



Essays on Unemployment and Real Exchange Rates

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Abstract

This thesis consists of four self-contained essays.

In the first essay, *Persistence in Swedish Unemployment Rates*, the objective is to study the persistence in Swedish unemployment rates. Persistence exists if there is no or weak tendency in unemployment rates to revert back to previous levels. Persistence is caused by: natural rate shocks, long unemployment cycles, and spill-over from cyclical to permanent unemployment. The analysis is carried out in an unobserved components model, where unemployment is decomposed into a permanent, natural rate, component and a cyclical component. There is evidence of high persistence; an increase in the cyclical component of unemployment by 1 percentage point spills over and increases the natural rate by 0.5-0.8 percentage points. The results also suggest that the quick rise of unemployment rates during 1992-1994 was caused by both large permanent and cyclical shocks in combination with spill-over effects.

In the second essay, *The Equilibrium Rate of Unemployment in a Small Open Economy*, we challenge the common assumption, when empirically analyzing the determinants of unemployment, that the economy is closed. However, the equilibrium rate of unemployment is not identified in an open economy unless the foreign sector is modeled. Therefore, we set up and estimate a structural unobserved components open economy model for the unemployment rate and the real exchange rate. This approach enables us to simultaneously determine changes in cyclical as well as in equilibrium components of these two variables. Our estimates indicate that the foreign sector is of substantial importance when explaining movements in the NAIRU.

In the third essay, *A Simultaneous Model of the Swedish Krona, the US*

Dollar and the Euro, the objective is to increase the understanding of exchange rate movements. We simultaneously estimate the real exchange rates between the Swedish Krona, the US Dollar and the Euro. The exchange rate movements are shown to be well explained by potential output, the output gap, terms of trade, the fraction of prime-aged people in the population, and structural government budget deficits. Since potential output is unobservable, cyclical and potential output are estimated in an unobserved components framework together with a Phillips curve. The model works well in out of sample exercises. The point estimates suggest that the relative budget situation for the US versus Europe is a prime candidate for explaining the changes in the USD/EUR exchange rate.

The last essay, *Wages, Employment, and Unemployment: The Effect of Benefits, Taxes and Labor Mobility*, studies how wages and employment are affected by unemployment insurance and labor mobility. I show that the wage effect of higher unemployment benefits can be either positive or negative, depending on the specification of union utility function and the taxation scheme for financing the benefits. The common claim in the literature that wages are lower when a sector bears a higher fraction of unemployment costs does not hold in general. I also show that labor mobility across sectors normally reduces the wage level, and thereby also reduces unemployment. It is also shown that increased competition reduces wages and unemployment.

To Agnetha, Caroline and Madeleine

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Chapter 1

Introduction

During the better part of the 1980s economic policy in Sweden was clearly expansionary, which is not sustainable in the long run. At the same time, the credit market was deregulated and the savings rate fell rapidly. One consequence of the deregulation was that real estate prices rose during the late 1980s and the early 1990s. In the early 1990s the economy was severely overheated and Sweden was hit by a dramatic financial crisis. The overheated economy had also led to an appreciation of the real exchange rate and thus losses in competitiveness.

The situation was clearly not sustainable and eventually the bubble bursted. Expected and actual inflation fell. Sveriges Riksbank (Central Bank of Sweden) and the government initially tried to defend the fixed exchange-rate regime through extreme interest rates (500%) and fiscal tightening. However, keeping in mind Sweden's history of devaluations, these policies lacked credibility. This in combination with the size of the relative price adjustment needed to restore competitiveness lead to a break down of the fixed exchange rate regime. The nominal exchange rate depreciated. Uncertainty and the lack of credibility kept nominal interest rates high. Thus given falling expected inflation, real interest rates increased enormously while GDP fell and public finances deteriorated, the government fiscal deficit reached double-

digit figures. The lower activity in the economy in combination with a pick-up in productivity triggered a massive rise in the unemployment rate. Open unemployment rose from less than 2% in 1989 to 8% in 1994, and total unemployment (the sum of open unemployment and participation in active labor market programs) increased from 3% to 13% during the same period. See Jonung (2003) for a more elaborate description of that period.

A key question was whether the higher unemployment rate would persist as it had in many other countries, or if Sweden was different. Given this question, the main theme in this thesis is to increase the understanding of the determinants of the Swedish unemployment rate. Since Sweden is a small and very open economy, special attention is given to the real exchange rate which plays a crucial role in explaining the unemployment dynamics.

Paper 1 The Swedish unemployment record during the early 1990s was similar to the development in the rest of Europe a decade earlier. In my first paper, *Persistence in Swedish Unemployment Rates*, the main question is whether the increase in Sweden is temporary or if the high unemployment figures would persist, as it had in many other European countries.¹ In Sweden, active labor market programs (ALMPs) have been an important part of the labor market during much of the post-war period. If such programs are successful, persistence would be lower and the unemployment rate would decrease rapidly. However, if ALMPs push wages higher they would worsen the problem.

Persistence or hysteresis could be due to several reasons. Layard, Nickell and Jackman (1991) suggest that temporary unemployment might lead to such a depreciation of human capital that the probability of re-employment is considerably reduced for the unemployed. Blanchard and Summers (1986) suggest that reductions in the capital stock associated with reduced employment after an adverse shock might reduce the demand for labor. Finally,

¹This paper is my Ph-Licentiate thesis, examined in December 1996 and has not been revised since then.

Blanchard and Summers (1986), Gottfries and Horn (1986) and Lindbeck and Snower (1988) suggest that insiders might be important in the wage formation process. If the insiders, when negotiating wages, do not care about outsiders, the unemployed, wages will be set too high to increase employment.

There was no consensus in the empirical literature in the first part of the 1990s regarding the persistence of the Swedish unemployment rate. Holmlund (1993) suggested that the natural rate of unemployment (NAIRU) was slightly higher in the beginning of the 1990s than two decades earlier. Forslund (1995) argued that the rise of the open equilibrium unemployment rate "could be of the order of magnitude of 1-4 percentage points between 1990 and 1993". Assarsson and Jansson (1998), on the other hand, suggested that the unemployment rates were very persistent and that the NAIRU had increased at least as much as the unemployment rate and that the cyclical fluctuations in the unemployment rate were very small.

Assarsson and Janssons results were too provocative to be left unchallenged. In order to investigate the existence and the extent of persistence in Swedish open and total unemployment, and to test the robustness of the results in Assarsson and Jansson, I developed an unobserved components (UC) labor-market model. The UC model is combined with the well known Layard, Nickell and Jackman model for price-setting and wage-setting in an open economy. The resulting model is identified in different ways. The estimated model incorporates the appealing time series features of the UC model and has a clear economic interpretation. In addition, previous studies on persistence had only addressed open unemployment. As mentioned above, active labor market programs have always been an important part of the Swedish labor market. Thus, the first paper also investigates if total unemployment exhibits persistence patterns similar to those of open unemployment. In the model, persistence can be caused by three factors: permanent shocks may change unemployment permanently, unemployment may contain a cycle with long periodicity, and cyclical shocks may spill over to permanent unemploy-

ment (hysteresis).

In order to investigate the stability of the estimates, the models are estimated over two different time periods, 1972-1994 and 1972-1991. The reason for splitting the sample in 1991 was that unemployment increased dramatically during the period 1992-1994.

The results suggest, as in Assarsson and Jansson, large spill-over effects from cyclical to permanent unemployment and that the NAIRU increased substantially during the last years of the sample. However, when shortening the sample, the point estimates of the spill-over parameter are reduced. The estimated parameter is in general not significantly different from zero, and significantly different from the long-sample point estimates.

In the case of total unemployment and the long sample, there is no evidence that total unemployment reinforces the unemployment effects on the first difference of inflation. However, there is robust evidence of a significant spill-over effect, and contrary to the open unemployment case, the point estimates of the spill-over effect are not significantly different from the short-sample estimates. The average periodicity of the cyclical component increases somewhat, compared to the case with open unemployment. In other words, ALMPs increase persistence.

It is important to recognize that, up to 1991, both open and total unemployment rates in Sweden were low and stable. However, the variations in the short sample made it possible to trace out a significant spill-over effects in some cases. In total, a significant spill-over effect is detected in 7 out of 10 cases, and in 6 out of 10 cases for open and total unemployment respectively. Thus, there is fairly robust evidence for a substantial spill-over effect.

A common assumption when analyzing unemployment is that the economy is closed. In empirical research, such models are often used even when dealing with economies where foreign trade constitutes a considerable fraction of the economy. However, Layard, Nickell and Jackman (1991) and Bean (1994) show that the NAIRU is not identified in an open economy unless the

foreign sector is modeled. Omitting the foreign sector could therefore potentially bias the NAIRU estimates. A closed economy alternative model is nested in the model that I set up. When tested, the closed economy model cannot be rejected.

A main result of the first paper is that open and total unemployment exhibit similar patterns of persistence. Moreover, the results suggest that the favorable Swedish unemployment experience up to 1991 was due to small shocks, rather than to the presence of spill-over effects from cyclical unemployment to the NAIRU. The unemployment development during 1992-1994, however, seems to be caused by large shocks as well as the presence of a substantial spill-over effect. Comparing these results with the results in the next chapter suggests that the identification of the model over-emphasizes the role of the permanent component.

One policy conclusion from the model would be that to reduce the high unemployment rate in the early 1990s one ought to stimulate the economy and thereby reduce the rate of cyclical unemployment. The output gap effect on inflation would be short lived since the large spill-over effect would reduce NAIRU quite rapidly. In 1996, Sveriges Riksbank indeed lowered the interest rate by nearly 500 basis points, from 8.91 percent to 4.10 percent.

Paper 2 In 1997, the Swedish unemployment rate started to decline and by mid 2001, it had reached the lowest level since the early 1990s. Obviously, it is important to know whether this decline in unemployment reflects a change in NAIRU or a narrowing of the unemployment gap. Apel and Jansson (1999) suggest that the NAIRU increased during the first half of the 1990s. Turner et al. (2001) found that NAIRU increased substantially from 1980 to 1995.

My second paper, *The Equilibrium Rate of Unemployment in a Small Open Economy*, written together with Peter Sellin, is to some extent an update of the first paper. Central questions are how the NAIRU has evolved, and what explains the movements. Moreover, the open economy aspect is

revisited and modeled and estimated in a more elaborate way.

One policy conclusion from the results in the first paper is to stimulate the economy when unemployment is high. Large spill-over effects from cyclical to permanent unemployment implies that an expansionary policy reduces the NAIRU in the near future. Thus, in order to design appropriate policies to combat unemployment it is important to know to what degree observed unemployment is due to a lack of demand and to what degree it is due to structural factors. Even though the first paper suggests that the NAIRU is affected by the cyclical unemployment rate, theory tells us that it is also explained by a set of structural factors, e.g. taxes, active labor market policies, the replacement ratio and demographic factors.

As discussed above, omitting the foreign sector can bias the NAIRU estimates. It is straightforward to show that in an open economy the unemployment rate will, at least partly, be driven by the real exchange rate. A depreciation of the real exchange rate increases consumer prices. In order to restore consumer real wages, real wage costs for firms must increase and this reduces employment. The determinants of the real exchange rate should thus be included in the set of structural factors determining the NAIRU.

Instead of modelling the NAIRU as a stochastic trend, which I did in the first paper, we now model it as a function of a set of theoretically motivated variables. Our approach takes the unobserved components model of Salemi (1999) a step forward by setting up an open economy framework and simultaneously estimate the rate of unemployment and the real exchange rate. To identify the model, we also estimate an expectations-augmented Phillips curve.

As it turns out, we can safely reject the assumption of a closed economy. Indeed, the foreign sector turns out to be quite important in explaining the development of the unemployment rate and the NAIRU. Ignoring the existence of the foreign sector will thus bias the results, and according to the point estimates, the bias can be substantial.

Our analysis successfully explains the development of the Swedish unemployment rate. A depreciation of the real exchange rate, a higher replacement ratio and higher taxes will raise the NAIRU, whereas an increase in the size of labor market programs tends to reduce it. According to our point estimates, the NAIRU increased by approximately 1-1.5 percentage points during 1980-1985, and remained quite stable thereafter. This finding implies that the dramatic unemployment hike in the 1990s was mainly a cyclical phenomenon, which is quite a different conclusion from the one reached in paper 1. The difference is probably due to the identification of the model and the assumption in the first paper that NAIRU is a random walk.

The real exchange rate is successfully modeled as a function of the terms of trade, the evolution of demographics relative to the rest of the world, and the domestic and foreign structural budget deficits. It is assumed that net foreign assets – which are often treated as exogenous to the real exchange rate – are determined by demographic variables and structural budget deficits. Our focus on demographics relative to the rest of the world and the use of structural deficits in the exchange rate equation is a novelty. A larger fraction of the population aged 45-59 years and a larger domestic structural budget deficit depreciate of the real exchange rate, while improved terms of trade and a larger foreign structural budget deficit appreciate it. Our model explains a surprisingly large fraction of the variation in the real exchange rate, especially keeping in mind that the sample period spans no less than five devaluations and a shift from a fixed to a floating nominal exchange rate – events that we do not control for. We also find that the real exchange rate does not revert faster to the equilibrium real exchange rate (REER) during the floating-rate period, than in the fixed rate period. Thus it seems as adjustments to the real exchange rate during the fixed-rate period mainly took place through devaluations and not through changes in the relative price level.

The Phillips curve seems to be "alive and well" and changes in the rate

of inflation are well explained by the unemployment gap and different supply side shocks. An interesting result is that persistence in the unemployment rate influence the results. The change in the rate of inflation is affected by the change in the unemployment gap, indicating that if the gap is closed too rapidly, this may cause rising inflation.

Paper 3 Given the results in paper 2, the exchange rate appears to be of great importance, both theoretically and empirically, when explaining the development of the unemployment rate. Therefore, it is troublesome that the evolution of a real exchange rate is hard to understand, making it hard to analyze the movements in unemployment. It is often claimed that the best guess about tomorrow's real exchange rate is today's going rate.

In my third paper, *A Simultaneous Model of the Swedish Krona, the US Dollar and the Euro*, written together with Peter Sellin, we challenge this conclusion and try to explain the large, and often persistent, swings we observe in a set of real exchange rates.

The most common approach when estimating real exchange rates is to study a bilateral exchange rate or to compare one currency to a basket of other currencies, adjusting for relative price levels. The challenge and contribution of this chapter is to estimate a small system of different real exchange rates in order to simultaneously analyze movements in the real exchange rate between the Krona, the Euro and the Dollar, the most important real exchange rates for Swedish exports. A tri-polar model for the German Mark, the US Dollar and the Japanese Yen has previously been estimated by MacDonald, R. and I. Marsh (1999).

Our empirical model is based on theoretical results from the new open economy macroeconomics literature inspired by the work of Obstfeld and Rogoff (1995). In our specification the real exchange rate is determined by terms of trade, relative potential output and a set of exogenous variables that are assumed to determine the net foreign asset position. Potential output in

Sweden, the Euro area and the US is estimated separately in an unobserved components framework, including an expectations augmented Phillips curve.

Our results are promising. We are able to surprisingly well explain the variation in output, inflation and in the change of the real exchange rates. Our point estimates are in line with theory, of expected magnitude and highly statistically significant.

An increase in the terms of trade, in net foreign assets or in relative production, in one country raises wealth which, in turn, stimulates consumption of non-traded goods. In addition, higher income reduces labor supply which reduces the production of non-traded goods and thus raises the relative price of non-tradables. Both these effects appreciate the real exchange rate. However, net foreign assets can not be treated as exogenous. We assume that the relative demographic situation and relative structural fiscal position of the government are exogenous determinants of net foreign assets and the real exchange rate.

Our results imply that potential output growth is highest in the US, followed by the Euro area. This is not very surprising given the fact that actual growth is ranked in the same way. The Phillips curve seems to be steepest in the US. Inflation is more sensitive to the output gap in the US than in Sweden and the Euro area. An increase in relative potential output strengthens, as expected, the real exchange rate. The Krona and the Dollar benefit more from this effect than the Euro. An increase in export prices relative to import prices – i.e. the terms of trade – strengthens the currency of the exporting country, which again is as expected. It seems as if the Euro area benefits the most from an increase in export prices. An increase in the relative middle-age cohorts is found to weaken the exchange rate, but this result is not very robust. The structural budget situation is, however, of great importance and an increase in the deficit has a depreciating effect. The point estimates indicate that this effect is larger for the US and the Euro area than for Sweden. Our results indicate that an increase in the US deficit

by one per cent of GDP could depreciate the USD/EUR by as much as 8 per cent.

Our exchange rate models seem to be quite stable. In an out-of-sample exercise, stretching over 8 years, we are able to closely track the actual development of the three real exchange rates.

Moreover, for countries that have joined the European Union but not yet adopted the Euro, it is important to understand the development of real exchange rates. When determining the nominal conversion rate, it is important that it does not induce an inflation shock in order to restore an economically motivated real exchange rate. We believe that our model can be of some help in this respect.

Paper 4 The macro labor literature often appeals to a mechanism whereby wages are set as a mark-up on the unemployment benefit level, such that higher benefits will raise wages and reduce employment. The empirical results are, however, not clear-cut (e.g. Calmfors, Forslund and Hemström, 2004). One way of getting around the adverse, wage-raising and employment-dampening, effect might be to finance unemployment benefits in such a way as to create incentives for lower wages or not laying off workers. An example is an experience-rated pay-roll tax, where the pay-roll tax, at least to some extent, is set to reflect individual employers' lay-off history (e.g. Krueger and Meyer, 2002). However, at the same time hiring costs are increased which reduces the incentive to hire workers (Hamermesh, 1993). Holmlund and Lundborg (1988, 1989) and Calmfors (1995) suggest that wage setting and employment can be influenced by differentiating the contributions to unemployment support by areas of wage bargaining. The idea is to get the bargaining parties to internalize some of the costs for unemployment, thereby increasing the perceived benefits of wage moderation.

In my last chapter, *Wages, Employment, and Unemployment: The Effects of Benefits, Taxes and Labor Mobility*, I analyze how wages, employment

and unemployment are affected by introducing labor mobility in a model with different sectors. Within this framework, I check some of the established results on how wages and employment respond to changes in the unemployment benefit level, and to changes in the fraction of unemployment costs borne by each sector in the economy. Regarding the analysis of the unemployment insurance, I revisit some earlier results, while the analysis of mobility and wages is a novelty.

The general result is that intersectoral labor mobility can both reduce and increase the incentive for high wages, depending on the elasticity of labor demand. However, for elasticity values often found in the empirical literature, mobility reduces the incentive for higher wages. The reason is that higher wages in a sector increase labor supply and unemployment, which reduces the gains from pushing up wages. Given that labor mobility reduces wages, it is also shown that wages decrease in the number of sectors in the economy. Thus, competition reduces wages and increases employment.

Moreover, I show that the wage level is unambiguously decreasing in the weight on employment in the union utility function – this result holds regardless of whether labor is mobile or not.

Introducing a tax scheme where the bargaining parties have to consider that their actions affect the tax rate, is expected to mitigate the adverse effects on wages and employment from unemployment benefits. This result is shown to be robust to different specifications of utility functions only as long as labor is not mobile. However, when labor is mobile the result hinges on the specification of the utility function.

It is also shown that a standard result in the literature, that an increased unemployment benefit level increases the wage level, does not hold in general.

A policy conclusion from the analysis in this last chapter is that lower unemployment can be achieved either by making unions care about employment or by facilitating labor mobility.

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Chapter 2

Persistence in Swedish Unemployment Rates*

1 Introduction

Sweden experienced a dramatic rise in the rate of unemployment during the early 1990s. Open unemployment rose from 1.7% in 1990 to 8.0% in 1994, and total unemployment (the sum of open unemployment and participation in active labor market programs) increased from 2.9% to 13.3%. This rise is illustrated in Figure 1. During 1995 the figures moderated slightly.

The Swedish unemployment record during the early 1990s is similar to the development in the rest of Europe in the late 1970s and the beginning of the 1980s. A crucial question is whether the Swedish increase is temporary or if the high unemployment figures will persist, as in many other European countries.

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Previous empirical studies on the natural rate of unemployment suggests at least four different ways to approach this question.

(1) Holmlund (1993) estimates recursively an expectations-augmented Phillips curve model. His results suggest that the natural rate of open unemployment was higher in the beginning of the 1990s than two decades earlier. However, the change is small and uncertain which might be due to several factors. Holmlund's sample ends in 1992 and the method used is not without problems. The development during 1994 and 1995, with rising wage inflation, might, however, be interpreted as an indication that the natural rate has increased.

(2) An alternative approach is to estimate a structural model. Forslund (1995) estimates a dynamic version of the Layard, Nickell and Jackman (1991) model (henceforth denoted the LNJ model) for price and wage setting under imperfect competition and a reduced-form unemployment equation. His results indicate that the rise of the open equilibrium unemployment rate "could be of the order of magnitude of 1-4 percentage points between 1990 and 1993". This spread is large when considering that unemployment increased by 6.5 percentage points during that period.

(3) Univariate time series models have also been used for studying the persistence in open unemployment rates (Alogoskoufis and Manning, 1988; Barro, 1988; Elmeskov, 1994). An important result is that the degree of persistence seems to be high in Europe and low or lower in the US.

However, a univariate analysis does not recognize that supply and demand shocks might affect unemployment in different ways. Supply shocks, like productivity shocks and changes in institutional settings, are usually expected to affect unemployment permanently, whereas demand shocks and stabilization policy often are assumed to have transitory effects only. However, a demand shock might also permanently affect unemployment. If the transition following a shock is slow, temporary unemployment might be quite long lived. There might be several reasons for this longevity. One explanation

might be that even temporary unemployment can lead to such a depreciation of human capital that the probability of re-employment is considerably reduced for the unemployed (Layard, Nickell and Jackman, 1991). Another explanation is that reductions in the capital stock associated with reduced employment after an adverse shock reduce the demand for labor (Blanchard and Summers, 1986). Finally, insiders might be important in the wage formation process (Blanchard and Summers, 1986; Gottfries and Horn, 1986; Lindbeck and Snower, 1988).

(4) The time series properties of the open unemployment rate have also been studied in an unobserved components model, allowing for different types of shocks and letting the cyclical stance of unemployment have permanent effects (Jaeger and Parkinson, 1994; Assarsson and Jansson, 1995). In this model the unemployment rate is decomposed into a non-stationary and a stationary component. The results in Assarsson and Jansson concerning Sweden, indicate that the non-stationary part closely follows the actual open unemployment rate, i.e. that the cyclical fluctuations are very small. Moreover, according to their estimates, 77% of the cyclical unemployment spills over to the permanent component. This effect is very large in an international comparison.

The time series approach is interesting and reveals some important properties of the unemployment series, but to some extent it lacks a theoretical underpinning. This deficiency is not present in the structural models.

This paper has three objectives. First, the time series approach in Jaeger and Parkinson is given more structure by combining it with the LNJ open-economy model. Thus, the resulting model will incorporate the appealing time series features of the UC model and have a more clear economic interpretation.

Second, this combined model is used to test the robustness of the results in Assarsson and Jansson regarding persistence and large spill-over effects from the cyclical to the permanent component of unemployment.

Third, previous studies on persistence have only addressed open unemployment. In Sweden active labor market programs (ALMPs) are an important part of the labor market. This paper also investigates if total unemployment exhibits patterns similar to those of open unemployment regarding persistence and the spill-over from the cyclical to the non-stationary component. Thus, this section provides new evidence regarding persistence in total unemployment rates.

2 The model

2.1 The unobserved components model

Since one of the objectives of this paper is to test if the results in Assarsson and Jansson for Sweden are robust, the unobserved components (UC) model of the unemployment rate used by these authors is adopted.

There is persistence if there is no or weak tendency for unemployment to revert back to previous levels after a change. Persistence may be caused by three factors, either individually or in combination. First, natural rate shocks change unemployment permanently. Second, unemployment may contain a cycle with long periodicity, i.e. it takes a long time for cyclical unemployment to revert back to previous levels after being hit by a shock. Third, cyclical shocks may spill over to permanent unemployment. Thus, spill-over effects imply persistence but the converse is not true.

Unemployment, u , is assumed to consist of two unobserved components, a non-stationary component, u^n , and a stationary component, u^c . Hence,

$$u_t = u_t^n + u_t^c. \quad (2.1)$$

A non-stationary process can be modelled in many different ways. Here, the permanent component is assumed to follow a random walk plus a spill-over term.

The random walk assumption is an important, but not problem-free, restriction on which the results are conditioned. Quah (1992) shows that "a random walk specification is biased towards establishing the permanent component as important". However, if only employed workers have insider power in wage setting, employment will follow a random walk (Blanchard and Summers, 1986).

Unemployed workers are not likely to turn into outsiders immediately. Nor will a depreciation of human capital due to unemployment occur directly. Below, it is assumed that the spill-over from cyclical to permanent unemployment occurs with a two-period lag (i.e. a one year lag in the empirical part below). This lag assumption is not crucial, but it fits the data well. An expression for the non-stationary part of unemployment is thus

$$u_t^n = u_{t-1}^n + \varepsilon_t^n + \alpha u_{t-2}^c, \quad (2.2)$$

where α measures the spill-over effect of interest, $\alpha \in [0, 1]$.

The cyclical component is described by the following stationary process

$$u_t^c = \phi_1 u_{t-1}^c + \phi_2 u_{t-2}^c + \varepsilon_t^c, \quad (2.3)$$

where the parameters ϕ_1 and ϕ_2 provide a measure of the periodicity of the cyclical component. Stationarity implies that the roots of the polynomial equation

$$1 - \phi_1 L - \phi_2 L^2 = 0,$$

where L is the lag operator, should lie outside the unit circle. The assumption of an AR(2) process for the cyclical component can be relaxed, but in the empirical work it is found that it fits the data well.

The innovations ε_t^i are assumed to be mutually uncorrelated and normally distributed with variances σ_i^2 , $i = n, c$. For the model to make sense, a unit root in the unemployment rate is a necessary and testable assumption.

2.2 Alternative identifying equations

The UC model given by equations (2.1)-(2.3) is in general not identified, i.e. the second moments of the observed variable are insufficient to uniquely determine all parameters of the model. In order to identify the model, information on an additional variable that is related to either the permanent or the cyclical component is needed.

Jaeger and Parkinson assume that mean-adjusted real growth rate of output in the G-7 countries is related only to changes in the cyclical unemployment rate in each country. Assarsson and Jansson instead use a mean-adjusted growth rate of a world industrial production series. Hence, the identifying assumption in these papers is that mean-adjusted foreign production growth rates are exogenous with respect to country-specific natural rate shocks. Assarsson and Jansson claim that "although not problem-free, we note that this identifying assumption is consistent with most traditional models of the labour market in that it implies that structural domestic factors are considered to be the key determinants of a country's natural rate".

In the model below, depending upon how the equilibrium is defined, the natural rate may or may not depend upon the demand/output gap abroad. Moreover, the interpretation of the identifying equation in Assarsson and Jansson is unclear. The cyclical unemployment in Sweden can obviously not be of any great importance in explaining the world output gap. Instead their identifying equation should be seen as representing a co-movement relationship without causality implications.

In this paper, the LNJ open-economy model for price and wage setting is used in order to derive an identifying equation. The model will actually suggest two equations, where either can be used to achieve identification. In addition, a version of Phelps' (Phelps, 1968) expectations-augmented Phillips curve is tested for comparison.

A simplified and log-linearized version of the LNJ model is briefly presented below. The model is highly simplified with respect to information,

but it follows the usual convention that focuses only on price uncertainties.

The general idea is that real wages and employment are determined by two relationships, describing firm and union behavior. It is assumed that both product and labor markets are characterized by imperfect competition.

Firms are assumed to have perfect foresight about price and wage levels. Prices are set as a mark-up on wage costs. Changes in demand may influence price-setting because the marginal productivity of labor depends on the amount of labor used. The price-setting behavior can be modelled as

$$p - w = \beta_0 + \beta_1(y - y^n), \quad (2.4)$$

where p , w , y , and y^n respectively denote the producer price level, the nominal wage cost including payroll taxes, actual demand, and equilibrium demand. Output is determined by firms supplying whatever is demanded. Lower-case letters denote natural logarithms unless otherwise indicated. It is unclear what is to be expected with respect to β_1 . On the one hand, a positive value indicates that decreasing returns to labor tend to make the mark-up an increasing function of demand. On the other hand, empirical evidence indicates that the mark-up is insensitive to changes in demand, suggesting that β_1 is close to zero (Layard, Nickell and Jackman, 1991; Forslund, 1995).

The deviation of demand from its equilibrium level is related to the labor market by an "Okun's-law" equation

$$y - y^n = -\mu(u - u^n), \quad (2.5)$$

where u^n denotes the equilibrium unemployment rate. The expected sign of μ is positive.

Wage setting is described by a relationship that can be derived from e.g. bargaining models (Layard, Nickell and Jackman, 1991; Blanchflower and Oswald, 1994; Forslund, 1995). Bargaining is assumed to take place at the firm or industry level. The outcome is that wages are set as a mark-up on

the value of the bargaining parties' alternative pay-offs.

The value of the alternative to being employed at the current firm depends on two sets of factors: the probability of ending up in other states and the incomes in these states. In the Swedish case, it is reasonable to distinguish between three different states: employment elsewhere in the economy, open unemployment, and participation in a labor market program. In this section, it will be assumed that participation in a labor market program is a perfect substitute for employment (this assumption is relaxed in section 3.2). The probability of ending up in employment elsewhere and receiving the going market wage, depends on the employment rate in the economy. Individuals in open unemployment are assumed to receive a given fraction, the replacement ratio, of the prevailing market wages as an income.

Wage setters are assumed to be concerned about the real consumption wages, w_c , i.e. take-home wages in relation to consumer prices,

$$w_c = w + \ln(1 - T) - \ln(1 + S) - p_c,$$

where T is the average income tax rate, S is the payroll tax rate, and p_c is the consumer price level. The real product wage, w_p , is defined as $w - p$. Thus, there is a wedge between the real product wage and the real consumption wage,

$$w_p - w_c = \ln(1 + S) - \ln(1 - T) + p_c - p.$$

The wedge consists of two parts, a tax part which depends on payroll and income taxes, and a price part which consists of the ratio of the consumer price to the producer price. The (logarithm of the) consumer price can be expressed as a weighted average of product and import prices, $p_c = \varpi p + (1 - \varpi)(e + p^*)$, where e is the (logarithm of the) nominal exchange rate, p^* the (logarithm of the) foreign price level and $\varpi < 1$ the weight of domestic

goods in the consumption basket. The relative price can be written as

$$p_c - p = (1 - \varpi)(e + p^* - p).$$

Thus, the price part of the wedge is a function of the real exchange rate, c , where $c = e + p^* - p$.

The assumptions and considerations above can give the following wage equation (Layard, Nickell and Jackman, 1991);

$$w - p = \gamma_0 - \gamma_1 u + \gamma_2 r + \gamma_3 c + \gamma_4 \theta,$$

where r denotes the replacement ratio and the tax part of the wedge is measured by θ :

$$\theta = \ln \left(\frac{1 + S}{1 - T} \right).$$

Wage setters are assumed not to have perfect foresight regarding prices. A usual assumption is that wages are set with respect to expected producer prices, p^e , where superscript e denotes expectations. Taking this into consideration, the wage equation above can be rewritten as

$$w - p = \gamma_0 - (p - p^e) - \gamma_1 u + \gamma_2 r + \gamma_3 c + \gamma_4 \theta \quad (2.6)$$

The expected signs of the parameters are all positive. Underpredicted prices result in too low realized real wages. High unemployment indicates high competition for available jobs, hence lowering the probability of re-employment and thus restraining real wages. A higher replacement ratio is assumed to increase utility while unemployed, and hence increase real wage pressure and unemployment. A rise in the real exchange rate, c , raises wage pressure by making consumption goods more expensive relative to domestic value-added output.

In the simple expectations-augmented Phillips curve approach, the NAIRU is often calculated in a closed-economy framework (by setting the inflation

expectation error to zero). However, in an open economy this assumption is not consistent with a unique natural rate, because unemployment might be affected by, for instance, fiscal policy. An expansionary fiscal policy that increases the demand for domestically produced goods will lead to a crowding-out of net exports through an appreciation of the real exchange rate. This real appreciation reduces the price part of the wedge and hence lowers the equilibrium unemployment rate. Thus, there is actually a whole set of "quasi-equilibrium" unemployment levels, where each level corresponds to a different level of the current account (Layard, Nickell and Jackman, 1991; Bean, 1994). In order to complete the model, a current account equation is specified:

$$\delta_1 b = -\delta_0 + \delta_1 d + c - \delta_2(y - y^n) + \delta_3(y^* - y^{n*}) \quad (2.7)$$

where b is the current account position relative to GDP, y^* the foreign demand, y^{n*} the equilibrium foreign demand, and d the sum of net capital income from abroad and the balance of transfers relative to GDP. The net capital income primarily consists of net interest payments from foreigners, which in turn depend on net foreign assets, i.e. the sum of previously accumulated current account surpluses. The balance of transfers for Sweden consists mainly of aid to developing countries. All parameters are expected to have positive signs. The coefficient of d is by definition set to δ_1 , i.e. the trade balance of goods and services is equal to $b - d$.

The model described by (2.4)-(2.7) has a solution for the real wage, the price-expectation error, unemployment and the current account.

In a full equilibrium, it is assumed that expectations are fulfilled and demand is equal to its equilibrium level. Moreover, persistent deficits or surpluses in the current account are not sustainable. In a static open economy equilibrium it is reasonable to impose a condition that states that the current account must be in balance. Thus, equilibrium is defined as $p - p^e = 0$, $y - y^n = 0$, $u - u^n = 0$ and, $b = 0$. Using equations (2.4)-(2.7) and the

equilibrium conditions gives,

$$\gamma_1 u^n = \beta_0 + \gamma_0 + \gamma_2 r + \gamma_3 [\delta_0 - \delta_1 d - \delta_3 (y^* - y^{n*})] + \gamma_4 \theta. \quad (2.8)$$

The term within the brackets is the equilibrium real exchange rate, c^* , i.e. the real exchange rate that is consistent with $b = 0$ and $y - y^n = 0$. In addition to the conditions above, the equilibrium may be defined given "normal" demand in the rest of the world, i.e. to set $y^* - y^{n*} = 0$. Hence, the equilibrium unemployment can depend on both domestic and international factors.

Now use equations (2.4)-(2.8) and solve for the expectation error $p - p^e$. This operation gives

$$(p - p^e) = -(\mu\beta_1 + \gamma_1)(u - u^n) + \gamma_3 (c - c^*), \quad (2.9)$$

where

$$c - c^* = c - \delta_0 + \delta_1 d + \delta_3 (y^* - y^{n*}).$$

Thus, the expectation error is a function of the unemployment deviation from the natural rate and real exchange rate deviation from its equilibrium level. Equation (2.9) satisfies the conditions for solving the identification problem.

The only remaining problem is to specify a process for the price expectations. A unit root in different measures of the rate of inflation cannot be rejected (see Table 1). For simplicity, assume that the rate of inflation follows a random walk.¹ Then, equation (2.9) can be rewritten and simplified as

$$\Delta^2 p = \lambda_0 + \lambda_1 u^c + \lambda_2 c + \lambda_3 (y^* - y^{n*}) + \lambda_4 d, \quad (2.10)$$

where $u^c = u - u^n$ and Δ is the difference operator. Equation (2.10) is the first relationship used to identify the UC model outlined above.

As noted above, identification requires a variable that is related to ei-

¹This assumption is tested and not rejected for three out of four different measures of the rate of inflation.

ther the cyclical or the permanent component of unemployment, but not to both. The current account equation, (2.7), combined with (3.7) fulfills these requirements, and can be written as

$$b = \psi_0 + \psi_1 u^c + \psi_2 c + \psi_3 (y^* - y^{n*}) + d. \quad (2.11)$$

This equation is used as an alternative to equation (2.10).

The third alternative relationship that is used originates from Phelps' expectations-augmented Phillips curve (Phelps, 1968). Phelps' idea is that changes in labor demand cause a disequilibrium in the labor market. When wages respond, the rate of change is determined by two factors, the deviation of demand from its equilibrium and the expected rate of wage increase (Calmfors, 1978).

$$\Delta w = \Delta w^e + f(u^c)$$

Another way of stating Phelps' idea is that if a firm/sector in the economy wants to change the level of employment, the firm/sector has to change its rate of wage change in relation to the rest of the economy. Assume that firms in this situation follow a wage-setting rule of thumb, according to which they set the unit labor cost increase (unit labor cost, ULC , is wage cost in relation to productivity) relative to that of other firms when employment is below its equilibrium level and vice versa. Then the expectations-augmented Phillips curve can be written as

$$\Delta ULC - \Delta^e ULC = f(u^c), f' < 0.$$

Under the assumption that ΔULC follows a random walk (tested and not rejected), this relationship can be rewritten as

$$\Delta^2 ULC = \pi_1 u^c, \pi_1 < 0. \quad (2.12)$$

2.3 The empirical model

In order to estimate the model, it is put in state space form. The transition equations are given by

$$\begin{pmatrix} u_t^n \\ u_t^c \\ u_{t-1}^c \end{pmatrix} = \begin{pmatrix} 1 & 0 & \alpha \\ 0 & \phi_1 & \phi_2 \\ 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} u_{t-1}^n \\ u_{t-1}^c \\ u_{t-2}^c \end{pmatrix} + \begin{pmatrix} \varepsilon_t^n \\ \varepsilon_t^c \\ 0 \end{pmatrix}, \quad (2.13)$$

and the first measurement equation is given by

$$u_t = \begin{pmatrix} 1 & 1 & 0 \end{pmatrix} \begin{pmatrix} u_t^n \\ u_t^c \\ u_{t-1}^c \end{pmatrix}. \quad (2.14)$$

In Appendix 2, it is shown that both product and consumer prices may enter the LHS of equation (2.10), and that the RHS can be augmented with the change in the rate of import inflation. Since the model above does not uniquely suggest a specific product price, three different measures of inflation in equation (2.10) are used: the change in the deflators for private consumption, GDP and business-sector value added. The stationary part of the unemployment rate is also identified by using the current account equation (2.11) and the Phelps' specification (2.12). This gives five different ways to identify the UC model. Thus, the second measurement equation is given by choosing one of the following equations:

$$\begin{pmatrix} \Delta^2 p_{c,t} \\ \Delta^2 p_{GDP,t} \\ \Delta^2 p_{BVA,t} \\ b_t \\ \Delta^2 ULC_t \end{pmatrix} = \begin{pmatrix} 0 & \lambda_1^c & 0 \\ 0 & \lambda_1^{GDP} & 0 \\ 0 & \lambda_1^{BVA} & 0 \\ 0 & \psi_1 & 0 \\ 0 & \pi_1 & 0 \end{pmatrix} \begin{pmatrix} u_t^n \\ u_t^c \\ u_{t-1}^c \end{pmatrix} + \\
\begin{pmatrix} \lambda_0 & \lambda_{2a}^c & \lambda_{2b}^c & \lambda_3^c & \lambda_4^c & \lambda_5^c & \lambda_6^c \\ \lambda_0 & \lambda_{2a}^{GDP} & \lambda_{2b}^{GDP} & \lambda_3^{GDP} & \lambda_4^{GDP} & \lambda_5^{GDP} & \lambda_6^{GDP} \\ \lambda_0 & \lambda_{2a}^{BVA} & \lambda_{2b}^{BVA} & \lambda_3^{BVA} & \lambda_4^{BVA} & \lambda_5^{BVA} & \lambda_6^{BVA} \\ \psi_0 & \psi_{2a} & \psi_{2b} & \psi_3 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} k \\ c1_{t-1} \\ c2_{t-2} \\ (y^* - y^{n*})_t \\ d_t \\ \Delta^2 p_{m,t-1}^g \\ \Delta^2 p_{m,t}^s \end{pmatrix} + \begin{pmatrix} v_t^c \\ v_t^{GDP} \\ v_t^{BVA} \\ v_t^b \\ v_t^{ULC} \end{pmatrix}, \quad (2.15)$$

where k is a constant, $c1_{t-1}$ and $c2_{t-2}$ are two different measures of the real exchange rate, $\Delta^2 p_{m,t-1}^g$ and $\Delta^2 p_{m,t}^s$ are two import price shocks and $v_t^i, i = c, GDP, BVA, b, ULC$, are innovations. A full description of the variables is given in Appendix 1. Seasonality is handled by a seasonal dummy. The inclusion of the foreign output gap among the exogenous variables means, as discussed above, that it is assumed to be closed in equilibrium.

All innovations are assumed to be normally distributed and uncorrelated in time and with each other.

The parameters of the state-space model are estimated by maximizing the prediction-error decomposition form of the log-likelihood function. The prediction errors are calculated via the state-space model and the Kalman filter (see Harvey, 1989).

The Kalman filter is a recursive procedure for computing the optimal (minimal mean square error) estimator of the transition vector at time t , based on the information available at the same time. The information set consists of the observations up to and including time t of all observable variables. When the disturbances and the initial transition vector are normally

distributed, the Kalman filter makes it possible to calculate the likelihood function via what is known as the prediction-error decomposition. This approach gives a method for estimating the unknown parameters in the model.

3 Empirical results

The empirical analysis uses seasonally unadjusted semi-annual data starting in 1972.

In order to identify the stationary component of the UC model, the identifying variables must also be stationary. In the model above, it is assumed that the unemployment and the inflation processes both contain unit roots, i.e. their first differences are stationary. Table 1 presents the statistical results on the occurrence of unit roots based on augmented Dickey-Fuller tests.

The hypothesis of a unit root in unemployment as well as in all different measures of inflation (including the change in unit labor cost) is not rejected.² Regarding the current account, the unit root hypothesis is rejected at the 5% level. Thus, all identifying variables seem to be stationary as required.

3.1 Open unemployment and robustness

The results from estimating the state-space model for the period 1972 to 1994 are presented in Table 2. As noted above, the model is identified in five different ways. These alternative ways of identification generate five different series for the permanent and cyclical components. The different series are very similar, and unweighted averages are presented in the figures below.

The point estimates of the spill-over parameter, α , range from 0.59 to 0.84 and always differ significantly from zero. This interval also covers the

²The hypothesis of inflation following a random walk is only rejected in the case of Δp_c . However, the tests in the tables below indicate that the model performs satisfactory when using $\Delta^2 p_c$ in the LHS of (2.10).

$\Delta z_t = c + \varphi z_{t-1} + \sum_{i=1}^m b \Delta z_{t-i} + \varepsilon_t$		
z	t statistic on φ	lag length m
u	-1.88	6
u_{tot}	-1.27	4
Δp_c	-1.72	3
Δp_{GDP}	-1.70	2
Δp_{BVA}	-2.23	2
b	-2.95**	2
Δp_{ULC}	-2.42	2

Note: p_c = private consumption deflator, p_{GDP} = gross domestic product deflator, p_{BVA} = business-sector value added deflator, and ULC denotes unit labor costs in manufacturing. *, **, and *** denote significance at 10, 5, and 1% level respectively.

Critical values are taken from Hamilton (1994) Table B:6 case 2.

Table 1: Tests for unit roots

point estimate (0.77) in Assarsson and Jansson.

Thus, six different ways of identifying the labor market model and the use of different data sets (Assarsson and Jansson use seasonally adjusted quarterly data for the period 1965:1-1994:2) all produce significant point estimates within a close range. This stability suggests that the results are robust.

Figure 2 shows the average permanent open unemployment component together with the open unemployment rate. The model suggests that the permanent part has increased substantially during the early 1990s, from 1.4% in 1990 to 9.2% in 1994, which is consistent with earlier work. The estimated permanent component for 1994 is higher than the open unemployment rate, suggesting that the cyclical component, (see Figure 3), is negative.

Contrary to the results in Assarsson and Jansson, the estimated variance of the cyclical shocks is always larger than that of the natural rate shocks.

The average periodicity of the cyclical component can be calculated as

Identifying variable	$\Delta^2 p_c$	$\Delta^2 p_{GDP}$	$\Delta^2 p_{BVA}$	b	$\Delta^2 ULC$
ϕ_1	1.52	1.51	1.51	1.59	1.57
ϕ_2	-0.85	-0.84	-0.84	-0.85	-0.84
α	0.84	0.82	0.82	0.59	0.65
u_t^c	-1.17	-1.10	-0.91 ¹⁾	$1.6 \cdot 10^{-3}$	-2.2
$\Delta^2 p_{m,t-1}$	0.10	0.18	0.28	-	-
$\Delta^2 p_{m,t}^s$	0.21	0.01	0.05	-	-
Periodicity	10.4	10.4	10.4	11.8	11.6
σ_n^2	0.01	$3.9 \cdot 10^{-4}$	$3.9 \cdot 10^{-4}$	$9.5 \cdot 10^{-7}$	$2.1 \cdot 10^{-3}$
σ_c^2	0.10	0.12	0.12	0.12	0.11
σ_v^2	1.89	3.07	2.78	$1.2 \cdot 10^{-4}$	16.77
Sample	1972-94	1972-94	1972-94	1972-94	1972-94
Tests					
LR $\alpha = 0$	7.36***	9.38***	8.40***	5.12**	7.8***
LR $\alpha_{72-94} = \alpha_{72-91}$	3.10*	1.40	3.12*	0.12	1.5
LR b -parameters= 0	1.12	1.48	1.08	-	-
LR λ_5 and $\lambda_6 = 0$	21.88***	3.82	15.08***	-	-
Serial cor. (unempl.)	2.11	2.14	2.02	2.44	2.2
Serial cor. (ident.var.)	10.0	10.33	17.09**	8.55	4.5
Heterosc. (unempl.)	0.01	0.07	0.06	0.007	0.002
Heterosc. (ident.var.)	1.05	0.97	0.43	0.07	0.2
R ² (unempl.)	0.97	0.97	0.97	0.97	0.97
R ² (ident.var.)	0.50	0.32	0.40	0.68	0.19
Log likelihood	-89.11	-98.83	-96.81	114.69	-134.05

Notes: 1) u_{t-1}^c . Serial cor. are Box-Ljung Q(k) tests against serial correlation based on k=7 autocorrelations. Heterosc. are F(15,15) tests against heteroscedasticity, see Harvey (1989, p. 259). R² is the multiple coefficient of determination. LR are likelihood ratio tests. LR b -parameters=0 is a LR test of the joint hypothesis that the parameters in front of $c1, c2, d,$ $y^* - y^{n*}$, and the constant all are zero. *, **, and *** denote significance at the 10, 5, and 1% level respectively.

Table 2: Open unemployment, long sample

(Jaeger and Parkinson, 1994)

$$\left[\frac{1}{2\pi} \arccos \left[|\phi_1| / (2\sqrt{-\phi_2}) \right] \right]^{-1}. \quad (2.16)$$

According to the point estimates in Table 2 the average periodicity is around 5 years and two months when using (2.10) for identification and a little more than half a year longer when using the current account or unit labor cost measures. This interval does not cover, but is close to, the periodicity of 6 years and one month, estimated by Assarsson and Jansson.

Above it is argued that an open economy framework must be used when estimating the trade-off between inflation and unemployment. When using equation (2.10) the (non-reported) parameters in front of the variables originating from the current account equation (the two real exchange rate measures, $c1, c2$, the foreign output gap, $y^* - y^{n*}$, and the net capital income from abroad, d) all have their expected signs. However, the joint hypothesis that they (and the constant) all are zero is not rejected. Hence, the LNJ open economy model does not provide any additional significant information compared to the closed economy model (augmented with shocks in import inflation).

When using the current account equation (2.11) the (non-reported) parameter on the foreign output gap variable is negative and significantly different from zero. The reason for this is not clear, but it might be due to the filtering process (HP-filter, $\lambda = 800$) that generates the variable.

A check on model adequacy is given in the last part of Table 2; here the properties of the residuals and the degree of fit are summarized. The Box-Ljung Q test does not indicate presence of serial correlation in the prediction errors except in the case of changes in business-sector value added inflation. Homoscedasticity is tested by an F test, and is always accepted at the 5 percent level of significance. The tests suggest that the unobserved components model performs satisfactory.

An interesting question is if the results of Table 2 are affected by the large rise of unemployment during the last years of the sample. In Table 3 the results from re-estimating the model for the period 1972-1991 are presented. The point estimate of the spill-over parameter, α , is always less than the long-sample estimates and falls within a smaller interval, now ranging from 0.49 to 0.54. In three out of five cases, the short-sample spill-over parameters are not significantly different from zero. Moreover, the parameters are in general also significantly lower than the long-sample point estimates. These results weaken the robustness of the results in Table 2.

A corresponding comparison is presented in Table 2, i.e. the question is if the long-sample point estimates are significantly different from the point estimates in the short sample. In general, the long-sample estimates of α are significantly different from zero but not different from the short-sample estimates.

In the short sample, the estimated variances of the cyclical and permanent shocks are often smaller than in the long sample. A possible interpretation of this result is that unemployment during the period 1992-1994, in addition to spill-over effects, is affected by large shocks (both permanent and cyclical). This conclusion is also supported by the fact that a hypothesis of normality of the unemployment prediction errors is always accepted in the short sample but never in the long sample.

The short-sample point estimates of the AR(2) parameters give an average periodicity of 6 years and two months in all five cases. This periodicity is approximately three quarters of a year longer than in the long sample.

The test statistics in the lower part of Table 3 again indicate that the model performs satisfactory, except for serial correlation in the prediction error series of changes in business-sector value added inflation.

Thus on the one hand, the short-period regressions cast some doubt about the robustness of the results in Table 2 and about those in Assarsson and Jansson. On the other hand, it is important to recognize that up to 1991,

Identifying variable	$\Delta^2 p_c$	$\Delta^2 pgDP$	$\Delta^2 p_{BVA}$	b	$\Delta^2 ULC$
ϕ_1	1.70	1.69	1.69	1.69	1.69
ϕ_2	-0.95	-0.94	-0.94	-0.94	-0.94
α	0.49	0.54	0.51	0.52	0.49
u_t^c	-0.72	-1.2	-0.03 ⁽¹⁾	$9.3*10^{-4}$	-3.20
$\Delta^2 p_{m,t-1}^g$	0.10	0.22	0.29	-	-
$\Delta^2 p_{m,t}^s$	0.12	-	-	-	-
Periodicity	12.3	12.3	12.3	12.3	12.3
σ_n^2	$8.2*10^{-9}$	$2.3*10^{-9}$	$1.0*10^{-5}$	$1.1*10^{-6}$	$8.8*10^{-9}$
σ_c^2	0.03	0.03	0.03	0.03	0.03
σ_v^2	1.83	2.68	2.85	$1.3*10^{-4}$	15.72
Sample	1972-91	1972-91	1972-91	1972-91	1972-91
Tests					
LR $\alpha = 0$	1.26	2.44	1.74	3.00*	8.4***
LR $\alpha^{72-91} = \alpha^{72-94}$	3.62*	4.46**	5.36**	0.30	2.4
LR b -parameters=0	9.5*	0.44	0.64	-	-
LR λ_5 and $\lambda_6 = 0$	4.00	7.90***	12.38***	-	-
Serial cor. (unempl.)	4.31	3.92	4.19	4.16	4.3
Serial cor. (ident.var.)	9.49	7.09	16.44**	8.56	4.2
Heterosc. (unempl.)	0.72	0.74	0.81	0.88	0.9
Heterosc. (ident.var.)	0.07	0.65	0.21	0.09	1.2
R^2 (unempl.)	0.99	0.99	0.99	0.99	0.99
R^2 (indent.var.)	0.60	0.49	0.48	0.69	0.42
Log likelihood	-51.46	-58.34	-59.36	120.02	-90.18

Notes: see notes to 2.

Table 3: Open unemployment, short sample

both open and total unemployment rates in Sweden have been low and stable. The variations are perhaps not sufficient to produce significant effects. However, it is possible to trace out a significant spill-over parameter in some cases in the short sample despite this small variation. These results could, in combination with the long-sample results, be interpreted as fairly robust evidence for a substantial spill-over effect.

3.2 Total unemployment

Active labor market programs, ALMPs, have to a great extent been used in Sweden during the sample period. A nice overview of the different programs are found in Forslund and Krueger (1994) and Ackum-Agell (1995). In the analysis above, ALMPs have been treated as perfect substitutes for employment. It could, however, be argued that participation in ALMPs is a closer substitute for unemployment than for employment.

The main purpose of ALMPs is to prevent a depreciation of human capital due to unemployment. However, if the programs are not successful in this task or if ALMPs increase real wage pressure as suggested by Calmfors and Forslund (1990, 1991), non-employment might be characterized by persistence in the same fashion as open unemployment. A micro study concerning the Swedish unemployment insurance and ALMPs shows that "A very large share of the participants in programmes re-entered unemployment: 60 per cent were unemployed again within six months and 85 per cent after one year" (Ackum-Agell *et al.*, 1995).

In order to investigate the problems of persistence in non-employment, the assumption that employment and ALMPs are perfect substitutes is relaxed. The most extreme way is to treat open unemployment and ALMPs as perfect substitutes. However, the usual assumption is that the utility when being unemployed differ from the utility when participating in an active labor market program. This inequality implies that open unemployment and ALMPs are imperfect substitutes. These considerations are simply imposed

by defining total unemployment as

$$u_{tot} = u + a, \quad (2.17)$$

where a is the ratio of ALMPs to the labor force and substituting u_{tot} for u in the equations above (this procedure is also valid if open unemployment and ALMPs are perfect substitutes). Figure 1 shows how total unemployment has developed during the period 1972-1994.

Since it is assumed that open unemployment and ALMPs are imperfect substitutes, the inclusion of ALMPs affect the wage equation. Wage setting is now influenced by the probability that an unemployed person will end up in a labor market program and the level of compensation in this state. The compensation when participating in active labor market programs has usually been at least as large as in the state of open unemployment. In the case of total unemployment, equations (2.6) and (2.8) are augmented with a variable that can be understood as a measure of the conditional probability of ending up in an ALMP when not regularly employed. This variable is often referred to as the accommodative stance of labor market programs (Calmfors and Forslund, 1990), and is denoted Q .

$$q = \ln \left(\frac{a}{u_{tot}} \right)$$

In general, the accommodative stance can affect both the price- and wage-setting relations in different ways and the sign is ambiguous, as discussed in i.a. Calmfors and Lang (1995) and Calmfors and Skedinger (1995). However, Calmfors and Forslund (1990, 1991) provide empirical evidence which indicates that a rise increases real wage pressure.

As in the case of open unemployment, a unit root in the total unemployment rate is a necessary and testable assumption. Table 1 presents the results from testing for the presence of a unit root in total unemployment. As is shown, the unit root is not rejected.

Figures 4-5 and Table 4 present the full sample estimates of the UC model. The model suggests that the permanent part has increased from 3.0% in 1990 to 13.9% in 1994.

The point estimates of the coefficient for the cyclical total unemployment in the measurement equations are always smaller than estimates derived from the case of open unemployment. Thus, there is no evidence that the inclusion of ALMPs reinforces the unemployment effects on the different inflation measures or on the current account.

The estimates of the spill-over parameter are all significantly different from zero and range from 0.50 to 0.64, i.e. partly overlapping the interval from Table 2. Thus, total and open unemployment rates show very similar degrees of spill-over effects and the results seem to be robust.

The variance of the cyclical shocks is, as before, much larger than that of the permanent shocks. The estimated AR(2) parameters indicate a periodicity in the interval ranging from 6 years and three months to 7 years. Thus, the inclusion of ALMPs has somewhat increased the estimated average periodicity of the cyclical component and hence the persistence.

Again, the results in the first three columns of Table 4 indicate that no significant information is added by including the variables originating from the current account equation. Thus, the closed economy model can not be rejected.

When using the current account to achieve identification, the foreign output gap parameter is, as before, wrongly signed and significantly different from zero.

A check on model adequacy is given in the lower part of Table 4. The tests suggest that the model performs satisfactory in most cases.

As with open unemployment, the equations are re-estimated over a shorter period, 1972-1991. The results are presented in Table 5.

The point estimate of λ_1 in the case of p_{BVA} changes sign. This sign reversal indicates that the identification of the model, and hence the results, are

Identifying variable	$\Delta^2 p_e$	$\Delta^2 pgDP$	$\Delta^2 p_{BVA}$	b	$\Delta^2 UIC$
ϕ_1	1.72	1.70	1.74	1.78	1.73
ϕ_2	-0.95	-0.94	-0.96	-0.98	-0.95
α	0.64	0.64	0.59	0.50	0.61
$u_{tot,t}^{(c1)}$	-0.64	-0.62	-0.16	$8.8*10^{-4}$	-1.36
$\Delta^2 p_{m,t-1}^g$	0.11	0.18	0.25	-	-
$\Delta^2 p_{m,t-1}^s$	0.19	-	0.03	-	-
Periodicity	12.8	12.5	13.2	13.9	13.1
σ_n^2	$1.0*10^{-8}$	$3.0*10^{-4}$	$1.2*10^{-4}$	$1.4*10^{-6}$	$4.5*10^{-4}$
σ_c^2	0.13	0.13	0.13	0.13	0.13
σ_n^2	1.85	3.08	3.04	$1.2*10^{-4}$	16.56
Sample	1972-94	1972-94	1972-94	1972-94	1972-94
Tests					
LR $\alpha = 0$	14.16***	8.12***	5.50**	5.18**	13.48***
LR $\alpha^{72-94} = \alpha^{72-91}$	11.64***	0.08	1.74	1.08	0.83
LR b -parameters=0	0.62	0.26	1.02	-	-
LR λ_5 and $\lambda_6 = 0$	22.64***	7.72***	11.00***	-	-
Serial cor. (u_{tot})	5.95	5.82	5.61	6.45	5.59
Serial cor. (ident. var.)	9.32	9.67	15.34**	9.30	5.44
Heterosc. (u_{tot})	0.75	0.65	0.75	0.58	0.71
Heterosc. (ident. var.)	1.55	4.96**	0.73	0.06	0.18
$R^2 (u_{tot})$	0.99	0.99	0.99	0.99	0.99
R^2 (indent. var.)	0.51	0.29	0.35	0.67	0.25
Log likelihood	-89.93	-100.56	-99.99	112.96	-135.58

Notes: 1) In the case of p_{BVA} and b it is $u_{tot,t-1}^c$. See notes to 2.

Table 4: Total unemployment, long sample

Identifying variable	$\Delta^2 p_c$	$\Delta^2 p_{GDP}$	$\Delta^2 p_{BVA}$	b	$\Delta^2 ULC$
ϕ_1	1.78	1.66	1.78	1.78	1.68
ϕ_2	-0.96	-0.98	-0.97	-0.97	-0.98
α	0.10	0.59	0.11	0.12	0.53
$u_{tot,t}^{cl}$	-0.51	-0.74	0.36	$1.3 \cdot 10^{-4}$	-1.79
$\Delta^2 p_{m,t-1}^g$	0.09	0.22	0.28	-	-
$\Delta^2 p_{m,t}^s$	0.09	-	-	-	-
Periodicity	14.7	10.9	14.2	14.2	11.3
σ_n^2	$1.1 \cdot 10^{-4}$	$3.1 \cdot 10^{-6}$	$1.22 \cdot 10^{-4}$	$1.2 \cdot 10^{-6}$	$2.2 \cdot 10^{-6}$
σ_c^2	0.11	0.12	0.11	0.11	0.12
σ_v^2	1.70	2.57	2.70	$1.3 \cdot 10^{-4}$	15.33
Sample	1972-91	1972-91	1972-91	1972-91	1972-91
Tests					
LR $\alpha = 0$	1.44	2.50	1.92	1.44	4.41**
LR $\alpha_{72-91} = \alpha_{72-94}$	3.42*	0.24	3.96**	1.24	0.61
LR b -parameters = 0	2.56	0.10	1.46	-	-
LR λ_5 and $\lambda_6 = 0$	4.74*	8.70***	13.36***	-	-
Serial cor. (u_{tot})	5.61	4.83	6.15	5.81	4.39
Serial cor. (ident.var.)	12.34*	7.03	19.40***	8.44	5.28
Heterosc. (u_{tot})	0.50	0.04	0.36	0.40	0.03
Heterosc. (ident.var.)	0.29	2.77*	0.16	0.12	0.29
R^2 (u_{tot})	0.99	0.99	0.99	0.99	0.99
R^2 (indent.var.)	0.59	0.50	0.50	0.69	0.39
Log likelihood	-72.47	-80.99	-80.95	97.84	-112.98

Notes: Regarding 1) see notes to 4. See notes to 2.

Table 5: Total unemployment, short sample

not reliable when using the change in business-sector value added inflation.

The point estimates of the spill-over parameter now span the interval 0.10-0.59, and are only significantly different from zero in the last column. Once again the results from the short sample tend to weaken the robustness of the results in the long sample. However, in three cases out of five, the short-sample point estimates are not significantly different from the estimates in the long sample. Table 4 reveals that the long-sample estimates are only significantly different from the short-sample estimates in one case.

The point estimates of the variance of the permanent shocks in the short sample decrease in two cases, remain unchanged in two others, and increase in one case as compared to long regressions. The variance of the cyclical shocks decreases only slightly when shortening the sample, as opposed to the case of open unemployment. The interpretation of these differences between the samples are not all that obvious, but they indicate that the rise in total unemployment during the period 1992-1994 could be due to cyclical shocks in combination with spill-over effects. In this interpretation, the contribution from spill-over effects is more pronounced compared to the case with open unemployment, which is also supported by the fact that a hypothesis of normality of the total unemployment prediction errors is never rejected in either the long sample regressions or in the short sample regressions.

The average periodicity of the cyclical component increases in three cases out of five, and ranges from 5 years and 5 months to 7 years and 4 months with an unweighted average of 6 and a half years.

4 Summary and conclusions

In order to investigate the existence and the extent of persistence in Swedish open and total unemployment (the sum of open unemployment and participation in active labor market programs, ALMP), an unobserved components (UC) labor-market model is developed. The UC model is combined with the

well known Layard, Nickell and Jackman (1991) model for price-setting and wage-setting in an open economy. The resulting model is identified in several different ways. The estimated model incorporates the appealing time series features of the UC model and has a clear economic interpretation.

Persistence is caused by three factors, either individually or in combination: permanent shocks may change unemployment permanently, unemployment may contain a cycle with long periodicity, cyclical shocks may spill over to permanent unemployment, and thus have permanent effects.

In order to investigate the stability of the estimates, the models are estimated over two different time periods, 1972-1994 and 1972-1991. The reason for splitting the sample in 1991 is that unemployment increased dramatically during the period 1992-1994.

The results suggest that the permanent component in the unemployment series has increased substantially during the last years of the sample. In the case of open unemployment, the permanent component increased from 1.4% in 1990 to 9.2% in 1994, and from 3.0% to 13.9% during the same period in the case of total unemployment. In this respect, the Swedish development is similar to that of the rest of Europe during the late 1970s and early 1980s.

In the case of open unemployment, the long-sample point estimates of the spill-over from cyclical to permanent unemployment are always significantly different from zero and within a close range. Thus, the spill-over results seem to be quite robust. In addition, the estimates are in general not significantly different from the short-sample point estimates. In a comparison with some other countries, it is evident that the Swedish spill-over effect is very large.³

However when shortening the sample, the point estimates of the spill-over parameter are reduced. The estimated parameter is in general not significantly different from zero, and significantly different from the long-sample point estimates. The average periodicity is somewhat increased.

³Canada, Germany, UK, US (Jaeger and Parkinson, 1994), and Denmark (Assarsson and Jansson, 1995).

Above, it was argued that it is important to control for the current account in models estimating the trade-off between changes in the rate of inflation and cyclical unemployment. That is, it is important to model the economy as an open economy. However when testing, the closed economy model could not be rejected in favor of the open economy model.

A drawback in previous studies is that they focus only on open unemployment. There are several reasons, and some evidence, indicating that total unemployment might exhibit similar patterns of persistence as open unemployment. In this paper the model is estimated for total unemployment as well, treating ALMPs as imperfect substitutes for open unemployment.

In the case of total unemployment and the long sample, there is no evidence that total unemployment reinforces the unemployment effects on the change of the rate of inflation or on the current account. At the same time, there is robust evidence of a significant spill-over effect. In addition, the point estimates of the spill-over effect are not significantly different from the short-sample estimates. The average periodicity of the cyclical component increases somewhat, compared to the case with open unemployment. Thus, the inclusion of ALMPs increases persistence.

As in the case of open unemployment, the closed economy model could not be rejected when estimating the trade-off between changes in the rate of inflation and cyclical unemployment.

When the sample is cut in 1991, the spill-over effect is smaller and only significantly different from zero in one out of five cases. However, the point estimates are not generally different from the long-sample results either, thus indicating large standard errors. The different estimates of the periodicity of the cyclical component in the short sample span a larger range that covers the long-sample results.

Regarding the spill-over parameter in the short sample, it is important to recognize that up to 1991 both open and total unemployment rates in Sweden have been low and stable. The variations are perhaps not sufficient to produce

significant effects, indicating that it is not really clear how much information the unemployment figures actually contain. This lack of information could explain some of the results above. However, the variations in the short sample made it possible to trace out a significant spill-over parameter in some cases. In total, a significant spill-over parameter is detected in 7 out of 10 cases, and in 6 out of 10 cases for open and total unemployment respectively. These results can be interpreted as fairly robust evidence for a substantial spill-over effect.

A main result of this paper is that open and total unemployment exhibit similar patterns of persistence. Moreover, the results above suggest that the favorable Swedish unemployment experience up to 1991 is due rather to small shocks, than to the presence of spill-over effects. The unemployment development during 1992-1994, however, seems to be caused by both large shocks and the presence of a substantial spill-over effect.

During 1995 the rate of open unemployment was in principle unchanged. Total unemployment fell by slightly more than one percentage point. For 1995, the model above predicts a permanent component in the range of 8-9% for open unemployment and a permanent component of 14-15% for total unemployment.

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A Appendix

A.1 Appendix 1

The data used in this paper are semi-annual and seasonally non-adjusted, ranging from 1972-1994. The data was collected from the National Institute of Economic Research (NIER), if nothing else is noted below.

P_c = Private consumption deflator.

P_{GDP} = Gross domestic product deflator.

P_{BVA} = Business-sector value added deflator.

b = Current account as percent of GDP, Sveriges Riksbank (Central Bank of Sweden) and NIER.

ULC = Unit labor costs in manufacturing.

$ALMP$ = The sum of all different active labor market programs that have existed during the period 1972-1994.

a = ALMP as percent of labor force.

u = Open unemployment as percent of the labor force.

u_{tot} = The sum of open unemployment and active labor market programs as percent of labor force.

P_m^g = Deflator for imported goods, in Swedish crowns.

P_m^s = Deflator for imported services, in Swedish crowns.

d = Net capital income from abroad and the balance of transfers as percent of GDP. That is, d is the difference between the current account and the trade balance of goods and services as percent of GDP. Sveriges Riksbank (Central Bank of Sweden) and NIER.

$y^* - y^{*n}$ = Foreign cyclical demand, HP-filtered ($\lambda = 800$) series of OECD GDP.

$c1$ = Real exchange rate measured as: OECD export prices of manufactured goods (in Swedish crowns) in relation to Swedish export prices of the same goods.

$c2$ = Real exchange rate measured as: OECD export prices of services (in

Swedish crowns) in relation to Swedish export prices of the same goods.

In the empirical work Δ denotes annual change, measured in percent. Δ^2 denotes the difference between the annual percentage change in time t and in time $t-1$.

A.2 Appendix 2

The purpose of this appendix is to demonstrate how the change of rate of import inflation (import price shocks) enter the model of section 2.2. The expected signs of these shocks depend on which prices expectations refer to.

In order to keep things as simple as possible, consider a stripped version of the model in section 2.2 where the tax rates, the replacement ratio, and the current account equation are ignored. Moreover, assume that firms have perfect foresight and set prices according to

$$p - w = -\beta(u - u^n). \quad (2.18)$$

In the model in section 2.2, it was assumed that wages were set with respect to an expected *producer price*, but with full knowledge of the relative price between consumption and production,

$$w - p^e = \gamma_0 - \gamma_1 u + p_c - p$$

or

$$w - p = \gamma_0 - \gamma_1 u + (p_c - p) - (p - p^e), \quad (2.19)$$

where the wedge $(p_c - p)$ reflect the assumption that wage setters are concerned about real consumption wages.

Solving equations (2.18) and (2.19) for unemployment, under the assumption that $p - p^e = 0$ and $u - u^n = 0$, gives the natural rate:

$$\gamma_1 u^n = \gamma_0 + (p_c - p). \quad (2.20)$$

Now, solve the same equations but for the expectation error, making use of the natural rate expression and $p - p^e = \Delta^2 p$. This gives:

$$\Delta^2 p = -(\beta + \gamma_1)u^c, \quad (2.21)$$

where u^c is the difference between unemployment and the natural rate.

The consumer price is a weighted sum of producer and import prices, $p_c = \alpha p + (1 - \alpha)p_m$, where p_m is the price of imports measured in Swedish crowns and $\alpha < 1$. Taking differences of this expression gives:

$$\Delta^2 p_c = \alpha \Delta^2 p + (1 - \alpha) \Delta^2 p_m. \quad (2.22)$$

Combining equations (2.21) and (2.22) gives:

$$\Delta^2 p_c = -\alpha(\beta + \gamma_1)u^c + (1 - \alpha)\Delta^2 p_m. \quad (2.23)$$

Thus, if expectations are formed over producer prices the parameter in front of the change of rate of import inflation should be:

1) insignificant when identifying the labor market model by use of producer prices, e.g. gross domestic product or business-sector value added deflators (see equation 2.21),

2) significantly greater than zero when using the private consumption deflator for identification (see equation 2.23).

Alternatively, expectations could be formed over *consumer prices*. The wage equation then becomes

$$w - p_c^e = \gamma_0 - \gamma_1 u$$

or

$$w - p = \gamma_0 - \gamma_1 u + (p_c - p) - (p_c - p_c^e). \quad (2.24)$$

Combining equations (2.18), (2.22), and (2.24) gives the analogous to equations (2.21) and (2.23).

$$\Delta^2 p_c = -(\beta + \gamma_1)u^c \quad (2.25)$$

and

$$\Delta^2 p = - \left(\frac{\beta + \gamma_1}{\alpha} \right) u^c - \left(\frac{1 - \alpha}{\alpha} \right) \Delta^2 p_m. \quad (2.26)$$

Thus, if expectations are formed over consumer prices, the parameter in front of the import price shocks should be:

- 1) insignificant when identifying the labor market model by using the private consumption delator (see equation 2.25),
- 2) significantly smaller than zero when using producer prices (see equation 2.26).

No matter how expectations are formed in the simple set-up above, the use of producer or consumer prices should not both yield significant parameters in front of the import price shocks. This result does not carry over to the case with mixed expectations, i.e. firms and wage setters form expectations over producer and consumer prices respectively. In that case the use of producer or consumer prices should yield significant parameters in front of the import price shock but with different signs.

In Tables 2–5 the point estimates of the parameters in front of the import price shocks are always positive, and significant in 10 out of 12 cases. Thus, no firm conclusion can be drawn about how the simplifying information assumptions work with respect to wage setting.

Figure 1. Open and total unemployment

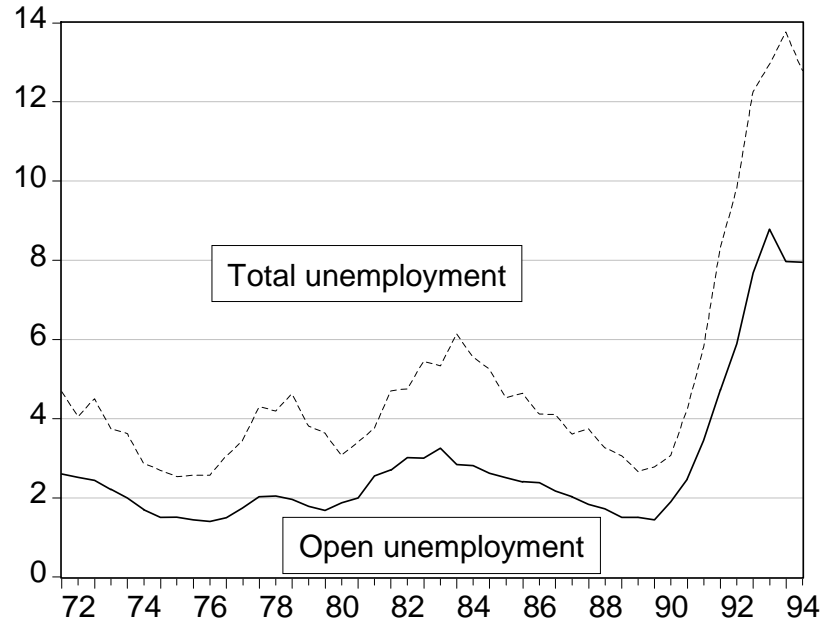


Figure 2. Open unemployment and permanent component

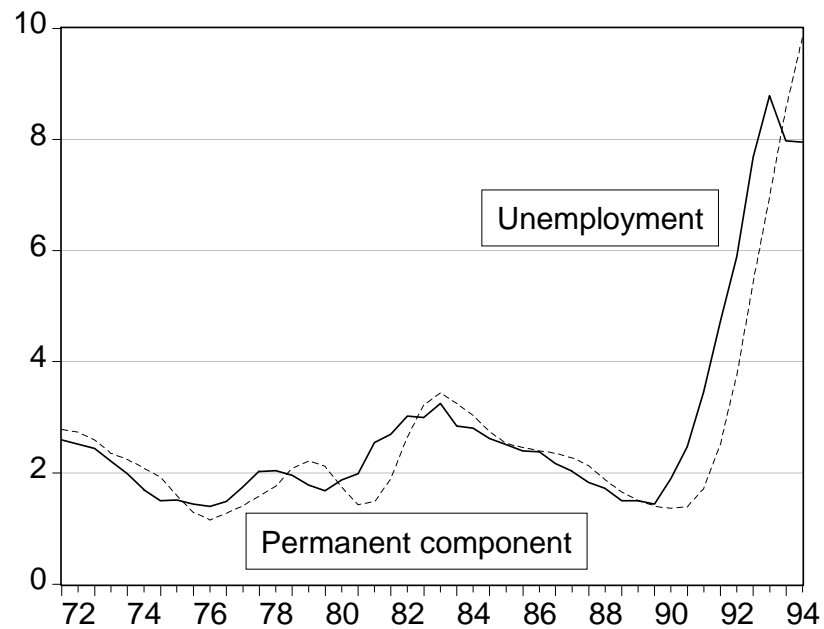


Figure 3. Cyclical component in open unemployment

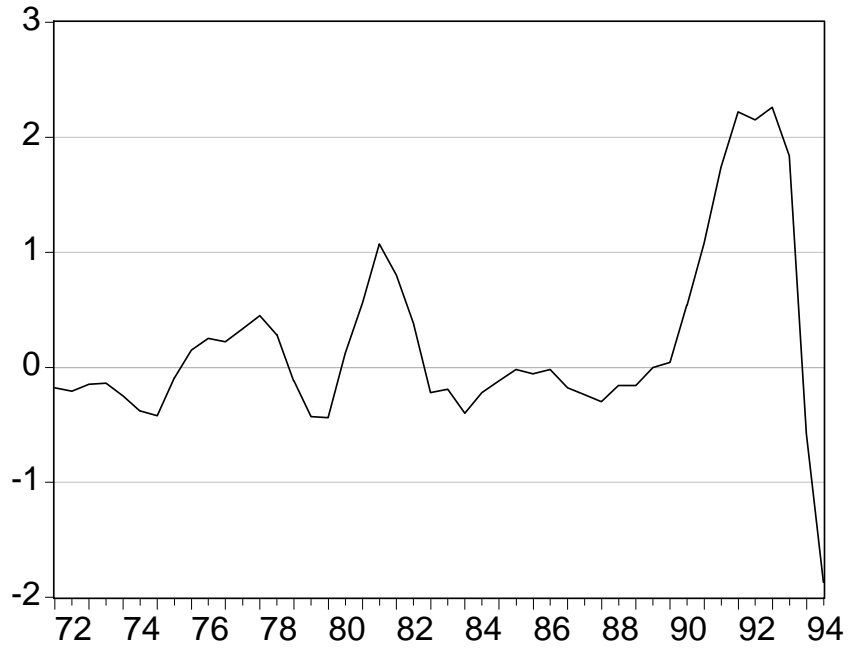


Figure 4. Total unemployment and permanent component

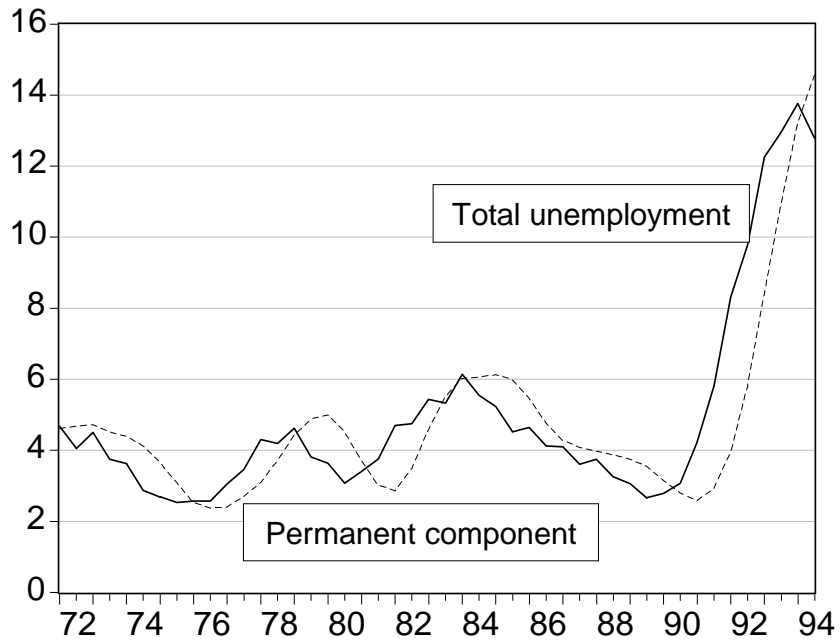
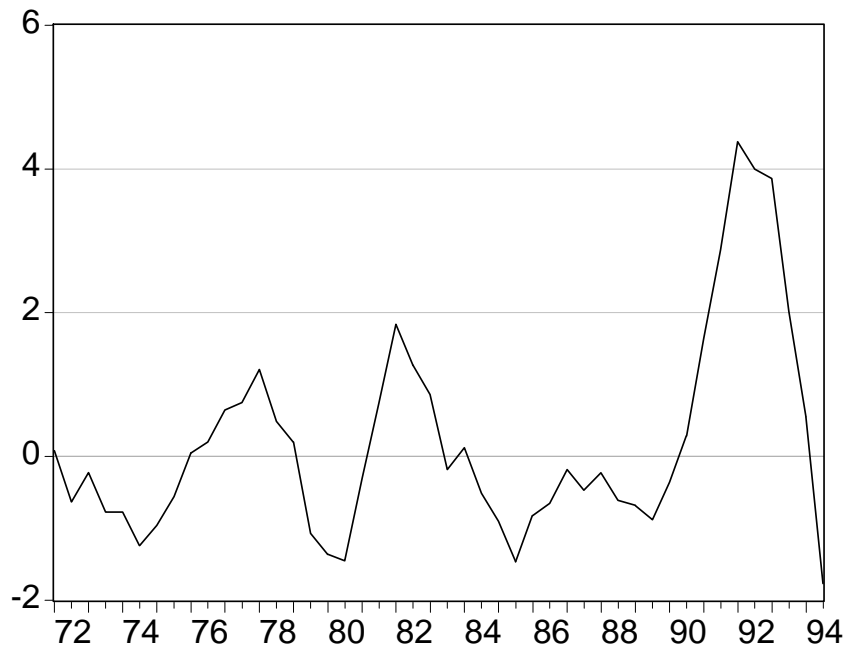


Figure 5. Cyclical component in total unemployment



Chapter 3

The Equilibrium Rate of Unemployment in a Small Open Economy*

1 Introduction

In order to design appropriate policies to combat unemployment it is important for the policy-maker to know to what degree unemployment is due to a lack of demand and to what degree it is due to structural factors. Changing structural unemployment, also known as the natural rate of unemployment or NAIRU, requires a different and more complex set of policies than a mere adjustment of aggregate demand. It is therefore imperative that economists come up with a good approach for dividing up unemployment in its two constituent parts. This task involves many problems. In this paper we focus on

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a specific problem that relates to open economies.

A common assumption when analyzing unemployment is that the economy is closed. In empirical research, such models are often used even when dealing with economies where foreign trade constitutes a considerable fraction of the economy. However, Joyce and Wren-Lewis (1991), Layard, Nickell and Jackman (1991) and Bean (1994) show that the NAIRU is not identified in an open economy unless the foreign sector is modeled. It is straightforward to show that in an open economy the unemployment rate will, among other factors, be driven by the determinants of the real exchange rate. Omitting the foreign sector could therefore potentially bias the NAIRU estimates. The size of the bias is, of course, an empirical question, which we would like to investigate.

Because of the highly open nature of its economy and the dramatic swings in its unemployment in recent years, the Swedish case is especially interesting for our purposes. In 2008 Swedish exports and imports amounted to about 54 and 47 percent of GDP respectively. After having enjoyed decades of low unemployment, the Swedish unemployment rate increased dramatically in the early 1990s. The rate of open unemployment rose from approximately 1.5 per cent in 1990 to over 9 per cent two years later. The rapid rise in unemployment immediately raised the question how much of this development should be attributed to a change in the NAIRU versus a lack of demand.

The purpose of this paper is to relax the closed-economy assumption and re-assess whether and to what extent changes in unemployment could be regarded as movements in the NAIRU or in cyclical unemployment. As it turns out, we reject an assumption of a closed economy, because the foreign sector turns out to be quite important in explaining the development of the unemployment rate and the NAIRU. Our estimates imply that the dramatic unemployment changes in the 1990s were mainly cyclical and that NAIRU increased only little during this period.

Previous studies have come to different conclusions. Holmlund (1993) and

Elmeskov (1994) addressed the issue by recursively estimating simple Phillips curves and imposing equilibrium restrictions in order to derive a measure of the NAIRU. Their results did not indicate any substantial changes in the NAIRU. Forslund (1995) estimated a structural open economy model for wage and price setting under imperfect competition and solved it for the NAIRU. He found evidence of a more substantial increase in the NAIRU. Lindblad (1997) and Assarsson and Jansson (1998) estimated different structural unobserved components models, allowing for hysteresis, and found robust evidence for substantial hysteresis in Swedish unemployment, and that a large part of the rise in the unemployment rate was due to an increase in its permanent component. Apel and Jansson (1999) estimated a different unobserved components model and found that the NAIRU increased during the first half of the 1990s. Turner et al. (2001), who also modeled NAIRU as a stochastic trend, found that it increased substantially from 1980 to 1995.¹

In 1997, the Swedish unemployment rate started to decline and reached the lowest level since the early 1990:s in 2001. Thereafter the level has fluctuated and 2008 it reached the same level as in 2001. The central question, whether the change in unemployment reflects a change in NAIRU or a narrowing of the unemployment gap, is still important.

Instead of modelling the NAIRU as a stochastic trend, the most common approach in the literature, we use theory to define it as a function of taxes, active labor market policies, the replacement ratio, demographic factors and the real exchange rate. The real exchange rate is treated as endogenous and is therefore estimated simultaneously with the unemployment rate.

Our approach is to extend the unobserved components model of Salemi (1999) to an open economy and simultaneously estimate the unemployment rate and the real exchange rate. An alternative would have been to extend the VAR-approach in King and Morley (2007). However, our approach is

¹The international empirical literature regarding NAIRU is surveyed in Turner et al. (2001) and Ball and Mankiw (2002).

better theoretically motivated, less restrictive and more efficient from an econometric perspective.

The paper is organized as follows. First, we very briefly sketch a simple open economy framework for wage and price setting under imperfect competition and combine it with an exchange rate model. This gives us two equilibrium relationships: one for the unemployment rate and one for the real exchange rate. Our framework also gives us two cyclical relationships: an expectations-augmented Phillips curve and a cyclical real exchange rate. Second, these equations are combined with a statistical model for the cyclical behavior of unemployment in order to get an empirical model. Third, we estimate the system simultaneously, present the results, and discuss them. Finally, we sum up.

2 Theoretical discussion

In this section, we sketch a small open-economy framework that can serve as a basis for analyzing movements in unemployment, the real exchange rate and inflation and give guidance for an empirical specification.

According to conventional macro economic theory, the NAIRU and the equilibrium real exchange rate (REER) are determined by a wide range of institutional and economic factors. Since these factors can vary over time, the NAIRU and the REER are also expected to be time varying.

One theoretical basis underpinning the unemployment relationship is the Layard, Nickell and Jackman (1991) “work horse” model for price and wage setting. The general idea is that real wages and employment are determined by two relationships, describing firm and union behavior. It is assumed that both product and labor markets are characterized by imperfect competition. A more complete and thorough discussion of the model set up below is given in Lindblad (1997).

Firms set prices as a mark-up on wage costs. Changes in demand may

have an effect on prices because the marginal productivity of labor depends on the amount of labor used and because the profit margin might vary over the business cycle. The output gap is assumed to be related to the labor market by an Okun's-law relationship.

Wage setting is described by a relationship that can be derived from e.g. bargaining models (Layard, Nickell and Jackman, 1991; Blanchflower and Oswald, 1994; Forslund, 1995; Nickell and Layard, 1999). Wages are set as a mark-up on the value of the bargaining parties' outside options. The value of not being employed will depend on the unemployment rate, the degree of accommodation through active labor market policies (ALMP) (Calmfors and Forslund, 1990 and 1991) and the compensation when not employed, captured by the replacement ratio.

Higher unemployment indicates a higher probability of not being employed, which reduces wage pressure. ALMP can, on the one hand, increase the welfare of the unemployed and thus increase wage pressure. On the other hand, it could reduce wage pressure by improving matching or raising competition and productivity (Calmfors and Lang, 1995; Calmfors, Forslund and Hemström, 2004). The net effect of ALMP is an empirical question. Higher compensation when not employed should raise wage pressure.

Wage setters are assumed to care about the after-tax real consumption wage, W_c , while firms are concerned about the real product wage, W_p , that is the real wage cost. Thus, there is a wedge between these measures of real wages that consist of a tax part and a relative price part:

$$w_p - w_c = \ln(1 + S) + \ln(1 + VAT) - \ln(1 - T) + p_c - p, \quad (3.1)$$

where small letters denote logarithms of the variables, S is the payroll tax rate, VAT the value-added tax rate and T the income tax rate, while p_c and p are the logs of consumer prices and producer prices.

The logarithm of the tax part will be denoted θ below. It is, however, an empirical question to what extent a change in the tax wedge will influence

unemployment (Calmfors and Holmlund, 2000). If the after-tax real consumption wage completely absorbs changes in the tax wedge, unemployment will be independent of the wedge.

The price part of the wedge is the ratio of the consumer price (net of VAT), P_c , to the producer price, P . Since consumers in open economies consume both home produced and imported goods and services, the price part of the wedge can be expressed as:

$$p_c - p = \varpi p + (1 - \varpi)(c + p^*) - p = (1 - \varpi)(c + p^* - p), \quad (3.2)$$

where ϖ is the weight of domestic goods and services in the consumption basket, C is the nominal exchange rate and P^* is the foreign price level. Thus, and this is very important, the price wedge is a function of the real exchange rate E , where $E = CP^*/P$. This is how the open economy dimension enters the model. An increase in the real exchange rate, a real depreciation, increases the consumer price level and tends to push up the nominal wage level in order to counteract a fall in the real consumption wage. This will raise the real product wage and reduce employment.²

Since wages are set for long contract periods, wage setters have to form expectations about the various variables that enter the wage decision. We stress in particular the uncertainty about the producer price level, since this has proven empirically important in earlier work (Nickell and Layard, 1999).

Combining price and wage setting, the considerations above motivate a

²Beside the standard model, it has been suggested that demographic variation can affect unemployment (Salemi, 1999; Barwell, 2000; Nordström Skans, 2002). Wages, unemployment and probabilities to reenter employment after being unemployed differ among different age groups. Youth unemployment is higher but the length of the spells shorter compared to the case of older workers. Thus an increase in the fraction of young people in the labor force could on the one hand, increase unemployment but on the other hand reduce persistence and thus long-term unemployment. Likewise, an increase in the number of old workers in the labor force could reduce average unemployment, but increase persistence and long-term unemployment. However, including demographic variables did not improve the empirical results, so this channel is not discussed above.

reduced unemployment relationship of the following form:

$$u = \gamma_0 - \gamma_1(p - p^e) - \gamma_2(u - u^n) + \gamma_3r + \gamma_4e + \gamma_5\theta + \gamma_6a, \quad (3.3)$$

where p^e is the (logarithm of) expected producer price level, u is the open unemployment rate, u^n is the NAIRU, r is the (logarithm of the) replacement ratio, a is (the logarithm of) the ratio between ALMP and the sum of ALMP and open unemployment. Thus a measures the degree of accommodation of unemployment through active labor market policies. Superscript e denotes expectations.

The open-economy dimension enters the model, as indicated above, through relative prices of domestically produced and imported goods and services. From expression (3.3) it is clear that the real exchange rate affects unemployment. To complete the model we thus need to specify a relationship for the exchange rate.

One specific exchange rate model is more thoroughly discussed in Lindblad and Sellin (2010), and is therefore only very briefly described here. Our starting point is the model of Lane and Milesi-Ferretti (2004). This model has its theoretical foundations in the new open economy macroeconomics paradigm. Lane and Milesi-Ferretti derive a real exchange-rate equation in which the explanatory variables are exogenous terms of trade, net foreign assets and wealth. The intuition is straightforward: an increase in the terms of trade (defined as the export price relative to the import price), in net foreign assets or in output raise income, stimulate consumption and appreciate the real exchange rate by pushing up the relative consumer price level (increase in the relative price of non-tradeables). A higher income also reduces labor supply, which pushes up wages, which in turn also tends to appreciate the real exchange rate. Thus, any variable that increases wealth will appreciate the real exchange rate.

However, net foreign assets cannot really be treated as exogenous. An important and presumably exogenous determinant of accumulated net saving

is the evolution over time of the demographic composition of the population, since savings and investment differ among age cohorts (Lindh and Malmberg, 1999) and since the demographic composition is quite persistent. A positive effect on saving, which indicates a higher net foreign asset position and thus a stronger real exchange rate, can reflect the fact that the middle-aged are nearing retirement. However, if the net cohort effect is to increase savings, the only way to do this is to reduce demand and increase exports. The textbook way of achieving higher net exports is by depreciating the real exchange rate (Ball and Mankiw, 1995). A positive effect on investment, which would reduce net savings, can reflect a transfer of wealth from real to financial assets by the middle aged. Given a home bias in financial investment, this would decrease the local cost of capital. A positive investment effect of middle-aged people may also reflect a relatively productive age group, which means lower effective capital intensity and thus a higher marginal productivity of capital.³ Thus, the demographic composition is of importance, even though the net effect on net foreign assets and the real exchange rate of the possible impacts on savings and investment is an empirical question.

While the demographic composition is likely to influence private savings, the fiscal position of the government sector determines public savings and is thus also an important determinant of the country's net foreign assets (to the extent that Ricardian equivalence does not hold). It is also not completely clear what effect an increase in the fiscal debt and deficit will have on the real exchange rate. Hakkio (1996) discusses some possible channels through which the fiscal position could influence the exchange rate. On the one hand, increased borrowing by the government in order to increase demand will lead to higher prices on non-tradable goods and thus an appreciation

³Lindh and Malmberg (1999) define middle-aged as the age group 50-64 years old, while we use 45-59 years old in the empirical part of the paper. We use this definition because many of the countries in our 'rest of the world variables' have a lower retirement age than 65. Also, Domeij and Flodén (2005) show that the increase in this age group could explain the significant current account surpluses in Switzerland during the 1990's.

of the exchange rate. On the other hand, if a higher public debt is not offset by higher private assets – as it would under Ricardian equivalence – it will reduce net foreign assets. In this case, a higher public debt would depreciate the real exchange rate through the wealth channel discussed above. Thus, whether increased debt will lead to an appreciation or a depreciation of the real exchange rate is an empirical question. For further reference we label the two conflicting effects the "demand effect" and the "wealth effect", respectively.

As noted in Lindblad and Sellin (2010), using public debt levels is not without problems. Since structural deficits/surpluses are persistent, these variables will be used as an indicator of how the debt and thus the net foreign asset position develop. Our focus on the demographics, relative to the corresponding foreign group, and the use of structural deficits in the exchange rate equation is new to the literature.

Beside the wealth effect, an increase in output can appreciate the exchange rate via the so-called Balassa-Samuelson effect. If productivity growth is faster in the domestic tradeables sector than in the foreign tradeables sector, this will lead to an increase in the domestic wage relative to the foreign wage. When this spills over into the non-tradeables sector, it causes the domestic non-tradeables price to rise relative to the foreign price. Higher domestic to foreign non-tradable prices imply an appreciation of the real exchange rate. Lane and Milesi-Ferretti (2004) use domestic GDP relative to foreign GDP as a proxy for relative productivity in the tradeables sector of the economy. But what really should matter in the longer run is relative output or productivity trends. We therefore use an unobserved components (UC) model to decompose GDP into trend and cycle. Another reason for decomposing GDP into trend and cycle in an exchange rate model is that the real interest rate should vary over the business cycle. The real interest differential is often argued to be an important determinant of the real exchange rate (e.g. in Mankiw, 2006). If there exists a stable relation between

the interest rate set by the central bank and the output gap, the difference in capacity utilization should then help explain the dynamics of the exchange rate.

Based on the discussion above, we arrive at the following equation for the real exchange rate:

$$e = \alpha_0 + \alpha_1 q + \alpha_2 (d - d^*) + \alpha_3 (g - g^*) + \alpha_4 (y^n - y^{n*}) + \alpha_5 [(y - y^n) - (y^* - y^{n*})], \quad (3.4)$$

where q is the terms of trade, d is the share of middle aged people in the population, g is the structural government budget deficit as a share of GDP, and y and y^n are output and potential output, respectively, and where asterisks denote foreign variables.

We define equilibrium as: $p - p^e = y - y^n = u - u^n = y^* - y^{n*} = 0$. This means that there are no price expectations errors and that the output and unemployment gaps are closed. Using equations (3.3) and (3.4), as well as the equilibrium conditions, we arrive at the following expression for the equilibrium unemployment rate u^n , and for the equilibrium real exchange rate e^n .⁴

$$u^n = \gamma_0 + \gamma_3 r + \gamma_4 e^n + \gamma_5 \theta + \gamma_6 a, \quad (3.5)$$

$$e^n = \alpha_0 + \alpha_1 q + \alpha_2 (d - d^*) + \alpha_3 (g - g^*) + \alpha_4 (y^n - y^{n*}). \quad (3.6)$$

Using the Okun relationship

$$(y - y^n) = -\mu (u - u^n), \quad (3.7)$$

⁴The equilibrium concept used here is that of a medium-term “equilibrium” and should not be confused with a steady state solution. The rationale for talking about an equilibrium in the medium term is that the explanatory variables we are considering move slowly over time relative to the sample size we, and most other studies, are considering. Because of the relatively short sample the variables will usually be found to be non-stationary and will have to be treated as such in the empirical analysis.

where the parameter μ is expected to be positive, the cyclical part of the exchange rate, e^c , can be expressed as

$$e^c = e - e^n = -\alpha_5 [\mu (u - u^n) + (y^* - y^{n*})]. \quad (3.8)$$

Finally, using equations (3.3), (3.5) and (3.6) we get

$$u - u^n = -\gamma_1 (p - p^e) - \gamma_2 (u - u^n) + \gamma_4 (e - e^n)$$

and solving for the price expectation error, we get

$$p - p^e = -\frac{(1 + \gamma_2)}{\gamma_1} (u - u^n) + \frac{\gamma_4}{\gamma_1} (e - e^n). \quad (3.9)$$

Thus deviations in the actual price level from the expected level in the open economy model is explained by the unemployment gap and out-of equilibrium movements in the real exchange rate.

During more than a decade, Sweden has enjoyed a credible inflation targeting monetary policy regime. Thus, it would be reasonable to assume that the rate of inflation is stationary. However, looking at our sample, a unit root in the rate of inflation is not rejected (see Table 1) and we should therefore treat inflation as non-stationary. Assuming that the rate of inflation follows a random walk and using equation (3.8), (3.9) can be rewritten as:

$$\Delta^2 p = \lambda_1 u^c + \lambda_2 y^{c*}, \quad (3.10)$$

where

$$\lambda_1 = -\frac{(1 + \gamma_2 + \gamma_4 \alpha_5 \mu)}{\gamma_1}, \lambda_2 = -\frac{\gamma_4 \alpha_5}{\gamma_1}$$

and where $u^c = u - u^n$ is cyclical unemployment, $y^{c*} = y^* - y^{n*}$ is the foreign output gap, and Δ^s is the s^{th} difference operator.⁵ Thus the change in the rate

⁵We achieve equation (3.10), by assuming that the rate of inflation follows a random walk.

of inflation will depend on the domestic and foreign unemployment/output gaps.

The specification of equation (3.10) will be crucial, since it is this relationship that will identify our empirical model.

3 The empirical model

We divide unemployment, output and the real exchange rate into two unobserved components, one equilibrium rate which could be non-stationary and a stationary cyclical component,

$$u_t = u_t^n + u_t^c + \varepsilon_{u,t}^n, \quad (3.11)$$

$$y_t = y_t^n - \mu u_t^c + \varepsilon_{y,t}^c \quad (3.12)$$

and

$$e_t = e_t^n + e_t^c + \varepsilon_{e,t}^n, \quad (3.13)$$

where u^n , e^n and e^c are given by equations (3.5), (3.6), and (3.8)

The cyclical component of unemployment, u^c , is modelled as a stationary AR(2)-process

$$u_t^c = \phi_1 u_{t-1}^c + \phi_2 u_{t-2}^c + \varepsilon_{u,t}^c. \quad (3.14)$$

$$\begin{aligned} \Delta p_t &= p_t - p_{t-1}, \\ \Delta p_t^e &= \Delta p_{t-1} \\ p_t &= \Delta p_t + p_{t-1}, \\ p_t^e &= \Delta p_t^e + p_{t-1}, \\ p_t - p_t^e &= \Delta p_t - \Delta p_t^e \\ p_t - p_t^e &= \Delta p_t - \Delta p_{t-1} = \Delta^2 p_t. \end{aligned}$$

Stationarity implies that the roots of the polynomial equation

$$1 - \phi_1 L - \phi_2 L^2 = 0,$$

where L is the lag operator, should lie outside the unit circle. The assumption of an AR(2) process is not crucial, but it fits the data well.

Potential output is modelled as a random walk with drift

$$y_t^n = c + y_{t-1}^n + \varepsilon_{y,t}^n.$$

Note that we so far have five shocks, a NAIRU shock, an Okun law shock, a REER shock, a cyclical unemployment shock and a potential output shock.

The real exchange rate and the explanatory variables discussed above are non-stationary; see below. Theory and previous studies indicate that there exists a long-run relationship between the real exchange rate, output, the terms of trade, demographic variables, and government budget deficits. A standard way of estimating non-stationary variables is to use an error-correction specification.

3.1 Identification and the Phillips curve

The UC-model given in the previous section is generally not identified. To achieve an identified model we follow Lindblad (1997) and Salemi (1999).

First, identification requires a variable that is related to either the cyclical or the permanent component of unemployment (or of the real exchange rate), but not to both components. The expectations-augmented Phillips curve given by equation (3.10) meets this requirement.

Since the Phillips curve is used for identification, it is important that the specification is chosen carefully so that no bias is introduced into the parameter estimates for the rest of the model. Ignoring supply side changes will in general give rise to misspecification problems. Following Apel and Jansson

(1999) and Lindblad and Sellin (2010), we have chosen to use the change in the annual rate of import price changes, $\Delta\Delta_4p_m$, and the change in the annual rate of labor productivity growth, $\Delta\Delta_4pr$, as proxies for supply shocks. Thus the extracted NAIRU and REER are the unemployment and real exchange rate levels which are consistent with stable inflation in absence of these supply shocks. We tested several different specifications of our Phillips curve, mainly varying the number of lags of the exogenous variables and including an oil price variable as an alternative supply side shock. The selected specification is parsimonious and the point estimates of the parameters seem reasonable.

We have modeled an MA(4) error term for the Phillips curve:

$$\varepsilon_{p,t} = \rho\varepsilon_{p,t-4} + \xi_{p,t},$$

where $\xi_{p,t}$ is an i.i.d. error. The reason for this specification is that we use $\Delta\Delta_4$ rather than Δ^2 in the estimations in order to handle the seasonality in the inflation series. Serial correlation will result because of this way of constructing the variables and implies that the residual follows an MA(4) process. Thus, the Phillips curve is modeled as:

$$\begin{aligned} \Delta\Delta_4p_t = & \lambda_{20}u_t^c + \lambda_{21}u_{t-1}^c + \beta_{21}y_t^{c*} + \beta_{22}\Delta\Delta_4p_{m,t} + \beta_{23}\Delta\Delta_4p_{m,t-3} \\ & + \beta_{24}\Delta\Delta_4pr_{t-2} + \beta_{25}\Delta\Delta_4pr_{t-3} + \rho\varepsilon_{p,t-4} + \xi_{p,t} \end{aligned} \quad (3.15)$$

The second assumption is that all four shocks, $\varepsilon_{j,t}^i$ and $\xi_{p,t}$, are mutually uncorrelated and normally distributed with variances $\sigma_j^{2,i}$, $i = n, c$ and $j = u, e, p$.

In our model, we are not able to identify separate means for unemployment and the NAIRU or for the real exchange rate and the REER. Salemi (1999) and King and Morley (2007), who have the same problem, suggests that the problem can be circumvented by subtracting sample means from all variables. We follow this route, noting that subtracting sample means

from non-stationary variables does not make these variables stationary. Our purpose is only to handle the identification problem. Thus the third assumption is that sample means of u^n and e^n are the same as sample means of u and e i.e., we assume that the sample means of the cyclical components of unemployment and the real exchange rate are both zero. The restriction that the sample means of the cyclical components are zero is reasonable if the sample is long enough. These restrictions are imposed by defining all explanatory variables in equations (3.5), (3.6) and (3.10) as deviations from sample means and excluding constants from the unemployment, real exchange rate and Phillips curve equations. This third assumption unfortunately implies that we cannot make an assessment of the levels of NAIRU, REER, and the cyclical position. However, the dynamics are not affected, and we are able to assess changes in all variables over time.

3.2 The state space form

To estimate the model, we put it in state space-form (Harvey, 1989). The transition equations are given by

$$U_t = \Phi U_{t-1} + \varepsilon_t,$$

where

$$U_t = \begin{pmatrix} u_t^c \\ u_{t-1}^c \\ \varepsilon_{p,t} \\ \varepsilon_{p,t-1} \\ \varepsilon_{p,t-2} \\ \varepsilon_{p,t-3} \\ y_t^n \end{pmatrix}, \Phi = \begin{pmatrix} \phi_1 & \phi_2 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \rho & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}, \varepsilon_t = \begin{pmatrix} \varepsilon_{u,t}^c \\ 0 \\ \xi_{p,t} \\ 0 \\ 0 \\ 0 \\ \varepsilon_{y,t}^n \end{pmatrix}.$$

The measurement equations are given by

$$Y_t = \Lambda U_t + \Psi X_t + \nu_t,$$

where

$$Y_t = \begin{pmatrix} u_t \\ \Delta e_t \\ \Delta \Delta_4 p_t \\ y_t \end{pmatrix}, \Lambda = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \lambda_{10} & 0 & 0 & 0 & 0 & 0 & \lambda_{16} \\ \lambda_{20} & \lambda_{21} & 1 & 0 & 0 & 0 & 0 \\ \lambda_{30} & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}, \nu_t = \begin{pmatrix} \varepsilon_{u,t}^n \\ \varepsilon_{e,t}^n \\ 0 \\ \varepsilon_{y,t}^c \end{pmatrix}$$

and X_t is a vector of exogenous or predetermined variables.

Our theoretical discussion suggests what variables to be included in our empirical model, but it does not tell us much with respect to dynamics. Thus, in the empirical analysis we have chosen a specification that is flexible enough to capture lagged effects and to fulfill different statistical criteria. Using a general-to-specific approach (Campos, Ericsson and Hendry, 2005), the exact specification of the measurement equations that we end up estimating is the following:

$$\begin{aligned} u_t = & u_t^c + \beta_1 a_t + \beta_2 a_{t-1} + \beta_3 r_t + \beta_4 r_{t-1} + \beta_5 \theta_t + \beta_6 \theta_{t-1} \\ & + \beta_7 \theta_{t-3} + \beta_8 e_{t-1} + \varepsilon_{u,t}^n \end{aligned} \quad (3.16)$$

$$\begin{aligned} \Delta e_t = & \lambda_{10} u_t^c + \beta_{11} e_{t-1} + \beta_{12} (d - d^*)_{t-1} + \beta_{13} q_{t-1} + \beta_{14} g_{t-1} + \beta_{15} g_{t-1}^* \\ & + \beta_{16} \Delta (d - d^*)_t + \beta_{17} \Delta q_t + \beta_{18} \Delta g_t + \beta_{19} \Delta g_t^* + \beta_{20} (y^* - y^{n*}) + \lambda_{16} y_t^n + \beta_{21} y_t^{n*} + \varepsilon_{e,t}^n, \end{aligned} \quad (3.17)$$

where the first difference of all non-stationary variables are included as explanatory variables to capture the short-run dynamics along with the domestic unemployment gap and the foreign output gap. Moreover we do not impose the restrictions $\beta_{14} = -\beta_{15}$, $\lambda_{16} = -\beta_{21}$, which are implicit in equa-

tion (3.6).

The two final measurement equations are

$$\begin{aligned} \Delta\Delta_4p_t = & \lambda_{20}u_t^c + \lambda_{21}u_{t-1}^c + \beta_{22}y_t^{c*} + \beta_{23}\Delta\Delta_4p_{m,t} + \beta_{24}\Delta\Delta_4p_{m,t-3} \\ & + \beta_{25}\Delta\Delta_4pr_{t-2} + \beta_{26}\Delta\Delta_4pr_{t-3} + \rho\varepsilon_{p,t-4} + \xi_{p,t}. \end{aligned} \quad (3.18)$$

$$y_t = \lambda_{30}u_t^c + y_t^n + \varepsilon_{y,t}^c \quad (3.19)$$

This yields a total of 40 coefficients to be estimated: $\phi_1, \phi_2, \lambda_{10}, \lambda_{16}, \lambda_{20}, \lambda_{21}, \lambda_{30}, \beta_1, \beta_2, \dots, \beta_{26}, \rho, \sigma_u^n, \sigma_u^c, \sigma_y^n, \sigma_y^c, \sigma_e$, and σ_p . In our estimates, the relative budget deficit variable is never significant and we therefore decided to relax the restriction of equal coefficients on the domestic and foreign deficits. A long-run exchange rate relationship can be formed using the coefficients $\beta_{11}, \beta_{12}, \dots, \beta_{15}$. We derive such a relationship for the estimated model in the next section.

The coefficients in the model are estimated by Maximum Likelihood, using the prediction error decomposition form of the likelihood. The mean and covariance matrix of the conditional distribution are given by the Kalman filter.⁶ The specification in (3.16) may need some comment. As one might suspect, and as we will show in the next section, all variables in (3.16), with the exception of the unemployment gap u_t^c , are nonstationary. However, as we will see in the next section, the error term, $\varepsilon_{u,t}^n$, is actually well behaved. This is the result of having employed a general-to-specific modelling approach. Standard inference can thus be used (see Phillips and Hansen, 1990, for the asymptotic results and Hendry and Juselius, 1999, for some small sample

⁶The BFGS algorithm in RATS for Windows 4.31 was used. We also used the Marquart algorithm in Eviews as a robustness check. The point estimates were approximately the same. In preliminary work we used the SIMPLEX algorithm in RATS. However, this algorithm did not do a good job of maximizing the likelihood. Repeated restarting of the maximization from a converged state yielded additional improvement in the likelihood value, even though the convergence criterion had not been changed.

results).

4 Empirical results

The empirical analysis uses Swedish quarterly data ranging from 1972:1 to 2001:4 (after having allowed for lags). The data are described in an appendix. Even though the model discussed above is always estimated jointly, we discuss the results equation by equation except for output in the tables below. The inclusion of potential output in the exchange rate equation always resulted in a inferior model, and the potential output variables were therefore dropped from the specification. Since we do not use potential output, there is no need for estimating the Okun's law relationship.

In Model 1 the exchange rate is the TCW real effective exchange rate, while in Model 2 we look at the SEK/EUR real exchange rate. Models 3 and 4 are subperiod estimates of Model 1 for the periods 1972-1992 and 1982-2001 respectively, with approximately 80 observations in each subsample.⁷ Analyzing standardized residuals and autocorrelations for the residuals from the estimated equations in the different models does not indicate that there are any major statistical problems that we have not already dealt with.

4.1 Order of integration in the data

Before we look at the estimated models, we ask if the variables involved in the analysis are stationary.

Identification of the stationary cyclical component requires all variables in the expectation-augmented Phillips-curve to be stationary. In addition, all variables describing the natural rate of unemployment and the equilib-

⁷Using a subsample for the floating exchange rate period 1993-2001 would have yielded too few observations for the exercise to be meaningful. Even the 80 observations now used for each subsample represents a very small sample size, considering the number of parameters estimated, and the results should therefore be interpreted with caution.

rium real exchange rate must be integrated of the same order. However, the first-differenced variables in the exchange rate equation should be stationary. Table 1 presents the results from the standard augmented Dickey-Fuller test. The lag length is determined by the Akaike information criteria. The way we interpret the results; all variables are integrated of the expected order. We do not reject a unit root in unemployment, the real exchange rate, rate of inflation, the tax wedge, demographic variables, terms of trade and budget deficit variables. However, for the degree of accommodation of ALMPs and the replacement ratio the hypothesis of a unit root is marginally rejected (at the 10 % level). Nevertheless, we choose to treat these variables as non-stationary in the following analysis.⁸ We reject a unit root in the change of the stationary variables.

4.2 Unemployment

Main results

When estimating models 1 and 2 we started out with a general specification and then reduced the model by eliminating non-significant variables as long as the models behaved well in a statistical manner. For the model to make sense, the point estimates of the AR(2) parameters and thus the cyclical part of open unemployment must fulfill the requirements for stationarity. Looking at Table 2, it is clear that this is the case.⁹

The NAIRU in an open economy is not identified unless the foreign sector is modeled. A central objective of the paper is thus to relax the, oft-used, closed economy assumption. The unemployment relationship is given

⁸The rate of unemployment is bounded by definition. However, using our sample we could not reject that the rate of unemployment is non-stationary. Forslund (1995) tests several different samples and generally gets the same result.

⁹Conditions for stationarity:

$$\begin{aligned}\phi_1 + \phi_2 &< 1, \\ -\phi_1 + \phi_2 &< 1, \\ \phi_2 &> -1.\end{aligned}$$

in equation (3.16). The open economy model assumption is examined by testing the hypothesis that the exchange rate parameter is zero in the unemployment equation reported in Table 2, and by examining different statistical properties. Looking at the exchange rate parameter, we reject the hypothesis of a closed economy framework at the 5 percent level in 3 out of 4 cases. The closed economy assumption also give clear signs of misspecification in terms of serial correlation in the residuals. Also, the goodness of fit is poorer in the closed economy model. Moreover the exclusion of the foreign sector results in a severely misspecified Phillips curve. The residuals are serial correlated, and not normally distributed. The missecification of the Phillips curve is extra troublesome since it is used for identifying the whole model. These results are important and show that modeling the economy as closed might give biased results.

In the estimated open economy model, as expected, a depreciation of the real exchange rate raises the natural rate of unemployment/NAIRU. A depreciation of 10 percent will increase the NAIRU by 0,2 percentage points or around 5-6 percent. The intuition is that a depreciation tends to push up consumer prices. In order to counteract a reduction of the consumers real wages, wages have to increase. However, higher wages will raise the real product wage level. Higher real product wages will reduce labor demand and increase unemployment.

An increase in labor market programs reduces the natural rate of open unemployment. An increase in ALMP by 1 percent of the labor force reduces open unemployment by approximately 0,4 percentage points. This is in line with the result of other studies (Calmfors et al., 2004). The replacement ratio has the expected positive sign, but is imprecisely estimated. This could be due to the treatment of the replacement ratio as exogenous. Forslund and Kolm (2000) found an empirical relationship between the replacement ratio and the accommodation rate. A higher tax wedge leads to an increase in the NAIRU, as expected. This indicates that the consumer real wage does

not fully accommodate changes in the wedge. The estimated variance of the cyclical shock is larger than that of the natural rate shocks. This is in line with the results in Lindblad (1997), but contrary to the results in Apel and Jansson (1999).

Figure 1 shows the actual, natural and cyclical rates of unemployment according to our estimates. The levels of the NAIRU and the cyclical component should be interpreted with great caution due to the identifying restriction that the sample mean of the actual rate of unemployment and the NAIRU are the same. The results suggest that the NAIRU increased by 1-1.5 percentage points during 1980-85 and has remained more or less stable since then. Thus, during the last decade of the sample the NAIRU increased little, which implies that the dramatic changes in the Swedish unemployment rates during the 1990s mainly was a cyclical phenomenon.

These results are in contrast to the results in Lindblad (1997), where the permanent part of the unemployment rate rose at least as fast as the actual rate during the early 1990s. In Lindblad (1997) we assumed that the NAIRU followed a random walk and was affected by a spill over from the cyclical part of unemployment. The random walk specification can be biased establishing the permanent component as important. Moreover, the cycle and thereby the whole model is identified by a Phillips curve model without allowing for speed limits, i.e. how fast the unemployment gap can be closed without causing a change in inflation. Thus, not modeling a speed limit can give appearance that the NAIRU is closer to the current unemployment level than is actually the case. Given the dramatic development of the unemployment rate in the early 1990s, the random walk assumption and the spill over channel from the cycle to the permanent component, and the specification of the cycle makes it difficult to capture the fast rise in unemployment in the early 1990s as a cyclical component.

Beside these important differences, there are some results that are similar. The variance of the cyclical shock is smaller than for the permanent shock,

and some of the point estimates of the supply side shocks in the Phillips curve are ruffly of the same magnitude in both papers.

The importance of selected variables

We did some further analysis of what is driving the NAIRU in model 1. We found that the tax wedge has contributed to an increase in the NAIRU during the period 1972-1990 of almost a full percentage point. During 1990-1991 the tax wedge resulted in a 0.5 percentage points reduction in the NAIRU, coinciding with the encompassing tax reforms of 1990 and 1991, which were designed to bring down rates and broaden the tax base. After 1991, the tax wedge has had a negligible effect. The weakening of the real exchange rate since 1972 has resulted in an increase of the NAIRU of around 0.6 percentage points. An increasing accommodation ratio tended to reduce the NAIRU during the 1970s, followed by a sharp increase in 1980-81. In the 1990s, the accommodation ratio contributed to making the NAIRU more volatile. The replacement ratio has contributed to a decrease in the NAIRU since 1994.

Robustness

Models 3 and 4 suggest that the estimates in the unemployment equation could be unstable across the subperiods. Model 3 especially does not seem to be well specified. This evidence of instability is not surprising considering the small sample size and the evolution of the open unemployment series depicted in Figure 1. However, we note that the positive effect of a depreciation of the real exchange rate and the negative effect of labor market programs on open unemployment nevertheless are stable across the subperiods.

4.3 Real exchange rates

Main results

In Table 4 we present the estimated real exchange rate equation (3.17). The first difference of all non-stationary variables are included as explanatory variables to capture the short-run dynamics along with the domestic unemployment gap and the foreign output gap. Recall that a negative parameter indicates that an increase of the variable will appreciate the real exchange rate.

The unemployment gap coefficient λ_{10} is positive as expected and highly significant in model 1 and marginally significant in model 2. Our results also show that the relative size of middle aged cohorts depreciates the real exchange rate. This is consistent with a desire among middle-aged to increase savings by increasing net exports, but it can also be interpreted as evidence that the investment effect dominates. Increased terms of trade appreciates the currency as expected. An increased domestic structural deficit and a decreased foreign deficit depreciates the real exchange rate, indicating that the wealth effect dominates the demand effect. A decreased foreign deficit by one percentage point depreciates the exchange rate by 5-8 percent. The foreign output gap parameter is always significant, but the sign is not the expected one. The error correction component implicit in Table 4 for Models 1 (TCW) and 2 (SEK/EUR) are:

$$-0.186 \left[e_{t-1} - (0.16(d - d^*)_{t-1} - 0.86q_{t-1} + 0.009g_{t-1} - 0.075g_{t-1}^*) \right],$$

and

$$-0.198 \left[e_{t-1} - (0.11(d - d^*)_{t-1} - 0.56q_{t-1} + 0.006g_{t-1} - 0.045g_{t-1}^*) \right].$$

The speed of the error correction is about the same for the two exchange rates, with a half-life of 3-4 quarters. The long-run elasticities are generally

higher for the TCW compared to the SEK/EUR.¹⁰

The long-run relationship or the equilibrium real exchange rate according to model 1 is shown together with the actual rate in Figure 2. Both follow a depreciating trend over the whole sample period 1972-2001. The nominal exchange rate was fixed (but devalued several times) up until November 19, 1992, when the previous peg was given up and the krona was allowed to float. In contrast to the NAIRU and cyclical unemployment, the transitory component of the exchange rate in the graphs includes the foreign output gap and the first differences of the long-run exogenous variables in addition to the domestic unemployment gap. According to the model, the real exchange rate has been undervalued during most of the floating rate period, since 1993. However, due to the identification of the model, this interpretation rests on the assumption that the mean of the equilibrium exchange rate coincides with the sample mean of the actual rate.

In Figure 3, we show results from the complete model that allows for short-run dynamics as well as both domestic and foreign cyclical movements. The model does a good job of tracking the movements in the actual exchange rate, except for the mid-1980s. The results are promising, especially keeping in mind that the sample period spans no less than five devaluations under the fixed exchange rate regime and a regime shift to a free float.

Figure 4 decomposes the estimated model into a cyclical component, a component depending on the first-differenced variables, and an error correction component in each period. We note that the cyclical component exerted a depreciating effect on the exchange rate during most of the 1990's and that some of the overshooting after the floating of the krona in late 1992 can actually be explained by the cyclical position of the Swedish economy relative to its main trading partners.

¹⁰The long-run elasticities are obtained by dividing the parameter of interest with the parameter in front of the lagged exchange rate.

The importance of selected variables

When analyzing how different factors in model 1 have influenced the REER, we find that the demographic variable contributed to appreciating the exchange rate in the 1970s, which was a period when the group of middle-aged was declining relative to the TCW area. However, during the 1980s this group increased and contributed to a weakening of the exchange rate but this trend was reversed again in the 1990s.

During the early 1970s the terms of trade deteriorated and had a depreciating effect followed by a sharp appreciating effect in 1986, as oil prices plummeted in the aftermath of the OPEC debacle. In recent years the terms of trade have again deteriorated and contributed to the weakening of the real exchange rate.

The Swedish structural budget deficit had obviously its most noticeable effect on the real exchange rate during the crisis years of the early 1990s. During the deep recession of 1991-93 the budget stance went from a surplus of 2 percent to a deficit of 7 percent. This increase in the deficit contributed to the depreciation of the exchange rate, which is in line with the wealth effect discussed above. The reduction of the foreign budget deficit had a strongly depreciating effect on the real exchange rate during the floating exchange rate period since 1992, although the trend was broken in 2000. Even though it is natural, given our point estimates, to expect an appreciation of the TCW or Euro when the budget stance in these currency areas improves, we had not expected to find such a strong effect of the foreign deficit on the REER, a reduced deficit by 1 percentage point depreciates the real exchange rate by 5-8 percent. A closer look at the time series of the foreign structural deficit led us to suspect a spurious regression result. However, looking at Model 3 for the shorter period 1972-1992, excluding the foreign budget consolidation during the 1990's, still results in a highly significant (but smaller) estimated coefficient. In Model 4 (1982-2001) the coefficient is twice as high in absolute terms and even more significant. Thus, the results suggest that the strong

appreciation of the TCW and the Euro against the Swedish Krona during the 1990's was primarily driven by the improved foreign fiscal position. Even though the improvement in the Swedish fiscal balance during the second part of the 1990's was greater, the effect was smaller.

Different regimes

A key result in Larsson (2002) is that the real exchange rate dynamics are regime dependent. She finds that "deviations from long run equilibrium are corrected more quickly when the nominal exchange rate has been allowed to float freely". In order to test the robustness of this result, we estimated a version of Model 1 with an exchange rate regime-shift variable.¹¹ We did this by specifying the coefficient on the lagged exchange rate as $\beta_{11} = b_0 + b_1 D_t$, where $D_t = 1$ during the floating rate period and $D_t = 0$ during the fixed rate period. In this model we can test whether or not the error correction is faster during the floating rate period ($|b_0 + b_1| > |b_0|$). This proves to be the case, with a half-life of less than a year compared to a half-life of four years during the fixed-rate period, when corrections through devaluations are excluded by using dummy variables to account for the spikes in the series caused by the devaluations. Since Larsson (2002) uses devaluation dummies, our result indicate that her findings are robust.

However, if we instead include the devaluations, i.e. do not use devaluation dummies, there is no significant difference between the error correction coefficient in the floating versus fixed-rate periods. Hence, during the fixed-rate period adjustments of the real exchange rate also mainly took place through changes in the nominal exchange rate (devaluations) and not through changes in the relative price level. Our results indicate that the question whether or not the exchange rate dynamics are regime dependent is still open, and partly a matter of how the large devaluations of the nominal

¹¹Other variables can also behave differently under different regimes. This is, however, not examined in this paper.

exchange rate are handled.

4.4 The Phillips Curve

Main results

The Phillips curve is naturally of special interest for stabilization policy. As seen above, a unit root in the rate of inflation is not rejected. A unit root is however rejected for the change in the rate of inflation. Even though Sweden has had a credible inflation target regime since mid 1990s, the rate of inflation should statistically be treated as a non stationary variable.

All parameters in the Phillips curve equation have the expected signs and are significant and surprisingly stable (see Table 4). The size of the different parameters seem reasonable. An increase in the unemployment gap by 1 percentage point in Model 1 will reduce the rate of inflation by about 0.6 percentage points four quarters later.¹² The Okun coefficient μ is often estimated to be in the range 1.5-2. Given this, our estimates suggest that an increase in the output gap by 1 percentage point will increase inflation a year later by 0.3-0.4 percentage points. This is much in line with the results in Apel and Jansson (1999) as well as with existing rules of thumb. The sum of the import price shocks are reasonable, and not far from the import penetration in private consumption according to Statistics Sweden. Regarding productivity, our point estimates indicate a limited pass-through in the short run as expected.

Speed limit

Different kinds of rigidities can give rise to persistence and hysteresis (Layard, Nickell and Jackman, 1991; Lindblad, 1997). Persistence can exert a strong

¹²See equation (3.20) where the point estimates are included. A shift in cyclical unemployment lasting a year gives an effect on inflation that can be calculated as $0.51 + 4 * 0.02 \approx 0.6$.

influence on short-run inflationary pressure and it can give the appearance that the (long-run) NAIRU is closer to the current level of unemployment than is actually the case. This is important for policy makers since it has implications for both the size and the timing of the proper policy.

The finding of a significant effect from the lagged unemployment gap suggests that there may be a limit to the speed with which the gap can be closed without causing a change in inflation. This can be illustrated by rewriting the Phillips curve (dropping the import price and productivity shocks) as:

$$\Delta\Delta_4p_t = (\lambda_{20} + \lambda_{21})u_t^c - \lambda_{21}\Delta u_t^c$$

or using the point estimates from Model 1,

$$\Delta\Delta_4p_t = -0.021u_t^c - 0.51\Delta u_t^c. \quad (3.20)$$

Thus, it is clear that not only the level but also the *change* in the unemployment gap may be of notable importance for the inflation dynamics. The speed-limit, i.e. how fast cyclical unemployment can fall without causing a change in inflation, can be calculated by setting $\Delta\Delta_4p_t = 0$ and solving for Δu_t^c , which gives

$$\Delta u_t^c = -0.04u_t^c.$$

The gap should be closed by maximum 4 percent per quarter. Thus even if the unemployment gap is positive and exerting a downward pressure on inflation, inflation will increase if cyclical employment is falling too fast.¹³

5 Conclusions and summary

The Swedish unemployment rate rose rapidly during the early 1990s, but has fallen from 1997 to 2008. The central question in the introduction of this

¹³The presence of a speed limit, showing that the gap only can be closed slowly, supports the idea of a smooth monetary policy.

paper is to what degree the dramatic changes in the Swedish unemployment rate during the 1990s reflect changes in the natural rate/NAIRU and changes in the business cycle.

To answer this question we estimate an open-economy version of the Layard, Nickell and Jackman (1991) model for price and wage setting in an unobserved components framework.

Instead of modelling the NAIRU as a stochastic trend in a closed-economy framework, we have modeled it in an open economy framework as a function of theoretically motivated variables: taxes, active labor market policies, the replacement ratio, demographic factors and, since we are modelling an open economy, the real exchange rate. All variables except the real exchange rate are treated as exogenous. The real exchange rate is modeled and estimated simultaneously with the rest of the model. Hence, we have simultaneously estimated equilibrium and cyclical movements in the rate of unemployment and in the real exchange rate and – to identify the model – an expectations-augmented Phillips curve.

We reject the closed-economy framework. Our results show that it is important to model the open-economy aspects. The closed-economy version, nested by the open-economy model, is safely rejected. Moreover, the closed-economy version misbehaves in a statistical manner, and it is not identified properly. Ignoring the existence of the foreign sector will bias the results, and according to the point estimates, the bias is of considerable importance.

The development of the Swedish unemployment rate is successfully explained. A depreciation of the real exchange rate, a higher replacement ratio and higher taxes will, as expected, raise the NAIRU. An increase in the size of labor market programs tends to reduce open unemployment, which is also expected. According to our point estimates, the NAIRU increased by approximately 1-1.5 percentage points during 1980-1985. Thereafter it has remained quite stable. This finding implies that the dramatic unemployment changes in the 1990s were mainly a cyclical phenomenon.

Most econometric studies of real exchange rates use the terms of trade and some measure of net foreign assets as explanatory variables. However, net foreign assets cannot be treated as exogenous. In the empirical analysis we therefore assumed that net foreign assets are determined by demographic variables and structural budget deficits. The real exchange rate was successfully modeled using the terms of trade, the evolution of demographics relative to the rest of the world, and the domestic and foreign structural budget deficits. Our focus on the demographics relative to the corresponding foreign group and the use of structural deficits in the exchange rate equation is a novelty to the literature. A larger fraction of the population aged 45-59 years and a larger domestic structural budget deficit cause a depreciation of the real exchange rate. Improved terms of trade and a larger foreign structural budget deficit cause an appreciation of the real exchange rate. Regarding the strong appreciating effect from a higher foreign structural deficit, we believe that it should be thought of as a depreciation of the foreign currency rather than as a strengthening of the Swedish Krona. Our exchange rate model explains a surprisingly large fraction, up to 50 percent, of the variation in the real exchange rate. The results are promising, especially keeping in mind that the sample period spans no less than five devaluations and a shift from a peg to a float of the nominal exchange rate, which are events that we do not control for.

We also find that the real exchange rate does not revert any faster to the REER during the floating-rate period, than during the fixed exchange rate period. It appears that adjustments to the real exchange rate during the fixed-rate period mainly took place through devaluations and not through changes in the relative price level.

The Phillips curve seems to be "alive and well". Changes in the rate of inflation are well explained by the unemployment gap and shocks to import prices and productivity. Our results also indicate that the change in the rate of inflation is affected by the change in the unemployment gap, due to

persistence or other rigidities. This suggests that there is a limit to the speed with which the gap can be closed without causing rising inflation, and thus gives an argument for a smooth monetary policy.

Moreover, the obvious policy conclusion from the results in this paper is the high unemployment rate in the 1990s was due to a lack of demand and that an expansionary policy had been a proper response. This is the same recommendation as in Lindblad (1997), despite the different results. The reason for this is that if the NAIRU is affected by persistence and cyclical unemployment, then a demand shock will actually not only decrease the cyclical part of unemployment but also the permanent component.

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A Appendix

A.1 Data appendix

Foreign variables have been computed from the weights used in constructing the TCW index for the Swedish krona. When computing the weights for the EMU, the TCW weights have been rescaled to sum to one. Population statistics were obtained from Statistics Sweden and the respective statistics bureaus of the other countries involved.

- $a = \ln(ALMP/(ALMP + OU))$ is the accommodation rate.
- $ALMP$ = The sum of all different active labor market programs that have existed during the period 1972-2001. Source: Swedish Public Employment Service (formerly AMS). Monthly data have been converted to quarterly by taking the mean.
- d = Net savers ratio, computed as the sum of 45-59 years old relative to the total population.
- d^* = TCW (or EMU) weighted net savers ratio.
- $e = \ln(TCW \cdot P^*/P_c)$ or $e = \ln(SEK/EUR \cdot P^*/P_c)$ is the real exchange rate for Model 1 and 2 respectively (the real TCW index is set equal to 100 at 18 November 1992, while the real SEK/EUR is set equal to its nominal equivalent at 2001:1). Source: Sveriges Riksbank.
- g = structural government deficit (as percent of potential GDP). Source: OECD, Main Economic Indicators.
- g^* = TCW (or EMU) weighted structural government deficit (as percent of potential GDP). Source: OECD, Main Economic Indicators.
- $Y = GDP$ = Real gross domestic product (s.a.). Source: Statistics Sweden, National Accounts.

- $Y^* = GDP^* =$ TCW (or EMU) weighted gross domestic product (s.a.). Source: OECD Main Economic Indicators and own computations.
- $P =$ Swedish consumer price index. Source: Statistics Sweden.
- $P^* =$ A TCW (or EMU) weighted consumer price index. Source: OECD Main Economic Indicators and own computations.
- $pr =$ log of labor productivity (GDP per hours worked). Source: Statistics Sweden.
- $P_c = P_{UND} =$ The UND1X core inflation price index is our measure of inflation in the Phillips curve. Source: Swedish Riksbank.
- $q = P_X/P_M,$ the terms of trade computed as export deflator over import deflator. Source: Statistics Sweden.
- $r =$ replacement ratio: the log of maximum daily unemployment compensation divided by eight times the average hourly wage. The latter is computed as the total wage bill divided by the total number of hours worked. Source: Swedish Public Employment Service (unemployment compensation) and Statistics Sweden.
- $TCW =$ A competitiveness weighted nominal effective exchange rate index (18 November 1992 = 100). Source: Sveriges Riksbank.
- $\theta = \ln \left[(1 + VAT) \left(\frac{1+S}{1-T} \right) \right],$ where VAT is direct effects on the CPI from indirect taxes and subsidies, S is pay-roll tax and T is income tax.
- $u = OU/TLF$ is the rate of unemployment, where $OU =$ open unemployment and $TLF =$ total labor force. Source: Statistics Sweden, Labour Force Survey (AKU).
- $(y^* - y^{n*}) =$ Foreign cyclical demand, where potential output is computed as the HP-filtered (1600) series of GDP^* .

Figure 1. The actual, natural and cyclical rates of unemployment

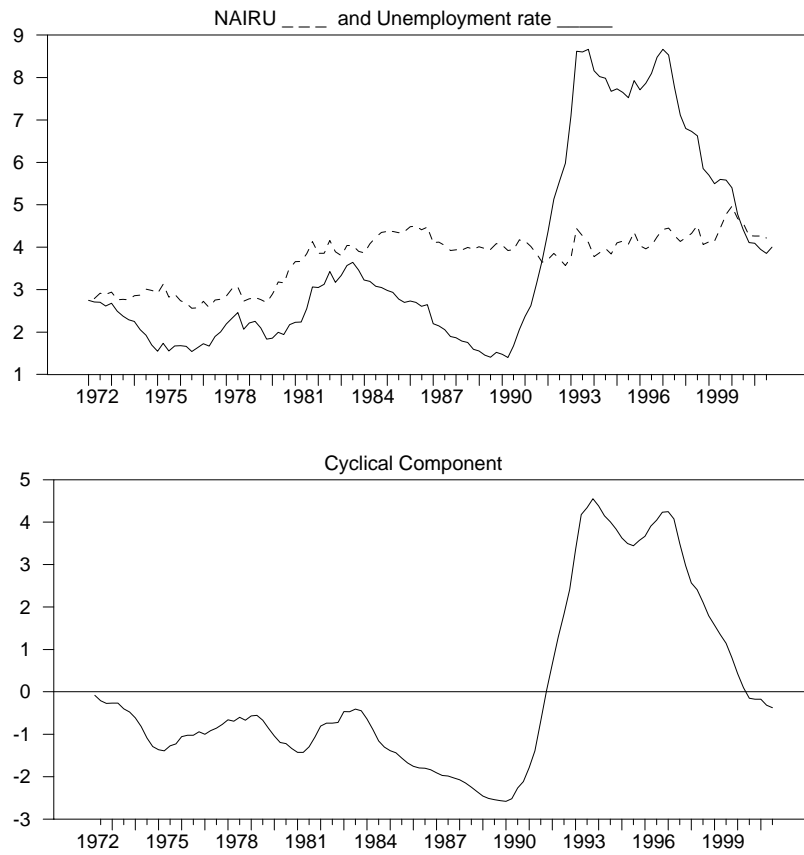


Figure 2. The actual and equilibrium real exchange rates

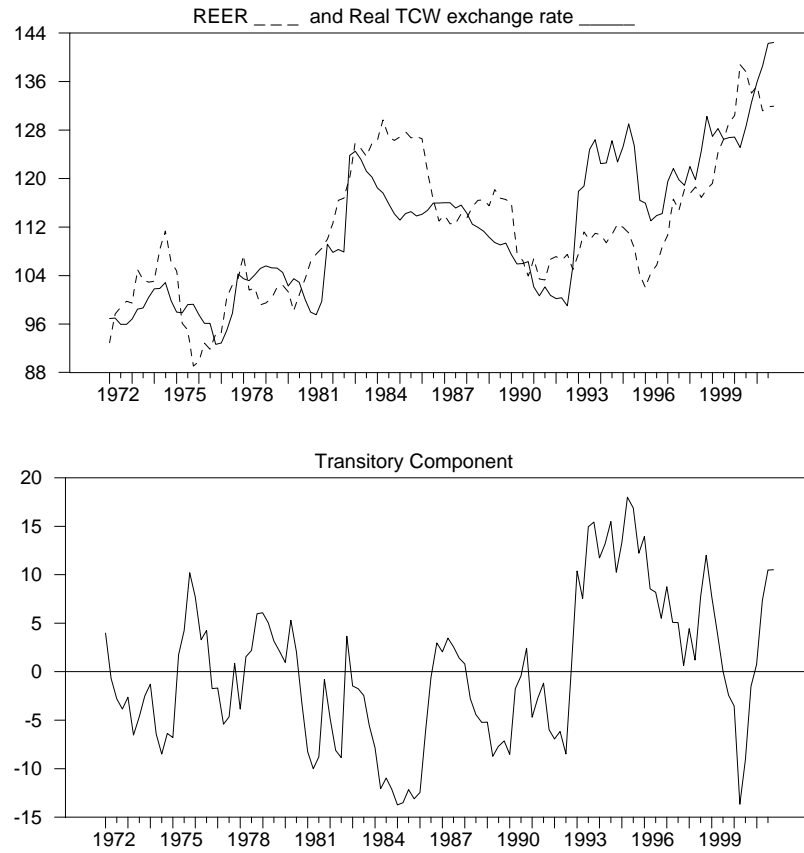


Figure 3. The actual and predicted values for the real exchange rates

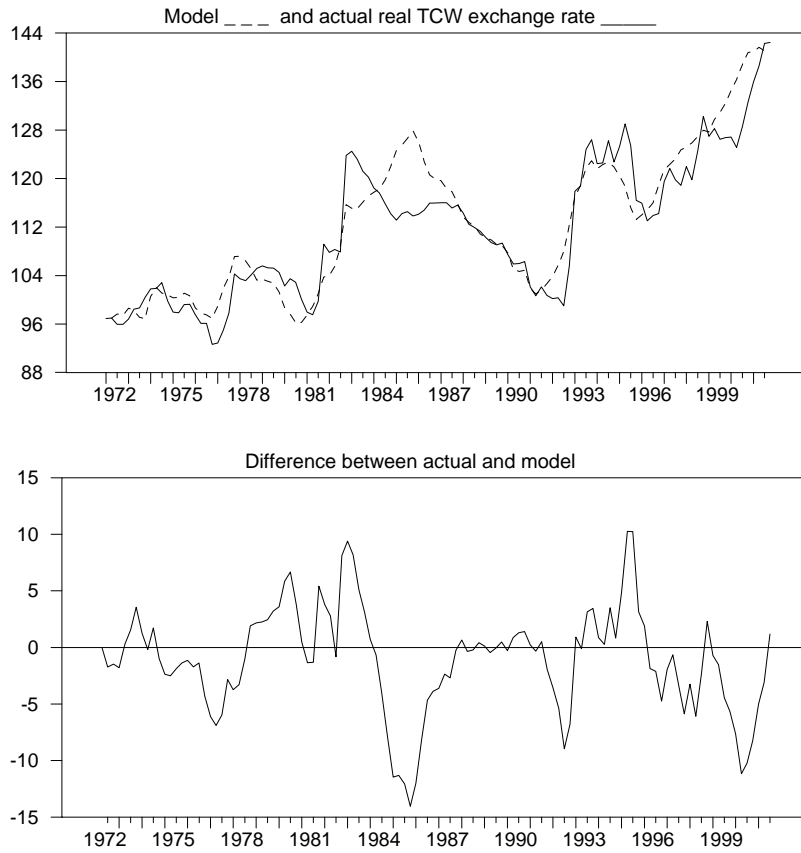


Figure 4. A decomposition of the real exchange rate

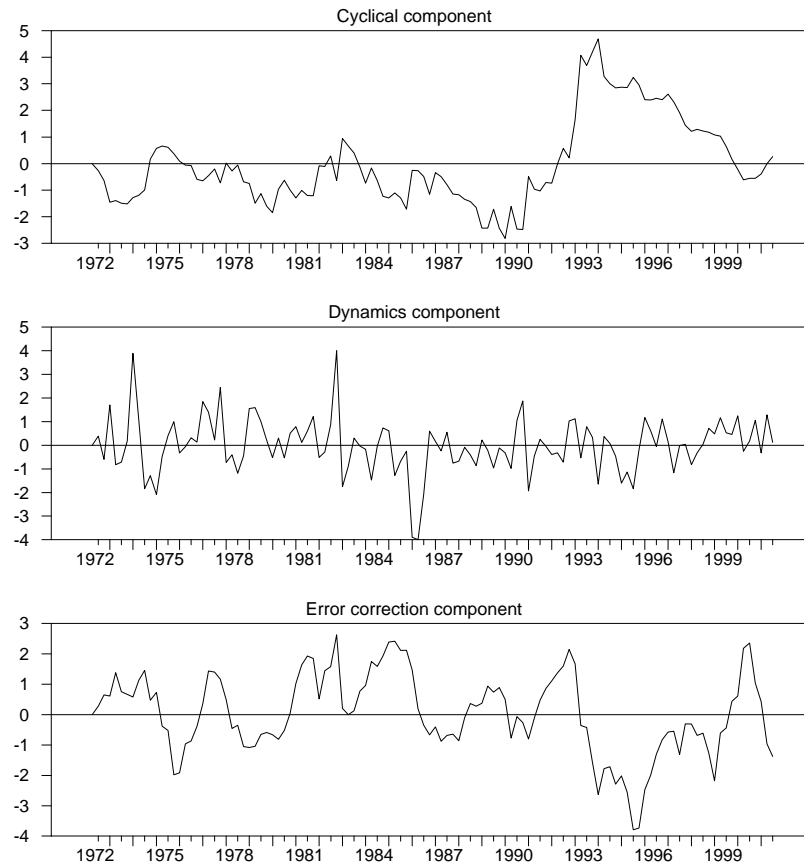


Table 1: Unit root tests

***, **, * denote significance at the 1, 5, and 10 percent level respectively, using Mac Kinnon critical values for rejection of the hypothesis of a unit root. Two sets of statistics are reported for foreign variables: Model 1 (TCW)/Model 2 (SEK/EUR).

Variable	Test statistic	Lags
u	-1.36	1
e	-1.68/-1.97	1/1
Δe	-7.28***/-7.18***	1/1
$\Delta_4 p$	-0.24	4
$\Delta \Delta_4 p$	-5.74***	2
a	-2.83*	1
r	-2.88*	1
θ	-2.15	4
$d - d^*$	-1.50/-1.63	6/5
$\Delta (d - d^*)$	-3.12**/-2.55	5/5
q	-2.04	1
Δq	-7.50***	1
g	-2.08	3
Δg	-3.42**	3
g^*	-1.58/-1.38	2/4
Δg^*	-5.11***/-4.73***	1/4
$y^* - y^{n*}$	-5.24***/-5.32***	4/4
$\Delta \Delta_4 p_M$	-8.98***	3
$\Delta \Delta_4 p_r$	-8.46***	4

Table 2: Unemployment equation

Dependent variable: open unemployment, percent of total labor force. White standard errors are reported within parentheses below the estimated coefficients. Serial corr. is a Box-Ljung Q(k) test against serial correlation based on k=11 autocorrelations. Cross corr. is a Q(k) test of the correlation of residuals across equations with k = 5 lags/5 leads. Heterosk. is Engle's LM test against first order autoregressive conditional heteroskedasticity (Chi-squared with 1 d.f.). R_d^2 is the coefficient of determination suggested for non-stationary time series by Harvey (1989). A positive R_d^2 implies a better fit than a random walk.

Variable	Model 1	Model 2	Model 3	Model 4
u_{t-1}^c	1.83 (0.04)	1.83 (0.02)	1.94 (0.10)	1.83 (0.10)
u_{t-2}^c	-0.85 (0.04)	-0.84 (0.02)	-0.99 (0.10)	-0.85 (0.10)
a_t	-1.82 (0.27)	-1.81 (0.25)	-1.56 (0.19)	-1.71 (0.30)
a_{t-1}	-0.50 (0.33)	-0.48 (0.37)	0.05 (0.19)	-0.60 (0.42)
r_t	0.04 (0.14)	0.09 (0.13)	-0.16 (0.15)	0.45 (0.42)
r_{t-1}	0.23 (0.25)	0.25 (0.26)	-0.12 (0.15)	1.28 (0.49)
θ_t	0.68 (0.30)	0.64 (0.38)	-0.43 (0.39)	0.96 (0.91)
θ_{t-1}	0.51 (0.41)	0.41 (0.45)	-0.37 (0.43)	-0.14 (1.02)
θ_{t-3}	0.84 (0.33)	0.77 (0.44)	-0.13 (0.34)	0.18 (1.04)
e_{t-1}	1.81 (0.70)	1.55 (0.71)	-0.18 (0.48)	2.31 (1.17)
σ_u^c	0.13 (0.02)	0.13 (0.02)	0.08 (0.02)	0.16 (0.03)
σ_u^n	0.08 (0.02)	0.08 (0.02)	0.04 (0.01)	0.09 (0.02)
R^2	0.99	0.99	0.98	0.99
R_d^2	0.57	0.57	0.72	0.58
Serial corr. (p-value)	0.630	0.576	0.501	0.466
Cross corr. ε_e^n (p-value)	0.538/0.739	0.751/0.654	0.106/0.014	0.325/0.361
Cross corr. ε_p (p-value)	0.515/0.488	0.566/0.536	0.051/0.053	0.946/0.689
Heterosk. (p-value)	0.005	0.001	0.597	0.326
Exchange rate	TCW	SEK/EUR	TCW	TCW
Sample	1972-2001	1972-2001	1972-1992	1982-2001

Table 3: Exchange rate equation

Dependent variable: the percentage change in the real exchange rate. White standard errors are reported within parentheses below the estimated coefficients. Serial cor. is a Box-Ljung Q(k) test against serial correlation based on k=11 autocorrelations. Cross corr. is a Q(k) test of the correlation of residuals across equations with k = 5 lags/5 leads. Heterosk. is Engle's LM test against first order autoregressive conditional heteroskedasticity (Chi-squared with 1 d.f.).

Variable	Model 1	Model 2	Model 3	Model 4
u_t^c	$4.7 \cdot 10^{-3}$ ($1.6 \cdot 10^{-3}$)	$3.6 \cdot 10^{-3}$ ($2.2 \cdot 10^{-3}$)	$3.7 \cdot 10^{-3}$ ($4.0 \cdot 10^{-3}$)	$6.1 \cdot 10^{-3}$ ($2.8 \cdot 10^{-3}$)
e_{t-1}	-0.186 (0.048)	-0.198 (0.055)	-0.238 (0.065)	-0.217 (0.057)
$(d - d^*)_{t-1}$	0.030 (0.010)	0.021 (0.006)	0.027 (0.008)	0.082 (0.029)
q_{t-1}	-0.160 (0.058)	-0.111 (0.067)	-0.203 (0.064)	-0.152 (0.074)
g_{t-1}	$1.6 \cdot 10^{-3}$ ($1.5 \cdot 10^{-3}$)	$1.2 \cdot 10^{-3}$ ($1.7 \cdot 10^{-3}$)	$-1.2 \cdot 10^{-4}$ ($1.6 \cdot 10^{-3}$)	$2.4 \cdot 10^{-3}$ ($1.6 \cdot 10^{-3}$)
g_{t-1}^*	-0.014 (0.004)	-0.009 (0.003)	-0.012 (0.004)	-0.023 (0.005)
$\Delta(d - d^*)_t$	0.014 (0.040)	0.033 (0.048)	0.004 (0.047)	0.100 (0.071)
Δq_t	-0.601 (0.204)	-0.437 (0.141)	-0.577 (0.146)	-0.608 (0.208)
Δg_t	$-2.9 \cdot 10^{-4}$ ($3.7 \cdot 10^{-3}$)	$1.0 \cdot 10^{-3}$ ($4.2 \cdot 10^{-3}$)	$-9.5 \cdot 10^{-3}$ ($5.0 \cdot 10^{-3}$)	$2.1 \cdot 10^{-3}$ ($3.8 \cdot 10^{-3}$)
Δg_t^*	$-3.2 \cdot 10^{-3}$ ($6.4 \cdot 10^{-3}$)	$-2.4 \cdot 10^{-3}$ ($6.9 \cdot 10^{-3}$)	$5.9 \cdot 10^{-4}$ ($7.9 \cdot 10^{-3}$)	$-1.6 \cdot 10^{-3}$ ($11.3 \cdot 10^{-3}$)
$(y^* - y^{n*})_t$	$-5.3 \cdot 10^{-3}$ ($1.6 \cdot 10^{-3}$)	$-6.3 \cdot 10^{-3}$ ($2.2 \cdot 10^{-3}$)	$-2.1 \cdot 10^{-3}$ ($2.3 \cdot 10^{-3}$)	$-15.3 \cdot 10^{-3}$ ($4.6 \cdot 10^{-3}$)
σ_e	0.022 (0.002)	0.024 (0.001)	0.019 (0.002)	0.022 (0.002)
R^2	0.34	0.27	0.39	0.53
Serial corr. (p-value)	0.439	0.091	0.005	0.169
Cross corr. ε_u^n (p-value)	0.739/0.539	0.654/0.751	0.014/0.106	0.361/0.325
Cross corr. ε_p (p-value)	0.177/0.486	0.562/0.779	0.105/0.160	0.056/0.140
Heterosk. (p-value)	0.951	0.775	0.876	0.833
Exchange rate	SEK/TCW	SEK/EUR	SEK/TCW	SEK/TCW
Sample	1972-2001	1972-2001	1972-1992	1982-2001

Table 4: The expectations-augmented Phillips curve

Dependent variable: the quarterly change in the annual rate of inflation. White standard errors are reported within parentheses below the estimated coefficients. Serial corr. is a Box-Ljung Q(k) test against serial correlation based on k=11 autocorrelations. Cross corr. is a Q(k) test of the correlation of residuals across equations with K = 5 lags/5 leads. Heterosk. is Engle's LM test against first order autoregressive conditional heteroskedasticity (Chi-squared with 1 d.f.).

Variable	Model 1	Model 2	Model 3	Model 4
u_t^c	-0.531 (0.118)	-0.609 (0.124)	-0.610 (0.067)	-0.455 (0.057)
u_{t-1}^c	0.510 (0.112)	0.586 (0.122)	0.364 (0.060)	0.462 (0.053)
y_t^{c*}	0.060 (0.036)	0.045 (0.037)	0.058 (0.041)	0.151 (0.095)
$\Delta^2 p_{m,t}$	0.062 (0.018)	0.065 (0.017)	0.060 (0.020)	0.064 (0.017)
$\Delta^2 p_{m,t-3}$	0.056 (0.016)	0.056 (0.017)	0.057 (0.017)	0.066 (0.015)
$\Delta^2 pr_{t-2}$	-0.100 (0.030)	-0.100 (0.026)	-0.106 (0.031)	-0.107 (0.056)
$\Delta^2 pr_{t-3}$	-0.086 (0.034)	-0.086 (0.025)	-0.098 (0.032)	-0.062 (0.045)
σ_p	0.527 (0.044)	0.527 (0.045)	0.546 (0.046)	0.460 (0.057)
ρ	-0.554 (0.081)	-0.555 (0.077)	-0.616 (0.095)	-0.301 (0.114)
R^2	0.56	0.56	0.64	0.57
Serial corr. (p-value)	0.612	0.614	0.214	0.145
Cross corr. ε_u^n (p-value)	0.488/0.515	0.536/0.566	0.053/0.051	0.689/0.946
Cross corr. ε_e^n (p-value)	0.486/0.177	0.779/0.566	0.160/0.105	0.140/0.056
Heterosk. (p-value)	0.998	0.812	0.765	0.812
Exchange rate	TCW	SEK/EUR	TCW	TCW
Sample	1972-2001	1972-2001	1972-1992	1982-2001

Chapter 4

A Simultaneous Model of the Swedish Krona, the US Dollar and the Euro*

1 Introduction

Sweden is a small open economy with exports and imports amounting to about 54 and 47 per cent of GDP respectively in 2008. The value of the Krona (SEK) against other currencies thus becomes an essential determinant of the state of the Swedish economy. When analyzing exchange rates, the most common approach in the empirical international macroeconomics is to look at either a bilateral exchange rate or at a weighted index of foreign currencies. Sweden's largest trading partner is the Euro area, which absorbs about 40 per cent of Sweden's exports. Thus the exchange rate vis-a-vis the

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Euro (EUR) is of natural interest. But since about 60 per cent of Swedish exports are destined elsewhere, the SEK and the EUR exchange rate against other currencies – such as the US Dollar (USD) – are also of great interest.

The main contribution of this paper is to simultaneously estimate the short- and long-run dynamics of the real exchange rates between the SEK, the EUR and the USD.

Usually, and this paper is no exception, the real exchange rate is expressed in terms of consumer goods. Then, the real exchange rate between two currencies shows how much consumption the home country has to spend in order to obtain one unit of foreign consumption. For instance, the real exchange rate between the SEK and the USD measures how many units of the Swedish consumption basket it takes to buy one unit of the US consumption basket. From this definition, the real exchange rate can be written as the product of the nominal exchange rate and the ratio between the foreign and the domestic consumer price levels.

According to international macroeconomic theory, the real exchange rate is determined by a set of institutional and economic factors such as relative productivity, terms of trade (the relative price between exported and imported goods and services), net foreign assets and openness (Masson, Kremers, and Horne, 1994; Bergvall, 2002 and Lane and Milesi-Ferretti, 2004). A voluminous literature takes its starting point in some simple accounting relationships and is reviewed in MacDonald (2000). Empirical testing of the more rigorous theoretical models in the new open macroeconomics literature is surveyed in Ghironi (2000) and Lane (2001).

It is usually postulated that there exists a long-run empirical relationship between the real exchange rate and a set of theoretically motivated explanatory variables. Bergvall (2002), Nilsson (2002), and Lane and Milesi-Ferretti (2004) estimate real exchange rate equations derived from new open economy models and find that the real exchange rate is cointegrated with relative GDP, the terms of trade, and net foreign assets. Alexius (2001) estimates a

common trends model for the Nordic countries and finds that relative productivity is the most important determinant of long-run movements in the real exchange rate in all the countries investigated. Hjelm (2001) also finds that productivity shocks are the main force driving the US real exchange rate relative to the UK, Germany and Japan. MacDonald and Marsh (1999) use a purchasing-power-parity model augmented with an interest-rate differential to simultaneously estimate the exchange rates between the US Dollar, the German D-Mark and the Japanese Yen. Their study highlights the complex interactions among the variables in a tri-polar exchange rate system.

A prime determinant of real exchange rate dynamics is relative trend productivity or relative trend output. If there exists a stable reaction function between the interest rate and the output gap, the difference in capacity utilization should also be of importance when explaining the dynamics of the exchange rate. Since neither potential output nor output gaps are observable, actual output is often used as a proxy for the former and output minus an ad hoc trend as a proxy for the latter. An alternative is to use economic theory to define and estimate the output gap and potential output.

In this paper, we will define cyclical output in a standard Phillips-curve framework and estimate cyclical and potential output for each country in an unobserved components (UC) model. We subsequently use these estimated variables in our exchange rate model. Other examples of UC-model applications are found in Lindblad (1997), Apel and Jansson (1999), Laubach (2001), Turner et al. (2001) and Horn et al. (2007).

Our results indicate that a surprisingly large part, up to two thirds, of the variation in the percentage change in the real exchange rates is explained by variations in potential output, terms of trade and structural budget deficits. Moreover, in terms of explanatory power, it appears preferable to use estimated potential output instead of actual output.

This paper is organized as follows. First, we discuss the theoretical background for the determination of real exchange rates. Second, we specify the

empirical model. Third, we discuss the output from estimating the models and briefly comment on forecasting results. Finally, we sum up.

2 Theoretical discussion

A theoretical background to our empirical exchange rate specification is found in the new open macroeconomics literature, e.g. Lane and Milesi-Ferretti (2004).¹ These authors set up a small open-economy model, where consumers maximize lifetime utility subject to an intertemporal budget constraint and firms maximize profits. Instantaneous household utility is a function of consumption of tradable and non-tradable goods and labor input. For simplicity, firms are assumed to only produce a non-traded good and set prices in order to maximize profits. Production of traded goods is an endowment that sells in the world market at a given export price. Solving the Lane and Milesi-Ferretti model, gives the following long-run determinants of the real exchange rate: exogenous terms of trade, net foreign assets, and relative production in the tradeable sector. The intuition is quite straightforward: an increase in the terms of trade, net foreign assets or production in one country raises that country's income and stimulates consumption of non-traded goods, which tends to appreciate its real exchange rate. Higher income also reduces labor supply, which reduces the production of non-traded goods and thus raises the relative price of non-tradeables, also causing a real appreciation. Thus, two effects, higher demand for goods and lower labor supply, push the real exchange rate in the same direction.

In the model described above, the terms of trade effect is unambiguous through its wealth effect on the relative price of non-tradeables: an increase

¹The (log) real exchange rate between SEK and USD can be written as

$$e^{su} = c^{su} + p^u - p^s,$$

where c^{su} is the (log) nominal SEK/USD exchange rate and p is the (log) consumer price level. Superscript u denotes the US and superscript s denotes Sweden.

will strengthen the real exchange rate.² In other models, the effect of a terms of trade shock on the real exchange rate can be theoretically ambiguous, depending e.g., on whether there is a home bias within the category of tradeable goods as in Obstfeld and Rogoff (2004). A home bias implies that home-produced tradeables have a greater weight than foreign-produced tradeables in the consumption basket. A relative increase in the price of home-produced tradeables (improved terms of trade) will then have a greater impact on the consumer price index in the home country compared to the foreign country, leading to an appreciation of the real exchange rate. Empirically a positive terms of trade shock has in most cases been found to lead to a significant appreciation of the real exchange rate (Dungey, 2002; Nilsson, 2002; and Lane and Milesi-Ferretti, 2004), which is consistent with both the wealth effect and a home bias, although there are exceptions (see e.g. Alexius and Nilsson, 2000).

Higher net foreign assets induce households to increase their demand for non-traded goods. At the same time higher net foreign assets cause a reduction of labor supplies, which reduces the production of non-traded goods. Both the goods demand and the labor supply effects raise the relative price of non-traded goods, implying an appreciation of the real exchange rate. Hence, higher (lower) net foreign assets are related to an appreciated (depreciated) real exchange rate.

A country's net foreign asset position is determined by its accumulated private and public net savings.³ Since the private savings ratios differ among cohorts of the population, an important and plausibly exogenous determinant

²It is important to understand that there is a fundamental difference between terms of trade and the real exchange rate. Terms of trade is the relative price of tradeable goods and services. An increase in terms of trade increases wealth. Wealth increases the demand for non-tradeables and lowers labor supply. This increases the relative price of non-tradeables, and thereby the real exchange rate, since the real exchange rate is measured as the relative price of consumer goods. Non-tradeables are not a part of terms of trade.

³A similar decomposition of net foreign assets into demographic and fiscal variables is employed in Masson, Kremers and Horne (1994) and Lane and Milesi-Ferretti (2001).

of accumulated net savings is the evolution of demography over time. Since the demographic composition is quite persistent, it also is an indicator of the net foreign asset position.

Usually, a higher proportion of prime- or middle-aged people in the population is assumed to stimulate savings as these cohorts prepare for retirement. Higgins (1998) finds substantial demographic effects on the current account balance for a number of countries. However, he also shows that the demographic structure has little effect on net saving in more closed economies. Lindh and Malmberg (1999) present evidence that the proportion of middle-aged people in the population has a positive effect on investment as well as on saving, making the effect on net saving ambiguous. The reason for a positive effect on investment is not obvious. Two possible explanations are given. First, the middle-aged tend to transfer wealth from real to financial assets which, given a home bias in financial investment, would decrease the local cost of capital. Second, the group of middle-aged people is a relatively productive age group, which means a lower effective capital intensity and thus a higher return to capital.⁴

However even if the net cohort effect is to increase the country's financial saving, the only way to do so is via an improved current account. The textbook way of achieving higher net exports is by depreciating the real exchange rate (Ball and Mankiw, 1995). Thus, net effect of the demographic composition on net foreign assets and the real exchange rate is an empirical question.

Another important determinant of net saving is the fiscal position of the government sector (to the extent that Ricardian equivalence does not hold fully). Thus, high levels of public debt may be associated with a low level of net foreign assets. A higher public debt that is not offset by higher private assets will reduce the net foreign assets. In this case, a higher public

⁴Lindh and Malmberg (1999) define middle-aged as the age group 50-64 years old, while we use 45-59 years old in the empirical part of the paper. We use this definition because the countries in our study have a lower *actual* retirement age than 65.

debt would depreciate the real exchange rate through the wealth channel discussed above – a wealth effect. However, other effects could go in the reverse direction. Hakkio (1996) discusses several possible channels through which the fiscal position could influence the exchange rate. One of these channels is the textbook effect that an increase in the government budget deficit, and thus also an increase in debt, should raise demand and thus prices of non-tradeable goods, which is synonymous with an appreciation of the real exchange rate – a demand effect. However, this requires that fiscal policy is credible. Thus, whether an increased debt will lead to an appreciation or a depreciation is an empirical question depending on the relative size of the wealth and demand effects.

Thus, we regard the net foreign asset position as a function of the demographic composition and the fiscal position of the government sector. These variables are treated as exogenous in the reduced form exchange rate equations below. Lindh and Malmberg (1999) and Hakkio (1996) also argue that these variables affect the real exchange rate directly.

Yet, another mechanism is that higher relative productivity strengthens the real exchange rate through the Balassa-Samuelson effect. If productivity growth is faster in the domestic tradeable sector, compared to the foreign tradeable sector, this triggers higher real wage increases which spill over to relatively higher price increases for non-tradeables relative to tradeables. This implies an appreciation of the real exchange rate.

Since data on relative productivity are often unreliable, a standard short-cut is to use relative GDP, c.f. Lane and Milesi-Ferretti (2004). However, this short-cut is not without problems. Relative GDP reflects both trend and business cycle differences. What should matter in the long run is really relative trend output, implying that a more appropriate measure is relative potential GDP.

The interest differential is often argued to be an important determinant of the real exchange rate (e.g. in MacDonald and Marsh 1999). In the short

run, we know that real interest rates vary over the business cycle. If there exists a stable reaction function between the interest rate and the output gap, we can use our output gap variables to capture these determinants.

3 Empirical specification

Based on the discussion above, we arrive at the following empirical equations for the (log) real exchange rates of the Krona:

$$e^{su} = \alpha_0 + \alpha_1 q^s + \alpha_2 q^u + \alpha_3 d^s + \alpha_4 d^u + \alpha_5 g^s + \alpha_6 g^u + \alpha_7 y^{n,s} + \alpha_8 y^{n,u} + \alpha_9 y^{c,s} + \alpha_{10} y^{c,u}, \quad (4.1)$$

$$e^{se} = \beta_0 + \beta_1 q^s + \beta_2 q^e + \beta_3 d^s + \beta_4 d^e + \beta_5 g^s + \beta_6 g^e + \beta_7 y^{n,s} + \beta_8 y^{n,e} + \beta_9 y^{c,s} + \beta_{10} y^{c,e}, \quad (4.2)$$

and, ruling out arbitrage possibilities, we have

$$e^{ue} = e^{se} - e^{su} \quad (4.3)$$

where q is the terms of trade, d is the share of middle-aged people in the population, and g is the structural government budget deficit as a share of GDP, and y^n and y^c are trend output and output gap, respectively. Superscript su , se and ue denote SEK/USD, SEK/EUR and USD/EUR and superscript u , e and s denote the US, the Euro area and Sweden respectively. The discussion above indicated that both the public debt and deficit could be included in the equations above. However, as will be discussed shortly, we will only use the deficit variable.

Since Sweden is a small economy, and the SEK unlike USD, EUR and Yen is not a reserv currency, we impose a set of restrictions – which we tested and could not reject – ensuring that Swedish variables do not affect the USD/EUR exchange rate. Thus, we assume that Sweden's terms of trade, demographics, structural budget deficit and output influence the

SEK/USD and the SEK/EUR exchange rates by the same amount, leaving the USD/EUR unaffected. With these restrictions, equation (4.2) becomes:

$$e^{se} = \beta_0 + \alpha_1 q^s + \beta_2 q^e + \alpha_3 d^s + \beta_4 d^e + \alpha_5 g^s + \beta_6 g^e + \alpha_7 y^{n,s} + \beta_8 y^{n,e} + \alpha_9 y^{c,s} + \beta_{10} y^{c,e}. \quad (4.4)$$

All movements in the exchange rates at business cycle frequencies are assumed to be captured by the output-gap variables in equations (4.1) and (4.4). The specifications above are flexible and allow for distinct coefficients on e.g., domestic and foreign potential output. The results from estimating a more restricted model are reported below.

Based on findings in the previous empirical literature, which have found a robust positive relation between the terms of trade and the real exchange rate, we expect that $\alpha_1 < 0$, and α_2 and $\beta_2 > 0$. To what extent terms of trade shocks in the Euro area and the United States could truly be treated as exogenous is perhaps debatable, but here we follow the current practice in the empirical literature, to get comparable results. Examples of exogenous terms of trade shocks are oil price shocks and shocks to other prices of raw materials determined in the world market. The coefficients on the share of the middle-aged, α_3 , α_4 and β_4 , as well as the coefficients on the structural budget deficits, α_5 , α_6 and β_6 , could take on any sign, as discussed above. Regarding trend output, we expect that $\alpha_7 < 0$ and, α_8 and $\beta_8 > 0$, reflecting an appreciation of the real exchange rate. Regarding the coefficients on the cyclical component of output, we expect $\alpha_9 < 0$ and, α_{10} and $\beta_{10} > 0$. A higher domestic output gap should result in rising domestic prices and higher interest rates, both of which tend to appreciate the currency.

3.1 The empirical model

As explained above, we wish to use potential and cyclical output in our exchange rate equation. However, since these variables are not observable they must be estimated. Splitting up a time series in a trend and a cyclical

component can be done in several ways. We have chosen an unobserved-components (UC) model, where parameters are identified through a set of restrictions discussed below and a Phillips curve in order to give the cycle an intuitive economic interpretation.⁵ The UC-model is set up in the following way.

Output in each country is assumed to consist of two unobserved components, a permanent non-stationary component and a stationary cyclical component. Dropping country superscripts, the model can be written as:

$$y_t = y_t^n + y_t^c,$$

where the permanent component y^n is assumed to follow a random walk with drift

$$\Delta y_t^n = C + \varepsilon_t^n,$$

and the cyclical component y^c is modelled as a stationary AR(2)-process

$$y_t^c = \phi_1 y_{t-1}^c + \phi_2 y_{t-2}^c + \varepsilon_t^c.$$

Stationarity implies that the roots of the polynomial equation

$$1 - \phi_1 L - \phi_2 L^2 = 0,$$

where L is the lag operator, should lie outside the unit circle. The assumption of an AR(2) process is not crucial for our purposes, but it fits the data for all three countries.

⁵The structural budget deficit will turn out to be a very important variable in the analysis below. It could be argued that the structural deficits should be estimated in the UC framework simultaneously with potential output. However, to keep the model simple, we have chosen to use estimates of the structural deficits produced by the OECD.

Identification

The unobserved components model above is generally not identified, see Harvey (1989), Jaeger and Parkinson (1994) and Morley, Nelson and Zivot (2003). To obtain an identified model, we need to impose some restrictions and add an additional equation to the system.

In order to separate the cycle from the trend and identify the other parameters, we impose the restriction that the shocks ε_t^i are mutually uncorrelated and normally distributed with variances $\sigma^{2,i}$, $i = n, c$. In addition to this, we need to add an observable variable to the system that is related to either the cyclical or the permanent component of output, but not to both. An expectations augmented Phillips curve meets these requirements and is modeled as

$$\Delta p_t = \lambda_0 + \lambda_1(L)\Delta p_{t-1} + \lambda_2(L)y_t^c + \lambda_3(L)Z_t + \varepsilon_t^p, \quad (4.5)$$

where Δp_t is the rate of consumer price inflation and Z_t a vector of supply shocks. The shock ε_t^p is assumed to be mutually uncorrelated with the other shocks in the model and normally distributed with variance $\sigma^{2,p}$. A more thorough discussion of the Phillips curve is given in Lindblad (1997) and Apel and Jansson (1999).

We restrict $\lambda_1(L) = 1$ and temporally aggregate (4.5) so as to work with the quarterly change in the year-on-year rate of inflation. This takes care of the strong seasonal effects in the data. The overlapping observations are obtained by multiplying through (4.5) with $\delta(L) = (1 + L + L^2 + L^3)$. We then obtain the following expression for the change in the year on year inflation rate:

$$\Delta\Delta_4 p_t = \lambda_0 + \lambda_2(L)\delta(L)y_t^c + \lambda_3(L)\delta(L)Z_t + \mu_t, \quad (4.6)$$

where $\mu_t = \delta(L)\varepsilon_t^p$. Obviously, overlapping observations make the errors serially correlated, $E(\mu_t\mu_{t-s}) \neq 0$ for $0 < s < 4$. When estimating the model we will therefore allow for a flexible ARMA process for the error term and check the Ljung-Box statistics to arrive at a preferred specification. We use

the untransformed cyclical component of output in the estimations, i.e. we estimate the parameters of the polynomial $\lambda_2^*(L) = \lambda_2(L)\delta(L)$.

Since the Phillips curve is used for identification, it is important that the specification is chosen carefully so that no bias is introduced into the parameter estimates for the growth rate. Ignoring supply-side changes will in general give rise to misspecification problems. In order to handle this, we have chosen to use import-price shocks, $\Delta^2 p_M$, and labor-productivity shocks, $\Delta^2 pr$, as proxies for supply shocks, Z_t . Thus, extracted potential output is the output level which is consistent with stable inflation in the absence of these two supply shocks.

After temporal aggregation, the supply shocks are the quarterly change in the annual rate of import price changes, $\Delta\Delta_4 p_M$, and the quarterly change in the annual rate of labor productivity growth, $\Delta\Delta_4 pr$.⁶ We tested several different specifications of our Phillips curves, mainly varying the number of lags of the exogenous variables and testing an oil prize variable as an additional supply-side shock. The selected specification for Sweden, the US and the Euro area explain 48-66 percent of the variation in the rate of inflation, are parsimoniously specified and have reasonable point estimates of parameters.

In order to estimate the model, we put it in state space form.

The transition equations

The transition equations for each country (still dropping country subscripts) are given by

$$U_t = \Phi U_{t-1} + \varepsilon_t, \quad (4.7)$$

⁶A temporally aggregated supply shock, $\delta(L)\Delta^2 z_t$, can be rewritten as $(1 + L + L^2 + L^3)(1 - L)^2 z_t = (1 - L)(1 + L + L^2 + L^3)(1 - L)z_t = (1 - L)(1 - L^4)z_t = \Delta\Delta_4 z_t$.

where

$$U_t = \begin{pmatrix} \Delta_4 y_t^n \\ y_t^c \\ y_{t-1}^c \\ y_{t-2}^c \\ y_{t-3}^c \\ y_{t-4}^c \\ \mu_t \\ \mu_{t-1} \\ \mu_{t-2} \\ \mu_{t-3} \\ \mu_{t-4} \end{pmatrix} \Phi = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \phi_1 & \phi_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \rho_1 & \rho_2 & \rho_3 & \rho_4 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{pmatrix} \varepsilon_t = \begin{pmatrix} \varepsilon_t^n \\ \varepsilon_t^c \\ 0 \\ 0 \\ 0 \\ 0 \\ \varepsilon_t^p \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix},$$

and where μ_t is the shock in equation (6). The model thus includes three transition equations, namely the random walk part of the trend growth (the drift or constant is included in the measurement equation), the output gap, and the ARMA process for the residual in the Phillips curve.⁷ In addition the system includes a set of identities.

The measurement equations

The measurement equations for each country are given by

$$Y_t = \Lambda U_t + \Psi X_t, \quad (4.8)$$

where (dropping country superscripts) the measurement vector contains changes in output and inflation

$$Y_t = \begin{pmatrix} \Delta_4 y_t \\ \Delta \Delta_4 p_t \end{pmatrix}.$$

⁷A moving average specification proved not to be as successful in removing serial correlation as the AR(4) specification eventually chosen for the error term.

Here Λ and Ψ are matrices and X_t is a vector of exogenous or predetermined variables and a constant, where the exact specifications are given in the tables below.

The exchange-rate equations

The real exchange rates and the explanatory variables discussed above are all non-stationary, see below. Theory and previous studies indicate that there exists a long-run relationship between the real exchange rate, output, terms of trade, demographic variables, and government budget deficits. A standard way of estimating non-stationary variables is to use an error-correction specification. Thus, when estimating the real exchange rates we have chosen the structure in equation (4.9) below, where the non-stationary variables appear in levels lagged one period. The first difference of all non-stationary variables are also included as explanatory variables in order to capture the short-run dynamics along with the domestic and the foreign output gap. The bilateral exchange rates given in (4.1) and (4.4) are thus modelled as

$$\Delta E_t = \Omega U_t^* + \Pi \begin{pmatrix} E_{t-1} \\ V_{t-1} \end{pmatrix} + \Gamma \Delta V_t + \nu_t, \quad (4.9)$$

where

$$E_t = \begin{pmatrix} e_t^{su} \\ e_t^{se} \end{pmatrix} U_t^* = \begin{pmatrix} U_t^s \\ U_t^u \\ U_t^e \end{pmatrix} \nu_t = \begin{pmatrix} \varepsilon_t^{su} \\ \varepsilon_t^{se} \end{pmatrix}$$

and Ω , Π and Γ are matrices. The matrix Ω picks out the three countries' cyclical outputs from the U_t^* vector, while the vector V_t contains the rest of the exogenous determinants of the real exchange rates: terms of trade, the share of middle-aged people in the population, the structural government budget deficit as a share of GDP and trend output. The exchange rate shocks are assumed to be normally distributed and correlated with each other but uncorrelated with the other shocks in the model.

4 Empirical results

The empirical models are estimated on a sample of quarterly data ranging from 1973:1 to 2000:4, after having allowed for lags and data availability. We have set aside eight years of data, 2001:1-2008:4, for a forecasting exercise.

During the sample period the Swedish krona was devalued several times and was allowed to float freely in November 1992. The regime shift can be handled in different ways. In the present analysis we have used four impulse dummies. This is in line with the results in Lindblad and Sellin (2010), where it was shown that the adjustment of the real exchange rate mainly takes place through changes in the nominal exchange rate (devaluations) and not through changes in the relative price level under the two different monetary regimes in Sweden.

In a first step, we estimate the output gap, potential output and the inflation rate separately for each country. In a second step, we estimate the two bilateral exchange rates simultaneously, using the output-gaps and potential output from the first step as regressors.⁸ The exchange-rate shocks will be correlated with each other and we take advantage of this in using a seemingly unrelated regression estimator. We also impose economically meaningful cross-equation restrictions, as explained when discussing equation (4.4) above, making this a full-fledged system estimation.

When using generated regressors, there is a risk that the estimated standard errors in the second step are biased downwards. However, this is not the case if the generated variables are strongly exogenous for the parameters of interest (c.f. Pagan, 1984; Jansson, 1994). In the model above this requirement is fulfilled. Both potential and cyclical output, are strongly exogenous since there is no feedback from the exchange rate to output in our model.

⁸Initially we tried to estimate the whole system simultaneously, but without success. We tried several different specifications, additional restrictions, different algorithms, different computer packages, but we were never able to generate any standard errors. However, many of the point estimates were close to the ones reported in this paper.

4.1 Stationarity

Before estimating the models, we consider the question of stationarity of the variables involved in the analysis.

Identification of the stationary cyclical GDP component requires all variables in the expectations augmented Phillips-curve to be stationary. All explanatory variables of the real exchange rates must also be integrated of the same order. However, the first-differenced variables in the exchange rate equations should be stationary. As mentioned above, theory states that the real exchange rate is driven by public debt among other variables. Public debt, measured as accumulated structural deficits, $accg$, seems to be integrated of order one (see Table 1). However, so does the structural deficit, g , which is the first difference of the debt level. In addition, the first difference of the deficit seems to be stationary. Juselius (2004) notes "We argue here that the order of integration should be based on statistical rather than economic arguments". We note that structural deficits/surpluses are persistent and can thus serve as an indicator of how the debt and thus the net foreign asset position will develop. Thus, in the empirical analysis below, we only use the structural deficit, g^i , $i = s, u, e.$, rather than both the public debt and deficit level as the theoretical discussion suggested. Table 1 presents the results from the standard augmented Dickey-Fuller test. The lag length is determined by the Akaike information criteria. As we read the results, all variables are integrated of the expected order.

4.2 Output and inflation

Table 2 reports the results from the estimation of output. The estimated potential growth rates are all of an expected magnitude, close to the sample averages. The point estimates of the AR(2) parameters and thus the cyclical part of output fulfills the stationarity criteria for all countries. The cycles are plotted in Figure 1. An inspection of the AR-parameters shows that the roots

to the corresponding polynomial equations are real.⁹ This was not expected, but the results are robust to alternative specifications of the models. For all countries, the estimated variance of the cyclical shock is larger than that of the potential growth shock. This is in line with the results in e.g. Lindblad (1997). In the case of Sweden, we cannot rule out that potential output has a deterministic trend, again an unexpected result. The test statistics suggest that the models are well behaved, we reject e.g. serial correlation and heteroskedasticity, and the models explain a surprisingly large fraction of the variation in the output growth rate, namely more than 75%.

Before estimating the output gaps, we had to specify the empirical Phillips curve. As discussed above, we started out with a flexible specification and ran a set of OLS regressions to reduce the model with respect to whether or not a variable was significant and whether or not the models behaved well in a statistical manner. In particular, we started out including many lags and also tested oil-price variables as proxies for supply side shocks and checked for serial correlation, heteroskedasticity and goodness of fit.

The resulting Phillips-curve specification was augmented with the output gap according to equation (4.5), to complete the second equation in the measurement system.

The estimation results are reported in Table 3. All parameters in the Phillips curve equation have the expected signs and are highly significant. The output gap and import price shocks increase the rate of inflation and productivity shocks reduce it. The parameters also proved to be surprisingly stable with respect to specification. They did not change significantly when including or excluding different lags or oil-price variables. The different parameters seem to have a reasonable magnitude. The sum of the import price shocks are close to the results in Lindblad and Sellin (2010), and not far from the import penetration in private consumption in the case of Sweden.

⁹The roots will be complex if $\phi_1^2 + 4\phi_2 < 0$.

Considering that the Euro area and US are more closed economies than Sweden, it is however a bit surprising that the import price effects on the Euro area and US inflation are of the same magnitude as in Sweden. The output gap parameter is perhaps slightly smaller than expected, see Lindblad (1997) and Lindblad and Sellin (2010). Regarding productivity shocks, our point estimates indicate a limited pass-through to inflation in the short run, which should be expected. The test statistics reported suggest that the three models are well behaved and explain a large fraction of the variation of the change in inflation.

The Phillips curve is of special interest for stabilization policy. As in Lindblad and Sellin (2010), we find some evidence that there is an effect from both contemporary and lagged output gaps suggesting that there is a limit to the speed with which the gap can be closed without causing a increase in inflation. The speed-limit is of the same magnitude for Sweden and the Euro-zone. The size of the speed limit is smaller than in Lindblad (2010), suggesting that demand policy can be more activist without changing inflation. In the case of US there is no clear evidence of a speed-limit, which could indicate that the US economy is more flexible.

4.3 Real exchange rates

The restrictions implying that Swedish variables do not affect the USD/EUR exchange rate are imposed by setting the adjustment parameters equal and also equalizing the parameters relating to Swedish variables when estimating the SEK/USD and SEK/EUR exchange rates. We have tested these restrictions, both one by one and simultaneously, and they were not rejected.

Below, we discuss and report the results from estimating the exchange rate system with respect to two different sets of restrictions. Model 1 is more flexible with fewer restrictions on the parameters beside the restriction that Swedish variables should not affect the USD/EUR exchange rate. In model 2 we use *relative* terms of trade and *changes in relative* terms of trade, that

is we impose the same parameter for q^s and q^i , and for Δq^s and Δq^i , $i=e,u$, instead of separately estimating the effect for each of these variables for the US and the Euro area. Thus, we impose four additional restrictions in model 2. In both models we have used four devaluation dummies.^{10,11}

The cointegrating relations presented below have all been derived from the variables (with associated estimated coefficients) that appear in levels in Table 4. The cointegrating relations derived for the Euro area in Model 1 are

$$-0.16 \left[e_{t-1}^{se} - \begin{pmatrix} k_1 & -3.25 & y_{t-1}^{n,s} & +2.44 & y_{t-1}^{n,e} & -1.25 & q_{t-1}^s & +2.38 & q_{t-1}^e \\ (-4.5,-2.0) & & (1.38,3.51) & & (-1.76,-0.63) & & (1.68,2.85) & & \\ -0.02 & d_{t-1}^s & -0.31 & d_{t-1}^e & +0.02 & g_{t-1}^s & -0.06 & g_{t-1}^e & \\ (-0.85,0.50) & & (-1.39,0.26) & & (0.01,0.03) & & (-0.07,-0.02) & & \end{pmatrix} \right],$$

$$-0.16 \left[e_{t-1}^{su} - \begin{pmatrix} k_2 & -3.25 & (y_{t-1}^{n,s} - y_{t-1}^{n,u}) & -1.25 & q_{t-1}^s & +1.75 & q_{t-1}^u \\ (-4.5,-2.0) & & (-1.76,-0.63) & & (1.23,2.45) & & \\ -0.02 & d_{t-1}^s & -2.94 & d_{t-1}^u & +0.02 & g_{t-1}^s & -0.06 & g_{t-1}^u & \\ (-0.85,0.50) & & (-4.38,-1.22) & & (0.01,0.03) & & (-0.07,-0.02) & & \end{pmatrix} \right].$$

where the k_i are unknown constants.¹² Bootstrapped 90 percent t-confidence intervals (using 5000 replications) are reported within parentheses below the coefficients, which have been computed from the estimated coefficients in Table 4. We also bootstrapped percentile confidence intervals. These were very similar to the t-confidence intervals, indicating no need for more elaborate bootstrapping methods.

¹⁰To remove spikes in the residuals due to devaluations of the Krona we have used impulse dummies for the following quarters: 1977:4, 1981:4, 1982:4, and 1993:1.

¹¹Different monetary regimes could motivate different models of the real exchange rate. Larsson (2002) tests this and finds some support for a regime-dependent behavior in the SEK/DEM real exchange rate. In Lindblad and Sellin (2010) also find some support of regime-dependency, however the result is not robust and depends how the devaluations are treated in the estimations.

¹²The constants are unknown since we do not know from the estimated equations what part of the estimated constant pertains to the cointegrating relation.

The corresponding cointegrating relations for Model 2 are

$$-0.13 \left[e_{t-1}^{se} - \begin{pmatrix} k_3 & -2.85 & y_{t-1}^{n,s} & +1.85 & y_{t-1}^{n,e} & -1.64 & (q_{t-1}^s - q_{t-1}^e) \\ (-3.63, -1.42) & (0.82, 2.66) & (-2.21, -1.16) & & & & \\ +1.24 & d_{t-1}^s & +0.06 & d_{t-1}^e & +0.013 & g_{t-1}^s & -0.076 & g_{t-1}^e \\ (0.05, 1.59) & (-1.07, 0.91) & (0.001, 0.020) & (-0.085, -0.019) & & & & \end{pmatrix} \right],$$

$$-0.13 \left[e_{t-1}^{su} - \begin{pmatrix} k_4 & -2.85 & (y_{t-1}^{n,s} - y_{t-1}^{n,u}) & -1.64 & (q_{t-1}^s - q_{t-1}^u) \\ (-3.63, -1.42) & (-2.21, -1.16) & & & & & & \\ +1.24 & d_{t-1}^s & -3.64 & d_{t-1}^u & +0.013 & g_{t-1}^s & -0.10 & g_{t-1}^u \\ (0.05, 1.59) & (-4.32, -1.19) & (0.001, 0.020) & (-0.12, -0.03) & & & & \end{pmatrix} \right].$$

Using these equations we can calculate the corresponding cointegrating relations for the USD/EUR real exchange rate as

$$-0.16 \left[e_{t-1}^{ue} - \begin{pmatrix} k_5 & -3.25 & y_{t-1}^{n,u} & +2.44 & y_{t-1}^{n,e} & -1.75 & q_{t-1}^u & +2.38 & q_{t-1}^e \\ (-4.5, -2.0) & (1.38, 3.51) & (-2.45, -1.23) & (1.68, 2.85) & & & & & \\ +2.94 & d_{t-1}^u & -0.31 & d_{t-1}^e & +0.06 & g_{t-1}^u & -0.06 & g_{t-1}^e \\ (1.22, 4.38) & (-1.39, 0.26) & (0.02, 0.07) & (-0.07, -0.02) & & & & \end{pmatrix} \right]$$

in the case of model 1, and for model 2 we get

$$-0.13 \left[e_{t-1}^{ue} - \begin{pmatrix} k_6 & -2.85 & y_{t-1}^{n,u} & +1.85 & y_{t-1}^{n,e} & -1.64 & (q_{t-1}^u - q_{t-1}^e) \\ (-3.63, -1.42) & (0.82, 2.66) & (-2.21, -1.16) & & & & & & \\ 3.64 & d_{t-1}^u & -0.06 & d_{t-1}^e & +0.10 & g_{t-1}^u & -0.076 & g_{t-1}^e \\ (1.19, 4.32) & (-0.91, 1.07) & (0.03, 0.12) & (-0.085, -0.019) & & & & \end{pmatrix} \right].$$

The results presented in Table 4 and above are well in line with what we expected from our introductory theoretical discussion. Thus, potential output in the home country and terms of trade increase wealth, and strengthens the exchange rate. An increase in the budget deficit in the home country depreciates the currency.

One objective of this paper is to make use of estimated potential output instead of approximating it with GDP, which has so far been the standard route in the literature (Lane and Milesi-Ferretti, 2004). To find out if it is worthwhile to filter output, we replaced our potential output estimates in the regressions above with observed GDP. This resulted in a less accurate

model, as measured by adjusted R^2 . In terms of this criterion, estimates of potential and cyclical output consequently resulted in a superior empirical model.

As seen in Table 4, relative potential output and potential output always enter significantly and with the expected signs. The long-run coefficients given in the error correction equations above indicate that an increase in relative potential output strengthens the exchange rate substantially, a one per cent higher *level* of potential output will increase the real exchange rate level by as much as three per cent

According to previous studies, an increase in terms of trade should cause an appreciation of the exchange rate. Relative terms of trade, terms of trade and the change in terms of trade always enter highly significantly and with expected signs. The point estimates show that terms of trade is potentially of substantial importance in explaining the evolution of the real exchange rates, which is in line with previous results (c.f. Lane and Milesi-Ferretti 2004). An improvement of the relative terms of trade by one per cent strengthens the real exchange rate by up to two per cent. In the short run, a one percent change in term of trade will increase the real exchange rate by almost one per cent.

Theory suggests that net foreign assets are important. As discussed above, exogenous determinants of the net foreign asset position include demographic structure and government fiscal position. Regarding the demographic variables the results are mixed. However when the parameters are more precisely estimated, as is always the case for the US and Swedish demographic variables in Model 2, the point estimates suggest that a relative increase in the fraction of middle-aged people will depreciate the real exchange rate. This is consistent with our discussion that a large middle-aged cohort accumulate funds ahead of retirement, which requires that the real exchange rate depreciates.

The structural budget situation is clearly of importance. Our point esti-

mates are highly significant and indicate that an increased structural deficit will have a substantial depreciating effect. The estimates indicate that the effect is larger for the Euro area and the US than for Sweden. An increase of the structural deficit by one per cent of GDP in the US could depreciate the USD/EUR exchange rate by as much as 10 per cent in the long run. The structural deficit is obviously a prime candidate for partly explaining the USD/EUR development.

Regarding the short run dynamics, changes in the terms of trade are important and estimated quite precisely. However, this does not apply to the business cycle effect on the real exchange rate dynamics.¹³

The test statistics reported in Table 4 suggest that the models are well behaved and explain a large fraction of the variation in the real exchange rate changes. The values of the adjusted R^2 's range from 0.57 to 0.67.

The long-run relationships are shown together with the actual real bilateral exchange rates in Figures 2-4.¹⁴ The Swedish krona has followed a depreciating trend over the whole sample period 1973-2000. The nominal exchange rate was fixed (but devalued several times) up until November 19, 1992, when the Krona was allowed to float. The fundamentals of the model are able to surprisingly well explain the long-run movements in the SEK/USD and SEK/EUR exchange rates. Especially noteworthy is the depreciation of the SEK/EUR given by our models which occurs well ahead of the floating of the krona in late 1992. The implied USD/EUR long-run relations shown in Figure 4 also provide a good fundamental explanation of the actual USD/EUR exchange rate. The major movements in our model precede major movements in the actual exchange rate.

In Figures 5-7 we show the complete model (in levels form) that allows for short run dynamics as well as the error correction term. The devaluation

¹³We tried to include several measures of the real interest differential, but this did not improve the results.

¹⁴The constants, k_i , have been determined such that the sample averages of the error correction terms are equal to zero.

effects in 1977:4, 1981:4 and 1982:4, as well as the large depreciation in 1993:1, have been captured by including devaluation dummies to handle the resulting spikes in the time series. Compared to the long-run relations we get an even better fit, although the major movements are already captured in Figures 2-4. Of course, with dummy variables included the level shifts will occur in those quarters after a devaluation took place and not precede the devaluations as was the case before.

The proof of the pudding is in the eating. Figures 5-7 illustrate the models' out-of-sample forecasts from the end of 2000 up to the 4th quarter of 2008. During the forecast period, we use actual values of the explanatory variables, and projections of cyclically adjusted fiscal balances from the OECD. Regarding potential output we used the estimated values of potential output for Sweden and the Euro-area. In views of changing productivity trends we used the average growth rate of actual GDP between 2000 and 2008 for the US.

Compared with the actual exchange rate movements our small models do unexpectedly well in capturing the rise and fall of the Dollar. The models also captures well the ongoing depreciation of the Krona vis-a-vis the Euro. Looking at Figure 7, the model does a very good job capturing the strengthening of the Euro vis-a-vi the Dollar. The structural budget deficit and potential output are central variables responsible for the success of the forecast performance during this particular period. The out-of-sample results indicate that the models are surprisingly stable.

5 Conclusion

The evolution of a real exchange rate is often hard to rightly understand, especially in the short run. Ever since Meese and Rogoff's (1983) celebrated study it is often claimed that a real exchange rate is best approximated by a random walk; that is, the best guess for tomorrow is the going rate today.

Theoretically, it has been shown that a real exchange rate is determined, at least in the long run, by a set of factors such as e.g., terms of trade, output or productivity differentials and the net foreign asset position.

The most common approach when analyzing and estimating real exchange rates is to study a bilateral exchange rate or comparing one currency to a weighted basket of other currencies and adjusting for relative price levels. In the case of Sweden, the usual approach has been to compare the Swedish Krona with a trade-weighted basket or the Euro, and multiplying the nominal exchange rate with the relative consumer price level.

The contribution of this paper is to estimate a small system of different real exchange rates in order to simultaneously analyze movements in the real exchange rate between the Krona, the Euro and the Dollar, the three most important real exchange rates for Swedish exports.

Our empirical model is based on the theoretical results from the new open macroeconomics literature. In our specification, the real exchange rate is determined by terms of trade, relative potential output and a set of exogenous variables assumed to determine the net foreign asset position. Potential outputs in Sweden, the Euro area and the US are successfully estimated in separate unobserved components frameworks, including an expectations augmented Phillips curve.

We are able to explain a surprisingly large fraction of the variation in the change of the real exchange rates. Our point estimates are in line with theory and highly significant. This is also true for the estimated output equation as well as for the Phillips curve.

Starting with potential output, our estimates indicate that potential growth is highest in the US, followed by the Euro area. Our Phillips curve estimates show that inflation is more sensitive to the output gap in the US than in Sweden and the Euro area. A somewhat unexpected result is that inflation is at least as sensitive to import price shocks in the US and the Euro area as it is in Sweden, despite the fact that the Swedish economy is much more

open.

Regarding the real exchange rates, an increase in relative potential output by one per cent strengthens the currency by up to more than three per cent in the long run. The Krona and the Dollar benefit more from this effect than the Euro. Terms of trade are also important, both in the long run and in the short run. An increase in the export prices relative to import prices by one percent strengthens the currency of the exporting country by up to two per cent, indicating that the wealth effect dominates. The result is also consistent with a home bias in the consumption of tradeable goods. The appreciating effect from a strengthening of terms of trade is also well in line with previous results. When estimating the effect without restrictions it seems as if the Euro area benefits the most from an increase in the export prices. We have chosen to use the relative demographic situation and relative structural fiscal position of the government as determinants of net foreign assets. When statistically significant, an increase in the relative middle-age cohorts is found to weaken the exchange rate. The structural budget situation is of great importance and an increase in the deficit has a depreciating effect. The depreciating effect again indicates that the negative wealth effect dominates. The point estimates indicate that the effect is larger for the US and the Euro area than for Sweden. An increase in the US deficit by one per cent of GDP could depreciate the USD/EUR by as much as 10 per cent in the long run, and is thus an important candidate explaining the large movements in the relative value of the dollar and the Euro.

We also show that the models do a very good job in tracking the real exchange rates in an out-of-sample exercise covering more than 30 observations.

Finally, we believe that the approach in this paper can be of use when analyzing the equilibrium value of a real exchange rate. This is an important task, e.g., for countries that have joined the European Union but not yet adopted the Euro. When determining the central rate within the European

Exchange Rate Mechanism, ERM2, and later on the conversion rate, it is important that the nominal rate does not induce an inflation shock in order to restore an economically motivated real exchange rate.

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A Appendix

A.1 Data appendix

Foreign variables have been computed from the weights used in constructing the TCW index for the Swedish krona. When computing the weights for the EMU, the TCW weights have been rescaled to sum to one. Population statistics were obtained from Statistics Sweden and the respective statistics bureaus of the other countries involved.

- $accg$ = accumulated structural budget deficits g , as a percent of potential GDP. Computed by the OECD.
- d = Middle-age ratio, computed as the sum of 45-59 years old relative to the total population. Statistics Sweden and the respective statistics bureaus of the other countries involved.
- e = Real exchange rate computed as the (log) of the product of the nominal exchange rate and relative consumer prices. In the case of SEK/USD the real exchange rate is $\log(SEK/USD \cdot P^u/P)$. Sveriges Riksbank and Statistics Sweden.
- g = structural government deficit as percent of potential GDP. Computed by the OECD).
- P = Consumer price index. Statistics Sweden.
- P_X = Export deflator. Statistics Sweden.
- P_M = Import deflator. Statistics Sweden.
- pr = log of labor productivity (GDP per hours worked). Statistics Sweden.
- $q = \log(P_X/P_M)$, the terms of trade, computed as export deflator over import deflator.

- $y = \log$ of real gross domestic product (s.a.). Statistics Sweden.

Figure 1. The cyclical part of output

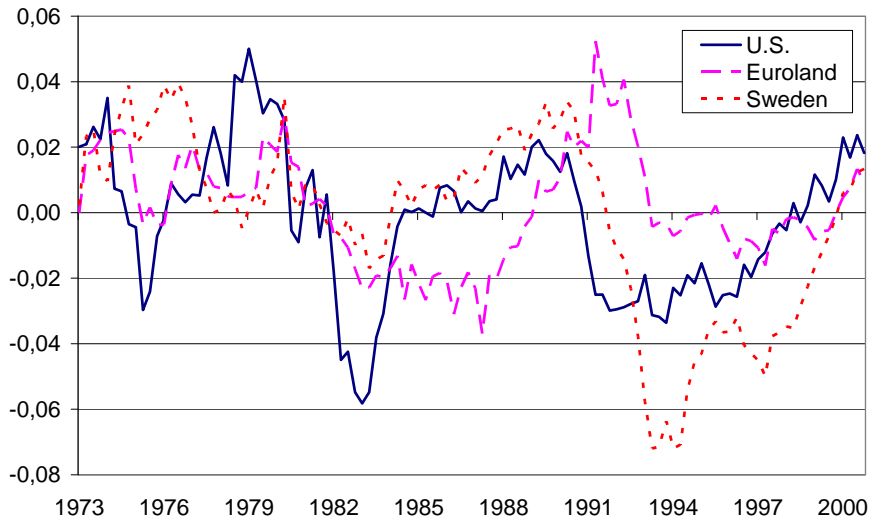


Figure 2. Real SEK/USD and long-run relations

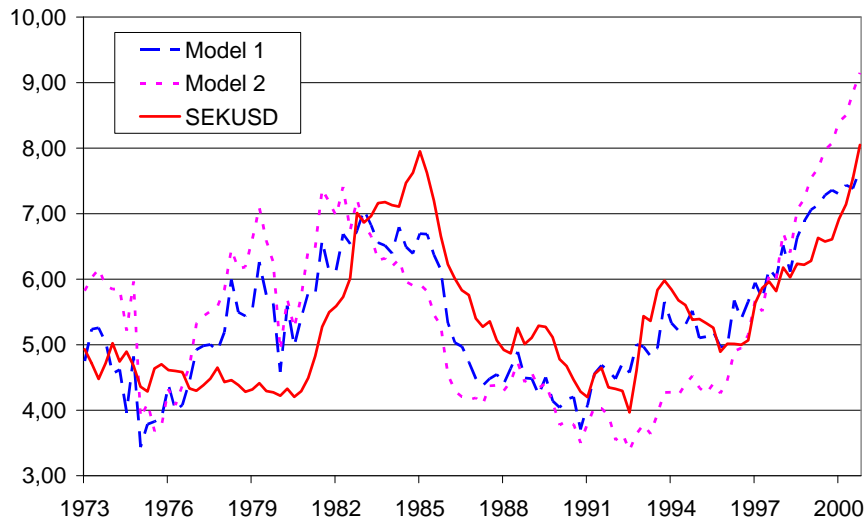


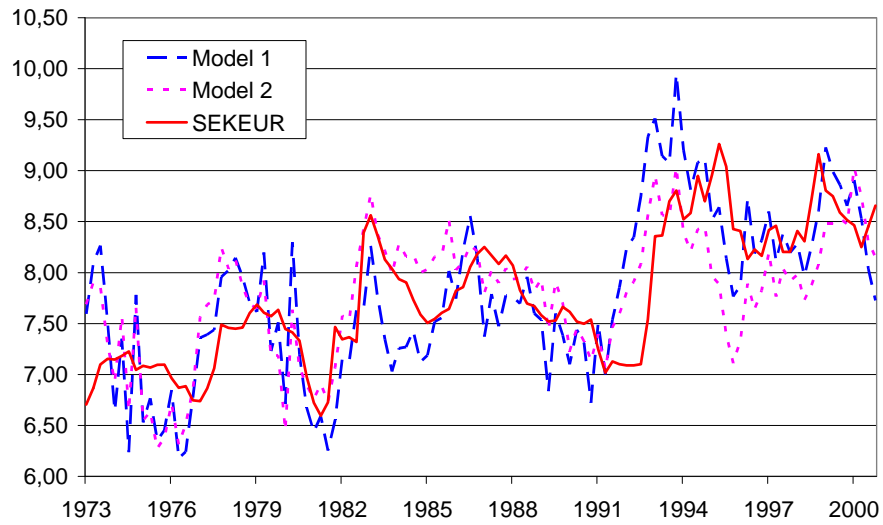
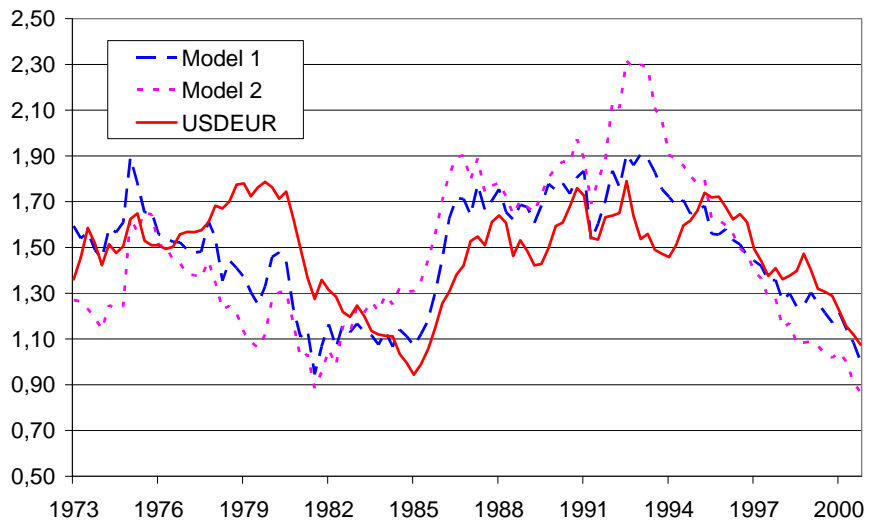
Figure 3. Real SEK/EUR and long-run relations**Figure 4. Real USD/EUR and long-run relations**

Figure 5. Real SEK/USD and forecast 2001:1 - 2008:4

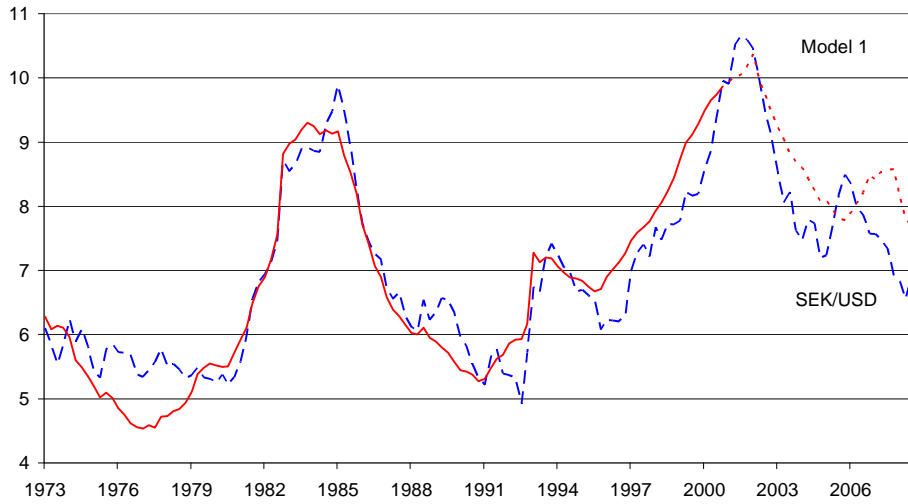


Figure 6. Real SEK/EUR and forecast 2001:1 - 2008:4

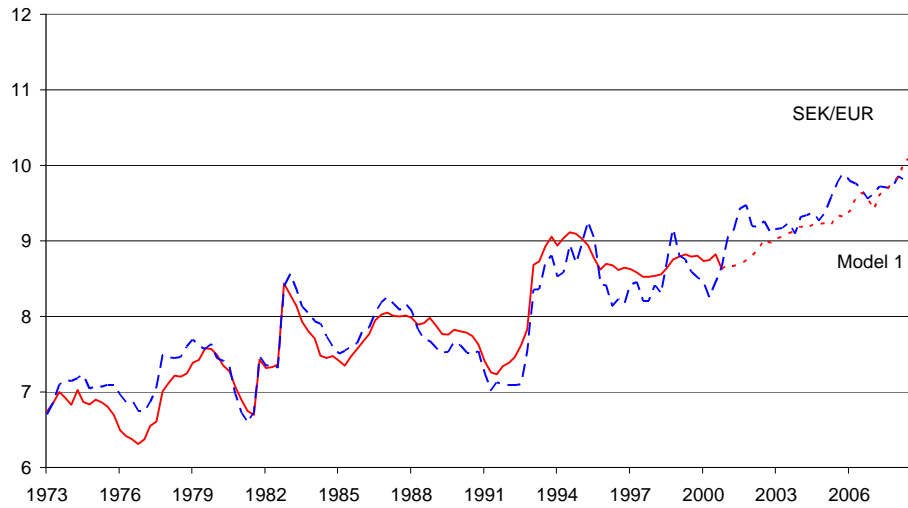


Figure 7. Real EUR/USD and forecast 2001:1 - 2008:4

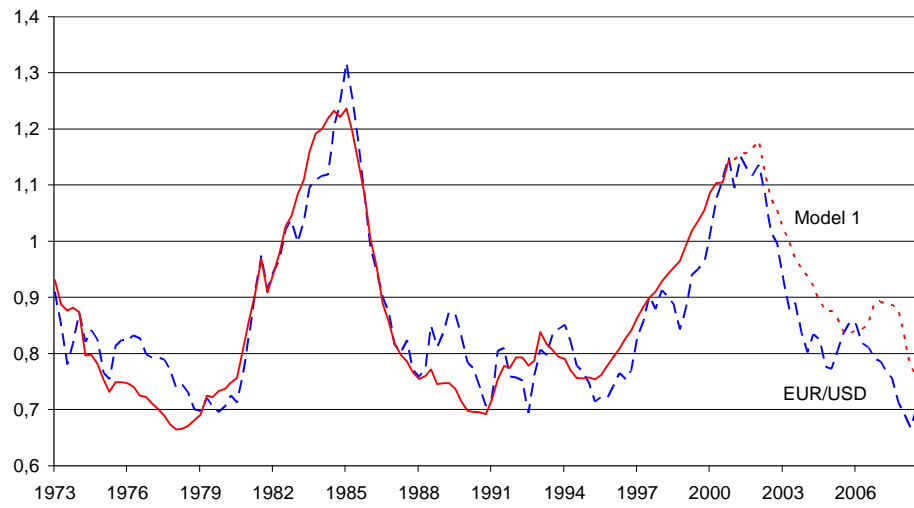


Table 1: Unit root tests

Augmented Dickey-Fuller test. ***, **, * denote rejection of a unit root at significance level 1, 5, and 10 percent respectively. Two statistics are reported for the exchange rates, one relating to SEK/USD and one relating to SEK/EUR. Three statistics are reported for the other variables relating to Sweden, Euroland, and the United States. The number of lags used in the tests are also reported.

Variable	Test statistic	Lags
y	-0.04/-0.87/-0.01	1/1/1
Δ_4y	-4.40***/-3.35***/-3.91***	3/5/5
$\Delta\Delta_4p$	-3.35**/-4.28***/-4.08***	7/7/4
$\Delta\Delta_4p_M$	-9.08***/-8.08***/-7.48***	3/3/3
$\Delta\Delta_4pr$	-8.33***/-8.20***/-7.32***	4/3/4
e	-1.62/-2.12	3/1
Δe	-6.43***/-7.50***	1/1
q	-2.12/-1.68/-3.33*	3/4/5
Δq	-7.83***/-5.64***/-7.09***	1/3/1
d	-1.38/-4.07***/-0.73	5/5/5
Δd	-3.68***/-1.85/-2.27	4/4/4
$accg$	-1.54/-1.21/-1.32	5/3/3
g	-2.29/-0.99/-0.28	2/1/1
Δg	-4.62***/-4.43***/-4.00***	1/4/2

Table 2: Output equation

Dependent variable: the quarterly change in annual output. The exact specification of the dynamics differ among the models and are available on request. Probability values are reported within parentheses below the estimated coefficients. Serial corr. is a Box-Ljung Q(k) test against serial correlation based on k=12 autocorrelations. Heterosk. is a Q(12) test of the squared residuals.

Variables	Sweden	Euroland	US
<i>constant</i>	$1.95 * 10^{-2}$ (0.00)	$2.41 * 10^{-2}$ (0.00)	$3.08 * 10^{-2}$ (0.00)
ϕ_1	0.64 (0.00)	1.15 (0.00)	1.21 (0.00)
ϕ_2	0.28 (0.00)	-0.23 (0.03)	-0.30 (0.01)
σ^c	0.01	$6.4 * 10^{-3}$	$8.3 * 10^{-3}$
σ^n	$1.1 * 10^{-7}$	$5.5 * 10^{-4}$	$2.0 * 10^{-4}$
R^2	0.77	0.94	0.95
Serial corr.	(0.281)	(0.716)	(0.261)
Heterosk.	(0.681)	(0.702)	(0.242)
Skewness	-0.52	0.93	-0.29
Kurtosis	5.15	6.76	5.23
Jarque-Bera	(0.000)	(0.000)	(0.000)

Table 3: The expectations-augmented Phillips curve

Dependent variable: the quarterly change in the annual rate of inflation. The exact specification of the dynamics differ among the countries and the full results are available on request. Probability values are reported within parentheses below the estimated coefficients. Serial corr. is a Box-Ljung Q(k) test against serial correlation based on k=12 autocorrelations. Heterosk. is a Q(12) test of the squared residuals.

Variables	Sweden	Euroland	US
y_t^c	0.07 (0.00)	0.07 (0.00)	0.10 (0.00)
y_{t-3}^c			
y_{t-4}^c	-0.04 (0.09)	-0.04 (0.02)	-0.03 (0.14)
$\Delta\Delta_4p_{m,t}$	0.07 (0.00)	0.07 (0.00)	0.11 (0.00)
$\Delta\Delta_4p_{m,t-3}$	0.06 (0.00)	0.05 (0.00)	0.04 (0.01)
$\Delta\Delta_4pr_{t-2}$	-0.09 (0.01)	-0.07 (0.14)	$3.8 * 10^{-3}$ (0.92)
$\Delta\Delta_4pr_{t-3}$	-0.07 (0.01)	-0.04 (0.33)	
σ^p	$5.2 * 10^{-3}$	$2.5 * 10^{-3}$	$4.1 * 10^{-3}$
ρ_1			0.16 (0.10)
ρ_2			-0.30 (0.00)
ρ_3			0.22 (0.01)
ρ_4	-0.56 (0.00)		-0.41 (0.00)
R^2	0.48	0.66	0.65
Serial corr.	0.767	0.253	0.264
Heterosk.	0.340	0.842	0.001
Skewness	0.05	-0.38	-0.14
Kurtosis	3.07	3.46	3.44
Jarque-Bera	(0.969)	(0.161)	(0.530)

Table 4: Exchange rate equation

Dependent variable: the percentage change in the real exchange rate. Probability values are reported within parentheses. Full model results are available on request. We have used four devaluation dummies, 1977:4, 1981:4, 1982:4 and 1993:1 (the SEK has floated freely since 19 November 1992). Serial corr. is a Box-Ljung Q(k) test against serial correlation based on k=12 autocorrelations. Heterosk. is a Q(12) test of the squared residuals.

Variables	$\Delta \log(\text{SEK}/\text{USD})$		$\Delta \log(\text{SEK}/\text{EUR})$	
	Model 1	Model 2	Model 1	Model 2
$y^{c,s}$	0.06 (0.58)	-0.06 (0.60)	0.06 (0.58)	-0.06 (0.60)
$y^{c,*}, * = u, e$	-0.25 (0.19)	-0.28 (0.12)	-0.14 (0.37)	-0.03 (0.86)
e_{t-1}	-0.16 (0.00)	-0.13 (0.00)	-0.16 (0.00)	-0.13 (0.00)
$y_{t-1}^{n,s}$			-0.52 (0.00)	-0.36 (0.00)
$y_{t-1}^{n,*}, * = u, e$			0.39 (0.01)	0.24 (0.02)
$(y^{n,s} - y^{n,*})_{t-1}$	-0.52 (0.00)	-0.36 (0.00)		
q_{t-1}^s	-0.20 (0.02)		-0.20 (0.02)	
$q_{t-1}^*, * = u, e$	0.28 (0.01)		0.38 (0.00)	
$(q^s - q^*)_{t-1}$		-0.21 (0.01)		-0.21 (0.01)
d_{t-1}^s	$-2.8 * 10^{-3}$ (0.97)	0.16 (0.04)	$-2.8 * 10^{-3}$ (0.97)	0.16 (0.04)
$d_{t-1}^*, * = u, e$	-0.47 (0.02)	-0.46 (0.00)	-0.05 (0.64)	0.01 (0.94)
g_{t-1}^s	$3.3 * 10^{-3}$ (0.01)	$1.7 * 10^{-3}$ (0.09)	$3.3 * 10^{-3}$ (0.01)	$1.7 * 10^{-3}$ (0.09)
$g_{t-1}^*, * = u, e$	-0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)	-0.01 (0.00)
Δq_t^s	-0.76 (0.00)		-0.76 (0.00)	
$\Delta q_t^*, * = u, e$	0.94 (0.00)		0.95 (0.00)	
$(\Delta q^s - \Delta q^*)_t$		-0.86 (0.00)		-0.86 (0.00)
SE	0.03	0.03	0.02	0.02
$\overline{R^2}$	0.57	0.57	0.67	0.64
Serial corr.	(0.409)	(0.439)	(0.467)	(0.680)
Heterosk.	(0.470)	(0.750)	(0.000)	(0.000)
Skewness	0.40	0.57	0.27	0.30
Kurtosis	3.54	4.02	3.32	3.20
Jarque-Bera	(0.113)	(0.004)	(0.395)	(0.391)
Dummies	Yes	Yes	Yes	Yes

Chapter 5

Wages, Employment, and Unemployment: The Effects of Benefits, Taxes and Labor Mobility *

1 Introduction

The main purpose of this paper is to analyze how unemployment benefits, the financing of those benefits, the behavior of trade unions, and labor mobility affect wages and employment. As for unemployment insurance, the aim is to examine the robustness of some earlier results in the literature. Unlike much of the earlier literature, I also introduce labor mobility between sectors. The general result is that mobility can reduce or increase the incentive for high wages, depending on the elasticity of labor demand. However, for elasticity values common in the empirical literature, mobility reduces the incentive

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for higher wages since higher wages in a sector increase labor supply and unemployment. The wage dampening effect increases with the number of sectors. Thus, competition increases employment.

The wage and employment effects of changes in unemployment benefits have been analyzed in a number of studies, (e.g. Oswald, 1982; Calmfors and Forslund, 1990; Atkinson and Micklewright, 1991; Layard *et al.*, 1991; Fredriksson and Holmlund, 2003). According to the theoretical analysis in that work, wages are set as a mark-up on the unemployment benefit level. Thus, higher benefits raise wages and reduce employment. Empirical results are, however, less clear-cut (e.g. Atkinson and Micklewright, 1991; Forslund, 1995; Carling *et al.*, 1996; Forslund and Kolm, 1999; Carling *et al.*, 2001; Calmfors, Forslund and Hemström, 2004 and Lindblad and Sellin, 2010).

One way of getting around the adverse effect of unemployment benefits on employment is to finance unemployment benefits in a way that creates incentives for lower wages or for not laying off workers. An example of the latter is the experience-rated tax system in the US, where the pay-roll tax, at least to some extent, is set to reflect individual employers' lay-off history (e.g. Anderson and Meyer, 1995; Krueger and Meyer, 2002). Such a tax scheme increases firing costs and creates a disincentive to lay off workers. However, at the same time, hiring costs are increased which reduces the incentive to hire workers (Hamermesh, 1993).

Holmlund and Lundborg (1988, 1989) and Calmfors (1993, 1995) have suggested an alternative to the experience-rated pay-roll tax system. In these proposals, wage setting and employment are influenced by differentiating the contributions to unemployment support by areas of wage bargaining. Calmfors (1995) notes that "this approach should be of relevance for Europe where bargaining often occurs at an intermediate (usually industry) level, in which case hiring and firing costs of firms are not directly affected". The idea is to face the parties of bargaining with some of the costs for unemployment, thereby increasing the perceived benefits of wage moderation.

In Sweden, the unemployment insurance system is combined with active labor market policies. Until recently, an unemployed person could therefore receive benefits indefinitely. However, the system was changed in 2007 and since then unemployment benefits can only be received during at most a year.

The Swedish unemployment insurance system is non-compulsory and has by tradition been administered by labor unions. Thus, different sectors already have their own unemployment insurance administration and the fees from the insured members differ among sectors. Nevertheless, the system has been heavily subsidized by the central government. Until recently, more than 90 per cent of the costs in the insurance system were borne by the government. At the margin, the contribution from the government was effectively 100 percent (Holmlund, 1998 and 1999). Thus, employee contributions only covered a small fraction of the unemployment costs. Similar systems exist in Belgium, Denmark, and Finland. In 2007 and 2008, the Swedish system was reformed and the subsidy was reduced in order to strengthen the incentives to reduce unemployment. Both the average and marginal subsidy were reduced to approximately 65-70 per cent.

In the pre-2007 system, the bargaining parties in one industry could settle for high wages without having to pay for the resulting unemployment. The costs were instead borne by all workers via the tax system. An institutional set-up with sector-specific insurance administrations does, however, make it possible to differentiate contributions from both insured members and from firms operating within the sector.

Results in the previous literature were usually obtained from monopoly-union models, or bargaining models where unions maximize the expected utility (income) of a representative member. No distinction is made between insiders and outsiders, however, and taxes are treated as exogenous when wages are set. Moreover, labor supply to each sector is assumed to be fixed and all sectors are symmetric. An exception to the treatment of labor supply as fixed is Holmlund and Lundborg (1990) who model a segmented labor

market with both a unionized sector and a non-unionized sector.

In this paper, the wage effects of unemployment benefits, benefit financing and mobility are analyzed in a simple model where labor can move freely between sectors in the economy. In the first section, I examine the robustness of some previous results in the literature. More specifically, I study how wages and employment are affected by the objective of the unions, the level of unemployment compensation, and the tax scheme in order to finance unemployment benefits. The analysis is carried out in a unionized multi-sector economy where all sectors are identical and union membership is compulsory. In the second section, I study how wages and employment are affected by labor mobility *per se* and by unemployment insurance and its financing when labor can move between sectors. In the third section, I sum up and conclude.

2 A model of wage setting without labor mobility

Assume that the economy is open and consists of I sectors labeled $i = 1 \dots I$. In each sector there are many firms, and prices are given from the world market. In each sector there is one union, which organizes all workers, m_i , and one employer organization, which organizes all firms in the sector. At the going wage level, l_i workers are employed and $m_i - l_i$ workers are unemployed in sector i . When unemployed, a union member receives the unemployment benefit b which is common across sectors. A union member is assumed to care about her expected income, that is a weighted average of the income in the two states, employed or unemployed.

In the economy, there is only one type of public expenditure, namely the common unemployment benefits. The unemployment insurance (UI) costs are financed through contributions from the employees. The contribution is modelled as a proportional income tax levied on employed workers' wages, which can differ across sectors.

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Thus, the expected income of a representative member in union i can be written as

$$u_i = \frac{l_i}{m_i} w_i (1 - t_i) + \left(1 - \frac{l_i}{m_i}\right) b,$$

where w_i is the prevailing wage level for all employees in sector i and t_i is the income tax rate.

Now, divide the tax rate in each sector into two components; a common component, t_0 , and a sector-specific component, \bar{t}_i , i.e.,

$$t_i = t_0 + \bar{t}_i.$$

The sector-specific component, \bar{t}_i , is chosen such that the employees in a given sector cover a certain fraction, γ , of the unemployment costs in the sector, $b(m_i - l_i)$. In other words, we have

$$w_i l_i \bar{t}_i = \gamma b(m_i - l_i)$$

or

$$\bar{t}_i = \gamma b \frac{(m_i - l_i)}{w_i l_i}.$$

Thus, the tax rate t_i can be written as

$$t_i = t_0 + \gamma b \frac{m_i - l_i}{w_i l_i}. \quad (5.1)$$

The parameter, γ , is going to determine how much of sector-specific unemployment costs are internalized in the wage setting procedure. If $\gamma = 0$ the sector-specific costs will not be taken into account at all; if $\gamma = 1$ the unemployment costs are fully taken into account.

The standard approach is to assume that union utility is the same as the utility of the representative union member. This assumption implies that the union cares as much as employees about employment. To relax this assumption, I formulate a more general utility function that nests several

alternative specifications (Nickell, 2003). Union utility u_i is assumed to be given by:

$$u_i = \left(\frac{l_i}{m_i}\right)^\delta w_i(1 - t_i) + \left(1 - \left(\frac{l_i}{m_i}\right)^\delta\right) b$$

or

$$u_i = \left(\frac{l_i}{m_i}\right)^\delta (w_i(1 - t_i) - b) + b$$

The parameter $0 \leq \delta \leq 1$ is a measure of the weight unions put on employment. If $\delta = 1$, the unions fully care about sector specific employment when negotiating wages. If $\delta = 0$, unions only care about employed members' (insiders') after-tax wage level.

Thus, this specification nests, among others, three different cases that will be analyzed below. In the first, and most general case considered, $0 < \delta < 1$. In the second case $\delta = 1$: this is the standard specification in earlier studies. In the third case $\delta = 0$. This specification implies that unions only care about the after-tax wage, which could be the case if the representative union member is an insider facing no risk of becoming unemployed.

Firms are assumed to maximize profits and the employer organization in sector i maximizes aggregate profit in the sector, denoted Π_i .

Wages are determined by negotiations between the union and the employer organization at the sector level. In case of disagreement between unions and employers it is assumed that the union members obtain the utility u_0 and the firms' profits are zero. The fall-back position of the union members, u_0 , is assumed to be either the unemployment benefit level, b , or zero, which is the case if unions only care about the after-tax wage level.

Taking into consideration the different alternative fall-back positions of the union members, I end up analyzing four different alternative specifications below. In the first, and most general, case considered, $0 \leq \delta \leq 1$ and $u_0 = b$. In the second case $\delta = 1$ and $u_0 = b$, the standard specification in earlier studies. In the third case $\delta = 0$ and $u_0 = b$. This specification is an insider-outsider specification, and implies that unions only care about the

after-tax wage mark-up over benefits. The fourth and last case is an alternative insider-outsider specification where $\delta = 0$ and $u_0 = 0$, implying that the union only cares about the after-tax wage level. This last specification has been studied by Calmfors (1995).

Case	δ	u_0	Label
1	$0 \leq \delta \leq 1$	b	General
2	1	b	Standard
3	0	b	Mark-up IO
4	0	0	Pure IO

2.1 Wage setting

Wages are assumed to be set so as to maximize the Nash bargaining product

$$\Omega = [u_i - u_0]^a \Pi_i^{1-a}$$

subject to equation (5.1) and the labor demand equation

$$l_i = l(w_i), \tag{5.2}$$

which follows from profit maximization of the individual firms.

In case 1 the Nash bargaining product is

$$\Omega = \left[\left(\frac{l_i}{m_i} \right)^\delta (w_i(1 - t_i) - b) \right]^a \Pi_i^{1-a}. \tag{5.3}$$

Assuming an interior solution, the first order condition (FOC) for case 1 can be written as

$$\Omega_{w_i} = \frac{1}{w_i(1 - t_i) - b} \left(1 - t_0 - \frac{\gamma b m_i \varepsilon_i}{w_i l_i} \right) - \delta \frac{\varepsilon_i}{w_i} - \frac{(1 - a) l_i}{a \Pi_i} = 0, \tag{5.4}$$

where the envelope theorem result

$$\frac{\partial \Pi_i}{\partial w_i} = -l_i$$

has been used¹ and where ε_i is the wage elasticity of labor demand, i.e.,

$$\varepsilon_i = -\frac{\partial l_i}{\partial w_i} \frac{w_i}{l_i}.$$

In order to rule out corner solutions, union members are always assumed to prefer work to being unemployed, i.e.,

$$w_i(1 - t_i) - b > 0.$$

The FOC (5.4) is standard, and shows that the marginal increase in the union's utility (captured by the two first terms of the equation) is traded off against the marginal loss of profits (captured by the last term of the FOC). As for the union's marginal utility, the first term captures the direct utility gain from an after-tax wage increase, and the second term, $\delta\varepsilon_i/w_i$, captures the (smaller) utility loss from the employment reduction following a wage increase. Since the last profit term is always negative, the sum of the two first terms is positive.

¹To see this note that aggregate profits in sector i , Π_i , is

$$\Pi_i = N_i [F(l_{ji}) - w_i l_{ji}]$$

where N_i is the number of firms in sector i , F is the production function and l_{ji} is employment in firm j in sector i . Profit maximization gives

$$F'(l_{ji}) - w_i = 0.$$

The wage-setting parties take into account that firms set employment according to profit maximization. If firms in each sector are symmetric, it holds that $N_i l_{ji} = l_i$. Thus

$$\frac{\partial \Pi_i}{\partial w_i} = N_i \left[(F'(l_{ji}) - w_i) \frac{\partial l_{ji}}{\partial w} - l_{ji} \right] = -N_i l_{ji} = -l_i.$$

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To analyze the general-equilibrium implications from a change in δ , b or γ , I assume symmetry, that is, that all sectors are alike ($w_i = w$, $l_i = l$, and $m_i = m$), and insert a balanced-budget condition in the FOC.

A balanced budget requires that

$$wlt = (m - l)b. \quad (5.5)$$

Using this requirement together with equation (5.1) gives the common component of the tax rate, t_0 , as

$$t_0 = (1 - \gamma) \frac{m - l}{wl} b. \quad (5.6)$$

Equation (5.6) shows that the common tax finances a fraction $(1 - \gamma)$ of the aggregate unemployment costs. If $\gamma = 0$ then all of the UI costs are borne in the same way by all employees. If $\gamma = 1$ the common part of the tax rate is zero and the UI costs emerging in each sector are completely borne by the same sector. I assume that each sector i is small enough that the bargaining parties do not take into account that their actions affect the common part of the tax rate.

As noted in the introduction, it is a standard result that an increase in the benefit level, b , pushes up the wage level. Another standard result is that an increase in the share of sector-specific unemployment costs borne by the sector, γ , increases the incentive for wage moderation and thus reduces the wage level. I now check the robustness of the standard results.

To facilitate the calculations, I can use equation (5.6) to rewrite the FOC (5.4) as

$$\Lambda_w = (wl - mb) \left[1 - \delta\varepsilon - \frac{(1 - a)wl}{a\Pi} \right] + b \left(l - \gamma m \left(\varepsilon - \left(1 - \frac{l}{m} \right) \right) \right) = 0, \quad (5.7)$$

where I have used that

$$wl - mb = l(w(1 - t) - b) > 0, \quad (5.8)$$

from the balanced-budget condition (5.5).

Equation (5.7) changes in an obvious way when setting $\delta = 1$ or $\delta = 0$ (case 2 and 3).

However, if $u_0 = 0$ and $\delta = 0$ (case 4), the problem has to be recalculated. It is then straightforward to show that equation (5.7) reduces to

$$\Lambda_w = (wl - (m - l)b) \left[1 - \frac{(1 - a)wl}{a\Pi} \right] - \gamma mb \left(\varepsilon - \left(1 - \frac{l}{m} \right) \right) = 0. \quad (5.9)$$

The comparative statics are given by

$$\frac{dw}{d\delta} = -\frac{\Lambda_{w\delta}}{\Lambda_{ww}}, \quad \frac{dw}{db} = -\frac{\Lambda_{wb}}{\Lambda_{ww}} \quad \text{and} \quad \frac{dw}{d\gamma} = -\frac{\Lambda_{w\gamma}}{\Lambda_{ww}}.$$

The expression for Λ_{ww} is not a second-order condition for a maximum and is often complicated to sign without further assumptions. However, a standard way around this problem is to use Samuelson's correspondence principle or "dynamic stability" (Sargent, 1987), which requires that the static equilibrium also fulfills the requirement of stability in a dynamic setting. This requires that

$$\Lambda_{ww} < 0.$$

Thus the comparative statics are determined by the signs of $\Lambda_{w\delta}$, Λ_{wb} and $\Lambda_{w\gamma}$.

2.2 Effects of a change in parameter δ

The effect of a variation in δ can only be studied in case 1 where $0 < \delta < 1$. Using equation (5.7) gives

$$\begin{aligned}\Lambda_{w\delta} &= -(wl - mb)\varepsilon = \\ &= -l(w(1 - t) - b)\varepsilon < 0.\end{aligned}$$

This shows that the more unions care about employment the lower is the wage level. A higher parameter δ , results in a smaller utility gain from an increase in the wage and a larger utility loss from the associated employment reduction. Hence a higher value of δ , results in a lower wage level and higher employment.

2.3 Effects of a change in the unemployment benefit level b

Turning to the benefit level, differentiating equation (5.7) gives

$$\Lambda_{wb} = -m \left[1 - \delta\varepsilon - \frac{(1 - a)wl}{a\Pi} \right] + \left[l - \gamma m \left(\varepsilon - \left(1 - \frac{l}{m} \right) \right) \right]. \quad (5.10)$$

By using equation (5.7) again, this expression can be rewritten as

$$\Lambda_{wb} = \frac{wl}{wl - mb} \left[l - \gamma m \left(\varepsilon - \left(1 - \frac{l}{m} \right) \right) \right]. \quad (5.11)$$

Repeating the analysis but setting $\delta = 1$ (case 2) or setting $\delta = 0$ (insider-outsider model, case 3) gives exactly the same expression. Thus the sign of dw/db is independent of δ .

The first term within the square brackets in equation (5.11) is always positive and captures the standard effect in the literature: an increase in the benefit level raises the utility from unemployment and thus pushes up the

wage. The second term inside the bracket captures the wage effect due to a change in the tax rate when the benefit level is increased. When $\gamma > 0$, a higher unemployment benefit level changes the gain from a wage increase because it will trigger a change in the sector-specific tax rate. However, this expression can not be signed without further assumptions. The reason for this is that an increased wage level will affect both the tax base, wl , and the unemployment level, $m - l$, and hence both the denominator and the numerator in the tax rate expression (5.1).

If the elasticity of labor demand is not too small, a wage increase will increase unemployment and the unemployment benefit expenses faster than it would increase tax revenues. Thus in order to keep the budget balanced, the tax rate must increase. However, if the elasticity of labor demand is small, the opposite will apply.

Using equation (5.5), it is straightforward to show that a wage increase will raise the tax rate if the elasticity of labor demand is not too small or more precisely if

$$\varepsilon > 1 - \frac{l}{m}, \quad (5.12)$$

where $1 - l/m$ is the unemployment rate. This requirement, that the elasticity of labor demand is larger than the unemployment rate, is not especially restrictive since I am modelling economies near full employment.

Using the elasticity condition (5.12), the second term (including the minus sign) inside the brackets in equation (5.11) is negative. This captures that the higher the value of γ , the smaller the utility gain from a higher unemployment benefit because a wage increase triggers a larger rise in the sector-specific tax rate. This reduces the willingness to increase wages. The net effect of the two terms is thus ambiguous. However, higher benefits will raise the wage as long as

$$\varepsilon < 1 + \frac{(1 - \gamma)l}{\gamma m},$$

which is not very restrictive. Hamermesh (1993), Blanchflower and Oswald

(1994) and Nickell (2003) report that the labor demand elasticity is often estimated to be smaller than unity. In the case of many developed countries the right-hand-side of the expression is substantially larger than one, since the employment rate is around 90-95 per cent and $\gamma > 0$. Thus, in case 1-3 an increase in the unemployment benefit level raises the wage level and reduces employment.

But this result depends on the specification of the outside option for union utility u_0 . This can be illustrated by analyzing the pure insider-outsider case, where $u_0 = 0$ and $\delta = 0$.

If the union only cares about the after-tax wage level ($u_0 = 0$), an increased benefit level actually reduces the wage level. Repeating the analysis using equation (5.9) gives that

$$\Lambda_{wb} = -\frac{\gamma m}{(1-t)} \left(\varepsilon - \left(1 - \frac{l}{m} \right) \right),$$

which always is negative given the elasticity condition above and that $\gamma > 0$. The intuition is straightforward, a higher unemployment benefit level reduces the gain from a wage increase because the latter will trigger a larger rise in the sector-specific tax rate. However, a special case occurs if the sector-specific tax rate is zero i.e. $\gamma = 0$. Then an increase in the benefit level does not influence the wage level at all if workers act as insiders.

To sum up, implementing a tax scheme where the actions of the bargaining parties affect the tax rate will mitigate the adverse effects on wages and employment from unemployment benefits, regardless of whether the unions care explicitly about the employment rate or not. This result in the literature seems to be robust.

However, the standard result that an increased benefit level increases the wage level does not always hold. If the outside option is independent of the benefit level – which could be the case if union members are insiders with full job security and act as such – then an increased benefit level *reduces* the wage

level unless the elasticity of labor demand is very small. The explanation is that the higher the benefit level, the larger the sector specific tax increase and thus the smaller the after-tax wage increase, triggered by a pre-tax wage increase.

2.4 Effects of a change in parameter γ

We now turn to the influence of the share of sector-specific unemployment costs borne by the sector, γ . For this parameter, equation (5.7) implies

$$\Lambda_{w\gamma} = -mb \left(\varepsilon - \left(1 - \frac{l}{m} \right) \right). \quad (5.13)$$

Given the elasticity condition above we have:

$$\frac{dw}{d\gamma} = -\frac{\Lambda_{w\gamma}}{\Lambda_{ww}} < 0,$$

This result holds in general: equation (5.13) is independent of δ and u_0 and is exactly the same in all cases considered. Thus if γ is increased, it raises the marginal cost of a wage increase. This is so because the tax rate increases. The higher the parameter γ , the more the bargaining parties internalize the unemployment consequences of a wage increase even if they do not care about the level of employment *per se*. Hence, a rise in the share of sector-specific unemployment costs borne by the sector creates an incentive to reduce wages.

2.5 Comparing wage levels

Finally, equations (5.7 and 5.9) can be used for comparing the wage levels in the cases discussed above, given the elasticity condition above (and that $\Lambda_{ww} < 0$). It is straightforward to show that the wage level is highest in the mark-up insider-outsider case (case 3) where $u_0 = b$ and $\delta = 0$. Next comes the general case ($u_0 = b$ and $0 < \delta < 1$) and then the standard case ($u_0 = b$ and $\delta = 1$). The wage level in the pure insider-outsider case where $u_0 = 0$

and $\delta = 0$ is lower than in the mark-up insider-outsider case. Thus the more the union cares about employment the lower is the wage level. Given δ , the wage level is always increasing in u_0 , reflecting the importance of the fall-back level if there is no agreement. The smaller the utility loss when not agreeing, the higher is the wage level and the lower is the employment level.

3 A model with endogenous mobility

The analysis in section 2 takes labor supply in each sector as a given. However, a wage increase in one sector might induce an inflow of workers from other sectors and thus affect the outcome from wage negotiations. Moreover, changes in parameters δ and γ and the benefit level b might cause changes in sectorial labor supplies and hence affect the response of wages and employment.

The purpose of this section is to introduce endogenous mobility in the model and study how wages and employment are affected. Mobility is introduced by allowing individual workers to move freely between sectors in order to maximize their expected utility. Thus, workers will supply their labor to the sector that gives them the highest expected utility. In addition to the effects analyzed in Section 2, and given that labor demand is not too elastic, a wage increase in a sector will now increase the sector's labor supply and thus reduce the employment probability in the sector.

The assumption that labor can move freely across sectors is of course a simplification. In reality the possibility of changing sector depends on the level of education, general or sector-specific training and skills, if the person is employed or unemployed and so forth. In addition hiring, firing and training are not without cost. It is well known that such cost's would introduce an incentive to set wages higher than would otherwise be the case in order to prevent employed workers from moving. However, people do change job and sector affiliation. Thus, it could be worthwhile to introduce mobility in a

simple way into the model. A plausible interpretation is that free mobility captures the long-run effects of various changes. Again, that might be a plausible assumption to analyze the long-run effects of changes in policies.

Assume as before that there exists one union and one employer organization in each sector, and that these two organizations negotiate and determine the after-tax wage in the sector. The utility of the union can, as before, be formulated in several ways. One question is how to handle the fact that some initial members of the union might leave the sector and that some new members might be joining from other sectors, as a result of unions actions. One way of formulating the problem would be to assume that the union maximizes the utility of the members present when setting wages at a first stage and that mobility occurs at a second stage. I instead make the assumption that the union maximizes the expected utility of the representative member *ex post*. The rationale is that union membership follows employment with a lag and that union members hold union leaders accountable *ex-post* on the basis of the expected utility achieved for the member.

The negotiating parties consider, when setting the wage, that the outcome will influence the attractiveness of working in the sector. Put differently, the negotiating parties know that the wage outcome will, in addition to the analysis above, affect the sector-specific labor supply and thus the number of union members in each sector. Firms determine employment given the wage, and employees decide on sector affiliation.

The labor force in the whole economy is assumed to be fixed. Since the specification of the utility function proved to be of importance in the previous section, some alternative specifications will be analyzed.

Wages are, as before, assumed to be set so as to maximize the Nash bargaining product

$$\Lambda = [u_i - u_0]^a \Pi_i^{1-a}$$

or, following the analysis above, in case 1

$$\Lambda = \left[\left(\frac{l_i}{m_i} \right)^\delta (w_i(1 - t_i) - b) \right]^a \Pi_i^{1-a}. \quad (5.14)$$

Taxes Taxes are collected according to the same principles as in the preceding section. Thus, the tax rate in a sector consists of a common part and a sector-specific part.

$$t_i = t_0 + \gamma b \frac{m_i - l_i}{w_i l_i} \quad (5.15)$$

The balanced budget condition for the economy is now given by

$$\left(m - \sum_{i=1}^I l_i \right) b = \sum_{i=1}^I w_i l_i t_i, \quad (5.16)$$

where m now denotes the fixed labor supply in the whole economy.

Combining equations (5.15) and (5.16) gives the common part of the tax rate as

$$t_0 = (1 - \gamma) \frac{m - \sum_{i=1}^I l_i}{\sum_{i=1}^I w_i l_i t_i} b. \quad (5.17)$$

Labor mobility In equilibrium, the sector-specific labor supply is determined by two conditions. The first one shows that the sum of the supplies of labor in the I sectors is constant, i.e.,

$$m = \sum_{i=1}^I m_i. \quad (5.18)$$

The second relationship divides total labor supply between the different sectors. Workers are assumed to join the sector where the expected utility is highest. The expected utility for a representative employee in a sector is as before:

$$U_i = \frac{l_i}{m_i} w_i (1 - t_i) + \left(1 - \frac{l_i}{m_i} \right) b.$$

In equilibrium, expected utility in the each sector must be equal so that there are no unexploited gains to be made from moving from one sector to an other. Thus, relative labor supply is determined by the following "no-arbitrage condition"

$$\frac{l_i}{m_i} w_i (1 - t_i) + \left(1 - \frac{l_i}{m_i}\right) b = \frac{l_j}{m_j} w_j (1 - t_j) + \left(1 - \frac{l_j}{m_j}\right) b. \quad (5.19)$$

The interpretation of this no-arbitrage condition is this: If the take-home wage is higher in sector i than in sector j , then unemployment must also be higher in sector i than in sector j , otherwise expected income can not be equal in the sectors. A higher unemployment level can be achieved through both lower employment and higher labor supply. Equation (5.19) can be rearranged as

$$\frac{\frac{l_i}{m_i}}{\frac{l_j}{m_j}} = \frac{[w_j (1 - t_j) - b]}{[w_i (1 - t_i) - b]}. \quad (5.20)$$

Thus, the relative employment rate is determined by the relative difference between the after-tax wage and the unemployment benefit.² In order to rule out corner solutions, it is again assumed that the union members always prefer to work compared to being unemployed, i.e. that,

$$w_i (1 - t_i) - b > 0. \quad (5.21)$$

To express sector-specific labor supply in terms of relative wages and employments rates, the parameters (b and γ) and the variables (t_0 and m),

²Combining equation (5.15, 5.17 and 5.19) it can be shown that the relative employment rate collapses to

$$\frac{\frac{l_i}{m_i}}{\frac{l_j}{m_j}} = \frac{w_j}{w_i}$$

when the unemployment costs are fully borne by the employees in a sector, that is when $\gamma = 1$.

combine equations (5.15), (5.18) and (5.20) and iterate to obtain

$$m_j = \frac{w_j l_j (1 - t_0) - (1 - \gamma) b l_j}{\sum_{i=1}^I [w_i l_i (1 - t_0) - (1 - \gamma) b l_i]} m. \quad (5.22)$$

Note that the numerator and the denominator of equation (5.22) always are positive from the assumption in equation (5.21). To see this, note that

$$l_i (w_i (1 - t_i) - b) = w_i l_i (1 - t_0) - (1 - \gamma) b l_i - \gamma b m_i > 0,$$

and that the last term, $-\gamma b m_i$, is non-positive. Thus the numerator and the denominator in (5.22) are positive.

3.1 A symmetric case

The wage in each sector is determined through bargaining between the union and the employer organizations which both are assumed to take the common part of the tax rate, t_0 , the wage and thus the employment level in the other sectors as given. The assumption is thus that the sectorial bargaining units play a Nash game against each other. The government is not a strategic player, but sets the common part of the tax-rate, t_0 , in a "mechanical way" according to equation (5.17). Thus, the problem for wage setters in sector i is to maximize equation (5.14) subject to equations (5.15), (5.2) and (5.22). Assuming an interior solution, the FOC can be written as

$$\Lambda_{w_i} = \frac{1 - t_0 - \frac{\gamma b m_i \varepsilon_i}{w_i l_i} - \frac{\gamma b}{l_i} \frac{\partial m_i}{\partial w_i}}{w_i (1 - t_i) - b} - \delta \left(\frac{\varepsilon_i}{w_i} + \frac{1}{m_i} \frac{\partial m_i}{\partial w_i} \right) - \frac{(1 - a) l_i}{a \Pi_i} = 0. \quad (5.23)$$

Compared to the analysis in the model without cross-sectoral labor mobility above (equation 5.4), there are two new terms in the FOC. These additional terms capture the effects on the marginal utility of the wage from a change in the sector-specific labor force. The first of these new effects (last term in the numerator) captures the change in utility due to the change in the sector

specific tax rate as sectorial labor supply changes. The second new effect (the second term inside the parenthesis) captures the utility effect from a change in the probability of being employed when labor supply changes. An increased labor supply reduces the expected utility of a representative union member. Thus, if $\partial m_i / \partial w_i$ is positive, the utility gain from a wage increase is reduced. The reason is that labor supply, unemployment and thus the tax rate increases. This labor supply effect on unemployment adds to the effect on unemployment from lower employment caused by a higher wage level.

From equation (5.22) the following expression can be obtained

$$\frac{\partial m_i}{\partial w_i} = \frac{[w_i l_i (1 - \varepsilon_i) (1 - t_0) + (1 - \gamma) b l_i \varepsilon_i] \left[\sum_{j=1, j \neq i}^I (w_j l_j (1 - t_0) - (1 - \gamma) b l_j) \right]}{w_i \left[\sum_{i=1}^I (w_i l_i (1 - t_0) - (1 - \gamma) b l_i) \right]^2} m. \quad (5.24)$$

Thus in the second bracket we a sum of $I-1$ sectors, all sectors except sector i . In general, the sign is ambiguous. Thus, the supply effect can decrease or increase wage pressure.

Making use of the balanced budget condition, given by equation (5.17), and imposing symmetry, that is $l_i = l$, $w_i = w$, $m_i = \bar{m}$, $\Pi_i = \Pi$ and $m = I\bar{m}$, allows us to rewrite equation (5.23) as

$$\begin{aligned} \Lambda_w = & (wl - \bar{m}b) \left[1 - \delta\varepsilon - \frac{(1-a)wl}{a\Pi} \right] + b \left(l - \gamma\bar{m} \left(\varepsilon - \left(1 - \frac{l}{\bar{m}} \right) \right) \right) \\ & - \frac{w}{\bar{m}} \frac{\partial m_i}{\partial w_i} (\gamma\bar{m}b + \delta(wl - \bar{m}b)) = 0. \end{aligned} \quad (5.25)$$

Note that expression in equation (5.25) coincides with the FOC (5.7) in the model without labor mobility, except for the third term, which collects the new terms associated with mobility. We can express the critical mobility

term as

$$\frac{\partial m_i}{\partial w_i} = \frac{(I-1)\bar{m}}{Iw} \left[(1-\varepsilon) + \frac{(1-\gamma)lb}{(wl - (1-\gamma)\bar{m}b)} \right]. \quad (5.26)$$

The necessary condition for

$$\frac{\partial m_i}{\partial w_i} > 0$$

is

$$\varepsilon < 1 + \frac{(1-\gamma)lb}{wl - (1-\gamma)\bar{m}b}, \quad (5.27)$$

where the right-hand side of the inequality is larger than unity, except in the limit when $\gamma = 1$. Thus, unless employment decreases substantially due to a higher wage level, labor supply in the sector will increase and contribute to higher sectorial unemployment as the wage level increases. Hence, the direct wage effect on utility dominates the employment effect. Otherwise, labor supply would fall due to a fall in expected utility triggered off by a large reduction in employment as wages increase.

To unambiguously sign $\partial m_i/\partial w_i$ requires additional assumptions based on empirical experience. For standard values of the replacement rate, the parameter γ and the employment rate, it is sufficient that the elasticity is smaller than approximately 3 to ensure that $\partial m_i/\partial w_i > 0$.³ As noted above, the standard empirical finding is that the elasticity of labor demand is smaller than unity.

Given $\partial m_i/\partial w_i > 0$, equation (5.25) implies that the additional mobil-

³Equation (5.27) can be rewritten as

$$\varepsilon < 1 + \frac{(1-\gamma)\frac{b}{w}}{1 - (1-\gamma)\frac{b}{w}\frac{m}{l}}.$$

Replacement ratios, $\frac{b}{w}$, are often around 0.75. The parameter γ is larger than zero and a good estimate is around 0.1. The unemployment rate is about 5-10 percent in many developed countries. Using 0.75 for the replacement ratio, 0.1 for the γ -parameter and 0.95 for $\frac{l}{m}$ gives that

$$\frac{\partial m_i}{\partial w_i} > 0, \text{ as long as } \varepsilon < 3.3.$$

ity effect reduces the utility gain of a wage increase. A higher wage level will not only lower employment, but also increase sectorial unemployment through higher sectorial labor supply: This, in turn, will reduce the employment rate and increase the tax rate in the sector. In equation (5.25), the wage-dampening tax rate effect is captured by the first term, $\gamma\bar{m}b$, inside the parenthesis multiplying $\partial m_i/\partial w_i$. The wage-dampening unemployment effect is captured by the second term, $\delta(wl - \bar{m}b)$. Thus, the lower employment rate and the higher tax rate reduces the marginal utility of wage hikes, which gives an incentive to settle for lower wages than in the model without labor mobility. This result holds regardless of the weight δ put on the employment rate, but the incentive increases in δ . Thus, in the insider-outsider cases (where $\delta = 0$) the wage-dampening effect is smaller and only due to the effect through the tax rate.

We can now show how wages differ between the previous model without mobility and the present model. Equation (5.7) looks a lot like the first line in equation (5.25), except the non-positive supply effect captured by the second line in the latter equation. Recall that the partial derivatives of these equations with respect to the wage are negative from "dynamic stability". Thus evaluating the first-order condition (5.25) in the present model at the optimal wage level in the model without mobility we get a negative value of Λ_w . The only way of fulfilling the first-order condition is to reduce the wage. Thus, given $\partial m_i/\partial w_i > 0$, labor mobility always reduces the wage level and increases employment, except in the special case when both $\gamma = 0$ and $\delta = 0$.

The intuition for the result is straightforward; since labor demand is not too elastic, a wage increase in a sector raises expected income in that sector. To equalize expected incomes across sectors, unemployment in that sector has to go up. In addition to a reduction in labor demand, this is achieved through an inflow of labor to the sector. This raises the sectorial unemployment rate and hence the sector-specific tax rate. Through this mechanism, the utility gain of a wage increase is dampened compared to the

case with no labor mobility, both through a lower employment rate, as long as $\delta > 0$ but regardless of γ , and through a higher tax rate, as long as $\gamma > 0$ but regardless of δ .

The bottom line is that it becomes optimal for bargainers in each sector to settle for a lower wage compared to the case without mobility. The lower wage level reduces unemployment and increases labor demand. Thus, when unions care about employment and there is a tax scheme where each sector has to carry a fraction of their sector-specific unemployment costs, mobility creates an incentive to settle for lower wages and higher employment.

3.2 Comparative statics

In the model without mobility it was found that the wage level was decreasing in the weight, δ , for the employment rate and that an increased benefit level, b , had an ambiguous effect on the wage level, while an increased share of unemployment costs borne by the sector, γ , reduced the wage level. To test the robustness of these results, we now repeat these previous experiments. However, first we investigate how the wage level is affected by the number of sectors.

The comparative statics are, as before, given by

$$\frac{dw}{dI} = -\frac{\Lambda_{wI}}{\Lambda_{ww}}, \quad \frac{dw}{d\delta} = -\frac{\Lambda_{w\delta}}{\Lambda_{ww}}, \quad \frac{dw}{db} = -\frac{\Lambda_{wb}}{\Lambda_{ww}} \quad \text{and} \quad \frac{dw}{d\gamma} = -\frac{\Lambda_{w\gamma}}{\Lambda_{ww}},$$

where $\Lambda_{ww} < 0$ from "dynamic stability". Thus, the signs of the comparative statics are, as previously, determined by the signs of Λ_{wI} , $\Lambda_{w\delta}$, Λ_{wb} and $\Lambda_{w\gamma}$.

Using equations (5.25) and (5.26) we have that

$$\Lambda_{wI} = -\frac{1}{I(I-1)} \frac{w}{\bar{m}} \frac{\partial m_i}{\partial w_i} (\gamma \bar{m} b + \delta (wl - \bar{m} b)).$$

Given that $\partial m_i / \partial w_i > 0$, an increase in the number of sectors reduces the wage level and increases employment, unless both $\gamma = 0$ and $\delta = 0$. The

intuition is as follows. If the number of sectors increase, a given wage increase in one sector will induce labor from a larger number of other sectors to change jobs. Thus, recruitment becomes more easy and it requires a smaller sector specific wage increase to attract a given number of additional labor to the specific sector. The labor supply effect increases as $I \rightarrow \infty$. However, equation (5.25) and (5.26) suggest that the additional wage dampening effect from increased competition is decreasing in the number of sectors. The intuition is that unions will take the larger supply effect into consideration when negotiating wages. Thus, the initial distortion will be smaller and the extra contribution from an additional sector is decreasing. Nevertheless, stimulating competition by increasing the number of sectors will reduce wages and stimulate employment.

From equation (5.25) it is straightforward to show that the wage level is always decreasing in δ .

$$\Lambda_{w\delta} = -(wl - \bar{m}b)\varepsilon - \frac{I-1}{I} \left(1 - \varepsilon + \frac{(1-\gamma)lb}{(wl - (1-\gamma)\bar{m}b)} \right) (wl - \bar{m}b)$$

The first term shows the effect without mobility and the second term, captured by the last two parenthesis, is the additional effect from mobility. Further simplification gives

$$\Lambda_{w\delta} = -\frac{wl - \bar{m}b}{I} \left(\varepsilon + (I-1) \frac{(wl - b(1-\gamma)(\bar{m}-l))}{(wl - (1-\gamma)\bar{m}b)} \right)$$

Thus, an increased weight on employment reduces the wage level and increases employment. This result is what should be expected.

In order to facilitate the interpretation of the comparative statics, equation (5.25) is used to derive the following expression:

$$\begin{aligned} \Lambda_{wb} = & \frac{wl}{wl - \bar{m}b} \left[l - \gamma \bar{m} \left(\varepsilon - \left(1 - \frac{l}{\bar{m}} \right) \right) \right] \\ & - \frac{\gamma w^2 l}{wl - \bar{m}b} \frac{\partial m_i}{\partial w_i} - \frac{w}{\bar{m}} (\gamma \bar{m}b + \delta (wl - \bar{m}b)) \frac{\partial}{\partial b} \left(\frac{\partial m_i}{\partial w_i} \right) \end{aligned} \quad (5.28)$$

Equation (5.28) captures the wage effect of an increased benefit level when labor is mobile. The first row captures the same effect as in the case with no labor mobility in equation (5.11), while the second row captures additional effects due to labor mobility. Under the same assumptions as before (see discussion in section 2.2) the net effect in the first row is positive; a higher benefit level will trigger higher wages and lower employment. The first term in the second row captures the fact that an increase in the benefit level magnifies the wage dampening effect via the tax rate when labor supply and unemployment in the sector goes up. This reduces the utility gain of higher wages, and the incentives for high wages. This effect is independent of the weight δ . The second term of the second row of equation (5.28) captures the fact that an increased benefit level not only magnifies the effect from a given increase in labor supply but also the labor supply response to higher wages.

$$\frac{\partial}{\partial b} \left(\frac{\partial m_i}{\partial w_i} \right) = \frac{(I-1)(1-\gamma)\bar{m}l^2}{I(wl - (1-\gamma)\bar{m}b)^2} > 0, \text{ unless } \gamma = 1.$$

An increase in the benefit level thus raises the labor supply effect of a wage increase, which through both the tax rate and the employment rate gives an incentive to lower wages. The sign of the first row is ambiguous unless the union's outside option, u_0 , is unrelated to the benefit level (case 4). In that case the sign of the first row is negative. The second row is negative. The net effect is ambiguous unless u_0 is unrelated to the benefit level because the union only cares about wages of the employed. In that case (case 4) an increased benefit level will unambiguously reduce the wage level because a higher benefit level will increase the sector specific tax rate and thus reduce

the gain of higher wages. However, in case 2 where $\delta = 1$, (5.28) can be simplified. Using equation (5.25) in order to calculate $\Lambda_{wb}|_{\delta=1}$ gives

$$\Lambda_{wb}|_{\delta=1} = \frac{wl}{I(wl - \bar{m}b)} \left[l - \gamma \bar{m} \left(\varepsilon - \left(1 - \frac{l}{\bar{m}} \right) \right) \right].$$

Thus, given the assumption that the elasticity of labor demand is not too large, an increase in the unemployment benefit will result in higher wages and lower employment.

The results from the previous section seem to be robust only in case 2 and 4.

Finally, we turn to γ , the share of sector-specific unemployment costs borne by the sector. Following similar steps as above, we obtain that the wage effect of an increase in γ is determined by the sign of:

$$\begin{aligned} \Lambda_{w\gamma} &= -\bar{m}b \left(\varepsilon - \left(1 - \frac{l}{\bar{m}} \right) \right) \\ &\quad - \frac{w}{\bar{m}} (\gamma \bar{m}b + \delta (wl - \bar{m}b)) \frac{\partial}{\partial \gamma} \left(\frac{\partial m_i}{\partial w_i} \right) - wb \frac{\partial m_i}{\partial w_i} \\ &= -\bar{m}b \left(\varepsilon - \left(1 - \frac{l}{\bar{m}} \right) \right) \\ &\quad + \frac{(I-1)wl^2b}{I(wl - (1-\gamma)\bar{m}b)^2} (\gamma \bar{m}b + \delta (wl - \bar{m}b)) - wb \frac{\partial m_i}{\partial w_i} \quad (5.29) \end{aligned}$$

Again, the first row is the same as in the case without mobility, in equation (5.13). The first row shows that an increase in γ raises the marginal cost of a wage increase (unless labor demand is too inelastic). This is so because unemployment rises and so does the tax rate, which creates an incentive to reduce the wage level. The first term in the second row captures the fact that an increase in γ actually dampens the sectorial inflow of labor due to a wage increase, because a larger share of the unemployment cost is borne by

the workers. This will raise the utility gain from a wage increase and give incentives for higher wages. The magnitude will depend on the parameter δ . Thus, this effect works in the opposite direction compared to the effect in the first row. The second term in the second row reflects that labor supply raises the tax rate, regardless of δ , and creates an incentive for lower wages. Thus, there are two effects creating incentives for lower wages and one effect working in the other direction. The sign of the whole expression is unclear. However, in case 2, that is $\delta = 1$, (5.29) simplifies to

$$\Lambda_{w\gamma}|_{\delta=1} = -\frac{\bar{m}b}{I} \left(\varepsilon - \left(1 - \frac{l}{\bar{m}} \right) \right). \quad (5.30)$$

Thus, given that the elasticity of labor demand is not too small, this expression is negative. Thus, the previous result, that an increase in the share of unemployment costs borne by the sector reduces wage pressure, is not robust except in case 2.

3.3 Future research

In the analysis above it was assumed that the unemployment insurance system was compulsory. This is a simplification and not the case in many countries. An interesting extension of the model above would therefore be to allow for endogenous membership as in for instance Holmlund and Lundborg (1999). Another simplification in my model is the assumption of symmetry. An interesting extension would be to introduce different risks of becoming unemployed. However, both these extensions would probably require some substantial simplifications in order to be able to obtain firm conclusions.

4 Summary

The main purpose of this paper is to analyze how wages, employment and unemployment are affected by introducing labor mobility between sectors. I

also revisit some established results of how wages and employment respond to changes in the unemployment benefit level, and to changes in the fraction of unemployment costs borne by each sector in the economy. These comparative statics are carried out in four cases with different specifications of the union utility function.

Introducing a tax scheme where the bargaining parties have incentives to consider how their actions affect the cost of unemployment benefits, will mitigate the adverse effects on wages and employment from unemployment benefits. A rise in the share of sector-specific unemployment costs borne by each sector creates an incentive to reduce wages. While this result has been shown previously, I show that this result is robust with respect to different specifications of utility functions as long as labor is not mobile. However, in the case of mobility the result does not hold in general and depends on the specification of the utility function. In the most common specification, the standard wage dampening effect holds.

I also demonstrate that the standard result in the literature that an increased unemployment benefit level increases the wage level does not hold in general. Whether an increased benefit level raises or lowers the wage level depends on the specification of the utility function as well as on labor mobility. The standard result is achieved when labor demand is not too elastic and unions maximize expected utility. The wage effect from an increased benefit level is only unambiguously signed in the case where the union's outside option is irrelevant or independent of the unemployment benefit level, which could be the case if the employees act as insiders. In that case, an increased benefit level will actually reduce the wage level unless the elasticity of demand is very small, a result that holds regardless whether labor is not mobile or not. The reason is that an increased benefit level raises the sector specific tax rate. In order to reduce this utility loss it is optimal to settle for a lower wage level and higher employment.

Moreover, I show that the wage level is unambiguously decreasing in the

weight put on employment by unions, and that this result holds regardless whether labor is mobile or not.

Given that labor demand is not too elastic, higher wages in a sector increases the attractiveness of working in that sector. Thus, unless employment decreases substantially due to a higher wage level, labor supply will increase and contribute to higher unemployment. Hence, the direct wage effect on the utility dominates the employment effect. The introduction of mobility gives an incentive to settle for lower wages and higher employment compared to the cases of a fixed labor supply, given that labor demand is not too elastic. The mobility labor supply effect reduces the marginal utility of a wage increase as long as unions care about employment, or there is a tax scheme where each sector bears a fraction of its sector-specific unemployment costs. A higher wage level will, in addition to lower employment, raise sectorial unemployment through higher sectorial labor supply and thereby reduce the sectorial employment rate and increase the sector specific tax rate. However, in the insider-outsider cases, where the unions do not care about employment, the wage-dampening effect is smaller and only due to the effect through the tax rate.

In general, the wage-dampening effect is increasing in the number of sectors in the economy. Thus, increased competition lowers wages and increases employment.

The first policy conclusion from this paper is that adverse effects of unemployment benefits can be mitigated by introducing a financing scheme that creates incentives for lower wages. A way of doing this is to let each sector cover a fraction of the sector-specific unemployment costs. This will affect the wage-setting incentives in two ways. First, it will typically reduce the wage response of an increase in the benefit level. Second, the introduction of the sector-specific financing scheme can create an incentive for lower wages at any given benefit level.

The second policy conclusion is that lower unemployment can be achieved

by facilitating an increase in the number of bargaining sectors in the economy and stimulate labor mobility in response to differences in expected utility among different sectors. In this way, the analysis supports the general ideas that it may be beneficial to decentralize wage bargaining and lower mobility costs in the labor market.

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