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NOMINAL WAGE FLEXIBILITY, WAGE INDEXATION AND MONETARY UNION*

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Membership in a monetary union implies stronger incentives for nominal wage flexibility in the form of wage indexation and shorter contract length than non-membership. This counteracts the stabilisation policy cost of giving up monetary independence. But more wage flexibility is only an imperfect substitute for an individual monetary policy. It is possible that an increase in wage flexibility is welfare-decreasing because of the accompanying rise in price variability. The interaction between wage setting and central bank behaviour may result in either multiple equilibria or a unique full-indexation equilibrium.

Asymmetric (country-specific) shocks play an important role in the theory of optimal currency areas. It is a common hypothesis that macroeconomic variability increases with the formation of a monetary union because of the loss of national monetary policy as a stabilisation tool to counter such shocks. This aspect has featured prominently in the discussion on the Economic and Monetary Union (EMU) in Europe. The effects of asymmetric shocks have recently been analysed by, e.g., Coricelli *et al.* (2000) and Lane (2000) in models with nominal wage rigidity. A key issue is, however, how monetary union affects the incentives for other adjustment mechanisms that can substitute for national monetary policy. We analyse whether increased nominal wage flexibility can play such a role. More precisely, we ask the *conditional* question: if membership in a monetary union tends to increase macroeconomic variability, to what extent do nominal wages become more flexible? This issue has so far been dealt with mainly in reduced-form models of labour market reform; see e.g. Sibert and Sutherland (2000), Calmfors (2001) or Bentolila and Saint-Paul (2001).

There are several ways of thinking about nominal wage rigidity. A first set of explanations emphasises general difficulties of changing nominal wages: the reasons may be social norms against wage cuts (Akerlof and Yellen, 1990; Bewley, 1998), menu costs (Blanchard and Kioyotaki, 1987; Ball and Romer, 1991), that past nominal wage levels act as fall-back positions in new bargaining (Holden, 1997), or that insiders have a small interest in wage flexibility, as employment variations fall largely on outsiders (Gottfries, 1992). A second approach stresses the existence of predetermined contract periods, the length of which depends on a trade-off between contract and variability costs (Gray, 1978; Ball, 1987; Calmfors

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and Johansson, 2004). A third approach focuses on the incentives for contingent rules, viz. indexation, as a way to achieve nominal wage flexibility during contract periods (Gray, 1976; Blanchard, 1979; Ball, 1988; Van Hoose and Waller, 1991; Hutchison and Walsh, 1998).

Our main focus is on how monetary union (EMU for short) affects the incentives for wage indexation but we also analyse the effect on contract length. As different types of nominal wage rigidity depend on similar factors, this analysis highlights how wage flexibility in general is likely to be influenced. But the analysis of wage indexation and contract length is also interesting in its own right. It is well known that high inflation is conducive both to wage indexation arrangements (Duca and Van Hoose, 1998) and to nominal wage flexibility in general (Ball *et al.*, 1988). Hence, it is not surprising that wage indexation was abolished in the 1980s and early 1990s in some European countries, such as Denmark, Italy, the Netherlands, and Sweden, at the same time as inflation was brought down. But it is also noteworthy that in Europe it is only in some EMU countries that wage indexation persists. Belgium, Luxembourg, Finland and Spain are such cases. In the two latter countries indexation arrangements seem to have become more common after the entry into the EMU (*Inkomstpolitiskt avtal*, 2000; OECD, 2001). More formal evidence is provided by Gagnon (2005), who finds that the influence of past inflation on wage increases has increased and wage stickiness decreased in most EMU countries as opposed to non-members. This suggests that, holding the average rate of inflation over the business cycle constant, membership in a monetary union may imply stronger incentives for wage indexation than non-membership.

We set up a model without any inflation bias of monetary policy neither outside nor inside the EMU. This is a reasonable characterisation of central bank behaviour in today's Western Europe, where non-EMU countries, such as Denmark, Norway, Sweden, Switzerland and the UK, have been as successful as the euro countries in holding down inflation. Under reasonable parameter values, our model does indeed imply more nominal wage flexibility inside than outside the EMU. In the presence of indexation costs, wage setters might choose non-indexation outside the EMU but indexation inside. Similarly, EMU membership is likely to reduce contract length. More nominal wage flexibility inside than outside the EMU is, however, at best an imperfect substitute for a national monetary policy. Increased nominal wage flexibility may even be socially undesirable: although employment and real wage variability is reduced, the welfare gain from this could be outweighed by the welfare loss from more price variability. Socially optimal indexation is always lower than equilibrium indexation in our model. Hence, the more centralised the decisions on indexation are, the less likely it is. This conclusion squares well with the fact that the earlier abolition of indexation in, for example, Denmark, Italy and the Netherlands, was associated with government intervention.

Section 1 sets up the basic model. Section 2 derives equilibrium indexation inside and outside the EMU in the absence of indexation costs. Section 3 analyses the likelihood of indexation versus non-indexation equilibria when there are indexation costs. Section 4 discusses the social welfare consequences of indexation. Section 5 shows that contract length can be analysed in a similar way as indexation. Section 6 concludes.

1. The Model

The theory of wage indexation originated with Gray (1976) and Fischer (1977). It starts out from the premise that wage contracts usually are concluded in advance for a certain time period and that renegotiation of the contracts is costly. If wages in the contract are indexed to the consumer price index (CPI) – as has been done in many countries – this provides a way of adjusting the nominal wage to unanticipated events without renegotiation. Most of the literature has focused on the incentives to stabilise employment in such contracts. With nominal demand shocks, wage setters prefer full indexation to the CPI, as this stabilises the real wage and thus also employment. In the case of real supply shocks, wage setters want lower indexation, possibly zero, because this leads to real wage changes that offset the direct employment effects of the shocks. When both types of shocks occur, partial indexation is optimal. Other work raised the possibility of fixed costs of indexation, which might imply that the stabilisation gains are not large enough to motivate indexation (Gray, 1978; Ball, 1988). Some of the work has also emphasised the similarity between the problem of choosing the degree of indexation and that of choosing contract length (Gray, 1978; Ball, 1988).

Later work by e.g. Waller and Van Hoose (1989, 1992), Ball and Cecchetti (1991), Van Hoose and Waller (1991), Milesi-Ferretti (1994), Walsh (1995), Hutchison and Walsh (1998) and Heinemann (1999) has analysed the interaction between wage indexation and monetary policy. The earlier insight that the incentives for wage indexation are weaker the larger is supply-side variability remains. This may be an additional explanantion of the abolition of earlier indexation schemes in some European countries in the 1980s, after they were hit by serious supply shocks.

Most of the literature has modelled closed economies, although there are exceptions, such as Flood and Marion (1982), Marston (1982), Turnovsky (1983), Aizenman (1985), Aizenman and Frenkel (1985) and Bryson *et al.* (1998). Leichter (1998) analysed the impact of monetary union on the incentives for indexation and concluded that they would be strengthened. The reason is that a common monetary policy does not stabilise country-specific supply shocks; hence the cost of indexation in terms of reducing the effectiveness of monetary policy to stabilise supply shocks becomes lower. The analysis assumes that all countries produce a homogenous good, so that no real exchange rate changes occur.

We focus on the open-economy aspects of the analysis of nominal wage flexibility by explicitly distinguishing between three rather than two types of shocks: real supply, real demand and nominal exchange rate shocks.[1] This modelling of shocks is important for a proper comparison between membership and non-membership in a monetary union. Unlike most of the earlier literature, we also emphasise the objective of stabilising the real consumption wage on the part of wage setters as this seems to be a key concern in reality; see e.g. Calmfors *et al.* (2001).[2] A novel feature

[1] Saint-Paul and Bentolila (2001) analysed *inter alia* how nominal wage flexibility is affected by EMU membership but their results are hard to interpret because no distinction is made between nominal exchange rate and real demand shocks.

[2] Ball and Cecchetti (1991), Milesi-Feretti (1994), Hutchison and Walsh (1998) and Heinemann (1999) do, however, analyse real-wage objectives as well.

of our analysis is that we model carefully which types of equilibria are possible. There are multiple indexation equilibria under some circumstances, whereas there is only a unique full-indexation equilibrium under other circumstances.

1.1. *Basic Model Structure*

We assume a small open economy, which may either have its own currency or be in a monetary union with the rest of the world. The economy produces a domestic good and consumes both this good and a foreign good. As our interest is in how asymmetric shocks affect wage setting in different monetary regimes, we neglect symmetric (common) shocks to all countries, and focus on domestic productivity and demand shocks, as well as on exchange rate shocks (which by definition only occur when the economy is outside the EMU). This set-up allows us to focus on the *differences* in wage flexibility and macroeconomic variability between membership and non-membership in a monetary union.[3] One can read our analysis as one of how countries like Sweden, the UK, the Czech Republic, Hungary or Poland might be affected by joining the EMU.

Monetary policy is modelled in a stylised fashion. Outside the EMU, the domestic central bank pursues its own monetary policy, which influences the exchange rate. Inside the EMU, the exchange rate of the small open economy is irrevocably fixed, so there is no monetary policy that can react to country-specific shocks.

The model has the following time structure. Wage contracts are concluded before the realisations of all shocks. Outside the EMU, the domestic central bank acts after demand and supply shocks but before exchange rate shocks. These assumptions imply that outside the EMU there is scope for using domestic monetary policy to counter real supply and demand shocks but not exchange rate shocks. The idea is to capture the 'stylised fact' that central banks have only limited possibilities of influencing exchange rates.

1.2. *The Structure of the Economy*

Output is produced by a continuum of identical perfectly competitive firms indexed on the interval [0, 1]. Firm i has a Cobb-Douglas production function

$$y_i = al_i + \theta, \tag{1}$$

where y_i is output, l_i is employment, θ is a productivity shock, which is common to all firms, and $0 < a < 1$ is the elasticity of output with respect to employment. All lower-case variables are logs.

Profit maximisation gives employment in firm i as

$$l_i = -\frac{1}{1-a}(w_i - p - \ln a - \theta), \tag{2}$$

where w_i is the nominal wage in the firm and p is the price of the domestic good.

[3] Our small-open-economy assumption is very stylised but allows more focus on the endogenous determination of nominal wage flexibility than would be possible in a model with two countries, where interdependencies would greatly complicate the analysis; see e.g. Bryson *et al.* (1998).

Wage setting occurs in a decentralised way with separate wage contracts in each firm. A wage contract applies for an exogenously given time period and is concluded before shocks are realised. A contract has two components. It determines: (*i*) a nominal base wage, w_{i0}, which is set on the basis of expected prices; and (*ii*) an indexation parameter, b_i, which indexes the nominal wage to unexpected changes in the CPI, p_c, as a way of making the actual wage during the contract period contingent on the realisation of shocks. This gives

$$w_i = w_{i0} + b_i(p_c - p_c^e), \tag{3}$$

where the e superscript indicates expected variables. It is well known that, in the absence of contract costs, such a wage contract is not optimal: the first-best solution would be to index wages to the shocks themselves (Blanchard, 1979). However, real-world contingent wage contracts almost without exception have the above form. A plausible reason is that indexation to the CPI may offer a second-best solution: contract costs are held down because of the simplicity of the indexation scheme and because CPI changes – as opposed to the underlying shocks themselves – are easy to verify for both firms and employees (trade unions).[4]

A local wage setter has the quadratic loss function

$$L_i^{TU} = l_{it}^2 + \gamma(w_i - p_c - \phi)^2 + \delta p_c^2. \tag{4}$$

A wage setter thus wants to minimise the fluctuations of employment and the real consumption wage around target levels, which we set to zero for employment and to ϕ for the real consumption wage. The postulated loss function, which is analytically convenient, shares the weakness with most of the indexation literature that it is not explicitly derived from assumptions on the bargaining process and the wage-setting preferences of firms and employees (trade unions). The two first arguments in the loss function can, however, be interpreted as a simple representation of the idea that unions care about both real wages and employment for their members, whereas firms want as low wages as possible in order to maximise their profits.[5] Wage setters are also assumed to experience disutility from variations in the CPI, which in our one-period framework are equivalent to changes in the rate of inflation.[6] The main motivation for this assumption is that the preoccupation of central banks with inflation is difficult to understand unless employees, who make up the majority of the population, are also concerned with inflation; see e.g. Cukierman and Lippi (1999).[7] γ and δ are the relative weights for real wage and price variability, respectively.

[4] Because of its theoretical underpinnings as a measure of the cost of living, the CPI is widely regarded as the most reliable price index. Substantial resources are usually invested in the construction of it, and in many countries there are formalised procedures for how the decisions on index numbers should be taken (often by specific index boards).

[5] In the theoretical literature on trade unions and wage bargaining, wages and employment are standard arguments in union utility functions; see e.g. Naylor (2003).

[6] If we set the preceding period's CPI level to zero, our formulation is equivalent to entering inflation into the loss function.

[7] Note, however, that the inclusion of inflation in the wage setters' preference function in additive form does not make any difference for decisions on the base wage and the indexation parameter in our model – but only for welfare evaluations – because of the assumption of decentralised wage setting, which means that each local wage setter takes inflation as exogenous.

The CPI is

$$p_c = \alpha p + (1 - \alpha)e, \tag{5}$$

where α is the weight of domestic goods in consumption and the foreign price has been normalised to zero.

Aggregate supply is $y^S = \int_0^1 y_i \mathrm{d}i$. Aggregate demand for the domestic good, y^D, depends on the real exchange rate, $e - p$, where e is the nominal exchange rate, and on a stochastic real demand shock, v. β is the elasticity of demand for domestic goods with respect to the real exchange rate. Hence, we have:

$$y^D = \beta(e - p) + v. \tag{6}$$

It is well known that, with a given foreign real interest rate and a given expected future exchange rate, there is a one-to-one relationship between the domestic real interest rate and the real exchange rate under uncovered interest parity; see e.g. Krugman and Obstfeld (2002). Hence, one can think of (6) as a reduced form covering the effect of both the real exchange rate and the real interest rate on demand for domestic products.[8] Inside the EMU, the nominal exchange rate, e, is irrevocably fixed. Outside the EMU, where there is a domestic monetary policy, this can be characterised by an intermediate exchange rate target, e^{CB}, which we shall refer to as the monetary policy instrument; see also Bentolila and Saint-Paul (2001) or Bergvall (2002). The actual exchange rate outside the EMU varies around the desired level due to exchange rate shocks. We thus have

$$e = e^{CB} + \xi, \tag{7}$$

where ξ is a *nominal* shock. The central bank has the loss function

$$L^{CB} = (l - l^*)^2 + \lambda p_c^2, \tag{8}$$

where $l = \int_0^1 l_i \mathrm{d}i$, l^* is the bank's employment target, and λ is the relative weight for price variability. The central bank is thus assumed to care only about inflation and employment, which is the standard assumption in the huge literature on inflation and central bank behaviour.[9] We set $l^* = l^e$, i.e. the bank's employment target is equal to the expected employment level. This assumption rules out any inflation bias of monetary policy of the Barro-Gordon type, which we find reasonable to do in an analysis of Western Europe today.[10] This allows us to hold the expected inflation rate constant across monetary regimes and to focus only on

[8] Such reduced forms with microeconomic underpinnings have been derived by e.g. Svensson (1998, 2000) and McCallum and Nelson (1999). See also Bergvall (2002). The reason why domestic real income = output, y^S, does not appear on the RHS of (6) is that the equation is a reduced form where $y^D = y^S$ has been solved out.

[9] As output and employment are linked through the production functions, it is, of course, equivalent whether we have employment or output in the central bank loss function. According to Svensson (1997), central banks that formally have only an inflation target also behave *in practice* as if they have a preference function like (8). One reason is that the inflation target usually applies over the medium term, so that deviations from it only have to be corrected gradually.

[10] According to the analysis of Barro and Gordon (1983), the inflation bias is proportional to the difference between the employment (output) target of monetary policy makers and the natural rate (= the expected rate).

the implications of monetary union *per se* on nominal wage flexibility: technically we do this by setting the irrevocably fixed exchange rate inside the EMU equal to the expected rate outside.

The three shocks are all i.i.d. with zero means and known variances: σ_θ^2, σ_v^2, and σ_ξ^2.

1.3. *Price Determination*

By equating aggregate supply and demand, and using the wage formula (3), we obtain:

$$\begin{aligned} p = {} & \frac{(1-a)\beta}{a+\beta(1-a)} e + \frac{a}{a+\beta(1-a)}(w_0 - \ln a) \\ & + \frac{ab}{a+\beta(1-a)}(p_c - p_c^e) + \frac{(1-a)}{a+\beta(1-a)} v - \frac{1}{a+\beta(1-a)}\theta, \end{aligned} \tag{9}$$

where $w_0 = \int_0^1 w_i \mathrm{d}i$ is the aggregate base wage and $b = \int_0^1 b_i \mathrm{d}i$ is aggregate indexation.

From (9) and (5), we obtain:

$$\begin{aligned} p_c - p_c^e = {} & \frac{(1-\alpha)a + (1-a)\beta}{a+\beta(1-a)-ab\alpha}(e - e^e) + \frac{\alpha(1-a)v}{a+\beta(1-a)-ab\alpha} \\ & - \frac{\alpha\theta}{a+\beta(1-a)-ab\alpha}. \end{aligned} \tag{10}$$

1.4. *Monetary Policy*

Outside the EMU, the central bank sets its monetary policy instrument e^{CB} so as to minimise the expectation of the loss function (8) subject to (2),(3),(5),(7),(9),(10), and the definitions of w_0,b, and l. When the bank acts, it knows the realisations of w_0, b, θ and v, and responds to them in a discretionary way.[11]

From the FOC we can derive the policy response function of the central bank:

$$e^{CB} = q + H\theta + Kv, \tag{11}$$

where q is an uninteresting constant and H and K are given in Appendix A.1. H and K cannot be unambigously signed, but for all the parameter values we use $H > 0$ and $K < 0$.

Consider first a negative demand shock. $K < 0$ then implies that monetary policy is eased with the aim of depreciating the currency. This can be understood as follows. With a constant exchange rate, the output price falls. This causes both employment and the CPI to fall. The bank responds by easing monetary policy. The optimal response is to limit the fall in employment by allowing a rise in the CPI.

[11] The assumption is thus that the bank cannot precommit to a policy rule, which would allow it to act as a Stackelberg leader, taking the responses of wage setters into account.

Consider then a negative supply shock. $H > 0$ then implies that monetary policy is tightened in order to appreciate the currency. The effects on employment and the CPI depends on parameter values. If β is sufficiently large, the optimal response of the bank is to allow a rise in the CPI and a fall in employment in this case, too.[12]

Inside the EMU there is no monetary policy in our model, since the exchange rate to the other EMU countries (the rest of the world) is then irrevocably fixed. More precisely, we then assume that $e = e^e = q$, i.e. that the irrevocably fixed exchange rate is equal to the expected exchange rate outside the EMU.

2. Wage Decisions with No Indexation Costs

2.1. *EMU Membership*

We first analyse wage contracts with EMU membership. We look at a symmetric Nash equilibrium where each local wage setter chooses w_{i0} and b_i, taking the aggregate base wage, w_0 and aggregate indexation, b, as given. The optimisation is made by minimising the expectation of (4) subject to (2), (3),(5),(10),(11) and $e = e^e = q$. Equilibrium aggregate indexation is obtained by setting $b_i = b$ as

$$b = \frac{(1-\beta) + [(1-a) + \gamma\alpha(1-a)^3]\sigma_1 + \gamma\alpha(1-a)}{\alpha + [\alpha(1-a) + \gamma\alpha(1-a)^3]\sigma_1 + \gamma\alpha(1-a)}, \tag{12}$$

where $\sigma_1 = \sigma_v^2/\sigma_\theta^2$ is the ratio between the variance of the demand shock and the variance of the supply shock.

Equation (12) shows the standard property that an increase in the relative variability of demand, σ_1, increases indexation. This follows from the objective to stabilise employment. Consider the extreme case when $\alpha = 1$ (only domestic goods are consumed), $\beta = 1$ (a unitary elasticity of demand with respect to the real exchange rate), and $\gamma = 0$ (wage setters do not care about the real consumption wage). Then $b = (1 - a)\sigma_1/[1 + (1 - a)\sigma_1]$, which is the expression for a closed economy derived by Gray (1976). Hence $b = 0$, if there are only supply shocks ($\sigma_v^2 = 0$). In this case, according to (9), $\mathrm{d}p = -\mathrm{d}\theta$. As employment in each firm depends on $w_i - p - \theta$, a supply shock hence causes a change in the real product wage, $w_i - p$, that exactly offsets the direct employment effect of the shock. With only demand shocks ($\sigma_\theta^2 = 0$), $b = 1$: in this case equally large price and wage changes keep the real product wage, and thus also employment, constant. When there are both types of shocks, there is partial indexation.

In the general case when $0 < \alpha < 1$, $\beta > 0$ and $\gamma > 0$, we have that $(1 - \beta)/\alpha \leq b \leq 1/\alpha$. Some indexation is then optimal also if there are only supply shocks.[13] As $b = 1$ stabilises the real consumption wage completely, indexation is closer to unity, the larger the weight for the real wage, γ. Indexation may also be

[12] The precise condition is $\beta > 1 - \alpha$. See van Hoose and Waller (1991), Waller and van Hoose (1992), Walsh (1995), Hutchison and Walsh (1998) and Leichter (1998) for similar analyses.

[13] If $\beta > 1$, the optimal indexation could be negative.

greater than unity. This happens with a small weight for the real wage and large relative demand variability. The reason is that domestic output makes up only part of the CPI. If a demand shock raises the output price by 1%, the percentage rise of the CPI is α; hence the indexation parameter must be $1/\alpha$ if the money wage is also to rise by 1% so as to leave the real product wage constant.

2.2. *Non-membership in the EMU*

As in the EMU case, we analyse a symmetric Nash equilibrium. Each wage setter sets w_{i0} and b_i so as to minimise the expectation of (4), taking w_0 and b as given. But wage setters now also take the possibility of exchange rate shocks as well as the domestic central bank's response function (11) into account when forming expectations.[14] The FOCs now give:

$$b_i = \frac{A + B\sigma_1 + C\sigma_2}{[1+\gamma(1-a)^2](D + E\sigma_1 + F\sigma_2)} + \frac{\gamma(1-a)^2}{1+\gamma(1-a)^2} = f(b), \qquad (13)$$

where in addition to earlier explained symbols $\sigma_2 = \sigma_\xi^2/\sigma_\theta^2$. A, B, C, D, E and F are all functions of b and are given in Appendix A.2.

Setting $b_i = b$ in (13) gives an equation for aggregate indexation. Indexation now depends on the relative importance of the *three* shocks: the ratio between the variances of the demand and the supply shocks, σ_1, and the ratio between the variances of the exchange rate and supply shocks, σ_2. The equation for aggregate indexation is a fifth-degree polynomial in b. Two possible sets of solutions are illustrated in Figure 1 by the intersections of the 45-degree line and the $f(b)$ curves, which represent the RHS of (13).

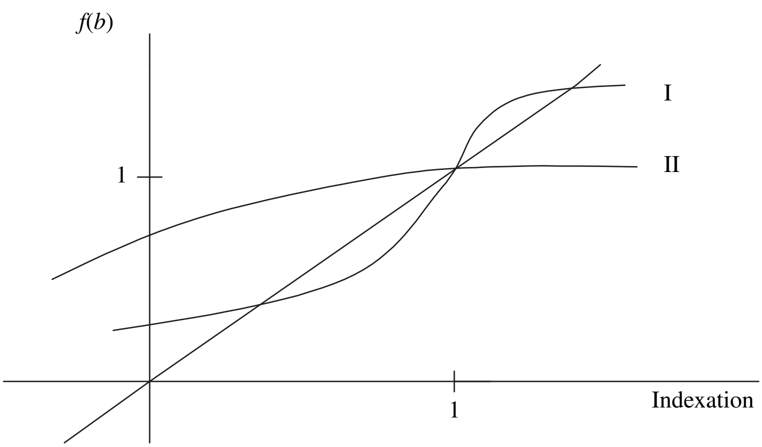

Fig. 1. *Equilibrium Indexation Inside the EMU*

[14] Note that each (local) wage setter takes only the response of monetary policy to shocks into account but assumes that policy is unaffected by the own wage decision. So, the equilibrium is a rational-expectations Nash equilibrium and not a Stackelberg equilibrium.

Curve I illustrates a case with three equilibria: there is then usually one with $0 < b < 1$, always one with $b = 1$, and usually one with $b > 1$. Curve II shows a case where $b = 1$ is the only equilibrium. The $b = 1$ equilibrium can be explained as follows. With $b = 1$, the central bank cannot affect the real product wage, $w - p$, as an exchange rate change leads to equal changes in the output price and the money wage. This makes the bank unable to influence employment. The best it can do is then to focus solely on price stability. Hence, the central bank offsets all effects on the CPI of real demand and supply shocks completely. All variations in the CPI are therefore due to exchange rate shocks. More precisely $p_c = \xi$, as shown in Appendix A.3. $b = 1$ is a Nash equilibrium because the best response of each local wage setter is then to set $b_i = 1$, as this insulates both the real consumption wage and employment from exchange rate shocks. This does not stabilise employment in the case of demand or supply shocks but there is no point in trying to do so through indexation, as these shocks do not move the CPI.[15]

With curve I, the $0 < b < 1$ and $b > 1$ equilibria in Figure 1 are both (dynamically) stable, whereas the $b = 1$ equilibrium is unstable.[16] In these cases, social welfare is the highest in the $0 < b < 1$ equilibrium. When there is only one equilibrium with $b = 1$, as with curve II, this equilibrium is always stable.

2.3. *Numerical Examples*

As general analytical results are difficult to derive, we resort to numerical examples. Throughout, we assume $a = \alpha = 0.7$, which are relevant values for most EU countries (Walsh, 1995; Hutchison and Walsh, 1998; Lane, 2001). We set $\beta = 0.5$ in most examples, which is consistent with conventional estimates of export and import elasticities, as reported in e.g. Krugman and Obstfeld (2002),[17] but we also report computations with $\beta = 1$ as an example of a possible future situation with more integrated markets than today. As to λ, Broadbent and Barro (1997) found a weight of inflation in the central bank's loss function of 3 for the US. We regard lower values of λ as more plausible, as we find it hard to believe in such a high weight on price stability in a credible low-inflation regime such as we have assumed.[18] Indeed, Bergvall (2002) estimated λs for a number of OECD countries in the interval 0.17–2.4 under recent periods of floating exchange rates and in the interval 0.82–2.49 in cases where explicit inflation targeting had been adopted. Based on this, we vary λ between 1 and 3 in our examples.

[15] The possibilities of multiple equilibria and a single $b = 1$ equilibrium are not specific to our open economy model. Similar results are obtained in closed-economy models with an optimising central bank if there is a nominal shock that policy cannot counter. This has not been recognised generally. See, however, Heinemann (1999) for an exception.

[16] Stability is then defined as local stability around the equilibrium if we impose a dynamic adjustment process according to which $\dot{b}_i = \phi[f(b) - b_i]$, where $\phi > 0$. A necessary condition for such stability is that the $f(b)$-curve is less sloped than the 45-degree line around the equilibrium.

[17] With export and import shares in GDP of 0.3, export and import elasticities of 0.8 correspond to $\beta = 0.48$. Lane (2000) also assumes $\beta = 0.5$. Bergvall (2002) estimates a demand equation like (6) for Sweden and finds point estimates of 0.49 and 0.45, respectively.

[18] If the employment goal equals equilibrium employment, so that there is no inflation bias, then there is no reason to appoint a conservative central banker in the Rogoff (1985) sense. One should then expect the weight of inflation in the central bank's preference function to equal the 'true' social weight.

As to the weight of the real wage in the wage setters' loss functions, $\gamma = 1$ is our main assumption but we also experiment with larger weights. We look at several shock patterns but they are all chosen so as to give larger macroeconomic variability inside the EMU than outside when nominal wages are rigid (zero indexation), so that there is a potential stabilisation cost of EMU membership.[19] In our Tables, the three shocks have equal variances in the first row. In the second row, the variance of the supply shock is twice the variance of the other shocks. In the third row, the variance of the demand shock is twice the variance of the other shocks, and in the fourth row the variance of the exchange rate shock is twice the variance of the other shocks.

Tables 1 and 2 give equilibrium indexation under various assumptions. When there are multiple equilibria outside the EMU, we focus on the partial-indexation equilibrium. This is regarded as a focal point both because it has reasonable characteristics (stability and the highest social welfare) and because partial indexation schemes have been the most common in practice. In a few cases, there are deviations from the described pattern. We then report the stable equilibrium with the lowest indexation, which is also the one with the highest welfare for wage setters.

Inside the EMU, indexation is always partial. When $\beta = 1$, indexation is around 0.5, but in our main case with $\beta = 0.5$ it is always close to unity. Outside the EMU, there are sometimes multiple equilibria and sometimes only one full-indexation equilibrium. The $b = 1$ equilibria are more common when (*i*) exchange rate

Table 1
Equilibrium Indexation when $\gamma = 1$

	Inside the EMU		Outside the EMU*					
	$\beta = 1$	$\beta = 0.5$	$\beta = 1$			$\beta = 0.5$		
Variances	$\lambda = 1, 2, 3$		$\lambda = 1$	$\lambda = 2$	$\lambda = 3$	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$
$\sigma_1 = \sigma_2 = 1$	0.46	0.90	0.52	0.57‡	1†	0.54‡	1†	1†
$\sigma_1 = \sigma_2 = 1/2$	0.36	0.85	0.34	0.24	0.21	0.37	1†	1†
$\sigma_1 = 2, \sigma_2 = 1$	0.62	0.99	0.48	0.48	1†	0.25	0.19‡	1†
$\sigma_1 = 1, \sigma_2 = 2$	0.46	0.90	0.79‡	1†	1†	1†	1†	1†

*Unless stated otherwise there are three equilibria: $0 < b < 1$, $b = 1$ and $b > 1$. The Table gives the stable equilibrium with the lowest indexation.
†This is the only equilibrium. It is stable.
‡There are three equilibria: two with $0 < b < 1$ and one with $b = 1$.

[19] See Section 4. Canzoneri *et al.* (1996) and Artis and Ehrman (2000) find nominal shocks to be the main determinant of exchange rate variability, whereas Clarida and Gali (1994) and Thomas (1997) find real shocks, especially demand shocks, to be important as well. Most studies agree that nominal (exchange rate) shocks are unimportant for relative output variability among countries, which is instead explained by real shocks, with supply shocks being the most important. Our assumptions are a compromise between the differing empirical results on relative output and exchange rate variability. Note that we have normalised nominal shocks to zero in the case of EMU membership. We have thus assumed away the possibilities of both monetary control errors by the ECB and exchange rate shocks vis-á-vis third countries. The real-world counterpart to exchange rate shocks in our model is thus the 'net difference in nominal shocks' between non-membership and membership.

Table 2
Equilibrium Indexation when $\beta = 0.5$

	Inside the EMU			Outside the EMU*					
	$\gamma = 1$	$\gamma = 2$	$\gamma = 3$	$\gamma = 1$			$\gamma = 2$		$\gamma = 3$
Variances	$\lambda = 1, 2, 3$			$\lambda = 1$	$\lambda = 2$	$\lambda = 3$	$\lambda = 1$	$\lambda = 2, 3$	$\lambda = 1, 2, 3$
$\sigma_1 = \sigma_2 = 1$	0.90	0.91	0.93	0.54	$1^\dagger$	$1^\dagger$	$1^\dagger$	$1^\dagger$	$1^\dagger$
$\sigma_1 = \sigma_2 = 1/2$	0.85	0.88	0.89	0.37	$1^\dagger$	$1^\dagger$	$0.53^\ddagger$	$1^\dagger$	$1^\dagger$
$\sigma_1 = 2, \sigma_2 = 1$	0.99	0.99	0.99	0.25	0.19	$1^\dagger$	0.42	$1^\dagger$	$1^\dagger$
$\sigma_1 = 1, \sigma_2 = 2$	0.90	0.91	0.93	$1^\dagger$	$1^\dagger$	$1^\dagger$	$1^\dagger$	$1^\dagger$	$1^\dagger$

*Unless stated otherwise there are three equilibria: $0 < b < 1$, $b = 1$ and $b > 1$. The Table gives the stable equilibrium with the lowest indexation.
†This is the only equilibrium. It is stable.
‡There are three equilibria: two with $0 < b < 1$ and one with $b = 1$.

shocks are large (as full indexation is the optimal response to such shocks); (*ii*) the central bank's weight on inflation, λ, is high (because exchange rate shocks are relatively more important when the central bank stabilises the CPI to a large extent in the case of demand and supply shocks); and (*iii*) the wage setters' weight on the real consumption wage, γ, is high (as stabilisation of the real consumption wage requires full indexation).

When there is partial indexation outside the EMU, larger exchange rate shocks push indexation closer to unity. Increases in both supply and demand variability (compare rows 2 and 3 with row 1) reduce indexation outside the EMU if it is partial. The result for supply variability is standard, whereas the result for demand variability is not. But the explanation is similar. Take the cases of negative supply or demand shocks. With a constant nominal wage, the CPI rises and employment falls in both cases (see Section 1.4). So, to the extent that a wage setter wants to stabilise employment, there is an incentive to reduce the nominal wage. This requires negative indexation. Larger supply and demand shocks enhance this incentive.

Whether or not indexation is higher inside the EMU than outside depends on the equilibrium outside. With partial indexation outside, indexation is usually higher inside than outside the EMU. The explanation is that both demand and supply variability give a motive for negative indexation outside the EMU, as discussed above. But with full indexation outside the EMU, indexation is lower inside in our examples.

3. Indexation in the Presence of Fixed Costs

So far, we have assumed indexation always occurs. A more realistic assumption is that indexation takes place only when the gains exceed some threshold. Following Gray (1978), Ball (1988), and Ball and Cechetti (1991), we shall assume a fixed cost of indexation, which depends on the existence of such arrangements *per se* but is unrelated to the amount of indexation.

This cost can be thought of as being associated with the complexity of an indexation scheme as compared to an ordinary nominal wage contract. The cost may arise because of the psychological effort of computing optimal indexation formulas (as the authors of this article can verify), the effort of learning about the values of the parameters in such formulas, the difficulties of agreeing among employees on the degree of indexation, and the difficulties of negotiating the indexation arrangements with employers. Also, indexation arrangements usually increase the frequency of wage adjustments, so there are likely to be larger menu costs of wage changes (Ball and Cechetti, 1991).

Another possibility has to do not with indexation *per se* but with the general cost of *changing* wage contracting arrangements, which tend to show a high degree of inertia (Traxler *et al.*, 2001). If there have been no indexation arrangements, there may be a large cost of introducing them, because this requires a consensus on the need to change the design of contracts. This may be particularly difficult to achieve in those countries that, after a drawn-out process in the 1980s, dismantled such arrangements in response to earlier supply shocks.

When deciding whether to index, each wage setter compares the stabilisation gain with the cost. The anticipated gain depends on the expectation of what other wage setters will do: as indexation elsewhere increases price variability, each wage setter's gain from indexation is increasing in aggregate indexation (indexation arrangements are *strategic complements*). We analyse this in a way that is similar to the Ball and Romer (1991) model of how menu costs and coordination failures may interact to produce nominal wage rigidity in non-indexed contracts.[20]

We first compute the expected losses for an individual wage setter of not indexing and indexing, respectively, under the assumption that aggregate indexation is zero. The difference between these losses is the wage setter's stabilisation gain from indexation when others do not index, ΔEL_0. We then compute the expected losses for an individual wage setter of not indexing and indexing, respectively, under the assumption that aggregate indexation is at the equilibrium level. The difference between theses losses is the stabilisation gain from indexation when others index, ΔEL_b. The calculations are described in Appendix B.

We assume a uniform indexation cost, F. If $\Delta EL_0 > F$, it always pays for each wage setter to index. The economy then ends up in an indexation equilibrium. If instead $\Delta EL_b < F$, it never pays for an individual wage setter to index. Then the economy ends up with zero indexation. If $\Delta EL_0 < F < \Delta EL_b$, two equilibria are possible. If each wage setter expects others not to index, it is optimal not to index oneself, and the equilibrium implies zero indexation. If each wage setter expects all others to index, it is optimal to index oneself, and the outcome is an indexation equilibrium.

Table 3 gives ΔEL_0 and ΔEL_b inside and outside the EMU, respectively, when $\beta = 0.5$, $\gamma = 1$, and $\delta = \lambda$ (i.e. when the weights of price variability are the same in the wage setters' and the central bank's loss functions). When there are three equilibria outside the EMU, we show the same case as in Table 2. The losses are

[20] Ball and Romer (1991) did not analyse indexation formally but noted the analogy to the problem they discussed.

Table 3

The Expected Gain of Indexation for an Individual Wage Setter

Variances	Outside	Inside	Outside	Inside
	Others do not index		Others index	
$\delta = \lambda = 1$				
$\sigma_1 = \sigma_2 = 1$	0.10	1.23	2.04	31.82
$\sigma_1 = \sigma_2 = 1/2$	0.06	1.84	1.03	47.40
$\sigma_1 = 2, \sigma_2 = 1$	0.03	1.95	0.50	50.44
$\sigma_1 = 1, \sigma_2 = 2$	0.41	1.23	24.22	31.82
$\delta = \lambda = 2$				
$\sigma_1 = \sigma_2 = 1$	0.08	1.23	12.11	31.82
$\sigma_1 = \sigma_2 = 1/2$	0.04	1.84	12.11	47.40
$\sigma_1 = 2, \sigma_2 = 1$	0.01	1.95	0.19	50.44
$\sigma_1 = 1, \sigma_2 = 2$	0.41	1.23	24.22	31.82
$\delta = \lambda = 3$				
$\sigma_1 = \sigma_2 = 1$	0.08	1.23	12.11	31.82
$\sigma_1 = \sigma_2 = 1/2$	0.04	1.84	12.11	47.40
$\sigma_1 = 2, \sigma_2 = 1$	0.01	1.95	12.11	50.44
$\sigma_1 = 1, \sigma_2 = 2$	0.44	1.23	24.22	31.82

normalised by setting $\sigma_v^2 = \sigma_\theta^2 = \sigma_\xi^2 = 1$ in row 1. In *all* cases shown, the expected gains from indexation are larger inside the EMU than outside. This can be shown to hold also for all the other cases in Tables 1 and 2.[21]

It is intuitive that the gains from indexation are larger inside than outside the EMU when equilibrium indexation in the absence of fixed costs is higher. It is less obvious why the gains are larger when equilibrium indexation inside is partial but full outside. However, the explanation is this. In the EMU, each wage setter chooses indexation to minimise employment and real wage variability arising from both demand and supply shocks. Hence, the gain of indexation is 'large'. Outside the EMU, (the full) indexation only protects against the employment and real wage instability caused by exchange rate shocks. Because the central bank then does not allow demand and supply shocks to affect the CPI, there is no *need* to stabilise the real wage through indexation against these shocks, and there is no *point* in trying to stabilise employment this way. Therefore, indexation outside the EMU gives only a 'small' stabilisation gain.

The incentives to index are thus stronger inside than outside the EMU. This raises the possibility of a non-indexation equilibrium outside the EMU, but an indexation equilibrium inside. An economy joining the EMU might therefore move from non-indexation to indexation. This presupposes that the indexation cost is high enough to prevent indexation outside the EMU, but not high enough to prevent the larger gains from indexation inside the EMU to tilt the balance.

To reverse the result that indexation incentives are stronger inside than outside the EMU, exchange rate shocks must be much larger than in our examples. We

[21] The conclusion also holds if we look at the other equilibria outside the EMU than the partial-indexation equilibria when there are multiple equilibria.

experimented with increasing the size of these shocks to the values where the expected social welfare is the same inside and outside the EMU when wages are rigid, so that there would be no potential stabilisation cost of EMU membership (see Section 4). At these cut-off points, the stabilisation gains for each wage setter of indexing are still larger inside than outside the EMU when others are expected not to index, whereas the reverse holds when others are expected to do so. As the former case is the most relevant one when analysing a possible move from non-indexation to indexation, this sensitivity analysis seems rather to support our conclusions.

4. Macroeconomic Variability

Table 4 reports how the variability in employment, the CPI and the real wage differs between EMU membership and non-membership depending on whether indexation is chosen or not. We confine ourselves to the cases with $\beta = 0.5$, $\lambda = \delta = 1$, and $\gamma = 1$, which are representative also of the other cases in Tables 1–2.[22] We also evaluate the *gross social loss* deriving from macroeconomic variability in the various cases. We do this by aggregating the loss functions of wage setters. (The results are,

Table 4
Macroeconomic Variability ($\beta = 0.5,\ \lambda = \delta = \gamma = 1$)

	Non-indexation		Indexation	
Variances	Inside	Outside	Inside	Outside
Employment variability				
$\sigma_1 = \sigma_2 = 1$	1.73	0.46	0.92	0.66
$\sigma_1 = \sigma_2 = 1/2$	2.08	0.50	0.97	0.65
$\sigma_1 = 2,\ \sigma_2 = 1$	3.11	0.54	1.70	0.65
$\sigma_1 = 1, \sigma_2 = 2$	1.73	0.81	0.92	1.00
CPI variability				
$\sigma_1 = \sigma_2 = 1$	0.74	0.40	3.22	0.58
$\sigma_1 = \sigma_2 = 1/2$	1.42	0.47	5.43	0.61
$\sigma_1 = 2,\ \sigma_2 = 1$	0.80	0.56	4.29	0.67
$\sigma_1 = 1,\ \sigma_2 = 2$	0.74	0.58	3.22	2.00
Real wage variability				
$\sigma_1 = \sigma_2 = 1$	0.74	0.40	0.03	0.12
$\sigma_1 = \sigma_2 = 1/2$	1.42	0.47	0.12	0.24
$\sigma_1 = 2,\ \sigma_2 = 1$	0.80	0.56	0.0009	0.38
$\sigma_1 = 1,\ \sigma_2 = 2$	0.74	0.58	0.03	0
The gross social loss				
$\sigma_1 = \sigma_2 = 1$	3.21	1.27	4.17	1.37
$\sigma_1 = \sigma_2 = 1/2$	4.91	1.45	6.53	1.50
$\sigma_1 = 2,\ \sigma_2 = 1$	4.71	1.67	5.98	1.70
$\sigma_1 = 1,\ \sigma_2 = 2$	3.21	1.98	4.17	3.00

[22] The computation formulas are reported in Calmfors and Johansson (2002). The calculations assume $\phi = \ln a$. Letting $\phi \neq \ln a$ would add a constant to all expected values but not affect the comparisons.

however, similar if the evaluation is instead made using the central bank's preference function.)[23] Note that our gross social loss does not take the fixed indexation cost discussed in Section 3 into account. Nor does our social loss function take any transaction costs in trade associated with the existence of different currencies into account, since we do not model these. Hence, our welfare evaluations can be used only for analysing how the possible stabilisation cost in terms of increased macroeconomic variability may be affected by endogenous changes in the extent of wage flexibility, but not for evaluating the overall desirability of EMU membership; see e.g. Calmfors *et al.* (1997).

Columns 1 and 2 show that the gross social loss is larger inside the EMU than outside when wages are rigid (no indexation). This reflects greater variability in all the three goal variables, although the difference is particularly large for employment. This difference in gross social welfare is the standard stabilisation cost of joining a monetary union.[24]

If wages are indexed inside the EMU but not indexed outside, the comparison between membership and non-membership involves columns 2 and 3. The Table shows that indexation inside the EMU increases the difference in gross social welfare.[25] This is so because the gross social loss in the EMU is always larger with indexation than without. Indexation in the EMU reduces both employment and real wage variability but it increases price variability even more. If indexation in the EMU is to reduce the gross social loss, one has to assume either weights on inflation, $\delta = \lambda$, that are considerably below unity (0.60 for equal supply and demand variability, 0.61 for large supply variability and 0.64 for large demand variability, if $\gamma = 1$) or γs (the weight on real wages) that are considerably above unity (2.59 for equal supply and demand variability, 2.56 for large supply variability and 2.64 for large demand variability, if $\delta = \lambda = 1$). But in these cases, too, gross welfare is lower inside than outside the EMU, so a move from non-indexation to indexation is at best an imperfect substitute for a national monetary policy. EMU membership always increases employment variability to a large extent.

Equilibrium indexation in the EMU leads to lower gross social welfare than nominal wage rigidity, because decentralised wage setters choose more indexation than is socially efficient: they do not take into account that indexation increases price variability. Table 5 shows that socially optimal indexation levels are much lower than the equilibrium levels (see Appendix C for the formulas).

Table 6 compares the gross social losses under socially optimal indexation and non-indexation. The Table shows that a move to indexation in the EMU is an imperfect substitute for a national monetary policy in this case, too: the loss under socially optimal indexation in the EMU is larger than the loss without indexation

[23] The main reason for our choice of social welfare function is that, starting with Rogoff (1985), there is a large literature viewing the central bank's preference function as different from the true social welfare function, either because monetary policy has been delegated to a 'conservative' central banker or because the central bank has been assigned a different welfare function than society's; see also Svensson (1997).

[24] For there to be a welfare gain of EMU membership in our model, i.e. a stabilisation benefit, in the non-indexation case, exchange rate variability must be quite large. The cut-off values for σ_2 are 3.75 for $\sigma_1 = 1$, 5.91 for $\sigma_1 = 1/2$, and 5.33 for $\sigma_1 = 2$.

[25] Note that the welfare difference increases even more if we take indexation costs into account.

Table 5

Socially Optimal and Equilibrium Indexation Levels ($\beta = 0.5$, $\lambda = \delta = \gamma = 1$)

	Inside		Outside	
Variances	SO	EI	SO	EI
$\sigma_1 = \sigma_2 = 1$	0.41	0.90	0.15	0.54
$\sigma_1 = \sigma_2 = 1/2$	0.35	0.85	0.07	0.37
$\sigma_1 = 2$, $\sigma_2 = 1$	0.52	0.99	−0.005	0.25
$\sigma_1 = 1$, $\sigma_2 = 2$	0.41	0.90	0.31	1

SO = socially optimal indexation, EI = equilibrium indexation.
The equilibrium levels of indexation are taken from Table 1.

Table 6

The Gross Social Loss with Socially Optimal Indexation and Non-indexation ($\beta = 0.5$, $\lambda = \delta = \gamma = 1$)

	Inside			Outside		
Variances	NI	SO	NI−SO	NI	SO	NI−SO
$\sigma_1 = \sigma_2 = 1$	3.21	3.02	0.19	1.273	1.265	7.7×10^{-3}
$\sigma_1 = \sigma_2 = 1/2$	4.91	4.69	0.22	1.448	1.446	2.0×10^{-3}
$\sigma_1 = 2$, $\sigma_2 = 1$	4.71	4.34	0.37	1.666	1.666	2.0×10^{-5}
$\sigma_1 = 1$, $\sigma_2 = 2$	3.21	3.02	0.19	2.00	1.92	0.08

NI = non indexation, SO = socially optimal indexation

outside the EMU. The welfare differences between socially optimal indexation and non-indexation are small inside the EMU compared to the welfare differences between indexation and non-indexation for individual wage setters acting in a decentralised way (see Table 3). So, it is much less probable that EMU membership will entail a move from non-indexation to indexation if decisions are centralised rather than decentralised. The even smaller differences in welfare between socially optimal indexation and non-indexation outside the EMU explain why centralised decisions are likely to rule out indexation in this case.

5. EMU Membership and Contract Length

Do the results on indexation carry over to other ways of modelling nominal wage flexibility? An alternative is to discard the possibility of indexation and let contracts determine only a nominal wage, but instead endogenise contract length. The assumption is then that uncertainty is increasing over time, so that optimal contract length reflects a trade-off between contract costs on one hand and employment and real wage variability on the other.

Our model can easily be adapted in this way. We change to a continuous-time formulation and assume shocks to follow Wiener processes, which are the continous-time analogues of random walks. The expected values of the shocks are zero, but the variances increase over time. For example, the conditional forecast variance evaluated at time T of the supply shock at the future time t is $\mathrm{Var}_T(\theta_t) = (t-T)\sigma_\theta^2$, where σ_θ^2 is now the instantaneous variance.

Outside the EMU, the national central bank is assumed to set it policy instrument so as to minimise the expectation of the loss function (8) at each point of time. This assumption captures that monetary policy is adjusted much more frequently than wages. The outcome is a policy response function like (11), but which now applies at each instant.

Wage setters have the same preferences over employment, the real consumption wage and the CPI as in Section 1, but they now incur a cost $\bar{C}$ each time a new contract is concluded. The total loss for a wage setter over a contract period is the sum of the contract cost and the squared deviations from the employment, real wage and CPI goals. Each wage setter's objective is now to choose contract length, x_i, to minimise the total expected loss over a relevant time horizon. If we set the discount rate to zero and again take the CPI level as exogenous for each wage setter, this is equivalent to minimising the expected loss per unit of time:

$$\mathrm{E}_0(L^{TU}) = \frac{1}{x_i}\left(\int_0^{x_i} \mathrm{E}_0[l_i(t)^2]\mathrm{d}t + \gamma\int_0^{x_i} \mathrm{E}_0\{[w_i(t) - p_c(t) - \phi]^2\}\mathrm{d}t + \bar{C}\right). \tag{14}$$

5.1. *Contract Length*

Choosing x_i to minimise (14) subject to the continous-time versions of (2), (3), (5), (9) and (11) with $b = 0$, we obtain:

$$\frac{\partial \mathrm{E}_0(L^{TU})}{\partial x_i} = -\frac{1}{x_i^2}\left(\int_0^{x_i} \mathrm{E}_0[l_i(t)^2]\mathrm{d}t + \gamma\int_0^{x_i} \mathrm{E}_0\{[w_i(t) - p_c(t) - \phi]^2\}\mathrm{d}t + \bar{C}\right) + \frac{1}{x_i}\mathrm{E}_0[l_i(x_i)^2] + \frac{1}{x_i}\gamma\mathrm{E}_0\{[w_i(x_i) - p_c(x_i) - \phi]^2\} = 0.$$

Contract length is chosen so that the cost savings per unit of time of lengthening the contract period balances the loss from larger employment and real wage fluctuations at the margin. Assuming symmetry and synchronisation of contract periods, contract length outside the EMU, x^O, can be solved out as (see Appendix D)

$$x^O = \sqrt{\frac{2\bar{C}[a + \beta(1-a)]^2}{S\sigma_\theta^2 + U\sigma_v^2 + V\sigma_\xi^2}},$$

where $S = [H_0\beta - (1-\beta)]^2 + \gamma\{\alpha - [a(1-\alpha) + \beta(1-a)]H_0\}^2$, $U = (1 + K_0\beta)^2 + \gamma\{\alpha(1-a) + [a(1-\alpha) + \beta(1-a)]K_0\}^2$, and $V = \beta^2 + \gamma[a(1-\alpha) + \beta(1-a)]^2$. Contract length is increasing in the contract cost and decreasing in the (instantaneous) variances of the shocks.

Proceeding as above, we can derive contract length inside the EMU as:

$$x^I = \sqrt{\frac{2\bar{C}[a + \beta(1-a)]^2}{[(1-\beta)^2 + \gamma\alpha^2]\sigma_\theta^2 + [1 + \gamma\alpha^2(1-a)^2]\sigma_v^2}}.$$

Again contract length is increasing in the contract cost. It is decreasing in the (instantanous) variances of both supply and demand shocks.

The ratio between the contract length outside and inside the EMU can be written:

$$\frac{x^O}{x^I} = \sqrt{\frac{[(1-\beta)^2 + \gamma\alpha^2] + [1 + \gamma\alpha^2(1-a)^2]\sigma_1}{S + U\sigma_1 + V\sigma_2}}. \tag{15}$$

In general, it is not clear whether this ratio is larger or smaller than unity. We resort again to numerical examples. Table 7 shows that wage contracts are shorter inside than outside the EMU in all our cases.

5.2. *Macroeconomic Variability*

As before, we also examine the consequences for macroeconomic variability of increased nominal wage flexibility in the case of EMU membership. We do this for a time period that coincides with the contract length chosen outside the EMU. First, we compute the variability in employment, in the CPI, and in the real wage as well as the gross social loss outside and inside the EMU, respectively. This is done under the assumption that the contract length outside the EMU is also chosen inside, so that there is no endogenous adjustment of contract length. We use the instantaneous aggregate loss function of wage setters consistent with (4), which only reflects macroeconomic variability, but not contract costs. Second, we evaluate macroeconomic variability in the EMU under the assumption that wage setters then choose their desired contract length.

In Table 8, the first two columns give the macroeconomic outcomes inside the EMU when there is no adjustment of contract length. The third and fourth columns give the outcomes inside the EMU when there is such an adjustment. The measurement unit for the outcome variables is the contract cost, which we have normalised to unity. The computation formulas are given in Appendix D.

Employment, real consumption wage and price variability, and hence the gross social loss, are always larger inside than outside the EMU in the Table. An adjustment of contract length in the EMU always reduces employment and real wage variability but increases price variability. As in the indexation case, the increase in nominal wage flexibility in the EMU reduces gross social welfare with the λs and γs shown in the Table, because the negative effects on price variability

Table 7

The Ratio Between Contract Length Outside and Inside the EMU ($\beta = 0.5$, and $\gamma = 1$)

Variances	$\lambda = 1$	$\lambda = 2$	$\lambda = 3$
$\sigma_1 = \sigma_2 = 1$	2.85	2.71	2.53
$\sigma_1 = \sigma_2 = 1/2$	3.59	3.39	3.13
$\sigma_1 = 2, \sigma_2 = 1$	3.54	3.32	3.04
$\sigma_1 = 1, \sigma_2 = 2$	1.77	1.72	1.64

Table 8

Macroeconomic Variability ($\beta = 0.5,\ \gamma = 1,\ and\ \delta = \lambda.$)

	Inside, NA		Inside, A		Outside	
Variances	$\lambda = 1$	$\lambda = 2$	$\lambda = 1$	$\lambda = 2$	$\lambda = 1$	$\lambda = 2$
Employment variability						
$\sigma_1 = \sigma_2 = 1$	1.99	1.90	1.05	1.01	0.53	0.67
$\sigma_1 = \sigma_2 = 1/2$	4.27	4.03	2.18	2.07	1.03	1.33
$\sigma_1 = 2,\ \sigma_2 = 1$	2.82	2.65	1.44	1.36	0.49	0.67
$\sigma_1 = 1\ ,\sigma_2 = 2$	1.24	1.20	0.79	0.78	0.58	0.66
CPI variability						
$\sigma_1 = \sigma_2 = 1$	0.85	0.81	2.57	2.42	0.47	0.33
$\sigma_1 = \sigma_2 = 1/2$	2.91	2.75	7.66	7.22	0.97	0.67
$\sigma_1 = 2,\ \sigma_2 = 1$	0.72	0.68	2.79	2.61	0.51	0.33
$\sigma_1 = 1\ ,\sigma_2 = 2$	0.53	0.51	1.36	1.29	0.42	0.33
Real wage variability						
$\sigma_1 = \sigma_2 = 1$	0.85	0.81	0.64	0.61	0.47	0.33
$\sigma_1 = \sigma_2 = 1/2$	2.91	2.75	1.93	1.83	0.97	0.67
$\sigma_1 = 2\ ,\sigma_2 = 1$	0.72	0.68	0.63	0.59	0.51	0.33
$\sigma_1 = 1,\ \sigma_2 = 2$	0.53	0.51	0.43	0.42	0.42	0.34
The gross social loss						
$\sigma_1 = \sigma_2 = 1$	3.70	4.34	4.23	6.46	1.47	1.67
$\sigma_1 = \sigma_2 = 1/2$	10.10	12.20	11.78	17.36	2.97	2.13
$\sigma_1 = 2\ ,\sigma_2 = 1$	4.27	4.68	4.86	7.17	1.51	1.67
$\sigma_1 = 1\ ,\sigma_2 = 2$	2.31	2.75	2.57	3.77	1.42	1.67

NA = non-adjustment of contract length, A = adjustment of contract length

dominate the positive effects on employment and real wage variability. As before, this result is reversed for low λs or high γs. The cut-off values for λ below which the adjustment of contract length leads to a reduction in the (gross) social loss are 0.68 (equal variances for supply and demand shocks), 0.64 (large supply shocks) and 0.71 (large demand shocks). The cut-off values for γ are 2.70 (equal variances for supply and demand shocks), 2.63 (large supply shocks) and 2.81 (large demand shocks).

6. Discussion

It is commonly believed that membership in a monetary union like the EMU tends to increase macroeconomic variability. We have shown that if this is the case, and the average rate of inflation over the business cycle is unaffected by EMU membership, then nominal wage flexibility is likely to be larger with membership than with non-membership. It may be the case that there is wage indexation inside the EMU but non-indexation outside. Similarly, contract length may be shorter with EMU membership than with non-membership.

More flexible nominal wages reduce the variability of employment and the real consumption wage, but at a cost of more price variability. Hence, increased nominal wage flexibility in a monetary union might reduce social welfare. If this is not to occur, the relative weight of inflation versus employment in the social welfare function must be below unity (0.6–0.7) or the relative weight of the real consumption wage considerably above unity (2.5–2.8). But also then, increased nominal wage flexibility in a monetary union is a very imperfect substitute for a national monetary policy, mainly because it offsets the tendency to increased employment variability only partially. In all our examples, the socially optimal degree of indexation is much lower than equilibrium indexation. Hence, wage indexation is more likely if indexation decisions are taken in a decentralised than in a centralised fashion.

In the numerical examples, we have assumed the same weight on inflation in the preference functions of the central bank and society. An alternative would be to assume more inflation aversion in the central bank's preference function than in the social welfare function. Experimenting shows, however, that such modifications do not change the results substantially. But a deeper analysis requires that the welfare functions are derived from well-specified preferences of the individual agents.

An extended analysis should analyse the interaction between different economies. This would require an explicit modelling of both symmetric and asymmetric shocks. Such an analysis would be more complex and is likely to result in multiple indexation equilibria not only outside the monetary union but also inside.

It might also be worthwhile introducing pricing-to-market assumptions, according to which there is only a partial pass-through of exchange rate changes to import prices in local currency; see e.g. Lane (2001) or Obstfeld (2001). This would reconcile the empirical findings that exchange rate shocks are not very important for output and inflation variability, although they are the main determinant of exchange rate volatility according to several studies.

Our analysis shares the feature with the earlier literature that indexation is not subject to downward nominal rigidity: indexation is symmetric and could lead to both higher and lower wage increases than in the base contract. An alternative is to allow for asymmetric indexation, i.e. index clauses that are triggered only when inflation is above a certain threshold. This is likely to result in contracts with a lower base wage and higher indexation than in our analysis, allowing wage setters to use the indexation clauses symmetrically to achieve both upward and downward flexibility in this case as well (Cover and Van Hoose, 2002).

Finally, a worthwhile development might be to embed the analysis in a New Keynesian Phillips curve framework, where also (average) contract length and the degree of indexation are derived from an optimising framework; see, e.g., Clarida *et al.* (1999) or Gagnon (2005).

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Appendix A: Indexation without Indexation Costs

A.1 *The Central Bank's Decision Rule*

In (11) we have $K = \{-(1-b)(1-\alpha b)\beta - \lambda\alpha[(1-\alpha)a + \beta(1-a)](1-a)\}/V$ and $H = \{\alpha\lambda[(1-\alpha)a + \beta(1-a)] + \beta(1-b)(1-\beta-\alpha b)\}/V$, where $V = (1-b)^2\beta^2 + \lambda[(1-\alpha)a + \beta(1-a)]^2$. $0 \leq b \leq 1$ and $0 < \beta \leq 1$ always imply that $K < 0$. $b = 0$ and $0 < \beta \leq 1$ always imply $H > 0$. $0 \leq b \leq 1$ and $0 < \beta \leq 1$ imply $H > 0$ for the parameter values we subsequently use.

A.2 *Equilibrium Indexation Outside the EMU*

In (13) we have: $A = \{abD - \sqrt{D}[(1-a)(1-\beta) - \beta(1-a)H]Z\}/T$, $B = abE/T + \{\sqrt{E}[(1-a) + \beta(1-a)K]Z\}/T$, $C = [abF + \sqrt{F}\beta(1-a)Z]/T$, $T = a + \beta(1-a)$, $D = \{[(1-\alpha)a + \beta(1-a)]H - \alpha\}^2$, $E = \{[(1-\alpha)a + \beta(1-a)]K + \alpha(1-a)\}^2$, $F = [(1-\alpha)a + \beta(1-a)]^2$ and $Z = a + \beta(1-a) - ab\alpha$.

A.3 *The $b = 1$ Equilibrium*

Using (5), (7), (9), (10), (11) and $w_{i0} = w_0 = p_c^e + \phi + l^e/[\gamma(1-a)]$, which follows from the FOC for w_{i0}, we can derive that:

$$p_c = \frac{\{[(1-\alpha)a + \beta(1-a)]H - \alpha\}}{a + \beta(1-a) - ab\alpha}\theta + \frac{\{[(1-\alpha)a + \beta(1-a)]K + \alpha(1-a)\}}{a + \beta(1-a) - ab\alpha}v + \frac{(1-\alpha)a + \beta(1-a)}{a + \beta(1-a) - ab\alpha}\xi. \tag{A1}$$

when $b = 1$, $H = \alpha/[(1-\alpha)a + \beta(1-a)]$ and $K = -\alpha(1-a)/[(1-\alpha)a + \beta(1-a)]$. Substituting these expressions into (A1) gives $p_c = \xi$.

Appendix B: Indexation in the Presence of Fixed Costs

The expected loss for wage setter i of not indexing when others are not expected to do so either, $E[L_i^M(0, 0)]$, where $M = I$, O denotes EMU membership and non-membership, respectively, is obtained by evaluating the expectation of (4) with $b_i = b = 0$. To evaluate the loss of indexing when others are expected not to index, $E[L_i^M(b_i, 0)]$, we first compute the optimal degree of indexation in this case by minimising the expectation of (4) when $b = 0$. It is:

$$b_i = \frac{(1-a)(1-\beta) + \gamma\alpha(1-a)^2 + (1-a)^2\sigma_1 + \gamma\alpha(1-a)^4\sigma_1}{\alpha + \gamma\alpha(1-a)^2 + \alpha(1-a)^2\sigma_1 + \gamma\alpha(1-a)^4\sigma_1}, \tag{A2}$$

inside the EMU. Outside the EMU it is obtained by setting $b = 0$ in (13). The expected losses are obtained by setting b_i equal to these values and $b = 0$.

The expected loss for wage setter i when he/she does not index, but others are expected to do so, $E[L_i^M(0, b)]$, is computed by setting $b_i = 0$ and b equal to the lowest value that is a solution to (13) when $b_i = b$ in the expectation of (4). The expected loss for wage setter i when he/she indexes and also others are expected to do so, $E[L_i^M(b_i, b)]$, is obtained by setting $b_i = b$ equal to the lowest value that is a solution to (13). All expected losses are calculated under the assumption that $E(p_c^2)$ is exogenous.

The stabilisation gains for wage setter i of indexing are:

$$\Delta EL_0 = E[L_i^M(0,0)] - E[L_i^M(b_i,0)]$$

$$\Delta \mathrm{E} L_b = \mathrm{E}[L_i^M(0, b)] - \mathrm{E}[L_i^M(b_i, b)].$$

The exact expressions are reported in Calmfors and Johansson (2002).

Appendix C: Socially Optimal Indexation

Minimising the expectation of (4) w.r.t b subject to (2), (3), (5), (9), (10), and a fixed exchange rate gives the socially optimal indexation in the EMU as:

$$b = \frac{(1/\alpha)[\beta(1-\beta) + \beta(1-a)\sigma_1] - \lambda a\alpha[1 + (1-a)^2\sigma_1] + \gamma\sqrt{F}[1 + (1-a)^2\sigma_1]}{\beta + \beta(1-a)\sigma_1 + \gamma\sqrt{F}[1 + (1-a)^2\sigma_1]}. \tag{A3}$$

Minimising the expectation of (4) w.r.t b subject to (2), (3), (5), (7), (9), (10) and (11) gives the socially optimal indexation outside the EMU as:

$$\begin{aligned} b = &\frac{\hat{A} + \hat{B}\sigma_1 + \hat{C}\sigma_2 - \lambda(J + Q\sigma_1 + L\sigma_2) - \gamma(b-1)\sqrt{F}[(b-1)\sqrt{D}Z\mathrm{d}H/\mathrm{d}b + D]}{\hat{D} + \hat{E}\sigma_1 + \hat{F}\sigma_2} \\ &- \frac{\gamma(b-1)\sqrt{F}[(b-1)\sqrt{E}Z\mathrm{d}K/\mathrm{d}b + E]}{\hat{D} + \hat{E}\sigma_1 + \hat{F}\sigma_2}\sigma_1, \end{aligned} \tag{A4}$$

where $\hat{A} = (1 - \beta - \beta H)(\alpha\beta - \beta H\sqrt{F}) + (1 - \beta - \beta H)[\beta(1 - b)Z\mathrm{d}H/\mathrm{d}b]$, $\hat{C} = \beta^2\sqrt{F}$, $\hat{B} = (\beta K + 1)[\alpha\beta(1 - a) + \beta K\sqrt{F} - \beta(1 - b)Z\mathrm{d}K/\mathrm{d}b]$, $\hat{D} = (\alpha - \beta H)(\alpha\beta - \beta H\sqrt{F}) + (\alpha - \beta H)[\beta(1 - b)Z\mathrm{d}H/\mathrm{d}b]$, $\hat{E} = (\beta K + \alpha)[\beta K\sqrt{F} + \alpha\beta(1 - a) - \beta(1 - b)Z\mathrm{d}K/\mathrm{d}b]$, $\hat{F} = \beta^2[a(1 - \alpha) + \beta(1 - a)]$, $J = Da\alpha + \sqrt{D}\sqrt{F}Z\mathrm{d}H/\mathrm{d}b$, $Q = \sqrt{E}\sqrt{F}Z\mathrm{d}K/\mathrm{d}b + Ea\alpha$, and $L = a\alpha F$.

Appendix D: Contract Length

We assume that wage contracts are synchronised at time $t = 0$, so that there is no staggering and we obtain a symmetric equilibrium. The FOC for the optimal wage during the contract period, which we denote $w_i(0)$, is then:

$$\begin{aligned} \frac{\partial \mathrm{E}_0(L^{TU})}{\partial w_i(0)} = &-\frac{2}{1-a}\int_0^x \mathrm{E}_0\left\{-\frac{1}{1-a}[w_i(0) - p(t) - \ln a - \theta(t)]\right\}\mathrm{d}t \\ &+ 2\gamma\int_0^x \mathrm{E}_0\{[w_i(0) - p_c - \phi]\}\mathrm{d}t = 0. \end{aligned}$$

Using that $\theta(0) = v(0) = \xi(0) = 0$, we can derive that:

$$w(0) = w_i(0) = \frac{1}{\gamma(1-a)}l^e + p_c^e + \phi.$$

Letting $\phi = \ln a$, expected employment variability outside the EMU can be derived as:

$$\mathrm{E}_0^O[l_i(t)^2] = \frac{[H_0\beta - (1-\beta)]^2}{[a + \beta(1-a)]^2}t\sigma_\theta^2 + \frac{(1 + K_0\beta)^2}{[a + \beta(1-a)]^2}t\sigma_v^2 + \frac{\beta^2}{[a + \beta(1-a)]^2}t\sigma_\xi^2,$$

where H_0 and K_0 are obtained from H and K in (11) by setting $b = 0$. Expected CPI and real consumption wage variability outside the EMU is:

$$\mathrm{E}_0^O[p_c(t)]^2 = \mathrm{E}_0^O\{[w_i(0) - p_c(t) - \phi]^2\} = \frac{\bar{D}t\sigma_\theta^2 + \bar{E}t\sigma_v^2 + \bar{F}t\sigma_\xi^2}{[a + \beta(1-a)]^2},$$

where $\bar{D}$, $\bar{E}$ and $\bar{F}$ are obtained from Appendix A.2 by setting $b = 0$.

The expected variabilities inside the EMU are:

$$\mathrm{E}_0^I[l_i(t)^2] = \frac{(1-\beta)^2 t\sigma_\theta^2 + t\sigma_v^2}{[a+\beta(1-a)]^2},$$

$$\mathrm{E}_0^I[p_c(t)^2] = \mathrm{E}_0^I\{[w_i(0) - p_c(t) - \phi]^2\} = \frac{\alpha^2 t\sigma_\theta^2 + \alpha^2(1-a)^2 t\sigma_v^2}{[a+\beta(1-a)]^2}.$$

The expected gross social losses when actual contract length both outside and inside the EMU = the optimal contract length for a local wage setter outside the EMU are:

$$\bar{\mathrm{E}}_0^O(L^{TU}) = \int_0^{x^O} \mathrm{E}_0[l(t)^2]\mathrm{d}t + \delta\int_0^{x^O} \mathrm{E}_0[p_c(t)^2]\mathrm{d}t + \gamma\int_0^{x^O} \mathrm{E}_0\{[w(0) - p_c(t) - \phi]^2\}\mathrm{d}t,$$

$$\bar{\mathrm{E}}_0^I(L^{TU}) = \int_0^{x^O} \mathrm{E}_0[l(t)^2]\mathrm{d}t + \delta\int_0^{x^O} \mathrm{E}_0[p_c(t)^2]\mathrm{d}t + \gamma\int_0^{x^O} \mathrm{E}_0\{[w(0) - p_c(t) - \phi]^2\}\mathrm{d}t.$$

The expected gross social loss inside the EMU over the period x^O when wage setters choose their optimal contract length, x^I, inside the EMU is:

$$\begin{aligned}\hat{\mathrm{E}}_0^I(L^{TU}) = &\int_0^{x^I} \mathrm{E}_0[l(t)^2]\mathrm{d}t + \int_{x^I}^{x^O} \mathrm{E}_0[l(t)^2]\mathrm{d}t + \delta\int_0^{x^I} \mathrm{E}_0[p_c(t)^2]\mathrm{d}t \\ &+ \delta\int_{x^I}^{x^O} \mathrm{E}_0[p_c(t)^2]\mathrm{d}t + \gamma\int_0^{x^I} \mathrm{E}_0\{[w(0) - p_c(t) - \phi]^2\}\mathrm{d}t \\ &+ \gamma\int_{x^I}^{x^O} \mathrm{E}_0\{[w(0) - p_c(t) - \phi]^2\}\mathrm{d}t.\end{aligned}$$

In Table 8, the social losses for each shock configuration and inflation weight are measured for a time period that equals the contract period outside the EMU in this case. Hence, social losses can be compared for a given shock configuration and a given inflation weight only, but not across shock configurations and inflation weights. Calmfors and Johansson (2002) report the computation formulas.

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