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Wage setting under different monetary regimes

by

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Abstract

Under centralised wage setting, the monetary regime affects the trade-off between consumer real wages and employment and profits faced by the wage setters. Thus, in contrast to the standard view, the monetary regime affects the outcome of the wage negotiations, and consequently also the equilibrium level of unemployment. An exchange rate target (and participation in a monetary union) is likely to involve lower wages and higher employment in the traded sector, and higher wages and lower employment in the non-traded sector, than does a price target. An exchange rate target also involves higher prices on non-traded goods relative to traded goods.

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I. Introduction

Over the last decades, most of the research on monetary regimes has focused on issues related to credibility and stability. In this research, the equilibrium level of output is usually taken as given, based on the view that the equilibrium rate of unemployment (and the associated equilibrium levels of employment and output) is determined in the labour market, and thus unaffected by monetary policy. In this paper I shall argue that the choice of monetary regime may indeed affect the equilibrium levels of output and employment in an economy with non-atomistic wage setting. The reason is that different monetary regimes involve different reaction functions of the central bank to the outcome of the wage setting, which in general will imply that large wage setters face a different trade-off between consumer real wages and employment and profits. In a regime where the monetary policy dampens the negative effects on employment and profits of a marginal increase in the consumer real wage, large wage setters will choose a high real wage, leading to low levels of employment and output.

I have chosen to compare three monetary regimes; an exchange rate target, a target for the consumer price level, and a target for non-traded prices. These regimes serve well in illustrating the consequences of the choice of monetary regime. Furthermore, the two former regimes are for many countries the two most plausible alternatives. In Europe, Denmark, Sweden and the UK have still not decided whether to join the European Monetary Union (which for a single country essentially involves an exchange rate target, even if the monetary union itself has an inflation target). In Norway, there is an ongoing debate on whether the current regime aimed at exchange rate stability should be replaced by a regime with an explicit inflation target (cf Christiansen and Qvigstad, 1997). The third regime, a target for non-traded prices, is a possible variety of an inflation target, intended to adjust for the effect of fluctuations in the exchange rate (cf. Ball, 1998). The regimes do not differ with respect to the underlying monetary target, which is low inflation in all regimes; fixed exchange rates are often seen as a means of importing price stability from a low inflation country.

The analysis is within a theoretical framework with an equilibrium rate of unemployment/equilibrium level of employment, cf eg Layard, Nickell and Jackman (1991) or Dixon (1987). Wages are set in negotiations between unions and employers, employment is given by the labour demand function of the firms, and the equilibrium rate of unemployment is given by the intersection of the wage curve and the labour demand schedule. The important innovation of the present paper compared to this literature, is the explicit integration of large wage setters that take the monetary policy response into consideration when setting wages.

My analysis shows that the different monetary regimes have different effects on the various sectors of the economy. An exchange rate target involves higher consumer real wages in the non-traded sector than does a target for the consumer price, while a target for non-traded prices involves even lower wages in the non-traded sector. The intuition is as follows: Under an exchange rate target, a rise in non-traded wages is not countered by the central bank, but allowed to increase non-traded prices. This dampens the negative effect on employment and profits. In effect, the trade-off between real wages on the one hand, and employment and profits on the other, is more favourable, and wage setters respond by setting a higher wage. The same mechanism is also present under a target for the consumer price, but the magnitude is smaller, while non-traded prices are not allowed to rise under a regime with a target for non-traded prices.

In the traded sector, the ranking is reversed. Consumer real wages are highest under a target for non-traded prices, lower under a consumer price target, and lowest under an exchange rate target. The mechanism is essentially the same as in non-traded sector: Under a target for non-traded prices, a wage rise in the traded sector is allowed to induce a depreciation of the exchange rate, that dampens the negative effect on employment and profits. This mechanism is weaker under a consumer price target, and not present under an exchange rate target.

As the regimes have different effect on different sectors, the aggregate outcome depends on which effect dominates. Numerical simulations suggest that overall welfare is higher, and aggregate unemployment is lower, under a target for the consumer price level than under the other regimes.

The feature that the monetary regime has different effects on the different sectors of the economy implies that the monetary regime affects both relative prices and the sectoral structure of the economy. The moderating effect on traded sector wage setting under an exchange rate regime implies that the price of non-traded goods relative to traded goods is likely to be higher under an exchange rate target, even in a long run steady state equilibrium where foreign trade is balanced. For the same reason, it is likely that the traded sector will constitute a large share of the overall economy under an exchange rate target than under a price target.

The paper also shows that the monetary regime has distributional consequences. Although the simulations indicate that most agents are better off under a target for the consumer price, the union in the non-traded sector benefits from high real wages under an exchange rate target. In some simulations, also the employers in the traded sector would benefit from an exchange rate target, due to the wage moderation effect of this regime in the traded sector.

Seen from a technical point of view, the results of the present paper are not surprising: Changing the strategic variable of one of the players (the central bank) will in general affect the outcome of a game. However, the results are in sharp contrast to the common view (e.g. Svensson, 1997) that in the long run monetary policy cannot affect real variables, nor can it affect the relative price of traded versus non-traded goods.

As the model is of a static equilibrium type, with no shocks, it cannot be used to discuss the stability properties of the various monetary regimes. Furthermore, it is not possible

to follow how the economy evolves over time under the different regimes. One implication of this is that there is no distinction between different forms of price level target regimes, as strict and flexible inflation targeting (see Svensson, 1998).

The present paper is not the first to study the relationship between monetary policy and equilibrium unemployment. Cubitt (1992, 1995), Skott (1997), Jensen (1997), Gruner and Hefeker (1998), and others, show that the monetary regime (central bank behaviour) affects the equilibrium rate of unemployment when unions are also concerned about inflation. The present paper is, however, closer to a very recent literature, including Bratsiotis and Martin (1999), Soskice and Iversen (1998, 1999), Cukierman and Lippi (1999a,b), Wibaut (1998a,b), and Vartiainen (1999), where it is shown that the monetary regime affects the equilibrium rate of unemployment even without unions being concerned about inflation. These papers appear to be written independently of each other, although the basic mechanism is very similar, and also similar to the mechanism of the present paper. Most of these papers consider a closed economy; exceptions are Wibaut (1998b) and Vartiainen (1999), which both compare fixed and floating exchange rate regimes in an economy with monopoly unions in the traded and non-traded sectors.¹ Distinguishing between the traded and non-traded sector yields results on sectoral basis, as well as providing a more complete picture of the aggregate outcome. Lawler (1998) compares an optimal managed float with a fixed exchange rate in an economy with a single monopolistic trade union.

At the more technical level, my paper also resembles Rasmussen (1992,1996). In his 1992 paper, Rasmussen focus on the asymmetry between traded and non-traded sectors; in the 1996 paper, the main idea is that the price normalisation rule affects the real economy in an

¹ I was made aware of Wibaut's papers after having presented my paper at the EEA Conference in Berlin, 1998, and have discovered the other papers later on.

economy with large wage setters. In neither of these papers, does Rasmussen compare different monetary regimes.

The paper is organised as follows. The model is presented in section II, while section III explores the equilibrium of the model, as well as providing results of numerical simulations. In section IV, the model is extended to an infinite horizon. This extension involves the additional realism that the nominal interest rate is the policy instrument of the central bank. Section V concludes.

II. The model

The economy under consideration consists of two sectors, with traded and non-traded goods. In each sector there is a large exogenous number, n , firms and one union organising all workers in the sector. Within each sector, firms are identical, producing a homogeneous good, with labour as the only input. The sectoral wage is set in a bargain between the union and the employers' federation in the sector. Traded goods have an exogenous world market price P^* , so that the price in domestic currency, P^T , is given by $P^T = SP^*$, where S is the nominal exchange rate. Households are either workers (who belong to either of the sector specific trade unions) or shareholders (who receive all profits of the firms). Including households in the model (instead of postulating demand functions directly) have the advantage that it allows for an explicit welfare comparison of the regimes. Throughout the paper, all agents are assumed to have perfect information.

The sequence of moves in the model is the following. First, wages are set simultaneously in each sector. Second, the central bank sets the exchange rate so as to ensure that the monetary target is fulfilled. Third, production and consumption take place.

Before proceeding with the model, let me briefly motivate two key assumptions. The reason for distinguishing between the traded and non-traded sectors is that the implications of

various monetary regimes differ sharply between the sectors.² It is true that in actual economies the distinction between traded and non-traded goods is not always sharp. Furthermore, over time an increasing number of goods have been subject to international trade. However, it is still the case that a wage rise in the export industry has a different impact on the consumer price level than a wage rise in the non-traded sector. It is also the case that a change in the exchange rate has different impact on output and employment in different sectors of the economy. These are important distinctions that should be taken into account in a comparison of different monetary regimes.

The assumption that there is a single union in each sector is made for analytical and pedagogical reasons. However, it also captures an important element of realism: In many European countries, large wage setters are typically industry unions, some of which belong primarily to the traded sector, while others primarily belong to the non-traded sector. In Sweden and Finland, unions operating in export industries have discussed the formation of bargaining cartels (Vartiainen, 1999).

Households

There is large number, M , households in the economy, of which M^j are members of the union in sector j , $j = T, N$, and $M - M^T - M^N$ are shareholders. All households have identical preferences that are separable in consumption and leisure, and where the subutility function associated with consumption is of the CES-type. The utility function of household h is

$$(1) V_h = \left[\gamma^{1/\rho} (C_h^N)^{(\rho-1)/\rho} + (1-\gamma)^{1/\rho} (C_h^T)^{(\rho-1)/\rho} \right]^{\rho/(\rho-1)} + v(H_h),$$

$$0 < \gamma < 1, \rho > 0, \rho \neq 1, h=1,2,... M$$

² Leitemo and Røisland (1998) and Røisland and Torvik (1999) explore the stabilising properties of monetary regimes in models with traded and non-traded sectors.

where C_h^N and C_h^T are consumption of non-traded and traded goods respectively, ρ is the elasticity of substitution, and $v(H_h)$ is the subutility function associated with leisure, H_h . To simplify the exposition by avoiding the possibility of work sharing, I assume that workers are either fully employed, supplying one unit of labour, or completely unemployed. As a normalisation, let $v(H_h) = 0$ for employed workers and $v(H_h) = v_0 > 0$ for unemployed workers. Cobb-Douglas utility can be seen as a special case of (1), where $\rho = 1$:

$$(1') \quad V_h = \frac{1}{a} (C_h^N)^\gamma (C_h^T)^\gamma + v(H_h), \quad a = \gamma^\gamma (1-\gamma)^{1-\gamma}, \quad 0 < \gamma < 1, h=1,2,.. M$$

The budget constraint of household h is $P^N C_h^N + P^T C_h^T = I_h$, where I_h is the nominal income of household h . Utility maximisation yields the demand functions

$$(2) \quad (a) \quad C_h^N = \gamma \left(\frac{P^N}{P} \right)^{-\rho} \frac{I_h}{P} \quad (b) \quad C_h^T = (1-\gamma) \left(\frac{P^T}{P} \right)^{-\rho} \frac{I_h}{P},$$

where P^j is the price of goods from sector j , $j = T, N$. Aggregate consumption demand is found by aggregating over all households; this is simple because households have identical, homotetic utility functions, so that the income distribution does not affect demand. Aggregate nominal income $\sum_h I_h$ is equal to PY , where

$$(3) \quad Y = (P^N Y^N + P^T Y^T)/P$$

is the real aggregate output in the economy, Y^j is output in sector j , $j = T, N$, and

$$(4) \quad P = (\gamma (P^N)^{1-\rho} + (1-\gamma)(P^T)^{1-\rho})^{1/(1-\rho)},$$

is the consumer price index that corresponds to the CES utility function (1). If $\rho = 1$ (the Cobb-Douglas case), the price index is

$$(4') \quad P = (P^N)^\gamma (P^T)^{1-\gamma}.$$

Aggregate domestic demand for traded goods, and aggregate demand for non-traded goods are

$$(5) \quad (a) \quad C^N = \gamma \left(\frac{P^N}{P} \right)^{-\rho} Y \quad (b) \quad C^T = (1 - \gamma) \left(\frac{P^T}{P} \right)^{-\rho} Y$$

Firms

The production function of a firm in the traded (T) or non-traded (N) sector is

$$(6) \quad Y^j = (1/\beta) (L^j)^\beta, \quad 0 < \beta < 1, \quad j = T, N,$$

where L^j is employment (to simplify notation I do not distinguish between aggregate and firm-level variables; taken literally there is only “one” firm in each sector which nevertheless acts as a price taker). The real profits of a firm in sector j are

$$(7) \quad B^j = (P^j Y^j - W^j L^j)/P, \quad j = T, N,$$

where W^j is the nominal wage in the sector.

Profit maximisation at exogenous price and wage levels, using the production function (6), results in the labour demand and supply functions

$$(8) \quad L^j = (P^j/W^j)^{1/(1-\beta)}, \quad j = T, N,$$

$$(9) \quad Y^j = (P^j/W^j)^{\beta/(1-\beta)} \beta^{-1}, \quad j = T, N.$$

Substituting out for (8) and (9) in (7), the real profits of a firm are

$$(10) \quad B^j = (1-\beta)\beta^{-1} (P^j)^{1/(1-\beta)} (W^j)^{-\beta/(1-\beta)}/P.$$

Unions

Unions are assumed to be utilitarian in the sense that they maximise the sum of their members' utilities. The indirect utility of an employed worker in sector j is (using (1) and (2))

$$(11) \quad u^j = (W^j - T^j)/P,$$

where T^j is the fee paid by union members to the unemployment insurance fund in the sector.

The unemployment insurance fund in each sector is assumed to be fully financed by fees paid by workers in the sector, so that $T^j L^j = B^j (M^j - L^j)$, where B^j is the nominal unemployment benefit in sector j .³ The indirect utility function of an unemployed worker in sector j is

$$(12) \quad u_b^j = B^j/P + v_0.$$

The sum of utilities of union members is (using (11) and (12))

³ As is apparent from equation (13) below, the level of the unemployment benefit does not matter when benefits are fully financed by the workers in the sector, and utility functions are linear.

$$(13) \quad U^j = L^j u^j + (M^j - L^j)u_b^j = L^j W^j/P + (M^j - L^j) v_0 = (W^j/P - v_0) L^j + M^j v_0.$$

Monetary policy

I consider three alternative regimes, a consumer price target $P = P^G$, a target for non-traded prices $P^N = (P^N)^G$, and an exchange rate target $S = S^G$.⁴ All targets are assumed to be perfectly credible. A possible interpretation of a perfectly credible exchange rate target is that the country under consideration is a small part of a monetary union; while a price target can be made credible under an independent central bank with a strong reputation. The central bank sets the exchange rate so that the monetary target always is fulfilled, and all agents in the model know that this will be the case. The alternative monetary regimes involve different response functions for the central bank, that is, for various outcomes of the wage setting, the exchange rate set by the central bank will differ.

Wage setting

The wage setting takes place simultaneously in both sectors, so that the outcome of the wage setting in one sector cannot affect the wage setting in the other sector. As there is no uncertainty, the wage setters in one sector can perfectly predict the outcome in the other sector. Formally, there is a Nash equilibrium in a static game between the wage setters in each sector, as represented by the Nash maximand.

In case of a dispute in the bargaining, the workers go on strike, so that the firm earns zero profits. Workers on strike have no strike pay, so they (as well as the unemployed workers) have utility v_0 . The union part of the Nash maximand is thus

⁴ As the model is static, and none of the specified agents are assumed to care about inflation per se, a price level target is identical to an inflation target in the theoretical model in the present paper.

$$(14) \quad U^j - U_0^j = (W^j/P - v_0) L^j, \quad j, = T, N.$$

The outcome in the wage setting is given by the Nash bargaining solution, that is, W^j is set so as to maximise the Nash product

$$(15) \quad H^j = (U^j - U_0^j) B^j, \quad J = T, N.$$

Substituting out using (7), (8), and (14), the Nash product reads (letting lower case letters denote natural logarithm)

$$(16) \quad h^j = \ln\left(\frac{W^j}{P} - v_0\right) - \frac{1}{1-\beta} w^j + \frac{1}{1-\beta} p^j + \ln\left(\frac{1-\beta}{\beta}\right) + \frac{1}{1-\beta} p^j - \frac{\beta}{1-\beta} w^j - p,$$

for $j = T, N$. Recognising that both prices are endogenous, the first order condition is

$$(17) \quad \frac{dh^j}{dw^j} \Big| = \frac{W^j/P}{W^j/P - v_0} \left(1 - \frac{dp}{dw^j}\right) - \frac{1+\beta}{1-\beta} - \frac{2}{1-\beta} \frac{dp^j}{dw^j} - \frac{dp}{dw^j} = 0.$$

(17) can be solved for

$$(18) \quad \frac{W^j}{P} = \frac{1+\beta - 2 \frac{dp^j}{dw^j} + (1-\beta) \frac{dp}{dw^j}}{2\beta - 2 \frac{dp^j}{dw^j} + 2(1-\beta) \frac{dp}{dw^j}} v_0.$$

The effects of a wage rise on the own sector price and the consumer price, dp^j/dw^j and dp/dw^j , depend on the monetary regime, and it is through these channels that the monetary regime affects wage setting. To the extent that a wage rise in one sector leads to higher prices

in the same sector, $dp^j / dw^j > 0$, this dampens the negative effect on employment and profits of a wage rise. Thus, this effect will lead the wage setters to agree on a higher real wage. To the extent that a wage rise leads to higher consumer prices, the purchasing power of money wages and profits is reduced. This effect makes the wage setters agree on a lower real wage.

III. Equilibrium

Equilibrium of the model is a situation where households choose consumption so as to maximise their utility; firms set employment so as to maximise their profits; the central bank sets the exchange rate to achieve the monetary target; the sectoral wage is set in a Nash bargain in each sector; and the price of non-traded goods is given by the market clearing condition

$$(19) \quad C^N = Y^N.$$

From the budget condition of the households, it follows that there is balanced trade, $Y^T = C^T$, in equilibrium. To derive the equilibrium, we must explore the marginal impact of the various prices of a wage rise, to be inserted into the solution for the outcome of the wage bargaining (18). The impact varies across monetary regimes, and this is the topic of the next subsections.

Exchange rate target

Under an exchange rate target, the price of traded goods is not affected by the wage setting, so $dp^T/dw^T = dp^T/dw^N = 0$. However, a wage rise will affect the price in the non-traded sector, and therefore also the consumer price level. Consider first wage setting in the traded sector. (All derivations are in the appendix)

$$(20) \quad \frac{dp}{dw^T} = \frac{-\gamma_s \beta}{\beta + \rho(1 - \beta)} < 0,$$

where

$$(21) \quad \gamma_i \equiv \left(\frac{P^N Y^N}{PY} \right) = \gamma \left(\frac{P^N}{P} \right)^{1-\rho}, \quad i = S, P, N$$

is the equilibrium share of non-traded goods of total nominal output under monetary regime i ; S (exchange rate), P (consumer price target), N (target for non-traded prices). (The latter equality in (21) can be derived from (5a), using that $C^N = Y^N$ in steady state.) As is apparent from (21), γ_i varies across regimes because the equilibrium values of P^N/P , Y^N and Y differ between the regimes.

The interpretation of (20) is that higher nominal wages in the traded sector lead to lower consumer prices. At first sight, this may seem counterintuitive. However, the mechanism is actually straightforward. Higher wages in the traded sector reduce traded sector output, so that aggregate output and income are reduced. When households' income goes down, they reduce their demand for non-traded goods, inducing a reduction in the price on non-traded goods, and thus also a reduction in consumer prices. As seen from (18), the dampening effect on consumer prices of a wage rise in the trade sector is favourable to the wage setters in the traded sector, which will lead them to agree on a higher real wage than they would have done if the consumer price level were exogenous.

Turning to wage setting in the non-traded sector, we have

$$(22) \quad \frac{dp^N}{dw^N} = \frac{\beta}{\beta + \rho(1 - \beta)} > 0,$$

$$(23) \quad \frac{dp}{dw^N} = \frac{\gamma_s \beta}{\beta + \rho(1 - \beta)} > 0.$$

Higher nominal wages in the non-traded sector lead to both higher prices on non-traded goods and higher consumer prices, due to the negative effect on the supply of non-traded goods. The increase in the price is dampened by the negative income effect in demand of the reduction in output. The increase in the price on non-traded goods is favourable to the wage setters, as it reduces the negative effect on employment and profits of a wage rise. On the other hand, the rise in consumer prices has a negative effect on the real wage as well as on real profits. As will be shown below, the former effect dominates, so that the overall effect of p^N and p being endogenous is that the wage setters agree on a higher real wage than they would have done if these prices were exogenous.

Consumer price target

Under a target for the consumer price level, wage rises may affect prices in both sectors.

However, the central bank adjusts the exchange rate so that the consumer price level is equal to the target, and thus unaffected by the wage setting, i.e. $dp/dw^T = dp/dw^N = 0$. Consider first wage setting in the traded sector

$$(24) \quad \frac{dp^T}{dw^T} = \frac{\gamma_P \beta}{\beta + \rho(1 - \beta)} > 0.$$

Higher nominal wages in the traded sector lead to higher prices on traded goods, via the following mechanism. Higher wages in the traded sector reduce traded sector output, so that aggregate output and income is reduced. When households' income go down, they reduce their demand for non-traded goods, inducing a reduction in the price on non-traded goods,

with a corresponding dampening effect on consumer prices. To maintain the price target, the central bank devalues the currency, so that traded sector prices increase measured in domestic currency. The increase in traded sector prices is favourable to the wage setters in the traded sector, as it mitigates the negative effect on employment and profits. This will lead them to agree on a higher real wage than they would have done if the exchange rate were exogenous.

Turning to the non-traded sector, we have

$$(25) \quad \frac{dp^N}{dw^N} = \frac{(1-\gamma_p)\beta}{\beta + \rho(1-\beta)} > 0.$$

Higher nominal wages in the non-traded sector lead to higher prices on non-traded goods, due to the negative effect on supply. The increase in non-traded prices arising from a wage rise in the non-traded sector is favourable to the wage setters in the non-traded sector, which will lead them to agree on a higher real wage than they would have done if non-traded prices were exogenous.

Target for non-traded prices

Under a target for non-traded prices, the central bank adjusts the exchange rate so that non-traded prices are at their target value, thus $dp^N/dw^T = dp^N/dw^N = 0$. However, the consumer prices and the price of traded goods are endogenous. The effect of a wage rise in the traded sector is

$$(26) \quad \frac{dp^T}{dw^T} = \frac{\beta}{\beta + \rho(1-\beta)} > 0,$$

$$(27) \quad \frac{dp}{dw^T} = \frac{(1-\gamma_N)\beta}{\beta + \rho(1-\beta)} > 0.$$

A wage rise in the traded sector leads to both higher traded sector prices and higher consumer prices. The mechanism is as follows. A wage rise in the traded sector has a negative effect on traded sector output, thus leading to lower aggregate output and lower aggregate income. The reduction in aggregate income reduces demand for non-traded goods, inducing a reduction in non-traded prices. To counteract this, the central bank devalues the currency, so that traded goods prices and consumer prices increase.

Turning to the non-traded sector, we have

$$(28) \quad \frac{dp}{dw^N} = \frac{-(1-\gamma_N)\beta}{\beta + \rho(1-\beta)} < 0.$$

A wage rise in the non-traded sector leads to lower consumer prices, because in order to counteract the direct positive effect on non-traded prices via the supply side, the central bank must appreciate the exchange rate so that traded sector output goes down, inducing a negative income effect on the demand for non-traded goods. The negative effect on consumer prices is favourable to the wage setters in the non-traded sector, and this will induce them to set a higher real wage than they would have done if the consumer price were exogenous.

Comparing regimes

A direct comparison of the effect of the monetary regime on the wage setting is made difficult by the fact that the share of non-traded output of total nominal output, γ_S , γ_P , or γ_N , depends on the monetary regime. This problem is circumvented in the Cobb-Douglas case, where the share of non-traded output is the same in both regimes, $\gamma_S = \gamma_P = \gamma_N = \gamma$. For the traded sector, we have the following Proposition.

Proposition 1: In the Cobb-Douglas case, $\rho = 1$, the consumer real wage in the traded sector, W^T/P , is given by

$$\begin{aligned} \frac{W^T}{P} \Big|_{S=S^G} &= \frac{1 + \beta - (1 - \beta)\gamma\beta}{2\beta - 2(1 - \beta)\gamma\beta} v_0, & \text{under an exchange rate target,} \\ \frac{W^T}{P} \Big|_{P=P^G} &= \frac{1 + \beta - 2\gamma\beta}{2\beta - 2\gamma\beta} v_0, & \text{under a target for the consumer price,} \\ \frac{W^T}{P} \Big|_{P^N=(P^N)^G} &= \frac{1 + (1 - \gamma)\beta}{2(1 - \gamma)\beta} v_0, & \text{under a target for non-traded prices.} \end{aligned}$$

The ranking of the regimes is as follows

$$\frac{W^T}{P} \Big|_{P^N=(P^N)^G} > \frac{W^T}{P} \Big|_{P=P^G} > \frac{W^T}{P} \Big|_{S=S^G}$$

Thus, consumer real wages in the traded sector are highest under a target for non-traded prices, followed by a target for the consumer price, and lowest under an exchange rate target. The numerical simulations presented in Table 1 below strongly suggest that all the Cobb-Douglas results also hold in the more general CES case, where $\rho \neq 1$.

The intuition behind the ranking builds on the fact that the highest real wage is set in the monetary regime that provides the wage setters with the most favourable trade-off between real wages on the one hand and employment and profits on the other. Under a target for non-traded prices, a wage rise in the traded sector is allowed to induce a considerable depreciation of the exchange rate, mitigating the negative effect on employment and profits. There is a counteracting effect in the increasing consumer prices, but this effect is less important. Under a target for consumer prices, the depreciation induced by a wage rise has the same favourable effect for the wage setters, but the magnitude of the depreciation is smaller. An exchange rate target provides the least favourable trade-off, because there is no offsetting

effect via the exchange rate; the favourable negative effect on consumer prices is less important.

The results for the non-traded sector are provided in Proposition 2. Comparing Propositions 1 and 2 shows that the results are symmetric in the sense that the wage outcome of the traded sector under an exchange rate target corresponds to the wage outcome in the non-traded sector under a target for non-traded price, and vice versa.

Proposition 2: In the Cobb-Douglas case, $\rho = 1$, the consumer real wage in the non-traded sector, W^N/P , is given by

$$\begin{aligned} \frac{W^N}{P} \Big|_{S=S^G} &= \frac{1+\gamma\beta}{2\gamma\beta} v_0, & \text{under an exchange rate target,} \\ \frac{W^N}{P} \Big|_{P=P^G} &= \frac{1+\beta-2(1-\gamma)\beta}{2\beta-2(1-\gamma)\beta} v_0, & \text{under a target for the consumer price,} \\ \frac{W^N}{P} \Big|_{P^N=(P^N)^G} &= \frac{1+\beta-(1-\beta)(1-\gamma)\beta}{2\beta-2(1-\beta)\beta(1-\gamma)} v_0, & \text{under a target for non-traded prices.} \end{aligned}$$

The ranking of the regimes is as follows

$$\frac{W^N}{P} \Big|_{S=S^G} > \frac{W^N}{P} \Big|_{P=P^G} > \frac{W^N}{P} \Big|_{P^N=(P^N)^G}$$

Thus, in the non-traded sector, consumer real wages are highest under an exchange rate target, followed by a target for the consumer price, and lowest under a target for non-traded prices.

This reflects that under an exchange rate target, a wage rise in the non-traded sector is allowed to feed into higher non-traded prices, mitigating the negative effect on employment and profits. The counteracting effect via the increasing consumer prices is less important. Under a target for consumer prices, the magnitude of this favourable effect is smaller. A target for

non-traded prices provides the least favourable trade-off, because there is no offsetting effect via higher non-traded prices. Again, the beneficial negative effect on consumer prices is less important.

The ranking of relative wages across regimes is immediate from Propositions 1 and 2:

Corollary: In the Cobb-Douglas case, the ranking of relative wages is

$$\frac{W^N}{W^T} \Big|_{S=S^G} > \frac{W^N}{W^T} \Big|_{P=P^G} > \frac{W^N}{W^T} \Big|_{P^N=(P^N)^G}$$

Thus, the wages in the non-traded sector relative to traded sector wages are highest under an exchange rate target, and lowest under a target for non-traded prices.

To derive the ranking of relative prices, we use (18) and the budget condition to get

$$(29) \quad \frac{C^N}{C^T} = \frac{Y^N}{Y^T}$$

Substituting out for (5a,b) and (9), and rearranging, we get

$$(30) \quad \left(\frac{W^N}{W^T} \right)^{\beta/(1-\beta)} = \left(\frac{P^N}{P^T} \right)^{\beta/(1-\beta)+\rho}$$

Inspection of (30) reveals that P^N/P^T is strictly increasing in W^N/W^T . From the Corollary above, we get the following Proposition.

Proposition 3: In the Cobb-Douglas case, the ranking of relative prices satisfies

$$\frac{P^N}{P^T} \Big|_{S=S^G} > \frac{P^N}{P^T} \Big|_{P=P^G} > \frac{P^N}{P^T} \Big|_{P^N=(P^N)^G}$$

Thus, prices of non-traded goods relative to traded prices are highest under an exchange rate regime, and lowest under a target for non-traded prices. The intuition is that the high non-traded wages under an exchange rate target decreases supply of non-traded goods, raising non-traded prices. Correspondingly, a target on non-traded prices keeps both wages and prices down in the non-traded sector.

Numerical solutions to the model

In this subsection I explore further the difference between the monetary regimes by use of numerical simulations of the model. Due to the symmetry, the results of a target for non-traded prices can be read directly from a simulation of an exchange rate target (and vice versa), by just reversing sectors, recalling that γ under this interpretation would be the share of traded goods. Some illuminating cases are presented in Table 1. Because of the highly stylised nature of the model, the magnitudes of the differences cannot be taken seriously, yet the simulations provide a rough indication of the effects that are at work. Comparing columns pair-wise, a number of features are apparent.

- The results of Propositions 1 and 2 that the real consumer wage in the traded sector is higher under a target for non-traded prices, and the real consumer wage in the non-traded sector is higher under an exchange rate target, show up in the CES-cases too.

Table 1: Numerical simulations of the model.

	Cobb-D. $\gamma = 0.5$	Cobb-D. $\gamma = 0.5$	$\rho=2$ $\gamma = 0.5$	$\rho=2$ $\gamma = 0.5$	$\rho = 2$ $\gamma = 0.75$	$\rho = 2$ $\gamma = 0.75$	$\rho = 2$ $\gamma = 0.75$
Var.\Target	Cons.p.	Exch.	Cons.p	Exch.	Cons.p.	Exch.	Non-t.p.
W^N/P	0.75	1	0.7	0.75	0.66	0.69	0.65
W^T/P	0.75	0.7	0.7	0.68	0.77	0.70	0.84
P^N/P^T	1	1.27	1	1.06	1.22	1.30	1.16
$\gamma^i, i = P, S$	0.5	0.5	0.5	0.49	0.71	0.70	0.72
L	4.74	3.40	5.83	5.50	5.52	5.37	5.27
Y	5.33	4.20	6.12	5.88	5.69	5.60	5.50
Y^N	2.67	1.88	3.06	2.78	3.84	3.63	3.81
Y^T	2.67	2.39	3.06	3.10	1.90	2.06	1.72
$V=Y - L v_0$	2.96	2.50	3.21	3.13	2.93	2.92	2.87
U^N	0.59	0.70	0.58	0.64	0.65	0.72	0.62
U^T	0.59	0.40	0.58	0.53	0.38	0.33	0.41
π^N	0.89	0.70	1.02	0.95	1.35	1.30	1.32
π^T	0.89	0.70	1.02	1.01	0.55	0.57	0.51

Notes: In all simulations, $\beta = 2/3$ and $v_0 = 0.5$. In the figures for household and union utility, V and U^j , the constant term $M^j v_0$ is left out.

- Relative prices are also affected; non-traded prices are considerably higher relative to traded sector prices under an exchange rate target than under a target for consumer prices, and even lower under a target for non-traded prices. In the Cobb-Douglas case, the sectoral distribution between the sectors is exogenous, equal to γ . However, in the CES-case, the higher relative wages and prices in the non-traded sector under an exchange rate target than under the other regimes implies that the traded sector constitutes a larger share of aggregate output (i.e. $\gamma_S < \gamma_P < \gamma_N$).
- In the non-traded sector, output, employment and profits are in all simulations higher under a target for consumer prices than under an exchange rate target. However, union

utility in the non-traded sector is higher under an exchange rate target, due to the high real wage in this sector under an exchange rate target. In the traded sector, the ranking of a consumer price target and an exchange rate target concerning output, employment and profits vary between the simulations. Union utility in the traded sector is however higher under a consumer price target.

- Overall, the consumer price target is superior. In particular, a consumer price target involves higher household utility and higher aggregate output and employment.

IV. The infinite horizon case

One limitation by using a static model is that when wage setters consider the effect of a deviation from equilibrium in the wage negotiations, the deviation is, in effect, considered permanent. This has the implication that there is no room for effects on the interest rate, as even a permanent rise in the wage level cannot affect the interest rate at permanent basis. To avoid this shortcoming, I extend the model to an infinite number of periods, where each period corresponds to the static model above: production technology, household utility functions, and union utility functions, are all the same as before. However, wages, prices, production and consumption are only set for one period at the time. Households now have the opportunity to save or borrow so as to transfer consumption between periods. In any single period, the trade balance can differ from zero, so that the country as a whole borrows or saves at the international financial market, to an exogenous nominal interest rate in foreign currency, denoted $i^* > 0$. Yet the intertemporal budget restriction of the households imply that trade is balanced over time. The instrument of the central bank is now the nominal interest rate on domestic currency.

There will be a steady state equilibrium of the infinite horizon model that corresponds to the equilibrium of the static model, where trade surplus is zero, the exchange rate and the

price level are constant (the world market price of traded goods, P^* , is assumed to be constant over time), and where the home nominal interest rate is equal to the foreign one. To derive the outcome of the wage negotiations in a steady state equilibrium, it is necessary to specify agents' perceptions of the consequences of a one-period deviation from steady state. I assume that when wage setters contemplate the consequences of a one-period deviation from steady state equilibrium, they expect the economy to return to its original steady state equilibrium in the subsequent period.⁵ This assumption implies that the wage negotiations can be modelled just as in the static case.

Aggregate consumption expenditure can be written as a function of contemporaneous and steady state income, and the real interest rate, according to

$$(31) \quad \frac{B_t}{P_t} = Y_t^\delta (Y_i)^{1-\delta} (1+r_{t+1})^{-\sigma} \alpha^{-\sigma}, \quad \text{where } \sigma > 0, 0 < \delta < 1, \alpha = \frac{1}{1+i^*},$$

where $B = P^N C^N + P^T C^T$ denotes per period nominal consumption expenditure, Y_t is current year aggregate output, Y_i is steady state aggregate output under monetary regime i , δ is the elasticity of current consumption expenditure with respect to current income, and r_{t+1} is the real interest rate, given by $(1+r_{t+1}) = (1+i_{t+1})P_t/P_{t+1}$. σ can be interpreted as the intertemporal elasticity of consumption. Note that in steady state equilibrium, $Y_t = Y_i$, $P_t = P_{t+1}$ and $i_t = i^*$, so that $(1+r_{t+1}) = 1/\alpha$ and $B_t/P_t = Y_t$, implying that trade surplus is zero.

⁵ In general, a deviation from steady state equilibrium in the wage setting, e.g. marginally higher wages in the non-traded sector, will affect households' wealth, implying that the economy does not return to the same steady state equilibrium as it was in prior to the deviation. The magnitude of the effect via households' wealth is, however, likely to be small, and to simplify the analysis, I neglect this effect.

Monetary policy

The relationship between the nominal interest rate and the nominal exchange rate is given by the uncovered interest parity condition, which in log form reads

$$(32) \quad s_t - E[s_{t+1}|t] = i^* - i_{t+1},$$

where $E[s_{t+1}|t]$ is the expected nominal exchange rate in period $t+1$, as viewed from period t . Under an exchange rate target, the market expects the target to be reached in the subsequent period, so that $E[s_{t+1}|t] = s^G$. To ensure that the exchange rate target is reached in period t , the central bank must always set the nominal interest rate equal to the nominal interest rate on foreign currency, $i_{t+1} = i^*$. Thus a deviation in the wage setting will not affect the interest rate set by the central bank.

Under a target for consumer prices, a deviation in the wage setting will trigger a change in the interest rate, so as to ensure that the price target is nevertheless fulfilled. (For sake of brevity, I do not consider a target for non-traded prices in the infinite horizon version.) If, say, nominal non-traded wages is above its steady state value, inducing an increase in non-traded prices, the central bank must counteract this by raising the interest rate, which also leads to an appreciation of the nominal exchange rate. As the deviation is only for that period, the nominal exchange rate is expected to be back at its equilibrium value in the next period. The effect on the nominal exchange of a marginal change in the nominal interest rate di_{t+1} follows directly from the uncovered interest parity condition (32)

$$(33) \quad ds_t = - di_{t+1} = dp^T.$$

Wage setting in the infinite horizon version

The analysis of the wage setting is just as in the static model, and the first order condition for the Nash bargain can be solved for the consumer real wage as in (18). The only difference from the static model is that the effect of a marginal wage rise on the various prices is different under infinite horizon. It turns out that all signs, as well as the intuition of the results, are the same as in the static case. For sake of brevity, I only summarise the results in the main text, the derivation is shown in the appendix.

Exchange rate target

Under an exchange rate target, $dp^T = di = 0$, and $dp = \gamma_i dp^N$. We obtain

$$(34) \quad \frac{dp}{dw^T} = \frac{-\gamma_s \beta \delta (1 - \gamma_s)}{\beta + \rho(1 - \beta) - \delta \beta \gamma_s - (1 - \beta)(\rho - \sigma) \gamma_s} < 0.$$

$$(35) \quad \frac{dp^N}{dw^N} = \frac{\beta(1 - \delta \gamma_s)}{\beta + \rho(1 - \beta) - \delta \beta \gamma_s - (1 - \beta)(\rho - \sigma) \gamma_s} > 0,$$

$$(36) \quad \frac{dp}{dw^N} = \frac{\gamma_s \beta (1 - \delta \gamma_s)}{\beta + \rho(1 - \beta) - \delta \beta \gamma_s - (1 - \beta)(\rho - \sigma) \gamma_s} > 0.$$

Consumer price target

Under a target for the consumer price level, we have $dp = 0$, so that $\gamma_i dp^N = -(1 - \gamma_i) dp^T = (1 - \gamma_i) di_t$. We obtain

$$(37) \quad \frac{dp^T}{dw^T} = \frac{\gamma_p \beta \delta (1 - \gamma_p)}{\beta + \rho(1 - \beta) - \beta \gamma_p - (1 - \beta)(\rho - \sigma) \gamma_p} > 0.$$

$$(38) \quad \frac{dp^N}{dw^N} = \frac{(1 - \gamma_p) \beta (1 - \delta \gamma_p)}{\beta + \rho(1 - \beta) - \beta \gamma_p - (1 - \beta)(\rho - \sigma) \gamma_p} > 0.$$

Numerical simulations of the infinite horizon version

In general it is not possible to rank the regimes analytically in the infinite horizon version.

However, numerical simulations of the infinite horizon model are presented in Table 2. The

general picture is much the same as in the static model. An exchange rate target involves higher wages in the non-traded sector, and slightly lower wages in the traded sector, than does a price target. Otherwise, a price target regime is superior.

Table 2: Numerical simulations of the infinite horizon model

	Cobb-D. $\gamma = 0.5$	Cobb-D. $\gamma = 0.5$	$\rho = 2$ $\gamma = 0.5$	$\rho = 2$ $\gamma = 0.5$	$\rho = 2$ $\gamma = 0.75$	$\rho = 2$ $\gamma = 0.75$
Var.\Reg.	Price	Exch.	Price	Exch.	Price	Exch.
W^N/P	0.99	1.66	0.79	0.99	0.74	1.04
W^T/P	0.67	0.65	0.65	0.64	0.67	0.64
P^N/P^T	1.30	1.87	1.10	1.24	1.39	1.66
$\gamma^i, i = P, S$	0.5	0.5	0.48	0.45	0.68	0.64
L	3.71	1.71	5.49	4.23	4.86	2.69
Y	4.43	2.39	5.85	4.84	5.24	3.44
Y^N	1.96	0.92	2.65	1.93	3.26	1.90
Y^T	2.55	1.72	3.21	2.96	2.10	1.76
$V = Y - L v_0$	2.58	1.54	3.11	2.72	2.81	2.10
U^N	0.73	0.56	0.68	0.71	0.78	0.76
U^T	0.39	0.18	0.48	0.40	0.28	0.19
π^N	0.74	0.40	0.93	0.72	1.19	0.74
π^T	0.74	0.40	1.02	0.89	0.55	0.41

Notes: In all simulations, $\beta = 2/3$, $v_0 = 0.5$, $\sigma = 0.02$, $\delta = 0.5$. In the figures for household and union utility, V and U^j , the constant term $M^j v_0$ is left out.

V. Concluding remarks

In the economics literature on monetary regimes, the natural rate hypothesis is usually taken as given; there are unique levels of output and employment (unemployment) that are unaffected by the monetary policy. The main argument of the present paper is that under non-atomistic wage setting, neutrality of money (in the sense that the price or exchange rate level, or the rate of inflation, have no effect on real variables) is not that same as neutrality of the monetary regime. In the present model money is neutral: it can easily be verified that in the static model, the real equilibrium is unaffected by the price or exchange rate level, and in the infinite horizon model, the real equilibrium would not be affected by a constant rate of inflation and depreciation. Yet the choice of monetary regime affects the equilibrium rate of unemployment. The reason is that the outcome of a wage negotiation depends on the slopes of the trade-offs between consumption real wages and employment, and between consumption real wages and profits. Under wage negotiations for large groups of workers, the slopes of these trade-offs depend on the monetary regime.

In the present model, traded sector wages are likely to be higher under a consumer price target than under an exchange rate target. The reason is that an increase in traded sector wages has a dampening effect on non-traded prices (via a negative income effect in the demand), and under a price target the dampening effect on non-traded prices provides room for a depreciation of the currency. The depreciation mitigates the negative effects on employment and profits of a wage rise, leading wage setters to agree on a higher wages. Traded sector wages are likely to be even higher under a target for non-traded prices, as there will then be more scope for a depreciation if traded sector wages increase. On the other hand, wages in the non-traded sector are likely to be higher under an exchange rate target than under a price target. Under an exchange rate target a wage rise in the non-traded sector is fully reflected in non-traded prices as well as in the consumer prices. Although wage setters dislike

the increase in the consumer prices, this is outweighed by the increase in non-traded prices, which mitigates the negative effects on employment and profits of a wage rise. Non-traded prices are likely to be lower under a target for non-traded prices, as there is then no scope for shifting a wage rise into higher non-traded prices.

An important consequence of the model is that the monetary regime affects relative prices and the sectoral structure of the economy. Higher non-traded wages under an exchange rate target implies that non-traded prices are higher, relative to the price of traded goods, even in steady state equilibrium where foreign trade is balanced. Furthermore, the traded sector is likely to constitute a greater part of the total economy under an exchange rate target than under a price target, because under an exchange rate target low traded sector wages stimulate production in the traded sector, while high non-traded wages dampen production in the non-traded sector. This is in contrast to the common view (e.g. Svensson, 1997) that in the long run monetary policy cannot affect real variables, nor can it affect the relative price of traded versus non-traded goods.

The results depend on the wage setting being non-atomistic. If wage setting is sufficiently decentralised so that the aggregate variables are exogenous to the individual wage setter, then the regimes are identical in the present model. The assumption that wage setting is completely centralised within the traded and non-traded sectors is made for analytical and pedagogical purposes. However, in many European countries, some wage setters are big enough to have a non-negligible impact on aggregate variables. There are powerful trade unions concentrated in industries that belong to the traded sector, and others in industries that belong to the non-traded sector. This suggests that the effects studied in this paper also are of considerable empirical relevance.

An interesting extension of the model would be to endogenise the capital stock. Although a proper analysis is outside the scope of the present paper, it seems likely that some

of the results of the paper might be exacerbated. A high real wage in one sector implies that the return to capital is low, leading to less investment in this sector. It seems likely that under an exchange rate target, capital would flow out of the high-wage non-traded sector and in to the low-wage traded sector, and thus further reducing non-traded production while traded production is increased. Under a price target, and in particular a target for non-traded prices, capital would flow in the opposite directions.

The results of the numerical simulations are favourable to a consumer price target regime, as this regime involves higher aggregate output and higher household utility. Now one should be very careful in drawing policy conclusions from numerical simulations of a stylised model as in the present paper. However, it appears that the main reason for this result is that an exchange rate target provides insufficient incentive to wage restraint in the non-traded sector. A possible policy implication is that countries with powerful unions in the non-traded sector should adopt a price target rather than an exchange rate target. Correspondingly, a target for non-traded prices provides little incentive to wage restraint in the traded sector, which might be a problem in a country with powerful unions in this sector.

The results of the present paper should also be of interest for a country with strong unions that is contemplating to enter EMU (Sweden is an obvious example). For a single country, EMU involves an exchange rate target, in the sense that a wage rise in the non-traded sector will feed into higher non-traded prices with negligible reaction from the central bank. Thus, the argument in this paper indicates that membership in the EMU may lead to higher equilibrium rate of unemployment (as also argued by Soskice and Iversen, 1998, and Cukierman and Lippi, 1999b) than an independent inflation target. However, an effect not identified by Soskice and Iversen (1988) and Cukierman and Lippi (1999b) is that membership in the EMU will lead to wage moderation in the traded sector, and thus strengthen in this sector. Numerical simulations suggest that unions in the non-traded sector

benefit from an exchange rate target (EMU), and employers in the traded sector may also do this, while other agents lose.

There are also other mechanisms, not analysed in the present paper, which might involve an effect of the monetary regime on the equilibrium rate of unemployment. This is most obvious for EMU membership, which involves many additional effects not analysed in the present paper (see e.g. Calmfors, 1998). But it also applies to a monetary regime chosen by one country individually. There is considerable empirical evidence suggesting that the equilibrium rate of unemployment depends on the degree of co-ordination in the wage setting (see e.g. Calmfors, and Driffill, 1988, and Layard et al, 1991). The monetary regime is one variable that might affect whether and to what extent co-ordination is likely to take place (cf. Holden, 1991, 1999, and Rødseth (1997)).

Appendix

To derive the effect of a wage rise on the various prices, we explore the effect on the market for non-traded goods. Substituting out in (19) for (5a), (3) and (9), we obtain (in log form)⁶

$$(A1) \frac{\beta}{1-\beta} (p^N - w^N) - \ln \beta = \ln \gamma_i - \rho(p^N - p) \\ + \ln(((e^{p^T})^{1/(1-\beta)} (e^{w^T})^{-\beta/(1-\beta)} \beta^{-1} + ((e^{p^N})^{1/(1-\beta)} (e^{w^N})^{-\beta/(1-\beta)} \beta^{-1} / e^p))$$

By total differentiation with respect to wages and prices, and rearranging, we get

$$(A2) (\beta + \rho(1-\beta) - \gamma_i) dp^N - \beta(1-\gamma_i) dw^N = (1-\gamma_i) dp^T - \beta(1-\gamma_i) dw^T - (1-\beta)(1-\rho) dp$$

⁶ To derive (A1), observe that (using (3) and (9))

$$\ln Y = \ln((P^T Y^T + P^N Y^N) / P) = \ln(((e^{p^T})^{1/(1-\beta)} (e^{w^T})^{-\beta/(1-\beta)} \beta^{-1} + ((e^{p^N})^{1/(1-\beta)} (e^{w^N})^{-\beta/(1-\beta)} \beta^{-1} / e^p))$$

Consider first the effect of a marginal increase in w^T under an exchange rate target. Thus, we set $dp^T = dw^N = 0$, so that (A2) simplifies to

$$(A3) \quad (\beta + \rho(1 - \beta) - \gamma_i)dp^N = -\beta(1 - \gamma_i)dw^T - (1 - \beta)(1 - \rho)dp$$

To solve for the effect on consumer prices, we need to substitute out for dp^N . From the definition of the consumer price level (4), total differentiation yields (in log form)

$$(A4) \quad dp = \gamma_i dp^N + (1 - \gamma_i) dp^T,$$

Under an exchange rate target, the price of traded goods is constant, so that there is a simple relationship between changes in prices on non-traded goods and changes in consumer prices

$$(A5) \quad dp = \gamma^i dp^N.$$

Substituting out for dp^N in (A3), using (A5), and rearranging, we obtain (21) in the main text. (22) and (23) are derived correspondingly.

Consider then the effect of a marginal increase in w^T under target for consumer prices. Thus, we set $dp = dw^N = 0$, so that (A2) simplifies to

$$(A6) \quad (\beta + \rho(1 - \beta) - \gamma_i)dp^N = (1 - \gamma_i)dp^T - \beta(1 - \gamma_i)dw^T$$

Under a consumer price target, the central bank must set the exchange rate so that changes in the prices of traded and non-traded goods balance each other, that is, $dp = 0$, which from (A5) entails that

$$(A7) \quad \gamma_i dp^N = -(1-\gamma_i) dp^T.$$

Substituting out for dp^N in (A6), using (A7), we obtain (24) in the main text. (25) is derived correspondingly.

Consider finally the effect of a marginal increase in w^T under a target for non-traded prices. We set $dp^N = dw^N = 0$, so that (A2) simplifies to

$$(A8) \quad 0 = (1-\gamma_i)dp^T - \beta(1-\gamma_i)dw^T - (1-\beta)(1-\rho)dp$$

Setting $dp^N = 0$ in (A4), we obtain $dp = (1-\gamma_i)dp^T$, and by substituting out in (A8) we obtain (26) and (27). (28) is derived correspondingly.

The infinite horizon version

If a deviation from steady state equilibrium takes place in the wage negotiations, supply of traded and non-traded goods are still given by (9). However, the market clearing condition (19) gives output and prices in the non-traded sector. Substituting out for (3), (9) and (32), and letting lower case letters denote natural logarithm (except for the interest rate, where I use the approximation that $\ln(1+i) \approx i$), (19) implies that

$$(A9) \quad (\beta/(1-\beta))(p^N - w^N) = \ln(\gamma) - \rho(p^N - p) + \delta y + (1-\delta)y_1 - \sigma(i - p_{t+1} + p),$$

Total differentiation of (A9) yields (y_i and p_{t+1} are kept constant equal to their steady state equilibrium values):

$$(A10) \quad \frac{\beta}{1-\beta}(dp^N - dw^N) = -\rho(dp^N - dp) + \delta\gamma_i \left(\frac{1}{1-\beta} dp^N - \frac{\beta}{1-\beta} dw^N \right) \\ \delta(1-\gamma_i) \left(\frac{1}{1-\beta} dp^T - \frac{\beta}{1-\beta} dw^T \right) - \delta dp - \sigma(di + dp)$$

(A10) can be rearranged to

$$(A11) \quad (\beta + \rho(1-\beta) - \delta\gamma_i)dp^N - \beta(1-\delta\gamma_i)dw^N = \delta(1-\gamma_i)dp^T - \beta\delta(1-\gamma_i)dw^T \\ + (1-\beta)(\rho - \delta - \sigma)dp - \sigma(1-\beta)di$$

(A11) shows the relationship between changes in prices and wages that must hold if the non-traded goods market is to be cleared. The results in the main text can now be derived just as in the static version

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