BANK OF FINLAND DISCUSSION PAPERS

6/98

Chris-Marie Rasi – Jan-Markus Viikari

Economics Department
15.4.1998

The Time-Varying NAIRU and Potential Output in Finland

SUOMEN PANKIN KESKUSTELUALOITTEITA • FINLANDS BANKS DISKUSSIONUNDERLAG

Suomen Pankki
Bank of Finland
P.O.Box 160, FIN-00101 HELSINKI, Finland
☎ + 358 9 1831

BANK OF FINLAND DISCUSSION PAPERS **6/98**

Chris-Marie Rasi – Jan-Markus Viikari

Economics Department
15.4.1998

The Time-Varying NAIRU and Potential Output in Finland

ISBN 951 686 571-2
ISSN 0785 3572

Suomen Pankin monistuskeskus
Helsinki 1998

The Time-Varying NAIRU and Potential *

Bank of Finland Discussion Papers 6/98

Economics Department
Chris-Marie Rasi – Jan-Markus Viikari

Abstract

This study presents statistical estimates of Non Accelerating Inflation Rate of Unemployment, or NAIRU, and potential output in Finland. The estimates are obtained by applying the structural time series/unobserved components method to quarterly data on inflation, rate of unemployment, aggregate production and a number of auxiliary variables covering the period 1982:1–1996:4. According to the basic idea underlying these methods, noisy estimates of the unobserved NAIRU and potential output can be obtained from the so called measurement equations, which in the present study are provided by the now standard specifications of the Okun's law and Phillips-curve. To pin down the dynamics of the unobserved components the study assumes that they are driven by stochastic trends. One of the main features of the method applied in the study is the system estimation of the NAIRU and potential output time seria along with other parameters. According to the results NAIRU and potential output variate in the long run less than the actual unemployment rate and output. Until the latter part of 1991 NAIRU has been above the unemployment rate. After this the NAIRU has remained clearly below the unemployment rate although it has risen trendwise to a level between 8 and 9.5 per cent in the 1990ies.

Key words: NAIRU, potential output, Phillips curve, structural time series models, unobserved components method

* We would like to thank Per Jansson from the Riksbank, whose methodology is used here and who provided us with the estimation program. Our thanks also go to Mikael Apel, Anne Brunila, Pasi Holm, Jouko Vilmunen, Kari Takala, Antti Suvanto and numerous other colleagues at the Bank of Finland for their assistance and helpful comments. We also thank Glenn Harma for a swift and skillful translation.

Tiivistelmä

Tässä tutkimuksessa arvioidaan tilastollisten menetelmien avulla vakaan inflaation ja potentiaalista tuotantoa Suomessa. Arviot perustuvat rakenteellisten aikasarjamallien / havaitsemattomien komponenttien menetelmän soveltamiseen kuluttaja-hintaindeksistä, työttömyysasteesta ja kokonaistuotannosta sekä muutamasta lisämuuttujasta koostuvaan neljännesvuosiaineistoon ajanjaksona 1982/1–1996/4. Näiden menetelmien perus-ajatuksen mukaan sinänsä havaitsemattomat vakaan inflaation työttömyysaste ja potentiaalinen tuotanto kytketään havaintoihin inflaatiosta, työttömyysasteesta ja tuotannosta ns. mittaus- tai havaintoyhtälöiden avulla, tässä tapauksessa Okunin lain ja Phillips-relaation avulla. Havaitsemattomien komponenttien ajallisen dynamiikan kiinnittämiseksi tutkimuksessa oletetaan, että komponentit ovat stokastisesti kehittyviä eli niiden kasvuvauhdit ovat stokastisesti vaihtelevia. Tutkimusmenetelmän keskeinen piirre on se, että vakaan inflaation työttömyysastetta ja potentiaalista tuotantoa vastaavat aikasarjat estimoidaan samanaikaisesti mallin muiden parametrien kanssa. Tulosten mukaan NAIRU ja potentiaalinen tuotanto varioivat pitkällä aikavälillä vähemmän kuin työttömyysaste ja toteutunut tuotanto. Vuoden 1991 loppupuolelle asti NAIRU on ollut toteutuneen työttömyysasteen yläpuolella. Tämän jälkeen NAIRU on jäänyt selvästi toteutunutta työttömyyttä pienemmäksi, vaikka se on trendimäisesti noussut 8–9,5 prosenttiin 1990-luvulla.

Asiasanat: NAIRU, potentiaalinen tuotanto, Phillips-relaatio, rakenteelliset aikasarjamallit, havaitsemattomien komponenttien menetelmä

Contents

1. Introduction

Economic research has recently reflected a renewed interest in defining potential output as well as the unemployment rate that is consistent with stable inflation, ie the nonaccelerating inflation rate of unemployment (NAIRU). The NAIRU has been a particularly timely topic in the United States, where an acceleration of inflation was anticipated as the unemployment rate receded to a record low of less than 5 per cent in 1997. Instead of realizing the acceleration scenario, the US has experienced a declining inflation rate. This has motivated further estimations of the NAIRU, and the idea has been expressed publicly that the effective NAIRU has fallen from over 6 per cent down to nearly 5 per cent.

Finland has also gone through a period of pronounced change in its inflation process, during the years 1979–1996. The exceptionally severe recession experienced in the early 1990s, the floating of the markka, the change in the monetary policy regime to inflation targeting, and the run-up to EMU have obviously had effects on the nature of the inflation process and on inflation expectations. The monetary policy regime change poses special challenges concerning measurement of both inflation and the NAIRU.

Many economists work on the assumption that there is an equilibrium unemployment rate for the economy, around which the actual unemployment rate fluctuates. Originally it was felt that this 'natural' rate of unemployment was constant over time, but today the prevailing view is that the rate changes over time. This interpretation was also stressed some time ago by the father of the natural rate hypothesis, Milton Friedman. It is especially clear that the equilibrium (ie structural) rate of unemployment has changed in Europe, which has been experiencing an uptrend in unemployment since the latter part of the 1970.

The weakening of the relationship between inflation and unemployment as described by the Phillips curve was a key motivating factor in the development of the natural unemployment rate concept. Friedman's arguments however did not result in complete rejection of the Phillips curve, which survived in a revised form. The unemployment gap (between equilibrium and actual rates) became a new cyclical indicator, inversely affecting the inflation rate: If the actual unemployment rate is higher than the NAIRU, inflation will decelerate; if lower, inflation will accelerate.

Developments in the OECD countries in the 1980s have shown that even this relationship is not a particularly stable or strong one. The reason might be either that estimation of a rising or otherwise changing NAIRU is difficult or that inflation gauges are misleading. Other possible reasons are that the unemployment gap is no longer a good cyclical indicator or that in an open economy, in which the share of foreign trade is large, excess demand raises the level of imports but does not necessarily boost the inflation rate.

The above-mentioned problems could explain the proclivity to distinguish between the NAIRU and structural unemployment concepts. OECD terminology distinguishes between the long-run structural rate of unemployment (SRU) and the NAIRU, which is a short-run phenomenon. The structural unemployment rate corresponds to Friedman's original natural unemployent rate, which is determined mainly by economic fundamentals, institutions, market regulations etc. Hence the functioning of labour and commodity markets, taxation and the level of unemployment compensation affect the structural unemployment rate.

The NAIRU, having its own dynamics, may differ from the structural unemployment rate in the short run, when the labour markets are buffeted by structural or demand shocks. It would be possible, for example, that actual unemployment would drop below the NAIRU and inflation woud accelerate even with the actual unemployment rate remaining above the structural unemployment rate. Changes in the unemployment rate fairly quickly affect the NAIRU and over time the NAIRU moves toward the unemployment rate.

According to another key hypothesis, the 'speed-limit' hypothesis, shocks that increase unemployment also raise the NAIRU and thus its approach to the structural unemployment rate becomes very sluggish. The extreme form of this is referred to as hysteresis, according to which it is not the level of the unemployment rate or of the unemployment gap that significantly impacts inflation but rather changes in the unemployment rate. In this framework, the NAIRU is considered to depend only on cyclical conditions and not on structural unemployment, and so the concept of structural unemployment is no longer well defined (see Giorno et al 1997, Blanchard and Summers 1986).

The slowness of the NAIRU adjustment process in the speed-limit case weakens the capacity of economic policy to push actual unemployment down to the structural level. Both theoretical studies and empirical studies based on data from different countries – this one included – point to the fact that inflation is affected not only by the gap between the actual and equilibrium unemployment rates but also by changes in unemployment (or in the unemployment gap). From the standpoint of economic policy, it is crucial to make this distinction. Because the estimation of the NAIRU is vague and because the relationship between the unemployment gap and inflation is not very stable in any of the OECD countries, monetary policy must be based on short-run indicators, of which the key ones are changes in output, unemployment and variables that measure the rate of inflation.

In section 2 we explain briefly the methods that have been developed for estimating the NAIRU and potential output. Section 3 contains a description of the structural time series/unobserved components (STM/UC) method used in this study and the model estimated. The empirical results are reported in section 4 and concluding remarks are given in section 5.

2. Methods for estimating the NAIRU and potential output

Numerous methods have been developed in recent decades for estimating the NAIRU and potential output[1]. In the so-called **structural methods**, the NAIRU or potential output is estimated by solving separate price and wage behaviour equations for the equilibrium unemployment rate. The price-wage approach has been applied to Finnish data e.g. by Holm and Somervuori (1997). If the equations are contained in a larger macro model, the solution is found using simulation techniques.

In the so-called **direct methods** the NAIRU is usually estimated from observed unemployment and inflation or using only time series (unemployment or output), for which different trends are estimated. The nonaccelerating wage rate of unemployment (NAWRU), used by the OECD, is an example of the direct method. The NAWRU, which is comparable to the NAIRU, is calculated as a function of wage inflation and the unemployment rate by applying the Hodrick-Prescott filter to the data (Elmeskow 1993). Results from this procedure have been highly controversial inter alia because the choice of the H-P filter smoothing parameter is always somewhat arbitrary.

A frequently used method of estimating potential output is the production function method, which can also be considered as a type of direct method (Giorno et al 1995). Potential output is estimated as a function of the trend components of labour and capital inputs, assuming eg a Cobb-Douglas production function. Here, the problem arises as to the appropriate method of calculating the trends for labour and capital. For the results, it is not at all a matter of indifference eg how one estimates the amount of labour input that is compatible with stable inflation. The known arbitrariness of the trend method is shifted here to the estimation of the inputs.

Structural vector autoregression (SVAR) models can in principle be considered direct estimation techniques, albeit they represent a step in the direction of structural methods. With SVAR models, the structural part of the output change, ie the change in potential output, is estimated for each period by separating permanent and temporary shocks by applying long-run restrictions on the parameters (Apel and Jansson 1997). The strength of this method is that the results do not suffer from the end-point problem, which is the weakness of mechanical filters such as the Hodrick-Prescott filter. On the other hand, SVAR models share the fault of mechanical methods in that they do not make explicit use of the definition of potential output as the output level that keeps inflation stable. The STM/UC method, on the other hand, permits use of the above-mentioned parametric restrictions, which enables an economically satisfying interpretation of potential output and the NAIRU.

There are uncertainties attached to the results derived on the basis of any of the currently used estimation methods, including the STM/UC method used in this study. The series generated have large confidence intervals or the methods do not

[1] An extensive collection of findings on the NAIRU and a summary are available in the report of the OECD WP1 meeting, October 1996.

enable the calculation of confidence intervals[2]. The latter is the case at least for the trend smoothing methods. Even in the US, where inflation has been relatively stable and little uncertainty has been associated with NAIRU estimations, confidence intervals generated by direct methods have had widths of ±1.3 per cent or ±2.5 per cent, depending on the model (Staiger et al 1996).

In general, one can say that direct estimation methods produce more precise results than structural methods. When the latter are used, the NAIRU or potential output are estimated as a function of several time series, which increases the uncertainty, and the choice of explanatory variables is always somewhat arbitrary. In the study of Holm and Somervuori (1996), the only significant explanatory variable in the price equation is the constant, and the width of the confidence intervals for NAIRU estimates for the 1990s are about ±2 percentage points. The estimated coefficients are highly uncertain, and even small changes in the estimation period or specification can result in substantially different estimates for certain time periods. Another problem is that the uncertainty associated with estimates increases toward the end of the period, which is just the point of greatest interest for evaluating the current situation.

One reason for the renewed interest in the NAIRU is the development of the above-mentioned STM/UC methods (eg Engle 1978, Harvey and Todd 1983, Harvey 1985). In STM/UC models the unobserved variables (only one variable in nearly all studies to date: potential output or the NAIRU) are estimated from the inflation equation or group of equations simultaneously with the other parameters. Typically these models contain a price equation including the Phillips relation with a stochastic NAIRU, which is assumed to take a simple functional form such as a random walk. Besides time, the NAIRU becomes dependent on the inflation dynamics and other factors affecting inflation. A single unobserved component is used for example in Gordons̓ (1997) model.

3. The unobserved components method and the empirical model

Apel and Jansson (1997) have developed a version of the STM/UC method, in which potential output and the NAIRU are both unobserved variables and are estimated simultaneously. It is perhaps the only known study, prior to the one at hand, in which both of these unobserved variables are estimated in the same model system along with the other parameters *and* in which use is made of a definition by which NAIRU and potential output are such levels of the unemployment rate and of output which are consistent with stable inflation.

The method of Apel and Jansson involves a five-equation system, in which the unobservable variables are combined with the observables, which are here the inflation rate (or changes therein), output and the actual unemployment rate. The unemployment gap (and thus the NAIRU) determine inflation via the Phillips curve relation (1) and the output gap via the Okun relation (2). These two are the **identifying** equations in the system. Equations (3), (4) and (5), are the so-called

[2] The Apel-Jansson (1997) STM/UC method, used in this study, enables calculation of confidence interval, but since the process is quite time-consuming, the calculations were not carried out for their study. For the same reason, this was not done for this study.

transition equations that comprise the trend-cyclical part of the model and are based on ad hoc assumptions on the behaviour of the unobservable variables.

Price equation

inertia demand supply

(1) $\pi_t = \rho(L)\pi_{t-1} + \eta(L)(u_t - u_t^n) + \omega(L)z_t + \varepsilon_t^{price}$ (basic form)

(1a) $\Delta\pi_t = \rho(L)\Delta\pi_{t-1} + \eta(L)(u_t - u_t^n) + \omega(L)z_t + \varepsilon_t^{price}$

(1b) $\Delta\pi_t = \rho(L)\Delta\pi_{t-1} + \eta(L)\Delta(u_t - u_t^n) + \omega(L)\Delta z_t + \varepsilon_t^{price}$

Okun's law

(2) $y_t - y_t^p = \phi(L)(u_t - u_t^n) + \varepsilon_t^{okun}$

NAIRU equation

(3) $u_t^n = u_{t-1}^n + \varepsilon_t^{nairu}$ (basic form)

(3a) $u_t^n = \beta + u_{t-1}^n + \varepsilon_t^{nairu}$

Potential output

(4) $y_t^p = \alpha + y_{t-1}^p + \varepsilon_t^{pot.output.}$

Cyclical unemployment

(5) $u_t - u_t^n = \delta(L)(u_{t-1} - u_{t-1}^n) + \varepsilon_t^{cycl.unempl.}$

where

π_t = inflation rate,

u_t = unemployment rate,

u_t^n = NAIRU, $(E(u_t - u_t^n) = 0)$,

z_t = vector of supply shock variables,

y_t = log of real output *100,

y_t^p = log of potential output * 100, $(E(y_t - y_t^p) = 0)$,

ρ (L), η(L), ω(L), ϕ(L), δ(L) are lag polynomials.

$\varepsilon_t^{price}, \varepsilon_t^{okun}, \varepsilon_t^{nairu}, \varepsilon_t^{pot.output.}, \varepsilon_t^{cycl.unempl.}$ are IID error terms.

$E(\varepsilon_t^{price}) = E(\varepsilon_t^{okun}) = E(\varepsilon_t^{nairu}) = E(\varepsilon_t^{pot.output}) = E(\varepsilon_t^{cycl.unempl.}) = 0.$

The error terms are assumed to be mutually independent with constant variance.

Equation (1) is precisely Gordon's (1997) **triangle Phillips model**. The name triangle emphasizes that inflation is defined as a tripartite set of basic determinants: (1) price stickiness (inertia) or expectations factors, (2) demand factors (ie cyclical conditions, measured here by the gap between the actual unemployment rate and the NAIRU) and (3) supply factors. Gordon-type inflation models have a long history in the US and have performed quite well there. Gordon's work has been frequently cited in US discussions as a significant argument for preserving the short-run Phillips curve.

The autoregressive components in the price equation can be interpreted as being reflective of price expectations, but here they are treated more conventionally as reflective of the stickiness of price adjustments, ie inertia. Gordon makes a clear distinction between these two factors. Price adjustment can be sluggish because of various micro structures in the market, supply lags, scattered wage settlements, incomplete information etc. Inflation expectations themselves can be much more susceptible to change.

In his earlier estimation exercises, Gordon used a constant, "textbook" NAIRU in equation (1). In his recent work (Gordon 1997), he estimated a stochastic NAIRU from equations (1) and (3). Gordon constrains the variance of the NAIRU to a specific value (eg 0.2) so that the NAIRU does not 'absorb' the whole residual from the price equation. In the model described above, whose basic form corresponds to the model estimated by Apel and Jansson (1997), such constraints on the residual term are not necessary as the other constraints on the system handle the variance of the residual.

Apel and Jansson (1997) deduce their empirical price equation from a basic form in which equation (1) includes a term depicting long-run inflation expectations, $(1-\rho(1))\pi^*$. This term disappears if inflation has a unit root, ie $\rho(1) = 1$. This means that $\rho_0 + \rho_1 + ... +\rho_q = 1$, ie the sum of the lagged endogenous inflation terms in equation (1) is one. This is necessary in order that the price equation define a NAIRU. In equilibrium, when inflation is stable, $\pi_t = \pi_{t-1}$ and $z_t = \varepsilon_t^{price} = 0$ for all t. Thus $u_t - u_t^n = 0$, ie the unemployment rate is at the NAIRU level; otherwise inflation is not stable. In the case of a unit root, inflation can be expressed in difference form (1a), ie as the change in the inflation rate.

Gordon (1997) did not estimate his inflation equation in difference form but the lagged inflation terms in his models are specified so that their coefficients generally add up to something very close to one; thus the constraint applies in practice. Apel and Jansson estimated models of both type (1) and (1a) without specifically testing the unit root restriction. They found that for the type (1) model the sum of the ρ (autoregressive) coefficients is negative with absolute value between 0 and 0.5, which does not indicate the existence of a unit root. In practice though, they prefer the type (1a) model, ie a specification based on the existence of a unit root, which we refer to here as a difference model.

In our application of the Apel-Jansson model using Finnish data, we also choose to express the inflation equation in difference form (specifically version 1b which we developed most) because in preliminary OLS testing of the type (1) model with Finnish data it was found that the coefficients of the lagged endogenous variables generally totalled approximately one. The above-discussed restriction regarding satisfactory specification of the NAIRU was a concern in this choice, as was the fact that other studies on Finnish inflation (eg Kinnunen 1996, appendix 1), suggest the existence of a unit root. We also noted that the estimation results of the supply variables, were more meaningful in the difference-form (1a) specification.

The purpose of including the supply variables in the inflation equation is to account for the effects of factors that increase or decrease inflation but which are not explained by the tightness of the labour market. Such factors include the rise in the price of energy, relative import prices (terms of trade), the real exchange rate and productivity. The inflation and unemployment rates can change in the same direction even in the absence of inflationary or deflationary pressures from the demand side. If the supply variables are positively correlated with the inflation rate, leaving them out results in a bias toward zero in the estimates of the demand variable coefficients. If the supply variables are sufficiently well specified, the resulting measure of the NAIRU will be consistent with stable inflation absent supply shocks.

This study reports estimation results from models including price equations (1a) and (1b). Type (1) models, which explain the inflation rate, are left for possible subsequent studies. The estimation was done by maximum likelihood method using Kalman filters. The numerical algorithm was SIMPLEX available in program packet RATS. The practical application was originally developed by Per Jansson and we modified it in conformity with our models and other requirements.

In order to proceed with the estimation, the system is expressed in **state-space** form. The identifying equations (1) [or (1a) or (1b)] and (2), together with an identity concerning the unemployment rate ($u_t = u_{tn} + (u_t - u_{tn})$), constitute a so-called measurement system. Equations (3)–(5) form the trend-cyclical part of the model, ie the transition system. Appendix 1 contains an example of a model written in state-space form. The idea behind the method is to use the estimated parameters and unobserved components to forecast the values of observed variables at time t on the basis of information available at t–1. Forecast errors are minimized using the numerical maximum likelihood method (see Apel and Jansson 1997).

4. Empirical results

In this section we report the results for models in which the dependent variable in the price equation is the change in the inflation rate, ie (1a) or (1b). All the models have five equations. They are named after the exact spesification of eq. (1) and (3).

The initial testing involved model (1a3), which is closest to the Apel-Jansson (1997) specification ($\Delta\pi^{CPI}$). In this model the unemployment gap is in level form and the supply variables are specified as changes in relative prices. In models (1b3) and (1b3a), also the unemployment gap is in difference form and for the supply variables second differences are used. Models (1b3) and (1b3a) differ from each other only in that model (1b3a) includes the β parameter in the NAIRU equation.

System simulation results are presented in table 1. Estimates of the NAIRU and potential output are presented in charts 1–3. Estimation period was quarterly data for the periods 1979:Q4–1996:Q4 (model types 1b3 and 1b3a) and 1977:Q4–1996:Q4 (type 1a3). The results given in charts 1–3 start ten quarters after the first quarter used in estimation because the forecasts (ie estimates) generated by the applied methodology are highly arbitrary for the first 2–3 years.

Table 1. **System estimations with different model specifications**[*)]

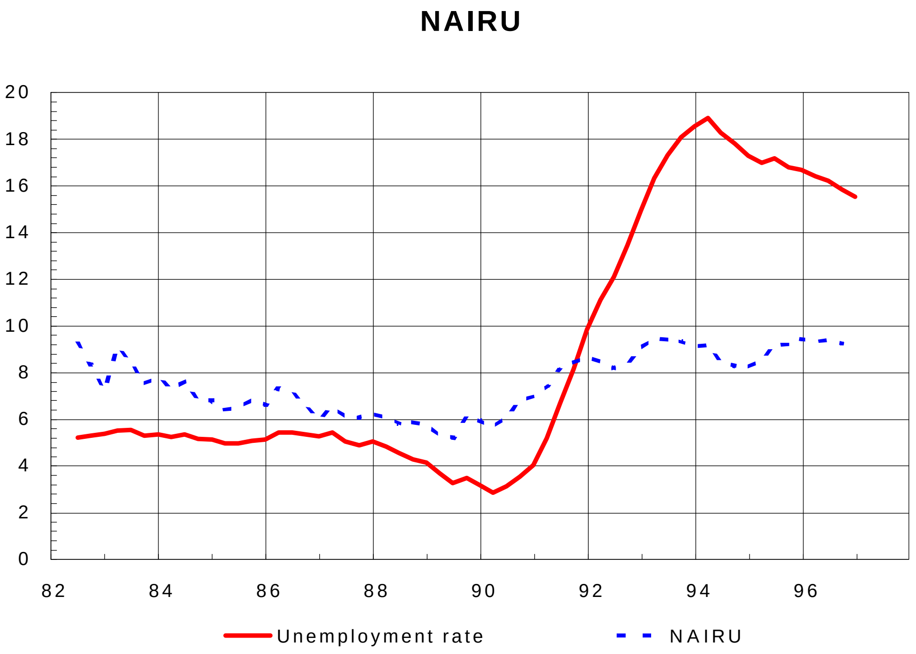
Model Dependent price var. Unemp. Gap Supply var. differences β incl.	**Model 1b3a** $\Delta\pi$ = CPImlddn $\Delta(U - U^N)$ $\Delta\Delta$ yes	**Model 1b3** $\Delta\pi$ = CPI mlddn $\Delta(U - U^N)$ $\Delta\Delta$ no	**Model 1a3** $\Delta\pi$ = CPImlddn $(U - U^N)$ Δ no
Equations	Parameter (p-arvo)	Parameter (p-arvo)	Parameter (p-arvo)
Price (1), (1a) or (1b)			
ρ_{t-1} (AR(1))	0.27 (0.00)	0.24 (0.00)	+0.47 (0.00)
η_{t-1}	-	-	-0.03 (0.00)
η_{t-4}	-	-	0.03 (0.00)
$\Delta\eta_{t-3}$	-0.05 (0.04)	-0.06 (0.02)	-
$PCIENERmlddn_{t}$	0.53 (0.00)	0.54 (0.00)	-
$PCIENERmldn_{t}$	-	-	0.33 (0.00)
$PCIENERmldn_{t-1}$	-	-	-0.56 (0.00)
$REXRATEmldn_{t-1}$	-	-	-0.05 (0.01)
$REXRATEmldn_{t-2}$	-	-	0.06 (0.03)
$REXRATEmldn_{t-3}$	-	-	-0.05 (0.02)
$REXRATEmldn_{t-5}$	-	-	0.06 (0.01)
$REXRATEmldn_{t-6}$	-	-	-0.05 (0.01)
$IMPRISmlddn_{t-4}$	0.05 (0.00)	0.05 (0.00)	-
$IMPRISmlddn_{t-5}$	-0.05 (0.00)	-0.05 (0.00)	-
$IMPRISmlddn_{t-8}$	0.04 (0.01)	0.04 (0.01)	-
$IMPRISmldn_{t}$	-	-	-0.03 (0.12)
$IMPRISmldn_{t-1}$	-	-	0.04 (0.03)
$ASCPImlddn_{t-2}$	0.04 (0.00)	0.04 (0.00)	-
σ^{hinta} (stand. error)	0.09 (0.00)	0.09 (0.00)	0.09 (0.00)
Okun (2)			
ϕ_t	-2.81 (0.00)	-3.94 (0.00)	-5.10 (0.00)
ϕ_{t-1}	0.87 (0.18)	2.32 (0.06)	3.65 (0.00)
ϕ_{t-2}	-	-	-
ϕ_{t-3}	-	-	-
ϕ_{t-4}	0.79 (1.00)	0.34 (0.66)	-
$\Sigma\ \phi$	-1.14	-1.28	-1.45
σ^{okun} (stand. Error)	0.56 (1.0)	0.57 (0.04)	0.67 (0.00)
NAIRU (3) or (3a)			
β	0.16 (0.01)	-	-
σ^{nairu} (stand. Error)	0.15 (0.13)	0.19 (0.03)	0.21 (0.00)
Potent. Output (4)			
α	0.50 (0.00)	0.70 (0.17)	0.76 (0.00)
$\sigma^{pot.output}$ (stand error)	-0.42 (1.00)	0.31 (0.58)	1.9e-6 (1.00)
Cyc. Unemployment (5)			
δ_1	1.27 (0.00)	1.42 (0.00)	1.94 (0.00)
δ_2	-	-	-0.94 (0.00)
δ_3	-	-	-
δ_4	-0.32 (0.00)	-0.83 (0.00)	-
δ_5	0.0007 (0.93)	0.40 (0.06)	-
$\Sigma\ \delta$	0.95	0.99	1.0
$\sigma^{cycl.unem.}$ (stand. error)	0.29 (0.00)	0.23 (0.00)	0.18 (0.00)
Estimation Period	1979Q4 -1996Q4	1979Q4 -1996Q4	1977Q4 -1996Q4
Number of observations	69	69	77
Log likelihood -f. value	-40.92	-42.14	-50.53
Q_y (10)	14.5 (0.15)	14.3 (0.16)	13.02 (0.22)
Q_U (10)	7.6 (0.67)	10.3 (0.41)	9.05 (0.52)

$Q\pi$ (10)	3.9 (0.95)	3.72 (0.96)	8.1 (0.62)

*) ρ_{t-1} (AR(1)) is an autoregressive parameter, lag 1. η_t is the coefficient of the unemployment gap, $\Delta\eta_{t-3}$ is the coefficient of the change of the unemployment gap, lag 3. PCIENERmldn and PCIENERmlddn are respectively the change and the change of the change of the relative price of energy. REXRATEmldn is change in the real exchange rate, ie in the ratio of markka-valued domestic consumer prices to those of competitor countries. The ratios are defined so that a decline in the real exchange rate implies an improvement in Finland's competitiveness. IMPRISmldn and IMPRISmlddn are respctively the change and change of the change of the producer price index relative to consumer prices. ASCPImlddn is change in relative change in housing prices, ie in the national index of housing prices (1983 = 100) relative to the CPI. (For greater detail, see appendix 2). The letters following the name of a variable, eg mldn, describe the transformation, as explained in the table in appendix 2.

The numbers in parentheses in the table are P-values. $Q_i(10)$ ($i = y, u, \pi$) are Ljung-Box Q test statistics measuring general AR(10) autocorrelations for the residuals. The values of these statistics do not allow the rejection of the zero correlation hypothesis.

Chart 1.
Nairu and potential output from model 1b3



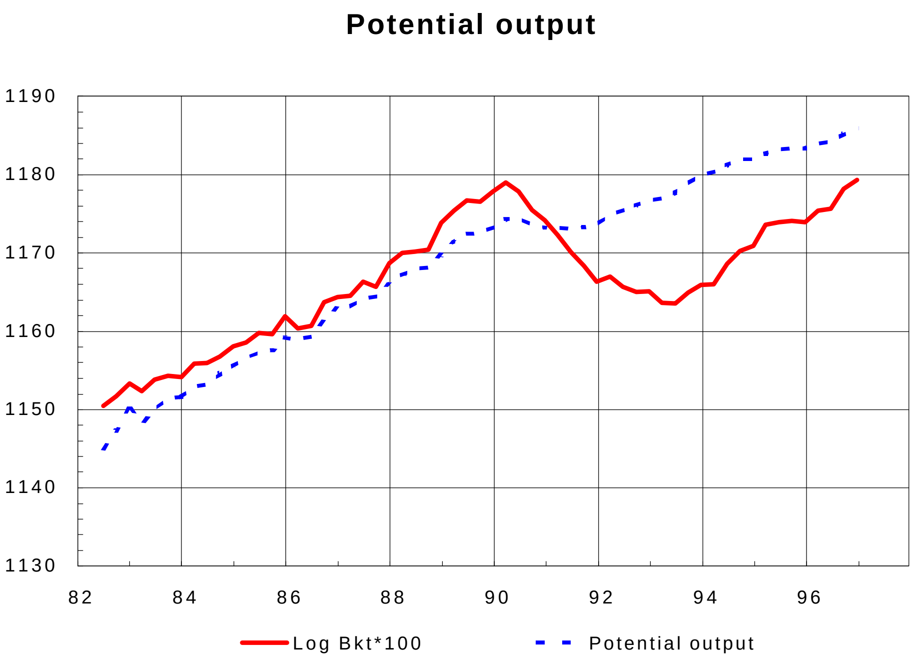
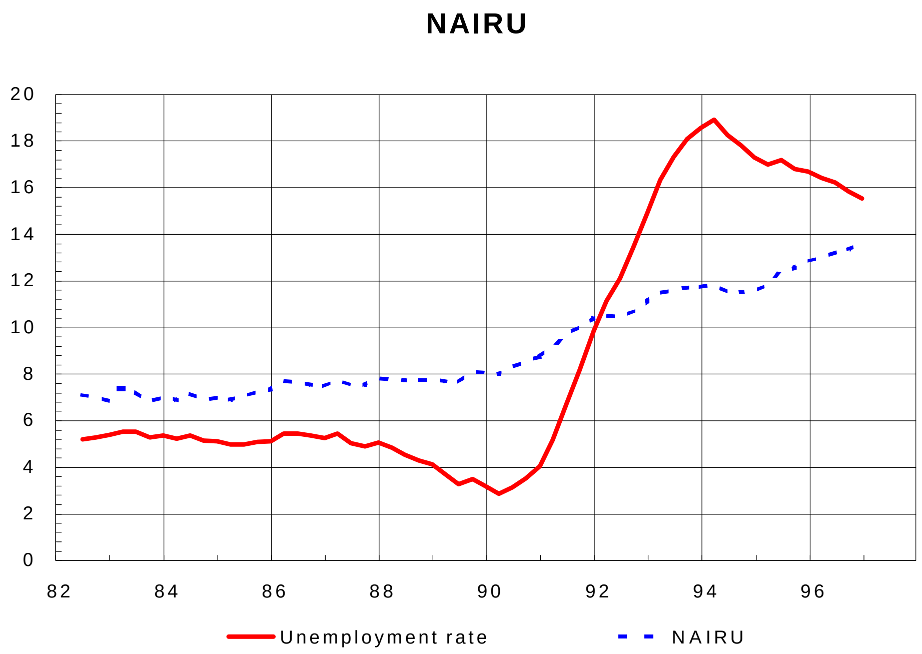


Chart 2.
Nairu and potential output from model 1b3a



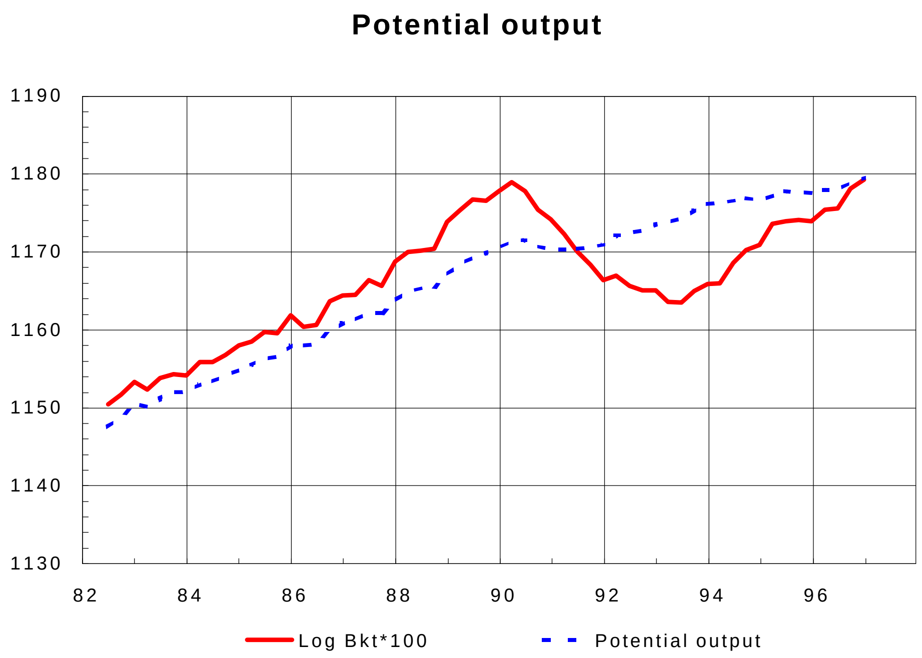
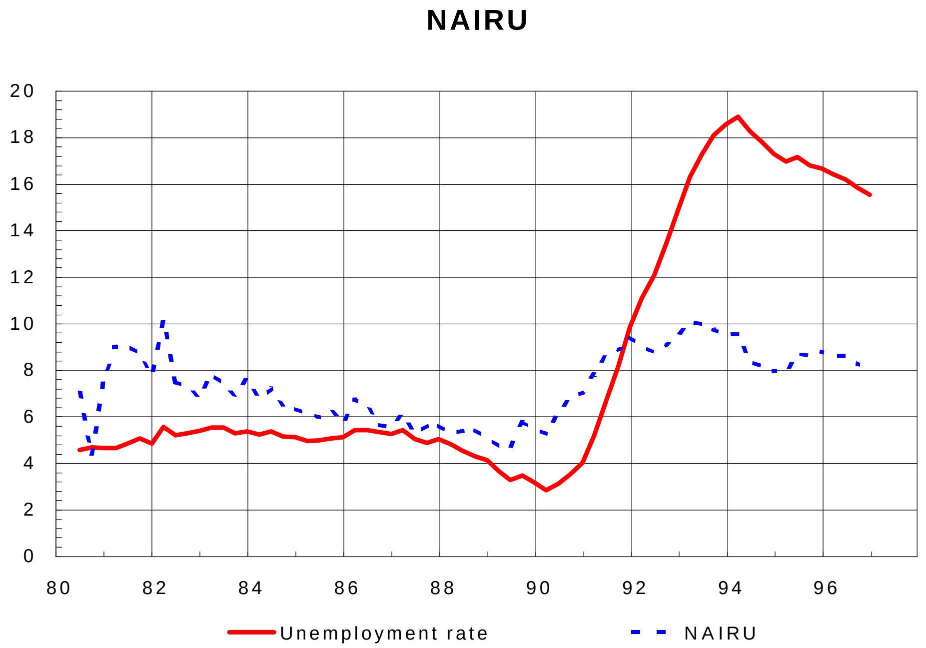
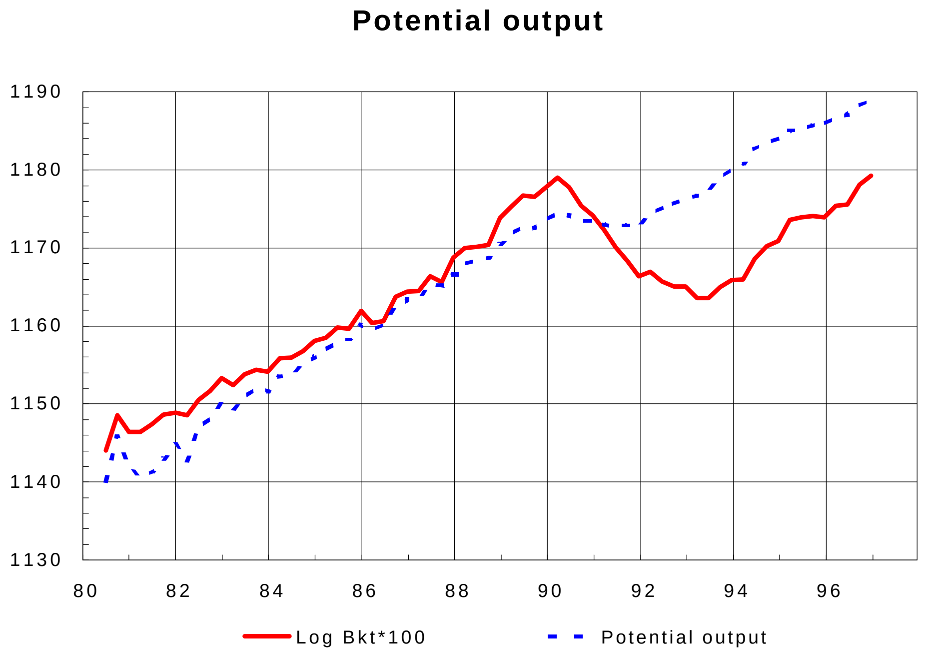


Chart 3.
Nairu and potential output from model 1a3





Estimation and specification of the inflation equation were done in two stages. Prior to actual system estimation, which is very time consuming, OLS was used as an aid in deciding on the specification of equation (1).

The length of the estimation period was restricted because of **data limitations**. The CPI was used for the price series. Other price indices were tested, but in the early stages the CPI proved to be the best price indicator and hence was used thereafter in order to limit the number of models involved. For the unemployment rate, Statistics Finland's seasonally adjusted (Stamp) series was used. The unemployment rate series of the Ministry of Labour was also tested and was found to be roughly on a par with the Statistics Finland series in terms of explanatory power. This comparison was made only in preliminary testing. The Statistics Finland series was chosen since it is official and more strictly internationally comparable. For the output series we used seasonally adjusted GDP valued at 1990 prices. More detail on data, transformations and other tested variables is given in appendix 2.

Since OLS cannot be used to estimate unobserved variables, testing was done using the NAIRU series developed in Holm–Somervuori (1996) as a surrogate as well as trends in the unemployment rate calculated via the Hodrick–Prescott filter, using different smoothing parameters. The best results were obtained using a trend calculated with a smoothing parameter of $\lambda = 200$. This produced a very smooth trend, ie the estimated NAIRU differed widely from actual unemployment and so the size of the unemployment gap varied a great deal.

In preliminary testing, the **unemployment gap** calculated from the Holm-Somervuori NAIRU series performed best, although the difference vs the results using the H-P filter NAIRU was not substantial. In both cases, the current and lag four unemployment gaps were significant explanatory variables, but their coefficients were very small in magnitude (approx. 0.05) and of alternating signs. This same result was repeated almost without exception for different model (1a) specifications and different surrogates for the NAIRU, which did, however, give highly differing unemployment gaps.

This phenomenon also appeared in the broader system estimations, in which u_t^n was estimated in the model. For example, in model (1a3), $\eta_\tau = -0.03$ and $\eta_{\tau-4} = 0.03$ were obtained as coefficients of the *level of the gap* (table 1). These results are equivalent to getting a value of 0.03 for the contemporary coefficient of the *difference of the gap* over four periods. These results support the hysteresis interpretation of the NAIRU. Changes in unemployment rate dominated the effects of the various unemployment gaps on inflation. The level of the gap was less important.

Because of these problems, we decided to test in the significance of the **first differences in the unemployment gap.** Lag 3 turned out to be significant and was hence used in models (1b3) and (1b3a). The coefficients are small but their negative sign is consistent with theory. Growth in the unemployment gap (ie in unemployment) reduces the change in the inflation rate. For both specifications, it appears that the level of the gap itself has no explanatory power.

Tests were done (not included in the table) on model (1b3), in which both $\Delta(u-u^n)_{t-3}$ and $(u-u^n)_{t-8}$ were used (the latter being the level of the unemployment gap, lag 8). In preliminary estimations, lag 8 was the closest to being significant. However, in the system estimations, lag 8 turned out not to be significant and its coefficient was positive. On the other hand, $\Delta(u-u^n)_{t-3}$ retained its significance.

In the same context, we also tested the version in which the variables $(u-u^n)_t$ and $(u-u^n)_{t-4}$ were included along with lags of Δu. This is the type of model that Giorno et al (1997) used to test the hysteresis hypothesis. In this model u^n_t is interpreted as structural unemployment. It turned out that the unemployment gap level variables were not significant and their coefficients were very small. The change in the current unemployment rate, Δu, by contrast, was significant, and the sum of the coefficients was -0.05. Testing of the hysteresis hypothesis, however, requires more careful testing than was possible here.

The search for **supply factors**, ie exogenous variables, for the model was also conducted via OLS testing. It turned out that it is not easy to find factors that explain inflation in Finland and that are significant over the entire estimation period. The most significant factors were the change in the relative price of energy (PCIENER), change in the relative import price (IMPRIS), change in the real exchange rate (REXRATE) and change in the relative price of housing (ASCPI).

In searching for supply variables, we tested different lag lengths, choosing those that were significant or almost significant. In the preliminary OLS testing for model-types (1) and (1a), the variables PCIENER, IMPRIS and REXRATE exhibited the same pattern as the level of the unemployment gap: The coefficients of the significant lags were nearly of the same magnitude but of alternating signs and their sum was approximately zero. In many cases the sign was also the opposite of that implied by theory. In model (1a3) (table 1) one can see this pattern in the coefficients of REXRATEmldn and IMPRISmldn.

Because of these problems, we decided to test second differences in the equations'supply variables Z, ie the change in the change in the relative price. This specification considerably improved the coefficients of the supply variables in models (1b3) and (1b3a) whose coefficients (or their sum) are of the correct sign and are significant.

To test the effects of the supply variables on the results, these variables were left out of model (1b3). It showed that with the supply shocks included, the NAIRU is 2–3 percentage points lower at the start of the estimation period. In the latter part of the period, starting with 1989, supply shock effects raised the NAIRU by 1–3 percentage points.

In the system estimation for the **Okun equation** (2), we first tested lags 0,1,2,3 and 4. Lags 2 and 3 were significant and their sum was between -1.1 and -1.5 regardless of the number of variables included. In model (1b3) a 1 percentage point rise in the unemployment rate was associated with a 1.28 per cent decline in output for the next year. The corresponding coefficient from the Apel and Jansson (1997) study is about -1.8 regardless of the version of the model. In both studies the standard error for the equation, σ^{okun}, was quite large (about 0.8 for Sweden and 0.56-0.67 for Finland). The residuals of this equation diminish and their characteristics (Q-test statistics) improve as the number of lags increases. We chose the two and three parameter versions for the Okun equation because these seemed to suffice.

In the equation for **trend growth of output** (4), the constant α = 0.70 in model (1b3) implies that potential putput grows by about 2.8 per cent a year. This is close to the commonly held view that the potential growth rate is about 3 per cent in Finland. The fairly large value of $\sigma^{pot.output}$ means that some specification for equation (4) other than log-linear might be worth testing. Apel and Jansson tested a stochastic α ; in place of the constant α they used $\alpha_\tau = \alpha_{\tau-1} + \varepsilon_t^\alpha$. This could be a suitable specification for models in which trend growth fluctuates a great deal, as is the case for Finland. Apel and Jansson however could not reject the hypothesis that $\varepsilon_t^\alpha = 0$ and thus the constant α appears to be suitable for Sweden. In this study only a constant α was used.

In the equation for **cyclical unemployment** the sum of the autoregressive parameters for different specifications were quite close to one, ie cyclical unemployment appears to behave like an I(1) prosess. Specification of cyclical unemployment and the NAIRU are naturally closely related.

Because unemployment rose sharply in Finland during the study period, it was decided to test the **NAIRU equation** for the same kind of constant as in the potential output equation, ie the **constant β** (random walk with drift) was added. β took values in the range of 0.1–0.2 and its significance varied. The effect of β can be seen by comparing models (1b3) and (1b3a). Inclusion of β reduces the residuals for the NAIRU equation but increases them for the cyclical unemployment equation. The NAIRU follows a clearly rising path, as expected. Estimates obtained for the 1990s are closer to those results from other studies. The constantness of β is however a problem. Here the NAIRU rises each time period by β, and it is possible that the other factors would push it down very little compared to β even if the estimation period was extended at the end. Inclusion of β is not *a priori* a better assumption than that of a pure random walk. If it gets a significant coefficient, as in model (1b3a), β reflects the rise in equilibrium unemployment and the effects of factors that are not captured by the model. A stochastic constant, such as is found in the potential output equation, might be worth testing also in the NAIRU equation. On the other hand, a stochastic constant in the potential output equation could also affect the estimated NAIRU, even if its equation remains unchanged.

From model (1b3) we obtained a **NAIRU that fluctuates between 8 and 9½ per cent in the 1990s**.[3] It should be kept in mind that in this model a narrowing (widening) of the unemployment gap increases (decreases) the change in the inflation rate whereas levels of the unemployment gap are not significant. From the curve in chart 1 for model (1b3) one can see that over the years 1982–1986 the unemployment gap widened (actual unemployment approached the NAIRU from below, ie $(u_t - u_t^n)$ increased), which is consistent with the receding inflation of that time. Moreover, the narrowing of the unemployment gap in 1987–1989 is consistent with the accelerating inflation of the time. Downward pressure on the inflation rate was caused by a pronounced increase in unemployment and in the unemployment gap in 1991–1993. Since then, there has been a degree of upward pressure on inflation. Because the estimated coefficient is small, the effects are not readily visible.

In order to test the robustness of the model 1b3 **the estimation period** was restricted to 1979Q4–1990Q4. The resulting NAIRU was somewat *below* the unemployment rate until 1988 after which a negative gap emerged as in figure 1. On the other hand, adding the year 1997 to the estimation period of model 1b3 gave similar results as for model 1b3.

From the results one can assert **in general** that model (1a3), which corresponds to one of the Apel´s and Jansson´s (1997) specifications, performed worse in a statistical sense than other reported models, and its estimates of the NAIRU and potential output appear to be highly unreliable (chart 3). It must be

---

[3] For 1994 there are two assessments: the OECD's NAWRU of 15% and Holm–Somervuori's NAIRU of 12%.

admitted, though, that one cannot place much credence in the results from models (1b3) and (1b3a), which were estimated using $\Delta\,(u{-}u^n)_{t-3}$, because the change in the unemployment rate appears to be dominant in the relationship, which means that the resulting NAIRU and potential output are not very well defined. It should also be noted that the results indicate that the size of the unemployment gap is not significant for inflation. The levels of the NAIRU and unemployment gap – even if 'correct' – are not crucial for the inflation dynamics according to these tentative results.

Results from model (1b3) suggest that at end-1996 the unemployment rate was about 6 percentage points above the NAIRU. The level of output was nonetheless only about 4 per cent below potential output. This apparently inconsistent result may be explained by the fact that unemployment reacts to cyclical changes more slowly than output. The sluggish reaction of the unemployment gap also shows up in a mutual comparison of the gaps for model (1b3a) in chart 2.

4.1 Preliminary results with a reversed model

Research on the inflation-unemployment link (eg Giorno et al 1997) suggest that in Europe and Japan the **output gap** is a better cyclical indicator than the unemployment gap and that output gap-inflation rate link is stronger than the unemployment gap-inflation rate link. The regulation and inflexibility of the labour market mean that higher costs are associated with unemployment adjustments than with production adjustments.

In order to test this assumption the model (1b3) was transformed so that the unemplyment gap (u_t - u_t^n) in equation 1b was replaced by the potential output gap (y_t - y_t^p). Consequently, the Okun's law was reversed so that the output gap was on the right hand side and eq. (5) was defined for cyclical output instead of cyclical unemployment. The preliminary testing for this kind of model is reported in Rasi (1998). It turned out that the output gap should also be specified in difference form as was the unemployment gap in models 1b3 and 1b3a. The coefficient of the gap variable remained small but significant. The estimates for the NAIRU in the reverse model are about 1 per cent point higher for 1996 when compared to model 1b3. Because some problems with the specification still exist the results are not reported here. This line of specification seems promising, though. Eg Okun's law seems to fit better in the reversed form.

5. Concluding remarks

Potential output and the NAIRU have often been treated in the literature as if mutually independent, even though it seems clear that they are closely connected. In this study that relationship is taken explicitly into account via Okun's law. Potential output and the NAIRU (unobserved variables) are estimated in a five-equation system using the STM/UC method. The basic elements of the model are the Phillips curve equation, specified so as to produce the NAIRU, which in the absence of shocks is consistent with stable inflation and with Okun's law, by which a gap between actual and equilibrium unemployment implies a gap between actual and potential output. This type of specification improves the performance of the model as compared to Gordon's (1997) specification, in which it is necessary to restrict a priori the variance of the NAIRU.

In defining the time series specification of potential output, the NAIRU and the unemployment gap, we tested the assumptions usually made in this regard in the STM/UC literature. One way of improving the model might be find a more accurate specification of the trend-cyclical components of these unobserved components.

The estimated NAIRU level is affected by certain supply factors, such as changes in the relative price of energy. Identification of supply factors that were crucial throughout the estimation period proved to be difficult, nor were the dependencies found here particularly pronounced.

According to our results, the NAIRU appears to have been higher than actual unemployment until 1991 and it is trending downwards until 1989. During the 1990s the NAIRU has risen but less than actual unemployment. No downward turn in the NAIRU trend appears during the estimation period, ending in 1996Q4. The NAIRU estimations turned out to be relatively sensitive to model specification so that one is well advised to view the point estimates with caution.

The estimates derived here for the NAIRU and potential output should be viewed with caution also because the findings suggest that the change in the unemployment gap/unemployment is more important than the level of the gap in explaining inflation. The absence of an effect running from the level of the gap to inflation suggests the existence of hysteresis, in which case the NAIRU (and possibly structural unemployment) rise (fall) as actual unemployment rises (falls). Our results indicate that the existence of hysteresis and the symmetry thereof are topics that might be worthy of further research. Symmetry relates to the shape of the Phillps curve: Is the accelerating-inflation effect of sub-NAIRU unemployment stronger than the decelerating-inflation effect of supra-NAIRU unemployment?

Although the findings of this study point to hysteresis, there is no need to completely abandon the type of models specified here. Future efforts might well be directed toward estimation of reversed models with the output gap in the price equation and with corresponding reformulations of the other equations.

References

Apel, M. and P. Jansson (1997) **System Estimates of Potential Output and the NAIRU**, Sveriges Riksbank, Working Paper no 41, 1997.

Blanchard, O. and H. Summers (1986) **Hysteresis in Unemployment**, European Economic Review, No 31, p. 288–295.

Elmeskov, J. (1993) **High and persistent unemployment: assessment of the problem and its causes**, OECD Economics Department Working Paper No. 132.

Engle, R.F (1978) **Estimating structural models of seasonality**, in A. Zellner (toim), Seasonal Analysis of Economic Time Series, Washington D.C., Department of Commerce, Bureau of the Census, 281–308.

Forsman, P., (1997) **Tuotantokuilun mittaamisesta**, KT-memo 63/97.

Giorno, C., A. Deserres and Sturm, P. (1997) **Macroeconomic Policy and the NAIRU in European Economies**, EUI Working Papers, 97/50.

Gordon, Robert J. (1997) **The Time-Varying NAIRU and Its Implications for Economic Policy**, NBER Working Paper no. 5735, 1997.

Hamilton, J.D. (1994) **Time Series Analysis**. Princeton: Princeton University Press, 1994.

Harvey, A.C. (1985) **Trends and cycles in macroeconomic time series**, Journal of Business and Economic Studies 3, 216–27.

Harvey, A.C. and P.H.J. Todd (1983) **Forecasting economic time series with structural and Box-Jenkins models**: A case study (with discussion), Journal of Business and Economics Statistics 1, 299–315.

Holm, P. and Somervuori, E. (1996), **Structural Unemployment in Finland**, VATT Discussion Papers no 136, 1996.

Kinnunen, Helvi, (1996), **Inflaatioindikaattorit ja niiden ennustekyky**, Suomen Pankin Economics Department Working Paper 7/1996.

OECD, WP1, **October 1996 conference on NAIRU data**, September, 1996.

Rasi, Chris-Marie (1998), **NAIRU and potential output in Finland − reversed model results**, Bank of Finland Economics Department, Memo (forthcoming).

Staiger, D., J.H. Stock and M.W. Watson (1996) **How Precise are Estimates of the Natural Rate of Unemployment**? NBER Working Paper 5477, March 1996.

Appendix 1. Example of the model in state-space form

Measurement equations for model system (1b),(2),(3a),(4) ja (5)

X(t): observed explanatory variables; U(t): unobserved components; Ω: coeff. matrix of Z(t)- vector; Z(t): lagged price and supply variables

$$
\underbrace{\begin{bmatrix} y_t \text{ (production)} \\ u_t \text{ (unempl.rate)} \\ \Delta\pi_t \text{ (change in inflation)} \end{bmatrix}}_{X(t)}
=
\underbrace{\begin{bmatrix} 1 & 0 & \phi_t & \phi_{t-1} & \phi_{t-2} & \phi_{t-3} & \phi_{t-4} \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \eta_{t-3} & -\eta_{t-3} \end{bmatrix}}_{M}
*
\underbrace{\begin{bmatrix} Y^P_t \\ U^N_t \\ U-U^N_t \\ U-U^N_{t-1} \\ U-U^N_{t-2} \\ U-U^N_{t-3} \\ U-U^N_{t-4} \end{bmatrix}}_{U(t)}
+
\underbrace{\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ \rho_{t-1} & \omega_1 & \omega_2 & \omega_3 & \omega_4 & \omega_5 \end{bmatrix}}_{\Omega}
*
\underbrace{\begin{bmatrix} \Delta\pi_{t-1} \\ PCIENERmlddn_t \\ IMPRISmlddn_{t-4} \\ IMPRISmlddn_{t-5} \\ IMPRISmlddn_{t-8} \\ ASCPImlddn_{t-2} \end{bmatrix}}_{Z(t)}
+
\underbrace{\begin{bmatrix} \varepsilon^{okun} \\ 0 \\ \varepsilon^{price} \end{bmatrix}}_{E(X)}
$$

Transition equations for model (1b),(2),(3a),(4) ja (5)

$$
\underbrace{\begin{bmatrix} Y^P_t \text{ (pot.output)} \\ U^N_t \text{ (nairu)} \\ U-U^N_t \text{ (unempl. gap)} \\ U-U^N_{t-1} \\ U-U^N_{t-2} \\ U-U^N_{t-3} \\ U-U^N_{t-4} \end{bmatrix}}_{U(t)}
=
\underbrace{\begin{bmatrix} \alpha \\ \beta \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}}_{g}
+
\underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \delta_1 & \delta_2 & \delta_3 & \delta_4 & \delta_5 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}}_{T}
*
\underbrace{\begin{bmatrix} Y^P_{t-1} \\ U^N_{t-1} \\ U-U^N_{t-1} \\ U-U^N_{t-2} \\ U-U^N_{t-3} \\ U-U^N_{t-4} \\ U-U^N_{t-5} \end{bmatrix}}_{U(t-1)}
+
\underbrace{\begin{bmatrix} \varepsilon^{pot.output} \\ \varepsilon^{nairu} \\ \varepsilon^{cycl.\ unempl.} \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}}_{E(U)}
$$

Appendix 2. Time series used and tested and transformations performed

The study is based on quarterly data from the period 1976:1 to 1996:4. The length of the **estimation period** is restricted in respect of certain variables. The exact estimation period varies depending on the maximum lag length in the particular model. The estimation periods are 1979:4 –1996:4 (models 1b3, 1b3a) and 1977:4 – 1996:4 (type 1a3).

For the **inflation series** (CPI) we tested different price indices, among which were the GDP deflator, private consumption deflator and indicator of underlying inflation. In the preliminary OLS testing, the consumer price index proved to be the best index. The shortness of the available time series argued against use of the indicator of underlying inflation.

As the **unemployment rate**, we used Statistics Finland's seasonally adjusted (Stamp) unemployment rate. The Ministry of Labour's unemployment rate was tested and turned out to be on a par with the Statistics Finland series. The latter was chosen because it is 'official' and more precisely internationally comparable. For the output series, we used Statistics Finland's seasonally adjusted GDP at 1990 prices.

Besides the supply variables (Z) that are included in the reported models, several others were tested. Among these were various versions of the relative price of energy such as the price of crude oil relative to the CPI, and the unit value index for energy imports relative to GDP. As a measure of the terms of trade, we tested three variables: the ratio of export prices to import prices, the so-called exogenous terms of trade (competitor-countries' export price relative to import prices), and the relative price of imported consumption goods. The tested-but-rejected variables Z-variables included also deviation-from-trend of labour productivity, the tax wedge in taxes on labour, and the tax rate index included in the consumer prices. The rate for the sales tax/value-added tax, first and second differences, depending on the specification in the preliminary estimation, was significant or nearly significant but dropped out of the system estimation.

In the system estimation, the **selected supply variables** were relative price of energy, PCIENER, calculated as the ratio of private consumption expenditure in the national accounts to an index from same source, from which the prices of transport, communication and housing energy were excluded. Because the sub-items in private consumption are available only annually in the national accounts, the series was disaggregated. IMPRIS is the ratio of the import price index to the CPI; REXRATE is the real exchange rate, ie the ratio of the domestic price level based on consumer prices to the markka-value of competitor-countries' prices. This variable is defined so that a fall in the real exchange rate implies an improvement in Finland's competitiveness (original series included in Bank of Finland database). ASCPI is the housing index for the whole country (1983 = 100) relative to the CPI.

The variables used in the estimations and the **transformations** performed are listed in the table below. Other than for GDP and the unemployment rate, which were already seasonally adjusted, we first used the four-period moving average method for smoothing the series. Then logarithms were taken and each observation differenced from the preceding observation one or two times, except for GDP and the unemployment rate. Finally, the obtained series were normalized by their respective means and multiplied by 100 in order to give them the same dimension as the unemployment rate.

			Transformations					
symbol used in the report	**title excluding transformations**	**symbol in BOF data base**	**moving averages moothing m**	**log** l	**1. or 2. difference** d or dd	***100**	**norma-lizing** n	**note**
π tai CPImldn	Consumer price index 1990=100	P090.Q	m	l	d	x	n	
Δπ tai CPImlddn	Consumer price index 1990=100	P090.Q	m	l	dd	x	n	
y	GDP, fixed 1990 FIM, billions, s.a. by Stat.Finland	GDPQ.K		l		x		
u	Unemployment, Stat. Finland, s.a.	L040.K to 88q1						
		L040.KS 88q1 forw.						
PCIENERmldn	Relative price of energy		m	l	d	x	n	
PCIENERmlddn	Relative price of energy		m	l	dd	x	n	
REXRATEmldn	Real exchange rate	1/E153RE.CP	m	l	d	x	n	
REXRATEmlddn	Real exchange rate	1/E153RE.CP	m	l	dd	x	n	
IMPRISmldn	Relative import price	MP90.M/P090.Q	m	l	d	x	n	
IMPRISmlddn	Relative import price	MP90.M/P090.Q	m	l	dd	x	n	
ASCPImldn	Price of housing, whole country, 1983=100	PA2.Q/PO90.Q	m	l	d	x	n	transformed
	related to CPI							to the same
ASCPImlddn	Price of housing, whole country, 1983=100	PA2.Q/PO90.Q	m	l	dd	x	n	base year
	related to CPI							

BANK OF FINLAND DISCUSSION PAPERS

ISSN 0785-3572

1/98 Sinimaaria Ranki **Monetary Policy in a Bipolar International Monetary System**. 1998. 46 p. ISBN 951-686-566-6. (TU)

2/98 David G. Mayes **Evolving Voluntary Rules for the Operation of the European Central Bank**. 1998. 32 p. ISBN 951-686-567-4. (TU)

3/98 Helvi Kinnunen **The Sources of Output Shocks in Finland and other EU Countries**. 1998. 21 p. ISBN 951-686-568-2. (KT)

4/98 Jukka Pirttilä **Earmarking of Environmental Taxes: Efficient, After All**. 1998. 32 p. ISBN 951-686-569-0. (ST)

5/98 Juhana Hukkinen – Matti Virén **How to Evaluate the Forecasting Performance of a Macroeconomic Model**. 1998. 25 p. ISBN 951-686-570-4. (KT)

6/98 Chris-Marie Rasi – Jan-Markus Viikari **The Time-Varying NAIRU and Potential Output in Finland**. 1998. 27 p. ISBN 951-686-571-2. (KT)