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

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Labour market flexibility and policy coordination in a monetary union

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Abstract

Sufficiently flexible labour markets are considered an important precondition for countries to benefit from membership in the monetary union. Economic policy coordination within the European Community is extensive and includes issues related to labour market structures. In this paper we study the determination of flexibility of the labour market and, ultimately, of wages in a member country of the monetary union. As a starting point, the analysis assumes that each country's government, in formulating its labour market policy, decides the degree of nominal wage flexibility in light of the fact that this involves political costs that increase with the degree of wage flexibility. The study then focuses on the effects of monetary union membership on each country's prospects for coordination of economic policies – specifically labour market policies. The study shows that coordination of labour market policies contributes to greater nominal wage flexibility in member countries. However, coordination of labour market policies will be effective only if unemployment is persistent or under discretionary monetary policy. From the perspective of macroeconomic stability, there is no particular need for coordinating labour market policies among member countries if the common central bank can credibly precommit to a low inflation target or if fluctuations in unemployment are white noise.

Key words: wage flexibility, economic policy coordination, credibility, precommitment

JEL classification numbers: E52, E58, E61, J51

Työmarkkinoiden joustavuus ja politiikkakoordinaatio rahaliitossa

Suomen Pankin keskustelualoitteita 11/2003

Anssi Rantala
Tutkimusosasto

Tiivistelmä

Työmarkkinoiden riittävää joustavuutta on pidetty tärkeänä edellytyksenä sille, että maat voivat hyötyä talous- ja rahaliiton jäsenyydestä. EU:n piirissä harjoitetaan laajaa talouspoliittista koordinaatiota, joka kohdistuu myös työmarkkinoiden rakenteisiin. Tässä tutkimuksessa tarkastellaan, miten työmarkkinoiden ja viime kädessä nimellispalkkojen joustavuus määräytyy rahaliittoon kuuluvassa maassa. Tutkimuksessa lähdetään siitä, että kunkin maan hallitus voi työmarkkinapolitiikallaan päättää nimellispalkkojen joustavuuden asteesta tietäen, että tähän liittyy poliittisia kustannuksia, jotka kasvavat sen mukaan, mitä suurempaa palkkojen joustavuutta tavoitellaan. Tutkimuksessa kysytään, miten rahaliiton jäsenyys ja mahdollisuus talouspolitiikan koordinointiin vaikuttavat hallitusten työmarkkinapolitiikkaan. Tulosten mukaan hallitusten välinen työmarkkinapolitiikan koordinaatio lisää nimellispalkkojen joustavuutta jäsenmaissa. Toisaalta työmarkkinapolitiikan koordinaatiolla rahaliitossa on merkitystä vain sikäli kuin työttömyys vähenee hitaasti tai rahapolitiikan harjoittaminen on lyhytnäköistä: jos keskuspankki kykenee täysin uskottavasti sitoutumaan alhaisen inflaation rahapolitiikkaan tai jos työttömyyden vaihtelut ovat lyhytkestoisia ja ohimeneviä, työmarkkinapolitiikan koordinaatioon ei ole tarvetta makrotaloudellisen vakauden kannalta.

Avainsanat: palkkojen joustavuus, talouspolitiikan koordinaatio, uskottavuus, sitoutuminen

JEL-luokittelu: E52, E58, E61, J51

Contents

1 Introduction

Labour market flexibility is an often suggested remedy for European unemployment problems. Recently the EU Council (2002) urged in its Employment Guidelines the member countries to continue implementing further structural reforms to improve the functioning of the European labour market, innovation and competitiveness and to examine the possibility of introducing more flexible labour contract types into their national law. In their reports, international organizations such as the IMF and the OECD quite seldom miss the opportunity to express their worries about the inflexible labour markets in various European countries (see eg IMF (2002) and OECD (2002)). The European Central Bank has also continuously advised the member countries of the Economic and Monetary Union (EMU) to continue reforming the labour markets in order to increase flexibility (see eg ECB (2002)).

There seems to be a consensus of opinion that flexible labour markets are especially important in a large monetary union, such as the EMU, where some shocks to the economy are very likely asymmetric so that only some regions or countries of the monetary union area are affected. Labour mobility in the EMU is relatively low, partly due to cultural differences and language barriers, so one can't count much on mobility as a shock absorber mechanism. National fiscal policy could in principle be used as a macroeconomic stabilization tool, but acknowledging that due to political biases fiscal policy tends to err on the lax side has led to a general perception that discretionary fiscal policy should be restricted by rules limiting the size of government deficits. Moreover, the lags in decision making and policy implementation make the correct timing of discretionary fiscal policy extremely difficult. The importance of prudent fiscal policy becomes even more pronounced in a monetary union, where fiscal profligacy of a member country can threaten the stability of the whole area through financial market reactions. In the EMU the Stability and Growth Pact was launched in order to enforce fiscal discipline. However, even without discretionary fiscal policy the government budget still has a stabilization role if the so-called automatic stabilizers are allowed to work, that is, the loss of fiscal revenue and the increase in welfare spending due to a downturn are not counteracted.

Against this background, it is quite natural to ask what factors do determine the flexibility of the national labour markets in a monetary union and what can policy makers do in order to promote flexibility. This paper attempts to give at least partial answers to these questions by adopting a simple political economics approach, in which national governments decide on nominal wage flexibility and face political costs, which are increasing in the chosen flexibility level. In particular, the paper investigates the role of labour market policy coordination in the determination of flexibility. Coordination in this paper refers to a situation where the flexibility parameters of the member states are chosen so as to minimize joint losses of the national governments. In the EU, labour market policy coordination intensified with the 1997 Amsterdam Treaty, which declares that member states shall treat employment 'as a matter of common concern, and shall co-ordinate their action'. However, in practice the main responsibility of deciding and implementing labour market policy remains with the member states, and so coordination is a somewhat stronger concept in the model than it is in reality in the EU.

Labour market flexibility is an often used, but somewhat vague concept. One interpretation is that flexibility determines how fast the adjustment process of the economy in response to shocks is. But, one labour market can be more flexible in responding to a one kind of shock, whereas another labour market can be more flexible when the adjustment is in response to another kind of shock. Therefore, ranking of different labour markets with respect to flexibility can be meaningfully made only in the context of a particular model of the labour market and with reference to a particular shock (for more discussion on this point, see Pissarides (1997)).

In this paper labour market flexibility is modeled as nominal wage flexibility. Increasing nominal wage flexibility brings about two benefits. First, since nominal wages become more responsive to production shocks, unemployment variability decreases. Second, the need for stabilization policy by the common central bank is reduced, which contributes to lower inflation variability. The degree of nominal wage flexibility is decided by the national government. This can be seen as a simplification of a complicated process where labour market institutions must be designed and legislation must be enacted. Changing the institutional setup of the economy is assumed to be so costly and time-consuming that the government sets the flexibility only once and it can't change it afterwards. However, making the labour markets flexible entails political costs, since nominal wage flexibility is not in the interests of labour unions or their leaders. One can argue that the opposition of flexibility arises from distributional conflicts among the workforce. Labour unions are usually considered to be in the hands of senior members, whose jobs are fairly safe. Long-term nominal wage contracting will transform disturbances to labour demand into employment fluctuations, but at the same time it provides more stable and more easily predictable incomes than shorter or more flexible contracts for senior members who are sheltered from unemployment. When the government sets flexibility, it therefore faces a trade-off between macroeconomic stability and political popularity.

The framework used in the analysis is based on the natural rate model of monetary policy pioneered by Kydland and Prescott (1977) and Barro and Gordon (1983).[1] This approach builds on the idea of a natural rate of unemployment, which was developed by Friedman (1968) and Phelps (1968). They argued on theoretical grounds that the inflation-unemployment trade-off was a short-run phenomenon, and that it can't be exploited in the long-run. Any attempt to lower unemployment below the natural rate by generating inflation will lead to higher inflation without any effect on unemployment. Lucas (1973) derives a Neo-Classical Phillips curve, or an expectations augmented Phillips curve, where unanticipated changes in money supply generate short-run effects in real economy due to imperfect information on the source of price changes. Fischer (1977), on the other hand, arrives

[1] The standard natural rate model is usually called the Barro-Gordon model, a convention which is somewhat unfair to the original contribution by Kydland and Prescott (1977). For brevity, this usual practice is also followed in this paper.

at the very same formulation by modelling labour markets with long-term nominal contracting. The Barro-Gordon model adds an optimizing policy maker into the analysis and points out that the policy maker may have an incentive to exploit the short-run trade-off between unexpected inflation and unemployment in order to push unemployment below the natural rate. Provided that the private sector has rational expectations, the government's attempt is anticipated and the result is the celebrated inflation bias without any improvement in the unemployment rate.

Modelling of monetary policy in this paper deviates from the standard Barro-Gordon model in two respects. First, there is persistence in the actual unemployment rate. Second, the central bank is assumed to target the 'long-run' natural rate instead of having an 'over-ambitious' unemployment target. Both of these assumptions will affect the equilibrium of the model and are discussed below. Monetary policy is modeled as being discretionary in the model, a view which is in line with the thinking of eg Blinder (1998), Bernanke and Mishkin (1997) and King (1997), who are not only prominent academics, but they all are or were also central bankers. However, a commitment solution for monetary policy is also derived, but it is used only as a reference point, since it yields optimal stabilization of shocks from the society's point of view.

Empirically it is well established that the unemployment rate is highly persistent. Blanchard and Summers (1986) and Layard et al (1994) report that when unemployment is regressed on one-period lagged unemployment, the coefficient estimate on the latter is close to unity in annual data for both the UK and the USA. Layard et al (1991, Ch. 9) estimates reduced-form employment equations for 19 OECD countries and uses two different measures of persistence. The results indicate that unemployment is highly persistent in most cases.

Unemployment persistence can arise from at least two sources. There may be labour adjustment costs affecting the firms' hiring and firing decisions. Alternatively, the wage setting process itself can work as a source for unemployment dynamics. This paper adopts the second option, which is advocated in Blanchard (1991), where he writes 'I believe–without, I must admit, a tightly argued case at this stage–that, for the issue at hand, the medium-run persistence of unemployment, the dynamics coming from wage bargaining dominate those coming from search, firing, and hiring costs.' In particular, in the spirit of Lindbeck and Snower (1986) and following Blanchard and Summers (1986), it is shown that when the wage setting process is dominated by insiders of the labour market, the effects of production shocks tend to persist, since changes in the number of insiders will lead to changes in the objectives of the labour unions. The insider-outsider approach to labour markets can be applied in many different questions related to employment and unemployment outcomes. A recent survey and assessment of the insider-outsider literature is provided by Lindbeck and Snower (2001).

When unemployment persistence is incorporated into the Barro-Gordon model the central bank's problem becomes explicitly dynamic in nature. When setting monetary policy, the central bank has to bear in mind that its policy will affect unemployment not only in the current period, but in the future all well. It follows that it becomes more important to stabilize production shocks, because once unemployment rises, it will take long time before it returns to the initial level. Needless to say that this reasoning presupposes that the central bank is forward-looking. Lockwood and Philippopoulos (1994) first analyzed the natural rate model with unemployment persistence under discretionary monetary policy and showed that inflation bias problem is aggravated in the dynamic model and that there is actually multiple equilibria and indeterminacy problems. Suggested solutions to these problems will be discussed later in the paper. Lockwood et al (1998) and Svensson (1997) showed that optimal stabilization is increasing in persistence and that discretionary monetary policy leads to a new problem, that is, a stabilization bias emerges. Inflation variability is too high and unemployment variability is too low from the society's point of view. This inefficient stabilization performance will play an important role in the analysis.

The central bank targets the 'long-run' natural rate in the model, which means that the inflation bias problem disappears, since the central bank's incentives to use monetary policy as a device in lowering the rate of unemployment below the natural rate are destroyed. A justification for rejecting the inflation bias argument is given in the following. First, it must be acknowledged, that the inflation bias model can be seen as a rather good description of the incentives facing politicians when they were in charge of monetary policy. Then, it is quite natural that if the natural rate is too high from the society's point of view, governments may be tempted to use monetary policy to bring down unemployment. As already said, this results in inflation bias, but the average unemployment rate is unchanged. Obviously, structural measures to lower imperfections in product and labour markets were actually needed to combat unemployment, but implementing such measures are assumed to be politically costly, and therefore politicians are inclined to take the soft option. However, when monetary policy is delegated to an independent central bank, there seems no reason whatsoever for the central bank to target anything other than the natural rate. Casual evidence suggests that this is indeed the case. In the 1990s central bank acts were reformed in many countries towards greater independence of political pressures, which was followed by convergence on low inflation.

As an extension to the basic model the paper considers an alternative unemployment target for the central bank and its implications for labour market flexibility and coordination. Due to persistence the 'short-run' natural rate of unemployment differs from the 'long-run' one. Svensson (1997) argued that the discretionary equilibrium can be improved on by directing the central bank to target the 'short-run' natural rate, and the outcome then would coincide with the commitment solution, which yields optimal stabilization of shocks. However, it turns out that this conjecture is incorrect. The central bank's reaction is the same as in an economy without any real persistence, which means that the central bank stabilizes shocks too little. The 'short-run' natural rate is defined as the unemployment level without inflation surprises and production shocks, that is, it is equal to last period's unemployment multiplied with the persistence parameter of the unemployment process. It follows that the 'short-run' natural rate is endogenous to the central bank. If, however, the central bank misinterprets the changes in the natural rate as arising solely from structural factors and hence fails to recognize the impact of its own actions, it can justify the choice of the 'short-run' natural rate as its target. This kind of central bank type resembles, but is a milder version of 'new conservatism' launched by De Grauwe (2000, Ch. 7). The 'new conservatism' refers to a central bank who systematically estimates the natural unemployment rate to coincide with the observed unemployment rate. According to De Grauwe there is a risk that the ECB behaves like this and he argues that the policy statements of the ECB often associate the observed level unemployment with structural unemployment.

The modeling strategy of the paper is very similar to that of Calmfors (2001), where the flexibility comparison is made between national monetary policy regime and a membership in a monetary union. Calmfors (2001) allows flexibility to interact with the 'long-run' natural rate and also studies the case where inflation bias is present. However, a notable difference to this paper is that there is no persistence in the economy and coordination of labour market policies is not considered. Another closely related paper by Sibert and Sutherland (2000) studies the same problem as Calmfors (2001), but there flexibility is of more limited nature and can't be interpreted as perfect nominal wage flexibility, because there it affects only the propagation of production shocks to the real economy leaving inflation surprises still as an effective means to control real activity.[2] The impact of the formation of a monetary union on the need and incentives for flexibility enhancing labour market reform is also discussed and analyzed, inter alia, in Pissarides (1997), Bean (1998) and Saint-Paul and Bentolila (2000).

This paper identifies at least some of the factors affecting the chosen level of labour market flexibility. In a monetary union the common monetary policy reacts only to common shocks, and therefore the structure of the shocks hitting the economy is a crucial factor. As expected, the more asymmetric the shocks are, the higher is the chosen level of nominal wage flexibility. Higher marginal political costs in turn discourage flexibility, since the marginal benefit from flexibility is unaltered. Higher persistence leads to prolonged deviations from the natural rate and, quite intuitively, encourages the government to choose more flexible markets.

The monetary union is assumed to be large in the sense that each government is so small relative to the common central bank that it will take monetary policy as given. However, coordination of national labour market policies brings in a strategic aspect to the model. It is shown that stabilization policy of the central bank is affected by the average flexibility in the monetary union area so that by choosing more flexibility it is possible to improve the stabilization properties of monetary policy. In particular, by choosing more flexibility in a coordinated fashion the governments can reduce the stabilization bias of monetary policy. Therefore, the marginal benefit from flexibility is higher under coordination and coordination results in more flexible labour markets than national decision making. But, coordination turns out to be irrelevant for flexibility, if stabilization policy is optimal from

[2] Sibert and Sutherland's (2000) way of modelling flexibility is consistent with a timing protocol, where wage negotiations occur after the production shock has been realized and observed, but before monetary policy is set in each period.

the society's point of view. This is the case when there is no persistence in the economy or the central bank has access to commitment technology. If the central bank is of 'new conservative' type described above, and stabilizes shocks too little, coordination leads to lower flexibility, thereby pushing the stabilization policy closer to the optimum. The paper discusses also the impact of coordination on social welfare and the government incentives for coordination. Relying on numerical simulations it seems that social welfare is higher under coordination and that government losses are lower, implying that governments do have incentives to coordinate their actions. However, in the 'new conservatism' regime social welfare decreases under coordination, but the reduction of political costs due to lower flexibility reduces government losses. The result is that governments have incentives to coordinate their actions, even though it brings about lower social welfare.

Finally, the paper very briefly investigates a situation where a country is not a member of a monetary union, but has an independent monetary policy.[3] Calmfors (2001) shows that the chosen labour market flexibility will then be lower than inside a monetary union, because monetary policy can stabilize the country-specific asymmetric part of the production shock, rather than just the common part like in a monetary union. This result is in line with the TINA (there is no alternative) argument discussed in Bean (1998), which states that once policy makers lose monetary policy as a stabilization tool, they will have no alternative but to make labour markets more flexible via reform. It turns out that this is not necessarily the case when unemployment persists, since like under policy coordination in a monetary union, with an independent monetary policy the government has an incentive to choose more flexible markets in order to improve on stabilization properties of the economy. But, inside a large monetary union this effect disappears. Hence, inside a monetary union flexibility tends to be more important because monetary policy can no longer stabilize country-specific shocks, but on the other hand, the disappearance of the incentive to increase flexibility for stabilization reasons lowers flexibility. Numerical simulations suggest that the latter effect dominates when persistence is high enough, and so flexibility can actually be lower in a monetary union.

This paper is organized as follows. In section 2 the basic structure of the model is presented and the related Phillips curves are derived. The common central bank's optimal policy rule under both commitment and discretion is presented in section 3. Finally, section 4 analyzes the determination of labour market flexibility assuming first that the flexibility decisions are made independently by the national governments. After deriving this benchmark case the focus shifts to policy coordination. Section 5 considers some extensions to the model and studies the impact of coordination on social welfare. Section 6 concludes.

[3] Independent monetary policy in this context means that a country can and is willing to use monetary policy as a stabilization tool. Hence, the exchange rate regime can eg be a flexible rate regime or a fixed but adjustable rate one.

2 The model

2.1 The basic structure

The monetary union consists of a continuum of countries indexed by i and distributed uniformly between $i = 0$ and $i = 1$. Each country contains a continuum of firms indexed by j and distributed uniformly between $j = 0$ and $j = 1$. For simplicity, the firms in all countries produce the same product, so the goods market is perfectly competitive. Throughout the paper, all countries are symmetrical in terms of structural parameters and preferences of the policy makers and labour unions. Only one type of asymmetry is allowed, namely production shocks have a country-specific part.

The model economy evolves over an infinite number of time periods $t = 0, 1, \ldots$. At $t = 0$, each national government chooses its preferred labour market flexibility, denoted by s_i. Following Calmfors (2001), labour market flexibility is introduced into the model by assuming that in each country there is a flexible sector and an inflexible sector of the economy. Slightly simplifying the Calmfors model a fraction s_i of the firms is characterized by competitive (spot) labour markets where labour supply and labour demand together determine the equilibrium wage, whereas in a fraction $1 - s_i$ of the firms one period nominal wage contracting prevails and employment is demand determined. After flexibility is determined in all countries, a dynamic game between the common central bank and the private sectors of all countries begins at $t = 1$. Within each time period evens unfold as follows. (i) Firm-specific labour unions set nominal wages in 'inflexible' firms in each country. (ii) Production shocks are realized. (iii) The common central bank sets inflation for the whole monetary union area. (iv) Competitive nominal wage is determined in 'flexible' firms and production occurs in each country.[4]

2.2 The labour market

In every period t, firm j's labour demand schedule in country i is given by

$$l^d_{jit} = p_{it} - w_{jit} - \varepsilon_{it}, \tag{2.1}$$

where l_{jit} is the log of employment, p_{it} is the log of the price level, w_{jit} is the log of the nominal wage and ε_{it} is a country i specific production shock, which has zero mean and a variance equal to σ^2_ε.[5] Each firm is assumed to have a pool of immobile workers, whose labour supply schedule is perfectly inelastic with respect to the real wage and is normalized to zero:[6]

$$l^s = 0. \tag{2.2}$$

[4] It could equally well be assumed that in the 'flexible' firms labor unions still determine wages, but instead of setting nominal wages at stage (i) before production shocks and monetary policy, they would act at stage (iv).

[5] The real wage elasticity of labor demand is normalized to unity for analytical simplicity.

[6] Complete symmetry across firms, countries and time periods implies: $l^s_{jit} = l^s_{it} = l^s_t = l^s$.

In the 'flexible' firms characterized by competitive labour markets labour demand equals labour supply at every time period and employment is hence constant at zero, $\widehat{l}_{jit} = 0$, which yields zero unemployment in competitive markets, $\widehat{u} = l^s - \widehat{l}_{jit} = 0$. The spot market nominal wage becomes

$$\widehat{w}_{it} = p_{it} - \varepsilon_{it}, \tag{2.3}$$

and thereby depend both on the realized production shock and monetary policy reaction, which in turn determines the price level.

In the 'inflexible' firms workers are organized in firm-specific labour unions, who set one-period nominal wages before the production shock is realized and inflation is chosen by the common central bank. Firms choose employment after the shock, so employment is demand determined and workers may be off their labour supply schedules. The utility function of a firm-specific labour union is given by

$$U_{jit} = -E_{t-1}\left(l_{jit} - \bar{l}_{jit}\right)^2, \tag{2.4}$$

where $\bar{l}_{jit}$ is the period t employment target of the labour union and E_{t-1} is a conditional expectations operator. In a standard labour union model the union's employment target, $\bar{l}_{jit}$, is assumed to be constant and quite often below the full employment level. These assumptions bring about a constant positive natural rate of unemployment. Here, the employment target is assumed be time varying and affected by 'insider power'. In the spirit of Lindbeck and Snower (1986), and following Blanchard and Summers (1986), it is assumed that the employment target of the union is a weighted (geometric) mean of the currently employed insiders, l_{jit-1}, and the total labour force available to the firm, l^s:

$$\bar{l}_{jit} = \rho l_{jit-1} + (1-\rho)\, l^s, \tag{2.5}$$

where ρ, $(0 \leq \rho < 1)$ is the measure of insider power in wage-setting.[7] By setting $\rho = 0$, the model collapses to the standard case with a constant real wage target.

The union's optimization problem is to set w_{jit} so as to maximize (2.4). Maximization yields a nominal wage rule of the form

$$w_{jit} = p_{it}^e - \left(\rho l_{jit-1} + (1-\rho)\, l^s\right), \tag{2.6}$$

with p_{it}^e being the expectation of the price level. Together with the labour demand schedule (2.1) (employment is demand determined) this gives

$$l_{jit} = \rho l_{jit-1} + (1-\rho)\, l^s + (p_{it} - p_{it}^e) - \varepsilon_{it}. \tag{2.7}$$

Defining inflation as $\pi_{it} = p_{it} - p_{it-1}$, from which $\pi_{it}^e = p_{it}^e - p_{it-1}$ follows, and defining the firm-specific unemployment rate at time t to be $u_{jit} = l^s - l_{jit}$, it is possible to derive a firm/union specific Neo-Classical Phillips curve (expectations augmented Phillips curve):

$$u_{jit} = \rho u_{jit-1} - (\pi_{it} - \pi_{it}^e) + \varepsilon_{it}. \tag{2.8}$$

[7] As is clear from (2.2), l^s is actually normalized to zero in the model. This assumption will be utilized in (2.8).

In this simple setup the parameter capturing the insider power in wage setting is translated directly into the measure of persistence in unemployment rate. The labour union's employment target is in the long-run consistent with the total labour force available to the firm, l^s. Thereby unemployment fluctuates around the full employment level and the existence of labour unions doesn't create unemployment in the long-run in this model. Hence, flexibility and average unemployment are independent of each other. Increasing nominal wage flexibility doesn't lower the average unemployment rate, but affects the temporal properties of the unemployment rate. The fact that average unemployment is zero in the model is just a normalization. It could equally well be assumed that the long-run employment target of the union is lower that full employment, in which case the average unemployment would be positive in the unionized sector of the economy. Likewise, the competitive markets could be assumed to have some matching frictions, which would cause frictional unemployment. The model setup is chosen because by setting the average unemployment in both flexible and inflexible sectors the same, it is possible to isolate the pure stabilization motive to make the economy more flexible from other possible reasons to promote flexibility.

The country-wide Neo-Classical Phillips curve is obtained by integrating over the firm/union specific Phillips curves in both union dominated firms and firms with competitive labour markets with respect to j, which gives

$$\begin{aligned} u_{it} &= \int_0^1 u_{jit} dj = \int_0^{s_i} \widehat{u}_{jit} dj + \int_{s_i}^1 u_{jit} dj \\ &= \rho u_{it-1} - (1 - s_i)\left(\pi_{it} - \pi_{it}^e\right) + (1 - s_i)\,\varepsilon_{it}, \end{aligned} \tag{2.9}$$

where $u_{it-1} = \int_0^1 u_{jit-1} dj = \int_{s_i}^1 u_{jit-1} dj$. Nominal wage flexibility affects the slope of the Phillips curve and the unemployment effect of the production shock, but persistence of the economy is unaffected. At first sight it may seem strange that the persistence of the aggregate unemployment is independent of labour market flexibility. However, the intuition behind this outcome is clear. An increase in flexibility will have a 'level effect' on unemployment rate so that after, say, a negative production shock u_{it} will not rise as much as with lower flexibility. But, there is no 'speed effect' in increasing flexibility, since unemployment in union dominated firms with long-term nominal contracts will return towards the long-run equilibrium at a constant rate, which is unaffected by flexibility.

The final step in developing the basic structure of the model is to aggregate the country-specific Phillips curves into a monetary union wide one. As already mentioned, the production shock consists of a common, monetary union wide, part μ_t and an asymmetric, country specific, part ν_{it}:

$$\varepsilon_{it} = \mu_t + \nu_{it}, \tag{2.10}$$

where the two shocks are independent and symmetrically distributed and have zero means and variances σ_μ^2 and σ_ν^2, respectively.[8] Integrating (2.9) over i gives

$$\begin{aligned} u_t &= \int_0^1 u_{it} di \qquad (2.11) \\ &= \int_0^1 \left(\rho u_{it-1} - (1-s_i)\left(\pi_{it} - \pi_{it}^e\right) + (1-s_i)\mu_t + (1-s_i)\nu_{it}\right) di \\ &= \rho u_{t-1} - (1-s)\left(\pi_t - \pi_t^e\right) + (1-s)\mu_t, \end{aligned}$$

where $u_{t-1} = \int_0^1 u_{it-1} di$ and $s = \int_0^1 s_i di$. The country-specific shocks, ν_{it}, cancel out, because s_i is decided before the dynamic game between the common central bank and the private sectors of all countries starts and is not allowed to be state-dependent.[9] Thus $1 - s_i$ is uncorrelated with the realization of the country-specific shock, ν_{it}, and according to the law of large numbers the integral $\int_0^1 (1-s_i)\nu_{it} di$ equals zero. From (2.11) it is clear that the 'short-run' natural rate of unemployment is different from the 'long-run' natural rate. The former is the rate of unemployment in the absence of an inflation surprise and a production shock, which is obviously state-dependent and equal to ρu_{t-1} at time period t. The latter, the 'long-run' natural rate, is the mean of the unemployment process and normalized here to zero.

2.3 Government and central bank preferences

The intertemporal social loss function of country i is assumed to be of the standard quadratic form:

$$SL_i = E_0 \left(\sum_{t=1}^{\infty} \beta^{t-1} \frac{1}{2} \left(\left(\pi_t - \pi^*\right)^2 + \lambda u_{it}^2 \right) \right), \qquad (2.12)$$

where $\beta, (0 < \beta < 1)$ is the discount factor, $\lambda > 0$ is the relative weight on unemployment stabilization and π^* is the inflation target of the society.[10] The government's loss function of country i consists of the social loss function (2.12) and an additional term κs_i, which is interpreted as a political cost of making the economy more flexible:

$$GL_i = E_0 \left(\sum_{t=1}^{\infty} \beta^{t-1} \left(\frac{1}{2} \left(\left(\pi_t - \pi^*\right)^2 + \lambda u_{it}^2 \right) + \kappa s_i \right) \right) \qquad (2.13)$$

[8] With this simple shock structure (equation (2.10)) the correlation of shocks between the member countries is given by

$$corr\left(\varepsilon_{it}, \varepsilon_{kt}\right) = \frac{cov\left(\varepsilon_{it}, \varepsilon_{kt}\right)}{\sqrt{var\left(\varepsilon_{it}\right)}\sqrt{var\left(\varepsilon_{kt}\right)}} = \frac{cov\left(\mu_t, \mu_t\right)}{\sqrt{var\left(\varepsilon_{it}\right)}\sqrt{var\left(\varepsilon_{kt}\right)}} = \frac{var\left(\mu_t\right)}{var\left(\varepsilon_{it}\right)} = \frac{\sigma_\mu^2}{\sigma_\mu^2 + \sigma_\nu^2}.$$

[9] Obviously, it may be the case that optimal s_{it} would depend on ν_{it}. This is ruled out in the analysis. Given the interpretation of s_i in the model, it is quite difficult to consider it as being adjustable over the business cycle.

[10] Again, symmetry across countries implies $\pi_i^* = \pi^*$.

As discussed already in the introduction, a natural explanation for the political cost can be derived from labour union behavior in the model. The senior members of the unions can guarantee stable incomes for themselves by long-term nominal contracting, thereby letting unemployment to absorb shocks which are not stabilized by common monetary policy. By increasing the flexible part of the economy by choosing a higher s_i the government increases wage flexibility in the economy, which contradicts the preferences of the senior members of the labour unions.

The objective function of the common central bank is similar to the social loss function (2.12), but has the monetary union wide unemployment rate as an argument instead of a country-specific one:

$$V = E_0 \left(\sum_{t=1}^{\infty} \beta^{t-1} \frac{1}{2} \left((\pi_t - \pi^*)^2 + \lambda u_t^2 \right) \right) \tag{2.14}$$

It is assumed that the common central bank has the same discount rate, the same inflation target, and the same zero unemployment target as the society. Since the unemployment target equals to the 'long-run' natural rate of zero there is no average inflation bias in the model. For simplicity, the central bank is assumed to have perfect control over the inflation rate π_t. It sets the inflation rate in each period after the productivity shock is realized and observed.

3 Monetary policy

3.1 The dynamic game

The equilibrium in the standard Barro-Gordon model is the one-shot Nash equilibrium, which is repeated indefinitely. Here, since unemployment is persistent (see equation (2.11)), the game between the common central bank and the private sector is dynamic instead of being a repeated one. The natural rate model with unemployment dynamics was first analyzed in Lockwood and Philippopoulos (1994). The derivation of optimal monetary policy under different policy regimes in this section follows quite closely that of Svensson (1997).

The stabilization problem of the central bank is a dynamic one, since the extent to which u_t is stabilized after a shock will affect next period's $t+1$ 'short-run' natural rate of unemployment, ρu_t. The state variable of this dynamic game is u_{t-1}, that is , u_{t-1} summarizes the impact of the history of the game on the current 'short-run' natural rate of unemployment, ρu_{t-1}. The fact that the persistence of the natural rate is endogenous in the model is crucial for the outcome.[11] In Barro and Gordon (1983) the natural rate is persistent, but it is exogenous to the central bank. Then the problem is still static in nature and the only change is that the inflation bias is persistent.

The solution concept used in the paper is the so-called Markov-perfect equilibrium, where the current actions of the players depend on the history of the game only through the state variable and trigger strategies are ruled out (see eg Fudenberg and Tirole (1991)). Since it is assumed that labour market flexibility is chosen before the dynamic game starts, $s = \int_0^1 s_i di$ is taken to be exogenous to the common central bank.

3.2 Commitment as a reference point

Even though the purpose of the paper is to focus on the interaction of discretionary (time-consistent) monetary policy and endogenously determined labour market flexibility, it is useful first to derive the commitment solution to the dynamic monetary policy game. The commitment outcome serves as a reference point, because it yields optimal stabilization of production shocks from the society's point of view. As mentioned in the introduction, it is generally not considered to be a good description of actual monetary policy.

The optimal policy rule under commitment can be derived by utilizing a dynamic programming approach. The Bellman equation characterizing the central bank's optimization problem can be written as

$$V^*(u_{t-1}) = \min_{\pi_t, \pi_t^e} E_{t-1}\left(\frac{1}{2}\left((\pi_t - \pi^*)^2 + \lambda u_t^2\right) + \beta V^*(u_t)\right) \tag{3.1}$$

[11] To be precise, persistence parameter, ρ, is exogenous to the central bank, but u_{t-1} is endogenous.

subject to (2.11) and

$$\pi_t^e = E_{t-1}\pi_t. \tag{3.2}$$

Since the central bank chooses its policy rule before inflation expectations are formed, it can actually choose the expectation π_t^e as well, subject to the requirement that π_t^e be rational. This implies that $\pi_t^e = E_{t-1}\pi_t$ is a constraint on the choice of policy rule by the central bank, not an identity.

The first-order conditions for a minimum with respect to π_t and π_t^e are

$$(\pi_t - \pi^*) - \lambda(1-s)u_t - \beta V_u^*(u_t)(1-s) + \phi_t = 0, \tag{3.3}$$

$$E_{t-1}(\lambda(1-s)u_t + \beta V_u^*(u_t)(1-s)) - \phi_t = 0, \tag{3.4}$$

where ϕ_t is the Lagrange multiplier of (3.2). Eliminating the Lagrange multiplier yields

$$\begin{aligned}&(\pi_t - \pi^*) - \lambda(1-s)u_t - \beta V_u^*(u_t)(1-s) + \\ &E_{t-1}(\lambda(1-s)u_t + \beta V_u^*(u_t)(1-s)) = 0.\end{aligned} \tag{3.5}$$

Taking expectations at $t-1$ of (3.5) gives

$$E_{t-1}\pi_t = \pi^*, \tag{3.6}$$

which implies that the expected inflation rate equals the target rate.

The central bank's problem is linear-quadratic, so the 'guess and verify' technique of solving dynamic programming problems can be applied (see eg Ljungqvist and Sargent (2000, Ch. 2–4) for more discussion on this point). In this class of problems the present value of losses to the central bank is a quadratic function of the state variable, u_{t-1}:

$$V^*(u_{t-1}) = \gamma_0^* + \gamma_1^* u_{t-1} + \frac{1}{2}\gamma_2^* u_{t-1}^2. \tag{3.7}$$

Substituting equations (2.11), (3.2), (3.6) and $V_u^*(u_{t-1}) = \gamma_1^* + \gamma_2^* u_{t-1}$ into (3.5) and solving the equation for π_t gives the precommitment inflation rule

$$\pi_t = \pi^* + b^*\mu_t \tag{3.8}$$

with

$$b^* = \frac{(1-s)^2(\lambda + \beta\gamma_2^*)}{\left(1 + (1-s)^2(\lambda + \beta\gamma_2^*)\right)}. \tag{3.9}$$

Average unemployment in the monetary union area will then follow the process

$$u_t = \rho u_{t-1} + (1-s)(1-b^*)\mu_t, \tag{3.10}$$

and country i unemployment is given by

$$u_{it} = \rho u_{it-1} + (1-s_i)(1-b^*)\mu_t + (1-s_i)\nu_{it}. \tag{3.11}$$

In order to solve b^* the coefficient γ_2^* need to be solved. The coefficients γ_0^* and γ_1^* are not of interest here, since they don't enter the policy rule. Substituting equations (3.7)–(3.10) into the Bellman equation and identifying the coefficient of u_{t-1}^2 results in a Riccati equation in γ_2^*

$$\frac{1}{2}\gamma_2^* = \frac{1}{2}\lambda\rho^2 + \frac{1}{2}\beta\rho^2\gamma_2^*, \tag{3.12}$$

which gives

$$\gamma_2^* = \frac{\lambda\rho^2}{(1-\beta\rho^2)}. \tag{3.13}$$

Finally, b^* is solved by inserting (3.13) into (3.9), which yields

$$b^* = \frac{(1-s)^2\lambda}{\left(1+(1-s)^2\lambda-\beta\rho^2\right)}. \tag{3.14}$$

It is noteworthy, that the optimal inflation response to a common component of the production shock, b^*, is increasing with unemployment persistence. In the presence of persistence, a one-time shock to unemployment will affect the unemployment rate also in the future, whereby stabilizing unemployment becomes more important than in a world without persistence. It follows that inflation variability will increase with real persistence, but inflation itself doesn't persist. By setting $\rho = 0$ (and $s = 0$) (3.14) reduces to a standard static equilibrium in a natural rate model will commitment (see eg Persson and Tabellini (2000, Ch. 15)).

3.3 Optimal monetary policy under discretion

In the discretionary regime the monetary authority can't commit to a certain policy rule before inflation expectations are formed, but it re-optimizes in every time period after inflation expectations are set and the production shock is realized so as to minimize the intertemporal loss function. Then the optimization problem of the central bank can be written as

$$V(u_{t-1}) = E_{t-1}\min_{\pi_t}\left(\frac{1}{2}\left((\pi_t-\pi^*)^2+\lambda u_t^2\right)+\beta V(u_t)\right) \tag{3.15}$$

subject to (2.11). Since inflation expectations are now given, minimization is carried out only with respect to π_t. The central bank sets inflation after observing the production shock, therefore $\min_{\pi_t}$ is moved inside the expectations operator. Even though the central bank does not take into account the impact of its choice of inflation on inflation expectations, it does pay attention to the fact that current unemployment will have an effect on current expectations of future inflation through $V(u_t)$.

The first-order condition for a minimum in this problem is given by

$$(\pi_t-\pi^*) - \lambda(1-s)u_t - \beta V_u(u_t)(1-s) = 0 \tag{3.16}$$

Again, the value function must be quadratic, since the objective function is quadratic and the constraint is linear. The coefficients of the value function in the discretionary case are written without asterisks:

$$V\left(u_{t-1}\right)=\gamma_0+\gamma_1 u_{t-1}+\frac{1}{2}\gamma_2 u_{t-1}^2. \tag{3.17}$$

The first-order condition becomes

$$\left(\pi_t-\pi^*\right)-\lambda\left(1-s\right)u_t-\beta\left(\gamma_1+\gamma_2 u_t\right)\left(1-s\right)=0. \tag{3.18}$$

Taking expectations of (3.18) yields

$$E_{t-1}\pi_t=\pi^*+\beta\left(1-s\right)\gamma_1+\left(1-s\right)\left(\lambda+\beta\gamma_2\right)\rho u_{t-1}. \tag{3.19}$$

Combining (3.18) and (3.19), using (2.11) and (3.2) yields an optimal discretionary decision rule

$$\pi_t=a+b\mu_t+cu_{t-1} \tag{3.20}$$

where

$$\begin{aligned} a&=\pi^*+\beta\left(1-s\right)\gamma_1, \\ b&=\frac{\left(1-s\right)^2\left(\lambda+\beta\gamma_2\right)}{\left(1+\left(1-s\right)^2\left(\lambda+\beta\gamma_2\right)\right)}, \\ c&=\left(1-s\right)\left(\lambda+\beta\gamma_2\right)\rho. \end{aligned} \tag{3.21}$$

Average unemployment in the monetary union area will follow the process

$$u_t=\rho u_{t-1}+\left(1-s\right)\left(1-b\right)\mu_t, \tag{3.22}$$

and country i unemployment is given by

$$u_{it}=\rho u_{it-1}+\left(1-s_i\right)\left(1-b\right)\mu_t+\left(1-s_i\right)\nu_{it}. \tag{3.23}$$

Now, the coefficients γ_1 and γ_2 show up in the policy rule and need to be determined. Substituting equations (3.20)–(3.22) into the Bellman equation (3.15) of the discretionary case and identifying the coefficients of u_{t-1} and u_{t-1}^2 yields two Riccati equations

$$\gamma_1=\left(1-s\right)^2\left(\lambda+\beta\gamma_2\right)\beta\rho\gamma_1+\beta\rho\gamma_1, \tag{3.24}$$

$$\frac{1}{2}\gamma_2=\frac{1}{2}\left(1-s\right)^2\left(\lambda+\beta\gamma_2\right)^2\rho^2+\frac{1}{2}\left(\lambda+\beta\gamma_2\right)\rho^2. \tag{3.25}$$

The system is recursive. Equation (3.25) determines γ_2, which can be substituted into (3.24) to identify γ_1. However, equation (3.25) is quadratic in γ_2 and thus there are in general two solutions for γ_2 with a given set of parameters. Re-organizing the second equation and using c from equation (3.21) results in

$$\left(1-s\right)\beta\rho c^2-\left(1-\rho^2\beta\right)c+\lambda\left(1-s\right)\rho=0, \tag{3.26}$$

which yields real solutions

$$c = \frac{(1-\rho^2\beta) \pm \sqrt{(1-\rho^2\beta)^2 - 4(1-s)^2\rho^2\beta\lambda}}{2(1-s)\rho\beta}, \tag{3.27}$$

if, and only if, the following existence condition holds:

$$\lambda \leq \frac{(1-\rho^2\beta)^2}{4(1-s)^2\beta\rho^2}. \tag{3.28}$$

Obviously, it is required that (3.28) is satisfied, since complex solutions make no sense for rates of inflation and unemployment.

Whenever there is a real solution to (3.26) there seem to be two of them. Lockwood and Philippopoulos (1994) show that the 'low inflation' equilibrium which is associated with a lower value of c has plausible comparative statics properties, whereas the 'high inflation' equilibrium responds counter-intuitively to changes in parameter values.[12],[13] Moreover, the high inflation equilibrium exists only when time horizon is infinite.

In the literature, two approaches to deal with the problem of multiple equilibria in this model has been applied. The first 'solution' is to ignore the 'bad equilibrium' with high inflation and to focus on the 'good equilibrium'. This strategy is followed eg in Svensson (1997, 1999), Beetsma and Jensen (1998, 1999) and Lockwood et al (1998). The second 'solution' treats the two equilibria more equally and considers both cases being possible outcomes of the model. This line of reasoning is followed eg in Lockwood and Philippopoulos (1994), Lockwood (1997) and Jensen (1999).

This paper adopts the first approach, that is, only the low inflation equilibrium in considered and c becomes

$$c = \frac{(1-\rho^2\beta) - \sqrt{(1-\rho^2\beta)^2 - 4(1-s)^2\rho^2\beta\lambda}}{2(1-s)\rho\beta}. \tag{3.29}$$

Multiple equilibria would be especially problematic in this paper, since the governments would then be uncertain about the inflation and unemployment processes with a given set of parameter values and would have to base their flexibility decisions on some expectation about the realized equilibrium. The justification for excluding the high inflation equilibrium is novel. By applying the theory of adaptive learning it is shown in a companion paper, Rantala (2003), that only the low inflation equilibrium is stable under least-squares learning. That is, if the agents don't know the parameters of the policy rule, but act as econometricians and re-estimate them from existing data in each time period using least-squares estimation technique, they can only learn the low inflation equilibrium. Evans and Honkapohja (2001) provides a comprehensive treatment of learning in macroeconomics.

[12] 'Low inflation' equilibrium means that with a given $u_{t-1} > 0$ the lower value of c gives lower inflation than the higher value of c. Obviously, when $u_{t-1} < 0$ the opposite happens.

[13] In the 'high inflation' equilibrium inflation increases when the weight given to inflation variability in the central bank's objective function increases and decreases when the real persistence increases or when the central bank cares more about the future.

Now, rearranging the first Riccati equation (3.24) gives

$$\gamma_1 \left(1 - \beta \left(\left(1 - s\right) c + \rho\right)\right) = 0, \tag{3.30}$$

which holds in general if $\gamma_1 = 0$.[14] The second Riccati equation (3.25) can be written as

$$\gamma_2 = \frac{\lambda \rho^2 \left(1 - s\right)^2}{\left(1 - \rho^2 \beta\right)} + \frac{c^2}{\left(1 - \rho^2 \beta\right)}. \tag{3.31}$$

Substitution of $\gamma_1 = 0$ and (3.31) into (3.21) gives the optimal policy rule under discretion

$$\pi_t = \pi^* + b\mu_t + cu_{t-1} \tag{3.32}$$

where

$$b = \frac{\left(1 - s\right)^2 \lambda + \left(1 - s\right)^2 \beta c^2}{\left(1 + \left(1 - s\right)^2 \lambda - \beta \rho^2 + \left(1 - s\right)^2 \beta c^2\right)}, \tag{3.33}$$

and c is given by equation (3.27). It is easy to see from the optimal policy rule that there is no average inflation bias. Inflation fluctuates around the target rate π^* like in the commitment solution. This is due to the fact that the unemployment target of the common central bank is not over-ambitious, but coincides with the 'long-run' natural rate. Since it is obvious from (3.27) that $c > 0$, it follows that there is a stabilization bias under discretion, that is, $b > b^*$. Discretionary monetary policy stabilizes production shocks too much causing too much inflation variability and too little unemployment variability relative to the socially optimal stabilization policy. Moreover, $c > 0$ implies, that even though there is no average inflation bias in monetary policy, there is a state-dependent inflation bias, that is, inflation responds inefficiently to changes in unemployment. The inefficient stabilization is induced by the fact that under discretion the future state-dependent inflation bias depends on the current unemployment rate. Hence it is important to stabilize unemployment in order to reduce the future state-dependent inflation bias. Quite interestingly, the optimal discretionary policy rule (3.32) indicates that unlike in the commitment solution, real persistence induces inflation persistence as well. This can be seen by noting that u_{t-1} follows the process (3.22).

Noting that $\lim_{\rho \to 0} \left(c\right) = 0$ (see the Appendix) it becomes evident that (3.33) and (3.14) are identical when $\rho = 0$. This is just the well-known fact that in the standard Barro-Gordon framework stabilization is efficient under discretion (see eg Persson and Tabellini (2000), Ch. 15).

[14] The expression inside the brackets can be zero only with specific parameter values, eg if $c = \frac{\left(1-\rho^2\beta\right)}{2(1-s)\rho\beta}$.

4 Determination of labour market flexibility

4.1 National labour market policies

When governments choose their preferred labour market flexibility, s_i, they know the monetary policy rule derived in the previous section. However, since there is a large number of countries in the monetary union, each government takes the discretionary monetary policy reaction as given when setting s_i. In other words, inflation variability is exogenous in the government's optimization problem. It is easy to show that social welfare is increasing in flexibility, since both inflation and unemployment variability are decreasing in s (see the Appendix).

Since the governments are assumed to be able to commit to a certain level of flexibility indefinitely, it is convenient to express the intertemporal loss function in terms of the model parameters, and the variances of production shocks. In order to do that, the following expected present values of squared future unemployment deviations are needed (for derivations, see the Appendix):

$$E_0\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{t-1}^2\right)=\frac{\beta\left(1-s\right)^2\left(1-b\right)^2\sigma_\mu^2}{\left(1-\beta\right)\left(1-\beta\rho^2\right)}, \tag{4.1}$$

$$E_0\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{it}^2\right)=\frac{\left(1-s_i\right)^2\left(\left(1-b\right)^2\sigma_\mu^2+\sigma_\nu^2\right)}{\left(1-\beta\right)\left(1-\beta\rho^2\right)}, \tag{4.2}$$

where it is assumed that the initial value of unemployment is zero in all countries, $u_{i0} = u_0 = 0$. This simplifies the expressions and is only a minor restriction assuming that the discount rate, β, is close to unity. Inserting the inflation rule (3.32) into the government's loss function (2.13) and using equations (4.2) and (4.1) gives

$$\begin{aligned}GL_i=\frac{1}{2\left(1-\beta\right)}&\left(\left(b^2+\frac{\beta\left(1-s\right)^2\left(1-b\right)^2}{\left(1-\beta\rho^2\right)}c^2\right)\sigma_\mu^2\right.\\&\left.+\lambda\frac{\left(1-s_i\right)^2\left(\left(1-b\right)^2\sigma_\mu^2+\sigma_\nu^2\right)}{\left(1-\beta\rho^2\right)}+2\kappa s_i\right)\end{aligned} \tag{4.3}$$

where b and c are functions of s (and not of s_i) and therefore taken as exogenous. The government faces a trade-off between unemployment variability (the second term) and political costs (the third term). A higher level of flexibility is needed in order to lower unemployment fluctuations, but it can be attained only through higher political costs.

The first-order condition of the government's problem will be

$$\begin{aligned}&\frac{\partial GL_i}{\partial s_i}\\&=\frac{1}{2\left(1-\beta\right)}\left(-\frac{2\lambda\left(1-s_i\right)\left(1-b\right)^2}{\left(1-\beta\rho^2\right)}\sigma_\mu^2-\frac{2\lambda\left(1-s_i\right)}{\left(1-\beta\rho^2\right)}\sigma_\nu^2+2\kappa\right)=0.\end{aligned} \tag{4.4}$$

The first-order condition determines implicitly the optimal level of labour market flexibility.[15] Solving s_i as a function of s from the first-order condition yields

$$s_i = H(s) = 1 - \frac{\kappa(1-\beta\rho^2)}{\lambda\left((1-b)^2\sigma_\mu^2 + \sigma_\nu^2\right)}, \tag{4.5}$$

where $H_s > 0$ implies that the flexibility choices of the governments are strategic complements.[16] It follows that multiple equilibria are possible in this model. Since the economic environment of the countries is ex ante identical, that is, the variances of the country specific shocks and the structural parameters are equal across countries, the equilibrium is symmetric, $s_i = s$.

Replacing s_i by s in the first-order condition gives

$$\kappa = F(s) = \frac{\lambda(1-s)(1-b)^2}{(1-\beta\rho^2)}\sigma_\mu^2 + \frac{\lambda(1-s)}{(1-\beta\rho^2)}\sigma_\nu^2, \tag{4.6}$$

where $F(s)$ represents marginal benefits from flexibility at the common level of s. Like in Calmfors (2001) the non-uniqueness of equilibria is ruled out by imposing the following condition

$$-\left((1-b)^2 + 2(1-s)(1-b)b_s\right)\sigma_\mu^2 - \sigma_\nu^2 < 0, \tag{4.7}$$

which implies that $F_s < 0$. The optimal level of labour market flexibility, s^*, solves equation (4.6) and the equilibrium is illustrated graphically as the intersection of the horizontal line at κ and function $F(s)$ in Figure 1.[17]

This graphical representation can be applied to analyze the comparative statics properties of the equilibrium. First, it is easy to establish that increasing the total variance of production shocks, $\sigma_\mu^2 + \sigma_\nu^2$, so that neither σ_μ^2 nor σ_ν^2 is reduced will shift $F(s)$ upwards while the horizontal line at κ remains unchanged. Other things equal, stronger disturbances thus bring about more flexible economies. Second, the more asymmetric the shocks, the more flexibility is chosen. This result is also intuitive and follows directly from (4.6). Raising σ_ν^2 and lowering σ_μ^2 by the same amount so that $\sigma_\mu^2 + \sigma_\nu^2$ is unchanged moves $F(s)$ upwards, since $(1-b)^2$ is always smaller than unity. Third, more persistence tends to increase flexibility, because it leads to prolonged deviations of unemployment from the target level of zero. Numerical analysis is applied to establish the third point, because the impact of ρ on the first term on the RHS of (4.6) is ambiguous due to the fact that $b_\rho > 0$ (see the Appendix). Numerical simulations, reported in Table 1, indicate that optimal flexibility is positively related to unemployment persistence:

[15] The second-order condition for a minimum, $\frac{1}{2(1-b)}\left(\frac{2\lambda(1-b)^2}{(1-\beta\rho^2)}\sigma_\mu^2 + \frac{2\lambda}{(1-\beta\rho^2)}\sigma_\nu^2\right) > 0$ is always satisfied.

[16] $H_s > 0$, because $b_s < 0$ (see the Appendix).

[17] By 'optimal flexibility' it is meant that flexibility is optimal from the government's point of view.

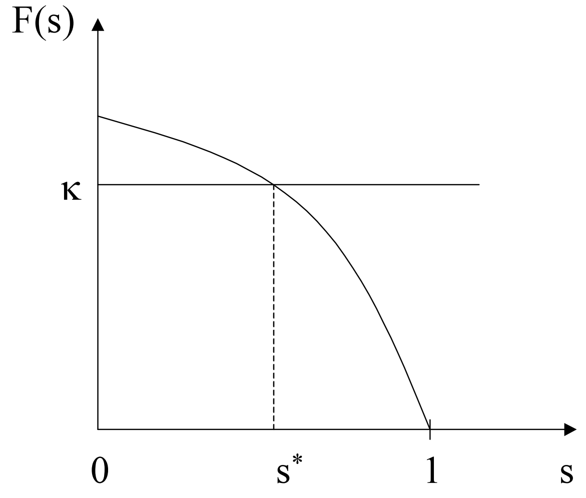

Figure 1: Determination of optimal labor market flexibility under national decision making

ρ	0.2	0.4	0.6	0.8
$\kappa = 0.08$	0.843	0.862	0.893	0.937
$\kappa = 0.16$	0.668	0.710	0.778	0.871
$\kappa = 0.24$	0.431	0.513	0.638	0.797
$\kappa = 0.32$	0	0.079	0.379	0.695

Other parameter values: λ=0.5, β=0.95, σ_μ^2=0.7 and σ_ν^2=0.3

Table 1. Optimal flexibility, s^*, as persistence varies

Table 1 also shows that a combination of low persistence and high marginal political costs can result in total inflexibility. Graphically this means that given the marginal political cost κ, the function $F(s)$ is below κ at $s = 0$. Another interesting feature of model becomes apparent from Table 1. It has been assumed that the marginal political cost of flexibility, κ, is independent of the insider power in the labour markets, ρ. Then it is fairly obvious that increasing ρ will push optimal flexibility upwards, since the marginal benefit from flexibility is increasing in ρ, whereas the marginal cost of flexibility, κ, is fixed. If this assumption is relaxed so that insider power also raises political costs of flexibility, the results can be overturned. The main diagonal of Table 1 from top left corner to bottom right corner demonstrates this point in a special case where $\kappa = 0.4\rho$. Contrary to the basic model, with low values of ρ more persistence decreases flexibility. When ρ is high enough, the impact of ρ on s^* is positive, so that the relation between optimal flexibility and real persistence can be U-shaped.

4.2 International labour market policy coordination

In the previous section the flexibility decision was left in the hands of the national governments. Since each government is assumed to be small in the sense that it will take monetary union wide variables as given, the choice of s_i is made without taking into account its impact on inflation variability. At first sight it seems that national decision making leads to a sub-optimal level of flexibility, because the inflation variability effect is ignored.

In this section the optimal flexibility is derived assuming that national governments coordinate their policy choices. In this setup, where all countries are ex ante symmetrical, the solution is extremely simple. Under coordination, the policy objective is the sum of member country governments' objective functions, that is $GL = \int_0^1 GL_i di$. Symmetry implies $s_i = s$ with all i, and the joint objective becomes

$$\begin{aligned} GL &= \int_0^1 GL_i di \qquad (4.8) \\ &= \frac{1}{2(1-\beta)} \left(\left(b^2 + \frac{\beta (1-s)^2 (1-b)^2}{(1-\beta\rho^2)} c^2 \right) \sigma_\mu^2 \right. \\ &\left. + \lambda \frac{(1-s)^2 \left((1-b)^2 \sigma_\mu^2 + \sigma_\nu^2 \right)}{(1-\beta\rho^2)} + 2\kappa s \right), \end{aligned}$$

which is otherwise the same as (4.3), but s_i is replaced by s. The flexibility parameter, s, is chosen so as to minimize (4.8). Reorganizing the loss function slightly gives

$$\begin{aligned} GL = & \frac{1}{2(1-\beta)} \left(\left(b^2 + \frac{(1-s)^2 (1-b)^2}{(1-\beta\rho^2)} \left(\lambda + \beta c^2 \right) \right) \sigma_\mu^2 \right. \qquad (4.9) \\ & \left. + \frac{\lambda}{(1-\beta\rho^2)} (1-s)^2 \sigma_\nu^2 + 2\kappa s \right). \end{aligned}$$

The term in front of σ_μ^2 can be further simplified by noting that

$$\frac{(1-s)^2 (\lambda + \beta c^2)}{1-\beta\rho^2} = \frac{b}{1-b}. \qquad (4.10)$$

Plugging $\frac{b}{1-b}$ into the loss function gives

$$GL = \frac{1}{2(1-\beta)} \left(b\sigma_\mu^2 + \frac{\lambda}{(1-\beta\rho^2)} (1-s)^2 \sigma_\nu^2 + 2\kappa s \right). \qquad (4.11)$$

The first-order condition under policy coordination will be

$$\frac{\partial GL}{\partial s} = \frac{1}{2(1-\beta)} \left(b_s \sigma_\mu^2 - \frac{2\lambda (1-s)}{(1-\beta\rho^2)} \sigma_\nu^2 + 2\kappa \right) = 0, \qquad (4.12)$$

and the second-order condition for a minimum

$$\frac{\partial^2 GL}{\partial s^2} = \frac{1}{2(1-\beta)} \left(b_{ss} \sigma_\mu^2 + \frac{2\lambda}{(1-\beta\rho^2)} \sigma_\nu^2 \right) > 0, \qquad (4.13)$$

is assumed to hold.[18] From (4.12) one obtains a similar type of expression as under national decision making (equation (4.6)):

$$\kappa = G(s) = -\frac{1}{2} b_s \sigma_\mu^2 + \frac{\lambda(1-s)}{(1-\beta\rho^2)} \sigma_\nu^2. \tag{4.14}$$

Again, the optimal level of labour market flexibility, s^{**}, solves equation (4.14) and the equilibrium can be presented graphically as under national policy making. The second order condition (4.13) limits the slope of $G(s)$ to be negative, that is, $G_s < 0$. This implies that multiple equilibria are not possible under policy coordination. Table 2 shows that like under national decision making, optimal flexibility is positively related to persistence[19]:

ρ	0.2	0.4	0.6	0.8
$\kappa = 0.08$	0.843	0.863	0.894	0.938
$\kappa = 0.16$	0.669	0.714	0.785	0.877
$\kappa = 0.24$	0.439	0.534	0.668	0.820
$\kappa = 0.32$	0	0.276	0.542	0.770

Other parameter values: λ=0.5, β=0.95, σ_μ^2=0.7 and σ_ν^2=0.3

Table 2 Optimal flexibility, s^{**}, as persistence varies

Comparing (4.14) with (4.6) reveals that the optimal flexibility under policy coordination is at the higher level than under national decision making if the following strict inequality holds:

$$b_s + \frac{2\lambda(1-s)(1-b)^2}{(1-\beta\rho^2)} < 0. \tag{4.15}$$

The graphical representation of the problem in Figure 2 shows that when this condition holds, the function $G(s)$ will be above the function $F(s)$ with all values of s between zero and unity.

In order to show that the condition (4.15) do actually hold in this model, it is necessary first to derive the following derivatives (see the Appendix):

$$b_s = \frac{-2(1-s)(1-\beta\rho^2)((\lambda+\beta c^2) - \beta c c_s(1-s))}{\left(1-\beta\rho^2 + (1-s)^2(\lambda+\beta c^2)\right)^2} < 0 \tag{4.16}$$

where

$$c_s = -\frac{(1-\rho^2\beta)\left((1-\rho^2\beta) - \sqrt{(1-\rho^2\beta)^2 - 4\rho^2\beta\lambda(1-s)^2}\right)}{2(1-s)^2\rho\beta\sqrt{(1-\rho^2\beta)^2 - 4\rho^2\beta\lambda(1-s)^2}} < 0. \tag{4.17}$$

[18] It is difficult to establish analytically that $b_{ss} > 0$, but numerical analysis suggests that this condition holds.

[19] Also, the main diagonal of the Table from top left corner to bottom right corner reveals that the relation between persistence and optimal flexibility can be U-shaped, provided that political costs and insider power (persistence) are positively related.

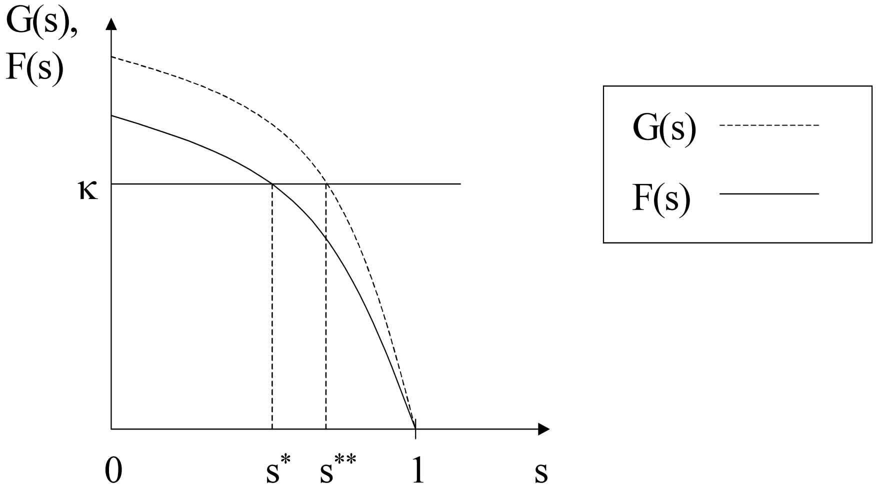

Figure 2: Determination of optimal labor market flexibility under policy coordination

Using (3.33) to rewrite $(1-b)^2$ the second term of (4.15) becomes

$$-\frac{2\lambda(1-s)(1-b)^2}{(1-\beta\rho^2)} = -\frac{2\lambda(1-s)(1-\beta\rho^2)}{\left(1+(1-s)^2\lambda-\beta\rho^2+(1-s)^2\beta c^2\right)^2}. \quad (4.18)$$

Finally, inserting (4.16) and (4.18) into (4.15) yields

$$b_s - \left(-\frac{2\lambda(1-s)(1-b)^2}{(1-\beta\rho^2)}\right) = \quad (4.19)$$

$$-\frac{2(1-s)\beta(1-\beta\rho^2)c(c-c_s(1-s))}{\left(1-\beta\rho^2+(1-s)^2(\lambda+\beta c^2)\right)^2} < 0,$$

which implies that optimal flexibility is higher under coordination of labour market policies in the case with unemployment persistence, since then $\rho > 0$ and $c > 0$.

It is noteworthy, that in the standard Barro-Gordon type framework without unemployment persistence, that is, $\rho = 0$, the above condition doesn't hold, but equals zero. This can be shown by noting that $c = 0$ and $c_s = 0$ when $\rho \to 0$ (see the Appendix). The fact that coordination of flexibility choice matters only in case with unemployment persistence and is thus irrelevant in the standard setup deserves a closer look. At first sight, it seems surprising that even though coordination internalizes the impact of flexibility on inflation variability, the optimal flexibility remains unchanged when $\rho = 0$. However, there is another new effect, which goes to the opposite direction, namely that by increasing flexibility in the monetary union area the stabilization parameter b goes down (see equation (3.33) with $\rho = c = 0$). This, in turn, reduces optimal flexibility through increased unemployment variability, since $(1-b)$ goes up (see equation (3.22)). It turns out that these two effects cancel out in the discretionary monetary policy equilibrium in the model without persistence.

The solution to this 'puzzle' is simple. As mentioned earlier, stabilization of production shocks in the standard Barro-Gordon model is socially optimal in the discretionary equilibrium. It means that under both national decision making and policy coordination the governments know that monetary union wide shocks are stabilized optimally for any level of flexibility. That is, the common central bank's optimal policy minimizes the social loss function (2.12) with any given s_i. Therefore, the government just balances the marginal loss arising from political costs associated with flexibility and marginal benefits deriving from reduced variability of inflation and unemployment. In other words, the government doesn't have to worry about whether the relative stabilization of inflation with respect to unemployment is optimal or not, and thus there is no interaction between flexibility and stabilization properties.

A similar line of argumentation can be applied in the case with unemployment persistence when the central bank has access to a commitment technology. Again, $c = 0$ and $c_s = 0$, which implies that (4.19) equals zero. Stabilization is optimal from the society's point of view, which brings about the same type of irrelevance result as in no persistence case.

These observations hint that the stabilization performance is the key to understand the impact of policy coordination on the chosen labour market flexibility. As shown in section 3.3, persistence in the real economy creates a stabilization bias and a state-dependent inflation bias under discretionary monetary policy. Relative to the optimal stabilization, which occurs in the commitment equilibrium, inflation variability is too high ($b > b^*$ and $c > 0$) and unemployment variability is too low relative to the optimum. The social loss function (2.12) is thus not minimized with a given s_i. This fact gives rise to an incentive to use the choice of flexibility as a tool to improve the stabilization properties of the economy. This can be seen by constructing a measure for the relative stabilization bias under discretion, $\widetilde{b}(s)$, as

$$\widetilde{b}(s) = \frac{b(s) - b^*(s)}{b^*(s)} = \frac{(1 - b(s))\beta c^2}{\lambda}. \tag{4.20}$$

It is important to notice that in $\widetilde{b}(s)$ the flexibility parameter, s, is the equilibrium outcome of the discretionary case also in $b^*(s)$, although in the model the optimally chosen endogenous s is different in the two monetary policy regimes. The correct interpretation of $b^*(s)$ is that it is the optimal and unattainable b which would result in optimal stabilization of production shocks with a given structure of the economy (that is, with a given s). The purpose of (4.20) is just to show the size of the stabilization bias under discretion as a function of s. A sufficient condition for the result that by increasing flexibility the stabilization properties of the economy are improved is two-fold. First, the relative stabilization bias, $\widetilde{b}(s)$, must be decreasing in s. This condition guarantees that b approaches b^* as flexibility is increased. Second, the state-dependent inflation bias parameter, c, must also be decreasing in s, because $c = 0$ under optimal stabilization. These two conditions together imply that the discretionary inflation rule (3.32) approaches the optimal rule (3.8) as s goes up.

The first condition, that is, $\partial \widetilde{b}(s)/\partial s < 0$ can be established as follows. The uniqueness of equilibrium condition (4.7) in the strictest form with $\sigma_{\nu}^{2} = 0$ implies

$$-b_s < \frac{(1-b)}{2(1-s)}, \tag{4.21}$$

and the condition $\partial \widetilde{b}(s)/\partial s < 0$ is given by

$$\frac{\partial \widetilde{b}(s)}{\partial s} = \frac{\beta c}{\lambda}\left(-b_s c + 2c_s(1-b)\right) < 0. \tag{4.22}$$

Now, if (4.22) holds when (4.21) is inserted into it, the first condition is shown to be valid. In order to proceed, it is useful to note the following relation between c and c_s, which can be derived from (3.29) and (4.17):

$$k\frac{c}{(1-s)} + c_s = 0, \tag{4.23}$$

where

$$k = \frac{1-\beta\rho^2}{\sqrt{(1-\beta\rho^2)^2 - 4(1-s)^2\rho^2\beta\lambda}} \geq 1.$$

Inserting (4.21) into (4.22) and using (4.23) gives

$$\begin{aligned}\frac{\partial \widetilde{b}(s)}{\partial s} &< \frac{2\beta c(1-b)}{\lambda}\left(\frac{1}{4}\frac{c}{(1-s)} + c_s\right) \\ &= \frac{2\beta c(1-b)}{\lambda}\left(\frac{1}{4} - k\right)\frac{c}{(1-s)} < 0,\end{aligned}$$

which shows that the first condition do hold.

The second part of the sufficient condition for improved stabilization as s increases, that is, $\partial c/\partial s < 0$, is always satisfied, as is evident from (4.17). Hence, the chosen level of flexibility is higher under policy coordination not because of internalization of inflation variability effect, but because flexibility interacts with stabilization performance so that by choosing more s it is possible to push stabilization closer to the optimum.

5 Extensions and variations

5.1 State-dependent unemployment target

This section reconsiders Svensson's (1997) claim, that the optimal stabilization, that is, commitment solution can be attained by directing the central bank to target the 'short-run' natural rate of unemployment, that is, $u_t^* = \rho u_{t-1}$ in (2.14) instead of targeting the 'long-run' natural rate of unemployment, which is normalized to zero in this model. However, it is argued below, that in this case the solution is not the commitment solution of the model with unemployment persistence, as argued in Svensson (1997), but the outcome coincides with the solution of the no persistence case. In other words, the monetary policy rule is not optimal from the society's point of view. After having derived the monetary policy rule, the implications of labour market policy coordination in this monetary policy regime will be studied. As discussed in the introduction, this regime can be seen to result from a misinterpretation concerning the source of variations of the unemployment rate. From a practical point of view, this kind of monetary policy regime can be questioned, because in reality it is a very demanding task to figure out the 'short-run' natural rate. Milton Friedman responded when he was asked about the natural rate by saying 'I don't know what the natural rate is, neither do you, and neither does anyone else' (quoted in King (1999)).

In order to work out the optimal monetary policy rule in this case the central bank's problem is restated with the state-dependent unemployment target as

$$V\left(u_{t-1}\right) = E_{t-1} \min_{\pi_t} \left(\frac{1}{2} \left(\left(\pi_t - \pi^*\right)^2 + \lambda \left(u_t - \rho u_{t-1}\right)^2 \right) + \beta V\left(u_t\right) \right), \quad (5.1)$$

where minimization is carried out subject to (2.11). The first-order condition is also sightly modified and is given by

$$\left(\pi_t - \pi^*\right) - \lambda\left(1 - s\right)\left(u_t - \rho u_{t-1}\right) - \beta\left(\gamma_1' + \gamma_2' u_t\right)\left(1 - s\right) = 0. \quad (5.2)$$

Taking expectations of (5.2) yields

$$E_{t-1}\pi_t = \pi^* + \beta\left(1 - s\right)\gamma_1' + \left(1 - s\right)\beta\gamma_2'\rho u_{t-1}. \quad (5.3)$$

Combining (5.2) and (5.3), using (2.11) and (3.2) yields an optimal discretionary decision rule

$$\pi_t = a' + b'\mu_t + c'u_{t-1} \quad (5.4)$$

where

$$a' = \pi^* + \beta\left(1 - s\right)\gamma_1' \quad (5.5)$$
$$b' = \frac{\left(1 - s\right)^2\left(\lambda + \beta\gamma_2'\right)}{\left(1 + \left(1 - s\right)^2\left(\lambda + \beta\gamma_2'\right)\right)}$$
$$c' = \left(1 - s\right)\beta\gamma_2'\rho$$

Average unemployment in the monetary union area will follow the process

$$u_t = \rho u_{t-1} + (1-s)(1-b')\mu_t, \tag{5.6}$$

and country i unemployment process is given by

$$u_{it} = \rho u_{it-1} + (1-s_i)(1-b')\mu_t + (1-s_i)\nu_{it}. \tag{5.7}$$

As before, γ_1' and γ_2' need to be determined. Substituting equations (5.4)–(5.6) into the Bellman equation (5.1) and identifying the coefficients of u_{t-1} and u_{t-1}^2 yields two Riccati equations

$$\gamma_1' = (1-s)^2 \beta\gamma_2'\beta\rho\gamma_1' + \beta\rho\gamma_1' \tag{5.8}$$

$$\frac{1}{2}\gamma_2' = \frac{1}{2}(1-s)^2 (\beta\gamma_2')^2 \rho^2 + \frac{1}{2}\beta\gamma_2'\rho^2. \tag{5.9}$$

Re-organizing the second equation and using c' from (5.5) results in

$$(1-s)\beta\rho c'^2 - \left(1-\rho^2\beta\right)c' = 0, \tag{5.10}$$

which yields two real solutions

$$c' = \frac{(1-\rho^2\beta) \pm \sqrt{(1-\rho^2\beta)^2}}{2(1-s)\rho\beta}. \tag{5.11}$$

As in Section 3.3, the larger root is ignored by appealing to the learning argument put forth in Rantala (2003). The smaller root $c' = 0$ is the relevant one, and from (5.5) it follows that $\gamma_2' = 0$. From (5.8) and $\beta\rho < 1$ it is thus evident that $\gamma_1' = 0$. The optimal inflation response to a production shock becomes

$$b' = \frac{(1-s)^2(\lambda + \beta\gamma_2')}{\left(1 + (1-s)^2(\lambda + \beta\gamma_2')\right)} = \frac{(1-s)^2\lambda}{1 + (1-s)^2\lambda}. \tag{5.12}$$

When the central bank targets the 'short-run' natural rate, there is neither average inflation bias ($\gamma_1' = 0$) nor state-dependent inflation bias ($\gamma_2' = c' = 0$), but a new stabilization bias problem emerges. As is clear from section 3.2, the optimal stabilization of production shocks is characterized by b^* in equation (3.14). The optimal stabilization parameter is increasing in the persistence of the real economy. However, in this case where the central bank targets the 'short-run' natural rate, b' coincides with the optimal stabilization parameter of the economy with no persistence. In other words, the central bank does not care about the temporal properties of the unemployment rate, and therefore stabilizes production shocks too little from the society's point of view. The direction of the stabilization bias is altered from under-stabilization of inflation in the basic setup with unemployment persistence to over-stabilization of inflation.

What about the implications for labour market flexibility? The government's problem is obtained from (4.3) by setting $c' = 0$

$$GL_i = \frac{1}{2(1-\beta)}\left(b'^2\sigma_\mu^2 + \lambda\frac{(1-s_i)^2\left((1-b')^2\sigma_\mu^2 + \sigma_\nu^2\right)}{(1-\beta\rho^2)} + 2\kappa s_i\right). \tag{5.13}$$

The first-order condition under national decision making is given by

$$\frac{\partial GL_i}{\partial s_i} = \frac{1}{2(1-\beta)} \left(-\frac{2\lambda (1-s_i)(1-b')^2}{(1-\beta\rho^2)} \sigma_\mu^2 \right. \tag{5.14}$$
$$\left. -\frac{2\lambda (1-s_i)}{(1-\beta\rho^2)} \sigma_\nu^2 + 2\kappa \right) = 0.$$

Numerical analysis presented in Table 3 reveals that optimal flexibility, s', under national decision making increases with persistence as in earlier cases[20]:

ρ	0.2	0.4	0.6	0.8
$\kappa = 0.08$	0.843	0.863	0.894	0.937
$\kappa = 0.16$	0.669	0.713	0.782	0.873
$\kappa = 0.24$	0.438	0.531	0.659	0.807
$\kappa = 0.32$	0	0.256	0.509	0.737

Other parameter values: λ=0.5, β=0.95, σ_μ^2=0.7 and σ_ν^2=0.3

Table 3 Optimal flexibility,s', as persistence varies

In order to derive the first-order condition under policy coordination it is useful to write the optimization problem as in the previous section in equation (4.9)

$$GL_i = \frac{1}{2(1-\beta)} \left(\left(b'^2 + \frac{\lambda (1-s)^2 (1-b')^2}{(1-\beta\rho^2)} \right) \sigma_\mu^2 \right. \tag{5.15}$$
$$\left. + \lambda \frac{(1-s)^2}{(1-\beta\rho^2)} \sigma_\nu^2 + 2\kappa s \right).$$

The first-order condition under policy coordination becomes

$$\frac{\partial GL}{\partial s} = \frac{1}{2(1-\beta)} \left(2b'_s \left(b' - \frac{\lambda (1-b')(1-s)^2}{(1-\beta\rho^2)} \right) \sigma_\mu^2 \right. \tag{5.16}$$
$$\left. -\frac{2\lambda (1-s)(1-b')^2}{(1-\beta\rho^2)} \sigma_\mu^2 - \frac{2\lambda (1-s)}{(1-\beta\rho^2)} \sigma_\nu^2 + 2\kappa \right) = 0,$$

with

$$b'_s = -\frac{2(1-s)\lambda}{\left(1+(1-s)^2 \lambda\right)^2} < 0. \tag{5.17}$$

Table 4 indicates that, as expected, persistence increases optimal flexibility, s'', under policy coordination[21]:

[20] See footnote 19.
[21] See footnote 19.

ρ	0.2	0.4	0.6	0.8
$\kappa = 0.08$	0.843	0.862	0.894	0.937
$\kappa = 0.16$	0.668	0.710	0.780	0.872
$\kappa = 0.24$	0.433	0.518	0.647	0.804
$\kappa = 0.32$	0	0.181	0.468	0.728

Other parameter values: λ=0.5, β=0.95, σ_μ^2=0.7 and σ_ν^2=0.3

Table 4 Optimal flexibility,s'', as persistence varies

Comparing the first-order condition (5.16) with the one obtained under national decision making (equation (5.14)) reveals that the sign of the first term inside the brackets in (5.16) determines the impact of coordination on optimal flexibility. If the term $2b'_s\left(b' - \frac{\lambda(1-b')(1-s)^2}{(1-\beta\rho^2)}\right)$ is positive, then the marginal benefit of choosing more s is smaller under coordination. Keeping in mind that the marginal cost is the same in both regimes, it follows that the optimal s will be lower under coordination. Using (5.12) to rewrite $(1-b')$ the first term becomes

$$2b'_s\left(b' - \frac{\lambda\left(1-b'\right)\left(1-s\right)^2}{\left(1-\beta\rho^2\right)}\right) = -2b'_s\frac{\beta\rho^2}{\left(1-\beta\rho^2\right)}b' > 0, \tag{5.18}$$

which verifies that optimal flexibility is indeed lower under policy coordination. The explanation is again related to the implied stabilization properties of the equilibrium monetary policy rule. The central bank's response to production shocks is too small from the society's point of view. In coordinated equilibrium the governments can affect the stabilization parameter b', and from equations (3.33) and (5.12) it is clear that choosing lower s will push b' upwards and stabilization is closer to the optimum. Naturally, when there is no persistence in the real economy, that is $\rho = 0$, the unemployment target of the central bank will be constant at zero, and the model collapses to the standard no persistence case where policy coordination is irrelevant.

5.2 Social welfare and government incentives for coordination

As noted earlier, social losses defined in (2.12) are decreasing in labour market flexibility.[22] In the absence of any institutional constraints, it would be possible to attain the first best solution with zero losses by just setting $s = 1$.[23] Fully flexible labour markets would bring about stable unemployment at zero level and real wages would be perfectly flexible. Inflation variability would as well be eliminated, since monetary policy is neither needed for nor capable of stabilizing the economy. However, in this model it is assumed that this ideal world can't be reached because it is not preferred by the labour unions (or their leaders), who have influence over the national government. In order to make

[22] See the Appendix for a proof.

[23] Obviously, political losses defined in (2.13) would not equal zero with fully flexible labour markets.

labour markets better functioning, the government therefore faces increasing political costs.

This section discusses the impact of coordination on social welfare under various monetary policy regimes and studies government incentives for coordination. When coordination is irrelevant for the equilibrium outcome, it obviously follows that social welfare is unchanged under coordinated equilibrium. This applies to both no persistence case and to commitment case treated in earlier sections. Hence, government losses are unaffected as well and governments have no reason to coordinate their actions.

In the basic case considered in paper, that is, when there is persistence in the real economy and the common central bank acts under discretion, coordination leads to more flexible labour markets and stabilization properties of the economy are improved. Both of these effects contribute to reducing the social loss measured by (2.12). By looking at the government's loss function (2.13) it becomes clear that even though social loss goes down under coordination, the government may not have incentives to pursue coordination, because political costs are higher. However, numerical analysis in Table 5 suggests that the increase in political costs is not strong enough to overshadow the benefits of flexibility on macroeconomic stability, and so both social losses (SL_i) and government losses (GL_i) are smaller under policy coordination (PC) than under national decision making (NDM)[24]:

ρ		0.2	0.4	0.6	0.8
SL_i	NDM	3.987	4.000	2.735	1.305
	PC	3.987	2.658	1.523	0.700
GL_i	NDM	3.987	4.506	5.160	5.753
	PC	3.987	4.424	4.992	5.628

Other parameter values: κ=0.32, λ=0.5, β=0.95, σ^2_μ=0.7 and σ^2_ν=0.3

Table 5 Social and government losses when persistence varies

When the central bank targets the 'short-run' natural rate coordination improves stabilization performance, which lowers the social loss, but at the same time flexibility decreases and both inflation and unemployment variability are increased. The net effect on social welfare is then ambiguous. However, political costs attached to flexibility will go down, which implies that there may be government incentives to coordinate, even though social welfare may decrease.

[24] Qualitatively similar, but quantitatively weaker, results are obtained with lower political costs ($\kappa = 0.08, 0.16, 0.24$). $\kappa = 0.32$ was chosen in order to make the difference between the two policy regimes as clear as possible.

ρ		0.2	0.4	0.6	0.8
SL_i	NDM	3.954	2.710	1.652	0.849
	PC	3.954	3.181	1.908	0.906
GL_i	NDM	3.954	4.348	4.910	5.567
	PC	3.954	4.339	4.903	5.565

Other parameter values: κ=0.32, λ=0.5, β=0.95, σ_μ^2=0.7 and σ_ν^2=0.3

Table 6 Social and government losses when persistence varies and the common central bank targets the 'short-run' natural rate

Simulations in Table 6 hint that in terms of social losses improved stabilization properties under policy coordination are overruled by decreasing flexibility, whereby coordination actually brings about higher social losses. However, as decreased flexibility lowers political costs, government losses under coordination will go down. Hence, governments do have an incentive to coordinate their flexibility choices, even though it entails increased social losses.[25]

The analysis above suggests that if the central bank misinterprets its unemployment target to coincide with the 'short-run' natural rate instead of the 'long-run' one, governments may respond by coordinating their actions although it leads to increased social losses.

5.3 Determination of flexibility in a country outside a monetary union

In Calmfors (2001) it is shown that when the central bank doesn't have an over-ambitious unemployment target which would result in inflation bias, chosen flexibility inside a monetary union is higher than in a country outside. In that study governments don't coordinate their actions in a monetary union. However, as shown in this paper in section 4.2, when there is no persistence in the economy, as is the case in Calmfors (2001), coordination doesn't matter and thus could be equally well assumed without changing the result. This section extends the Calmfors model to include real persistence and discusses how the results are affected.

Only minor modifications to the previous analysis are needed in order to work out the optimal flexibility level outside a monetary union. The optimization problem of the national central bank is identical to (3.15), except that monetary union wide variables are replaced by country specific ones. This means that the only change in the central bank's reaction function (3.32) is that now monetary policy is able to respond to the country specific shock ν_i as well. Therefore, the optimal discretionary monetary policy rule becomes

$$\pi_{it} = \pi^* + b\left(\mu_t + \nu_{it}\right) + cu_{it-1} \tag{5.19}$$

where b and c are defined as before. The government's problem is very similar to the one faced inside a monetary union under policy coordination.

[25] See footnote 24.

In both cases the government knows that the choice of flexibility will affect stabilization performance, since b is a function of s. The first-order condition of the government is obtained from (4.12) by dropping the term containing σ_ν^2, since monetary policy reacts also to the asymmetric shock, and by replacing σ_μ^2 with $\sigma_\mu^2 + \sigma_\nu^2$ in the first term inside the brackets. The optimal flexibility, s^{***}, solves

$$\kappa = P(s) = -\frac{1}{2} b_s \left(\sigma_\mu^2 + \sigma_\nu^2\right), \tag{5.20}$$

where b_s is given by (4.16).

Table 7 shows the optimal flexibility with various parameter values. When a comparison is made between these values and the ones presented in Table 1, it becomes apparent that with low levels of persistence flexibility is higher inside a monetary union, but when ρ is high enough ($\rho \geq 0.6$ in Table 7), flexibility is actually at a lower level inside a monetary union than outside. Thus the result obtained from a static model is overturned. The explanation is once again related to the stabilization properties of the economy. Even though the need for flexibility is higher inside the monetary union due to asymmetric shocks which can't be stabilized with common monetary policy, high persistence brings about severe stabilization bias which can be reduced only outside a monetary union by choosing more flexibility. In no persistence case analyzed in Calmfors (2001) the latter effect is absent and therefore flexibility is always higher inside a monetary union.

ρ	0.2	0.4	0.6	0.8
$\kappa = 0.08$	0.842	0.862	0.894	0.938
$\kappa = 0.16$	0.654	0.705	0.782	0.878
$\kappa = 0.24$	0	0.481	0.659	0.823
$\kappa = 0.32$	0	0	0.521	0.776

Other parameter values: λ=0.5, β=0.95, σ_μ^2=0.7 and σ_ν^2=0.3

Table 7 Optimal flexibility, s^{***}, as persistence varies

Another interesting comparison can be drawn between a country outside a monetary union and a country inside a monetary union where flexibility is chosen in a coordinated fashion. When countries consider whether to join or not to join a monetary union, behavioral effects should be taken into account. Hence, this exercise can be justified by noting that in a monetary union governments do have an incentive to coordinate their actions, as was shown in section 5.2. Numerical examples presented in Table 2 and Table 7 indicate, that flexibility is likely to be higher inside a monetary union. Intuition behind this result is clear, since in both regimes the governments internalize the effect increased flexibility has on stabilization properties, but inside a monetary union asymmetric shocks are not stabilized by common monetary policy and therefore more flexibility is called for. However, provided that persistence is high enough (eg $\rho = 0.8$), flexibility can be lower inside a monetary union. By looking at (4.14) and (5.20) it is clear that this extreme case is possible if $-\frac{1}{2}b_s > \frac{\lambda(1-s)}{(1-\beta\rho^2)}$. It is noteworthy, that if this condition holds, it also follows from (4.14) that some comparative statics properties of the coordination case are counter-intuitive. In particular, the more asymmetric the production shocks are, the less flexibility is chosen in a coordinated equilibrium.

6 Concluding remarks

This paper studied the determination of labour market flexibility in a large monetary union when national governments decide on the level of nominal wage flexibility independently of each other or in a coordinated fashion and flexibility entails increasing political costs to the governments. The main result of the paper is that coordination tends to yield more flexible labour markets because flexibility and stabilization properties of the economy are interrelated. More precisely, the stabilization bias of discretionary monetary policy in the presence of unemployment persistence can be alleviated by more flexible labour markets. Each government is too small to be able to affect the average flexibility in the monetary union area, but by coordinating labour market policies the governments can have influence on the common central bank's stabilization policy. Coordination internalizes the positive externality that flexibility generates by improving the stabilization properties of the economy, and therefore coordination results in more flexible markets.

The paper also analyzed a special case where the central bank misinterprets the changes in the 'short-run' natural rate as arising solely from structural factors, thereby stabilizing the production shocks too little. Then coordination is shown to result in less flexible markets, since lower flexibility calls for stronger reaction to production shocks, thereby pushing stabilization closer to the optimum. The paper also digressed from the subject and very briefly looked at the case where a country is outside a monetary union and has an independent monetary policy. The purpose was to examine whether the results of Calmfors (2001) are unchanged when real persistence is introduced. It turned out that if unemployment is persistent enough, flexibility is not necessarily higher inside a monetary union, as is the case without persistence. The explanation is once again related to the interplay between flexibility and stabilization policy identified in the paper.

Throughout the paper the countries are assumed to be perfectly symmetric in a sense that all structural parameters and preferences all identical. This modelling choice is obviously highly restrictive, but chosen because of analytical simplicity. Moreover, assuming symmetry conforms well with the common practice in the research field on international policy coordination (see eg Persson and Tabellini (2000, Ch. 18)). An apparent extension of the model would be to allow some asymmetries, other than country-specific shocks, between countries. It would be interesting to let the persistence parameter, that is, insider power or political costs very across countries. In that case the precise definition of coordination would become important. In the symmetric case there is no difference whether coordination means that all countries must set the same level of flexibility or that flexibility is allowed the vary across countries. In an asymmetric case this distinction certainly matters and will probably have implications for chosen levels of flexibility under coordination relative to national decision making. Also, it is likely that the desirability of coordination in terms of social welfare and government incentives will be affected as well. Asymmetries in country size is another related issue, which deserves a closer look. In the EMU it is certain that some member countries are so large that their actions do have an effect on the area wide variables. Adding this to the model would be important, but aggregation would certainly become more problematic.

There is at least one more simplifying assumption, which needs to be discussed. A starting point of the analysis of flexibility choice is that governments set flexibility only once and stick to it ever after. In other words, the governments commit to a certain level of flexibility. As was discussed in the introduction, this is quite plausible assumption provided that flexibility choice has irreversibilities in the form of relatively high costs of rewriting legislation and reshaping the institutional structure of the economy. It follows from this assumption that the central bank can't behave strategically towards the governments when setting monetary policy, because it takes the flexibility of the economies as given. However, in practice governments resign and new government are appointed. This fact has at least two implications. First, the discount factor of the government may be smaller than that of the society, since the expected life span of the government is only a few years.[26] Second, and probably more important point is that since the central bank knows that from time to time flexibility issue is reconsidered in every country in connection with general elections and the formation of the new government. This opens the door for strategic behavior on the common central bank's side. It may be optimal for the central bank to conduct monetary policy so that the governments are forced to choose a relatively high level of flexibility, since inflation and unemployment variability are decreasing in flexibility. So, one is inclined to conjecture that in this case the central bank could act very conservatively and let unemployment to fluctuate a lot in order to compel new governments to choose high flexibility. Obviously, a thorough investigation of this point is outside the scope of this paper and is left for future research.

[26] Same argument could be made about central bankers, eg King (1997) writes "Central bankers, despite their prudent and austere life-style, do not live for ever. They tend to be judged by the realised value of the loss function during their term of office, and rarely on whether the loss subsequent to their retirement was lower than it would otherwise have been."

A Appendix

A.1 Derivation of $lim_{\rho\to 0}(c)$

It is easy to see from (3.29) that $lim_{\rho\to 0}(c)$ is of the form $\left(\frac{0}{0}\right)$. Applying L'Hôpital's rule and simplifying yields

$$\begin{aligned}
&\lim_{\rho\to 0}(c) \\
= &\lim_{\rho\to 0}\frac{\rho\left(\left(1-\beta\rho^2+2\lambda(1-s)^2\right)-\sqrt{\left(1-\rho^2\beta\right)^2-4(1-s)^2\rho^2\beta\lambda}\right)}{(1-s)\sqrt{\left(1-\rho^2\beta\right)^2-4(1-s)^2\rho^2\beta\lambda}}=0.
\end{aligned}$$

A.2 Derivation of (4.16) and (4.17)

Taking the derivative from (3.33) with respect to s gives

$$\begin{aligned}
b_s &= \frac{\left(-2(1-s)\left(\lambda+\beta c^2\right)+2\beta cc_s(1-s)^2\right)\left(1-\beta\rho^2+(1-s)^2\left(\lambda+\beta c^2\right)\right)}{\left(1-\beta\rho^2+(1-s)^2\left(\lambda+\beta c^2\right)\right)^2} \\
&\quad -\frac{\left(-2(1-s)\left(\lambda+\beta c^2\right)+2\beta cc_s(1-s)^2\right)(1-s)^2\left(\lambda+\beta c^2\right)}{\left(1-\beta\rho^2+(1-s)^2\left(\lambda+\beta c^2\right)\right)^2} \\
&= \frac{-2(1-s)\left(\lambda+\beta c^2\right)\left(1-\beta\rho^2\right)+2\beta cc'(s)(1-s)^2\left(1-\beta\rho^2\right)}{\left(1-\beta\rho^2+(1-s)^2\left(\lambda+\beta c^2\right)\right)^2} \\
&= \frac{-2(1-s)\left(1-\beta\rho^2\right)\left(\left(\lambda+\beta c^2\right)-\beta cc_s(1-s)\right)}{\left(1-\beta\rho^2+(1-s)^2\left(\lambda+\beta c^2\right)\right)^2},
\end{aligned}$$

which is equation (4.16) in the text.

Taking the derivative from (3.29) with respect to s and simplifying gives

$$\begin{aligned}
c_s &= -\frac{1}{2}\left(1-\beta\rho^2\right)\frac{\left(1-\beta\rho^2\right)-\sqrt{\left(1-\rho^2\beta\right)^2-4(1-s)^2\rho^2\beta\lambda}}{\sqrt{\left(1-\rho^2\beta\right)^2-4(1-s)^2\rho^2\beta\lambda}\,(1-s)^2\rho\beta} \\
&= -\left(1-\beta\rho^2\right)\frac{c}{\sqrt{\left(1-\rho^2\beta\right)^2-4(1-s)^2\rho^2\beta\lambda}\,(1-s)}<0,
\end{aligned}$$

which is equation (4.17) in the text.

A.3 Derivation of $\frac{\partial(var(u_i))}{\partial s}$ and $\frac{\partial(var(\pi))}{\partial s}$

From (3.23) one obtains

$$\begin{aligned}
var(u_{it}) &= var\left(\rho u_{it-1}+(1-s_i)(1-b)\mu_t+(1-s_i)\nu_{it}\right) \\
&= \rho^2 var(u_{it-1})+(1-s_i)^2(1-b)^2\sigma_\mu^2+(1-s_i)^2\sigma_\nu^2,
\end{aligned}$$

assuming $var\left(u_{it}\right) = var\left(u_i\right)$ with all t and $s_i = s$ gives

$$var\left(u_i\right) = \frac{\left(1-s\right)^2\left(1-b\right)^2\sigma_\mu^2 + \left(1-s\right)^2\sigma_\nu^2}{1-\rho^2}.$$

The sign of $\frac{\partial(var(u_i))}{\partial s}$ depends on the sign of $\frac{\partial}{\partial s}\left(\left(1-s\right)^2\left(1-b\right)^2\right)$:

$$\frac{\partial}{\partial s}\left(\left(1-s\right)^2\left(1-b\right)^2\right) = \frac{-2\left(1-s\right)\left(1-b\right)\left(\left(1-b\right)+b_s\left(1-s\right)\right)}{\left(1-\beta\rho^2+\left(1-s\right)^2\left(\lambda+\beta c^2\right)\right)^2},$$

which is negative provided that

$$-b_s < \frac{1-b}{1-s}.$$

Using (4.21) from the paper, that is, $-b_s < \frac{1-b}{2(1-s)}$ it is clear that the condition above holds and

$$\frac{\partial\left(var\left(u_i\right)\right)}{\partial s} < 0.$$

From (3.32) one obtains

$$\begin{aligned} var\left(\pi\right) &= var\left(b\mu_t + cu_{t-1}\right) = b^2\sigma_\mu^2 + c^2 var\left(u\right) \\ \Rightarrow \quad \frac{\partial\left(var\left(\pi\right)\right)}{\partial s} &= 2bb_s\sigma_\mu^2 + 2cc_s var\left(u\right) + \frac{\partial\left(var\left(u\right)\right)}{\partial s}c^2 < 0, \end{aligned}$$

because $b_s < 0$, $c_s < 0$ (see Appendix A.2) and $\frac{\partial(var(u))}{\partial s} < 0$, where the last inequality follows directly from $\frac{\partial(var(u_i))}{\partial s} < 0$.

A.4 Derivation of (4.1)

The expected present value of squared future monetary union wide unemployment deviations is given by

$$E_0\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{t-1}^2\right) = E_0\left(u_0^2 + \beta u_1^2 + \beta^2 u_2^2 + \beta^3 u_3^2 + \beta^4 u_4^2 + ...\right),$$

where

$$
\begin{aligned}
\beta E_0\left(u_1^2\right) &= \beta\left(\rho^2 u_0^2+(1-s)^2(1-b)^2\sigma_\mu^2\right), \\
\beta^2 E_0\left(u_2^2\right) &= \beta^2 E_0\left(\rho^2 u_1^2+(1-s)^2(1-b)^2\sigma_\mu^2\right) \\
&= \beta^2\left(\rho^4 u_0^2+\rho^2(1-s)^2(1-b)^2\sigma_\mu^2+(1-s)^2(1-b)^2\sigma_\mu^2\right) \\
&= \beta^2\rho^4 u_0^2+\beta^2\left(1+\rho^2\right)(1-s)^2(1-b)^2\sigma_\mu^2, \\
\beta^3 E_0\left(u_{i3}^2\right) &= \beta^3 E_0\left(\rho^2 u_2^2+(1-s)^2(1-b)^2\sigma_\mu^2\right) \\
&= \beta^3\left(\rho^6 u_0^2+\rho^4(1-s)^2(1-b)^2\sigma_\mu^2+\rho^2(1-s)^2(1-b)^2\sigma_\mu^2\right. \\
&\quad \left.+(1-s)^2(1-b)^2\sigma_\mu^2\right) \\
&= \beta^3\rho^6 u_0^2+\left(1+\rho^2+\rho^4\right)(1-s)^2(1-b)^2\sigma_\mu^2, \\
\beta^4 E_0\left(u_{i4}^2\right) &= \beta^4 E_0\left(\rho^2 u_3^2+(1-s)^2(1-b)^2\sigma_\mu^2\right) \\
&= \beta^4\left(\rho^8 u_0^2+\rho^6(1-s)^2(1-b)^2\sigma_\mu^2+\rho^4(1-s)^2(1-b)^2\sigma_\mu^2\right. \\
&\quad \left.+\rho^2(1-s)^2(1-b)^2\sigma_\mu^2+(1-s)^2(1-b)^2\sigma_\mu^2\right) \\
&= \beta^4\rho^8 u_0^2+\beta^4\left(1+\rho^2+\rho^4+\rho^6\right)(1-s)^2(1-b)^2\sigma_\mu^2 \\
&\quad . \\
&\quad . \\
&\quad .
\end{aligned}
$$

The first terms of each time period make up an infinite sum of the form

$$
u_0^2+\beta\rho^2 u_0^2+\beta^2\rho^4 u_0^2+\beta^3\rho^6 u_0^2+\beta^4\rho^8 u_0^2+\ldots=\frac{1}{1-\beta\rho^2}u_0^2.
$$

The second term of each time period is a sum of a geometric progression, which is of the form

$$
\beta^t\left(1+\rho^2+\rho^4+\ldots+\left(\rho^2\right)^{t-1}\right)(1-s)^2(1-b)^2\sigma_\mu^2.
$$

If $\rho^2\neq 1$ (as is the case here, since $\rho<1$), the sum of a geometrical progression above is given by

$$
\left(1+\rho^2+\rho^4+\ldots+\left(\rho^2\right)^{t-1}\right)=\frac{1-\left(\rho^2\right)^t}{1-\rho^2}.
$$

Combining the second terms gives

$$\begin{aligned}
&\sum_{t=1}^{\infty}\left(\beta^{t}\frac{1-\left(\rho^{2}\right)^{t}}{1-\rho^{2}}\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}\right)\\
&= \frac{\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}}{1-\rho^{2}}\sum_{t=1}^{\infty}\left(\beta^{t}\left(1-\left(\rho^{2}\right)^{t}\right)\right)\\
&= \frac{\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}}{1-\rho^{2}}\left(\beta+\beta^{2}+\beta^{3}+...-\rho^{2}\beta-\left(\rho^{2}\beta\right)^{2}-\left(\rho^{2}\beta\right)^{3}-...\right)\\
&= \frac{\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}}{1-\rho^{2}}\left(\frac{\beta}{1-\beta}-\rho^{2}\beta\left(1+\rho^{2}\beta+\left(\rho^{2}\beta\right)^{2}+...\right)\right)\\
&= \frac{\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}}{1-\rho^{2}}\left(\frac{\beta}{1-\beta}-\frac{\rho^{2}\beta}{1-\rho^{2}\beta}\right)\\
&= \frac{\beta\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}}{1-\rho^{2}}\left(\frac{1-\rho^{2}}{\left(1-\beta\right)\left(1-\rho^{2}\beta\right)}\right)\\
&= \frac{\beta\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}}{\left(1-\beta\right)\left(1-\rho^{2}\beta\right)}.
\end{aligned}$$

Adding the first and the second terms up yields

$$E_{0}\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{t-1}^{2}\right)=\frac{\left(1-\beta\right)u_{0}^{2}+\beta\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}}{\left(1-\beta\right)\left(1-\rho^{2}\beta\right)},$$

and setting $u_0 = 0$ gives (4.1) in the text.

A.5 Derivation of (4.2)

The derivation of (4.2) is almost identical to the one above, but now $\left(1-s\right)^{2}\left(1-b\right)^{2}\sigma_{\mu}^{2}$ is replaced with $\left(1-s_i\right)^{2}\left(\left(1-b\right)^{2}\sigma_{\mu}^{2}+\sigma_{\nu}^{2}\right)$, and u_0 is replaced by u_{i0}, since the variable of interest is the unemployment rate of a country i. The flexibility parameter is thus the country specific one s_i instead of the average s. Another change to the previous derivation is the relevant time index. Now the infinite sum is over the current period unemployment rate, not over the previous period one.

The expected present value of squared future country i specific unemployment deviations is given by

$$E_{0}\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{i,t}^{2}\right)=E_{0}\left(u_{i1}^{2}+\beta u_{i2}^{2}+\beta^{2}u_{i3}^{2}+\beta^{3}u_{i4}^{2}+...\right).$$

Noting that

$$E_{0}\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{i,t-1}^{2}\right)=u_{i0}^{2}+\beta\left(E_{0}\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{i,t}^{2}\right)\right),$$

and solving this expression for $E_0\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{i,t}^2\right)$ and using the expression for $E_0\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{t-1}^2\right)$ derived above (remembering that $(1-s)^2(1-b)^2\sigma_\mu^2$ is replaced with $(1-s_i)^2\left((1-b)^2\sigma_\mu^2+\sigma_\nu^2\right)$) yields

$$\begin{aligned}
E_0\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{i,t}^2\right) &= -\frac{u_{i0}^2}{\beta}+\frac{E_0\left(\sum_{t=1}^{\infty}\beta^{t-1}u_{i,t-1}^2\right)}{\beta} \\
&= -\frac{u_{i0}^2}{\beta}+\frac{1}{\beta}\left(\frac{1}{1-\beta\rho^2}u_{i0}^2+\frac{\beta(1-s_i)^2\left((1-b)^2\sigma_\mu^2+\sigma_\nu^2\right)}{(1-\beta)(1-\rho^2\beta)}\right) \\
&= \frac{(1-\beta)\rho^2u_{i0}^2+(1-s_i)^2\left((1-b)^2\sigma_\mu^2+\sigma_\nu^2\right)}{(1-\beta)(1-\beta\rho^2)},
\end{aligned}$$

and setting $u_{i0}=0$ gives (4.2) in the text.

A.6 Derivation of b_ρ

Differentiating (3.33) with respect to ρ and simplifying yields

$$b_\rho = 2(1-s)^2\beta\frac{(1-\rho^2\beta)cc_\rho+\rho(\lambda+\beta c^2)}{\left(1+(1-s)^2\lambda-\beta\rho^2+(1-s)^2\beta c^2\right)^2}>0,$$

where c_ρ is given by

$$\begin{aligned}
c_\rho &= \frac{1}{2}\left(1+\rho^2\beta\right)\frac{(1-\rho^2\beta)-\sqrt{(1-\rho^2\beta)^2-4\rho^2\beta\lambda(1-s)^2}}{\sqrt{(1-\rho^2\beta)^2-4\rho^2\beta\lambda(1-s)^2}\,(1-s)\rho^2\beta} \\
&= \left(1+\rho^2\beta\right)\frac{c}{\sqrt{(1-\rho^2\beta)^2-4\rho^2\beta\lambda(1-s)^2}\rho}>0.
\end{aligned}$$

A.7 Derivation of $lim_{\rho\to 0}(c_s)$

It is easy to see from (4.17) that $lim_{\rho\to 0}(c_s)$ is of the form $\left(\frac{0}{0}\right)$. Applying L'Hôpital's rule gives (after tedious manipulation)

$$\begin{aligned}
& lim_{\rho\to 0}(c_s) \\
&= lim_{\rho\to 0}\frac{\frac{\partial}{\partial\rho}\left(-(1-\rho^2\beta)\left((1-\rho^2\beta)-\sqrt{(1-\rho^2\beta)^2-4\rho^2\beta\lambda(1-s)^2}\right)\right)}{\frac{\partial}{\partial\rho}\left(2(1-s)^2\rho\beta\sqrt{(1-\rho^2\beta)^2-4\rho^2\beta\lambda(1-s)^2}\right)} \\
&= lim_{\rho\to 0}-2\rho\left(\frac{-(1-\beta\rho^2)\sqrt{(1-\rho^2\beta)^2-4\rho^2\beta\lambda(1-s)^2}}{(1-s)^2\left((1-\rho^2\beta)^2-2\rho^2\beta\left(1-\beta\rho^2+4\lambda(1-s)^2\right)\right)}\right. \\
&\quad\left.+\frac{(1-\rho^2\beta)^2+\lambda(1-s)^2(1-3\rho^2\beta)}{(1-s)^2\left((1-\rho^2\beta)^2-2\rho^2\beta\left(1-\beta\rho^2+4\lambda(1-s)^2\right)\right)}\right) \\
&= 0.
\end{aligned}$$

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