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STOCKHOLM SCHOOL OF ECONOMICS IN RIGA

SSE Riga Student Research Papers
2007:6 (93)

THE NATURAL RATE OF UNEMPLOYMENT: HAS LATVIA REACHED FULL EMPLOYMENT?

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ISSN 1691-4643
ISBN 978-9984-822-05-1

November 2007
Riga

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May 2007
Riga

Acknowledgements

The author would like to admit that this paper would not have been viable without the contribution of a number of individuals. In particular, the author thanks to his supervisor Andrejs Jakobsons of Baltic International Centre for Economic Policy Studies, Riga, for his support during the course of the work.

The author is indebted to Daniels Jeļisejevs for active discussions, understanding, mental support, and inspiration. It must be stressed that his valuable advice, vivid spirit, and constructive criticism during the writing of the research are especially appreciated.

The author also thanks Ilze Kalniņa of London School of Economics and Political Science for methodological advice, and materials about simultaneous equations and Kalman filter.

Mārtiņš Kazāks of the Stockholm School of Economics in Riga is acknowledged for critical insights in choosing a topic and identifying potential problems of methodology.

Gratitude is expressed to Mark Chandler of the Stockholm School of Economics in Riga for his responsiveness and valuable advice in model development.

The author is indebted to Laila Faidy for support in language usage and a nice sound of English words.

Finally, the author is pleased to show appreciation to the most treasured family members, colleagues and friends for everlasting understanding and mental support.

Abstract

The aim of this paper is to estimate the NAIRU of Latvia during the period of 1997-2006. Based on a modified Basistha and Startz (2006) framework, a multivariate approach is applied and the time-varying NAIRU of medium-term estimated. The NAIRU is estimated step by step starting with the constant NAIRU, the time-varying NAIRU by Kalman filter, and ending with the implicitly derived time-varying NAIRU using Okun's Law. Results show that the NAIRU has decreased from 11.54% in 1997 to 4.85% in 2006. The range of confidence interval is 1.26%. Results are statistically feasible and plausible according to theory. Currently, according to econometric results, there is no negative unemployment gap in the medium term. As actual unemployment rate is approaching full employment, there is an increasing pressure on inflation. The author concluds that current unemployment rates might have reached short-term overshooting and could reach medium term full employment by the end of this year. The author suggests the implementation of labor and output market restructurization that will reduce labor intensity in low value-adding production.

Keywords: NAIRU, Okun's Law, Kalman filter, unemployment, inflation, supply shock, the augmented-expectations Phillips Curve.

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List of Abbreviations

3SLS – Three-Stage Least Squares

ARIMA – Autoregressive Integrated Moving Average

CI – Confidence Interval

CPI – Consumers Price Index

EMU – European Monetary Union

EU – European Union

GDP – Gross Domestic Product

LFS – Labor Force Survey

NAIRU – Non-Accelerating Inflation Rate of Unemployment

NAWRU – Non-Accelerating Wage-Rate of Unemployment

OLS – Ordinary Least Squares

PPI – Producers Price Index

REER – Real Effective Exchange Rate

SEA – State Employment Agency

UK – United Kingdom

US – United States of America

1. Introduction

The economy of Latvia has been booming for the last few years, reaching one of the highest growth rates in the European Union (EU[1]). The growth of aggregate output, structural changes and labor force outflow to the wealthiest EU countries is tightening the labor market of Latvia. The unemployment rate has decreased from 13.7% in 2000 to 6.8% in 2006, by 6.9 percentage points (Eurostat, "Harmonised Unemployment", 2007). At the same time with the decrease of unemployment there was a significant increase in CPI inflation that reached 6.9% and 6.6% in 2005 and 2006 (Eurostat, "Harmonized indices of consumer prices", 2007). Currently, CPI inflation data does not indicate any pressure from actual unemployment rates because indicators moved in one direction in 2006. However, the varying part of CPI inflation might be dependent on supply shocks while trend could be significantly influenced by decreasing actual unemployment rates.

According to Friedman (1968) there is an inflation-unemployment tradeoff in the short run. If the initial unemployment rate falls below the natural rate of unemployment (full employment), there is associated increase in the inflation rate due to increase in labor costs. A tight labor market enhances labor supply bargaining power, thus increasing wages, fringe benefits and improving working conditions.

Figure 8 shows that Latvia has experienced small or moderate (0.4-6.6%) labor cost growth in a period of 1997-2004. Moreover, situation changed in 2005 and 2006 when labor costs reached 7.6% and 15.6% of annual growth. The announcement by Erkki Raasuke (2006), Head of Baltic Banking of Hansabanka, informs that the Latvian labor market is overstretched. The actual unemployment rate is close to the natural rate of unemployment (hereinafter NAIRU[2]), and any other decrease in unemployment will raise the risk of overheating and additional pressure on inflation.

The problem is that nobody knows how big the unemployment gap is. The Central Statistical Bureau of Latvia and State Employment Agency can provide data for the actual unemployment rate, but there is no estimate of the NAIRU because it is an unobservable macroeconomic variable. The estimate of the NAIRU is not only a problem for Latvia, but also for the rest of the world. Staiger et al (1996) identified three main

[1] Here and hereinafter, the author implies the EU25, European Union before January 1, 2007.
[2] Non-accelerating Inflation Rate of Unemployment. Discussion on both terms is described in Section 2.

issues that do not make agreement between economists in the estimation of the NAIRU, and raise high uncertainty around figures:

- *Model uncertainty* – many models for the NAIRU are offered, but nobody knows which one shows the closest picture of reality.
- *Parametric uncertainty* – due to the statistical approximation of exogenous variables that affect the NAIRU.
- *Filtering uncertainty* – unpredictable stochastic shocks may significantly influence the smoothness of the NAIRU.

Two authors have tried to estimate the NAIRU of Latvia, such as Stikuts (2003) and Camarero et al. (2005), by applying two different approaches of estimation. However, their approaches lack completeness and concentration to the case of Latvia. This paper is aimed at applying a multiple indicator – common cycle approach by Basistha and Startz (2006) that offers theoretically well grounded and a statistically feasible estimate of the NAIRU and deals with the uncertainties listed above.

1.1 Relevance of the Study

Unemployment is one of the key variables to facilitate the adjustment process through macroeconomic equilibrium (Basistha and Startz, 2006). The Phillips Curve and the Okun's Law show the links between unemployment, inflation and output[3]. The basic conclusion says that the positive unemployment gap reduces output growth, but the negative unemployment gap induces higher inflation rate.

The positive unemployment gap indicates that the economy does not utilize full potential (Richardson et al., 2000). It has excess labor resources that may lose their skills if not employed over long periods of time. Whereas the negative unemployment gap, shows inefficiency of the economy as people without required skills are hired (due to a lack of labor force) and employees are overpaid (wage growth is not dependent on productivity growth) (Richardson et al., 2000). Shortly, the negative unemployment gap

[3] The Phillips Curve shows an inverse relationship between inflation and the unemployment gap (actual unemployment rate minus the natural rate). The Okun's Law shows negative relationship between the unemployment gap and the output gap (the potential real GDP minus actual real GDP) (Blanchard, 1997).

causes high inflation and decline in productivity. It is also one of the causes of overheating[4].

High inflation has a negative impact on the economy of Latvia - both internally and externally. Firstly, there is postponed Latvian integration in the European Monetary Union (EMU) as Latvia cannot fulfill the Maastricht Convergence Criteria that allows no more than 1.5 percentage points higher inflation than the 3 best-performing member states of the EU (European Central Bank, 2007). In 2006, Poland (1.3%), Finland (1.3%) and Sweden (1.5%) showed the lowest inflation in the EU (Eurostat, "Harmonized indices of consumer prices", 2007). As we see, Latvia performs still far from fulfilling the inflation criteria. Secondly, high inflation reduces the competitiveness of Latvia's exports due to a reduction in the difference between domestic and foreign prices. Thirdly, high inflation induces high relative consumption to saving rates, as the population expects the decrease of purchasing power in the future.

To reach long term stability of the economy, Latvia has to adjust its unemployment towards its NAIRU. The estimate of the NAIRU would be a good target and measure economic policies should stick to. The time-varying NAIRU is also a good tool to evaluate the impact of structural changes to the natural rate of unemployment. For policy makers it is advised to reduce the NAIRU rather than affect actual unemployment rates. However, stable NAIRU should indicate that short-term fluctuation of the actual unemployment rates might be more adequate.

1.2 Research Question

The primary purpose of this paper is to **estimate the NAIRU of Latvia during the period of 1997-2006**. To be more specific, the paper has the following objectives:

Firstly, the paper will adjust a multiple indicator – common cycle model to the case of Latvia by choosing the best fit of dependent and independent variables, number of lags and model specifications.

[4] Overheating is a state of an economy when its productive capacity cannot meet aggregate demand (aggregate supply < aggregate demand = excess demand) (Economist, 2007)

Secondly, the model will be explored in three steps: estimation of constant NAIRU, estimation of time-varying NAIRU and integration of gaps using the Okun's Law.

Finally, results will be interpreted and political implementation of the NAIRU will be discussed to solve current macroeconomic problems of Latvia concern to inflation and labor market.

1.3 Delimitations

Research area is bounded to several conditions that may not be avoided or expands research territory too wide. Therefore, the author sets delimitations to the paper.

Firstly, the paper does not deal with substantial data adjustments or corrections. Despite data is taken from reliable sources, such as Eurostat, the Central Statistical Bureau of Latvia, State Employment Agency and the Bank of Latvia, persistence of "shadow economy", statistical errors and other economic and statistical imperfections make data partially inconsistent.

Secondly, the study does not compare or evaluate efficiency and relevance of other methods and frameworks. The author critically looks at previous studies and methods, but do not analyze statistical efficiency and method reliability.

Finally, the research is not analyzing elasticity and sensitivity of the results. Due to significant number of input variables and complexity of the econometric model, sensitivity analysis is not employed.

1.4 Structure

This paper will be organized as following: Section 2 summarizes the historical development of the NAIRU concept and its estimation techniques starting with the Phillips Curve and constant NAIRU till the time-varying NAIRU, Kalman filter and multivariate approach. Section 3 presents the model by Basistha and Startz (2006) that is adjusted to the case of Latvia. Section 4 describes data and data series, as well as adjusts data for the econometric analysis. Section 5 delivers results of regressions and econometrical interpretation. Section 6 is devoted to the economical interpretation of results and discussions. Section 7 concludes and proposes questions for further research.

2. Review of Literature

2.1 Development of the NAIRU Concept and Estimation

The link between money supply, inflation and unemployment has been identified already in 1752 by the classic David Hume's essay "Of Money" (Ball and Mankiw, 2002). He wrote that the effect of monetary injections, such as gold discoveries, penetrate through the whole economy and affect each individual before the increase of wages. Later in the 20th century Samuelson and Solow (1960) founded the unemployment-inflation tradeoff relationship that is now known as the Phillips Curve. Main conclusions until now were that the persistence of unemployment cannot be eliminated at all. Then Friedman (1968) defined *the natural rate of unemployment* as "the level which would be ground out by the Walrasian system of general equilibrium equations, provided that there is imbedded in them the actual structural characteristics of the labor and commodity markets, including market imperfections, stochastic variability in demands and supplies, the cost of gathering information about job vacancies and labor availabilities, the cost of mobility, and so on". The concept involved in the inflation-unemployment tradeoff is known as *Non-Accelerating Inflation Rate of Unemployment* (NAIRU) that is used for econometric analysis.

The first estimations of the NAIRU started with Samuelson and Solow (1960) who called it 'full employment unemployment level' and estimated it at 6%. Over decades the NAIRU estimate has varied in a narrow range converging to 6% and many papers by Summers (1986), Juhn et al (1991), Staiger et al (1997a, 1997b), Gordon (1997,1998), Shimer (1998), Salemi (1999), Laubach (2001), Ball and Mankiw (2002) show how stable this estimate has been over the years (Gordon, 1996). The time-varying NAIRU shows that the most explored economy - the US - experienced the increase of the NAIRU in the late 1970s and early 1980s due to recession caused by oil shock. The falling NAIRU took place in the 1990s when technological advancement stimulated rapid growth in the world.

Despite the estimation of the NAIRU dating back several decades, the studies conducted since the 1990s indicate that the NAIRU is not well indicative to policy makers. This is due to a wide confidence interval around the estimate. Almost 2%

interval of the NAIRU is so uncertain, that the value that may say nothing about the existence of the negative unemployment gap. Starting with Staiger et al (1996), the issue of estimate range reduction was the key issue for researchers in this field. They proposed several areas that may influence uncertainty: choice of theory, model specification and assumptions behind variables. The NAIRU models are classified into two groups – with univariate and bivariate behaviors[5]. Next, they find substantial imprecision whether the natural rate is measured as a constant, as an observed random walk, or as a slowly changing function of time. The choice of theoretical framework, statistical methods and filters[6] matter in the estimation of the NAIRU.

Ball and Mankiw (2002) went to significant efforts to explain the theory of the NAIRU and its practical applicability. Moreover, they have good arguments why the NAIRU may change over time:

- change in the labor force structure;
- increase in competition via greater competition;
- better job matching through professional skills' interchangeability;
- productivity acceleration.

The recent and actual study of the NAIRU measurement is by Basistha and Startz (2006). They solve the problem of model, parametric and filtering uncertainties and reduce the variance of the NAIRU estimate by 50% and confidence interval by 29%. The significant improvement is based on the appropriate model choice, shock variance estimation and the choice of a multiple variable approach. Their model is used in this paper as a benchmark framework.

A good paper about the NAIRU is presented by Stankus (2002), Bachelor Thesis of the Stockholm School of Economics in Riga, about Estonia and Lithuania. He used the augmented-expectations Phillips Curve from which the NAIRU is derived as a dependent variable of supply shock and productivity growth. He estimated the long-term NAIRU of Estonia and Latvia. The author admits that he uses single equation-regression estimation,

[5] The univariate model assumes that over time unemployment returns to its natural rate, while the bivariate model allows also deviation in the NAIRU

[6] Filtering – statistical method of smoothing the estimated graph (reduces curvature of the line)

thus excluding the dynamic nature of the model. It also assumes fixed mark-ups on wages and other inputs as the determinant of prices.

2.2 Previous Studies of the NAIRU of Latvia

There are two previous studies of the NAIRU of Latvia (Stikuts (2003) and Camarero et al. (2005)) that are explored with different approaches. One is focused more on the long-term NAIRU, the other on the short-term NAIRU. Table 2 summarizes the two studies and Stankus (2002) paper about Estonia and Lithuania that will be used for the model construction of the research. Stankus (2002) paper is considered to be appropriate as it describes two similar economies of Latvia - Estonia and Lithuania.

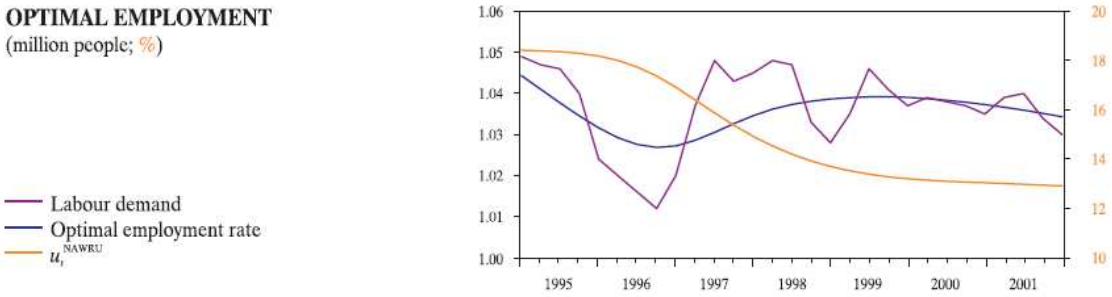
Simplistic trait is done by Stikuts (2003) who estimated that the NAIRU (more precisely, NAWRU) be use as an input variable for the calculation of the potential output of Latvia. The author used the NAWRU (*Non-Accelerating Wage-Inflation Rate of Unemployment*) concept because it is better linked with the output gap, rather than inflation. According to Torres (1990), "in equilibrium the unemployment rate is equal to the NAWRU and potential output is equal to actual output". It implies that the NAWRU in the potential output "ensures consistency between labor market equilibrium and product market equilibrium". Therefore, the NAWRU is calculated as actual unemployment adjusted with the relationship between unemployment change and wage-inflation[7]. The smoothness of trend is reached with the Hodrick-Prescott filter[8]. Figure 1 shows that the NAWRU sharply decreased between 1996 and 1998 from around 18% to around 14%, further decrease slowed down and fell to 13% in 2001. This approach proves that there is a strong link between unemployment and wage, but it is not the only determinant of wage – productivity, technological progress, demographics, mobility, taxes and other factors influence wage growth. Secondly, the natural rate of unemployment is affected by structural changes that are common to transition countries;

[7] Elmeskov (1993) approach is used where $u_t - u_t^{NAWRU} = \lambda \Delta^2 w_t$ ($\lambda < 0$) and after the modification of equality the NAWRU is derived as $u_t^{NAWRU} = u_t - \frac{\Delta u_t}{\Delta^3 w_t} \Delta^2 w_t$ where the first term on the right-hand side is actual unemployment and the second term is the relationship between the unemployment change and wage-inflation.

[8] Hodrick-Prescott filter is a mathematical tool used to obtain a smoothed non-linear representation of a time-series. It is more sensitive to long-term than to short-term fluctuations (Hyeongwoo, 2004).

therefore, there are structural breaks in the smoothness of the NAIRU. Finally, this model eliminates unemployment from the cyclical movements, not linking it with output and inflation.

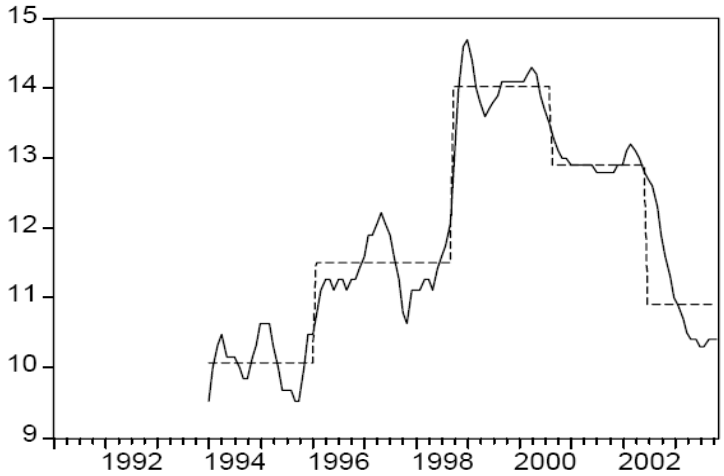
Figure 1 The estimate of the NAWRU (orange line) by Stikuts (2003)



Source: Stikuts (2003)

Another significant paper has been written by Spanish economists, Camarero et al. (2005), who analyzed the NAIRU of the accessing countries of the EU. He used the M unit root test[9] to find structural breaks in a dataset of Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovenia, Slovakia and Hungary. The author says that it is not appropriate to use any filtering method to analyze unemployment for the "new[10]" EU because transition economies experience frequent reforms that change the equilibrium of the labor market.

Figure 2 Unemployment rate and the NAIRU, OLS based estimate (Camarero, 2005)



Source: Camarero (2005)

[9] M-unit root test – a statistical method to capture breaks in a dataset
[10] Here, Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Slovenia and Hungary (EU-2004)

He found four structural breaks of Latvian NAIRU: Q1-1996, Q4-1998, Q3-2000 and Q3-2002 (Figure 2). The first two structural breaks are associated with the decreasing exports to Russia and the Russian financial crisis. The second two are explained by recovery from the Russian financial crisis and increasing economic activity with the EU. The result does not completely describe the actual NAIRU because it changes gradually over time, not with sharp jumps as in the Camarero et al. model. The same concerns also short-term unemployment between breaks. Therefore, the model might be poor in forecasting the dynamics of the NAIRU.

3. Theoretical Framework

Three distinctive concepts of the NAIRU are defined that differ according to the time horizon to which they refer (Richardson et al., 2000):

- The NAIRU – "the equilibrium rate towards which unemployment converges in the absence of temporary supply influences once the dynamic adjustments of inflation is completed (medium term)".
- The short-term NAIRU – "the rate of unemployment consistent with stabilizing the inflation rate at its current level in the next period".
- The long-term NAIRU (equilibrium unemployment rate) – "corresponds to a long-term steady state, once the NAIRU has fully adjusted to all supply and policy influences, including those having long-lasting effects".

There are different approaches to estimate each concept. The choice of NAIRU to be estimated fell to the medium-term NAIRU (hereinafter, NAIRU) because it might be the only relevant estimate that could describe the current state of unemployment in Latvia. Long-term NAIRU is not a relevant estimate as it has still not reached an equilibrium state of the labor market. Latvia also undergoes continuous structural changes. A short-term NAIRU might be an insignificant indicator because inflation was stable in the period of 1999-2004, thus the decreasing unemployment rates might not show a strong enough correlation between two variables. The following sections describe the choice of framework and the model that describes the medium-term NAIRU.

3.1 Choice of Framework

There are two main distinguished approaches of the NAIRU analysis: augmented-expectations Phillips Curve and a univariate approach (McAdam and McMorrow, 2003). The first one uses labor market variables as determinants of the NAIRU and is more appropriate to long-term NAIRU. The second, run time series that are purely analyzed by statistical methods are more appropriate to short-term NAIRU. The augmented-expectations Phillips Curve is chosen for analysis because it is highly integrated in the economic cycle, supply shock variables include other variables that affect prices and it partially contains the hysteresis effect. Here, short-term estimate is rescheduled to the medium-term via filtering and inclusion of output gap as reduction of unemployment has positive leading effect on production.

Plausibility of a model can observed in Figure 9 that presents change in CPI inflation versus previous period unemployment rate. This makes it evidently clear of a negative relationship between the two indicators, as smaller unemployment rate is associated with higher inflation change. However, ambiguity might arise in statistical significance of the NAIRU estimate - that is a line intersecting unemployment rate zero axis. In Figure 9 we see that in 3 out of 5 quarters (60%) when the unemployment rate was 8-10% there was an associated increase in CPI inflation; moreover, the same increase was observed in 6 out of 10 quarters (60%) when unemployment was 10-12%. From the data, we see that there is no difference between changes of CPI inflation over different unemployment levels. However, important variables are omitted that might improve measurements of the NAIRU, such as additional lags and supply shock variables. It is concluded that there is no doubt about the augmented-expectations Phillips Curve plausibility.

3.2 The Model

The baseline framework is taken from Basistha and Startz (2006) as well as previous studies that developed estimation of constant and time-varying NAIRU. This method seems to be more plausible and more precise as it integrates unemployment, employment and output gaps. The model is simplified and adjusted to the case of Latvia. The employment gap is excluded from equation systems in order to simplify estimation

procedures and reduce parametric variance[11]. Instead unemployment and output gaps are integrated by the Okun's Law. The framework is divided into three subsequent parts: estimation of constant NAIRU, estimation of time-varying NAIRU and output gap integration with unemployment gap using Okun's Law. Okun's Law is the newest and an effective feature in the estimation of the NAIRU that favors the choice of this model and substantially differentiates this paper from previous researches done on the NAIRU of Latvia.

Constant NAIRU

The simplest and most basic concept is a constant NAIRU that was said to be true in the 1960s when economists believed that over long-term unemployment converges to its natural rate of unemployment and is a constant figure. Following Staiger et al (1996) procedures, a benchmark model of the augmented-expectations Phillips Curve is exploited to reach a target. It says that change in inflation is 'implicitly driven by the unemployment gap and supply shock' (Staiger et al, 1996),

$$(1) \qquad \pi_t - \pi_t^e = \beta\left(u_{t-1} - \bar{u}\right) + \gamma X_t + \nu_t$$

where u_t is the unemployment rate, π_t is the rate of inflation, π_t^e is expected inflation, $\bar{u}$ is the NAIRU, X_t is supply shock variable, and ν_t is an error term. Empirical implications require an estimate for expected inflation. Previous studies by Gordon (1990), Weiner (1993) and Eisner (1995) stick to restriction on "random walk" thus imposing that inflationary expectations have a leading nature, $\pi_t^e = \pi_{t-1}$ (Staiger et al., 1996),

$$(2) \qquad \Delta\pi_t = \beta\left(u_{t-1} - \bar{u}\right) + \gamma X_t + \nu_t$$

In order to address uncertainty of the NAIRU estimate that was raised in the previous section, lagged effects of unemployment, inflation and supply shock are added to deal with serial correlation in the error term,

[11] As a result three equations and employment gap is disregarded and multicollinearity between employment and unemployment gap avoided.

(3) $$\Delta\pi_t = \beta(L)\left(u_{t-1} - \bar{u}\right) + \delta(L)\Delta\pi_{t-1} + \gamma(L)X_t + \varepsilon_t,$$

where L is a lag operator. Despite an unobserved variable, $\bar{u}$, the equation is run via OLS after respecification of variables. Choice of lags and respecification of variables is discussed in Section 5.1. This model is used in further procedures that will allow NAIRU to vary and integrate the unemployment gap with the output gap, using the Okun's Law.

Time-Varying NAIRU

The time-varying parameter (TVP) is added, breaking assumption that was set in the previous section - NAIRU follows a "random walk". Compared to other TVP models that allow all parameters to vary, Basistha and Startz (2006) and Staiger et al (1996) sticks to one time varying parameter – NAIRU,

(4) $$\bar{u}_t = \bar{u}_{t-1} + \eta_t$$

where η_t is an independent, identically distributed error term from a normal distribution with zero mean, and does not correlate with error term ε_t from equation (3). Estimation of the TVP model and the NAIRU proceeds by maximum likelihood using the Kalman filter. The Kalman filter is a widely used method that combines prediction and smoothing of realized values, removing the effect of the noise and getting a good estimate of the prediction target (Sorensen, 2005). It eliminates unstable/short-term fluctuations, thus targeting to long-term trends which change gradually over time. Practically, the Kalman filtering is obtained via ARIMA(p,d,q) (autoregressive integrated moving average) process that is described by the following equation,

(5) $$\left(1 - \sum_{i=1}^{p} \phi_i L^i\right)(1-L)^d \bar{u}_t = \left(1 + \sum_{i=1}^{q} \theta_i L^i\right)\varepsilon_t$$

where L is a lag operator, ϕ_i are parameters of the autoregressive part of the model, θ_i are parameters of the moving average part, and ε_t are error terms (i.i.d. and $N(0, \lambda\sigma_t^2)$). Here, equation (4) is ARIMA (0,1,0) and includes only an integrated term. According to Pindyck and Rubinfeld (1988), after model specification diagnostic checks are needed by looking at autocorrelation functions. Residuals should be uncorrelated and

autoregressive parameters – stationary (sum to a number smaller than 1 in magnitude). Further analysis can be permitted only after diagnostic checks.

Okun's Law

NAIRU got time-varying dynamics after the inclusion of equation (4) and letting it to follow a "random walk". Here it follows the innovation of Basistha and Startz (2006) who managed to reduce variance of the NAIRU estimate by dynamic interaction between output and unemployment gaps. Now, similar procedures are applied to generate a Phillips-type relationship between GDP (chained) deflator and the output gap,

$$(6) \qquad \Delta\pi_{G,t} = \beta_G(L)\Delta\pi_{G,t-1} + \gamma_G(L)g_{Yt-1} + \delta_G X_t + \varepsilon_{G,t}$$

where Y_t is current output, $\overline{Y}$ is potential output and other variables are the same. As this relationship can describe only constant potential output, it is let to vary-over-time,

$$(7) \qquad Y_t = T_t + g_{Yt}$$

where the permanent stochastic trend, Y_t, follows a random walk, g_t, with a constant drift - T_t. The output gap and the unemployment gap are linked by a dynamic version of Okun's Law,

$$(8) \qquad g_{Ut} = \sum_{k=0}^{K} \theta_{Y,k} g_{Yt-k}$$

Now, the model gains a dynamic nature and the interaction between output and labor (the most important input). Stikuts (2003) estimated labor input factor as 0.775 in Cobb-Douglas production function. Dynamic Okun's Law is achieved by 3SLS (Three-Stage Least Squares) approach that allows regression of simultaneous equations. Three simultaneous equations will be run:

1) Augmented-expectations Phillips Curve of GDP deflator;
2) Okun's Law;
3) Augmented-expectations Phillips Curve of CPI inflation.

As potential output level is needed, it will be derived in the same framework as time-varying NAIRU by Kalman filter. Here, NAIRU will be implicitly derived with the help of potential output that is a key input variable for three equations. Several authors note that 3SLS method has poorer statistical performance (in terms of result significance);

however, it is not proved and is one of the simplest approaches for simultaneous equations. It works similarly to 2SLS, but it allows multiple equations where one endogenous variable is an exogenous variable for other equation, and all of equations are connected with such links.

4. Data Description

The theoretical framework identifies seven variables for NAIRU estimation: CPI inflation, wage inflation, GDP deflator, GDP, unemployment rate, energy - food inflation and REER. It is a source of model and parametric uncertainty reduction. Previous studies prove consistency of an augmented-inflation Phillips Curve. Despite inconsistency of the Phillips curve that appeared in the 1970s and 1980s in the shade of supply shocks, the inclusion of supply shock variables regained truth in this model.

Three different inflation measures are tested in this model: CPI inflation that characterizes both export and import prices affecting general purchasing power of the population, GDP deflator that includes change in labor and raw material costs (goods and services), but mainly indicates export price changes, and wage inflation that purely present labor cost changes. Each of the inflation indicators have different impact on markets (labor, capital, imports, exports etc.), thus should be used in estimation of NAIRU, as NAIRU is a common indicator of an economy.

Unemployment rate can be calculated with three methods: Labor Force Survey (LFS), registered unemployment and institutional data of employed persons (employed persons / economically active persons). All three measures should strongly correlate in perfect market. Latvia's case is unique, because all three estimates are different. The explanation of such behavior is termed in a "shadow economy" that is estimated to be 20-25% of GDP according to the most recent data[12] (Benfelde, 2005), low social benefits (35-45% from average wage) and uninformed employees.

Figure 10 shows that the gap between average wage and average unemployment benefits slowly increasing. An increase in wages and a decrease in marginal unemployment benefits have a positive impact on decreasing unemployment rates.

[12] Oskars Spurdziņš, the Minister of Finance mentions these figures while estimates of economic experts varies from 15% to 40%

Moreover, Figure 11 presents data of LFS and SEA registered unemployment rates. It shows that the gap between two estimates has decreased by almost 5% from 2002 to 2006. The inconsistency of data appears by large gap between SEA registered and LFS unemployment rates in the beginning of 2002 and negative gap in 2006 Q3.

Shock variables for the model are energy-food relative inflation and REER. Energy-CPI relative inflation is substituted by energy-food and soft beverages in order to avoid multicollinearity and achieve a higher sensitivity of variables (Stankus, 2002). Energy inflation is calculated from PPI inflation as prices change in electricity, gas and fuel. Food and soft beverages inflation is taken from CPI inflation. Literature suggests that supply shock variables for an open economy are import prices. Unfortunately, import price indices are available from 1999 Q1; therefore the import price index was substituted by a real effective exchange rate (REER). Pearson's correlation shows negative trends between two variables (Figure 12). Additionally, the GDP indicator is needed to calculate the GDP deflator inflation.

4.1 Construction of Variables

Despite data for the paper being general macroeconomic indicators, they should fulfill two main requirements for time series: they should be quarterly and present annual change. As wage inflation is not available from the Central Statistical Bureau of Latvia sources, it was calculated using the gross average wage of the economy. Monthly wage data was available, thus allowing quarterly averages to be calculated. Indices of annual change in a period then were calculated. The same procedure was applied for the construction of REER.

Significant adjustments were needed for LFS unemployment rates because no data for 1997 and only semi-annual rates were available for the period of 1998 – 2001. It means that missing values and backward forecast were made. Based on 28 observations, difference between LFS and SEA unemployment rates were calculated and regressed. Figure 13 shows a linear relationship of the differences between LFS and SEA unemployment rates and time trend. Linear regression estimates were significant at 1% level and they explained 81.2% of data (R-squared = 0.812). Based on this linear

regression, missing difference values were estimated and added to SEA unemployment rates to get estimates for LFS data.

4.2 Data Series

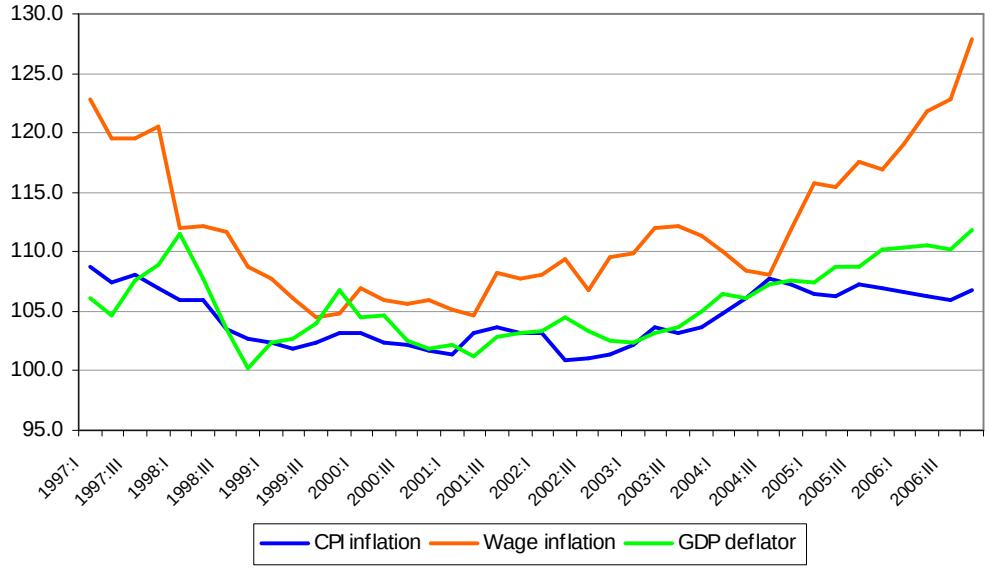
For the purpose of the research, quarterly data series for the period of 1997 Q1 to 2006 Q4 were employed. That particular period was chosen for several reasons. Firstly, the author planned to cover periods starting from 1995 Q1, but quarterly data of GDP for 1994 and quarterly data of REER for 1995 were not available. As the study used annual change of data, four observations were lost. Secondly, there was an unstable macro economical situation in Latvia until 1996: hyperinflation, the "Baltija" Bank crisis, economic restructurization and others. Thus, the data dated from 1997 should be of higher relevance and explanatory power. Annual inflation in 1995 and 1996 was 25.0% and 17.6% compared to the previous year.

Data was collected from different sources and carefully evaluated in order to choose the most truth-worthy source for input data in econometric regressions. All the data of GDP, CPI inflation, wage inflation, energy inflation, and food and soft beverage inflation was taken from the Central Statistical Bureau of Latvia on-line database, CDs and their calculations. Data on unemployment rate (LFS) and GDP deflator were taken from Eurostat on-line database. Missing values of unemployment rates were calculated by the author. REER data was provided by the Bank of Latvia.

Inflationary indicators (CPI inflation, wage inflation and GDP deflator) have peculiar structures that should be discussed. Figure 3 presents the movement of these indicators in the target period. Here, wage inflation shows different dynamics to CPI inflation and GDP deflator. As we see, the growth of wages varies from 5-27% and shows similar trends to CPI inflation and GDP deflator. This can be explained by stronger forces, rather than macroeconomical ones that affect wage setting: increase in productivity, new technologies, stronger negotiation power of employees and others. The slowdown of wage inflation in 1998-2004 is associated with the Financial Crisis of Russia in 1998 and economic stabilization beginning in 2001. Moreover, the growth of wage inflation since 2004 was due to decreasing number of free labor force and high inflation expectations. CPI inflation and GDP deflator shows smaller dynamics, being

under 5% growth level most of time. Higher volatility is presented by the GDP deflator (compared to CPI inflation) that is more sensitive to external shocks, such as the

Figure 3 CPI inflation, wage inflation and GDP deflator, 1997Q1 – 2006Q4 (index values compare to previous year respective period)



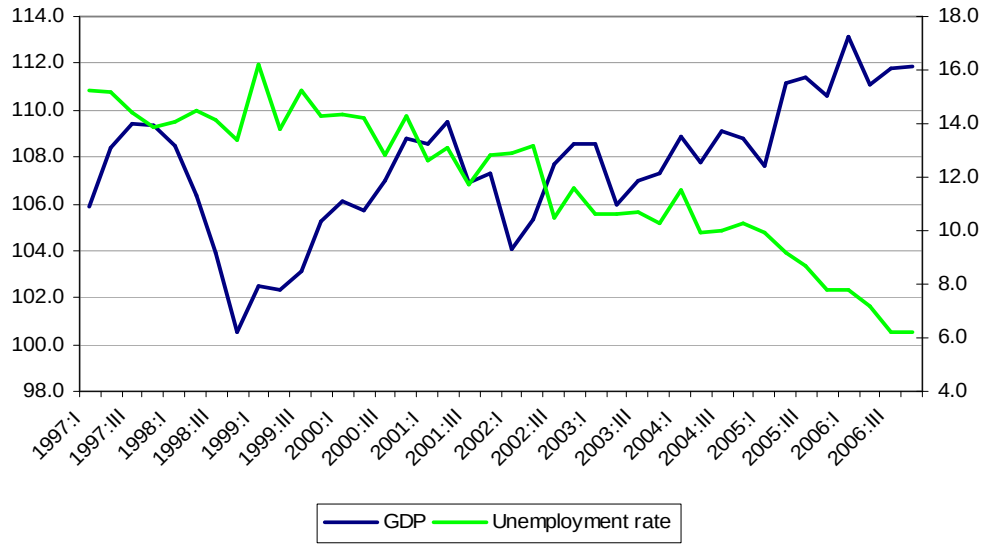
Source: Author's compilation based on the data of Central Statistical Bureau of Latvia and Eurostat

Financial Crisis of Russia in 1998, "dot-com bubble" in 2000, terror attack in the U.S in 2001, and Latvia's integration into the EU market since 2004. Since 2004, the GDP deflator has higher inflation growth rate compared to the CPI inflation. It is based on a sharp increase in input prices (e.g. labor, energy) and taxes.

GDP growth and LFS unemployment rates for that respective period is presented in Figure 4. It proves strong relationship between both macroeconomic indicators, thus confirming theories of business cycles (Table 3, 1). Moreover, negative correlations might be stronger if data were more consistent and more precise. GDP growth varies across external shocks that disturbed the economy of Latvia (Financial Crisis of Russia, "dot-com bubble" and terror attacks in the US). Unemployment rates have constantly reduced over time from 15-16% to 6-7%, indicating a positive development, despite external shocks. Some data inconsistency until 2001Q1 is observable in the graph, as strong demand shock had little effect on unemployment rate. Table 3 (2) and (3) presents correlation results of two data blocks: the first shows a very weak correlation that is insignificant, while the second data block correlates strongly and is significant at a 1%

level. Despite poor confidence of the first block of data, overall time series are significant and relevant for further analysis.

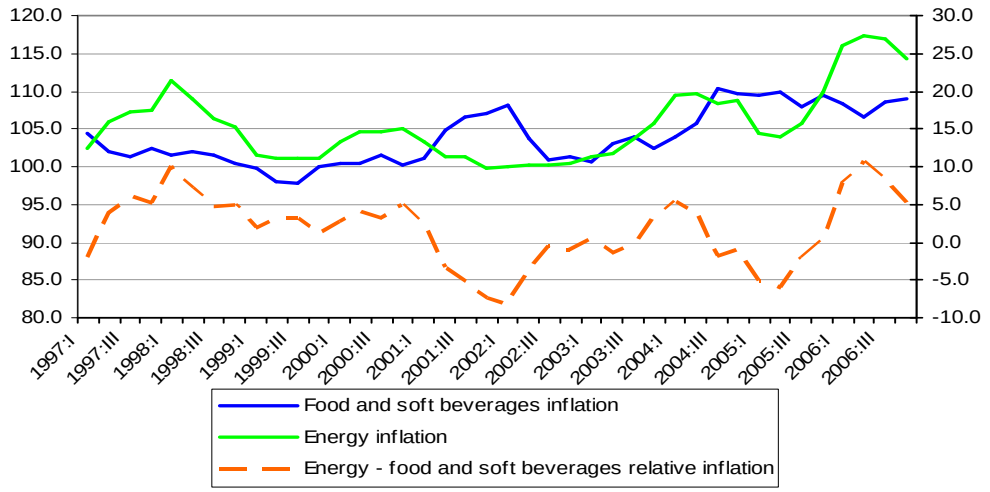
Figure 4 GDP growth and LFS unemployment rate, 1997 Q1 – 2006 Q4



Source: Author's compilation based on the data of the Central Statistical Bureau of Latvia and Eurostat

Demand and supply shocks of Latvia are characterized by energy-food and soft beverage relative inflation, and REER. Energy-food and soft beverage inflation is the best estimate for demand shock because it describes how much purchasing power has gone to

Figure 5 Energy, food and soft beverages, and both variables relative inflation, 1997Q1 – 2006Q4

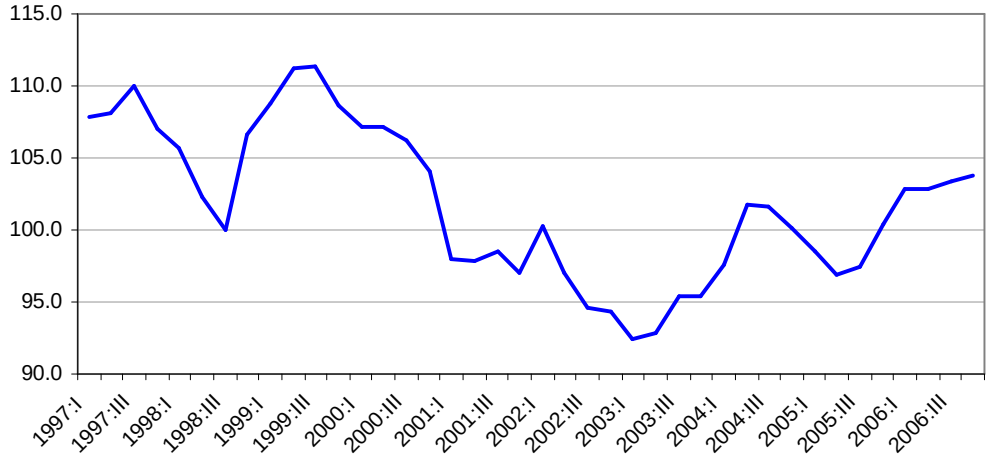


Source: Author's compilation based on the data of the Central Statistical Bureau of Latvia

first necessity needs - energy (heating, electricity etc.) - relative to other first necessity needs, such as food and soft beverage. According to Figure 5, over the target period

energy inflation had a stronger impact over the loss of purchasing power than food and soft beverage. Due to a weaker energy price growth, food and soft beverage inflation exceeded energy inflation in 2002 and 2005. It indicates the persistence of demand shock that has impacted on inflation. REER in Figure 6 describes supply shock of the economy in terms of import price impact on domestic inflation. REER has inverse relationship with import prices: if import prices increase, REER decreases; if import prices decrease, REER increases[13]. The graph clearly shows that until 2001 import prices decreased, while they rose during 2001-2006. Here, we see that supply shock had both negative and positive effects on inflation.

Figure 6 Relative effective exchange rate (REER), 1997Q1 – 2006Q4



Source: Author's compilation based on the data of the Bank of Latvia

5. Results of Econometric Analysis

Econometric analysis is based on theoretical framework developed in Section 3 and data described in Section 4. All regressions and filtering was run using STATA (statistical software).

Constant NAIRU

First, constant NAIRU is estimated using OLS. As $\bar{u}$ is an unobserved variable in equation (3), either filtering or re-specification is needed to run regression. When the

[13] Increase in import prices reduce the purchasing power of domestic currency – more local money is needed to buy the same amount of foreign goods. Therefore, domestic currency appreciates.

NAIRU is treated as constant over sample, it can be estimated directly from unrestricted regression, including an estimate (Staiger et al, 1996). It says that $\beta(L)\left(u_{t-1}-\bar{u}\right)=\beta(L)u_{t-1}+\beta(1)\bar{u}$, where $\beta(1)=\sum_{i=0}^{p}\beta_i$ (p is order of lag polynomial),

(9) $$\Delta\pi_t=\mu+\beta(L)u_{t-1}+\delta(L)\Delta\pi_{t-1}+\gamma(L)X_t+\varepsilon_t$$

Thus, specification (1) in Table 5 includes constant and the unemployment gap is substituted by actual unemployment. Based on the specification of lags, one lag is estimated to be significant for unemployment and CPI inflation. It might be reasonable to assume that only one lag is significant for most of indicators due to high volatility of macroeconomics in Latvia. Neither energy-food and soft beverages relative inflation nor REER were significant, therefore being excluded from this specification. Table 4 presents Pearson's correlation between CPI inflation and both supply shock variables. Possible explanation of such weak correlation could be market imperfections or small weights in CPI inflation.

Taking into account many discussions and previous research, wage inflation is tested in the augmented-expectations Phillips Curve to identify which indicator (CPI inflation or wage inflation) is the most explanatory when regressed by unemployment rate. Table 5 specifications (1) and (2) compares two measures. As we see, wage inflation is strongly influenced by unemployment based on a high negative estimate, -0.60 that is almost four times larger than one at CPI inflation. Specification (2) could be more suitable for constant NAIRU while CPI inflation will show better fit with the output gap from Okun's Law.

The estimate of regression's constant is significant. Constant NAIRU is estimated as a negative quotient of the estimated intercept and the sum of coefficients on lagged unemployment that should be negative and statistically significant, $\bar{u}=\hat{\mu}/\hat{\beta}(1)$. The constant NAIRU is estimated to be 11.46% over the period of 1997 and 2006 for regression with CPI inflation. This figure is a close estimate to the sample mean of unemployment rate that is 11.88% because of one lagged operator and excluded supply shock variables. NAIRU (more precisely, NAWRU – non-accelerating wage rate of

unemployment) from wage inflation Phillips curve presents more than one percentage point lower estimate, 10.28%. Therefore, I conclude that wage inflation and unemployment rate are more plausible variables than CPI inflation and unemployment. Despite CPI inflation is used for further analysis because general consumer price level is stronger linked to output rather than wages that are partially represent in macroeconomic driving forces.

Confidence intervals of the constant NAIRU cannot be calculated easily. This is due to a nonlinear function of the regression coefficients. Here, it can be calculated testing the hypothesis that the NAIRU is a specific value, $\bar{u}_0$. Assuming strict erogeneity of equation (9) regressors and that ε_t are i.i.d. normal, the null hypothesis against two-sided alternative can be obtained by comparing the sum of squared residuals from equation (3) and equation (9), using the F-statistic,

$$(10) \qquad F_{\bar{u}_0} = [SSR(\bar{u}_0) - SSR(\bar{u})]/[SSR(\bar{u})/df]$$

where $SSR(\bar{u}_0)$ is computed from equation (3) with $u_t - \bar{u}_0$ as a regressor, $SSR(\bar{u})$ is computed from unrestricted equation (4), and df is degrees of freedom (Staiger et al., 1996). Based on results F-statistic is equal to 9.35 and is significant at 95% CI. Further Gaussian confidence interval is used to determine an interval of 95% confidence around the constant estimate of NAIRU via STATA software. Figure 14 depicts results of 95% confidence interval. CI covers 3.86% and can be said to be a poor indicator for policy makers because it is in a range between 9.01% and 12.87%. It rejects the theory that the NAIRU returns to its long term level; however, this theory cannot be rejected at all because the research covers 10 year period that could be regarded as a recovery period in business cycle.

Time-Varying NAIRU

Constant NAIRU results showed a wide range of confidence intervals that might not be useful for economic policy and interpretation. Therefore, time varying estimate is researched. First, the ARIMA process was run to estimate the best fit function for historical prediction function. Based on the estimated function, standard errors were searched that were regressed with function. As a result, smoothed function was estimated

with no short-term fluctuations to be found. Figure 15 depicts unemployment rates and smoothed "long-term[14]" unemployment rate by the Kalman filter. As we see, all the time NAIRU has been changing with the actual rate – the hysteresis effect is strong enough, and the gap between actual and optimum level is constantly decreasing. If it was around 12.5% in the beginning of 1997, now it is a bit below 5.5%. This indicates significant structural changes in the labor market. Possible motives will be discussed in the next section. Figure 16 presents results of 95% confidence interval around time-varying NAIRU. Due to a non-constant NAIRU, the range of confidence interval has fell from 3.86% to 2.55% signaling that during a decade the medium-term NAIRU has decreased. Despite narrower range of confidence interval, the estimate of NAIRU is still too wide and is useless for economists to identify macroeconomic targets.

Okun's Law

Now, when there is an estimate for time-varying NAIRU, 3SLS can be applied to estimate time-varying NAIRU with reduced uncertainty via Okun's Law. Table 5 specification (4) presents results of STATA output. As we see, lags of inflation variables are now substituted with gap variables. All variables and χ^2 - statistic is significant at 95% confidence interval, thus the model seems to be consistent. Significance has reduced compare to previous specifications, as R^2 is smaller and output gap is significant at 90% confidence interval. As we see, the unemployment gap falls in between CPI and wage inflation specifications with medium strong influence. So, a percent decrease of unemployment gap has almost a half percent upward pressure on CPI inflation. The coefficient of output gap is quite small and significant only at 90% confidence interval, thus it is evident that output gap has no strong influence on unemployment gap that could be explained by increase of productivity and growth based on technological advancement rather than labor force. Impact from lagged CPI inflation also reduces indicating to increased explanatory power of unemployment gap variable. Figure 17 presents results of confidence interval that has substantially decreased and now is 1.26% compare to constant NAIRU 3.86% and 2.55% of time-varying NAIRU. Graph presents also higher

[14] Here, long-term is associated with an opposite of short-term. Thus it includes both medium and long-term trend.

volatility of NAIRU that is caused by implicit derivation from the Okun's Law. Function shows weaker correlation with actual unemployment as it is not anymore built on pure dynamics of actual unemployment. This specification is more realistic as it presents not only hysteresis effect, but also interaction with business cycle that is a benchmark for all theoretical reasoning. A range of 1.26% might seem too wide for economic implementations; however, structural changes and open economy suffers from high volatility that increases higher measurement errors.

6. Interpretation and Discussion of Results

Econometric analysis supports theoretical intuition towards NAIRU, which is an equilibrium value of the labor market. Basistha and Startz's (2006) model seems plausible because inclusion of the output gap using Okun's Law significantly reduces confidence intervals around the time-varying NAIRU. It also seems reasonable because the NAIRU is implicitly derived from three equations rather than trusting only on the Kalman filter - which is a purely statistical method that squeezes out short-term fluctuations. Here, economic interaction (business cycle) and interpretation play bigger roles than statistical smoothing. It indicates a weaker hysteresis effect as NAIRU itself can follow actual unemployment, but in general most structural changes have an indirect effect and different lagging periods. In general, statistical and econometric tools should have similar results when treated equally. It is more likely that there will be similar results for great economies like US, UK, Germany, Japan etc. However, small open economies suffer from very complex macroeconomical models that should not be treated as large ones. This is one of the explanations why supply shock variables were insignificant for analysis despite trade occupying around 2/3 of the Latvian economy. Another important factor for analysis is relevance of data. Most of the data is structurally split in periods of different methods. After 2000-2002 data for most indicators should be treated as consistent, but before they were incomplete. However, as it was mentioned before this paper is limited not to correct data.

Results are not surprising and show that since 1997, the NAIRU has fallen from 12.56% to 5.48% according to Kalman filter method, specification (3), and from 11.54% to 4.85% according to Okun's Law equation system, specification (4), in the end of 2006.

Thus, it indicates a dynamic progress in a labor market structure that allows 6.7-7.1% decrease in structural and frictional unemployment over one decade. Possible reasons for that are output growth, re-qualification of labor force, increase in mobility, increase in elasticity, sharp growth of wages, emigration of labor force, as well as legalization of hidden employment. These are some of the main factors that have strong and collinear influence on unemployment rates in Latvia.

Figure 17 shows that the path of the NAIRU correlates with actual unemployment rates. Indicatively, the NAIRU cannot decrease as fast as the actual unemployment in the long-run. The structural break that happened in 2004, around observation 29 in Figure 17, was highly determined by emigration and wage growth that reduced inactive part of the population. As graph presents medium-term NAIRU, current situation might hide short term overshooting in labor market. In 2006, the output grew by 11.9% that benefited in reduction of unemployment by around 2%. It might work for a short period that output is growing without substantial reduction of unemployment: firms pay higher wages to maintain at least the same number of employees (increasing workload), earn less profits and compete with other companies. However, competition squeezes out smallest and weakest companies, thus freeing capacity and workforce. Changes in microstructures could recover the whole economy unless there is no competition between industries or sectors. Therefore, there is a high certainty that the labor market of Latvia is overshooting in short-term.

As a proxy for short-term overshooting in labor market, productivity and real wage growth comparison can be used. Labor market is overstretched when real wage growth exceeds productivity growth – employers can pay higher wages to employees despite their value added is smaller than wage benefits only for a short-time of period. Table 1 depicts real GDP growth that is split between labor and capital, as well as real wage growth. Data shows that short term overshooting was observed in 2002, 2003 and 2005. The discrepancy between productivity and wage growth was relatively small (0.6-1.8%). Such gap in data may appear also when there is lagged real investment implementation – capital and labor resources are installed but technological learning is in progress. However, real wage growth in 2006 is more than twice as large as productivity

growth. Neither current CPI inflation nor inflation expectations could explain such a high growth. It certainly indicates to overshooting in labor market in short-term.

Table 1 Real GDP and wage growth structure, 2000-2006

Year	GDP growth, %	Employment growth,%	Productivity growth, %	Real wage growth, %
2000	6.9	-2.9	9.8	3.0
2001	8.0	2.2	5.8	3.5
2002	6.5	2.3	4.2	6.0
2003	7.2	1.0	6.2	7.8
2004	8.7	1.1	7.4	2.4
2005	10.6	1.5	9.1	9.7
2006	11.9	4.8	7.1	15.6

Source: Author's compilation based on the data of Eurostat

This year, a sharp decrease of unemployment indicates that the labor market is very dynamic and its activity is speedier than output or capital market. There is a great threat that in the second half of the year, actual unemployment could reach 5-5.5% of full unemployment. Then, inflation growth will be faster and squeezed up by the labor market. If we currently observe the lack of employees in retail, construction, timber processing, teaching, health care etc., then the gap of employees will increase in many other industries as growth of capacity and production will not be satisfactorily supplied.

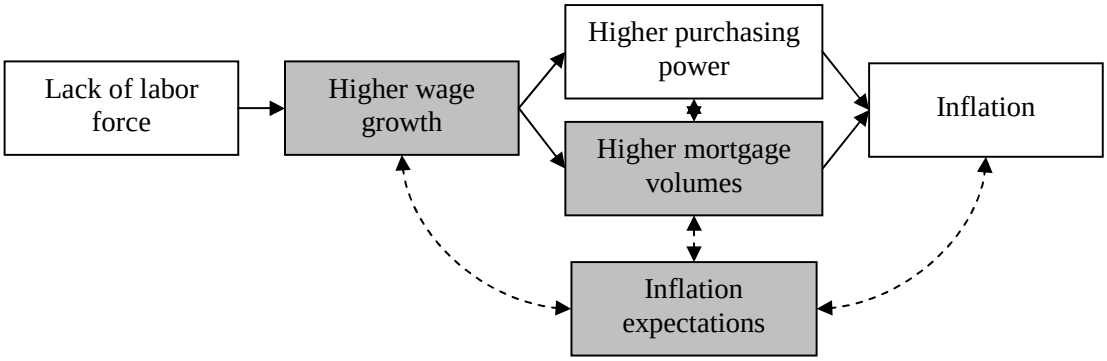
According to the recent informative report of the Ministry of Economics, the inflation of Latvia in 2007 is influenced by following four factors (The Cabinet of Ministers, 2007):

1) Expectations of inflation;
2) High volumes of mortgages;
3) Increase in prices of regulated goods/services (electricity, gas and heating);
4) Wage increase in private sector.

The government is preparing provisions for reduction of budget deficit, taxes on real estate transactions, loan control, influence to energy prices, increase of labor productivity and increase of competition. It is self-evident that inflation is largely influenced by lack

of labor force. Three out of four inflation affecting factors are rooted in the labor market (Figure 7).

Figure 7 Connecting factors of unemployment and inflation



Source: Author's schema

Regulated prices of energy are purely external shock variables as energy prices are determined by suppliers rather than consumers. Based on above mentioned reasons, I conclude that government solutions are effective in short term, as they do not deal directly with labor market. However, more activities should be implemented to make significant changes in labor market structure.

Currently, there is a need for fast action to reduce the NAIRU – structural changes of the labor market to avoid overshooting in longer period. The National Development Plan 2007-2013 expects huge investments in social processes and technological development. Most of them are long-term activities that will take 5 – 15 years, but there are instruments that could be applied in short term, 1-3 years:

- Change demographic structure of active population – support the young and the retired involvement in labor force. Tax reduction or special social benefits should be applied to these groups that might be more involved in labor processes.
- Integration of discriminated groups - educating and involving the disabled, widespread childcare for working mothers, social work for the homeless to integrate them into the labor market.
- Prevent labor emigration and benefit the returning citizens – increase wages and social benefits to the public sector, tax reductions and support for new

entrepreneurs (citizens) that have just immigrated, as well as simplify bureaucratic procedures for those who return.

- Enhance cheap labor force emigration – despite this question is very sensitive in political agenda, it should be recommended to import for a while labor force from less developed countries to employ them in low value-added industries of Latvia. Target audience could be Russians, Belarusians and Ukrainians as they can communicate with locals in Russian. Target industries could be construction works, timber processing, agriculture and elementary systemized work.
- Technological advancement of industry - state support for innovations in private enterprises, financial support for science research centers, wide spreading e-commerce, introduction of competence centers, state support for experience exchange.
- Restructurization of the economy - financing and guarantees for high-tech and high value-added enterprises, restructurization of the education system (supporting specialists for value-adding industries), increase competition among companies. This tool is somewhat medium or long-term, but some of the results can be observed in short-term.

7. Conclusions

The aim of this research was to find an estimate of the NAIRU for the last decade. The estimate was achieved step by step - starting with constant-NAIRU, proceeding with time-varying NAIRU and ending with implicitly derived NAIRU from output gap using Okun's Law. The result shows that the estimate of the NAIRU has decreased from 11.54% in 1997 to 4.85% at the end of 2006. The range of confidence interval is 1.26% wide. The econometric analysis seemed to be satisfactory as the target was achieved successfully and comparatively narrow confidence interval for the NAIRU was found. Based on results, it is concluded that:

- unemployment gap has been decreasing steadily;
- actual unemployment has not reached NAIRU in medium-term while been overshooting short-term equilibrium;
- there is expected full employment by the end of this year in medium-term.

Basistha and Startz's (2006) model was good for theoretical and practical reasoning and significantly reduced uncertainty. Specifics of data did not allow more than one lag operator and inclusion of shock variables that were insignificant. Detailed analysis can be run if data is consistent and a sample reflects the realistic situation of the market. Therefore, more thorough analysis could be run using this model if better quality data could be obtained.

As for the future, the first study could be of an improvement of data and complication of a multivariate approach. "Shadow economy" in labor market and wage determination could be identified to adjust official data and get a clear picture of the current situation. Elasticity of the Phillips Curve could be tested to understand how the decrease of unemployment affects inflation. Sensitivity and elasticity are important tools for the choice of economic instruments that could deal with inflation-unemployment tradeoffs. As for a model, new approaches and frameworks could be tested for the case of Latvia.

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Appendices

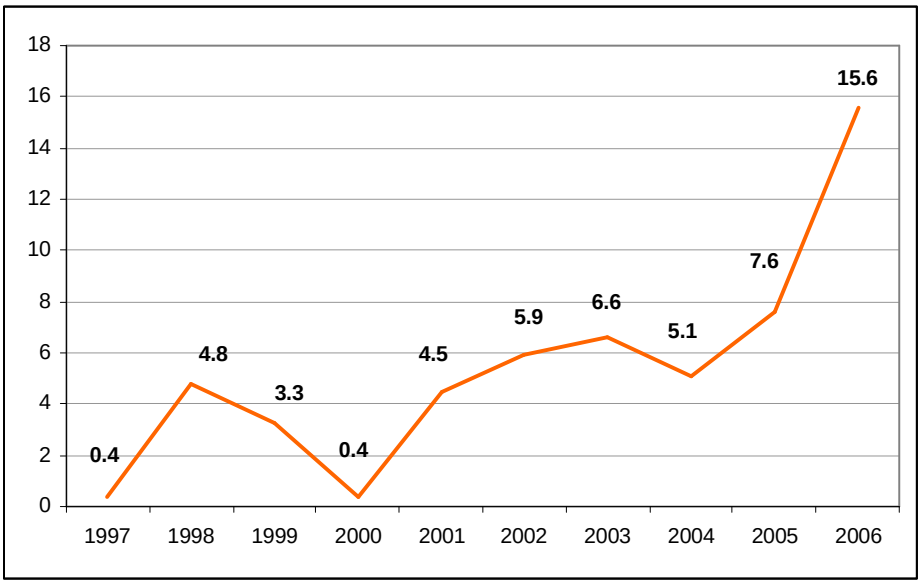
Table 2 Summary and analysis of papers that were used for the model of this paper

Author, Paper, Purpose of Research	Model, Results, Conclusions	Pros and Corns
Stikuts (2003) "Measuring Output Gap in Latvia" NAWRU of Latvia is estimated as an input variable of the potential output function	Elmeskov (1993) model where NAWRU consists of actual unemployment and relation between unemployment change and wage growth. Trend is smoothed by Hodrick-Prescott filter. Estimates show that NAWRU has fell from ~18% in 1995 to ~14% in 1998, slower fall happened next four years to ~13% in 2001.	+ NAWRU is chosen as the best approach to link unemployment with the output gap; + NAWRU has stronger relationship between labor and goods' market (according to Torres, 1990); + It proves that there is a weak linkage between the output gap and inflation due to high openness of economy where imports and own outputs are interrelated; + Labor supply and demand is used for calculations instead of LFS series; - Model lacks integration of unemployment in the cyclical economics chain with output and inflation; - It assumes that wage includes other employment determinants: productivity growth, technologies, demographics, taxes, business practices and others that may not fully appear in wages;
Camarero et al. (2005) "Unemployment Dynamics and NAIRU Estimates for Accession Countries: A Univariate Approach" NAIRU of Latvia is estimated to analyze the natural rate of unemployment for new accessing countries and use new approach for transition economies.	Short-term NAIRU is estimated in three methodological perspectives: 1) small sample problem, M unit root tests when testing for hysteresis; 2) endogenous multiple structural breaks; The univariate approach assumes that unemployment reverts to its mean or natural rate over time. The natural rate hypothesis: the unemployment rate fluctuates around an equilibrium level that depends on fundamentals in the economy (labor productivity, technology, real interest rates and the real exchange rate). The hysteresis effects: unemployment never attains its equilibrium, it reflects the cumulative effect of all past shocks, both demand and supply, to the economy.	+ Model solves small sample problem; + Model assumes structural breaks and reforms that has significant impact on the equilibrium level; - Model has no economical interpretation and background; - Implicitly derived data for 1994-1998; - Choice of model: the NAIRU should not be a step-like function (smooth function); - Hysteresis effect may have leading nature on the NAIRU; - Author lacks understanding of the historical path of economy since 1991 and experienced crises;

	The results show four structural breaks in Latvia: 1996:I, 1998:III, 2000:II and 2002:II that indicate to the bank crisis, Russia crisis and recovery from the loss of Russian market.	
Stankus (2002) Bachelor Thesis "Prices, Wages and Unemployment in the Baltics: 1995-2001" Paper explores inflation-unemployment trade-off in Estonia and Lithuania and identify the NAIRU	The paper uses augmented-expectations Phillips curve where the tradeoff stems from wage and price setting and examine the long-term NAIRU. 1) check unemployment data series; 2) missing values are interpolated; 3) annual price inflation and annual nominal gross monthly wages and salaries are calculated in each quarter; 4) relative energy-food prices are expressed as inflation of energy products less inflation of food and non-alcoholic beverages; 5) labor productivity is measured by average real output per quarter of one worker in the economy Hodrick-Prescott filter is used to tune the smoothness of the trend.	+ It successfully adjusts model and data to such transition economies as Estonia and Lithuania; - Paper delimits to a single equation-regression estimation; - Author assumes that prices are proportional to wages as wages comprise a large proportion of total production costs, whereas results show that prices and wages are not co-integrated and do not move together;

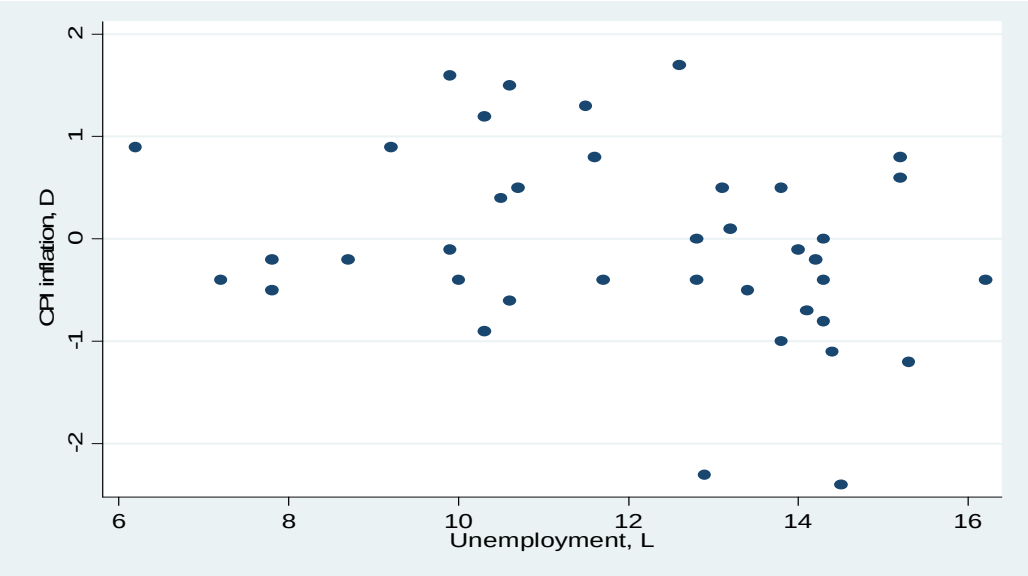
Source: Author's compilation

Figure 8 Labor cost index of Latvia (1997-2006), annual change in percentage



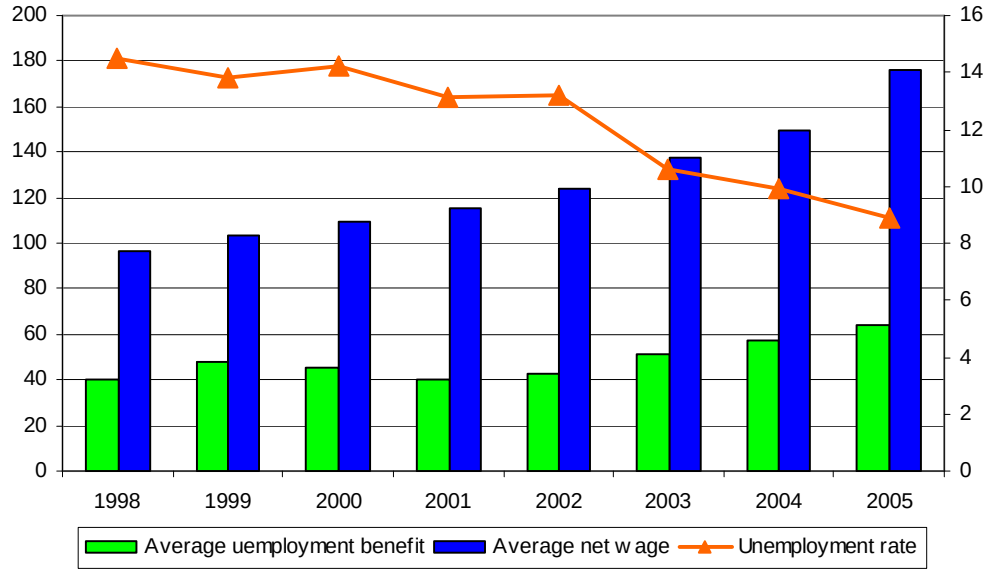
Source: Author's compilation based on the data of Eurostat

Figure 9 Change in annual CPI inflation versus unemployment rate, quarterly data for Latvia, 1997Q1 – 2006Q4



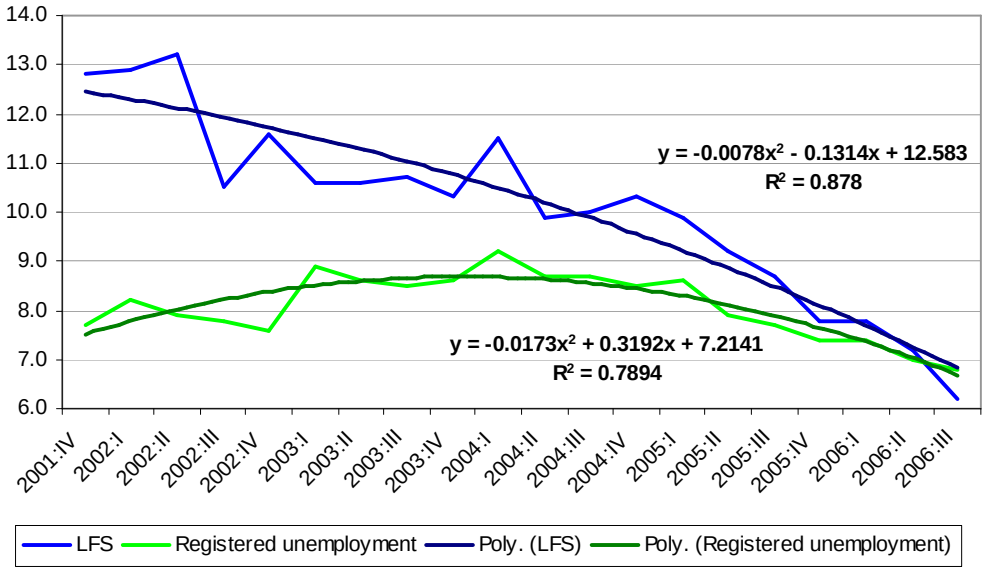
Source: Author's compilation based on the data of the Central Statistical Bureau of Latvia and Eurostat

Figure 10 Average unemployment benefit, average net wage and unemployment rate, 1998-2005



Source: Author's compilation based on the data of the Central Statistical Bureau of Latvia

Figure 11 LFS and registered unemployment rate, 2001Q4 – 2006 Q3



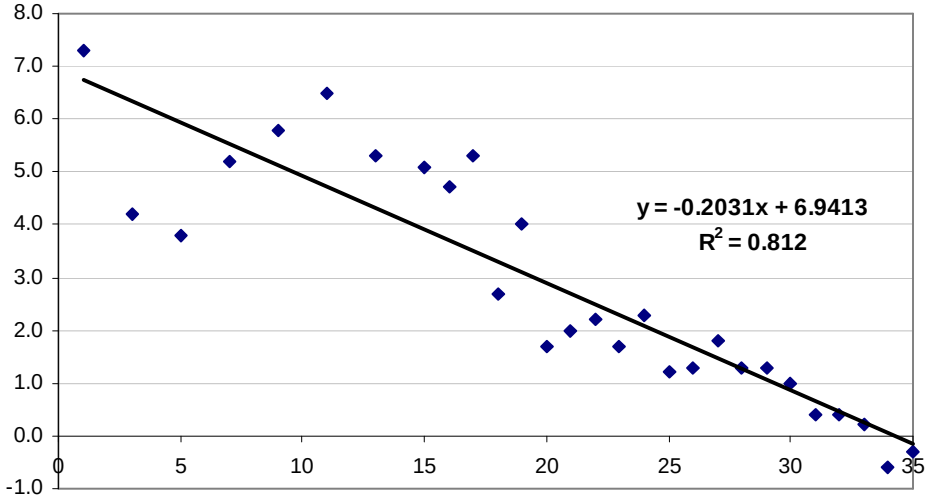
Source: Author's calculation based on the data of Eurostat and State Employment Agency

Figure 12 Correlation between import price index and REER, 31 obs (1999 Q1 – 2006 Q3)

Obs=31	Import price index	REER
Import price index	1.0000	
REER	-0.5097	1.0000

Source: Author's calculation based on the data of the Bank of Latvia and Eurostat

Figure 13 Difference between LFS and SEA registered unemployment rate with time trend and STATA output, 1998Q2 – 2006Q4



Source: Author's calculation based on the data of Eurostat and State Employment Agency

Table 3 Correlation between GDP growth and LFS unemployment rate

	Periods	Observations	Pearson's correlation	t-test	P-value
(1)	1997Q1 – 2006Q4	40	-0.6938	-5.94	0.000
(2)	1997Q1 – 2000Q4	16	-0.0988	-0.37	0.716
(3)	2001Q1 – 2006Q4	24	-0.7691	-5.64	0.000

Source: Author's calculation based on the data of the Central Statistical Bureau of Latvia and Eurostat

Table 4 Pearson's correlation between CPI inflation, and energy-food and soft beverages and REER, 1997Q1 – 2006Q4

	Energy-food inflation	REER
CPI inflation	0.1678	0.1967

Source: Author's calculation based on the data of the Central Statistical Bureau of Latvia and the Bank of Latvia

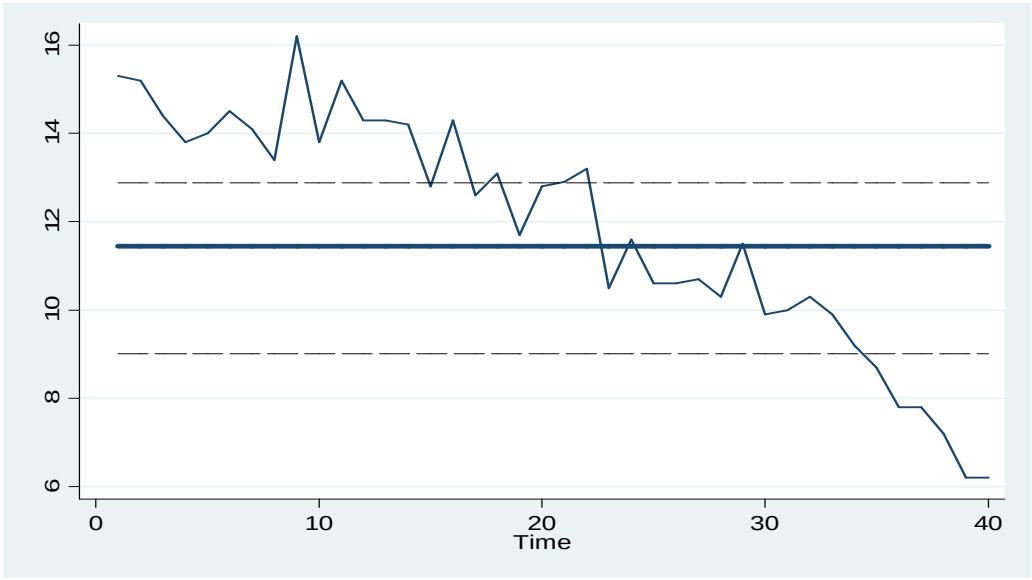
Table 5 Regression results

	(1)	(2)	(3)	(4)
# of obs	39	39	39	39
Method	OLS	OLS	Filter and OLS	Filter and 3SLS
NAIRU	11.4582%	10.2831%	Figure 12	Figure 13
Dependent variable	π_t^{CPI}	π_t^{W}	π_t^{CPI}	π_t^{CPI} , π_t^{W} , g_t^{U}
Constant	1.7067**	6.1236**	5.7772*	
u_{t-1}	-0.1489**	-0.5955***	-0.2118**	
π_{t-1}^{CPI}	0.8355***		0.8631**	0.7641**
π_{t-1}^{W}		0.8598***		0.7887**
g_t^{U}				-0.4842**
g_t^{Y}				-0.1593*
Regr. stat.				
Adjusted R^2	0.8533	0.8844	0.6954	0.7791
F-statistics	111.48	146.39	34.12	
χ^2 **- statistics**				235.36

* significant at 90% confidence interval, ** significant at 95% confidence interval, *** significant at 99% confidence interval

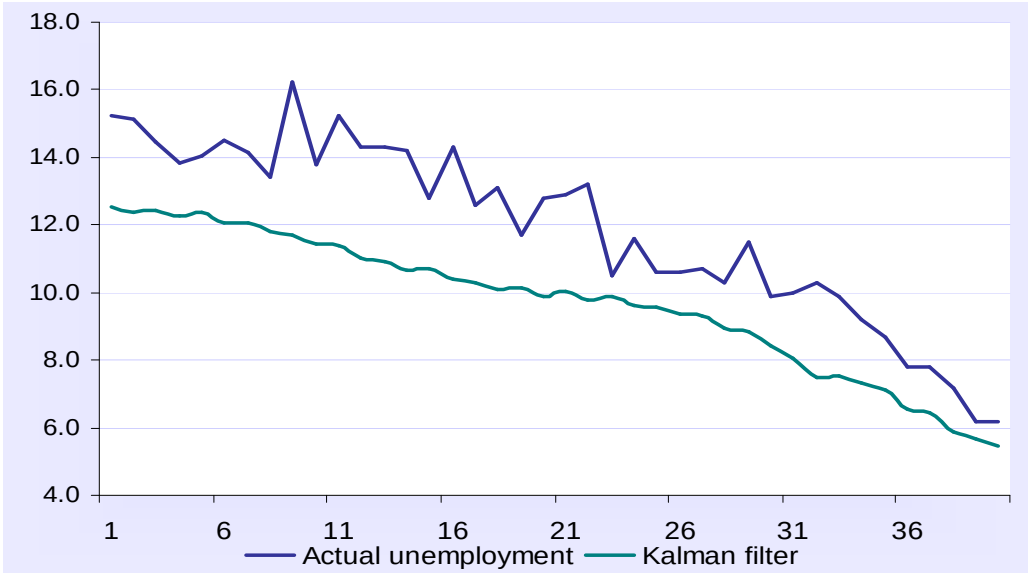
Source: Author's calculation

Figure 14 Unemployment rate, constant estimate of NAIRU (bold line) and 95% Gaussian confidence interval (long dashes)



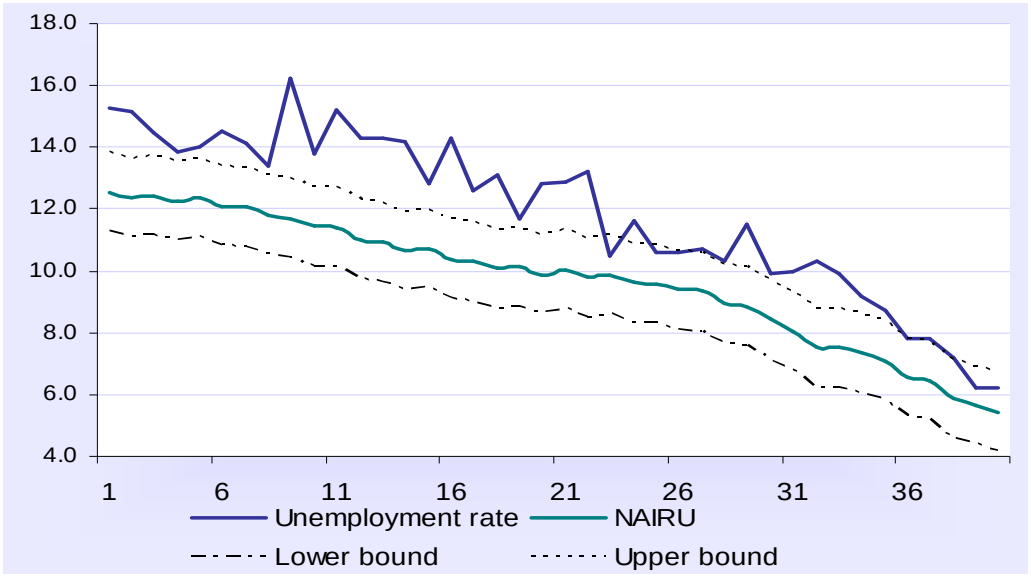
Source: STATA output

Figure 15 Estimate of NAIRU by Kalman filter (dark green trend line)



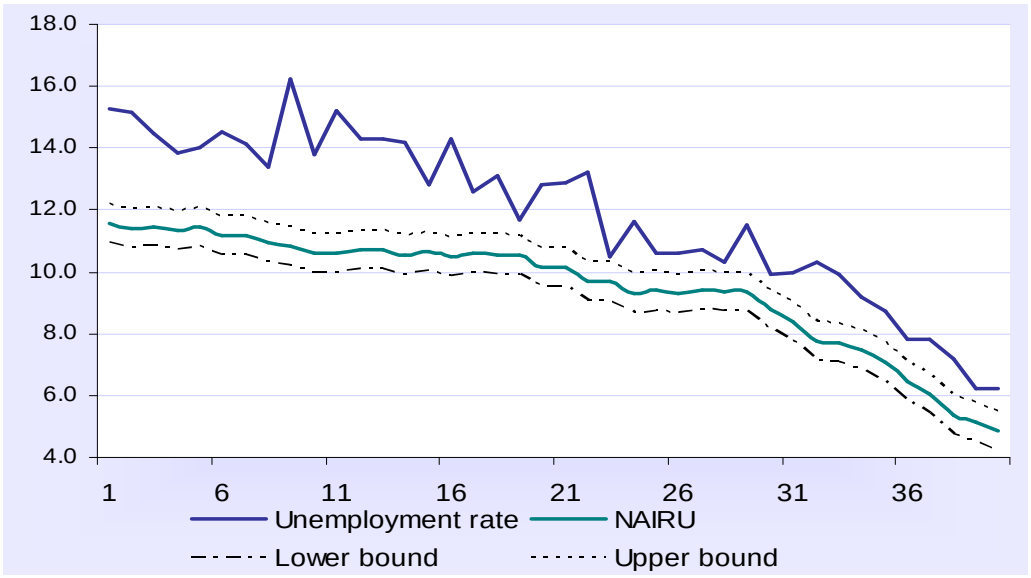
Source: STATA output

Figure 16 Confidence intervals around exogenously derived estimates of NAIRU (dashed lines)



Source: STATA output

Figure 17 Confidence intervals around implicitly derived estimates of NAIRU (dashed lines)



Source: STATA output