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# BANK OF FINLAND DISCUSSION PAPERS

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22 • 2004

Olli Castrén – Tuomas Takalo –  
Geoffrey Wood  
Research Department  
17.11.2004

## Labour market reform and the sustainability of exchange rate pegs

Suomen Pankin keskustelualoitteita  
Finlands Banks diskussionsunderlag

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The views expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

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# Labour market reform and the sustainability of exchange rate pegs

Bank of Finland Discussion Papers 22/2004

Olli Castrén – Tuomas Takalo – Geoffrey Wood  
Research Department

## Abstract

It is commonly thought that an open economy can accommodate output shocks through either exchange rate or real sector adjustments. We formalise this notion by incorporating labour market rigidities into an ‘escape clause’ model of currency crises. We show that the absence of structural reform makes a currency peg more fragile and undermines the credibility of the monetary authority in a dynamic setting. The fragility is captured by a devaluation premium in expectations that increases the average inflation rate when the currency peg is more vulnerable to ‘busts’ than ‘booms’. This interaction between macroeconomic and microeconomic rigidities suggests that a policy reform can only be consistent if it renders either exchange rates or labour markets flexible.

Key words: exchange rate policy, labour market flexibility, structural reform

JEL classification numbers: E42, F33, D84

# Työmarkkinauudistukset ja kiinteän valuuttakurssin kestävyys

Suomen Pankin keskustelualoitteita 22/2004

Olli Castrén – Tuomas Takalo – Geoffrey Wood  
Tutkimusosasto

## Tiivistelmä

Yleisesti katsotaan, että avoin kansantalous voi sopeutua ulkoisiin sokkeihin joko valuuttakurssien tai reaalityömarkkinoiden sopeutumisen kautta. Tässä tutkimuksessa formalisoidaan tämä ajatus liittämällä työmarkkinajäykkyydet valuuttakriisejä kuvaavaan malliin. Työssä osoitetaan, että työmarkkinauudistusten puuttuminen tekee kiinteän valuuttakurssin järjestelmästä haavoittuvan ja heikentää keskuspankin uskottavuutta. Tämä haavoittuvuus näkyy odotuksissa devalvaatio-preemiona, joka ylläpitää voimakkaampaa inflaatiota, jos kiinteän valuuttakurssin tavoitteesta luovutaan herkemmin taantumana kuin noususuhdanteen oloissa. Tällainen yhteys makro- ja mikrotason jäykkyyksien välillä tarkoittaa, että johdonmukaisen politiikkareformin pitäisi perustua joko valuuttakurssien tai työmarkkinoiden joustavuuteen.

Avainsanat: valuuttakurssipolitiikka, työmarkkinajoustot, rakenteelliset uudistukset

JEL-luokittelu: E42, F33, D84

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# 1 Introduction

A pegged exchange rate is nowadays seldom seen as a permanently sustainable exchange rate regime. There is general acceptance of the proposition, first articulated by Milton Friedman in 1953, that a currency has either to be fixed irrevocably to another – be in effect the same currency – or float freely on the foreign exchanges. But a currency peg has in recent years quite often been adopted as a temporary, *deliberately transitional*, arrangement. A common reason for so doing is that it is a form of commitment by the adopting country's monetary authorities. Once they have announced the peg, their actions must be concentrated on maintaining it, and, as a consequence of doing so, they will import the monetary policy of whichever country issues the currency to which they have pegged.

This has been done by developed and less developed countries, and in most parts of the world. The UK, for example, pegged its exchange rate when, under the governments of Mrs. Thatcher, various approaches to monetary control had been tried and failed (an entertaining and well referenced account of this period can be found in Lawson, 1992). Britain joined the ERM and monetary policy was, so to speak, imported from Germany because a better one was produced there than seemed at that time to be capable of being produced at home. But other countries have adopted a currency peg as part of a more wide-ranging set of policy reforms. Often there has been prior to the pegging of the currency neither monetary nor fiscal discipline. Sometimes, too, there has been very limited political stability; in some cases the peg has been part of a policy reform in which a civilian government replaced a military one. More recently, three of the ten countries that joined the European Union in May 2004 have entered the ERM II as a transitory step towards a membership of the EMU.

At the same time as changes in exchange rate regimes are implemented, tax structures, tariffs, product market regulation, and labour market regulation are often all up for discussion. Changes to these aspects of the economy affect its microeconomic structure. The changes can increase or reduce what is often called the 'flexibility of the economy' – a phrase which can be made operational if it is interpreted as meaning the persistence of the economy's response to shocks.

It is of course useful if the macroeconomic and microeconomic reforms are mutually consistent – that is to say, if one set neither undermines the effectiveness of the other nor threatens its durability. This paper examines a particular issue prompted by that observation. It is shown that structural reforms – labour market reforms in particular – which reduce the persistence of the effect of shocks make an exchange rate peg more robust, and therefore more credible. This in turn means that the benefits of pegging – a lower risk premium on interest rates, for example – come more quickly. In turn, the microeconomic reforms are themselves then

made more durable by the robustness of the peg, for they are not threatened by the political turmoil that can follow the collapse of an exchange rate commitment.<sup>1</sup>

To analyse the effects of structural rigidity on fixed exchange rate regimes, we build on the literature that focuses on the interaction between government and the private sector expectations in a macroeconomic game. Extending the closed-economy framework by Barro and Gordon (1983), Lockwood and Philippopoulos (1994) studied output persistence that has its microfoundations in the insider-outsider dynamics that is characteristic for corporatist wage-setting. Other contributions that are crucial for our model set-up are Obstfeld (1994, 1996, 1997) who modified the Barro-Gordon closed-economy policy framework by adding exchange rate pegs with escape clauses to analyse the occurrence of speculative attacks in the context of multiple equilibria. In a one-sided escape clause model that rules out revaluations, Drazen and Masson (1994) and Jeanne (1999) looked at the impacts of output persistence on the sustainability of an exchange rate regime and showed how persistence affects the policymaker's incentives to devalue by a fixed size in a two-period model. In contrast to these latter contributions, we build on the work by Obstfeld (1996) and Castrén and Takalo (2000) and incorporate structural rigidities in a two-sided escape clause setting where both devaluations and revaluations are possible. This choice of modelling makes our framework fully dynamic and allows for smooth exchange rate adjustments. It also gives rise to an explicit devaluation premium in expectations as a result of asymmetric costs associated with devaluations and revaluations. The equilibrium clearly highlights how the credibility of an exchange rate peg deteriorates with unemployment persistence as shocks that are not stabilised accumulate over time.<sup>2</sup>

This paper proceeds as follows. Section 2 discusses the role of insider-outsider dynamics as a source of structural rigidities and the relative importance such rigidities for the conduct of monetary and exchange rate policies in a stochastic environment. After presenting our model and key results in sections 3 and 4 we illustrate in section 5 the predictions of the model in the light of two historical episodes. First, the economic and financial turbulence in Finland in the early 1990s provides an apt example of the hazards of fixed currency regimes in the absence of structural reforms that contribute to the economy's resilience to shocks. Second, in more general terms, we discuss the need for consistent reforms

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<sup>1</sup> It should be noted at this point that although the collapse of Britain's exchange rate peg seems inconsistent with this, the opposite can be argued. The policy came under pressure, and was abandoned, after it had achieved its objective of delivering low and stable inflation. The collapse had as much to do with the politics of the time, on which again see Lawson (1992), as with the economics.

<sup>2</sup> In a somewhat related study, Irwin (2004) emphasised the incomplete information about the cost of devaluation in determining the credibility of a currency board.

against the background of problems associated with insufficient sequencing of reforms in the developing countries.

## 2 Motivation

The analysis of the role of microeconomic rigidities in generating macroeconomic distortions has developed to an influential literature. In particular, issues related to wage- and price-setting are in the core of analyses that have contributed to the understanding of why some economies are more resilient to shocks than others, why shocks sometimes produce persistent effects in employment, output and inflation, and why different policies might have different effects over different horizons.

Resilience of the economy is particularly important in the context of policy rules that take the form of target ranges for some key variables, such as inflation or the exchange rate. If the structure of the economy gives rise to stickiness and persistence, the adverse effects of repeated shocks might accumulate over time and complicate the task of the policymaker in keeping the target variable within the pre-specified band. Structural rigidities are seldom the immediate reason to acute policy problems, such as periods of high inflation or currency crises, but by slowing down the economy's reversal back to trend developments they increase the economy's vulnerability to distortions that are triggered by adverse supply and demand shocks, falling confidence, speculative attacks or contagion from other related crises. This indirect effect also means that it is difficult to measure the role of persistence per se as a factor behind currency crises, for example; the impact of structural rigidities typically comes about via the interplay with the various shocks in the dynamic context.

Our paper provides a novel contribution to the theoretical literature of currency crises in that we consider a Lucas-type supply curve that incorporates unemployment persistence as an explicit argument. In the past literature such persistence, or hysteresis, has been commonly modelled as arising from the relationship between employment and insider status (see in particular Lindbaeck and Snower, 1986). The key to the microfoundations of this kind is the fundamental asymmetry in the wage-setting process between insiders who are employed and outsiders who want jobs. In spite of the presence of outsiders, unionized wage-bargaining structure tends to yield nominal wages that are chosen with a view of providing employment for the insiders. In a dynamic context, adverse shocks that contribute to reduced employment change the number of insiders, lower the next period's employment target and alter the subsequent wage rate, giving rise to hysteresis. Membership considerations can thus explain the general tendency of the equilibrium unemployment rate to follow the actual

unemployment rate. The argument that the distortions in the labour market originate from wage setting process where a trade union selects an employment target that consists only of current union membership has been provided as one explanation to the persistence of the European unemployment (see for example Blanchard and Summers, 1986, Lockwood and Philippopoulos, 1994, Blanchard and Wolfers, 2000). Indeed, empirical work on trade union membership suggests that membership is not fixed over time, but responds strongly to changes in past employment.

In an empirically relevant context, the institutional set-up for the exchange rate regime should allow for both revaluations and devaluations. We show that such a structure gives rise to a devaluation premium in expectations that interacts with shocks, rigidities and preferences; it is the richness of these potential interactions that is the driving force of our analysis. For example, while a ‘conservative’ policymaker is generally seen as a more beneficial in an environment characterised by nominal rigidities, we demonstrate how in a dynamic context structural reform really is the only sustainable way to improve the economy’s resilience to shocks and hence the credibility of the exchange rate peg.

In a setting where insider-outsider considerations generate micro-level rigidities in the employment process, it is important to realize that discretionary macroeconomic policy measures not only affect current employment, but also future employment. Rational policymakers will take into account these future effects on current policy when pursuing their policy targets. The model below will highlight the particular repercussions of such dynamics in the context of a fixed exchange rate regime.

## 3 The model

### 3.1 The set-up

We consider an infinite horizon, discrete time economy, where the macroeconomic equilibrium is described by interaction between the private sector and the policymaker, who controls inflation rate and, under the assumption that purchasing power parity (PPP) holds, the exchange rate. Following Lockwood and Philippopoulos (1994), it is assumed that the economy is characterised by labour market rigidities that, in turn, give rise to output persistence. As is typical for models with macroeconomic policy interactions, the trade union sets the nominal wage  $W_t$  while the policymaker controls the price level  $P_t$ . In every period  $t$ , the demand for labour in the economy is determined by the real wage  $W_t/P_t$  as  $L_t = (W_t/P_t)^{-e}$ . Taking logs and setting  $e = 1$  for convenience, this can be written as

$$l_t^d = p_t - w_t + z_t \quad (3.1)$$

where  $l_t^d$  is the log of employment,  $p_t$  is the log of the price level,  $w_t$  is the log of the nominal wage and  $z_t$  is a log of stochastic output shock uniformly distributed on  $[-Z/2, Z/2]$ .<sup>3</sup>

Workers are organised in a trade union which sets one-period wages before the production shock is realised. The union's objective function is given by

$$U_t = -E_{t-1}(l_t - \hat{l}_t)^2 \quad (3.2)$$

where  $\hat{l}_t$  is the log of period  $t$  employment target of the union. We assume that the target is a weighted average of the currently employed insiders ( $l_{t-1}$ ) and the total labour force ( $l_t^s$ ). For simplicity, we fix the total labour force in the economy so that  $l_t^s = l^s$ . Then, the union's target rate of employment can be re-expressed as

$$\hat{l}_t = \rho l_{t-1} + (1 - \rho)l^s \quad (3.3)$$

where  $\rho \in [0,1]$  is the measure of insider power in wage setting. The union chooses  $w_t$  so as to maximise (3.2) subject to (3.1) and (3.3). This results in the following nominal wage demand by the union

$$w_t = p_t^e - [\rho l_{t-1} + (1 - \rho)l^s] \quad (3.4)$$

where  $p_t^e$  is the expectation of the price level. Substituting (3.4) for (3.1) yields

$$l_t = \rho l_{t-1} + (1 - \rho)l^s + p_t - p_t^e + z_t \quad (3.5)$$

Defining inflation as  $\pi_t = p_t - p_t^e$ , expected inflation as  $\pi_t^e = p_t^e - p_{t-1}^e$ , and unemployment as  $u_t = l^s - l_t$ , (3.5) can be rewritten as an expectation augmented Phillips curve, directly microfounded in the wage-setting process characterised by union membership dynamics

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<sup>3</sup> Note that work that focus on employment determination as a function of firms' labour demand and workers' labour supply typically use matching models to derive the equilibrium supply and demand conditions in the labour market. It is not clear, however, how such microfoundations based on search dynamics would be compatible with the microfoundations arising from union membership dynamics that will be introduced below.

$$u_t = \rho u_{t-1} - (\pi_t - \pi_t^e) - z_t \quad (3.6)$$

In this set-up, one can think that the expected inflation is formed by the private sector one period earlier, ie,  $\pi_t^e = E_{t-1}(\pi_t)$ . The autoregressive term,  $\rho u_{t-1}$ , introduces past unemployment as a state variable, showing how the persistence in the unemployment rate directly arises from the insider power in wage setting. Via Okun's law, there is also a mapping from unemployment persistence to output persistence.<sup>4</sup>

Given the expectation-augmented Phillips curve (3.6) and the institutional set-up, the policymaker chooses the rate of inflation to minimise a standard loss function that is quadratic in both unemployment and inflation.

$$L_t = \frac{1}{2} [\lambda u_t^2 + (\pi_t - \pi^*)^2] \quad (3.7)$$

We assume that the economy's transmission mechanism is known and such that the policymaker can directly control the inflation rate which, in a small open economy and under the PPP assumption, is equal to the realised rate of currency depreciation. In (3.7),  $\lambda > 0$  is the relative weight assigned by the policymaker on the respective policy objectives, and  $\pi^*$  is the log of policymaker's inflation target. Since the unemployment target is assumed to equal to the long run natural rate of zero, there is no average inflation bias in the model; however, under discretionary policy with a finite  $\lambda$  the policymaker has an incentive to generate policy surprises. Under an *exchange rate peg*, on the other hand, the policymaker commits ex ante to a zero rate of depreciation so that  $\pi_t = 0$ .

In practice, a binding commitment to an exchange rate peg is hardly possible. Instead, the policymaker usually devices an escape clause that allows her to abandon the currency peg in the aftermath of an exceptionally large output shock. Such 'partial' commitment will, however, still temper the credibility problem because it renders the exercise of the escape clause costly. We consider a two-sided escape clause by assuming that the policymaker places herself in a position where any upward change in the exchange rate (a devaluation, implying that

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<sup>4</sup> Ascari (2003) analyses the sources of output persistence and argues that an economy-wide union is a rather realistic assumption when deriving output persistence. This is because in the short run, mobility both across industries and skills tends to be limited. Castrén and Takalo (2000) endogenise output persistence as arising from capital market frictions reflecting limited access to outside funding and the subsequent dependence on revenue financing.

$\pi_t > 0$ ) has a cost of  $c_d$  whereas any downward change in the exchange rate (a revaluation, implying  $\pi_t < 0$ ) has a cost of  $c_r$ .<sup>5</sup>

The timing of events is as follows. (i) The private sector rationally forms its expectations on the future rate of depreciation, knowing the policymaker's preference parameter  $\lambda$ , inflation target  $\pi^*$  and the realignment costs  $c_r$  and  $c_d$ . (ii) The output shock is realised. (iii) The policymaker makes the realignment decision. (iv) The optimal rate of exchange rate depreciation is determined.

## 3.2 Equilibrium conditions and the devaluation premium

We begin by analysing the set of actions following a decision to *maintain* the currency peg. By definition, the rate of depreciation is then zero, and from (3.6) it is then trivial to see that the unemployment rate equals

$$\bar{u}_t = \rho u_{t-1} + \pi_t^e - z_t \quad (3.8)$$

If the policymaker instead *abandons* the peg and opts for discretionary monetary policy (floating exchange rate), the external value of the currency will be determined by private sector expectations. In other words, the policymaker simply chooses the rate of depreciation, after observing the shock and taking the expectations as given. In the discretionary equilibrium, we restrict our attention to Markov-perfect equilibria where strategies at date  $t$  depend on the past only through the payoff-relevant state variable  $u_{t-1}$ . Making this common restriction implies that we exclude strategies that directly depend on the realignment decision. The policymaker's strategy can then be expressed as a function of  $u_{t-1}$ , that is, the intertemporal decision problem has the following form

$$V(u_{t-1}) = E_{t-1} \min_{\pi} [L_t + \delta V(u_t)] \quad (3.9)$$

where  $\delta \in [0, 1]$  is the common discount factor.

When making the optimal policy decision, the policymaker takes into account that changes in *current* unemployment will affect *current expectations* of future inflation through  $V(u_t)$ . To solve (3.9), we employ the method of undetermined

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<sup>5</sup> Following the bulk of the literature on escape clauses (eg Obstfeld 1994, 1996, 1997, Jeanne 1999) we regard these fixed costs as exogenous. They are usually interpreted as political costs of breaking the commitment to the exchange rate peg (De Kock and Grilli, 1993). A deviation from the peg can also involve a direct cost if the policymaker has issued debt denominated in foreign currency (for a related argument, see Bohn, 1990).

coefficients. Because the problem is linear-quadratic, we can conjecture that the value function takes a quadratic form

$$V(u) = \gamma_0 + \gamma_1 u + \frac{1}{2} \gamma_2 u^2 \quad (3.10)$$

where coefficients  $\gamma_0$ ,  $\gamma_1$ , and  $\gamma_2$  are to be determined later. Upon inserting (3.6), (3.7), and (3.10) into the right-hand side of (3.9) and minimising with respect to  $\pi_t$ , we obtain that in period  $t$ , the optimal rate of depreciation under a floating exchange rate regime is

$$\tilde{\pi}_t = \frac{\pi^* + \delta\gamma_1 + b\bar{u}_t}{1 + b} \quad (3.11)$$

where  $\bar{u}_t$  is given by (3.8) and  $b = \lambda + \delta\gamma_2$ . Parameter  $b$  measures the degree of substitutability between the rate of unemployment and the rate of depreciation in the policymaker's value function, that is,  $-b = \partial^2 V / \partial u \partial \pi$ . This substitutability parameter is an important component of the equilibrium analysis as several of the insights below can simply be obtained by isolating the impact of unemployment persistence on  $b$ . The equilibrium unemployment rate under a free float is then

$$\tilde{u}_t = \bar{u}_t - \tilde{\pi}_t \quad (3.12)$$

where  $\bar{u}_t$  and  $\tilde{\pi}_t$  are given by (3.8) and (3.11).

The policymaker's expected *per period* welfare losses under the peg and under the floating exchange rate regime can be expressed by using (3.7), (3.8), (3.11) and (3.12) as

$$\bar{L}_t = \frac{1}{2} (\lambda \bar{u}_t^2 + \pi^{*2}) \quad (3.13a)$$

$$\tilde{L}_t = \frac{1}{2} [\lambda \tilde{u}_t^2 + (\tilde{\pi}_t - \pi^*)^2] \quad (3.13b)$$

Note that the costs of currency realignment can be ignored at this stage. The equilibrium intertemporal loss functions under the two regimes can now be expressed in terms of (3.8), (3.12) and (3.13a, b) as

$$\bar{V}(u_{t-1}) = E_{t-1}(\bar{L}_t + \delta \bar{V}(\bar{u}_t)) \quad (3.14a)$$

$$\tilde{V}(u_{t-1}) = E_{t-1}(\tilde{L}_t + \delta \tilde{V}(\tilde{u}_t)). \quad (3.14b)$$

We now turn to analyse the optimal realignment decision. Given the fixed costs of currency realignment,  $c_d$  and  $c_r$ , the authorities would deviate from the exchange rate peg only when the shock is negative and large enough so that  $\bar{V} - \tilde{V} > c_d$ , leading to a devaluation, or positive and large enough so that  $\bar{V} - \tilde{V} > c_r$ , leading to a revaluation. Invoking the unimprovability principle of dynamic programming, it is sufficient to consider one-period deviations only. Consequently, we can rewrite both intertemporal loss functions in (3.14a, b) by employing the same functional form given by (3.10)

$$\bar{V}(u_{t-1}) = E_{t-1} \left[ \bar{L}_t + \delta \left( \gamma_1 \bar{u}_t + \frac{1}{2} \gamma_2 \bar{u}_t^2 \right) \right] \quad (3.15a)$$

$$\tilde{V}(u_{t-1}) = E_{t-1} \left[ \tilde{L}_t + \delta \left( \gamma_1 \tilde{u}_t + \frac{1}{2} \gamma_2 \tilde{u}_t^2 \right) \right]. \quad (3.15b)$$

Substituting (3.8) and (3.13a) for (3.15a) and (3.12) and (3.13b) for (3.15b), the conditions  $\bar{V} - \tilde{V} > c_r$  and  $\bar{V} - \tilde{V} > c_d$  can be simplified to

$$z_r = \frac{\pi^* + \delta \gamma_1 + \sqrt{2c_r(1+b)}}{b} + \rho u_{t-1} + \pi_t^e \quad (3.16a)$$

$$z_d = \frac{\pi^* + \delta \gamma_1 - \sqrt{2c_d(1+b)}}{b} + \rho u_{t-1} + \pi_t^e \quad (3.16b)$$

Equations (3.16a, b) determine the ‘trigger shocks’ beyond which it will be optimal to switch from the peg to a floating regime. If the shock realisations are not extreme, that is, if  $z_t \in [z_d, z_r]$ , the exchange rate peg is maintained. On the other hand, a revaluation occurs when  $z_t > z_r$  and devaluation occurs when  $z_t < z_d$ .

Assuming that the policymaker’s decision rule is fully transparent, the trigger shocks have to be incorporated in the private sector’s rational expectations for inflation (and depreciation). Recalling that the output shock  $z_t$  is uniformly distributed on  $[-Z/2, Z/2]$ , the equilibrium expected depreciation is given by

$$E_{t-1} \pi_t = \int_{-Z/2}^{z_d} \tilde{\pi}_t(z) f(z) dz + \int_{z_r}^{Z/2} \tilde{\pi}_t(z) f(z) dz \quad (3.17)$$

Substituting (3.11) for  $\tilde{\pi}_t(z)$  and (3.16a, b) for  $z_r$  and  $z_d$  in (3.17) gives, after some algebra (see Appendix 1), an explicit form for the expected rate of depreciation under the escape clause regime

$$E_{t-1}\pi_t = \pi^* + \delta\gamma_1 + b\rho u_{t-1} + \frac{1+b}{b}\Delta c \quad (3.18)$$

In (3.18), the term  $\Delta c = (c_r - c_d)/Z$  captures *the devaluation premium* that is the higher the lower is the relative cost of devaluation. Empirically, the existence of the devaluation premium in expectations is well documented in the form of interest rate risk premia. However, in our case the premium is explicitly derived as a component of the private sector inflationary expectations arising from asymmetric costs of currency re-alignment.<sup>6</sup>

Substituting (3.18) for  $\pi_t^e$  in (3.11) yields the optimal rate of depreciation under the escape clause regime

$$\tilde{\pi}_t^* = \pi^* + \delta\gamma_1 + b\rho u_{t-1} + \Delta c - \frac{b}{1+b}z_t \quad (3.19)$$

The *average* rate of depreciation can now be obtained by substituting (3.19) for  $\tilde{\pi}_t(z)$  in (3.17). This exercise confirms that in the rational expectations equilibrium the actual average depreciation rate equals the expected depreciation rate shown in (3.18).

In the usual escape clause framework (eg Obstfeld 1994, 1996, 1997) a co-ordination game on the private sector can generate a self-fulfilling currency crisis. By the same logic, in our model there can be other equilibria than the one characterised by (3.16a,b), (3.18) and (3.19). Nevertheless, the range of parameter values where the self-fulfilling crisis can occur is rather restricted. If  $\Delta c < 0$  and the expected inflation is so high that the possibility of revaluation is ruled out, ie,  $z_r = Z/2$ , there may be another stable equilibrium where the peg is more fragile (like in Obstfeld, 1994, 1996, 1997). Since our main findings would qualitatively

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<sup>6</sup> The fact that the immediate relative costs of devaluation for the policymaker tend to be lower than the costs of revaluation finds empirical support in many institutional settings regulating fixed currency regimes. For example, Article 3 of Protocol No. 6 on the EMU convergence criteria referred to in Article 109j (1) of the Maastricht Treaty stipulates the following. ‘The criterion on the participation in the exchange rate mechanism of the European Monetary System... shall mean that the Member State has respected the normal fluctuation margins provided for by the exchange rate mechanism... without severe tensions for at least the last two years before the examination. In particular, the Member State shall not have devalued its currency’s bilateral central rate against any other Member State’s currency on its own initiative for the same period.’

also apply for this equilibrium, we will focus on the equilibrium characterised by (3.16a,b), (3.18) and (3.19).<sup>7</sup>

However, even if multiple equilibria cannot be based on escape clauses, they can still emerge from unemployment persistence. This can be seen when the model is completed by determining the coefficients  $\gamma_1$  and  $\gamma_2$ .<sup>8</sup> Since we have assumed that the policy-maker's unemployment target equals the long run natural rate (of zero), it turns out that  $\gamma_1 = 0$ . But there are two Markov-perfect equilibria that give rise to different values for  $\gamma_2$ . The literature on optimal monetary policy institutions under structural rigidities provides two alternative avenues to proceed. The more straightforward way, applied in eg Svensson (1997, 1999), Lockwood, Miller, and Zang (1998), Beetsma and Jensen (1999), and Rantala (2004), is to ignore the 'nonintuitive' equilibrium with strong persistence and 'perverse' comparative static properties. The second way, used, eg, in Lockwood and Philippopoulos (1994), Lockwood (1997), and Jensen (1999) is to consider both equilibria equally. While the second approach would certainly yield interesting findings, we focus on the 'intuitive' equilibrium with a lower level of unemployment persistence. This equilibrium, it should be remarked, is the limit of the unique equilibrium of the finite-horizon version of the game (see Lockwood and Philippopoulos, 1994) and stable under least-squares learning (see Rantala, 2004). We show in Appendix 2 that, following this approach,  $b$  can be written as

$$b = \frac{1 - \rho^2\delta - \sqrt{(1 - \rho^2\delta)^2 - 4\lambda\rho^2\delta}}{2\rho^2\delta} \quad (3.20)$$

In (3.20) the effect of persistence is captured by  $\rho^2\delta$ , ie, it arises from the interaction of the discount rate and the insider power in wage setting. Setting  $\gamma^1 = 0$  in (3.16a,b), (3.18), and (3.19) yields

$$z_r = \frac{\pi^* + \sqrt{2c_r(1+b)}}{b} + \rho u_{t-1} + \pi_t^e \quad (3.21a)$$

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<sup>7</sup> In fact, in the two-sided escape clause model considered here there is a wide range of parameter values where no other equilibria may arise from the interaction of escape clauses with private sector expectations. For example, if  $\Delta c = 0$  the 'self-fulfilling crisis' equilibria are ruled out. However, it is beyond the scope of this study to specify the exact range of parameter values where the combination of private sector expectations and escape clauses leads to multiple equilibria. See Jeanne (1999) for a discussion on the role of output persistence in creating multiple equilibria in a one-sided escape clause model.

<sup>8</sup> Because the identification of coefficients  $\gamma_1$  and  $\gamma_2$  using the method of undetermined coefficients is a rather tedious exercise, we relegate the details to Appendix 2. Equations (3.16a,b), (3.18), and (3.19) show how the coefficient  $\gamma_0$  is irrelevant as it affects neither the policy rules nor the market behaviour.

$$z_d = \frac{\pi^* - \sqrt{2c_d(1+b)}}{b} + \rho u_{t-1} + \pi_t^e \quad (3.21b)$$

$$E_{t-1}\pi_t = \pi^* + b\rho u_{t-1} + \frac{1+b}{b}\Delta c \quad (3.21c)$$

$$\tilde{\pi}_t^* = \pi^* + b\rho u_{t-1} + \Delta c - \frac{b}{1+b}z_t \quad (3.21d)$$

The macroeconomic equilibrium is now fully characterised by (3.20)–(3.21d).

## 4 Stability of exchange rate peg in the presence of unemployment persistence

When the model includes unemployment persistence, there is always the possibility that the dynamic system does not converge to a stationary state. To avoid such outcome we impose a stability restriction on the parameters. Substituting (3.21c) into (3.6) shows that the stability condition  $du_t/du_{t-1} < 1$  holds only under the following restriction.

**STABILITY CONDITION:**  $\rho(1+b) < 1$ .

The Stability Condition amounts to requiring that that the policymaker is sufficiently ‘conservative’ so that  $\lambda$  is not too large or, alternatively, that  $\rho$  is sufficiently small. These restrictions are well supported by results in previous research. For example, the literature following Rogoff (1985) shows that optimal delegation of monetary policy implies choosing a monetary authority with more conservative preferences than society. On the other hand, Ascari (2003) argues that labour market rigidities seldom generate extreme levels of persistence. Operating under this parameter restriction, we can summarise the relevant properties and consequences of equation (3.20).

**LEMMA 1.** It follows from the Stability Condition that (i)  $b \geq 0$ , (ii)  $db/d\rho > 0$ , and (iii)  $d\gamma_2/d\lambda > 0$ .

**Proof:** In Appendix 3.

Part (i) of Lemma 1 confirms the conjecture of the previous section, that is, that unemployment and currency depreciation are policy substitutes. Note from part (ii) that the degree of substitutability is increasing in unemployment persistence.

The third part shows that if the policymaker assigns a high weight on the unemployment target, she will also care more about the long-run unemployment implications.

From (3.21d) we see that if the peg is abandoned, the optimal policy response to past unemployment and output shocks is given by  $b\rho$  and  $-b/(1+b)$ . Combining the Stability Condition and Lemma 1 then yields our first result.

**PROPOSITION 1.** (i) If the peg is abandoned, the absolute values of optimal policy response to past unemployment and output shocks are increasing in the level of unemployment persistence. (ii) Under the exchange rate peg with escape clauses, the average rate of depreciation is increasing in the devaluation premium  $\Delta c$ .

Proof. The proof directly follows from (3.21c), (3.21d) and Lemma 1.

Q.E.D

The results of part (i) are standard, as the behaviour of the optimal policy responses reflects the message in Svensson (1997). If the economy shows unemployment persistence, a stronger response to supply shocks is required in the current period to avoid shocks accumulating in the future. Part (ii) warrants more attention. The devaluation premium  $\Delta c$  is positive if the cost of devaluation is lower than the cost of revaluation, since in that case the policymaker is ex ante known to be more prone to devalue than to revalue. The devaluation premium is incorporated in expectations, as can be seen from (3.21c). Hence in the case of a positive premium the policy surprises must be relatively large to reduce unemployment. In other words, even though the rate of depreciation is zero in the escape clause regime under small output fluctuations,  $z_t \in [\underline{z}, \bar{z}]$ , the average rate of depreciation will be higher due to the devaluation premium. Therefore, an exchange rate peg with escape clauses may lead to a lower average rate of inflation only when the policymaker is known to be relatively averse to depreciation so that the devaluation premium is negative, ie,  $\Delta c < 0$ . This is a clear justification as to why prospective devaluations are seen as more harmful than revaluations under a fixed currency regime.

We are now ready to analyse the effect of unemployment persistence on the credibility of the exchange rate peg. Equations (3.21a, b) determine the range of output shocks in which the exchange rate peg is optimally defended. As we focus on the two-sided escape clause model, we need to ensure that the revaluation option remains viable, which will be the case if the cost of revaluation is

sufficiently low or if sufficiently large shocks are possible.<sup>9</sup> For brevity, we also assume that  $c_r = c_d = c$  for the remainder of the paper. Then, (3.21a, b) yield the following simple measure of the credibility of the peg:

DEFINITION 1. The credibility of the exchange rate peg is measured by

$$\Phi \equiv z_r - z_d = \frac{2\sqrt{2c(1+b)}}{b}.$$

Observe first that  $\Phi$  is increasing in the cost of currency realignment. An exogenous reduction in the cost thus dilutes the credibility of the exchange rate peg. In addition to the realignment cost, the credibility measure is merely a function of unemployment persistence and the policymaker's preferences. Proposition 2 summarises the respective effects of these two parameters on the credibility of the exchange rate peg.

PROPOSITION 2. The credibility of the peg is decreasing in the degree of unemployment persistence and in the weight assigned to the unemployment objective, ie,  $d\Phi/d\rho < 0$ ,  $d\Phi/d\lambda < 0$ .

Proof: Because  $db/d\rho > 0$  by part (ii) of Lemma 1, and because Definition 1 shows that  $\partial\Phi/\partial b < 0$ , the claim  $d\Phi/d\rho < 0$  follows. To see that  $d\Phi/d\lambda < 0$ , let us first rewrite  $\Phi$  as  $\Phi \equiv \frac{2\sqrt{2c(1+\lambda+\delta\gamma_2)}}{\lambda+\delta\gamma_2}$ . Then, the effect of  $\lambda$  on  $\Phi$  can be split

in two

$$\frac{d\Phi}{d\lambda} = \frac{\partial\Phi}{\partial\lambda} + \frac{\partial\Phi}{\partial\gamma_2} \frac{d\gamma_2}{d\lambda} \quad (4.1)$$

From the definition of  $\Phi$  we see that the first term in the right-hand side of (4.1) is negative. Because the definition of  $\Phi$  also shows that  $\partial\Phi/\partial\gamma_2$  is negative, and because  $d\gamma_2/d\lambda > 0$  by part (iii) of Lemma 1, the second term in the right-hand side is also negative.

Q.E.D

Proposition 2 yields a straightforward policy recommendation: an exchange rate peg can be made more credible by structural reforms that reduce unemployment persistence. The reason is that the costs of insufficient shock stabilisation increase in the level of the persistence, because the shocks that are not stabilised in a given

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<sup>9</sup> The formal parameter restriction is  $\frac{Z}{2} \geq \frac{(1+b)\pi^* + \sqrt{2c_r(1+b)}}{b} + (1+b)\rho u_{t-1}$ .

period will affect future unemployment and hence the expected rate of currency depreciation. Under such conditions even small additional shocks to output can trigger a speculative attack that forces the policymaker to abandon the currency peg. Moreover, when the economy is characterised by unemployment persistence, a conservative policymaker (who shows a small  $\lambda$ ) is particularly credible, as she ignores both the usual short-run unemployment effects and also the long-run unemployment considerations. This is highlighted by equation (3.21) where the first and the second terms in the right-hand side depict the short-run and the long-run credibility effects, respectively. Because of the long-run credibility effect, the public further scales down its devaluation expectations, thus further increasing the sustainability of the peg.

Proposition 2 also provides a comment on the debated issue of delegation of monetary policy in the presence of unemployment persistence. Influential contributions by Svensson (1997) and Beetsma and Jensen (1999) show that unemployment persistence is crucial for ‘restoring’ the argument originally put forward by Rogoff (1985) that monetary policy should be delegated to a conservative agent who places a greater relative weight on exchange rate stability. From the outset, Proposition 2 seems to support this view as the credibility of the currency peg can be enhanced by delegation. However, an excessively strong preference for exchange rate stability means that unemployment shocks are not sufficiently stabilised, and they can accumulate over time. As shown by Lockwood, Miller, and Zhang (1998), the cumulative effect of the shocks can generate long run unemployment rates so severe that the delegation becomes counterproductive. In our set-up this effect is likely to be reinforced as the shocks are not stabilised at all when the peg is maintained. As we do not consider inflation targeting as Svensson (1997) and Beetsma and Jensen (1999), our view here is more similar to the Rogoff’s original argument and its ‘restorations’ by Herrendorf and Lockwood (1997) and Lockwood, Miller, and Zhang (1998): the cost of increased credibility is insufficient stabilisation of the real economy. Therefore, building on the results of Lohmann (1992) we can hypothesise that unemployment persistence would make an exchange rate peg controlled by an independent central bank more prone to overruling by a policymaker who has a strong preference for unemployment stabilisation.<sup>10</sup> This is yet another manifestation of our key conclusion: the only *sustainable* policy of enhancing the credibility of a peg is to invoke structural reforms that reduce unemployment persistence.

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<sup>10</sup> See Wood (2001) for discussion of this in the context of central bank constitutions.

## 5 Two illustrative applications

### (a) The financial crisis in Finland in the early 1990s

Throughout the 1980s and the 1990s the Finnish economy underwent the most volatile business cycle in the history of developed economies since the Great Depression. Careful ex post assessment of the potential causes and consequences has led to a conclusion that the interactions between exchange rate regimes and labour market rigidities could have been integral to the developments (see Honkapohja and Koskela 1999 for a detailed analysis).

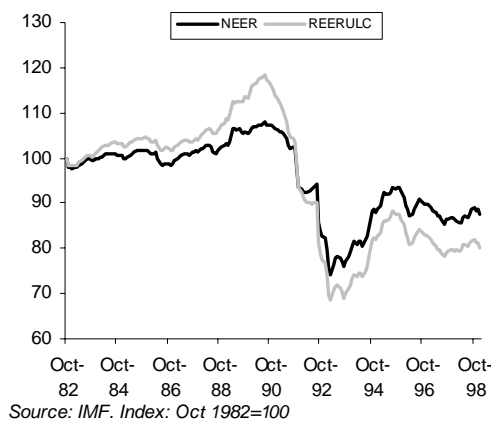
The Finnish labour market has been characterised by corporatist wage-setting, and since the early 1980s the union density has been over 80%. The harmonised wage system that was often disconnect from developments in industry-level productivity growth contributed from time to time to high inflation and loss of competitiveness that gave rise to the notorious devaluation cycles.

In early 1980, amid the surge in global inflation, the exchange rate of the Finnish markka was pegged to a basket of currencies. The currency regime was initially successful in importing credibility to monetary policy. However, towards the end of the 1980s the exchange rate regime came under increasing pressure when the combined effect of financial market liberalisation, relatively lax fiscal policy and very low levels of unemployment resulted in an overheated economy. Despite the obvious inflationary risks the possibility of enhancing the credibility of the regime through labour market reforms did not receive sufficient support among social partners. Against the background of the need to curb inflationary pressures, the Finnish markka was revaluated in November 1989.

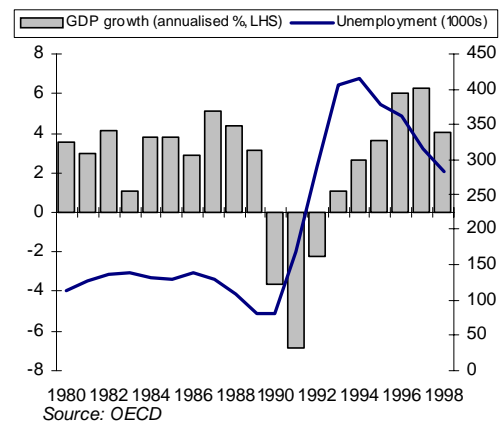
The boom of late 1980s came to an abrupt end in 1990 when the economy was successively hit by several large shocks. The GDP growth rate declined rapidly from over +4% in 1988 to almost -7% in 1991. The Finnish markka came under renewed pressure, but the policy response was to uphold the strong currency regime. In an attempt to improve credibility the markka was unilaterally pegged to the ECU in June 1991. This time around, however, the need for labour market reform was perceived. Government made an attempt to negotiate an agreement with trade unions that would have implied a cut in nominal wages and other labour costs, but the bargaining proceeded too slowly and ultimately the Bank of Finland ran out of currency reserves in defending the peg. The fixed exchange rate regime was then abandoned in two stages, with full floating ensuing in September 1992. In the event, the markka depreciated sharply suggesting that significant pressure could have accumulated in the economy over the past years. This chain of events made Finland a notorious example of a collapse of a fixed currency regime and paved the way to the ERM crisis in fall 1992 (see, eg, Dornbusch, Goldajn, and Valdès 1995).

In the absence of structural reform, the change of the exchange rate regime was indispensable to the economic recovery that gradually commenced in 1993. However, even if the ensuing recovery was rapid (the average annual GDP growth in 1994–2000 was 5.1%), unemployment rate soared to peak in 1994 when almost 20% of the labour force was out of a job. The unemployment rate has remained persistently high, declining below the 10% mark only in the early 2000s.<sup>11</sup>

### Finland Nominal and real effective exchange rate 1982–1998



### Finland GDP growth and unemployment 1980–1998



In 1995 Finland joined the European Union and started a programme that aimed at fulfilling the EMU convergence criteria. As a part of the programme the floating of the markka ended in October 1996 when Finland joined ERM, and after successfully fulfilling the convergence criteria Finland became part of the euro area among the first group of countries in January 1999. Because of the past experience, it was clear that abandoning the floating exchange rate regime meant that the ability of the labour markets to adjust to economic shocks should somehow be enhanced. Even under these circumstances it turned difficult to implement any radical changes in the existing institutions. Finally, government and trade unions agreed to establish ‘EMU buffer funds’, a rather ingenious way

<sup>11</sup> The experience of large devaluation after a period of exchange rate pegging under rigid labour market structures is to some extent not uncommon to the developments in Argentina a decade later. A major difference was, however, that Finland did not default on its debt obligations after the collapse of the peg. In addition, no IMF programme was subscribed to sort out the ensuing financial crisis.

to shelter the labour markets from the initial impact of unfavourable shocks.<sup>12</sup> The merits of the buffer funds continue to be debated (see, eg, Halko 2003), and their ability to stabilise employment fluctuations are yet to be tested in practise. Nonetheless, the introduction of the buffer funds has been discussed in other countries, especially in Sweden (see the report of the Committee on Stabilisation Policy for Full Employment if Sweden Joins the Monetary Union, 2002).

The relative role played by shocks and institutions in the rise and persistence of the Finnish unemployment has also been debated. For example, Nickell (1999) argues that the changes in institutions could explain only half a percentage change in the equilibrium unemployment rate in Finland. However, the analysis by Koskela and Uusitalo (2003) suggests that the persistence of Finnish unemployment is difficult to explain without interaction between shocks and institutions that, according to Blanchard and Wolfers (2000), is the driving force behind European unemployment. The role of unemployment persistence, and labour market rigidities more general, in increasing the vulnerability for currency crises could be tested empirically by looking at a set of early warning indicators for a large set of countries that are categorised according to some measure of labour market flexibility. We leave such an interesting exercise for one obvious avenue for future work.

### **(b) Sequencing of liberalisation in developing countries**

There has been extensive discussion of a related topic – the sequence of liberalisation in developing countries. A good, and still up-to-date, review can be found in a 1984 Princeton Essay in International Finance by Sebastian Edwards. To quote:

‘During the 1970s, a number of developing countries embarked on major attempts to liberalise their economies through reforms aimed at increasing the role of the market mechanism and reducing existing barriers to international trade and capital movements. The most dramatic of these episodes took place in Latin America. The main objective of these reforms was to transform these countries into open export-oriented economies. A decade after these reforms

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<sup>12</sup> The basic idea of the buffer funds is to stabilise the employers’ social security contributions, including unemployment insurance, over the business cycle. During a boom unemployment insurance contributions are kept at a higher level to collect a surplus that could then be used in a recession to compensate for the higher need of unemployment contributions. The ultimate goal of the funds is to smooth fluctuations in labour costs so that in bad times, the pressure on adjustments through wage cuts or higher unemployment could be reduced.

were first implemented, the evidence indicates that they were to a large extent failures.’ (p1)

Edwards goes on to observe that while a major cause of these failures was the unfavourable external environment of the time:

‘These recent experiences also indicate that a number of issues relating to the dynamics of the liberalisation are not well understood. The most important of these relates to the speed and order of economic liberalisation’. (p2).

As he correctly points out, one would wish to liberalise everything at once. But in a world with ‘externalities or distortions’ (p2) and, which he does not include, political and social constraints, this may well not be possible.

That last observation has led to an extensive literature on the order of reform most appropriate for making the liberalisation successful. One aspect of this focuses on the problems of opening the capital account (of the balance of payments) while the domestic capital market is still repressed (eg, McKinnon, 1973, 1982; Dornbusch, 1983, 1984). After studying the problems that result from such ‘premature’ capital account liberalisation, most authors have concluded that capital account liberalisation should follow domestic financial market liberalisation to avoid destabilisation through large capital inflows. In his controversial account of the prospective merits of globalisation, Stiglitz (2002) makes a powerful case for sequencing of reforms:

‘The [economic] theory says that an efficient market economy requires that all of the assumptions [underlying Adam Smith’s ‘invisible hand’] be satisfied. In some cases, reforms in one area, without accompanying reforms in others, may actually make matters worse. This is the issue of sequencing... economic theory and history show how disastrous it can be to ignore sequencing’.

Although the focus of these issues is somewhat different from those in our model above, the underlying problem addressed is the same: what has to be done domestically to ensure the success of reforms in which the relationship to the rest of the world changes. A similar analysis to that in the present paper could address these developing country problems. This is highlighted by Edwards’ (1984) concluding observations:

‘If the public perceives the policies to be inconsistent, it will expect the reform attempt to be discontinued or reversed. In that sense, even more important than determining the correct order of liberalisation may be defining a consistent and credible policy package that will support whichever order is chosen.’

That is plainly relevant to the issues we have discussed.

## 6 Conclusions

In a world with adjustment costs, externalities, and political and social constraints on policy regime changes, the order of carrying out the steps of a regime change can be important for both welfare and for the success of the changes. The wrong order may result in political or economic pressures which impede, halt, or even reverse the changes.

There is an extensive literature which discusses aspects of this in the context of developing countries. But there have been no generalisations of this literature, and little recognition of its relevance to policy regime changes (or adjustments) in economies with more developed institutional structures. This paper formalises the general question in this literature and provides a general answer which, as it turns out, underpins earlier work.

We augment the two-sided escape clause model developed by Obstfeld (1996) by incorporating labour market rigidities as in Lockwood and Philippopoulos (1994). Such rigidities are shown to generate output persistence in the face of shocks. We show that structural measures that successfully curb this persistence can reduce risk premia and enhance the credibility of stabilisation programmes based on exchange rate pegging. Our finding has clear implications for the sequence of reform as a more flexible labour market is shown to be paramount to increasing credibility of fixed exchange rate regimes. Such implications could be clearer for developed countries than for the much more frequently discussed developing countries case, for labour market rigidities are seldom regarded as a typical problem in the latter group. It also bears on the issue of ‘excessive conservatism’ with regard to inflation; that can undermine the low-inflation policy commitment in the absence of structural reform. Here, too, reducing labour market rigidities proves to be beneficial.

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# Appendix 1

## Derivation of equation (3.8)

Because  $z_t$  uniformly distributed on  $[-Z/2, Z/2]$ , we can rewrite (3.17) as

$$E_{t-1}\pi_t = \pi_t^e = \frac{1}{Z} \int_{-Z/2}^{z_d} \tilde{\pi}_t dz + \frac{1}{Z} \int_{z_r}^{Z/2} \tilde{\pi}_t f(z) dz \quad (\text{A1.1})$$

Substituting  $\tilde{\pi} = \frac{\pi^* + \delta\gamma_1 + b\bar{u}_t}{1+b}$  from (3.11) and  $\bar{u}_t = \rho u_{t-1} + \pi_t^e - z_t$  from (3.8) for

(A1.1) yields

$$\pi_t^e = \frac{1}{Z} \int_{-Z/2}^{z_d} \left[ \frac{\pi^* + \delta\gamma_1 + b(\rho u_{t-1} + \pi_t^e - z_t)}{1+b} \right] dz + \frac{1}{Z} \int_{z_r}^{Z/2} \left[ \frac{\pi^* + \delta\gamma_1 + b(\rho u_{t-1} + \pi_t^e - z_t)}{1+b} \right] dz$$

that equals

$$\pi_t^e = \frac{1}{Z(1+b)} \left\{ \int_{-Z/2}^{z_d} \left[ (\hat{\pi} + b(\rho u_{t-1} + \pi_t^e))z_t - \frac{bz_t^2}{2} \right] + \int_{z_r}^{Z/2} \left[ (\hat{\pi} + b(\rho u_{t-1} + \pi_t^e))z_t - \frac{bz_t^2}{2} \right] \right\} \quad (\text{A1.2})$$

where  $\hat{\pi} \equiv \pi^* + \delta\gamma_1$ . After simplifying (A1.2) we get

$$\pi_t^e = \frac{1}{Z(1+b)} \left[ (\hat{\pi} + b\rho u_{t-1} + b\pi_t^e)(z_d - z_r + Z) - \frac{b}{2}(z_d^2 - z_r^2) \right] \quad (\text{A1.3})$$

Then, from (3.16a,b) we can observe that  $z_d + z_r = 2\left(\frac{\hat{\pi}}{b} + \rho u_{t-1} + \pi_t^e\right) + \frac{\sqrt{R}}{b} - \frac{\sqrt{D}}{b}$

and  $z_d - z_r = -\left[\frac{\sqrt{R} + \sqrt{D}}{b}\right]$  where we have defined  $R \equiv 2(1+b)c_r$  and

$D \equiv 2(1+b)c_d$ . As a result we can rewrite (A1.3) as

$$2Z(1+b)\pi_t^e = 2(\hat{\pi} + b\rho u_{t-1} + b\pi_t^e) \left( Z - \frac{\sqrt{R} + \sqrt{D}}{b} \right) + (\sqrt{R} + \sqrt{D}) \left[ 2\left(\frac{\hat{\pi}}{b} + \rho u_{t-1} + \pi_t^e\right) + \frac{\sqrt{R}}{b} - \frac{\sqrt{D}}{b} \right]$$

or as

$$\begin{aligned}
& \pi_t^e \left\{ 2Z(1+b) - 2b \left[ Z - \frac{(\sqrt{R} + \sqrt{D})}{b} \right] \right\} \\
& = 2 \left\{ \hat{\pi} + b\rho u_{t-1} \left[ Z - \frac{(\sqrt{R} + \sqrt{D})}{b} \right] \right\} + (\sqrt{R} + \sqrt{D}) \left[ 2 \left( \frac{\hat{\pi}}{b} + \rho u_{t-1} + \pi_t^e \right) + \frac{\sqrt{R}}{b} - \frac{\sqrt{D}}{b} \right],
\end{aligned}$$

which finally collapses to

$$2Z\pi_t^e \equiv 2Z(\hat{\pi} + b\rho u_{t-1}) + \frac{R-D}{b} \quad (\text{A1.4})$$

Recalling that  $\hat{\pi} \equiv \pi^* + \delta\gamma_1$ ,  $R \equiv 2(1+b)c_r$  and  $D \equiv 2(1+b)c_d$  (A1.4) can be re-expressed as  $\pi_t^e = \pi^* + \delta\gamma + b\rho u_{t-1} + \frac{1+b}{b}\Delta c$ , which is equivalent to (3.18).

## Appendix 2

### Determining coefficients $\gamma_1$ and $\gamma_2$

Let us write the recursive value functions explicitly as

$$V_t(u_t) = \gamma_{0t} + \gamma_{1t}u_t + \frac{1}{2}\gamma_{2t}u_t^2 \quad (\text{A2.1})$$

and

$$V_{t-1}(u_{t-1}) = E_{t-1} \min_{\pi_t} \{L_t + \delta V_t(u_t)\} \quad (\text{A2.2})$$

Taking the derivative of (A2.2) with respect to  $u_{t-1}$  by using (3.7), and (A2.1) yields

$$\gamma_{1t-1} + \gamma_{2t-1}u_{t-1} = E_{t-1} \min_{\pi_t} \left\{ (b_t \rho u_t + \delta \gamma_{1t}) \frac{du_t}{du_{t-1}} \right\} \quad (\text{A2.3})$$

where  $b_t = \lambda + \delta \gamma_{2t}$ . After using (3.6), (3.18), and taking the expectations (A2.3) simplifies to

$$\gamma_{1t-1} + \gamma_{2t-1}u_{t-1} = \rho(1 + b_t)(b_t \rho u_{t-1} + \delta \gamma_{1t}) \quad (\text{A2.4})$$

Note that because of the envelope theorem, we do not have to take account the effect of  $u_{t-1}$  on  $\pi_t$  in deriving (A2.4) from (A2.2). Equation (A2.4) has a solution only if

$$\gamma_{1t-1} = \rho(1 + b_t)\delta \gamma_{1t} \quad (\text{A2.5})$$

and

$$\gamma_{2t-1} = \rho^2(1 + b_t)b_t \quad (\text{A2.6})$$

In the stationary state  $\gamma_{it-1} = \gamma_{it} = \gamma_i$  for  $i \in \{1, 2\}$  and, accordingly,  $b_t = b$ . After manipulating (A2.6) in the stationary state, the implicit solution for  $\gamma_2$  can be expressed in terms of  $b$  as

$$\delta \rho^2 b^2 - b(1 - \delta \rho^2) + \lambda = 0 \quad (\text{A2.7})$$

Equation (A2.7) has two positive solutions but, for the reasons given in the main text, we exclude the larger root. Solving (A2.7) for the smaller root gives

$$\mathbf{b} = \frac{1 - \delta\rho^2 - \sqrt{(1 - \delta\rho^2)^2 - 4\lambda\delta\rho^2}}{2\delta\rho^2} \quad (\text{A2.8})$$

which corresponds (3.21).

Given (A2.8), we immediately see that the only generic solution for (A2.5) is  $\gamma_1 = 0$ . The other solution  $1 = \rho(1 + \mathbf{b})\delta$  where  $\mathbf{b}$  is given by (A2.8) holds only for a specific parameter value.

## Appendix 3

The proof of Lemma 1.

i) We prove that the Stability Condition is a sufficient condition that  $b$  has a positive real solution. The Stability Condition is equivalent to  $\rho(1+b) < 1$  or, by using (A2.8), to

$$1 - \rho > \frac{1 - \rho^2\delta - \sqrt{(1 - \rho^2\delta)^2 - 4\lambda\rho^2\delta}}{2\rho\delta} \quad (\text{A3.1})$$

Simplifying and rearranging (A3.1) gives

$$\sqrt{(1 - \rho^2\delta)^2 - 4\lambda\rho^2\delta} > 1 - \rho^2\delta - (1 - \rho)2\rho\delta \quad (\text{A3.2})$$

Clearly, if the right-hand side is positive, the left-hand side also has to be positive. After some manipulation, the right-hand side of (A3.2) turns out to be equivalent to

$$(1 - \rho\delta)^2 + \rho^2\delta(1 - \delta) > 0 \quad (\text{A3.3})$$

which clearly holds. Thus the left-hand side of (A3.2) has a positive real-solution, if the Stability condition holds. From (A2.8) we can then confirm that if the left-hand side of (A3.2) has a positive real solution,  $b$  has a positive real solution, too.

Q.E.D

ii) Let us first rewrite  $b$  from (A2.8) as

$$b = \frac{1 - h - \sqrt{(1 - h)^2 - 4\lambda h}}{2h} \quad (\text{A3.4})$$

where  $h = \rho^2\delta$  captures the impact of unemployment persistence on  $b$ . Differentiating next  $b$  with respect to  $h$  yields

$$\frac{db}{dh} = \frac{1}{h^2} \left[ -1 + \frac{(1 - h + 2\lambda)h}{\sqrt{(1 - h)^2 - 4\lambda h}} + \sqrt{(1 - h)^2 - 4\lambda h} \right] \quad (\text{A3.5})$$

Equation (A3.5) is positive if the term in the square-brackets is positive, ie, if

$$-\sqrt{(1-h)^2 - 4\lambda h} + (1-h + 2\lambda)h + (1-h)^2 - 4\lambda h > 0 \quad (\text{A3.6})$$

Simplifying and rearranging (A3.6) gives

$$1-h-2\lambda h > \sqrt{(1-h)^2 - 4\lambda h} \quad (\text{A3.7})$$

Rewriting the right-hand side of (A3.7) yields

$$1-h-2\lambda h > \sqrt{(1-h-2\lambda h)^2 - 4\lambda h^2(1+\lambda)} \quad (\text{A3.8})$$

Q.E.D

iii) Because  $b = \lambda + \delta\gamma_2$ , (A3.4) can be rewritten as

$$\lambda + \delta\gamma_2 - \frac{1-h-\sqrt{(1-h)^2 - 4\lambda h}}{2h} = 0 \quad (\text{A3.9})$$

Differentiating (A3.9) with respect to  $\gamma_2$  and  $\lambda$  gives

$$\delta d\gamma_2 + \left[ 1 - \frac{1}{\sqrt{(1-h)^2 - 4\lambda h}} \right] d\lambda = 0 \quad (\text{A3.10})$$

The term in the brackets is negative because  $h < 1$  means that  $(1-h)^2 - 4\lambda h < 1$ .  
As a result,  $d\gamma_2/d\lambda > 0$ .

Q.E.D

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