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Institutional Drivers of NAIRU

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Abstract

We estimate NAIRUs and effects of institutional factors driving them for a group of 20 EU countries for the period 2000 - 2014. Employing Kalman filter on the Phillips curve relationship we first estimate the NAIRU for each country. Then, we regress the estimated NAIRUs on a set of institutional and control variables using various panel estimation techniques. Several robustness checks were performed including univariate correlations and Bayesian model averaging. Results show that the NAIRU is driven by the active labour market policy expenditures, rigidness of temporary jobs market, external mobility, and union density. Surprisingly, tax wedge and unemployment benefit replacement rate are insignificant. Policy recommendations for Slovakia build on a substantial increase of expenditures on effective active labour market policies, measures increasing mobility of the workforce and on a more flexible temporary jobs market.

Acknowledgement:

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1 Introduction

Rising structural unemployment has become a severe problem in many EU countries in the aftermath of the crisis in 2008. In Slovakia, the issue of persistently high structural unemployment has been catching the attention of policy-makers since the beginning of the transition period.[1] The structural unemployment rate represents the share of the labour force without job in the times when the economy is running at its full potential. Although unemployment is one of the priorities of the economic policies in the EU, we know very little about the sources of differences in structural unemployment rates among the countries. In fact we know also very little about the level of the structural unemployment rate. The goal of this paper is therefore twofold – to estimate the structural unemployment rates in EU countries and to estimate the effect of institutional factors driving them.

Most economists nowadays refer structural unemployment to the Non-Accelerating Inflation Rate of Unemployment (NAIRU) or Non-Accelerating Wages Rate of Unemployment (NAWRU). The former approach is used by the OECD or the National Bank of Slovakia while the latter is employed by the European Commission.

In this paper we decided to estimate a time-varying NAIRU by so-called semi-structural method, which represents a compromise between purely statistical methods (such as Hodrick-Prescott filter, which rests on the assumption of no long-run trade-off between inflation and unemployment) and structural methods, in which price- and wage-setting behaviour is directly modelled. This approach, which has gained prominence in recent years, in turn incorporates economic relationships via the Philips curve into statistical framework.

As the rich literature suggests, NAIRU may be driven by a number of institutional and macroeconomic factors. Empirical papers often show significant relationships, which however heavily depend on the specification and variables picked for estimation. It is reasonable to expect that many of the factors are mutually correlated and omitting some of them may lead to a significant bias of the estimate. Therefore we try to collect all the potential drivers and simultaneously estimate their effect on NAIRU. In addition to the existing literature we introduce the estimates for post-Communist EU member states (which was not the case in the previous studies because of lack of data). These countries underwent deep structural changes in relatively short time, so we are interested if the implemented reforms helped indeed to lower the structural unemployment.

The rest of the paper is organised as follows. Section 2 introduces theoretical framework and our estimate of NAIRU by means of Kalman filter. The third section analyses the relationships between NAIRU and the potential drivers. The last part sums up the results and formulates some policy recommendations.

[1] Machlica et al. (2014) provided in depth analysis of high level of unemployment rate in Slovakia.

2 NAIRU Estimation

The non-accelerating inflation rate of unemployment (NAIRU), a concept first introduced by Modigliani and Papademos (1975), stands for the rate of unemployment consistent with stable (short to medium-term) inflation. Moreover, as it has been often the case in previous research on this topic, we consider it to be equivalent to the natural unemployment rate[2], the concept developed by Friedman (1968) and Phelps (1968), i.e. the rate to which economy converges in the absence of structural changes in labour market and notion that is associated with well-established[3] long-run Philips curve.

This equivalence view of NAIRU and natural rate of unemployment highlights the importance of such estimate for economic policy. First of all, its relation to inflation, implies its importance for the conduct of especially monetary, but also fiscal policy, and the estimation of their impact on the economy. On the other hand, the structural interpretation highlights its use for assessing and guiding labour market policies, and studying the structural developments in labour markets.

2.1 Literature on NAIRU

Since the seminal paper of Modigliani and Papademos (1975) a vast amount of literature has been devoted to studying the NAIRU, notably Elmeskov (1993), Gordon (1996), Staiger et al. (1997), Ball (1997), Gianella et al. (2008) and many others. The research focuses not only on the NAIRU estimation procedure but surveys also the drivers behind it.

In Slovakia, to our knowledge only two papers paid attention to NAIRU estimation: Gylánik and Huček (2009) and Šrámková (2010). Both papers apply a multivariate Kalman filter framework where NAIRU is estimated together with the potential output. Both papers showed extremely strong hysteresis on the labour market and generated NAIRUs closely following the actual unemployment rate which is an unsatisfactory feature.

The literature covering the NAIRU estimation in Slovakia and in the other EU new member states pays no attention to the drivers behind its development. This holds for both country specific papers as well as for panel estimations done by for example the OECD. This is most probably due to the lack of data for these countries. We pay more attention to this issue in the third section.

2.2 The model

We employ the semi-structural approach in the state space model for estimating the time varying NAIRU by Kalman filter for all countries. This approach represents a compromise between the purely statistical methods (such as Hodrick-Prescott filter), which rest on the

[2] Hence we do not employ the distinction between the two terms as described for example in Estrella and Mishkin (1998)

[3] The discussion of inflation-unemployment trade off dates back to the 18th century to Hume´s 1752 essay „Of Money"

assumption of no long-run trade-off between inflation and unemployment, implying that actual unemployment rate fluctuates around its natural value, and structural methods, in which price and wage-setting behaviour is directly modelled. This approach, which has gained prominence in recent years, in turn incorporates economic relationship of the Philips curve in statistical framework[4]. We pay no attention to the estimate of potential output as it has been done in the papers of Šrámková (2010) or Gylánik and Huček (2009).

Our framework consists of two measurement equations, one defining the NAIRU:

$$(1)\quad U_t = NAIRU_t + Ugap_t$$

and the other one being the Philips curve[5], which takes into account supply shocks, namely oil and foreign price shocks:

$$(2)\quad \Delta\pi_t = \alpha_1 \Delta\pi_{t-1} + \alpha_2(\pi_t^f - \pi_t) + \alpha_3(\pi_{t-1}^f - \pi_{t-1}) + \alpha_4(\pi_t^o - \pi_t) + \alpha_5(\pi_{t-1}^o - \pi_{t-1}) + c_2 Ugap_t + c_3 Ugap_{t-1} + \eta_t$$

Where π_t is the core inflation (if time series for core inflation were insufficiently long, all items inflation was used instead)[6], π_t^f denotes foreign price inflation and π_t^o stands for oil price inflation (in domestic prices).

Hence, we apply a triangle model of inflation, in which inflation is assumed having three determinants: inertia (represented by lagged inflation) and demand and supply pressures represented by unemployment gap and oil and foreign prices respectively.

By considering first differences of inflation rates, we are assuming that inflation expectations follow a random walk or in other words are backward-looking. Moreover, as noted by Staiger et al (1997), inclusion of the first differences on the right hand side is equivalent to specifying equation in levels with the restriction that the sum of coefficients on lagged inflation terms must equal unity. This in turn corresponds to the existence of vertical long-run Philips curve, which is consistent with economic theory.

The foreign price index was calculated as the weighted sum of all items inflation of main import partners[7]. Weights are assigned according to import partners' shares.

In the Phillips Curve specification we allow for one lag of unemployment gap as well as supply side shocks. No further lags are included, since even the first lag turns out to be statistically insignificant in many countries. We allow for one lag so that the change in inflation depends not only on current levels, but also on current changes in the right hand side variables. As argued for example by Gordon (1996) for unemployment, this better captures previously identified statistical relationships between variables considered.

The inclusion of current unemployment gap in the Philips curve raises the issue of simultaneity bias, which would invalidate the estimates. Hence, to proceed with the given specification we must assume that there is no contemporaneous feedback from inflation to unemployment.

[4] For more detailed overview of estimation methods see Richardson et all (2000)

[5] We have experimented with the specification of the Philips curve a great deal, trying both levels of variables, differences of right hand side variables and so on. The specification was chosen based on the reliability of estimates in terms of their economic interpretation and statistical significance. We have also tried to replace core inflation by all items inflation, however, this approach did not deliver significantly different results in term of NAIRU estimates.

[6] This concerns the Czech Republic and Hungary

[7] Main import partners means countries which had at least 1% import share in any of the years considered subject to data availability in imports and foreign price indices

Such assumption is standard across similar studies and can be explained by short-term rigidity of prices, developments in unemployment rates lagging behind developments in output and by the existence of inventories, which facilitate short-run decoupling of output and prices (Gruen et al, 1999).

The two transition equations describe NAIRU and unemployment gap dynamics. NAIRU is assumed following a random walk process, a standard approach in academic literature (followed for example by Gianella et al (2008), Guichard and Rusticelli (2011)):

$$(3)\quad NAIRU_t = NAIRU_{t-1} + v_t$$

We have considered various forms of this relationship, including modelling NAIRU as AR(1) process in first differences (as considered for example by Boone (2000) or Kierzenkowski et al (2008)) or as a random walk with stochastic drift (used for example by Fabiani and Mestre (2001), Llaudes (2005)). The above-mentioned specification was chosen based on the plausibility of NAIRU estimates.

The unemployment gap follows an AR(2) process:

$$(4)\quad Ugap_t = c_{12}Ugap_{t-1} + c_{13}Ugap_{t-2} + \varepsilon_t$$

We opt for AR(2) process rather than higher-order processes sometimes used in similar studies, since the latter approach resulted in extremely flat NAIRU series, neglecting major structural changes in transition economies.

The equation (4) is equivalent to

$$U_t - NAIRU_t = c_{12}(U_{t-1} - NAIRU_{t-1}) + \varepsilon_t$$

Hence this equation ensures the convergence of unemployment rate to its natural state in the absence of external shocks.

BOX 1 – Assumptions

Estimating the system of equations (1)-(4) by the means of Kalman filter within the state-space representation requires several additional assumptions regarding unobserved components i.e. state variables included in the model.

First, starting values for state variables and variances of these values must be specified. The two most common approaches include the values from Hodrick Prescott filter and the use of average unemployment rate prevailing around the start of estimation sample. However, since our time sample starts in 2000 following either of these would lead to selecting unrealistic starting values especially for post-Communists´ countries which were experiencing unemployment rates far above NAIRU, often reaching 20 per cent. To overcome this issue we use OECD NAIRU estimates for the year 2000 where applicable. Only if the implied estimates lead to implausible results compared to previous studies, we resort to the previously mentioned approaches. Starting values for unemployment gaps are defined by the identity as differences between actual unemployment and priors for NAIRU.

To reflect high uncertainty of our initial estimates we set the starting variances equal to one for both unemployment gap and NAIRU[8]. However, our results are robust to changes in these values.

The parameters of the model are estimated by the maximum likelihood method, but due to the nonlinearity of the maximization problem these computations are done iteratively. Hence we must also specify starting parameter values. These come from the corresponding OLS regressions, in which NAIRU and unemployment gap are derived using Hodrick-Prescott filter (lambda=1600). Such choice of starting values employed for example by Llaudes (2005) and Fabiani and Mestre (2001). However, our estimates are robust to alternative choices of starting values.

Similarly to the choice of smoothness parameter in Hodrick-Prescott filter, the Kalman filter approach requires limiting NAIRU variability, since if NAIRU is understood as a natural unemployment rate it should move slowly over time, avoiding high variation in quarter-to-quarter changes. We follow a standard approach in the literature that fixes signal-to-noise ratio $\sigma_\eta/\sigma_\upsilon$, allowing variances to be freely estimated subject to the constrained ratio. We put no direct restriction on σ_ε[9]. Signal-to-noise ratios are determined country-by-country approach, allowing us to better capture cross-country differences which arise due to the substantial heterogeneity of countries in our sample.

The former approach results in most cases in statistically insignificant coefficient in unemployment gap in the Philips curve equation (although with correct signs). Hence, we resort to calibrating this parameter where relevant based on the estimates of Guichard and Rusticelli (2011)[10].

Our dataset for NAIRU estimation consists of quarterly data covering the period 2000q1 - 2015q1 and 20 EU countries. The estimates have been made one-by-one for each economy. We excluded Greece, Latvia, Lithuania, Romania, Bulgaria, Cyprus, Malta and Croatia due to data limitations for the subsequent step which is estimation of NAIRU determinants. In the end also Estonia had to be excluded from the panel but we keep it for demonstration of the NAIRU estimates.

2.3 NAIRU Estimates

The Kalman filter estimation of the Philips curve yields the intuitive results in terms of coefficient signs and parameter significance in majority of right-hand side variables. Both types of supply shocks are significant when all-items inflation is used, while in case of core inflation always only one supply shock term is so. In more detail, in most cases it is foreign price inflation. However, as has been already mentioned above, this favourable performance does not extend to unemployment gap, which was often found to be statistically insignificant (albeit with the expected sign) and thus we must rely on calibrated relationships.

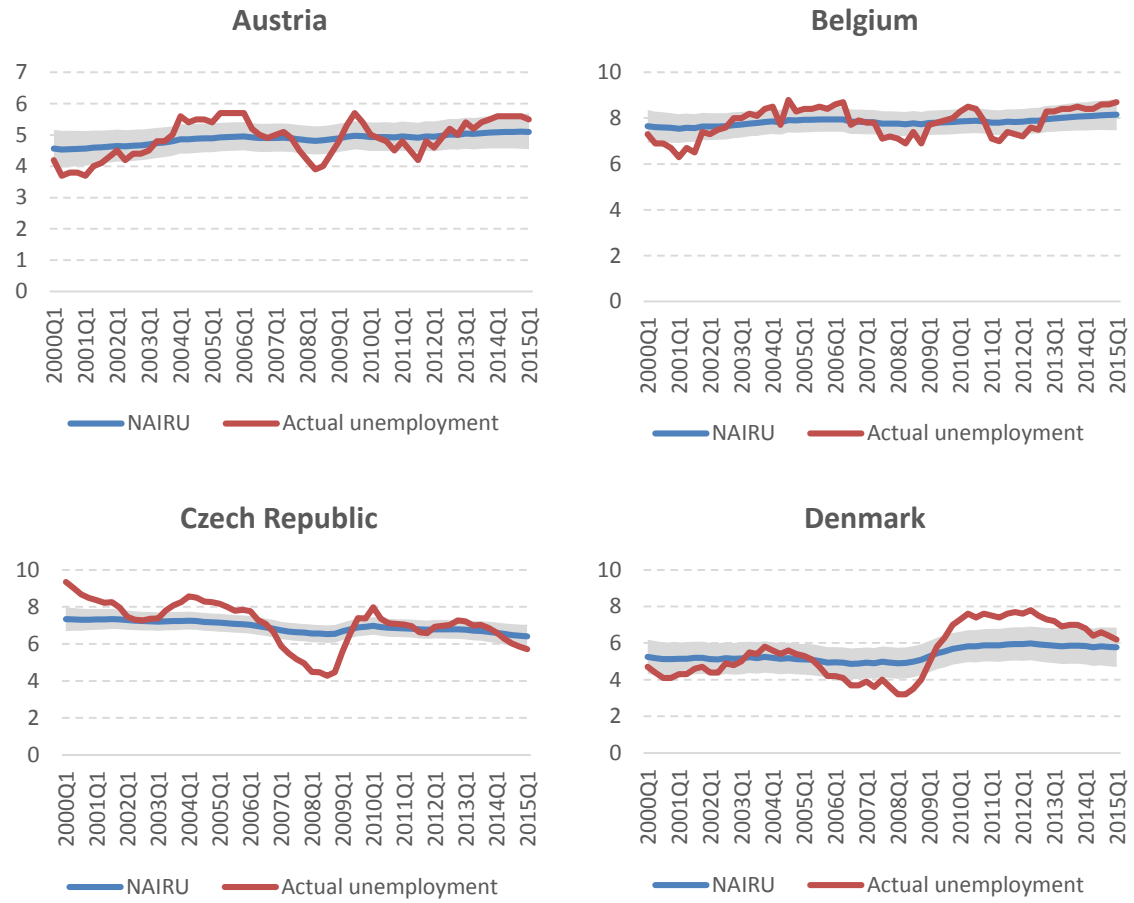
[8] By selecting higher variance values we in fact reduce the weight put on our prior estimates in the iterative procedure.
[9] An alternative approach would be to fix $\sigma_\varepsilon/\sigma_\upsilon$, but this does not alter our results in terms of both parameter and NAIRU estimates significantly.
[10] We select this study due to the very similar methodology used by authors as well as the goal of their study.

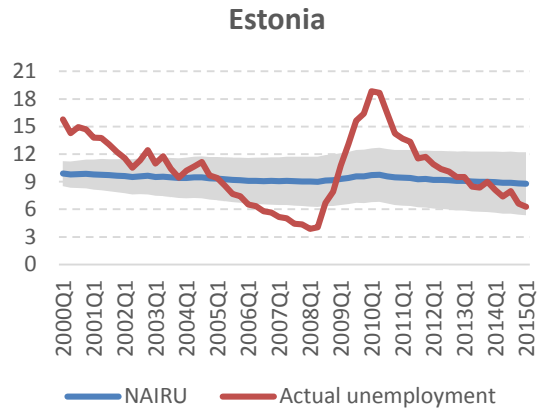
Figures below present NAIRU estimates together with 95% confidence intervals for all countries. As the graphs indicate, NAIRUs decreased significantly in the pre-crisis period only in case of two countries (by more than 2 p.p.), namely Poland and Slovakia. However only Poland managed to keep the NAIRU down also in the post-crisis period. In addition Poland and Germany are the only two countries where the actual level of NAIRU is lower compared to the pre-crisis rate.

Most of the analysed countries faced an increase of NAIRU during the last 15 years, especially in the aftermath of the crisis. Unsurprisingly such conclusion applies particularly on peripheral economies. However, it relates also to most countries from the core of the Eurozone, except Germany, France and Finland. The results also indicate the role of hysteresis in determining the natural unemployment rate.

The confidence bands reflect the uncertainty surrounding NAIRU estimates and apart from Ireland, Estonia and Slovenia, for which substantial ambiguity is present, they point to reasonably precise estimates.

Figure 1: Actual unemployment rates, NAIRU and 95% confidence intervals

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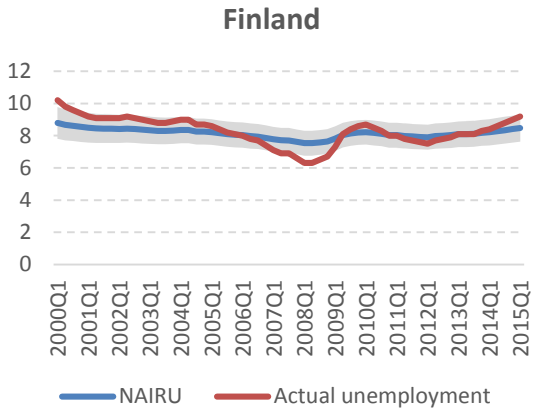
2015Q1
NAIRU
Actual unemployment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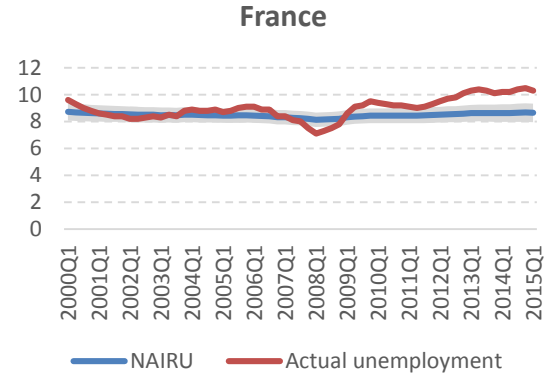
NAIRU
Actual unemployment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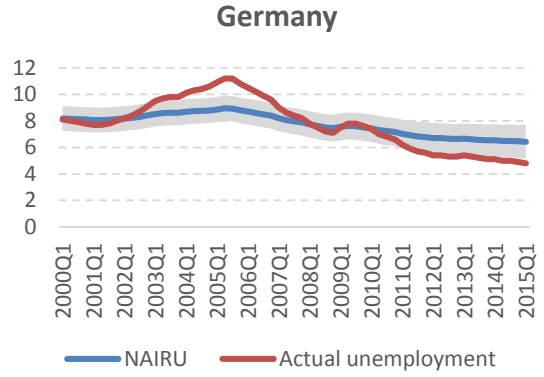
NAIRU
Actual unemployment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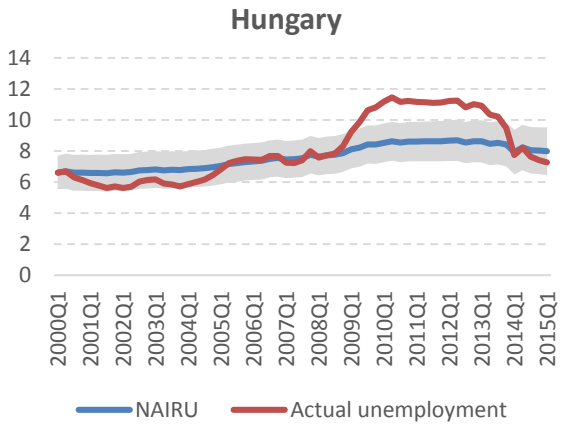
NAIRU
Actual unemployment


Hungary
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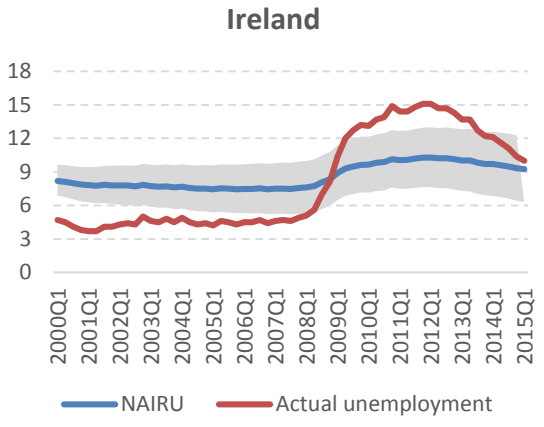
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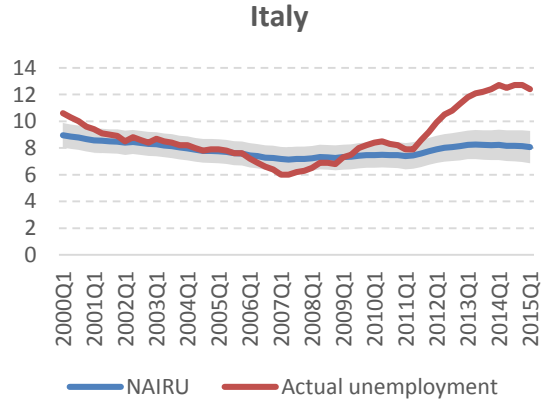
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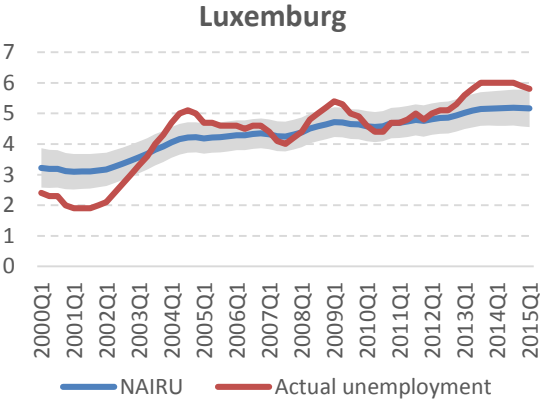
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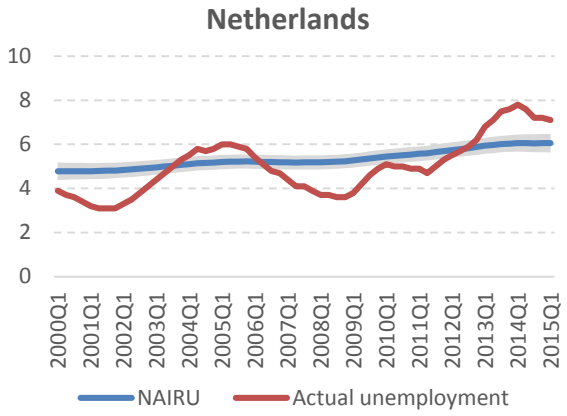
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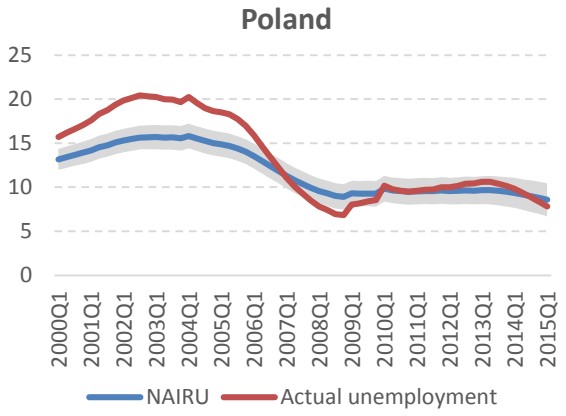
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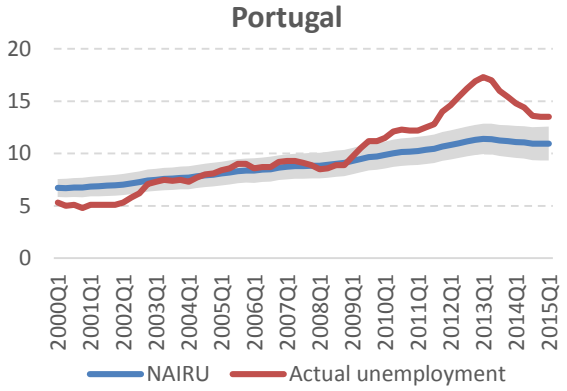
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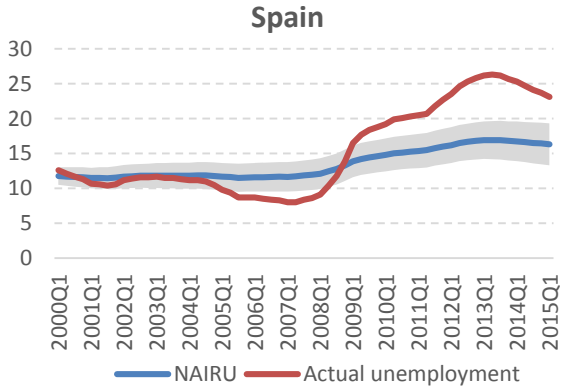
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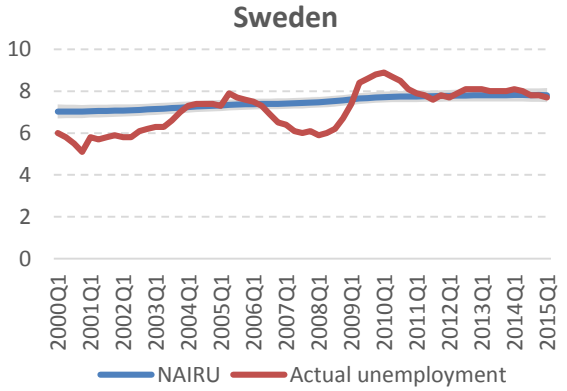
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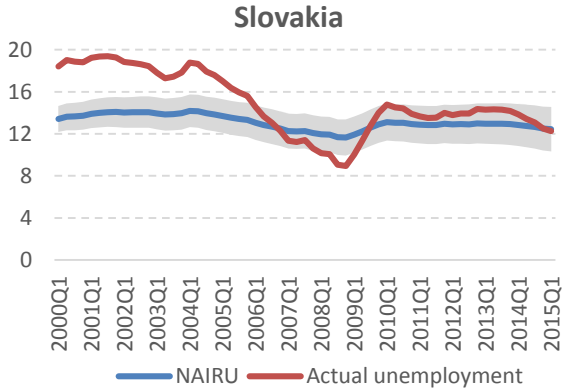
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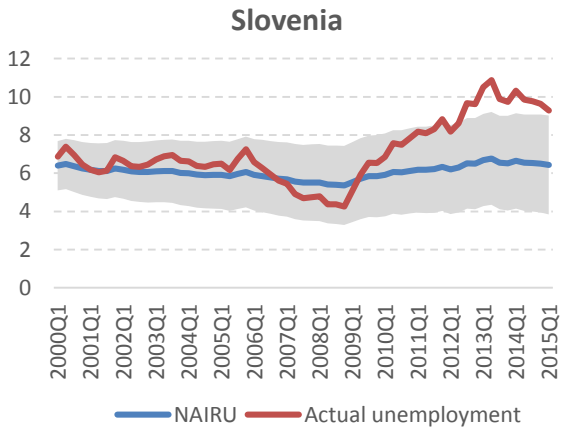
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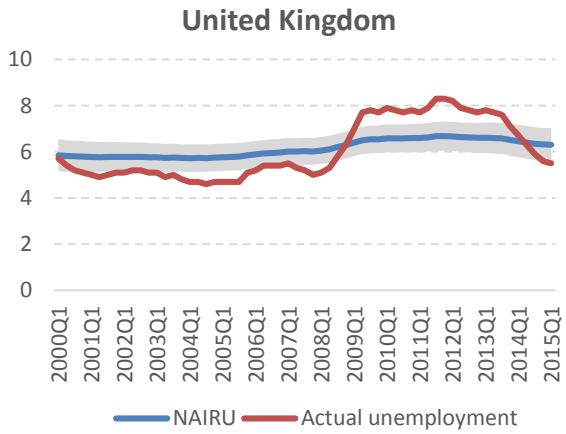
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NAIRU
Actual unemployment

Source: IFP

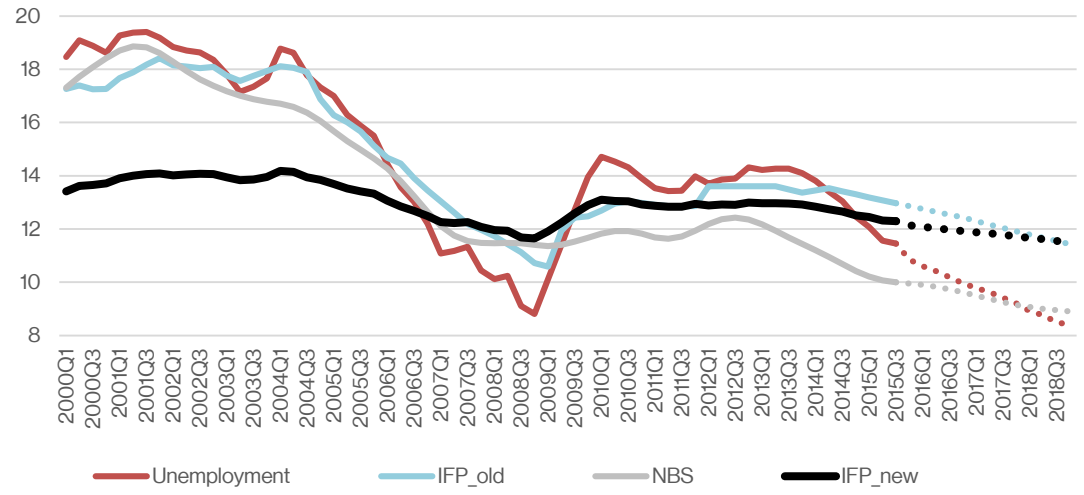
2.4 NAIRU estimate for Slovakia

A more detailed look at the estimate of structural unemployment in Slovakia shows a relatively strong hysteresis effect, but it has lower magnitude compared with previous studies by Šrámková (2010) or Gylanik and Hucek (2009). We found out that a 1 p.p. change in actual unemployment leads to a 0.25 p.p. change in the NAIRU estimate.

Our estimate of NAIRU peaked at 14 per cent during a relatively long period 2001-2004. This led to a substantial increase in the long-term unemployment and as a consequence the skills of the affected labour force faded out. We believe that the protracted period of the unfavourable labour market conditions in 1999-2004 hampered a sharper decrease in structural unemployment in the following years. The same applies to current economic cycle with limited recovery in between 2009 and 2013.

During the 2004 – 2008 period the NAIRU witnessed a gradual decline to 11.6 per cent, representing an all-time low. Following the economic crisis it increased back to 13 per cent. Favourable labour market conditions in 2014 and 2015 enabled a turnaround and most recently it decreased to 12.3 per cent.

Figure 2: Comparison to other NAIRU estimates for Slovakia (in %)

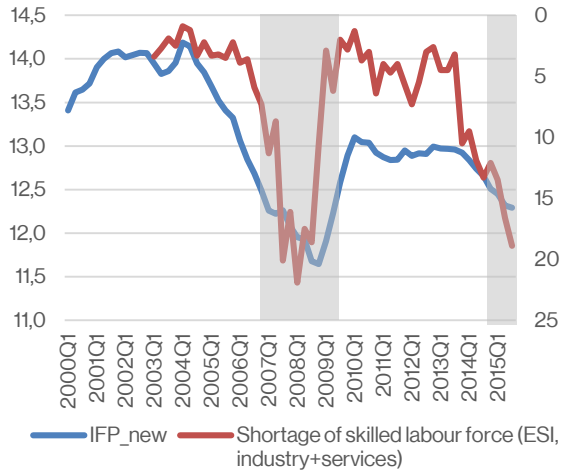


Source: IFP

The actual unemployment rate fell below NAIRU in the 4th quarter of 2014. The labour market should therefore show signs of overheating which is true as shown in Figure 3. Both industry and services face lack of skilled labour as reported by soft indicators.

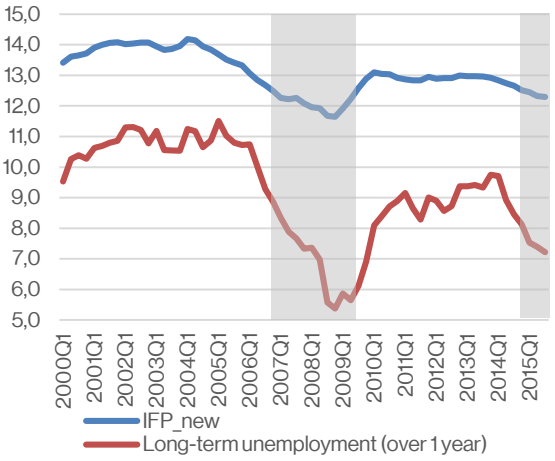
There is also a strong relation between NAIRU and the long-term unemployment. When the NAIRU hovers above the actual unemployment rate the employers are forced to utilize the long-term unemployed to a larger extent. As the Figure 4 suggests, the labour market needs to be overheated to successfully reduce the long-term unemployment, having the positive spiral effect on NAIRU.

Figure 3: Negative unemployment gap correlates with a shortage of skilled labour force



Source: IFP

Figure 4: Significant decrease in the long-term unemployment occurs only in the times of negative unemployment gap



Source: IFP

3 Institutional and macroeconomic drivers of NAIRU

Very important task in studying NAIRU is the identification of drivers behind it. Answering this question contains not only academic aspirations but also far reaching policy implications. Tackling high structural unemployment in the EU appears to be one of the most important economic policy tasks. As the rich literature suggests, NAIRU may be driven by a number of institutional and macroeconomic factors.

3.1 Literature

Investigation of the NAIRU drivers gained large attention in the 90's (Layard, Nickell and Jackman, 1991; Elmeskov, 1993) as a reaction to the unforeseen development of unemployment in the 70's and 80's in the developed countries. The list of candidates for the NAIRU drivers contains policy variables such as labour taxation, unemployment benefit replacement rate and its duration, expenditures on active labour market policies (ALMP), employment protection legislation (EPL), product market regulation (PMR), union coverage and coordination, minimum wage legislation, mobility of the workforce, skill mismatch and the role of temporary jobs market. In addition, there are macroeconomic and demographic indicators assumed having impact on the magnitude of NAIRU such as long-term real interest rates, productivity growth, demographic changes and even shifts in terms of trade.

Over the course of the last two decades, the empirical literature relying on panel data estimated the effect of the abovementioned variables on NAIRU with mixed results as presented in the table below. The meta-analysis of the empirical literature denotes the tax wedge, unemployment benefit replacement rate and its duration, expenditures on active labour market policies, mobility and union coverage and coordination significant in explaining NAIRU. Product market regulation and employment protection legislation show mixed results,

while the minimum wage legislation appears to be insignificant across the literature. Among the macroeconomic variables long-term real interest rates and productivity growth are evidenced having significant effect on NAIRU.

Table 1: Meta-analysis of NAIRU determinants

	Significant effect	Insignificant
Labour taxation	Gianella et al. (2008); Bassanini and Duval (2006); Belot and van Ours (2004); Nickell (1997); Blanchard and Wolfers (2000), Elmeskov et al. (1998); IMF (2003); Scarpetta (1996)	Baker et al.(2004)
Unemployment benefit replacement rate	Gianella et al. (2008); Bassanini and Duval (2006), Scarpetta (1996); Nickell (1997); Elmeskov et al. (1998); Nunziata (2002); Blanchard and Wolfers (2000); Boone and van Ours (2004); Belot and van Ours (2004)	Baker et al.(2004)
Active labour market policy	Bassanini and Duval (2006), Scarpetta (1996); Nickell (1997), Boone and van Ours (2004); Nickell and Layard (1999); Blanchard and Wolfers (2000)	
Union coverage and coordination	Gianella et al. (2008); Bassanini and Duval (2006); Elmeskov et al. (1998); Scarpetta (1996);Boone and van Ours (2004); Blanchard and Wolfers (2000); Belot and van Ours (2004); IMF (2003); Nickell (1997); Nunziata (2002)	
Product market regulation	Gianella et al. (2008); Bassanini and Duval (2006)	Scarpetta (1996)
Employment protection legislative	Gianella et al. (2008); Scarpetta (1996); Elmeskov et al. (1998); Blanchard and Wolfers (2000); IMF (2003)	Bassanini and Duval (2006); Nickell (1997); Nunziata (2002); Baker et al.(2004); Belot and van Ours (2004)
Minimum wage		Gianella et al. (2008), Bassanini and Duval (2006), Elmeskov et al. (1998)
Mobility	Bassanini and Duval (2006); Scarpetta (1996); Nickell (1997); Boone and van Ours (2004)	
Real interest rates	Gianella et al. (2008); Bassanini and Duval (2006); IMF (2003); Nunziata (2002)	Scarpetta (1996)
Productivity growth	Bassanini and Duval (2006); IMF (2003); Nunziata (2002)	
Terms of trade	Bassanini and Duval (2006), Nunziata (2002)	Scarpetta (1996)
Skill mismatch	-	-
Temporary jobs market	-	-
Demographic changes	-	-

Source: IFP

Note: Some of the papers regress the institutional and macroeconomic variables on the total unemployment instead of the NAIRU. Elimination of the cyclical effect is mainly done by including the output gap or inflation as exogenous variables.

BOX 2 – Mapping the channels of determinants influencing the structural unemployment

Tax wedge determines the structural unemployment in two ways. It increases the relative price of labour compared to capital, which leads to labour-adjusting technological changes. In addition, low net wages reduce the employees' utility from labour and hence their job search intensity.

Unemployment benefits affect the structural unemployment also by two mechanisms. First, they reduce the job search intensity. Second, by lowering economic costs of unemployment they put upward pressure on wages which reduces matching rate on the labour market. The adverse effect of unemployment benefits on labour market outcomes amplifies if they are provided for long period of time.

Active labour market policies can improve the efficiency of the job matching process and therefore increase the turnover of the workforce on the market. Thus they prevent the unemployed to fall into the long-term unemployment or help the long-term unemployed return back to the job market. The effect of an increase in ALMP expenditures however varies depending on the measures that are applied.

The temporary job market influences structural unemployment similarly to ALMPs. It helps typically the low-productive and low-qualified workers or students join the labour market before finding a permanent job. In Slovakia, these groups face very high unemployment or low participation rates respectively.

Voluntary part-time jobs are by definition not included in the temporary job market, but are determining the labour market in a similar way. It helps people who by whatever reason are not able to work full-time join the labour market. This leads to higher participation rate and lower unemployment.

Minimum wages set above a market-clearing level are thought to reduce labour demand and thus raise unemployment, at least in a perfectly competitive labour market environment. This especially holds for low productive workers. Empirical research exhibits ambiguous results about the potential effects of minimum wages to unemployment.

Product market regulation is thought to influence the labour market via barriers to entry. Firstly, high barriers increase the dominance and rents of the incumbent which leads to higher wage claims of the employees above a market clearing level effectively eliminating the low productive workers. Secondly, strict conditions for new entrants curb the economic activity leading to fewer jobs in the economy.

Employment protection legislation increases the costs of worker dismissals which results in low turnover rates and increased unemployment spells. In addition it increases the bargaining power of existing employees leading to wages above market clearing levels.

Union density determines NAIRU similarly to minimum wages. In the wage bargaining process the strong unions represent the interest of insiders and push wages above market-clearing levels. As a response firms invest more energy into productivity increases of the current employees rather than hiring new ones. This however leads to fewer job opportunities for outsiders represented by the low-productive workers.

Labour mobility helps the countries (or regions, respectively) with few vacancies to place its unemployed to countries (or regions) with abundancy of vacancies. The same mechanism is functioning also in the case of daily commuting between rural and urban areas or between cities. Therefore policies supporting mobility such as migration and daily commuting to regions and cities with abundance of vacancies are generally recommended. These include financial aid, changes in housing policy, infrastructure improvement or available and fast public transportation.

Skill mismatch between the skills held by the labour force and those required by employers represents a serious barrier for the job matching process. This leads to stockpiling of vacancies on one hand and structural unemployment on the other hand.

High long-term real interest rate, assuming to be a good proxy for the user cost of capital, affect the production costs and increase the pressure to shed labour.

The logic behind demographic changes affecting NAIRU suggests that if baby boom generations enter the labour market, it might affect the total unemployment rate and hence NAIRU positively. The young population entering the labour market naturally has higher unemployment rates because it takes some time till all the school leavers find a job.

3.2 Institutional drivers' estimation shortcomings

Papers evaluating the effects of the institutional variables on structural unemployment suffer from several limitations, namely the measurement error of these variables, omitted variable bias, as well as non-stationarity of the data. These problems may lead to a severe bias and therefore the results have to be interpreted with caution.

The measurement of the institutional factors is subject to huge uncertainty. Indicators such as employment protection legislation or product market regulation rely heavily on expert's judgement and are combined together with various parameters and/or arbitrary weights. Moreover, the structural unemployment variable (in our case NAIRU) itself is just an estimate, which depends heavily on the estimation approach.

The omitted variable bias arises due to the interactions between the above mentioned institutional and macroeconomic factors. If we regress unemployment only on a small subset of variables, the acquired coefficients include also the effect of the other correlated variables that are out of our subset. This appears to be a serious problem in many papers (e.g. Gianella et al., 2008).

Non-stationarity of the data appears to be a problem for dependent as well as independent variables. This shortcoming is most often overcome by using a specification in differences, which is also the approach in our study.

A solution to the problem of endogeneity arising from the omitted variable bias might be an IV estimation. This however requires finding a valid instrument or to use an atheoretical approach relying on lagged levels of the endogenous variables (in case of specification in differences). The atheoretical approach (used e.g. in Gianella et al., 2008) is problematic if the equation error or omitted variables are serially correlated (Angrist and Krueger, 2001) as it is in our case.

In addition there is a fourth problem when searching for a significant relationship and namely the lagged reaction. The behaviour of individual agents changes slowly (and at different speed among countries) as a response to policy changes. The structural policies undergo permanent changes, often with opposite direction and are highly correlated. As a consequence, their effects might be masked and combined to white noise. Therefore it might be a difficult task to establish significant relationships for certain variables. To overcome this issue we highlight those variables that are significant across various specifications and lag lengths.

3.3 Data and model

For estimation of NAIRU determinants we used an unbalanced panel of 19 countries containing annual data for the 2001-2013 period. The smaller sample compared to the NAIRU estimates has been driven by lack of data. Estonia has been excluded completely due to missing data on long-term interest rates which is a significant determinant in our estimates.

We tested simultaneously several possible institutional drivers mentioned in the literature: tax wedge, average unemployment-benefit replacement rate separately for long-term and for short-term unemployed, expenditures on active labour market policies, PMR, EPL, union density, share of temporary jobs, share of voluntary part-time jobs, external mobility[11] and share of young population in the labour force. This list is complemented by macroeconomic drivers such as economic growth and real long-term interest rate. For a smaller subsample we estimated also the effect of minimum wage and skill mismatch. Other variables have not been taken into account due to low quality and incomparability. The complete list of determinants including their description is presented in Annex D.

In the empirical estimation of the institutional and macroeconomic drivers we used pooled and fixed effects panel estimation with robust standard errors. All the models are specified in differences with various lag lengths, ranging from 0 to 2. Third lags have been insignificant for vast majority of cases and therefore are not included in results.

3.4 Results

Our results show that above all of the policy variables expenditures on **active labour market policies, temporary jobs market, external mobility** and **union coverage** play a significant role in explaining the changes in NAIRU. In addition, the **GDP growth** and the **real long-term interest rate** as macroeconomic variables also explain the variation of NAIRU changes. These variables are significant among various specifications and lag lengths.

We were not successful in establishing significant relationships[12] between the change in NAIRU and policy variables significant in OECD studies (e.g. Gianella et al., 2008), such as the tax wedge, unemployment benefit replacement rate, product market regulation or employment protection legislation. The same holds for the minimum wage or skill mismatch index which we tested for a subsample of countries for which we collected data. However we

[11] We resort to measuring only external mobility due to data limitations regarding internal mobility
[12] We mean significant relationships at least at 10% level of significance for majority of specifications

are not strictly rejecting the effect of these institutional factors. The possible impact might be shown in the long-run horizon or conveyed indirectly by the GDP growth.

Table 2: Regressions of differences in NAIRU on a set of institutional and macroeconomic factors (significant variables)

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.143***	0.162***	0.184***	0.227***	0.171***	0.243***
DLOG(ALMP_amount)*100	-0.004***	-0.004***	-0.004**	-0.004***	-0.004**	-0.004***
DLOG(ALMP_amount(-1))*100			-0.002**	-0.002**	-0.000	-0.000
DLOG(ALMP_amount(-2))*100					-0.001***	-0.000
D(TEMPORARY)	-0.014	0.002	-0.005	0.019	-0.031	-0.013
D(TEMPORARY(-1))			-0.058**	-0.051***	-0.019	-0.017
D(TEMPORARY(-2))					-0.047**	-0.034**
D(UD)	0.060	0.076*	-0.030	0.008	-0.016	0.020
D(UD(-1))			0.077**	0.101***	0.013	0.064***
D(UD(-2))					0.063**	0.087***
DLOG(GDP)*100	-0.046***	-0.044***	-0.047***	-0.050***	-0.041***	-0.042***
DLOG(GDP(-1))*100			-0.012**	-0.014**	-0.020***	-0.021***
DLOG(GDP(-2))*100					0.020***	0.016**
D(RLTIR)	0.056***	0.043***	0.050***	0.029***	0.043***	0.024*
D(RLTIR(-1))			0.045***	0.035**	0.060***	0.045***
D(RLTIR(-2))					0.008	0.006
D(FOREIGN)*100	-0.029**	-0.024**	-0.045***	-0.041***	-0.032***	-0.023**
D(FOREIGN(-1))*100			-0.032**	-0.021*	-0.026*	-0.013
D(FOREIGN(-2))*100					-0.008	0.002
Fixed effects	No	Yes	No	Yes	No	Yes
Adj. R-squared	0.40	0.57	0.56	0.68	0.56	0.69
Observations	197	197	178	178	159	159
DW statistics	1.049	1.434	1.093	1.491	1.295	1.814

Source: IFP

Note: The complete results including the insignificant variables can be found in annex A
", **, ***" denote the 10,5 and 1 % level of significance*

The results showed that the changes in policy variables explain only a part of the NAIRU development, whilst the long-run macroeconomic development[13] of the country remains "the" driver of the structural unemployment. Poland and Spain could serve as the textbook examples.

[13] Captured in the country fixed effects

3.5 Implications for Slovakia

Looking in a more detail on Slovakia, we find out that a boost in the temporary jobs market might be the most efficient way to lower the NAIRU. An increase of the share of temporary jobs by 5 p.p. (and thus reaching the EU level) might decrease the NAIRU by 0.25 p. p.. This can be done in a cost-effective way (compared to increases in ALMP expenditures), e.g. by relaxing the contractual work regulation or further extension of in-work benefits.

Similar effect is projected by increasing the ALMP expenditures by 50%. The effect of an increase in ALMP expenditures however varies depending on the measures that are applied. Slovak experiences (Lubyová, 1997; Harvan, 2011; Bořík & Caban, 2013; Štefánik et al., 2013) as well as international meta-analyses (Dar & Tzannatos, 1999; Card, Kluwe & Weber, 2010; Kluwe, 2010) robustly show that public employment programs, very popular in Slovakia, are even detrimental to the employment prospects of participants. First, this is driven by the lock-in effect due to the small amount of money participants earn. Second, the participants carry a stigma of low-productive workforce so they are disadvantaged on the open labour market. On the other hand the most effective measures identified in the literature include wage subsidies, training and job search assistance and counselling.

Further drop in the NAIRU due to decreases in the union density has only limited space since its actual level is one of the lowest in the EU. However, the corresponding cumulative coefficient is relatively high compared to other institutional determinants. Cutting the union density by 2 p.p. leads to identical effects as increasing the ALMP expenditures by 50%.

If we generalize the results on external migration also for the internal migration, increasing the mobility of the workforce by 5 p.p. would decrease the structural unemployment by 0.25 p. p. In light of large regional disparities in Slovakia, we therefore recommend policies supporting internal migration as well as daily commuting to regions and cities with abundance of vacancies, such as financial aid, changes in housing policy, infrastructure and public transportation enhancement.

Table 3: Cumulative effects of significant determinants on NAIRU

	Policy variable change	Cumulative effect	2014 Level in Slovakia	2014 Level in EU
ALMP expenditures	10 %	(-0.06 ; –0.04)	0.12 % of GDP*	0.47 %**
Union density	1 p.p.	(0.08 ; 0.15)	16.8 %***	-
Temporary jobs	1 p.p.	(-0.06 ; -0.03)	8.8 %	14.0 %
GDP growth	1 %	(-0.06 ; -0.04)	2.5 %	1.4 %
Real long-term interest rate	1 p.p.	(0.04 ; 0,10)	2.2 %	2.7%
Workers abroad	1 p.p.	(-0,08 ; -0,02)	5,1 %	-3,7 %

Source: IFP

** 2013, normalised to 10% unemployment rate*

*** 2011, normalised to 10% unemployment rate*

**** 2012*

In addition to the determinants tested in the panel estimates we have two other factors that determine NAIRU but are not included in the panel. Namely the **pension reforms** and **segregated communities**. Pension reforms increasing the pension age generally lead to higher employment rates and hence to lower structural unemployment. Segregated communities are effectively excluded from the labour market because of lacking skills, poor social environment and widespread discrimination. According to Machlica et al. (2014) the problem of excluded Roma in Slovakia adds 4 percentage points to the overall (or structural, author's note) unemployment rate. However, little or no progress has been made in the recent years regarding the exclusion of Roma population.

3.6 Robustness check

Although our results are in line with the empirical literature (except for the tax wedge and unemployment benefit replacement rate, for which we are not able to establish a significant relationship), we decided to perform additional robustness checks. Namely we

a. re-estimate the panel using alternative NAIRU data and total unemployment rate
b. check univariate relationships between NAIRU and the institutional variables for the level and differenced data and
c. apply Bayesian model averaging for identification of variables that should be included in the model.

As the identification of structural unemployment determinants may be sensitive to the estimated NAIRUs, we tried to re-estimate the panel using alternative NAIRU series, namely the OECD estimates; NAIRUs derived using assumptions identical for all the countries, and NAIRUs computed by HP filter. We regressed the determinants also on the actual unemployment rates. Altering the dependent variable changes in **ALMP expenditures, union density, GDP growth, the real long-term interest rate, and external mobility remain robustly significant**. **Temporary jobs** lose significance in some specifications in favour of part-time jobs. However the share of temporary and part-time jobs represent the same issue, i.e. flexible work agreements.

The average unemployment benefit replacement rate for short-term as well as for long-term unemployed are significant only in some specifications and are not robustly determining the NAIRU. Interestingly, these specifications show negative correlations between NAIRU and average unemployment benefit replacement rate for the short-term unemployed (AUBRR_short). This contradicts to the general knowledge from the literature suggesting higher benefits resulting in increased structural unemployment. Our counterintuitive result is probably a secondary effect of policies combinig higher benefits with higher activity in job search that is happening in many countries (Venn, 2012) and which leads to a substantial increase in job finding rate (Arni and Schiprowski, 2015). However more research and evidence is needed to draw general conclusions on this counterintuitive result.

Table 4: Significant relationships using alternative measures of NAIRU

	IFP NAIRU	OECD NAIRU	Equal variance and calibration	HP filter	Actual unemployment rate
Tax wedge		++	-	++ -	
AUBRR_long	++	+	+++	++++	+
AUBRR_short	---	----	----	-----	--
ALMP_expenditures	------	----	------	------	------
PMR index					
EPL index	-	----	-	-	-
Union density	+++++	-	++++	++++++	+++++
Real LT interest rate	++++++	++++++	++++++	++++++	++++++
Temporary jobs	----	-	-	--	---
Parttime jobs		------	---	------	-
Young population	+	+ -	-	+	-
GDP growth	------	------	------	------	------
External migration	------	---	------	------	------

Source: IFP

Note: +/- refer to the sign of coefficients and the number of specifications (out of 6) for which the variable was significant

By analysing differences we might overlook long-run tendencies that may indeed explain long-run NAIRU development but cannot be captured in short-term variability of the explanatory variables. Or vice versa we might overstate the significance shown in short-term fluctuations. A brief look at the univariate correlation of levels and differences of NAIRU and the institutional variables (Annex C) for the whole time horizon reveals **significant relationship only for ALMP expenditures**. For the level data only the share of part-time workers and AUBRR_short show expected relationship beside ALMP expenditures. For differences only the AUBRR_long and temporary jobs add to the ALMP expenditures. For both variables, however, the result is driven by outlier countries.

In cases such as ours when the theory is not conclusive about the explanatory variables, their lag lengths and functional form, we might be uncertain about the choice of model. Although we tried six models, the number of possible specifications is much larger. Therefore we applied a Bayesian model averaging[14] (BMA) method which enables us to evaluate all the possible combinations of explanatory variables and their lag lengths and identify those which are robustly significant across all the specifications. BMA shows[15] that among the institutional determinants **ALMP expenditures, union density and temporary jobs are significant determinants of NAIRU**, since they are significant with posterior probability of belonging to the true model being higher than 50% (Annex B). External mobility and AUBRR_short are approaching 20% probability and the rest of variables has probability less than 10%.

[14] Bayesian model averaging provides a coherent method of inference on the regression parameters of interest by taking explicit account of the uncertainty due to both the estimation and the model selection. By accounting for the uncertainty in model selection we overcome the problem of over-confident inference based on subjectively selected model. More on BMA in Hoeting et al.(1999).

[15] In our case we applied the BMA code developed by De Luca and Magnus (2011) for which GDP growth, RLTIR and ALMP expenditures are included with certainty and the rest of regressors are included as auxiliary variables. Since the number of auxiliary variables (k) reaches 27, the extent of the model space over which the method averages exceeds 134 million possible models (2^k).

4 Conclusions

Our NAIRU estimates across EU countries are close to those of the OECD. An exception is Slovakia for which the OECD produces a counterintuitive estimate. According to OECD, the Slovakian NAIRU rises even during the period following deep structural reforms 2005-2008, when the automotive FDIs spurred economic growth and employment in Slovakia. The new Slovak NAIRU differs from the old IFP and NBS estimates, as it is much less procyclical and in line with soft indicators.

Above all of the institutional drivers, **active labour market policy expenditures** are the most robust drivers of the NAIRU. However, the estimated effect of the ALMP expenditures is rather small. Doubling the expenditures would shift NAIRU downwards by only 0.4 – 0.6 p.p. Nevertheless, as the amount of ALMP expenditures in Slovakia is one of the lowest in EU we recommend to strengthen the ALMP measures considerably. Yet, the ALMP expenditures should be targeted effectively to maximize benefits of the policy.

Share of temporary jobs and **union density** are another significant institutional drivers of NAIRU. And even though these drivers were not robustly estimated in all of our specifications, their effect is supported by a number of other empirical studies as well. From the perspective of Slovakia, the very low union density is unlikely to be the crucial factor which keeps the NAIRU elevated. On the other hand, by increasing the share of temporary jobs in Slovakia to the EU average the NAIRU might fall by 0.15 – 0.3 p.p. Hence, more flexible contractual work agreements might be one effective measure in this area. The other measure might be enabling the unemployed to enter the temporary jobs market while at the same time keeping their status of the registered unemployed (further extension of in-work benefits).

The results also confirm a robust relation of NAIRU to **mobility**. Though it has been tested on external mobility only, we assume the findings can be generalized also on the internal migration, for which we lack good data. In light of large regional disparities in Slovakia, we recommend policies supporting internal migration as well as daily commuting to regions and cities with abundance of vacancies.

Surprisingly, we find no evidence of effects of the traditional NAIRU drivers, i.e. the tax wedge and the unemployment benefit replacement rate. On the other hand, we find evidence for the hysteresis as 1 p.p. change in actual unemployment results in a 0.25 p.p. change in the NAIRU. Therefore, a strong and long-lasting economic growth may reduce both cyclical and structural unemployment.

Beside institutional determinants the NAIRU development is determined by macroeconomic drivers such as the **GDP growth** and the **real long-term interest rate.** According to our estimates, 1 per cent increase in the economic growth reduces the NAIRU by 0.04 – 0.06 p.p. Yet, this holds only for the economic growth above certain threshold represented by Okun's law. High real long-term interest rate represents a proxy for the high cost of capital that translates into higher production costs and pressure the labour cost optimisation.

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Appendix

A. Statistical tables

Table 1: Regressions of differences in NAIRU on macroeconomic and institutional determinants, 2001-2013

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.143***	0.162***	0.184***	0.227***	0.171***	0.243***
	(0.043)	(0.051)	(0.037)	(0.041)	(0.040)	(0.046)
Dlog(ALMP_amount)*100	-0.004***	-0.004***	-0.004**	-0.004***	-0.004**	-0.004***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Dlog(ALMP_amount(-1))*100			-0.002**	-0.002**	-0.000	-0.000
			(0.001)	(0.001)	(0.001)	(0.001)
Dlog(ALMP_amount(-2))*100					-0.001***	-0.000
					(0.000)	(0.001)
D(TEMPORARY)	-0.014	0.002	-0.005	0.019	-0.031	-0.013
	(0.035)	(0.036)	(0.031)	(0.022)	(0.028)	(0.028)
D(TEMPORARY(-1))			-0.058**	-0.051***	-0.019	-0.017
			(0.022)	(0.019)	(0.033)	(0.024)
D(TEMPORARY(-2))					-0.047**	-0.034**
					(0.022)	(0.014)
D(PARTTIME_vol)	-0.028	-0.034	-0.005	-0.006	0.004	0.021
	(0.027)	(0.026)	(0.032)	(0.031)	(0.042)	(0.027)
D(PARTTIME_vol(-1))			-0.037	-0.043	-0.013	-0.022
			(0.025)	(0.027)	(0.030)	(0.029)
D(PARTTIME_vol(-2))					-0.023	-0.035
					(0.020)	(0.031)
D(AUBRR_long)	0.012	0.001	0.017*	0.005	0.021	0.011
	(0.013)	(0.008)	(0.010)	(0.008)	(0.013)	(0.012)
D(AUBRR_long(-1))			0.022***	0.004	0.016**	-0.002
			(0.007)	(0.008)	(0.007)	(0.010)
D(AUBRR_long(-2))					0.013*	-0.002
					(0.007)	(0.004)
D(AUBRR_short)	-0.007***	0.002	-0.004***	0.006	-0.007***	0.003
	(0.002)	(0.003)	(0.001)	(0.004)	(0.002)	(0.003)
D(AUBRR_short(-1))			-0.013***	-0.004	-0.011***	-0.002
			(0.002)	(0.003)	(0.003)	(0.004)
D(AUBRR_short(-2))					-0.006*	0.003
					(0.003)	(0.002)
D(TW)	0.032	0.029	0.018	0.015	0.010	0.005
	(0.024)	(0.019)	(0.019)	(0.020)	(0.008)	(0.015)
D(TW(-1))			-0.006	-0.009	-0.023	-0.019
			(0.021)	(0.017)	(0.026)	(0.018)
D(TW(-2))					0.005	0.008
					(0.018)	(0.018)
D(PMR)	-0.026	0.040	0.004	-0.040	-0.035	-0.087

	(0.176)	(0.151)	(0.172)	(0.157)	(0.225)	(0.227)
D(PMR(-1))			-0.009	-0.044	-0.097	-0.218
			(0.180)	(0.165)	(0.285)	(0.226)
D(PMR(-2))					0.053	0.20
					(0.183)	(0.167)
D(EPL)	-0.036	-0.024	-0.031	-0.019	-0.018	-0.005
	(0.045)	(0.038)	(0.029)	(0.025)	(0.030)	(0.030)
D(EPL(-1))			-0.040	-0.025	-0.045	-0.043
			(0.034)	(0.034)	(0.039)	(0.043)
D(EPL(-2))					-0.051**	-0.038
					(0.022)	(0.031)
D(UD)	0.060	0.076*	-0.030	0.008	-0.016	0.020
	(0.038)	(0.041)	(0.027)	(0.019)	(0.023)	(0.018)
D(UD(-1))			0.077**	0.101***	0.013	0.064***
			(0.036)	(0.028)	(0.018)	(0.11)
D(UD(-2))					0.063**	0.087***
					(0.029)	(0.026)
DLOG(GDP)*100	-0.046***	-0.044***	-0.047***	-0.050***	-0.041***	-0.042***
	(0.008)	(0.007)	(0.007)	(0.004)	(0.006)	(0.006)
DLOG(GDP(-1))*100			-0.012**	-0.014**	-0.020***	-0.021***
			(0.005)	(0.007)	(0.007)	(0.005)
DLOG(GDP(-2))*100					0.020***	0.016**
					(0.006)	(0.007)
D(RLTIR)	0.056***	0.043***	0.050***	0.029***	0.043***	0.024*
	(0.017)	(0.016)	(0.016)	(0.011)	(0.011)	(0.013)
D(RLTIR(-1))			0.045***	0.035**	0.060***	0.045***
			(0.017)	(0.017)	(0.017)	(0.015)
D(RLTIR(-2))					0.008	0.006
					(0.013)	(0.011)
D(YOUNG)*100	-0.044	-0.003	-0.025	0.026	-0.010	0.023
	(0.054)	(0.041)	(0.045)	(0.050)	(0.037)	(0.049)
D(YOUNG(-1))*100			-0.002	0.051	-0.062	-0.009
			(0.042)	(0.041)	(0.062)	(0.037)
D(YOUNG(-2))*100					0.015	0.081*
					(0.058)	(0.049)
D(FOREIGN)*100	-0.029**	-0.024**	-0.045***	-0.041***	-0.032***	-0.023**
	(0.014)	(0.011)	(0.014)	(0.013)	(0.011)	(0.010)
D(FOREIGN(-1))*100			-0.032**	-0.021*	-0.026*	-0.013
			(0.013)	(0.011)	(0.014)	(0.013)
D(FOREIGN(-2))*100					-0.008	0.002
					(0.016)	(0.012)
Fixed effects	No	Yes	No	Yes	No	Yes
Adj. R-squared	0.40	0.57	0.56	0.68	0.56	0.69
Observations	197	197	178	178	159	159
DW statistics	1.049	1.434	1.093	1.491	1.295	1.814

Notes: *,**,*** denote significance at the 10%, 5% and 1% level

B. Bayesian model averaging

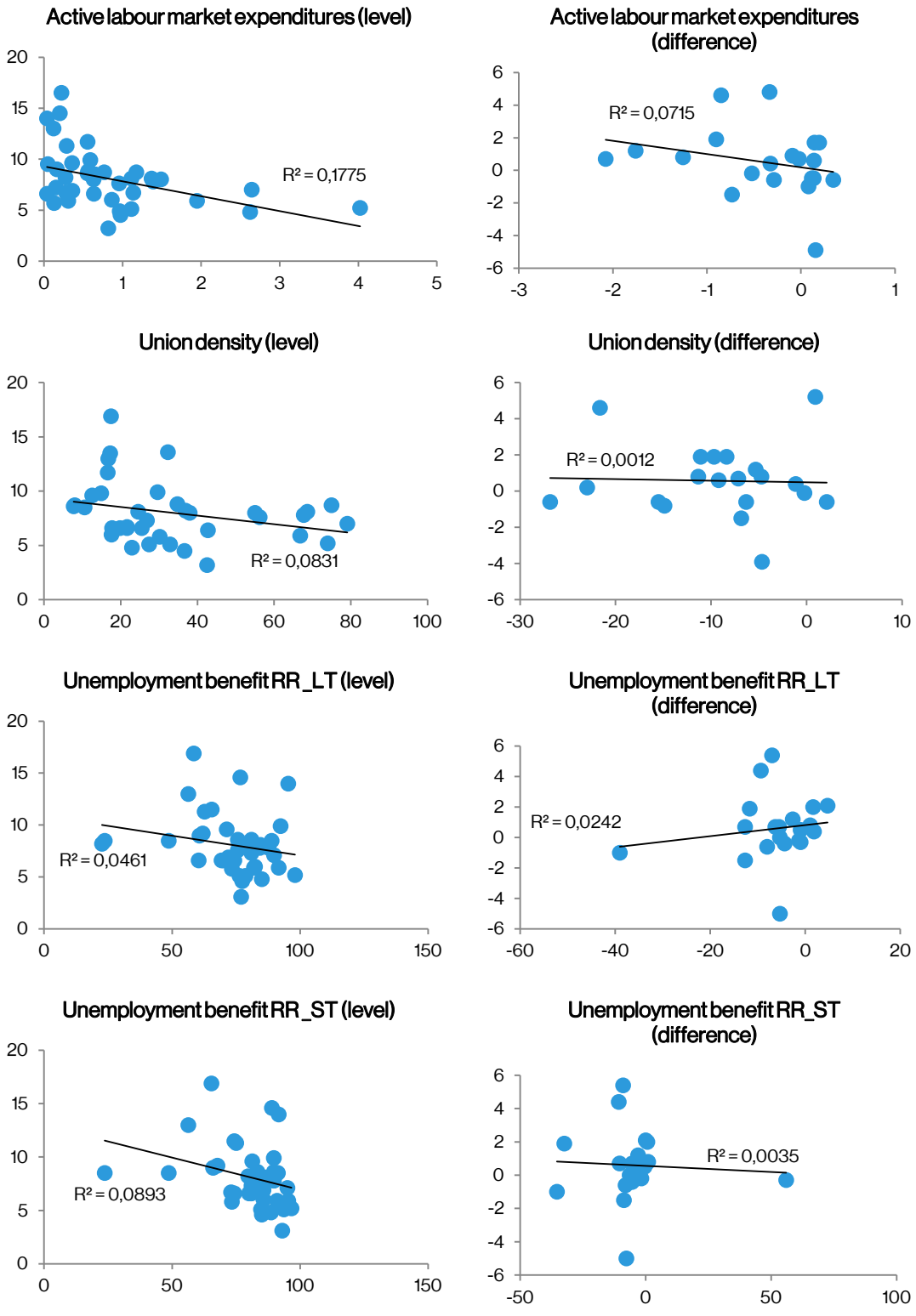
Table 1: BMA regression results (2001 – 2013)

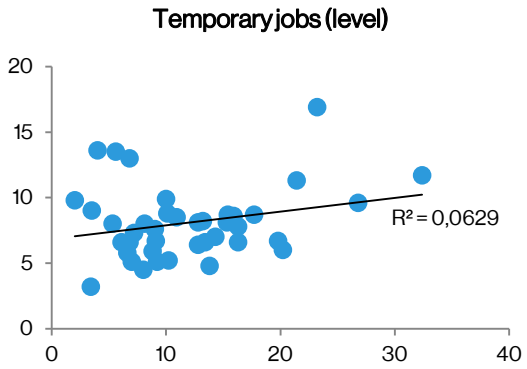
BMA estimates				Number of obs. =		159
				k1 =		10
				k2 =		27
d_nairu	Coef.	Std. Err.	t	pip	[1-Std. Err. Bands]	
_cons	0.1481	0.0283	5.23	1	0.1198	0.1764
gdp	-0.0388	0.0065	-5.99	1	-0.0453	-0.0324
gdp_1	-0.0173	0.0071	-2.43	1	-0.0244	-0.0102
gdp_2	0.0197	0.0077	2.56	1	0.0120	0.0274
d_rltir	0.0565	0.0151	3.75	1	0.0414	0.0716
d_rltir_1	0.0678	0.0158	4.28	1	0.0520	0.0837
d_rltir_2	0.0173	0.0169	1.02	1	0.0004	0.0342
dlog_almp	-0.4098	0.0933	-4.39	1	-0.5031	-0.3164
dlog_almp_1	-0.0522	0.0997	-0.52	1	-0.1518	0.0475
dlog_almp_2	-0.1334	0.0968	-1.38	1	-0.2302	-0.0366
d_ud	-0.0003	0.0053	-0.06	0.04	-0.0056	0.0050
d_ud_1	0.0024	0.0105	0.22	0.08	-0.0082	0.0129
d_ud_2	0.0472	0.0311	1.52	0.77	0.0161	0.0782
d_temporary	-0.0019	0.0091	-0.21	0.07	-0.0110	0.0072
d_temporar~1	-0.0172	0.0280	-0.61	0.33	-0.0453	0.0108
d_temporar~2	-0.0293	0.0321	-0.91	0.52	-0.0613	0.0028
d_parttime	-0.0005	0.0066	-0.08	0.04	-0.0072	0.0061
d_parttime_1	-0.0013	0.0090	-0.15	0.05	-0.0104	0.0077
d_parttime_2	-0.0013	0.0086	-0.15	0.05	-0.0098	0.0073
d_foreign	-0.0049	0.0121	-0.41	0.18	-0.0170	0.0071
d_foreign_1	-0.0011	0.0055	-0.20	0.07	-0.0066	0.0045
d_foreign_2	0.0001	0.0028	0.03	0.04	-0.0027	0.0028
d_aubrr_long	0.0010	0.0047	0.21	0.07	-0.0037	0.0057
d_aubrr_long_1	0.0014	0.0055	0.25	0.09	-0.0041	0.0069
d_aubrr_long_2	0.0006	0.0038	0.17	0.06	-0.0031	0.0044
d_aubrr_short	-0.0004	0.0020	-0.22	0.08	-0.0024	0.0015
d_aubrr_short_1	-0.0019	0.0045	-0.41	0.19	-0.0064	0.0026
d_aubrr_short_2	-0.0002	0.0013	-0.13	0.05	-0.0015	0.0012
d_tw	0.0018	0.0076	0.24	0.09	-0.0058	0.0095
d_tw_1	-0.0007	0.0046	-0.15	0.05	-0.0053	0.0039
d_tw_2	0.0000	0.0028	-0.02	0.04	-0.0028	0.0027
d_pmr	-0.0053	0.0413	-0.13	0.05	-0.0466	0.0360
d_pmr_1	-0.0012	0.0322	-0.04	0.04	-0.0334	0.0310
d_pmr_2	0.0042	0.0353	0.12	0.04	-0.0311	0.0395
d_epl	-0.0008	0.0076	-0.11	0.04	-0.0084	0.0067
d_epl_1	-0.0016	0.0100	-0.16	0.05	-0.0116	0.0084
d_epl_2	-0.0028	0.0132	-0.21	0.07	-0.0160	0.0104

Source: IFP

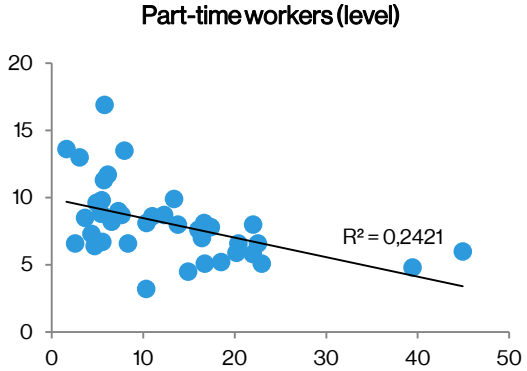
Note: "pip" refers to posterior inclusion probability = the probability that the variable is included in the true model. An auxiliary regressor is considered to be robustly correlated with the dependent variable if the t ratio on its coefficient is greater than one in absolute value

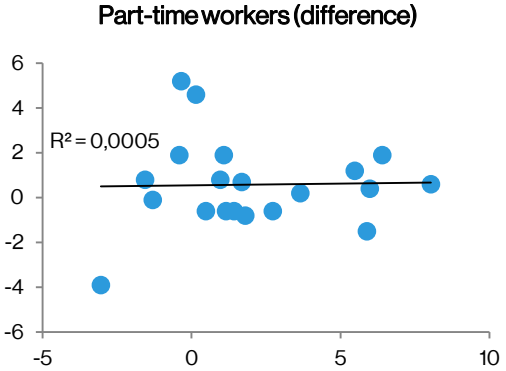
C. Univariate correlation between institutional variables and NAIRU (2000 and 2013 levels and differences)

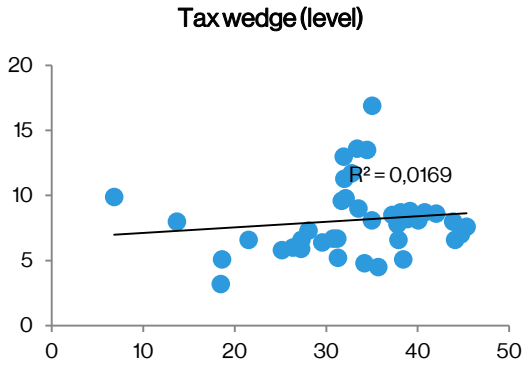


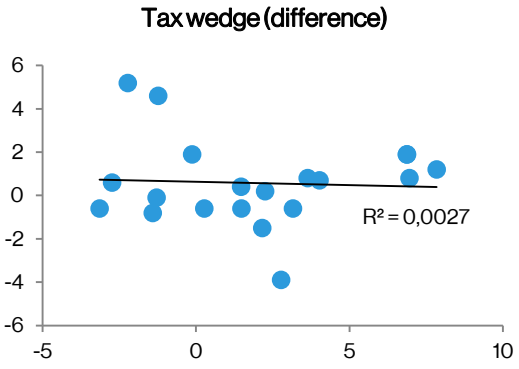

Temporary jobs (level)
R² = 0,0629

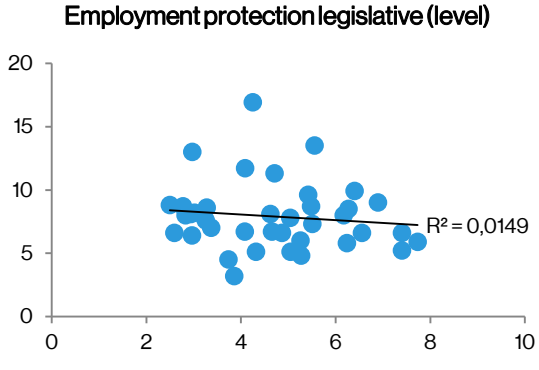

Temporary jobs (difference)
R² = 0,3351

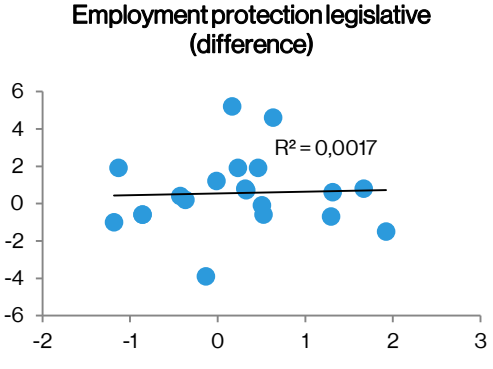

Part-time workers (level)
R² = 0,2421

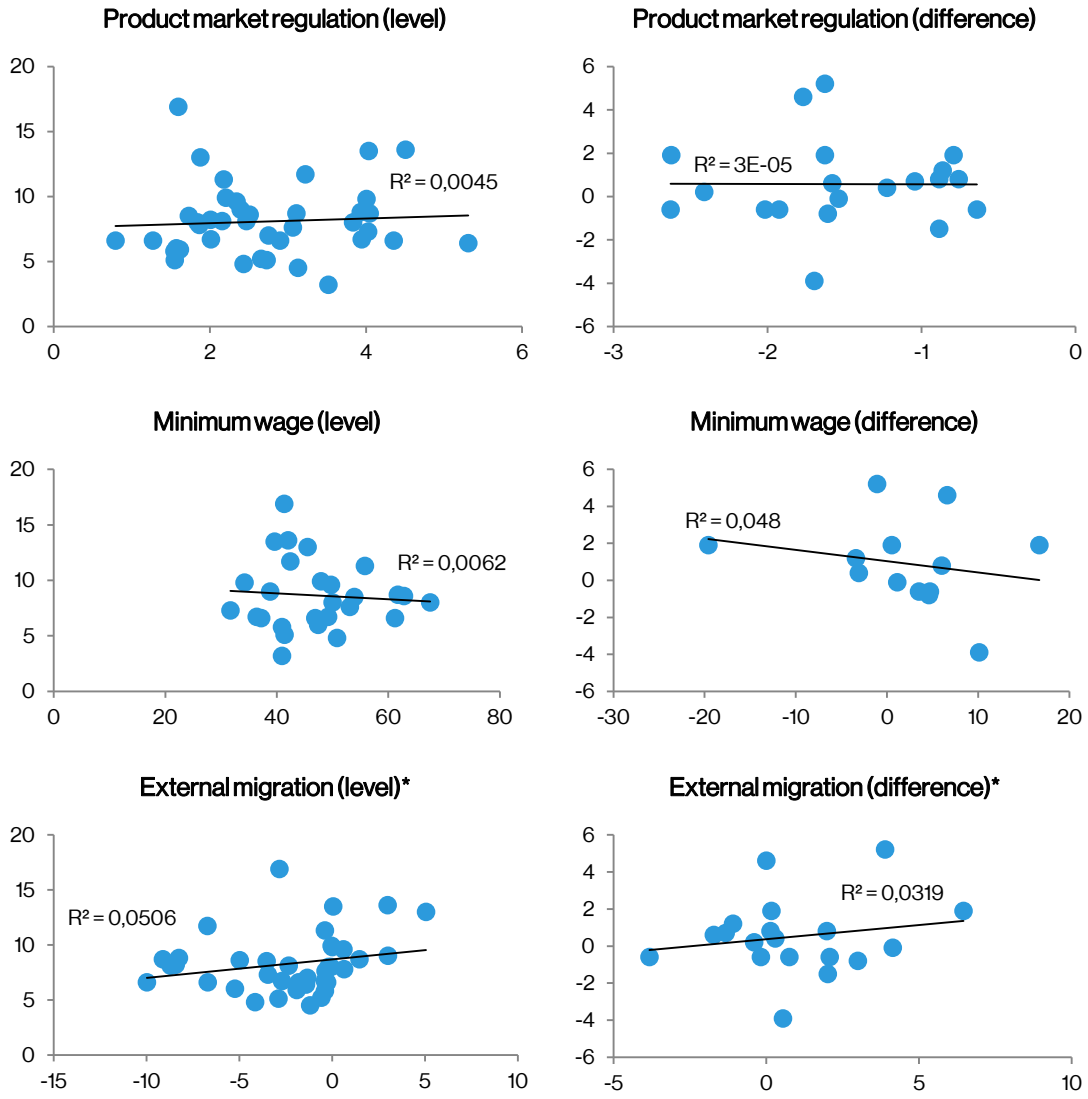

Part-time workers (difference)
R² = 0,0005


Tax wedge (level)
R² = 0,0169


Tax wedge (difference)
R² = 0,0027


Employment protection legislative (level)
R² = 0,0149


Employment protection legislative (difference)
R² = 0,0017



Source: IFP

Note: The difference covers the change between 2001 and 2013, except for unemployment benefit RR, where the time span begins in 2001. In selected cases the time period is shortened becuase of missing data

** Excluding Luxemburg*

D. Data sources and definitions

Tax wedge (WEDGE)

The tax wedge is defined as the ratio between the personal income tax and social security contributions paid and the total labour compensation + cash benefits. It is calculated as the average of 4 family types: single person at 67% of average wage and with no children, single person at 67% of average wage and with 2 children, one earner couple at 100% of average wage with 2 children, two-earner couple at 67 and 100% of average wage and 2 children. The data are taken from OECD Taxing Wages database. Link: http://stats.oecd.org/index.aspx?DataSetCode=AWCOMP

Average unemployment benefit

The indicator is calculated as the share of unemployment benefits (including housing benefits and social assistance) on previous net labour income. In our estimates we use two types of the indicator – for short-term and long-term unemployed separately. The average unemployment

replacement rate (AUBRR; AUBRR_short)	benefit replacement rate for short-term unemployed (AUBRR_short) is calculated for the unemployment duration of 7 months and previous income level at 50% of the average wage. It represents the average of three family situations (single, one-earner couple with two children, two-earner couple (spouse having income at 67% of average wage) with two children). The average unemployment benefit replacement rate for long-term unemployed (AUBRR) is calculated for the same family types, previous income level but for two types of unemployment duration – at 13 months and 60 months of unemployment spell. The data are taken from the Eurostat Tax and benefits database. Link: http://ec.europa.eu/economy_finance/db_indicators/tab/
Active labour market policy expenditures (ALMP_amount)	The active labour market policy expenditures are taken from the Eurostat database and covers expenditures on measures 2 – 7 (training, employment incentives, supported employment and rehabilitation, direct job creation and start-up incentives) and excludes expenditures on labour market services (staff) and supports (out-of-work income maintenance, early retirement). The indicator is expressed as percentage of GDP and normalized to 10% unemployment rate to be comparable across countries. Link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lmp_expsumm&lang=en
Product market regulation (PMR)	The PMR is the OECD indicator on regulatory impediments in network sectors (covers electricity, gas, telecom, post, rail, airlines and road networks) and takes the values 0-6 (6 being the most regulated). As the PMR indicator for the whole economy is calculated only every five years, we use the above mentioned PMR indicator for network sectors as a proxy instead. Link: http://www.oecd.org/eco/growth/indicatorsofproductmarketregulationhomepage.htm
Employment protection legislative (EPL)	The EPL indicator is represented by the parameter "Labour regulation" from the World Competitiveness Database, which is produced by the Institute for Management Development in Lausanne (IMD). The index takes values 0-10 (10 being the most regulated). Link: https://worldcompetitiveness.imd.org/
Union Density (UD)	The UD indicator is defined as the percentage of workers who are trade unions members. The date are taken from the OECD database. Link: http://stats.oecd.org/Index.aspx?DataSetCode=UN_DEN
Real long-term interest rates (RLTIR)	Real long-term interest rates are obtained by the difference between the nominal long-term interest rates (EMU convergence criterion) and inflation (HICP excluding energy). All the data are obtained from Eurostat.
Temporary jobs (TEMPORARY)	The variable is defined as a percentage share of workers who have temporary jobs. The source of the data is the Eurostat Labour Force Survey (LFS).
Voluntary part-time workers (PARTTIME_vol)	The variable is defined as a percentage share of employees who work part-time of their own accord. It is a supplement to the TEMPORARY variable which counts only the involuntary part-timers. The source of the data is the Eurostat Labour Force Survey (LFS).

Demographic changes (YOUNG)	The variable captures the proportion of the young generation (aged 15-24) in the active population (15+). The data are taken from the Eurostat database.
Foreign migration (FOREIGN)	Foreign migration captures the net balance from external migration. Because of lack of data it is defined as the share of the difference between LFS employment (national concept) and ESA employment (domestic concept) on total labour force. The source of data is the Eurostat Labour Force Survey (LFS) and National Accounts (ESA 2010).