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STRUCTURAL UNEMPLOYMENT IN FINLAND*

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ABSTRACT: Since the Finnish unemployment rate has rocketed to a very high level in the beginning of the 1990's, it is worth to study to what extent the unemployment rate prevailing today is due to cyclical or to structural reasons. In this paper we try to estimate two different indicators that represent the structural part of unemployment, the NAWRU and the NAIRU. The NAWRU (non-accelerating wage rate of unemployment) measures the structural unemployment simply by relating unemployment to wage inflation. The estimated NAWRU follows very closely the actual unemployment in Finland indicating that it is not the proper measure for the structural unemployment. The NAIRU (non-accelerating inflation rate of unemployment) in this paper is based on structural estimates of the price setting behaviour of firms and the wage setting behaviour of trade unions. The estimated NAIRU was at a low level up to the end of eighties. Since then both the actual unemployment rate and the NAIRU have rocketed. In the mid-nineties the NAIRU was about 12 percent (plus - minus 2 percentage points) while the actual unemployment rate was about 18 percent.

KEY WORDS: Actual and structural unemployment

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TIIVISTELMÄ: Koska Suomen työttömyys on noussut nopeasti hyvin korkealle tasolle, on syytä selvittää, missä määrin työttömyys on rakenteellista ja missä määrin suhdanteista johtuvaa. Tutkimuksessa rakenteellista työttömyyttä mitataan kahden eri indikaattorin avulla. Ensimmäinen mittari, ns. NAWRU, mittaa sellaista työttömyyden tasoa, jonka alittaminen johtaa palkkainflaation kasvuun. Koska tämä mittari seuraa hyvin läheisesti Suomen todellista työttömyysastetta, ei sitä voida pitää luotettavana tapana arvioida rakenteellista työttömyyttä. Toinen mittari, ns. NAIRU, mittaa sellaista työttömyyden tasoa, jonka alittaminen johtaa inflaation kiihtymiseen. Eli jos todellinen työttömyys on NAIRU-tason alapuolella, taloudessa on inflaatiopaineita. NAIRU-mittarilla arvioitu rakenteellinen työttömyysaste oli matala Suomessa aina 1980-luvun loppuun asti. Sen jälkeen rakenteellinen työttömyysaste on noussut noin 12 prosenttiin luottamusvälin ollessa noin plus-miinus 2 prosenttiyksikköä. Rakenteellinen työttömyysaste oli 1990-luvun puolivälissä 4 - 8 prosenttiyksikköä todellisen työttömyysasteen alapuolella. Työmarkkinoilta ei täten tullut talouteen inflaatiopaineita.

ASIASANAT: Todellinen ja rakenteellinen työttömyys

CONTENTS

1 INTRODUCTION

In the first part of the 1990's, Finland went through a very difficult economic and social adjustment, origins of which can be traced to the 1980's i.e. to the financial market liberalisation and the unexpected crash of the Soviet export markets. In the beginning of 1990's production dropped by 12 percent between 1991 and 1993, the terms of trade deteriorated quickly and the tax wedge started to increase. These events led to a sharp decrease of labour demand and the unemployment rate rose from 3.5 per cent in 1990 to 18.3 per cent in 1994. Still nominal wages continued to rise in the early 1990's although the rise was very modest.

The Finnish unemployment rate has rocketed to a very high level in the beginning of the 1990's decreasing the tax base and increasing considerably public expenditures and thus causing a huge increase in public sector indebtedness. It is worth to study to what extent the unemployment rate prevailing today is due to cyclical or to structural reasons. There are some indicators which try to separate these two elements of unemployment. In this paper we try to estimate two different indicators that represent the structural part of unemployment, the NAWRU and the NAIRU. The NAWRU (non-accelerating wage rate of unemployment) measures the structural unemployment simply by relating unemployment to wage inflation. The NAIRU (non-accelerating inflation rate of unemployment) in this paper is based on structural estimates of the price setting behaviour of firms and the wage setting behaviour of trade unions.

In addition to the decomposition of actual unemployment into its structural and cyclical components we try to 1) calculate the confidence interval for the structural unemployment rate, and 2) estimate effects of different factors on the structural unemployment rate. The factors considered are: activity variables, capital-labour ratio, the tax wedge and the price wedge.

The paper is organised as follows. In section 2 the NAWRU is estimated while section 3 considers shortly the theoretical background of the NAIRU and its estimation. Section 4 concludes.

2 NAWRU IN FINLAND

The NAWRU is defined as the non-accelerating wage rate of unemployment. The calculations of the NAWRU estimate in this paper are based on Elmeskov's article (see Elmeskov 1993). The method in the article includes the assumption that the change in wage inflation is proportional to the gap between actual unemployment and the NAWRU, thus

(1) $\Delta^2 w = \alpha(NAWRU - U), \qquad (a > 0)$

where w is the natural logarithm of the nominal wage rate and U is the unemployment rate. D is the first-difference operator, and $\Delta^2 w = \Delta(\Delta w) = \Delta(w - w_{-1}) = w - w_{-1} - (w_{-1} - w_{-2})$.

The parameter a can be calculated assuming that the NAWRU changes only gradually over time, in other words the NAWRU is constant in two consecutive years:

(2) $\alpha = -\Delta^3 w / \Delta U$.

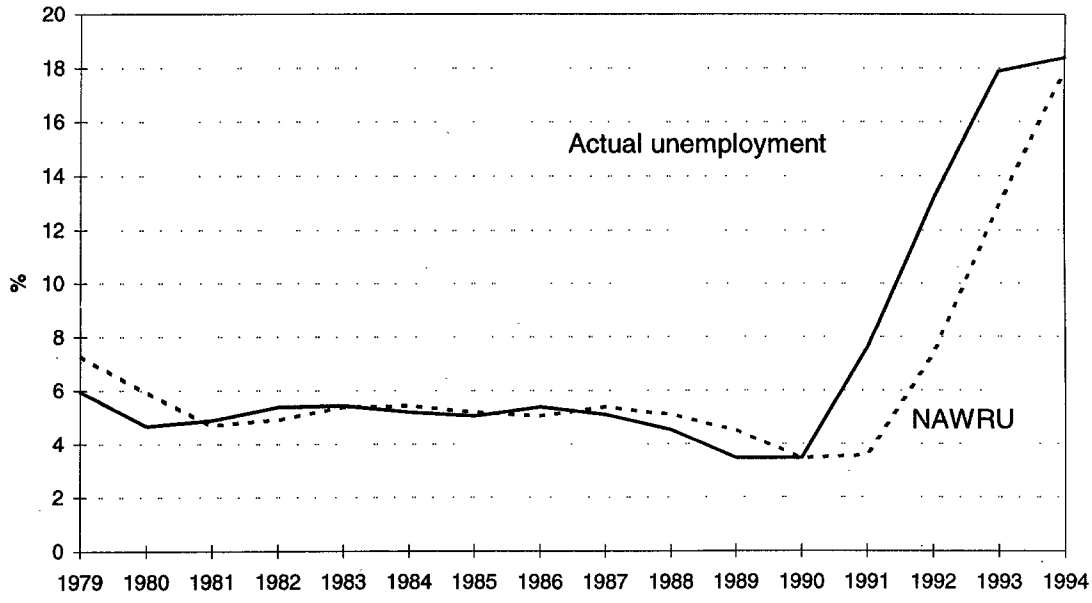
This was done by taking the first difference of equation (1). Equations (1) and (2) can be combined to get an estimate of the NAWRU:

(3) $NAWRU = U - (\Delta U / \Delta^3 w)\Delta^2 w$.

This method for estimating the NAWRU may produce some occasional large outliers which can be eliminated by a filtering procedure.

The NAWRU in Finland was estimated in years 1979-1994. The results are presented in figure 1. The estimated NAWRU in Finland follows very closely the actual unemployment rate during the period 1979-1990. In the beginning of the nineties it departs from the actual unemployment rate implying that the large increase in the unemployment rate was due to cyclical factors. According to this measure cyclical unemployment changed to structural unemployment very quickly.

FIGURE 1. The NAWRU in Finland



The reason why the NAWRU follows very closely the actual unemployment in Finland can be easily seen from equation (1) saying that when the changes in the nominal wage during two successive years are small the difference between the NAWRU and the actual unemployment is small.

The problem with this measure of the structural unemployment rate is that it bases on a very restrictive assumption of the wage formation. The next measure, the NAIRU (non-accelerating inflation rate of unemployment), tries to capture the wage and price formation in the economy more carefully.

3 NAIRU IN FINLAND, STRUCTURAL ESTIMATES

3.1 Theoretical background

The theoretical background of the structural NAIRU-estimate is based on Bean (1994) and on Layard – Nickell – Jackman (1991). The NAIRU is the long-term equilibrium unemployment rate when inflation is constant, that is when the expectations of employers on prices and the expectations of employees on wages are fulfilled. The NAIRU may be derived from wage and price equations assuming stable inflation. The formal presentation follows.

Let us first consider the price equation. The starting point is the general production function where the constant returns to scale technology is assumed and firms are assumed identical, Y = F (AN,K), where Y is net output, N is employment, K is capital and A is the labour-efficiency index. Under imperfect competition we can get the first-order condition for profit-maximisation which leads us to the demand-schedule of labour. The price-setting schedule may be derived from that. If prices are preset the price equation may be presented as follows:

$$(4) \qquad \log(p) - \log(w) = \gamma_0 - \gamma_1 \log(u) - \gamma_2 \log(w - w^e) + \gamma_3' \log(z^p)$$

where p is the price of value added, w is the wage rate, w^e is the expected wage rate, u is the unemployment rate[1], and z^p is a vector of other variables that influence pricing. γ_0, γ_1, and γ_2 are parameters to be estimated, whereas γ_3' is a vector of parameters. (For more details see Bean 1994.)

Then we turn to the wage equation. It can be derived from several models: monopoly union, efficiency wage and bargaining models. The wage equation may be written in the following form:

$$(5) \qquad \log(w) - \log(p) = \beta_0 - \beta_1 \log(u) - \beta_2 \log(p - p^e) + \beta_3' \log(z^w)$$

where p^e is expected price of value added and z^w is a vector of variables influencing the wage formation such as generosity and coverage of unemployment benefits and active labour market policies. β_0, β_1 and β_2 are parameters to be estimated, whereas β_3' is a vector of parameters.

By substituting out for the real wage and assuming that $p = p^e$ and $w = w^e$, we get the following form of the structurally derived NAIRU:

$$(6) \qquad \log(u^*) = \frac{\beta_0 + \gamma_0 + \beta_3' \log(z^w) + \gamma_3' \log(z^p)}{\beta_1 + \gamma_1}.$$

The equation (6) describes the determination of the structural rate of unemployment.

Layard et al. (1991) assume that both the level of unemployment rate and the change of unemployment rate affect the price and wage setting equations. They define the long-

[1] Some times the unemployment rate is entered into the wage and price setting equations in level form, not in log-level form as specified here.

run NAIRU so that the price and wage surprises vanish and the change of unemployment rate is zero; the long-run NAIRU is defined as in equation (6). In the short-run, the unemployment rate may slowly adjust to the long-run NAIRU. Taking slow adjustment into account they define the short-run NAIRU, which is a weighted average of the long-run NAIRU and previous period's unemployment rate, i.e. $u_s^* = f(u^*, u_{-1})$.

The actual unemployment is defined as the sum of the structural unemployment and the cyclical unemployment i.e.

$$u = u^* + u^e, \tag{7}$$

where u^e is the cyclical unemployment. According to Bean (1994) the cyclical unemployment is mainly due to different shocks hitting the economy. This is assumed to be the reason why expected wages (expected by firms) and expected prices (expected by trade unions) differ from their actual values[2] (see equations (4) and (5)).

The econometric model used in section 3.2 is derived from this theoretical background and especially from equations (4) and (5). In contrast to Layard et al. (1991), we will not try to estimate the short-run NAIRU and not try to model determination of the price and wage expectation. The latter is correct, if errors in expectations are only due to unexpected shocks hitting the economy.

3.2 Estimation results

The annual timeseries data for the years 1975-1994 is from the Bank of Finland's BOF4-model (see Appendix 1). Most of the variables used are from the manufacturing sector as they should produce more accurate NAIRU-estimates. Unfortunately the BOF4-model does not have all the variables divided by sectors. For those variables that we could not use the manufacturing sector the variable that presents the whole economy was chosen (see Appendix 1).[3]

Let us now examine the econometric model which was derived from the theoretical model. The estimated wage equation is of the following difference form:[4]

$$\begin{aligned}\Delta \log(w/q) = {} & \alpha_0 + \alpha_1 \Delta \log(u) + \alpha_2 \Delta \log((1-t)/p) + \alpha_3 \Delta \log(1+s) \\ & + \alpha_4 \Delta \log(q) + \alpha_5 \Delta \log(k) + \alpha_6 \Delta \log(y) + e\end{aligned} \tag{8}$$

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[2] It is assumed that price settings of firms are based on firms' expectations about future wages while wage settings of trade unions are based on their expectations about future prices.

[3] It is better, of course, to attempt to estimate the (economy wide) NAIRU using the data covering whole economy rather that the data in manufacturing sector. Our choice of data is based on the assumption that the rest of economy behaves on average like the manufacturing sector.

[4] We have estimated the wage and price setting equations both in the log-level form and the log-difference form. The latter specification seems to fit the data better. The detail estimation results are available on request.

where w is the nominal wage, q is the producer price, u is the unemployment rate, t is the marginal income tax rate, p is the consumer price, s is the proportional payroll tax rate, k is the capital stock and y is the production.

The price equation has the following difference form:

$$\begin{aligned}(9)\qquad \Delta\log(q/w) &= \lambda_0 + \lambda_1\Delta\log(u) + \lambda_2\Delta\log(k/l) + \lambda_3\Delta\log(p^f) + \lambda_4\Delta\log(c) \\ &\quad + \lambda_5\Delta\log(p^m) + \lambda_6\Delta\log(r) + e\end{aligned},$$

where q is the producer price, w is the nominal wage, u is the unemployment rate, k is the capital stock, l is the labour force, p^f is the foreign price measuring prices in foreign markets, c is the rate of capacity utilisation, p^m is the price of inputs and r is the nominal interest rate.

The most important structural parameters affecting the structural unemployment are the coefficients of the unemployment rate in the wage and price equations, i.e. the parameters a_1 and l_1. This is because they measure how the unemployment rate affects price and wage formation. If the influence of the unemployment rate on prices and wages is weak, i.e. the parameters a_1 and l_1 are small in the absolute value, the structural unemployment is high and vice versa (see equation (6)).

The estimation results can be briefly summarised as follows: First, although the system has been estimated in difference form the adjusted multiple correlation coefficients R^2 are relatively high in both equations. The test statistics do not show significant first-order serial correlation. Second, the parameter estimates are reasonably precise, at least in the wage equation. The price setting equation is more problematic in the sense that only statistically significant parameter is the constant term. This should not be worried too much, however, since we are going to calculate the confidence interval for the NAIRU. The more imprecise parameter estimates the wider the confidence interval.[5]

The estimation results of the system of the wage and price equations are presented in table 1.

[5] In the price setting equation we have imposed theoretical restriction that the nominal wage elasticity of the producer price is equal to minus one. When this restriction is relaxed the significance level of other parameters increase considerably.

Table 1. The SURE estimation results of the wage-price system (t-statistics in parentheses)

	Equation	
Variable	log(w/q)*	log(q/w)
Dlog(u)	-0.202 (-2.92)	-0.004 (-0.12)
Dlog((1-t)/p)	-0.464 (-2.40)	
Dlog(1+s)	-0.536 (-2.77)	
Dlog(q)	-0.464 (-2.40)	
Dlog(k)	-1.156 (-1.81)	
Dlog(y)	0.464 (2.40)	
Dlog(k/l)		-0.27 (-1.48)
Dlog(p^f)		0.141 (1.09)
Dlog(c)		0.123 (0.62)
Dlog(p^m)		0.200 (1.48)
Dlog(r)		0.000 (0.00)
constant	0.103 (4.04)	-0.042 (-4.25)
R^2	0.6386	0.7560
DW	1.9790	1.7226

R^2 is the multiple correlation coefficient, DW is the Durbin-Watson statistic for the first order serial correlation.

* The wedge restriction, namely that $\frac{w(1+s)}{q} = f\left(\frac{(1+s)p}{(1-t)q},\ldots\right)$, is used.

Third, the parameter estimates are mostly of the expected sign from the theoretical point of view. An increase in the unemployment rate lowers wage inflation. The absolute size of the coefficient in the wage equation is, however, relatively high compared with some other recent studies.[6] Changes in the marginal income tax rate and the payroll tax rate affect wages negatively, as do changes in the consumer prices and the producer prices. Thus the higher the tax-price wedge, defined as $[(p/q)(1+s)/(1-t)]$, the higher the gross producer wage, defined as $[w(1+s)/q]$, and the lower the employment. The coefficients of the tax variables are about the same size as usually obtained in Finland (see e.g. Tyrväinen, 1995). The capital stock seems to have a negative and the production a positive effect on nominal wages. The constant term gets a high value implying that the real producer wage increases considerably even when the other variables stay constant.

The foreign price, the capacity utilisation and the price of raw materials seem to have a weak positive effect on the ratio of producer price to the wage rate while the capital-labour ratio and the unemployment rate have a weak negative effect. The price-wage-ratio seems to be independent of the interest rate. The constant term is negative and

[6] According to the paper by Holm et al. (1996) the effects of the unemployment rate on nominal wages differ in the different branches of industries, the average being -0.05. According to Rantala (1995) the effects of the unemployment on wages varies between -0.11 and -0.03.

statistically significant, indicating that the producer price has a declining trend. This may be due to increasing competition in the Finnish manufacturing.

Since the wage and price setting equations are estimated in the difference form only the difference of the unemployment rate is included into the equations. If we had obtained better empirical results using log-level specification, we would have tried to include both the level and the difference of the unemployment rate into the equations.

3.3 NAIRU and its confidence interval

Using the parameter estimates of table 1 and the values of the explanatory variables we can apply equation (6) to solve for the structural unemployment rate (NAIRU). The actual unemployment rate and the estimated NAIRU and its confidence interval (see appendix 2 for details) are presented in figure 2. Because we have estimated the wage and the price equations in the difference form we have to fix the level of the NAIRU in the beginning of our estimation period. We have assumed that the NAIRU was 2.5 percent in the beginning of the estimation period. This is based on the following reasoning. According to the applied theoretical model (e.g. Bean, 1994) the difference between the actual unemployment rate and the structural unemployment rate follows mainly from price "surprises", defined as the difference between the expected producer price and the actual producer price. According to the view of the Bank of Finland inflation pressure prevailed during the mid-eighties implying that the inflation expectations might be higher than the actual inflation. This implied, in turn, that the actual unemployment rate should be higher than the structural unemployment rate in the mid-eighties (see figure 2).

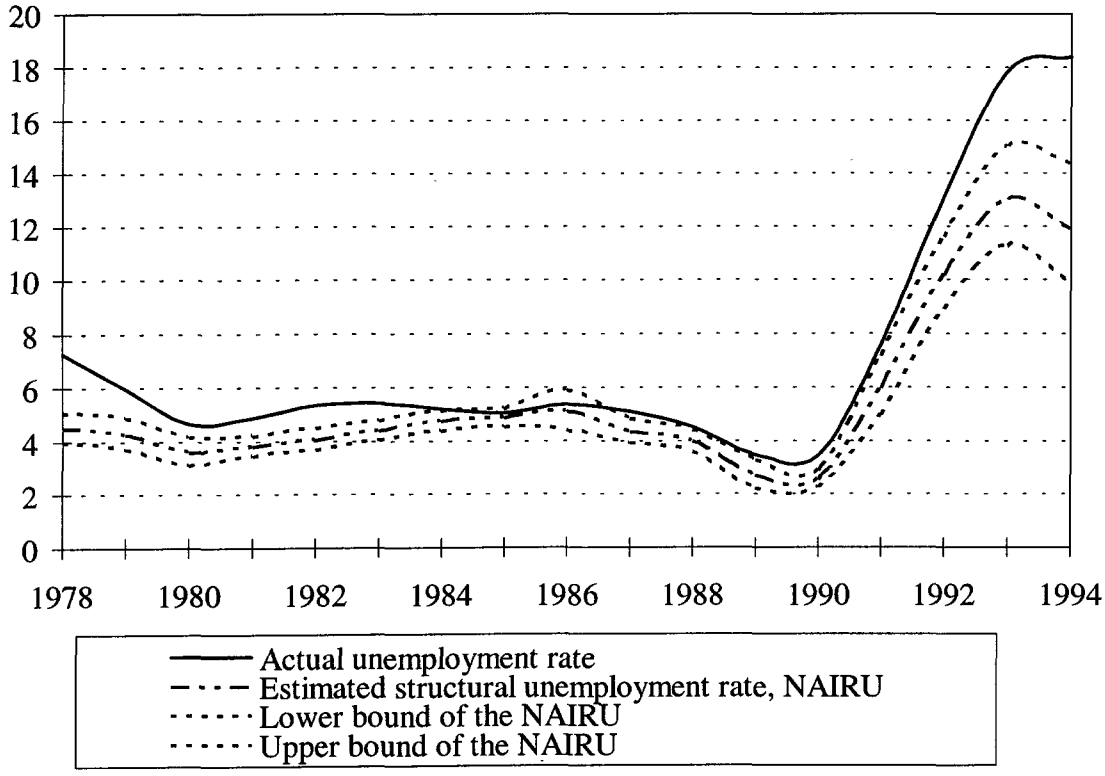
Both the actual unemployment and the estimated structural unemployment rate were at a low level up to the end of eighties. Since then they have rocketed. In the end of the estimation period the actual unemployment rate was about 18 percent and the estimated NAIRU was about 12 percent. The difference between the actual and the structural unemployment rate implies that the structural problems do not yet contribute any wage or price inflation pressure. It should be noticed, however, that structural unemployment started to decrease in 1993 when the actual unemployment rate started to stabilise.[7] The second implication of our result is that structural reforms should be done if we want to repress the unemployment rate below 10-14 percent without inflation pressure arising.

The confidence interval was about one percentage point until 1992. Since then it has increased to the level of four percentage points. This is due to the fact that both the parameter estimates and the values of explanatory variables affect the size of confidence interval. When the unemployment rate was relatively stable the confidence

[7] It should be remembered that the NAIRU is estimated using data mainly from the manufacturing sector where the growth rate started to increase before and more quickly than the rest of the economy. The NAIRU started to decrease while the actual unemployment rate still increased.

interval was quite small although the parameters in the price setting equation are not very precise.

FIGURE 2. The structural unemployment rate NAIRU[8] and its confidence interval



How can one explain the difference between the actual and structural unemployment rates in the early nineties? According to the applied theoretical model (see e.g. Bean, 1994, for details) the gap is due to the price "surprises", i.e. nominal demand shocks (see equations (4), (5) and (7)). We would like to argue that nominal demand shocks were not large enough to produce the gap prevailing in that time. In addition to potential price "surprises", the gap was partly due to firms' pessimistic expectations about future demand for their products. Pessimistic expectations prevented firms to increase labour demand as much as could be assumed by the economic situation. This statement is based on the following arguments. Firstly, there is some international evidence (see Giavazzi and Pagano, 1995) that the future expectations of consumers and of firms may affect considerably their behaviour. Giavazzi and Pagano find that in Sweden during the deep economic crises in the early nineties the predictions of econometric models strongly overestimate private consumption and private investment. Secondly, we could assume that the economic situation in Finland was a quite similar to that in Sweden. Thirdly, predictions of econometric models may

[8] The calculation of the NAIRU based on the assumption that the NAIRU was 2.5 percent in the beginning of the estimation period.

overestimate private labour demand during that time, since firms' expectations were too pessimistic.[9]

We conclude by noting that the structural unemployment rate was lower than the actual unemployment rate in early nineties. But it is difficult to obtain very precise estimates for the structural unemployment rate during that time. These results are quite realistic, 1) since labour productivity increases very rapidly during recession indicating that the actual unemployment rate raises 'too much', and 2) since deep recession has increased uncertainty in whole economy, implying that the effects of growth on employment has become weaker than before.

3.4 Contribution of different factors to the NAIRU

Next, we turn to consider what are the contributions of five different factors to the logarithm of the estimated NAIRU. Figure 3 presents the influence of labour taxes, i.e. the term $\frac{1+s}{1-t}$, and the price term to the structural unemployment rate.

The effect of the labour taxes (the term (1+s)/(1-t) measuring the pure "marginal" tax wedge) on the NAIRU has been positive and quite stable the whole period except the period 1990-95. The logarithm of the tax term was 0.12 in 1991 and 0.50 in 1994. This implies that an increase in the labour taxes has boosted the structural unemployment rate at 2.9 percentage points.[10]

The price factor has increased the NAIRU during the whole estimation period. The reason that the structural unemployment rate increased so rapidly in the early nineties was the unfavourable behaviour of prices in Finland. In 1989-91 producer prices collapsed while consumer prices stayed quite stable due to a devaluation of the Finnish Mark (see figure 4). The logarithm of the price term was 1.64 in 1990 and 2.17 in 1993, implying that an increase in the price factor has boosted the structural unemployment rate at 3.2 percentage points.[11]

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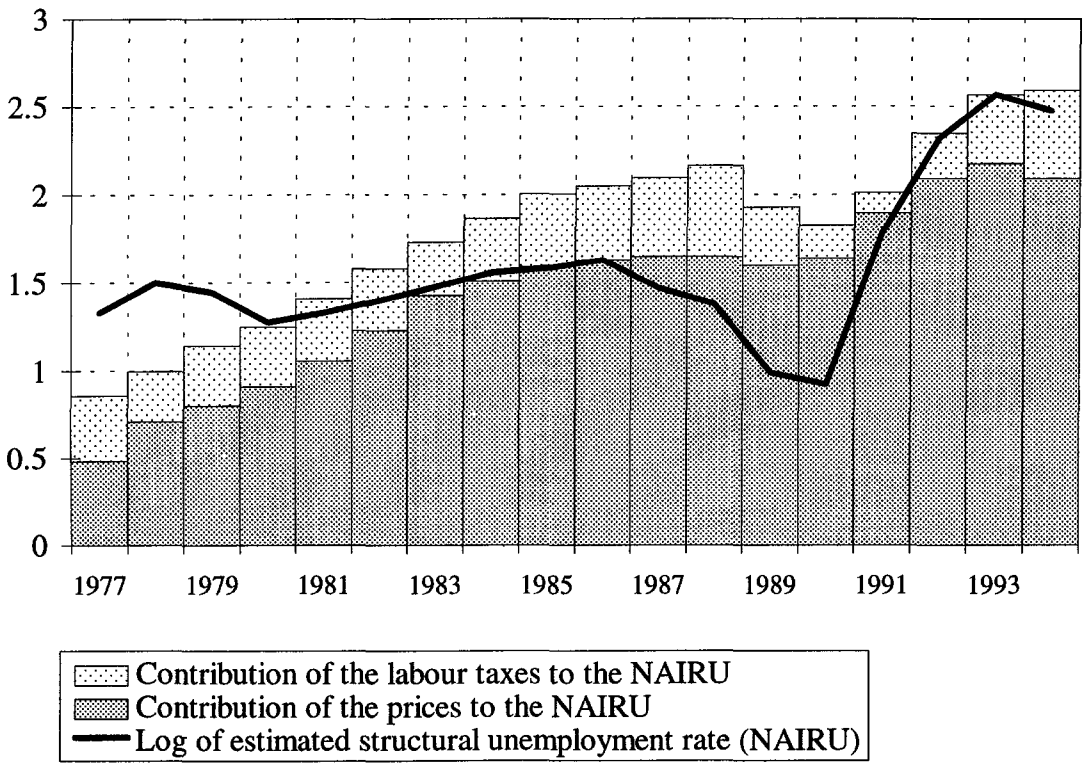
[9] According to our estimation, econometric models, developed by Holm et al. (1996), strongly overestimated labour demand in manufacturing sectors during early nineties.

[10] In 1991 the NAIRU was 6.0 percent implying that log(NAIRU) = 1.79. Adding the change in the tax factor to that, we obtain 2.18, implying the NAIRU of 8.86.

[11] In 1991 the NAIRU was 6.0 percent implying that log(NAIRU) = 1.79. Adding the change in the price factor to that we get 2.22 and thus the NAIRU is 9.21.

FIGURE 3. The contribution of labour taxes and prices to the logarithm of estimated structural unemployment rate[12]



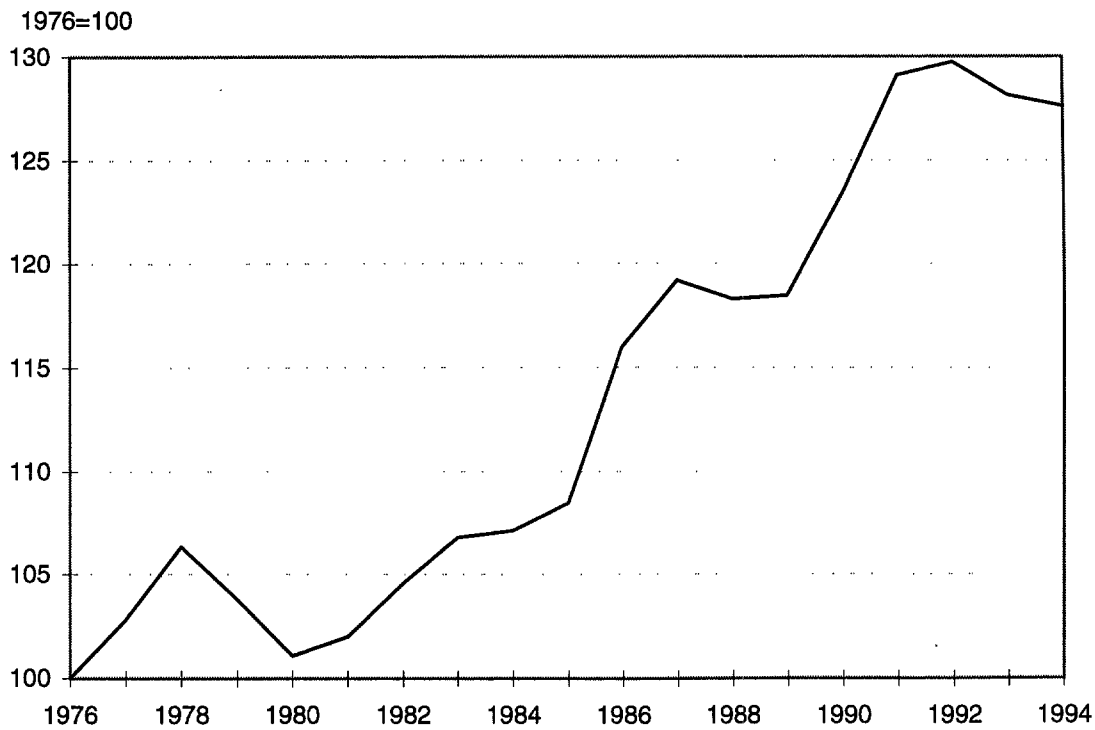
As the tax wedge defines the gap between the gross wage paid by firms and the net wage received by workers the ratio of the consumer and the producer prices measures the gap (in the level of the whole economy) between the price paid by domestic consumers and the price received by domestic producers. The latter gap is mainly due to an increasing trend in sales taxation and a decreasing trend in the value of the Finnish currency. In addition to an increasing trend, the ratio of the consumer to producer prices seems to be procyclical strengthening instability in the Finnish labour market.

The contribution of other factors to the logarithm of the estimated NAIRU are presented in appendix 3. The most important and all the time increasing factor affecting the structural unemployment is the unobserved structural factor captured by the constant terms in the estimated wage and price equations. Since the sum of the

[12] The calculation of the contribution of the different factors to the NAIRU based on the assumptions that i) the NAIRU was 2.5 percent in the beginning of the estimation period, ii) the share of the labour tax factor was 4/10 whereas price factors was 2/10 in that time. Although this affects the relative size of the different factors, the time profiles of factors are independent of their scales.

constant terms is 0.061 (= 0.103 - 0.042), the unobserved factor increases the wage inflation and thus the structural unemployment rate.[13]

FIGURE 4. The consumer price divided by the producer price



An increase in the capital-labour ratio between 1982 and 1993 has decreased the structural unemployment rate. This is due to the fact that the higher capital-labour ratio the higher the labour productivity. Thus both the activity variables and the capital-labour ratio capture the effects of the productivity.

The contribution of the activity variables (the capital stock and the total production in the wage equation) has mainly neutralised the contribution of the constant terms up to the end of eighties. This follows from the fact that the capital stock has increased reducing wage pressure.[14]

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[13] It should be noticed that we have estimated a local approximation of the structural unemployment rate. This is because we have allowed the constant terms in the difference form of the wage and price equation. When transferring the results of the difference form estimation to the level form one has to calculate cumulative sums. Therefore, the constant terms in our wage and price equations turn out to be trend factor in the NAIRU. This implies that we could only use this type of model to predict the behavior of the NAIRU in the near future.

[14] This is maybe counterintuitive argument. Holm et al. (1994) has shown, however, that the capital stock can have either positive or negative impact on the wage rate in the monopoly union model.

4 RESERVATIONS AND CONCLUDING REMARKS

This paper investigates, firstly the decomposition of the actual unemployment to its structural and cyclical components. Secondly, the confidence interval for the structural unemployment rate is estimated. Thirdly, contributions of different factors to the structural unemployment rate are calculated.

Two different indicators that represent the structural part of unemployment, namely the NAWRU and the NAIRU, are estimated. The estimated NAWRU (non-accelerating wage rate of unemployment) follows very closely the actual unemployment in Finland. This is mainly due to the definition of the measure. The NAWRU is not the proper measure for the structural unemployment.

The estimated NAIRU (non-accelerating inflation rate of unemployment) were at a low level up to the end of eighties. Since then both the actual unemployment rate and the NAIRU have rocketed. In the mid-nineties the NAIRU was about 12 percent while the actual unemployment rate was about 18 percent. The confidence interval was about one percentage point until deep recession in early nineties in Finland. Since then it has increased to the level of four percentage points.

Our confidence interval is about the same magnitude, when taking into account the size of the NAIRU, as reported by Staiger et al. (1996). They have demonstrated that estimates of the NAIRU are quite sensitive with respect to estimation methods, set of explanatory variables and data used. According to their estimates a typical 95 % confidence interval for the NAIRU in 1990 is 5.1 % to 7.7 % in the United States. They conclude that imprecision of the NAIRU estimates suggest caution in using the NAIRU to guide "monetary policy".

We have calculated the contribution of the different factors to the NAIRU. The labour tax factor has increased the NAIRU about 3 percentage points from 1991 to 1994. The price factor has increased the NAIRU about 3 percentage points from 1991 to 1994.

The paper leaves room, of course, for further work. Firstly, one should try to estimate the NAIRU and thus the wage and price setting equations using the data covering whole economy. Secondly, a better empirical model considering both short-run dynamics and long-run relations is needed to understand the wage and price setting behaviour of the Finnish firms.

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APPENDIX 1: Data

The data consists of time series from the Bank of Finland's BOF4 model.[15] It includes yearly timeseries for the years 1975-1994.

The following variables from the BOF4-model were used in the study:

w - nominal wage per hour. Wage bill in manufacturing (including employers' social security contributions) per performed working hours in manufacturing

q - producer price. Prices in manufacturing, 1985=100.

u - unemployment rate, total.

t - personal marginal tax rate

p - consumer price index, 1985=100.

s - employers' social security contributions in manufacturing. Proportion of wage bill.

k - net stock of fixed capital in manufacturing

y - production in manufacturing. Production at factor cost, 1985=100.

l - total labour force

p^f - foreign prices, competitors' prices on foreign markets, 1985=100.

c - rate of capacity utilisation[16] in manufacturing

p^m - price of inputs, import prices of raw materials 1985=100.

r - nominal interest rate, long-term

[15] See Bank of Finland's model (BOF4) 1994.

[16] The data is from the Statistics Finland.

APPENDIX 2: Computation of the confidence intervals

The confidence intervals for the structural unemployment rate are based on the Wald test in the following way. In a model with only one non-linear restriction the statistic W, defined e.g. in Harvey (1981), p. 167, has a Chi-square distribution, with one degree of freedom. In testing of the structural unemployment one can write the change in the NAIRU, using the estimated equations, as

$$\text{(A1)} \quad \Delta \log(u^*) = \frac{\alpha_0 + \lambda_0 + \alpha_3' \Delta \log(z^w) + \lambda_3' \Delta \log(z^p)}{\alpha_1 + \lambda_1},$$

so that one can test the hypothesis that the change in the NAIRU is zero. It should be noted that the change in the NAIRU must be centered, so its computed value is subtracted from it. Denoting the centered change in the NAIRU by N*, one next finds the critical value f for which the W statistic of N*+f is equal to 3.84, the 95 per cent critical value of the Chi-square distribution at one degree of freedom. Now f can be taken as an end point of the confidence interval.[17] The obtained confidence intervals must be considered approximate.[18]

Now we have the confidence interval for the change in the logarithm of structural unemployment rate. Next we calculate the confidence interval for the structural unemployment rate. The logarithm of NAIRU is defined at time t (t=1976,...,1993) as

$$\text{(A2)} \quad \log\left(U^*_{1975}\right) = \log(2.5) \quad \text{and} \quad \log\left(U^*_t\right) = \sum_{i=1975}^{t} \log\left(U^*_i\right).$$

Because we have estimated the wage-price-system in the difference form, we have to fix the NAIRU in the first period using a priori reasoning (see page 8). The lower and upper bound in the logarithm of NAIRU at time t is

$$\text{(A3)} \quad \log\left(\underline{U}^*_t\right) = \log\left(U^*_{t-1}\right) - \phi_t$$

$$\text{(A4)} \quad \log\left(\overline{U}^*_t\right) = \log\left(U^*_{t-1}\right) + \phi_t$$

respectively. Taking anti-log we obtain estimates for the structural unemployment rate and for its confidence interval.

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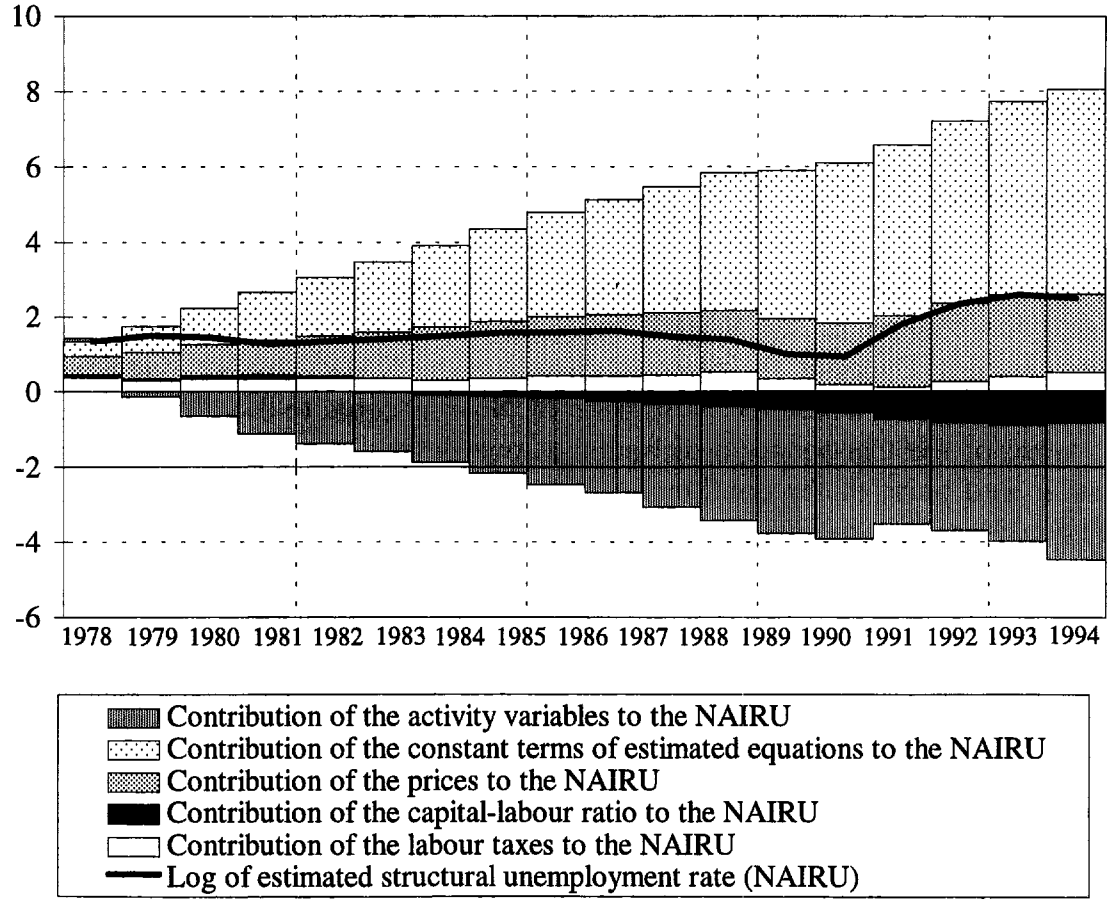
[17] Note that the centered Wald test statistic is symmetric around zero and that the matrix of derivatives of the restriction remains constant.

[18] The Wald test is only asymptotically chi-squared, so the nonlinear Wald test can be quite sensitive to the form of the restriction (see Lafontaine and White, 1986).

APPENDIX 3: The contribution of different variables to the logarithm of estimated structural unemployment rate[19]



[19] The calculation of the contribution of the different factors to the NAIRU based on the assumptions that i) the NAIRU was 2.5 percent in the beginning of the estimation period, ii) the share of the labour tax factor was 4/10, the share of the capital-labour and price factors was 2/10 each and the share of the rest was 1/10 each in that time. Although this affects the relative size of the different factors, the time profiles of factors are independent of their scales.