrt{(\kappa - l)^2 - 4k\lambda}\right], \tag{18}$$

hence the system has a unit-root whenever $k\lambda = 0$ *and* either $\kappa = 1$ or $l = 1$.

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[3]Note also that a non negative κ, as implied by $0 \le \kappa \le 1$, requieres that the two adjustment coeffients θ_w and θ_q are suitably restricted.

2.1 The stable solution

From (14) and (17) we conclude that the wage-price subsystem is stable *unless* one or more of the following conditions hold:

$$\theta_w \omega = 0, \tag{19}$$

$$\theta_w = \theta_q = 0, \tag{20}$$

$$\psi_q(1-\psi_q) = \theta_q = 0. \tag{21}$$

Note that $\theta_q > 0$ eliminates two out of three unstable cases. $\theta_q > 0$ says that prices are reacting to deviations from the price mark-up rule. This is realistic in the light of the available evidence: Empirical price equations are usually not cast in differences alone, but display equilibrium-correction with respect to an underlying long-run relationship. Given $\theta_q > 0$, the system is stable in the sense that $b_{q,t} \to b_q$ *and* $w_{q,t} \to w_q$ if $\theta_w \omega > 0$. For stability of the *system*, there must be error-correction in the nominal wage equation (4) *and* long-run wage ambitions must be influenced by consumer prices as well as product prices $\omega > 0$, i.e. there is real wage resistance in the form of a wedge term in the long-run wage equation.

Assuming that the stability conditions are satisfied, the long-run steady-state solution for the product real wage w_q and for price-competitiveness b_q can be written as

$$w_q = -\delta^0 + \xi^0 \Delta b + \eta^0 u, \tag{22}$$

$$b_q = -d^0 + e^0 \Delta b + n^0 u, \tag{23}$$

where the coefficients are given by

$$\begin{aligned}
\delta^0 &= (c_q - \theta_q m_q)/\theta_q, \\
\xi^0 &= (1-\psi_q)/\theta_q, \\
\eta^0 &= \mu_q/\theta_q, \\
d^0 &= \left[\theta_q(c_w + \theta_w m_w) + \theta_w(c_q - \theta_q m_q)\right]/\theta_w\theta_q\omega(1-\phi), \\
e^0 &= [\theta_q(1-\psi_{wq}-\psi_{wp}) + \theta_w(1-\psi_q)]/\theta_w\theta_q\omega(1-\phi), \\
n^0 &= (\theta_q\mu_w + \theta_w\mu_q)/\theta_w\theta_q\omega(1-\phi).
\end{aligned} \tag{24}$$

Finally, the steady-state inflation rate is found by noting that from (22) and (23) we have $\Delta b_q = \Delta b - \Delta q = 0$ and $\Delta w_q = \Delta w - \Delta q = 0$. Hence, $\Delta q = \Delta w = \Delta b$, and from (10) we obtain the standard open economy result that $\Delta p = \Delta b$ in this stable equilibrium.

Unless any of the restrictions captured by (19)–(21) apply, there is a unique steady-state solution for real wages, the real exchange rate and inflation. We obtain a dynamic equilibrium—the "tug of war" between workers and firms reaches a stalemate with constant real wages and competitiveness.

Note that in this equilibrium $w_q^w \neq w_q^f$. Hence, the "equal shares" condition $w_q^w = w_q^f$, that is invoked to derive the equilibrium in the standard ICM, is in general *not* implied by the dynamic ICM considered here.[4] Also note that the equilibrium real wage w_q is uniquely determined from the dynamic price equation (8), as shown by the three first rows in (24). Hence, although (12) shows that outside equilibrium, the development of real wage depends on the adjustment of both wages and prices, only price setting matters in the eventual steady state.[5] However, the three bottom rows in (24) show that the equilibrium real exchange rate becomes a weighted average of the two conflicting real wage claim.

The stalemate in the "tug of war" between workers and firms occurs at a given rate of unemployment and under quite general conditions, e.g. the equilibrium is consistent with dynamic homogeneity on the side of workers ($\psi_{wp} + \psi_{wq} = 1$) and firms ($\psi_q = 1$), see section 3.1 below. In sum, our model shows that the main insight of Haavelmo's conflict model of inflation, see e.g. Qvigstad (1975), namely that the rate of inflation itself is a generic equilibrating mechanism of conflicting claims, carries over to the open economy case.

In the standard ICM, the arbiter of conflicting claims is the rate of unemployment. This view is *not* contradicted by our model. Instead, the model brings out that even conditional on the rate of unemployment, the wage-price spiral is stable under quite wide assumptions. Hence, the rate of unemployment does not *have* to adjust in order to bring about a reconciliation of conflicting claims. However, in section 3.2 below we show that the result of the static ICM—that an equilibrium rate of unemployment reconciles competing real wage claims—can be derived as a special case of the above model, see section 3.2 below. Not surprisingly, the restrictions needed for that result entails a kind of homogeneity that makes it impossible for inflation to serve as an separate equilibrating mechanism.

Returning to the solution (22)-(24), note that the long run relationship between real wages and the rate of unemployment is given by $\eta^0 = \mu_q/\theta_q \geq 0$. Hence, in the (partial) steady-state equilibrium there is a non-negative relationship between unemployment and real wages.[6] The long run elasticity η^0 can be compared with the short run elasticity $-\eta$ of equation (12), which is negative under the reasonable assumption that $\mu_w(1 - \psi_q) > \mu_q(1 - \psi_{wq} - \psi_{wp}\phi)$, cf. (14). Hence, although the

[4] Hence, according to (Carlin and Soskice, 1990, p. 257): "Constant inflation requires that $w^B = w^P$,..." (corresponding to $w_q^f = w_q^w$ in our notation). Likewise, (Layard et al., 1991, p. 19): "In the long run, unemployment will have to be higher in order to reduce both sets of claims until they are equal with each other".

[5] The result for equilibium real wages reflects that there is no competitiveness term in the price equation (3).

[6] There is however a downward sloping curve for *consumer* real-wages as shown in Bårdsen et al. (1998), a different aspect of Nickell's (1988) point about the importance of which price to use in the wage equation.

model displays the conventional negative relationship between unemployment and real wages in the short-run ($-\eta < 0$), the degree of long-run real wage response implied by the steady state solution is either positive or zero ($\eta^0 \geq 0$), depending on unemployment putting downward pressure on prices or not, cf. equation (8) above.

The predicted *dynamic* real wage response is therefore of the type associated with *wage-hysteresis*, see Nickell (1987): The short-run wage depressing effect will be stronger than the long-run effect. This is interesting since we have not introduced any separate hysteresis-mechanism, such as unemployment composition effects (short-term and long-term unemployment, open unemployment and programmes), or insider-forces, see Lindbeck (1993). Instead the fading away of the initial negative effect of unemployment on real-wages is a generic system property: If, hypothetically, the rate of unemployment rises to a new level, real wages first fall, but the real exchange rate depreciates ($b_{q,t}$ rises) and this tends to increase real wage ambitions through the wedge term $p - q$. In equilibrium, the direct negative effect on real wages from unemployment and the subsidiary positive effect working through the wedge effect cancel out, allowing the price side to dominate.

2.2 An important unstable solution: The "no wedge" case

Real wage resistance is an inherent aspect of the stable solution, as $\theta_w \omega \neq 0$ is one of the conditions for the stability of the price-wage system, see equation (19) above. However, the existence or otherwise of wedge effects remains unsettled, both theoretically and empirically, see (Layard et al., 1991, Chapter 4.7), and it is of interest to investigate the behaviour of the system in the absence of real wage resistance, i.e. $\theta_w \omega = 0$ due to $\omega = 0$.

Inspection of (12) and (16) shows that in this case, the system partitions into a stable real wage equation

$$w_{q,t} = \delta + \xi \Delta b_t + \kappa w_{q,t-1} - \eta u_{t-1} \quad (25)$$

and an unstable equation for competitiveness

$$\Delta b_{q,t} = -d + e \Delta b_t - k w_{q,t-1} + n u_{t-1}. \quad (26)$$

Hence, if e.g. unemployment is strongly exogenous, the real wage follows a stationary autoregressive process whereas the real-exchange rate is non-stationary.[7]

The interpretation of this result is that without a wedge effect in wage formation, the inflation mechanism alone is unable to stabilize both real wages and the real-exchange rate—further equilibrating mechanisms are needed, for example

[7] Of course, if, there is a long run effect of competitivenss on prices, i.e. (3) is extended by a competitiveness term, $\omega = 0$ is not sufficient to produce an unstable solution.

adjustments of the nominal exchange rate or possibly adjustments of unemployment. That being said, we note that (25) does define a stable steady-state real wage equation:

$$w_q = \frac{\delta}{(1-\kappa)} + \frac{\xi}{(1-\kappa)}\Delta b - \frac{\eta}{(1-\kappa)}u. \tag{27}$$

Unlike the real wage given by (22) above, the long run real wage in (27) contains parameters from both sides of the bargain, not only price setting. Also note that unlike the stable case, the sign of $\partial w_q/\partial u$ can go either way. A negative signed elasticity, i.e. $\eta > 0$, requires that $\mu_w(1-\psi_q) > \mu_q(1-\psi_{wq}-\psi_{wp}\phi)$, as discussed in connection with (14) above.

The long run rate of inflation is in this case obtained by substituting the solution for the real wage (27) back into the two error-correction equations (6), imposing $\omega = 0$, and (8), and then using the definition of consumer prices (10). The resulting steady-state rate of inflation can be showed to depend on the unemployment rate and on import price growth, i.e. $\Delta p \neq \Delta b$ in the equilibrium associated with the "no wedge" case ($\omega = 0$). Instead, the long-run Phillips-curve is downward-sloping provided that $\eta > 0$. In other aspects as well, the system properties are very different from the wedge-case ($\omega > 0$) in the previous subsection. For example, from (27), the long-run responsiveness of real wages to unemployment is given by $\eta/(1-\kappa)$. This is larger than the short-run sensitivity η, provided that $\kappa > 0$. Hence the predicted real wage response is non-hysteretic in the "no wedge" case. However, in the real exchange is fundamentally hysteretic, being a unit-root process.

Finally we note that, unlike the static ICM, the "no wedge" restriction ($\omega = 0$) *in itself* does not imply a supply side determined equilibrium rate of unemployment.[8] The restrictions that are sufficient for the model to imply a purely supply side determined equilibrium rate of unemployment is considered in section 3.2 below.

3 Special cases

In section 2 we saw that the no-wedge condition had important implications for the behaviour of the system, i.e. for the long run solution and for the response to shifts. In this section we consider other special cases of the model. We first review how the solution of the system is affected by imposing dynamic homogeneity. We then move on to show two ways of restricting the system in order to obtain a supply side determined "natural rate of unemployment", namely *i*) a Phillips-curve natural rate and *ii*) an ICM natural rate.

[8] See e.g. (Layard et al., 1991, p. 391).

3.1 Dynamic homogeneity

Dynamic inhomogeneity is eliminated from the model by imposing $\psi_q = 1$ in price formation and $\psi_{wq} + \psi_{wp} = 1$ in the wage equation. The system is stable under these restrictions, cf. (19)–(21). The coefficients (14) of the reduced form equation for $w_{q,t}$ simplify to

$$\begin{aligned} \delta &= -(c_q - \theta_q m_q), \\ \xi &= 0, \\ \lambda &= 0, \\ \kappa &= 1 - \theta_q, \\ \eta &= -\mu_q, \end{aligned} \tag{28}$$

while the coefficients (17) of the reduced form equation (16) for b_q become

$$\begin{aligned} d &= \left[(c_q - \theta_q m_q) + (c_w + \theta_w m_w)\right] / \psi_{wp}(1-\phi), \\ e &= 0, \\ l &= 1 - \theta_w \omega / \psi_{wp}, \\ k &= (\theta_q - \theta_w)/(\psi_{wp}(1-\phi)), \\ n &= (\mu_w + \mu_q)/(\psi_{wp}(1-\phi)). \end{aligned} \tag{29}$$

Since $\lambda = 0$ in (28), there is no effect of the real-exchange rate in the reduced form equation for real wages, hence the solution for real wages can be obtained from equation (12) alone. Note also how all coefficients of the real wage equation (12) depend only on parameters from price-setting, whereas the competitiveness equation (16) still amalgamate parameters from both sides of the wage bargain, see the coefficients in (29).

The steady state is given by (22) and (23) as before. The expressions for η^0 and n^0 are unchanged, but $\xi^0 = e^0 = 0$ as a result of dynamic homogeneity, hence we obtain the expected result that the steady state real exchange rate and the real wage are both unaffected by the rate of international inflation.

3.2 Supply side determined equilibrium unemployment

In general our model of the wage-price spiral determines wages, prices and inflation, conditional on unemployment. However, the interpretation of the model is altered if sufficient conditions are imposed that eliminate inflation as an arbiter of conflicting claims. Two such sets of restrictions are considered. The first coincides with the vertical long-run Phillips-curve natural rate that was popular in the seventies. The second corresponds to the supply side determined unemployment rate of the ICM.

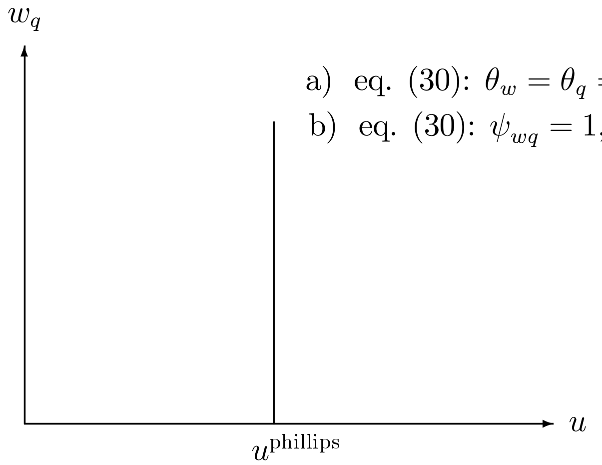

Figure 1: Open economy Phillips-curve natural-rate

3.2.1 Phillips-curve natural rate

In the case of $\theta_w = 0$, the dynamic wage equation (4) becomes an open economy Phillips-curve, see Calmfors (1977), Manning (1993). In this case, the impact coefficient of unemployment on wages is $\mu_w = \varphi$. Since $\theta_w = 0$ implies $\theta_w \omega = 0$, the system is unstable, but the real wage equation (25) by itself is stable, with steady-state given by (27). With $\mu_w = \varphi$ and $\theta_w = 0$ the slope of the steady-state real wage curve is given by:

$$\frac{\partial w_q}{\partial u} = -\frac{\eta}{(1-\kappa)} = \frac{-\varphi(1-\psi_q) + \mu_q(1-\psi_{wq}-\psi_{wp}\phi)}{\theta_q(1-\psi_{wq}-\psi_{wp}\phi)} \tag{30}$$

which is finite in general, but becomes infinite if $\theta_q = 0$ or if $\psi_{wq} + \psi_{wp}\phi = 1$, producing a vertical real wage curve, see figure 1. Case a) in the Figure refers to $\theta_q = 0$, while case b shows the situation when wages are dynamically homogeneous in *producer* prices, i.e. $\psi_{wq} = 1$ ($\psi_{wp}\phi = 0$) implying $1 - \psi_{wq} - \psi_{wp}\phi = 0$.

3.2.2 ICM natural rate

A rate of unemployment that reconciles conflicting real wage claims follows from our framework if we:

(i) eliminate the wedge in the long-run wage equation, $\omega = 0$, but maintain $\theta_w > 0$, and

(ii) impose short-run homogeneity of the particular form $\psi_q = \psi_{wq} = 1$, and hence $\psi_{wp} = 0$.

In this case, (6) and (8) become two *conflicting equations* of the product real wage $w_{q,t}$. There is no longer a role for inflation as an arbiter, instead unemployment has to converge to the level necessary to reconcile the "battle of mark-ups" incarnated in two conflicting real wage equations. This case is illustrated in figure 2.

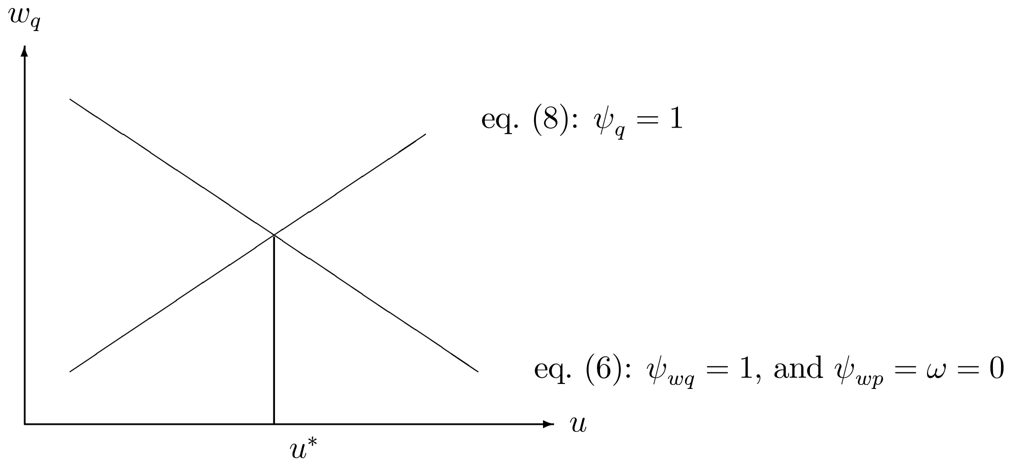

Figure 2: ICM natural-rate

One way of looking at the difference between the results in section 2 and the natural rate version of the ICM is the following: In the former case firms and workers fix real wage aspirations, but they do not have the instruments to put them through. They set nominal wages and prices, and eventually inflation mitigates the conflict. In the static ICM, each party actually tries to set the real wage on independent grounds. The resulting conflict has to be resolved by unemployment alone. Note however that if import prices influence domestic prices directly, via the "price determined real wage", cf. Carlin and Soskice (1990), we are once more back to a situation where the equilibrium rate of unemployment is again undetermined from the wage and price system alone.

4 An extension

The above special cases aside, the model of the wage-price system explains the development of real wages, competitiveness and inflation, for given paths of unemployment and world inflation. In order to determine unemployment, we need another equation, e.g.,

$$u_t = \alpha + \beta u_{t-1} + \gamma w_{q,t} - \zeta b_{q,t-1}, \quad 0 \leq \beta \leq 1, \quad 0 \leq \gamma, \zeta. \tag{31}$$

Corresponding to the stable case in section 2.1, we have a model consisting of (12), (16) and (31). In the no wedge case, the system becomes (25), (26) and (31). Note that in the unstable case, $b_{q,t}$ contains a unit root. Hence, barring that u_t is itself a unit root process, the principle of balanced equations implies that $\zeta = 0$ in the no wedge case.[9]

In both the stable and the unstable case, the full system will typically predict unemployment *persistence*: For example, in the stable case, permanent shocks in

[9]See Granger (1990). Since $b_{q,t}$ is unstable but u_t and $w_{q,t}$ is without a unit root, the only way the equation can become balanced is by having $\zeta = 0$.

either the wage-price part or in (31) will shift the steady-state values of both unemployment and real wages. In the new steady state, assuming stability, the rate of inflation is again constant. Hence, the steady state solution of unemployment is a NAIRU in the usual sense.[10] However, this NAIRU is not structurally invariant but will depend on the history of permanent shocks, both on the supply side and the demand side.

Furthermore, although the NAIRU determined from (12), (16) and (31) has some equilibrium connotations, it cannot be interpreted as a sustainable long-run equilibrium. After all, the model is still partial as several economy-endogenous variables have been assumed constant, e.g. the nominal exchange rate. Additional restrictions on the development of the variables, for example trade balance considerations, are likely to affect the determination of real wages and unemployment in an important way.

5 Supply side determined equilibrium unemployment: The evidence

We have seen that, in two special cases, does the model imply a unique equilibrium rate of unemployment. The first case was the Phillips curve natural rate in section 3.2.1. The second, slightly more general situation, was the ICM natural rate in section 3.2.2. We now briefly review the existing evidence for each of the two.

In our framework, a Phillips-curve natural-rate arises if $\theta_w = \theta_q = 0$ (and $\mu_w > 0$), i.e. neither wages nor prices are reacting to deviations from the desired levels of consumer real wages and producer real wages. Part of the reason for the demise of the Phillips curve natural rate model seems to be the accumulated evidence against the hypothesis that $\theta_w = 0$, see for example Grubb (1986), Nymoen (1989), Drèze and Bean (1990a), Graafland (1992) and Johansen (1995), which are all based on manufacturing wages for the different economies. Interestingly, the results in Manning (1993) indicate that his version of the Phillips-curve might work for the annual economy wide UK wage rate. This however contrasts with Bårdsen et al. (1998), who find that departures from a long-run cointegrating equation for UK wages is significant in the accompanying wage growth equation, implying $\theta_w > 0$.

The conflicting claims version of the natural rate NAIRU in section 3.2.2 *is* consistent with $\theta_w > 0$. However, a reading of recent studies makes it clear that the restrictions on the wedge term ($\omega = 0$) and on the dynamics ($\psi_q = 1$, $\psi_{wq} = 1$, $\psi_{wp} = 0$), are not easily accepted by the data. For example, six out of ten country-studies surveyed by Drèze and Bean (1990a) do not imply an ICM natural-rate, since

[10] NAIRU is an acronym for the non-accelerating inflation rate of unemployment. We follow normal usage, i.e. that NAIRU represents a situation where $\Delta^2 p = 0$, although taken literally the NAIRU involves the condition $\Delta^3 p = 0$, see Cross (1993).

they are not genuine *product* real wage equations: Either there is a wedge effect in the levels part of the equation ($\omega > 0$), or the authors fail to impose $\psi_{wq} = 1$, $\psi_{wp} = 0$.[11]

For the United Kingdom, there are several individual studies to choose from, some of which include a significant wedge effect, i.e. $\omega > 0$, see for example Carruth and Oswald (1989) and Cromb (1993). In a comprehensive econometric study of U.K. inflation, Rowlatt (1992) is able to impose dynamic homogeneity, $\psi_{wp}+\psi_{wq} = 1$ in wage formation, but the ICM natural-rate restriction $\psi_{wq} = 1$ appears not to be supported by the data.[12]

For the Nordic countries, Calmfors and Nymoen (1990) report manufacturing wage equations where dynamic homogeneity of the form $\psi_{wp} + \psi_{wq} = 1$ is imposed (after testing), but the restriction $\psi_{wq} = 1$ is never statistically acceptable. For Denmark, Norway and Sweden the point estimates for consumer price growth ($\hat{\psi}_{wp}$) are 0.35, 0.40 and 0.47 respectively, with highly significant "t-values".[13] For Finnish wages, there is complete short-run indexation with respect to consumer prices. Interestingly, Nymoen (1992) shows that only productivity and prices enter in the long-run Finnish wage-claim equation, highlighting that wage response to firm-side variables might be slow but nevertheless important in the long-run. For Norway, Johansen (1995) successfully implements the zero restriction on the wedge term. However, the importance of both Δq_t^e and Δp_t^e in the wage equation is confirmed anew in Johansen's wage equations, hence the ICM natural rate restrictions are not corroborated. Finally, we note that Bårdsen et al. (1998) estimate total economy wage and price models for UK and Norway. For both countries consumer prices growth is found to be important. The work of Davies and Schøtt-Jensen (1994) contains similar evidence for several EU-countries.

In sum, we agree with the earlier assessment in (Layard et al., 1991, pp. 219-211), that import prices have relatively long-last effects on product wages trough a levels effect, corresponding to $\omega > 0$ in our notation. In supplement to that conclusion, and equally damaging for the belief in the empirical relevance of a supply side determined equilibrium rate of unemployment, we find that the sufficient restrictions on the dynamics are rejected when made subject to testing.

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[11] From (Drèze and Bean, 1990b, Table 1.4), and the country papers in Drèze and Bean (1990a) we extract that the equations for Austria, Britain and (at least for practical purposes) Germany are "true" product real-wage equations. The equation for France is of the Phillips-curve type. For the other countries we have, using our own notation: Belgium and the Netherlands: Consumer real-wage equations, i.e. $\psi_{wp} = 1$, $\psi_{wq} = 0$ and $\omega = 1$. Denmark: $\omega = 1$, $\psi_{wp} = 0.24$, $\psi_{wq} = 0.76$. Italy: $\omega = 0$, $\psi_{wp} = 0.2(1-\phi)$, $\psi_{wq} = 0.8(1-\phi)$. United-States $\omega = 0.45(1-\phi)$, $\psi_{wq} = 1$, $\psi_{wp} = 0$. Spain: $\omega = 0.85 \cdot 0.15$, $\theta_w = 1$, $\psi_{wp} = \omega$, $\psi_{wq} = 1 - \omega$ (The equation is static).

[12] See (Rowlatt, 1992, Chapter 3.6).

[13] See (Calmfors and Nymoen, 1990, Table B1-B4). When the import price index appears as a separate variable, we attribute its effect to consumer prices.

6 Summary and conclusion

The model discussed in this paper builds on "classical" price-wage dynamics, and reconciles that older tradition with the now standard incomplete competition model—ICM. The chosen model is a simple dynamic model of the supply side that determines domestic inflation, real wages and the real exchange rate as functions of world inflation and unemployment.

The stability of the price-wage system is shown to depend on the presence of real wage resistance in the form of a so-called wedge effect. In the stable case, the real wage, inflation and the real exchange rate all have well defined steady state solutions for a given level of unemployment. The unstable case, corresponding to no wedge effect in wage formation, implies that the real exchange rate follows a unit root process, while stability is retained for the rate of inflation and the real wage. Both the dynamic behaviour of real wages and its eventual steady state are affected by the presence or otherwise real wage resistance. For example, there is *wage-hysteresis* in the case with real wage resistance, but not in the "no wedge" case. The sign of the implied long run relationship between the real wage and the rate of unemployment is also affected: It is non negative in the stable case, but may be negative in the case without real wage resistance.

In the static ICM, it is sufficient to assume that the system is without real wage resistance in order to be able to derive a supply side determined equilibrium rate of unemployment. In the dynamic ICM however, the "no wedge" condition is only a necessary condition for a natural rate solution—additional restrictions on the price-wage dynamics are required. Hence, on the basis of the model and the existing evidence, and counter to the natural-rate NAIRU proposition, we would not expect actual economies to possess very strong abilities of automatic stabilization. The fact that the model does not incorporate several additional sources of persistence (e.g. insider power, human capital depreciation) that appear frequently in the literature, only serves to strengthen this view.

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