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The NAIRU and the Extent of the Low-Pay Sector

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The NAIRU and the Extent of the Low-Pay Sector

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7th October 2010

Abstract

The creation of jobs in the low-pay sector is considered to be an approach to reduce unemployment, especially with respect to low-skilled workers. By now, the expansion of the German low-wage sector over the last 15 years is empirically confirmed, which indicates a successful implementation of corresponding recommendations from policy advisers. In order to evaluate the effects of an increasing low-wage sector on unemployment, the concept of the non-accelerating inflation rate of unemployment (NAIRU) is used. In a first step, the unobservable, exogenous NAIRU is estimated for Germany in a state space setting. In a second step, data from the German Socio-Economic Panel (SOEP) is used to calculate a time series of the extent of the low-pay sector. Finally, by treating the NAIRU as the dependent variable, the impact of the low-wage share is estimated within an error correction framework. According to the proponents of the low-pay expansion, there should be a negative relationship between the NAIRU and the share of the low-wage sector. This hypothesis is rejected empirically. Indeed, for the time after the German reunification, cointegration is found between both variables suggesting a slightly positive relationship.

Keywords: NAIRU, low-wage, Kalman filter, error correction, cointegration

JEL classification: C22, C32, E24, J30

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1 Introduction

As confirmed by a large number of empirical studies, the German low-wage sector has been growing for some years now (e.g. Bosch, G./Kalina, T. (2008), Eichhorst, W. et al. (2005), Kalina, T./Weinkopf, C. (2008) and (2008a)). Among other reasons, this development is the intended result of labour market reforms. Policies, such as the encouragement of part-time, fixed-term or minor[1] employment, the deregulation of temporary work or the introduction of top-up benefits as a de-facto combination wage are prominent components of the so-called Agenda 2010 and Hartz legislation (cp. Kommission "Moderne Dienstleistungen am Arbeitsmarkt" (2002)). Since those reforms are based on the assumption that the persistent German unemployment is caused by labour market inflexibility, their aim is to change the structural and institutional conditions held responsible for unemployment.

However, the impact of an increase in the number of low-wage jobs on unemployment is not clear-cut. This is problematic, because with a growing low-pay sector, more people suffer from disadvantages associated with these jobs, such as social inequality, precarious living conditions or stigmatisation.

For two reasons, the concept of the non-accelerating inflation rate of unemployment (NAIRU) is used in this study to evaluate the effects of the low-wage expansion on unemployment. Firstly, the NAIRU concept assumes a long-run, equilibrium unemployment rate that depends on structural and institutional factors. Therefore, the NAIRU concept supports labour market reforms targeting these factors. In other words, those reforms are based on policy recommendations that can be derived from the NAIRU concept. Secondly, embedding the investigation in the NAIRU context allows to control for important macroeconomic influences, such as inflation, cyclical demand pressures or short-term supply shocks.

A working hypothesis, which is in accordance with the general idea of the aforementioned labour market reforms, is that an increasing extent of the low-wage sector lowers the NAIRU.[2] This is because a growing low-pay sector creates additional labour demand by reducing labour costs. Thus, unemployed people are more likely to obtain work, especially those with a low qualification. The alternative hypothesis is that the NAIRU is not lowered, which could be an indicator for the substitution of regular employment by low-pay work.

The question whether or not a growing low-wage sector lowers the NAIRU is addressed

[1] In the following, the term "minor employment" refers to employment relationships with a maximum compensation of currently 400 euros per month ("Geringfügige Beschäftigung").

[2] The German Council of Economic Experts, for example, links a NAIRU downward trend beginning in 2005 to the labour market reforms of the last years (cp. SVR (2007), p. 324).

empirically in three steps.[3] Firstly, the NAIRU is theoretically derived and estimated by the Kalman filter (section 2). Due to its unobservable nature, the NAIRU is assumed to be exogenous and is modelled as a stochastic process within a Phillips curve framework. In a second step, the development of the low-wage sector is calculated (section 3). Finally, by combining the results of the first two steps, the impact of the low-wage sector on the NAIRU is determined within an error correction model (section 4). Thus, the NAIRU is treated as an endogenous variable at this point. For the described strategy, data is available for the period from 1984 to 2008.[4]

2 Estimation of the NAIRU

In what follows, the concept of the NAIRU is defined by theoretically deriving it from a system of wage and price setting (section 2.1). In section 2.2, the empirical model and the estimation method are introduced. A description of the data and unit root tests can be found in section 2.3. The estimation results are presented in section 2.4.

2.1 Theoretical Derivation of the NAIRU

A starting point for the NAIRU theory is the empirically observed negative correlation between unemployment and wage inflation in Phillips, A. (1958). The implied trade-off is graphically represented by a negatively sloped function, which is called the Phillips curve. Phelps, E. (1967) and Friedman, M. (1968) augment the Phillips with expectations and postulate that the trade-off only exists in the short run. For the long run, they assume a stable, natural rate of unemployment. Unfortunately, there is no unique definition of either the natural rate or the NAIRU. Moreover, both concepts are not clearly delimited from each other. Rogerson, R. (1997), for example, lists at least ten different, partly contradictory definitions of the natural rate. According to Grant, A. (2002), the natural rate should be viewed as the outcome of microeconomic labour market features in the sense of Friedman. The NAIRU, instead, has a rather empirical, macroeconomic focus. However, the variety of definitions necessitates an unambiguous theoretical concept. This is derived below on the basis of a system of wage and price setting equations. The general idea of this approach is to solve such a system for inflation, which gives a Phillips curve. This is explicitly done by Fabiani, S./Mestre, R. (2004) and Turner, D. et al. (2001) or, in a more complex and macroeconomically broader context by Carlin, W./Soskice, D. (1990) and Layard, R./Nickell, S./Jackman, R. (1997).

[3] A three-step approach is chosen since simultaneous estimation procedures do not prove to be successful in this context. This issue is further addressed in section 4.

[4] The software packages used for this paper are SPSS 16.0.1 (calculation of the low-wage extent, http://www.spss.com), EViews 6 (NAIRU estimates, error correction models and cointegration tests, http://www.eviews.com), JMulTi 4.22 (unit root tests, http://www.jmulti.de) and EcoWin Pro 5.70 (access to macroeconomic data, http://thomsonreuters.com).

The system of wage and price setting used in this paper is part of the macro model in Layard, R./Nickell, S./Jackman, R. (1997), pp. 361 - 396. This closed-economy model assumes homogeneous, profit-maximising firms acting as price setter. Wages are determined under incomplete competition. The price equation has the form:

$$p - w = \alpha_0 + \alpha_1 u + \alpha_2 \Delta u - \alpha_3 (p - p^e) - q + ZL_p + ZT_p. \tag{1}$$

Prices p, expected prices p^e, wages w, unemployment u and trend labour efficiency q are in logarithms. The operator Δ indicates first differences. In contrast to Layard, R./Nickell, S./Jackman, R. (1997), this price equation does not include terms for the labour force balance or the capital stock. Instead, a vector of variables (ZL_p) is supposed to have a long-run effect on the price setting. This vector captures influences such as capital costs or the structure and intensity of competition. Furthermore, the price equation includes a vector of short-term influences (ZT_p), such as oil or import price shocks.[5] From this price equation, aggregate labour demand can be interpreted as a function of the marginal labour product. Since prices are assumed to be a constant mark-up over labour costs, the equation reflects the firms' optimal choice of employment and real wages.

The wage-setting function is represented by:

$$w - p = \beta_0 + \beta_1 u - \beta_2 \Delta u - \beta_3 (w - w^e) + q + ZL_w + ZT_w, \tag{2}$$

where the ZL_w vector includes variables that affect wages in the long run, such as the level and duration of unemployment benefits, the degree of union power or the extent of mismatch unemployment. This vector is also supposed to contain the variable for the extent of the low-wage sector. Temporary influences, such as changes in the trade balance, are included in the ZT_w vector. Wage-setting is generally considered as an outcome of the collective bargaining process. Wage negotiations are based on price expectations and are hence focused on real wages.

The NAIRU (U^N) is obtained if the price and the wage equation are simultaneously in equilibrium. Furthermore, price and wage expectations have to be fulfilled ($(p - p^e) = (w - w^e) = 0$), unemployment has to be constant ($\Delta u = 0$) and temporary shocks have to be absent ($ZT_p = ZT_w = 0$). For $\gamma_0 = (\alpha_0 + \beta_0)$ and $\gamma_1 = (\alpha_1 + \beta_1)$ then holds:

$$U^N = \frac{\gamma_0 + ZL_p + ZL_w}{-\gamma_1}. \tag{3}$$

[5] These changes are based on Turner, D. et al. (2001), pp. 202 - 204.

This NAIRU is affected by long-term, institutional characteristics of the product and labour markets, which is reflected by the vectors of long-lasting shock variables. In this context, the NAIRU also depends on the extent of the low-pay sector.

To clarify the links between the NAIRU and the Phillips curve, price and wage surprises are assumed to be equal ($(p - p^e) = (w - w^e)$, cp. Turner, D. et al. (2001), p. 204). Equating the price and the wage function (equations (1) and (2)) and using the NAIRU (equation (3)) gives:

$$(p - p^e) = (w - w^e) = \frac{\gamma_1}{\gamma_3}(U - U^N) + \frac{\gamma_2}{\gamma_3}\Delta U + \frac{ZT_p + ZT_w}{\gamma_3}, \tag{4}$$

where $\gamma_2 = (\alpha_2 - \beta_2)$ and $\gamma_3 = (\alpha_3 + \beta_3)$. Inflation can be defined as $\Delta p = \pi$ and inflation expectations as $\Delta p^e = \pi^e$. Assuming adaptive expectations and using the lag operator $\alpha(L)$ gives:

$$p - p^e = \Delta p - \Delta p^e = \pi - \pi^e = \Delta\pi - \Delta\pi^e = \Delta\pi - \alpha(L)\Delta\pi_{-1}. \tag{5}$$

Applying equation (5) to equation (4) leads to the Phillips curve:

$$\Delta\pi = \alpha(L)\Delta\pi_{-1} + \frac{\gamma_1}{\gamma_3}(U - U^N) + \frac{\gamma_2}{\gamma_3}\Delta U + \frac{ZT_p + ZT_w}{\gamma_3}. \tag{6}$$

This Phillips curve essentially reflects the so-called triangle model of inflation (cp. Gordon, R. (1997), pp. 14 - 17). According to this interpretation of the Phillips curve, changes in the rate of inflation basically depend on three factors: inertia (here modelled by lagged values of inflation), demand excess (here the unemployment gap as a real indicator) and temporary supply shocks. Whereas the standard triangle model only incorporates a real indicator for the *level* of demand excess, equation (6) additionally accounts for *changes* in the level of the corresponding variable (U). This specification allows to capture hysteresis or persistence effects[6] concerning unemployment. If hysteresis effects were absent, the hysteresis parameter ($\frac{\gamma_2}{\gamma_3}$) would equal zero. In the case of $\frac{\gamma_2}{\gamma_3} > 0$, hysteresis or persistence would create inflationary pressure, which would also imply a lower impact of the parameter $\frac{\gamma_1}{\gamma_3}$.

A common interpretation of this standard NAIRU model holds structural factors and labour market inflexibility responsible for the persistent unemployment in Germany.

[6] In the presence of hysteresis effects, the NAIRU would be path dependent. Past unemployment would then increase the NAIRU, making the inflation-unemployment trade-off more costly. By a strict definition, full hysteresis would rule out the existence of a NAIRU. In the case of only partial hysteresis, the notion persistence is often used. Persistence then implies gradual path dependencies. Explanations for hysteresis and persistence usually refer to insider-outsider phenomena, processes of de-qualification, stigmatisation and capital scrapping (cp. Carlin, W./Soskice, D. (1990), pp. 444 - 448). For a comprehensive literature review of explanations for hysteresis see Roed, K. (1997).

Labour market reforms that are based on this interpretation are supposed to decrease insider power, which is achieved by lowering employment protection, for instance. In addition, the competitiveness of outsiders is targeted by investments into human capital and the improvement of mobility. Cuts in unemployment benefits are expected to generate additional work incentives by decreasing reservation wages. The NAIRU theory can thus be linked with the labour market reforms of the last years, as it provides the basis of corresponding policy recommendations (cp. Hein, E. (2003), p. 3 and Stockhammer, E. (2008), p. 493).

2.2 Estimation Method

The empirical model described below directly results from the theoretical framework presented in section 2.1. In order to apply the Kalman filter, the model is presented in state space form.[7] The observation equation represents the Phillips curve in equation (6):

$$\Delta\pi_t = \alpha(L)\Delta\pi_{t-1} + \beta(L)Gap_t + \gamma\Delta U_t + \delta(L)Pim_t + \eta D_t + \varepsilon_t^{\pi}. \tag{7}$$

The inflation rate is denoted as π_t, where Δ indicates the first difference. Lagged values of the change of inflation are allowed to enter as explaining variables. Gap_t represents the unemployment gap, ΔU_t the rate of change in the unemployment rate and Pim_t the import price index. In order to capture influences of the German reunification and some outliers, the vector D_t contains several dummy variables. The error term ε_t^{π} is assumed to be independently and normally distributed. The observation equation is complemented by the definition of the unemployment rate as the sum of the unemployment gap and the NAIRU:

$$U_t = Gap_t + NAIRU_t. \tag{8}$$

The stochastic properties of the unemployment gap and the NAIRU are described by the following state equations:

$$Gap_t = ar_1 Gap_{t-1} + ar_2 Gap_{t-2} + \varepsilon_t^{Gap}, \tag{9}$$

$$NAIRU_t = NAIRU_{t-1} + \theta I_{91q1,t} + \varepsilon_t^{NAIRU}. \tag{10}$$

[7]For technical details of the Kalman filter technique see Harvey, A. (1990), pp. 100 - 233 and Hamilton, James D. (1994), pp. 372 - 408.

In equation (9), the unemployment gap is modelled as an AR(2) process. With the condition $|ar_1 + ar_2| < 1$, this ensures the cyclical component of unemployment to be a stationary, autocorrelated process with a sample mean of zero. In the second state equation, the NAIRU is defined as a random walk without drift. The impulse dummy $I_{91q1,t}$ is included to account for the reunification break. The error terms of both state equations are assumed to be normally distributed and mutually uncorrelated.

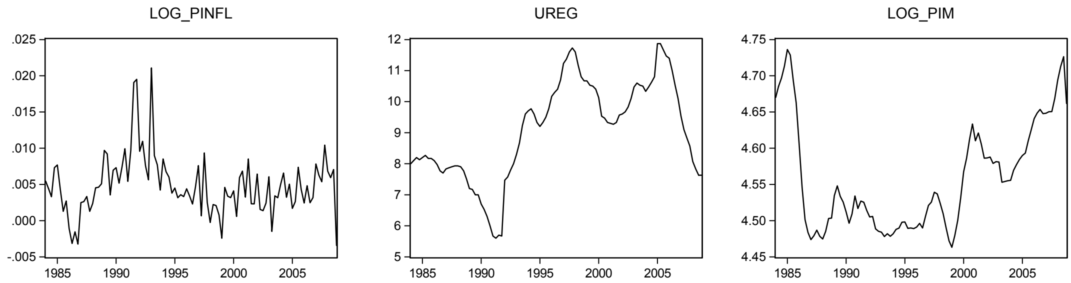
This state space set-up is similar to the specifications in Denis, C./McMorrow, K./Röger, W. (2002), Laubach, T. (2001), Llaudes, R. (2005), Logeay, C./Tober, S. (2003) and (2006), Turner, D. et al. (2001) and Stephanides, G. (2006). The attempt to model the NAIRU as a random walk with drift, as in some of these studies, produces rather unsatisfactory results (both the trend term and the trend state are statistically not significant). In addition, the inclusion of a stochastic trend term in the NAIRU equation characterises the unemployment rate as I(2), which is not supported by the unit root tests in section 2.3. It is furthermore attempted to enrich the system with an Okun's Law equation as in Apel, M./Jansson, P. (1999) and (1999a), Fabiani, S./Mestre, R. (2004), Fitzenberger, B. et al. (2008) and Schumacher, C. (2007). However, this is not successful as it causes convergence problems when applying the Kalman filter or leads to implausible results.

In comparison to simpler specifications as in Gordon, R. (1997) or Staiger, D./Stock, J./Watson, M. (1997), the described system has the advantage of avoiding the "pile-up problem". In the mentioned papers, the unemployment gap is not explicitly modelled, which implies a state space system consisting of only two equations. As a consequence, the error variance of the state equation tends to soak up all residual variation of the observation equation. A solution to this "pile-up problem" is to fix the ratio of error variances between the observation and the state equation. Usually, this signal-to-noise ratio is determined by an arbitrarily chosen parameter that affects the degree of smoothness of the NAIRU. Hence, this parameter can be interpreted similar to the smoothing parameter of the Hodrick-Prescott (HP) filter. Alternatively, Stock, J./Watson, M. (1998) suggest a median unbiased estimator to solve the problem. As mentioned, this is not necessary as the "pile-up problem" does not occur in more structured systems such as the one presented above.

2.3 Data and Unit Root Tests

The data for inflation and unemployment come from the OECD and are accessed via the EcoWin database. The inflation rate (LOG_PINFL) is defined as the first difference of the logarithm of the consumer price index. The unemployment rate (UREG) is the ratio of registered unemployed to the civilian labour force. The short-term supply shock variable is the logarithm of the import price index (LOG_PIM). This variable is also accessed via EcoWin, but is originally provided by the International Financial Statistics database of the IMF. All variables are available on a quarterly basis and at least for the period from 1970Q1 to 2009Q4. They are either already seasonally adjusted by the provider or using the Census X12 procedure by the author. All series refer to the unified Germany from the first quarter of 1991 and to West Germany prior to this date.

Figure 1: Inflation, Unemployment and Import Prices



Source: OECD, IMF.

For the relevant period, charts of the variables are presented in Figure 1. The graphical inspection of the data guides the choice and specification of the unit root tests. Since the German reunification implies a structural change, the usual augmented Dickey-Fuller (ADF) test is inappropriate. Instead, the test equation should include an impulse or step dummy, depending on the tested variable. The critical values corresponding to the Dickey-Fuller distribution are not valid in this case, because the presence of a dummy variable changes the limit distribution. Therefore, adjusted critical values have to be used. These are provided by Lanne, M./Lütkepohl, H./Saikkonen, P. (2002) and implemented in JMulTi. The number of lags for the difference of the dependent variable is chosen based on the Akaike and Schwarz criteria. In the case of contradicting recommendations, two test equations with different lag structures are estimated.

The results of the unit root tests are presented in Table 1. With respect to the inflation rate (LOG_PINFL), stationarity is suggested by the test equation with one endogenous lag. In contrast, the null hypothesis of a unit root cannot be rejected in the case of two lags. Although the unemployment rate (UREG) is a bounded variable, the test suggests non-stationarity. The import price index (LOG_PIM) has the same order of integration, because the null hypothesis cannot be rejected either.

Table 1: Unit Root Tests for the State Space Variables

Variable	Lags of Difference	Determinstics	T-Stat. $(\rho - 1)$	Crit. Value (5%)
LOG_PINFL	1	c, $i_{91q1,t}$	-3.61	-2.88
LOG_PINFL	2	c, $i_{91q1,t}$	-2.65	-2.88
UREG	2	c, t, $s_{91q1,t}$	-1.81	-3.03
LOG_PIM	4	c, t, $s_{91q1,t}$	-2.07	-3.03

Notes: The ADF test equation is $\Delta x_t = (\rho - 1)x_{t-1} + \gamma(L)\Delta x_{t-1} + Deterministics + \varepsilon_t$. The calculations are done with JMulTi. The critical values provided by the software are based on Lanne, M./Lütkepohl, H./Saikkonen, P. (2002). The tested sample is the period from 1984Q1 to 2008Q4.

2.4 Estimation Results

The Phillips curve variables and their lagged values are chosen on the basis of significance, which is guided by a preliminary stepwise ordinary least squares (OLS) regression. Starting at the general model, the most statistically insignificant variables are removed step by step, until all remaining variables are at least significant at the 5% level. In this context, the unobservable NAIRU is substituted by the HP-filtered unemployment rate. The potential explanatory variables are:

- eight lags of the dependent variable
- the unemployment gap with four lags
- the first difference of the unemployment rate
- the first difference of the import price index with four lags
- several impulse dummies to account for the German reunification and some outliers

Interestingly, the rate of change of the unemployment rate lacks statistical significance and does not enter the model. This is an indication for the absence of hysteresis effects. The resulting model is not only used to specify the Phillips curve equation in the state space model, but also to obtain the starting coefficient values for the Kalman filter.[8] The initial state values are chosen equal to the first observation of the

[8] Kalman filter estimates usually depend on exactly provided initial coefficient values. Tentatively changing these values indeed shows that the estimation results are sensitive to such changes. In most of the cases, inappropriate starting values produce implausible results or prevent the optimisation process from converging. The same applies if variables are added or removed without readjusting the initial coefficient values.

HP-filtered unemployment rate and the corresponding unemployment gap. The initial variance-covariance matrix is diagonal with large, arbitrarily set values. This approach allows the optimisation process to converge quickly.

Since the unit root tests are not clear-cut with respect to the inflation rate, two variants of the Phillips curve are estimated. As suggested by the theoretical model (equation (6)), the first variant involves the inflation rate in terms of first differences. In contrast, the second variant is estimated with the undifferenced inflation rate. Here, the Phillips curve additionally includes a constant since the inflation rate in levels has a non-zero mean. In the following, this specification is referred to as model 1b, whereas the variant with the differenced inflation rate is called model 1a.

Table 2 shows the estimation results for model 1a and 1b. It reports the estimated parameters of the state space system, the standard deviations of the respective error terms and tests for residual autocorrelation and normality. All estimated coefficients are in accordance with economic theory, except for the sign of the impulse dummy in the NAIRU state equation of model 1a. This is ignored, because the coefficient lacks statistical significance. The impulse dummies in the Phillips curve are also not significant, which is in contrast to the preliminary OLS estimate, where high significance is indicated. All impulse dummies are nonetheless retained in the system, because they contribute to residual normality. The rate of change of the unemployment gap is not included, because of its statistical insignificance in both the preliminary OLS estimate and the state space system. In both models, the sum of the autoregressive coefficients in the unemployment gap equation is slightly below one.[9] The log likelihood of model 1b is higher as compared to model 1a. Presumably, this can be explained mainly by the larger number of estimated parameters in model 1b. A formal comparison of both models with a likelihood ratio test is not possible, because no model can be interpreted as nested within the other. The Phillips curve residual tests are satisfactory. Both null hypotheses of normally distributed and serially uncorrelated residuals cannot be rejected.

Finally, although the coefficient of the unemployment gap in the Phillips curve has the correct sign, it has a surprisingly small influence. In model 1a, the coefficient is not even significantly different from zero.[10] In this case, the NAIRU is not identified. Whether or not a specification with an unemployment gap restricted to zero has a better fit than the unrestricted specification can be formally examined by a likelihood ratio test. For this purpose, the log likelihood of the restricted specification is compared to that of the unrestricted specification. The test results are presented in Table A.1 in the appendix. For both models, the unrestricted specification is supposed to have a better fit, since

[9]If the sum of the autoregressive coefficients was exactly one, the unemployment gap would not be stationary. ADF tests on the estimated gap series show that the null hypothesis of non-stationarity can be rejected with a p-value of 0.0607 for model 1a and a p-value of 0.0040 for model 1b.

[10]Attempts to fix this problem by changing the lag structure lead to autocorrelation in the residuals.

the null model can be rejected in each case. Therefore, it can be concluded that the unemployment gap has an impact on inflation, although only to a small extent.

Table 2: *State Space Estimation Results*

	Model 1a (Dependent Variable: $\Delta\pi_t^{CPI}$)	Model 1b (Dependent Variable: π_t^{CPI})
Sample	1984Q1 - 2008Q4 (T = 100)	
Log Likelihood	453.5665	475.4027
State Equations		
Gap_{t-1}	1.7471 (0.0000)	1.6738 (0.0000)
Gap_{t-2}	-0.7600 (0.0001)	-0.7007 (0.0082)
$I_{91q1,t}$	-0.0297 (0.9474)	0.0329 (0.9932)
Observation Equation		
$const$	-	0.0027 (0.0011)
$\Delta\pi_{t-1}^{CPI}$	-0.4673 (0.0000)	-
$\Delta\pi_{t-2}^{CPI}$	-0.2199 (0.0000)	-
π_{t-1}^{CPI}	-	0.2559 (0.0020)
π_{t-2}^{CPI}	-	0.1347 (0.0985)
Gap_t	-0.0001 (0.4861)	-0.0006 (0.0412)
ΔPim_t	0.1349 (0.0000)	0.1239 (0.0000)
ΔPim_{t-1}	-0.0872 (0.0000)	-0.0626 (0.0002)
ΔPim_{t-3}	-	0.0350 (0.0083)
$I_{91q3,t}$	0.0112 (0.9041)	0.0116 (0.5605)
$I_{91q4,t}$	0.0070 (0.9525)	0.0112 (0.3571)
$I_{92q1,t}$	-0.0075 (0.9681)	-
$I_{93q1,t}$	0.0138 (0.7935)	0.0155 (0.3229)
Standard Deviations		
σ^{Gap}	0.1401	0.1747
σ^{NAIRU}	0.1719	0.1895
σ^{π}	0.0022	0.0017
Autocorrelation (4 Lags)[1.)]	1.3778 (0.2483)	0.8132 (0.5202)
Normality[2.)]	0.0655 (0.9678)	1.1820 (0.5538)

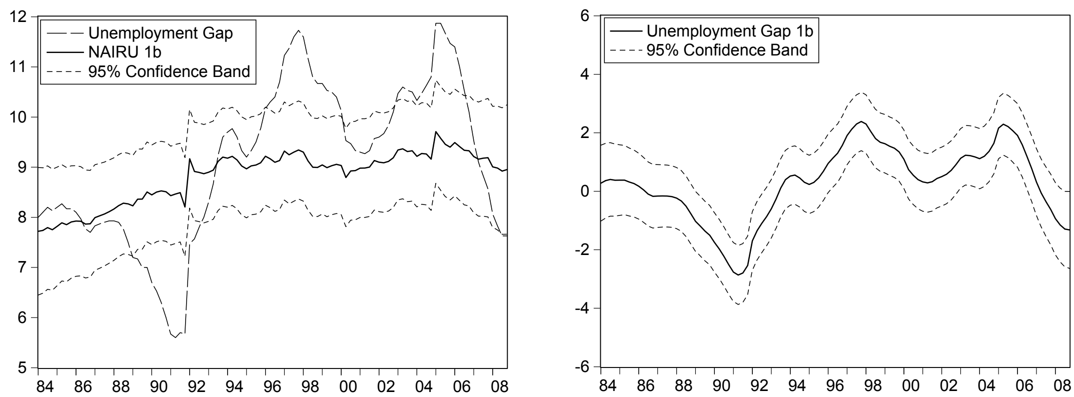
Notes: 1.) Breusch-Godfrey LM test F-statistic for residual autocorrelation; 2.) Jarque-Bera test statistic for residual normality; P-values for coefficients and test statistics are given in parentheses.

The estimated time paths of the Kalman smoothed NAIRUs and unemployment gaps are presented in Figure 2 and Figure 3. Both NAIRUs have some similarities concerning the level and the time path. The reunification break between 1991 and 1992 is clearly visible in both charts. The same is true for the peak in 2005. NAIRU 1a has less volatility than NAIRU 1b. Moreover, the point estimates have a larger statistical uncertainty as indicated by wider confidence bands. Accordingly, the point estimates of the unemployment gap of model 1a also have larger standard errors as compared to model 1b. NAIRU 1a seems to be nearly constant from 1984 to 1991 and only then increases until the peak in 2005, whereas NAIRU 1b increases almost continuously from 1984 to 2005. After 2005, both NAIRUs steadily decrease until the end of the sample.

Figure 2: *NAIRU and Unemployment Gap Point Estimates of Model 1a*

The presented NAIRUs are in general similar to those of previous studies with estimates for Germany (see for example Fitzenberger, B. et al. (2008), Logeay, C./Tober, S. (2006), SVR (2007) or Turner, D. et al. (2001)). The most substantial difference is a higher degree of NAIRU smoothness in these studies. A smoother curve can either be the result of fixing the error variances or of specifying the NAIRU as a random walk with drift.

Figure 3: *NAIRU and Unemployment Gap Point Estimates of Model 1b*



Within the confidence bands, both NAIRUs could possibly be constant over the entire sample. In order to rule this possibility out, a further likelihood ratio test is advisable.

Therefore, the restriction of a constant NAIRU is imposed on both models and tested against the unrestricted model. The test results can be found in Table A.2 in the appendix. The likelihood ratio test clearly rejects the restricted model. Hence, the constant NAIRU specification is inappropriate.

In summary, model 1b has better statistical properties than model 1a. This cannot be formally tested, but is indicated by a lower uncertainty concerning the state estimates, the significance of the unemployment gap and the correct sign of the impulse dummy in the NAIRU state equation.[11] As a consequence, the NAIRU point estimates associated with model 1b are used to evaluate the impact of the low-wage sector in section 4.

3 The development of the Low-Pay Sector

Over the last years, the development and the structure of the German low-pay sector have been investigated in many studies. All of these studies conclude that the share of low-wage earners among all dependent employees has been growing since the years after the German reunification. The calculated extent differs from study to study, depending on the choice of the low-wage threshold, the reference wage, the considered group of persons and the used data. Another finding relates to the overrepresentation of certain characteristics associated with low-wage jobs. For example, female, younger, less-skilled and migrant workers are more often employed in the low-wage sector than other groups. Low-pay jobs are found disproportionately often in East Germany and in small companies. Typical low-pay jobs are part-time, fixed-term, temporary or minor relationships (cp. Rhein, T./Stamm, M. (2006) and Schäfer, C. (2003)). Explanations for the findings are an increased labour force participation rate of women (cp. Göbel, J. et al. (2005)), skill-biased technological change (cp. Eichhorst, W. et al. (2005)) and increased wage pressures caused by globalised competition and outsourcing (cp. Kalina, T./Weinkopf, C. (2008)). Yet, the most important driving force is the politically intended expansion of atypical employment, such as minor and temporary work (cp. Brenke, K (2006) and Kalina, T./Weinkopf, C. (2006)). In addition to poor working conditions, such employment relationships are less often subject to collective wage agreements and trade union representation (cp. Bosch, G./Kalina, T. (2005) and Kalina, T./Weinkopf, C. (2008a)).

The data and the methodology for the calculation of the low-pay sector's extent are described in section 3.1. The resulting time series are presented in section 3.2.

[11] In order to check the robustness of the presented specification, model 1b is additionally estimated with three modifcations: The system is estimated with different shock variables (oil price, labour productivity and the price wedge), the CPI-based inflation rate is substituted by an inflation rate based on the GDP deflator and an alternative measure of the unemployment rate is used. A detailed description of these variables and the estimation results of the modified models are available from the author upon request. They are not presented here, as the results do not substantially differ from the statistically superior specification (model 1b).

3.1 Data and Methodology

The data for the investigation of the low-wage sector are provided by the German Socio-Economic Panel (SOEP), version 2008, of the German Institute for Economic Research (DIW). The interdisciplinary, longitudinal study is suited for representative analyses of the German residential population. The data are collected since 1984 by annually repeated surveys of households and individuals. The SOEP has been regularly extended by further subsamples, such as the integration of the new federal states in 1990 (cp. SOEP Group (2001), p. 7 and Haisken-DeNew, J./Frick, J. (2005), pp. 16 - 18).

Only dependently employed people of employable age are included. The lower age limit is predefined by the SOEP as questioning starts not before the eighteenth year of life. The upper limit is set to sixty-five, the usual age of departure from the labour force. The extent of the low-wage sector can be calculated for each year from 1984 to 2008, since this is the period for which the necessary data are available. Here, the period from 1984 to 1989 includes only West Germany, whereas the time from 1990 to 2008 refers to the reunified country. For the purpose of statistical inference, the data are cross-sectionally weighted, simultaneously implying a projection to the German residential population (cp. Haisken-DeNew, J./Frick, J. (2005), pp. 37 - 41 and Göbel, J. et al. (2008), pp. 88 - 92).

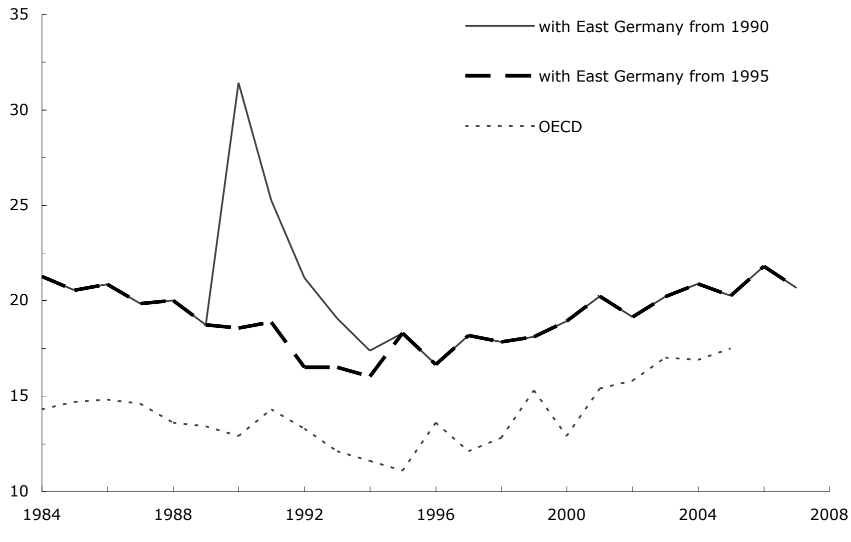
The OECD defines the low-wage threshold as two-thirds of the median wage (cp. OECD (1996), p. 68). This widely used definition is also employed in this paper. The reference wage is calculated on a net and hourly basis, which allows for a comparison between employees, regardless of their individual taxation or working time. Since the SOEP only provides monthly wages, hourly wages have to be approximated by the formula $\frac{Monthly\ Wage}{Actual\ Weekly\ Working\ Hours \times 4}$. In some of the previously mentioned studies, separate low-wage thresholds are calculated for East and West Germany in order to account for different living costs and purchasing powers. This approach can be useful in other contexts, but is not adopted here since most of the macroeconomic data employed in this paper are only available in aggregate form for the whole of Germany.

If the net wages are calculated as just described, the issue of extremely low wages arises. In general, net wages of 2.50 euro per hour are still conceivable for people in minor employment with a typical compensation of 400 euros per month and a weekly working time of 40 hours. Yet, there is a small share of workers with wages below this level. One possibility is to declare those wages as implausible, interpret the corresponding data as flawed and exclude all cases with net earnings below 2.50 euro per hour from the sample. Since both variables in question, monthly wage (LABNETxx) and actual working hours (xTATZEIT), have passed imputation procedures and plausibility checks (cp. SOEP Group (2010), pp. 24 and 60), this strategy is not adopted. In contrast, these cases are assumed to be realistic. This decision is supported by a closer look at the data. Most of these lowest wages are associated with voluntary/honorary work with only symbolic payment, working opportunities with additional cost compensation ("1-Euro-Jobs") or charitable work. There are several possible motives that induce people to accept jobs with extremely low hourly wages, such as self-fulfilment, altruistic reasons or the financial necessity of a secondary income. Since recently, a further motivation results from the threat of cuts in social benefits in the case of a rejected job offer. In addition to the data, the ongoing discussion of "wage dumping" or "unethical wages" is a further indication that net earnings far below 2.50 euro per hour can be found in reality.[12] To conclude, the exclusion of the lowest wages would be counter-productive, especially if the low-pay sector is the object of interest.

3.2 Descriptive Evidence

Figure 4 shows three time series. The first is the share of low-pay earners among all employees if East Germany is included in 1990. The German reunification clearly presents a structural break with some extreme outliers in 1990 and the following years. This gives reason to calculate a second time series, in which East Germany is first included in 1995. As a benchmark, the third time series shows the low-pay extent as calculated by the OECD.

Figure 4: *Low-Wage Earners as Percentage of Total Employees*



Source: Own calculations based on SOEP data. For the exact numbers see Table A.3 and Table A.4 in the appendix. The OECD numbers are accessed from http://www.oecd.org/dataoecd/9/59/39606921.xls.

[12]See for example Öchsner, T (2010).

The path of the first time series (the share of low-pay earners if East Germany is included in 1990) indicates a ratio of low-wage earners of about 21.3% at the beginning of the sample in 1984. This share decreases to ca. 18.7% in 1989, before the effects of the German reunification take place. From its peak of about 31.4% in 1990, the reunification shock is supposed to have some effect until 1994, where the level of the pre-reunification period is undercut with ca. 17.4%. The lowest share of the entire observation period is reached in 1996 with roughly 16.7%. From this point of time on, an upward trend begins, reaching an interim post-reunification peak of about 21.8% in 2006.

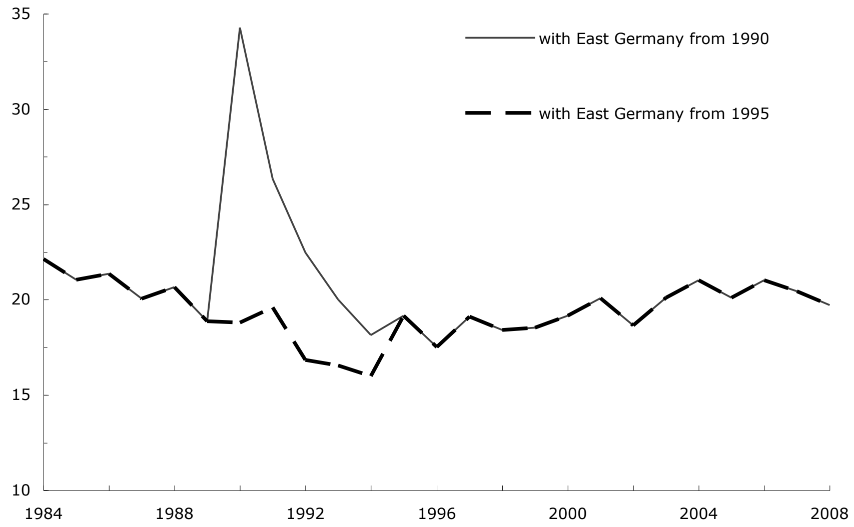
The second time series shows that the reunification bias can be circumvented if East Germany is first included in 1995. This manipulation is important with respect to the analysis in section 4.

The low-wage extent as calculated by the OECD is represented by the third time series. The OECD also employs SOEP data, but includes only West Germany. Moreover, the low-wage extent is calculated on the basis of gross monthly wages and only for full-time workers. This explains, why the time path, but not the level of this series is similar to that of the second time series. Taking all dependent employees into account, rather than only full-time workers, obviously leads to a greater low-wage extent on average. Also noteworthy is that including East Germany in 1995 causes both series to approach each other. Presumably, the lower wage level in East Germany decreases the all-German median wage, without completely compensating this shift by the additional amount of East German low-wage earners. In other words, the inclusion of East German workers decreases the low-pay share for the whole of Germany.

A number of further studies come to similar results, at least with regard to the development of the last fifteen years (cp. Bosch, G./Kalina, T. (2008), p. 29, Brenke, K. (2006), p. 198, Eichhorst, W. et al. (2005), p. 114, Kalina, T./Weinkopf, C. (2008), p. 4, Kalina, T./Weinkopf, C. (2008a), p. 451 and Rhein, T./Stamm, M. (2006), p. 11). For the years immediately following the German reunification, previous empirical research is rare. In those studies where this time is examined, only West Germany is considered. The expansion of the sample to the years before, during and shortly after the reunification thus provides a surprising result. Instead of showing the expected, incessant, sample-wide upward trend, the low-wage share is found to be roughly as large at the beginning of the sample as at the end. This is reflected by a stretched, U-shaped curve.

As a further reference, Figure 5 presents the low-pay extent based on working hours. Again, two different time series are shown, depending on the date of inclusion of East Germany. A comparison to Figure 4 reveals large similarities concerning the time path, the level and the structural change. Indeed, both the per capita and the working hour approach do not differ substantially. The calculation on a per capita basis is the most wide-spread approach in the literature. Hence, the series referring to the share of low-pay earners among all employees in which East Germany is included in 1995 is chosen for the analysis in section 4.

Figure 5: *Low-Wage Working Hours as Percentage of Total Working Hours*



Source: Own calculations based on SOEP data. For the exact numbers see Table A.5 and Table A.6 in the appendix.

4 The Impact of the Low-Wage Sector on the NAIRU

In this section, the estimated NAIRU of section 2 and the calculated low-pay extent of section 3 are brought together. In contrast to section 2, where the NAIRU is stochastically modelled as an independent variable, it now enters a structural model as the dependent variable. For this purpose, section 4.1 reviews the data and summarises the results of the unit root tests. The empirical model and the estimation results are presented in section 4.2.

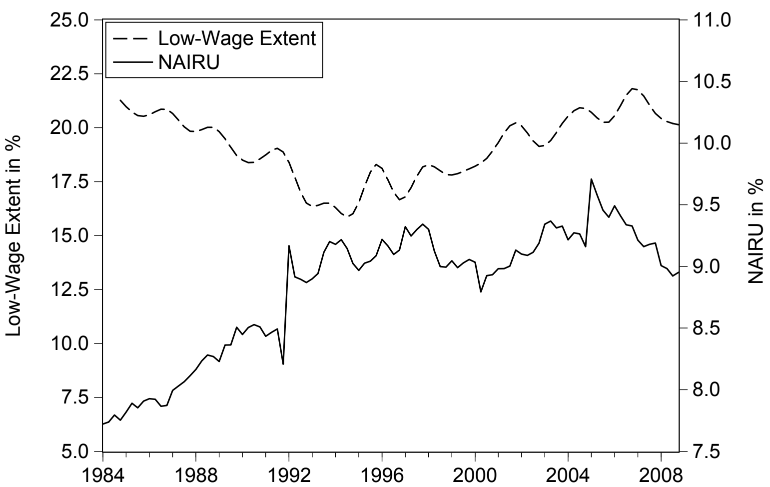
4.1 Data and Unit Root Tests

The two main time series for the following analysis are of a different frequency. The NAIRU is measured on a quarterly basis, whereas the low-wage share is only available annually. There are two possibilities to equalise the frequency of both series: Either by converting the NAIRU to an annual or by disaggregating the low-wage extent to a quarterly frequency. Choosing the latter option does not provide additional information from the low-wage variable, but prevents the loss of information from alternatively aggregating the NAIRU series. Moreover, using quarterly data allows for a separate investigation of the post-reunification subsample, which would be problematic on an annual basis implying fewer data points.

With the chosen disaggregation procedure, the annual observations of the low-wage variable are used as the values of the last quarter of the converted variable. The intermediate values are interpolated using a spline function, where each year is represented by a cubic polynomial. Each time point is obtained by global interpolation, which has the advantage of taking the information of the complete series into account. Unfortunately, this procedure does not allow to calculate the first three quarters of the disaggregated series. Nonetheless, in comparison to other disaggregation procedures, this method is simply implemented and has good properties concerning mean absolute and root mean square errors, especially in small samples (cp. Chan, W. (1993), pp. 683 - 687).

Figure 6 shows the NAIRU as estimated by model 1b in section 2.4 and the development of the low-wage extent calculated on a per capita basis as in section 3.2, disaggregated to quarterly frequency. The most interesting insight from this graph is that the relationship between both series seems to change at the point of the German reunification. The visual inspection indicates a negative relationship before 1991, which is obviously reversed after that.

Figure 6: *The NAIRU and the Low-Wage Extent*



The following analysis of the relationship between the NAIRU and the low-wage share is not exclusively bivariate, but is also carried out including control variables. The selection of the control variables is guided by the literature dealing either with the determinants of structural unemployment (e.g. Bassanini, A./Duval, R. (2002), Blanchard, O./Wolfers, J. (2000) or Nickell, S./Nunziata, L./Ochel, W. (2005)) or with NAIRU estimations using exogenous variables (e.g. Gianella, C. et al. (2008) or Logeay, C./Tober, S.

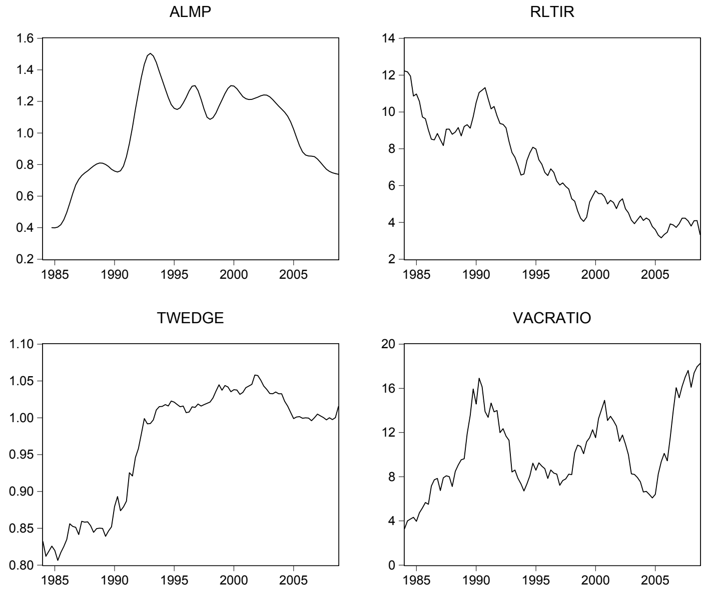
(2006)). With respect to appropriateness and availability, the following control variables are used:

- Overall expenditures on active labour market policies (ALMP) are measured as a percentage of GDP. Such expenditures can increase the chances of unemployed to find a job. Furthermore, labour market participation can be stimulated, in particular for groups at the "margin" of the labour market. The indicator covers expenditures for training, job rotation, employment incentives, rehabilitation, direct job creation, start-up incentives, out-of-work income maintenance and early retirement. Two missing observations (1984 and 2008) are extrapolated.
- The real long-term interest rate (RLTIR) is deflated by the GDP deflator. High interest rates are supposed to increase capital costs, which affects capital accumulation and productivity. This finally reduces labour demand.
- The tax wedge (TWEDGE) is defined as the ratio of total labour costs (deflated by the producer price index of the manufacturing sector) to the employee net take home pay (deflated by the CPI). It therefore comprises not only real taxes, but also contributions to the social security system. In general, high taxes are assumed to increase the cost of labour, which reduces labour demand.
- The vacancy rate (VACRATIO) is defined as the ratio of vacancies to the number of unemployed. It is used as an indicator of mismatch unemployment.

All control variables are provided by the OECD and are either accessed via the EcoWin database or directly via the OECD homepage. Except for the ALMP variable, all data are available on a quarterly basis. The ALMP variable is disaggregated following the same procedure as described for the low-wage extent. The variables based on quarterly data are either already seasonally adjusted by the provider or using the Census X12 procedure by the author. All series refer to the unified Germany from the first quarter of 1991 and to West Germany prior to this date. An exception is the extent of the low-wage sector. As mentioned before, East Germany is first included in 1995 in order to reduce the reunification bias.

The charts of the control variables are presented in Figure 7, whereas the unit root tests are summarised in Table 3. The test procedure is the same as described in section 2.3. The test results suggest that all variables are I(1). Therefore, the standard procedure is to use differences of the variables. Since differencing eliminates all influences that have an effect longer than one period, only short-term relationships would be considered. This is inappropriate, as the investigation focuses on the long-term perspective. However, ignoring the non-stationarity of the variables in an OLS estimation is also inappropriate because the regression could be spurious.

Figure 7: *Possible NAIRU Determinants*



Source: OECD.

Table 3: *Unit Root Tests for the Variables of the Error Correction Model*

Variable	Lags of Difference	Determinstics	T-Stat. $(\rho - 1)$	Crit. Value (5%)
NAIRU	1	c, t, $s_{91q1,t}$	-1.68	-3.03
LWS	6	c, t	-2.14	-3.41
ALMP	4	c, t, $s_{91q1,t}$	-1.15	-3.03
RLTIR	2	c, t, $s_{91q1,t}$	-2.68	-3.03
TWEDGE	0	c, t, $s_{91q1,t}$	-1.07	-3.03
VACRATIO	2	c, t, $s_{91q1,t}$	-1.64	-3.03

Notes: The ADF test equation is $\Delta x_t = (\rho - 1)x_{t-1} + \gamma(L)\Delta x_{t-1} + Deterministics + \varepsilon_t$. The calculations are done with JMulTi. The critical values provided by the software are based on Lanne, M./Lütkepohl, H./Saikkonen, P. (2002). The tested sample is the period from 1984Q4 to 2008Q4.

4.2 The Error Correction Approach

A solution to this problem is to estimate an error correction model (ECM). Although ECMs are usually employed in the presence of cointegrated relationships, cointegration is not a necessary condition for the estimation of those models (cp. Durr, R. (1992) and Keele, L./De Boef, S. (2005)). This can be explained by the fact that an autoregressive distributed lag (ADL) model, which necessitates stationary variables, can be transformed into error correction form. In fact, an ADL model and an ECM are equivalent. Apart from avoiding a spurious regression, the advantage of an ECM is that short-term effects, long-term effects and the speed of return to an econometric equilibrium can be analysed simultaneously. The employed ECM corresponds to the structural NAIRU in equation (3) and has the form:

$$\begin{aligned}\Delta NAIRU_t &= const_t + \alpha(L)\Delta NAIRU_{t-1} + \beta(L)\Delta LWS_t + \eta(L)\Delta X_t + \\ &\quad \gamma(NAIRU_{t-1} - \delta LWS_{t-1} - \theta X_{t-1}) + \varepsilon_t^{\Delta NAIRU}, \end{aligned} \tag{11}$$

where Δ denotes the first difference and L the lag operator. The model consists of a constant, possible endogenous lags, the first difference of the low-wage share (LWS_t) with possible lagged values, a vector of first differences of control variables (X_t), the error correction term ($NAIRU_{t-1} - \delta LWS_{t-1} - \theta X_{t-1}$) and an independently and normally distributed disturbance term ($\varepsilon_t^{\Delta NAIRU}$). Ceteris paribus, β measures the short-term and δ the long-run impact of the low-wage extent on the NAIRU. In the presence of cointegration, γ indicates the speed at which the long-run equilibrium is reached again after a deviation. The test for significance of γ simultaneously is a test for cointegration.[13] The condition $-1 < \gamma < 0$ guarantees stability.

The estimation results are presented in Table 4. The model is estimated for both the whole sample and the post-reunification period. The period before the reunification is not estimated separately, because there are not enough observations. The long-run coefficients and the constant are always included. The structure of the short-run dynamics is obtained by including only statistically significant variables at the 10% level up to the fourth lag.

Regarding the model of the *entire sample* reveals that the error correction parameter γ is not significant at the 5% level. Thus, the null hypothesis of no cointegration cannot be rejected and the long-term parameters are not identified. Indeed, none of the long-run coefficients are significant, except for the active labour market policies variable. The lagged values of the differenced NAIRU approximately sum up to zero. As the coefficient estimate of ΔLWS_{t-4} indicates, there is a delayed negative short-run impact of changes in the low-wage extent on changes in the NAIRU. Such a negative impact also emanates from a growing tax wedge, which is rather counterintuitive. The overall short-term impact of the vacancy ratio is, as expected, positive. Neither lagged nor current values of the differenced active labour market policies variable or the differenced real long-term interest rate are found to have an effect on the NAIRU in the short run.

[13] This cointegration test is proposed by Banerjee, A./Dolado, J./Mestre, R. (1998). The authors only provide critical values for cases with a maximum of five regressors. Therefore, the critical values for the t-ratio error correction mechanism test are calculated from the more comprehensive Table 3 in Ericsson, N./MacKinnon, J. (2002).

Table 4: *Error Correction Estimation Results*

Specification	1	2
Dependent Variable	$\Delta NAIRU_t$	$\Delta NAIRU_t$
Sample	1984Q4 - 2008Q4 (T = 97)	1991Q1 - 2008Q4 (T = 72)
γ (T-Stat./5% Crit. Value)[1.)]	-0.1474 (-4.09/-4.21)	-0.7458 (-7.13/-4.22)
LWS_{t-1}	0.0185 (0.7839)	0.1459 (0.0001)
$ALMP_{t-1}$	1.7617 (0.0121)	-0.1482 (0.5099)
$RLTIR_{t-1}$	-0.0416 (0.5253)	0.0908 (0.0291)
$TWEDGE_{t-1}$	-0.8780 (0.7690)	4.7721 (0.0105)
$VACRATIO_{t-1}$	0.0032 (0.8588)	-0.0536 (0.0000)
$const$	1.1617 (0.0325)	1.2876 (0.4855)
$\Delta NAIRU_{t-1}$	-0.1084 (0.0549)	-
$\Delta NAIRU_{t-4}$	0.1080 (0.0382)	-
ΔLWS_{t-1}	-	-0.1320 (0.0152)
ΔLWS_{t-4}	-0.0629 (0.0165)	-0.1686 (0.0080)
$\Delta ALMP_t$	-	-1.5517 (0.0045)
$\Delta RLTIR_{t-1}$	-	-0.1510 (0.0009)
$\Delta RLTIR_{t-3}$	-	-0.0903 (0.0546)
$\Delta RLTIR_{t-4}$	-	-0.1751 (0.0004)
$\Delta TWEDGE_t$	-2.1943 (0.0098)	-
$\Delta TWEDGE_{t-2}$	-2.8278 (0.0014)	-4.9062 (0.0082)
$\Delta TWEDGE_{t-3}$	-1.9030 (0.0392)	-
$\Delta TWEDGE_{t-4}$	-1.6299 (0.0502)	-
$VACRATIO_t$	-0.0169 (0.0606)	-
$VACRATIO_{t-1}$	-	0.0479 (0.0022)
$VACRATIO_{t-3}$	-	0.0517 (0.0005)
$VACRATIO_{t-4}$	0.0355 (0.0001)	0.0337 (0.0194)
$I_{92q1,t}$	0.9084 (0.0000)	-
$I_{00q2,t}$	-0.3071 (0.0000)	-
$I_{05q1,t}$	0.5554 (0.0000)	-
Adjusted R^2	0.8198	0.5800
Autocorrelation (4 Lags)[2.)]	1.1871 (0.3243)	0.6082 (0.6586)
Normality[3.)]	3.2246 (0.1994)	3.7928 (0.1501)

Notes: 1.) The 5% critical values of the t-ratio error correction mechanism test are calculated from Table 3 in Ericsson, N./MacKinnon, J. (2002); 2.) Breusch-Godfrey LM test F-statistic for residual autocorrelation; 3.) *Jarque-Bera test statistic for residual normality; P-values for coefficients and test statistics are given in parentheses unless otherwise stated.*

The error correction parameter in the model of the *post-reunification sample* is clearly significant and suggests the presence of cointegration. Actually, all long-term parameters are significant, except for the active labour market policies variable. Most interestingly, the low-wage extent positively affects the NAIRU. Increases in the low-wage extent cause the NAIRU to be too low as compared to the long-term equilibrium relationship. The NAIRU responses by increasing a total of 0.15 percentage points spread over future quarters. As γ indicates, the increase takes place at a rate of 75% per quarter, which implies a rather quick adjustment. The other long-run coefficients indicate positive influences of the real long-term interest rate and the tax wedge, whereas increases in the vacancy ratio cause the NAIRU to decrease. The total short-term impact of the low-wage share is again negative, but five times higher as compared to the entire sample. This is no contradiction to the positive long-run effect, because the coefficients are interpreted ceteris paribus, by setting all other coefficients to zero. Moreover, only values with a maximum of four lags are tested and included if significant. Negative effects of particular lagged values are therefore possibly offset by further, but not considered lags. The results should rather be interpreted as an overshoot reaction that is compensated in the long run. Regarding the short-term coefficients of the control variables shows that expenditures on active labour market policies have a significant negative influence. This is also true for the real long-term interest rate and the tax wedge. In contrast, the vacancy ratio positively affects the NAIRU. Endogenous lags are not found to be significant.

A comparison of both models shows a higher adjusted R^2 value for the entire sample. This is mostly due to the three impulse dummies ($I_{92q1,t}$, $I_{00q2,t}$ and $I_{05q1,t}$), which have to be added to compensate for outliers and to obtain normally distributed residuals.[14] The tests for residual autocorrelation and normality are satisfactory in both models.

The attempt to model the influence of the low-pay extent and the error correction mechanism within the state space setting fails. The inclusion of the low-wage share in differences, the control variables in differences and the error correction mechanism in the NAIRU state equation leads to completely implausible NAIRU estimates with mostly insignificant Phillips curve coefficients. This occurs for different sets of variables and independently of the used sample. Beyond these problems, it is doubtful that the distributions of the test statistics would be the same in a state space setting as in an OLS error correction model.

The presence of cointegration in the post-reunification model does not necessarily imply a cointegrated relationship between the NAIRU and the low-wage extent, since the estimated error correction parameter is influenced by the control variables too. Therefore, a separate, bivariate cointegration test is in order. The test is carried out following the Engle and Granger procedure. This implies the estimation of the long-run equilibrium between both variables. In the presence of cointegration, the residuals of this regression

[14]The inclusion of impulse dummies in the post-reunification model is not necessary to obtain normally distributed residuals. On the contrary, this would lead to a rejection of the null hypothesis of normality. Apart from this, impulse dummies do not substantially influence the coefficient estimates of the post-reunification model.

would be stationary, which is examined by an ADF test using the critical values as simulated by MacKinnon, J. (2010).

Table 5 summarises the results of this test. Again, both the entire and the post-reunification samples are used. The estimated long-run equilibrium relationships clearly indicate adverse effects of the low-wage share on the NAIRU. The negative impact in the entire sample has a slightly larger magnitude than the positive impact in the post-reunification period. However, the estimation of the long-run relationship for the whole sample does not lead to stationary residuals. The null hypothesis of no cointegration cannot be rejected. As consequence, the estimated long-run equilibrium is spurious. In contrast, for the period after the reunification, cointegration can be assumed at the 5% level. The long-run equilibrium regression is valid.

Table 5: *Engle-Granger Cointegration Tests*

Sample	1984Q4 - 2008Q4 (T = 97)	1991Q1 - 2008Q4 (T = 72)
Long-Run Equilibrium[1.)]	$NAIRU_t = \underset{(0.0000)}{10.3042} - \underset{(0.0180)}{0.0759}\, LWS_t$	$NAIRU_t = \underset{(0.0000)}{8.3200} + \underset{(0.0190)}{0.0417}\, LWS_t$
ADF Test Equation[2.)]	$\Delta\hat{\varepsilon}_t = (\rho - 1)\hat{\varepsilon}_{t-1} + \alpha\Delta\hat{\varepsilon}_{t-1} + \upsilon_t$	$\Delta\hat{\varepsilon}_t = (\rho - 1)\hat{\varepsilon}_{t-1} + \upsilon_t$
ADF Test T-Stat.	-1.93	-3.84
(5% Crit. Value)[3.)]	(-3.40)	(-3.42)

Notes: 1.) P-Values for coefficients are given in parentheses; 2.) The ADF test is applied to the residuals of the estimated long-run equilibrium. The lag length selection is based on the Schwarz information criteria; 3.) The 5% critical values are calculated from Table 2 in MacKinnon, J. (2010).

5 Conclusion

In this study, the question is investigated, whether increases in the low-wage sector actually lower the NAIRU as suggested by policy advisers. With the presented three-step strategy, the NAIRU is estimated by the Kalman filter, as recently done in several other studies. After that, the low-pay extent is calculated for each year of the period from 1984 to 2008. Finally, the long-term relationship between the NAIRU and the low-pay extent is investigated employing an error correction approach. Unfortunately, this strategy is associated with several obstacles and limitations. The occasional occurrence of convergence problems, insignificant coefficients and implausible estimation results creates a slightly unreliable impression of the Kalman filter technique. The failure to implement the error correction mechanism or an Okun's Law in the state space system is dissatisfying. Moreover, a better data availability concerning the low-pay sector would have been desirable. The interpolation to quarterly frequency does not change the situation of originally having only twenty-five data points.

However, these problems do not interfere with the main finding, according to which the working hypothesis has to be rejected. For the considered period from 1984 to 2008, it would be most appropriate to say that, apart from negligible small short-term impulses, there is no relationship between the NAIRU and the low-pay extent. Instead, a significant, long-run relationship is detected for the time after the German reunification. The impact on the NAIRU is also very small and close to zero, but with a positive sign.

If the current downward trend in actual unemployment, beginning in 2005, is related to the mentioned labour market reforms, this is independent of the development of the low-pay sector. Given the short time horizon, this could merely be a result of short-term or cyclical effects. Accordingly, the policy implication is that the intended creation of more jobs below the low-wage threshold will most probably not contribute to the reduction of structural unemployment. This insight becomes even more important against the backdrop of the "costs" of an expanding low-wage sector: It increases social inequality and causes more people to suffer from poor working conditions of "jobs at the margin". Workers changing from one atypical employment relationship to another have difficulties with life and family planning. This probably has a macroeconomic scope as it negatively affects the consumer behaviour concerning long-term purchases such as cars, furniture or houses. The argument of at least getting people into low-wage work, instead of remaining unemployed, is not well-founded. As shown, it is not likely that a newly created low-wage job reduces unemployment by one. Based on the data, it is more likely that the employee for a newly created low-pay job is recruited from the pool of regularly employed. However, it remains a task of future research to deal with this hypothesis of low-pay work crowding regular employment out.

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Appendix

Table A.1: *Likelihood Ratio Test (Relevance of the Unemployment Gap)*

	Model 1a (Dependent Variable: $\Delta\pi_t^{CPI}$)	Model 1b (Dependent Variable: π_t^{CPI})
Log Likelihood: Unrestricted Model	453.5665	475.4027
Log Likelihood: Restricted Model	428.5495	438.9723
Likelihood Ratio (P-Value)	50.0339 (0.0000)	72.8609 (0.0000)

Notes: The p-values of the χ^2 distribution with one degree of freedom are given in parentheses.

Table A.2: *Likelihood Ratio Test (Constancy of the NAIRU)*

	Model 1a (Dependent Variable: $\Delta\pi_t^{CPI}$)	Model 1b (Dependent Variable: π_t^{CPI})
Log Likelihood: Unrestricted Model	453.5665	475.4027
Log Likelihood: Restricted Model	410.1233	435.9875
Likelihood Ratio	86.8864 (0.0000)	78.8304 (0.0000)

Notes: The p-values of the χ^2 distribution with one degree of freedom are given in parentheses.

Table A.3: *Low-Wage Earners as Percentage of Total Employees (with East Germany from 1990)*

Year	Median Net Hourly Wage	Two-Thirds	Low-Wage Earners as Percentage of all Employees (with East Germany from 1990)
1984	5.3686	3.5791	21.27
1985	5.4324	3.6216	20.53
1986	5.5922	3.7281	20.85
1987	5.6810	3.7873	19.84
1988	5.9452	3.9635	20.02
1989	6.1115	4.0743	18.72
1990	5.6441	3.7627	31.41
1991	6.1355	4.0903	25.26
1992	6.6134	4.4089	21.19
1993	7.1012	4.7341	19.06
1994	7.3498	4.8999	17.39
1995	7.3853	4.9235	18.29
1996	7.6692	5.1128	16.66
1997	7.5415	5.0277	18.18
1998	7.6694	5.1129	17.83
1999	7.7385	5.1590	18.10
2000	7.9889	5.3259	18.91
2001	8.2171	5.4781	20.22
2002	8.3333	5.5555	19.13
2003	8.7167	5.8111	20.20
2004	8.7500	5.8333	20.89
2005	8.8889	5.9259	20.26
2006	8.7857	5.8571	21.81
2007	8.8889	5.9259	20.66
2008	8.8608	5.9072	20.14

Source: Own calculations based on SOEP data.

Table A.4: *Low-Wage Earners as Percentage of Total Employees (with East Germany from 1995)*

Year	Median Net Hourly Wage	Two-Thirds	Low-Wage Earners as Percentage of all Employees (with East Germany from 1995)
1984	5.3686	3.5791	21.27
1985	5.4324	3.6216	20.53
1986	5.5922	3.7281	20.85
1987	5.6810	3.7873	19.84
1988	5.9452	3.9635	20.02
1989	6.1115	4.0743	18.72
1990	6.5015	4.3343	18.55
1991	6.8172	4.5448	18.87
1992	7.1900	4.7933	16.51
1993	7.6362	5.0908	16.50
1994	7.7377	5.1585	16.01
1995	7.3853	4.9235	18.29
1996	7.6692	5.1128	16.66
1997	7.5415	5.0277	18.18
1998	7.6694	5.1129	17.83
1999	7.7385	5.1590	18.10
2000	7.9889	5.3259	18.91
2001	8.2171	5.4781	20.22
2002	8.3333	5.5555	19.13
2003	8.7167	5.8111	20.20
2004	8.7500	5.8333	20.89
2005	8.8889	5.9259	20.26
2006	8.7857	5.8571	21.81
2007	8.8889	5.9259	20.66
2008	8.8608	5.9072	20.14

Source: Own calculations based on SOEP data.

Table A.5: *Low-Wage Working Hours as Percentage of Total Working Hours (with Germany East from 1990)*

Year	Median Net Hourly Wage	Two-Thirds	Low-Wage Working Hours as Percentage of all Working Hours (with East Germany from 1990)
1984	5.3686	3.5791	22.12
1985	5.4324	3.6216	21.05
1986	5.5922	3.7281	21.37
1987	5.6810	3.7873	20.06
1988	5.9452	3.9635	20.66
1989	6.1115	4.0743	18.88
1990	5.6441	3.7627	34.28
1991	6.1355	4.0903	26.34
1992	6.6134	4.4089	22.47
1993	7.1012	4.7341	20.01
1994	7.3498	4.8999	18.14
1995	7.3853	4.9235	19.15
1996	7.6692	5.1128	17.53
1997	7.5415	5.0277	19.12
1998	7.6694	5.1129	18.41
1999	7.7385	5.1590	18.54
2000	7.9889	5.3259	19.16
2001	8.2171	5.4781	20.09
2002	8.3333	5.5555	18.66
2003	8.7167	5.8111	20.11
2004	8.7500	5.8333	21.02
2005	8.8889	5.9259	20.10
2006	8.7857	5.8571	21.02
2007	8.8889	5.9259	20.45
2008	8.8608	5.9072	19.72

Source: Own calculations based on SOEP data.

Table A.6: *Low-Wage Working Hours as Percentage of Total Working Hours (with Germany East from 1995)*

Year	Median Net Hourly Wage	Two-Thirds	Low-Wage Working Hours as Percentage of all Working Hours (with East Germany from 1995)
1984	5.3686	3.5791	22.12
1985	5.4324	3.6216	21.05
1986	5.5922	3.7281	21.37
1987	5.6810	3.7873	20.06
1988	5.9452	3.9635	20.66
1989	6.1115	4.0743	18.88
1990	6.5015	4.3343	18.80
1991	6.8172	4.5448	19.61
1992	7.1900	4.7933	16.83
1993	7.6362	5.0908	16.56
1994	7.7377	5.1585	16.01
1995	7.3853	4.9235	19.15
1996	7.6692	5.1128	17.53
1997	7.5415	5.0277	19.12
1998	7.6694	5.1129	18.41
1999	7.7385	5.1590	18.54
2000	7.9889	5.3259	19.16
2001	8.2171	5.4781	20.09
2002	8.3333	5.5555	18.66
2003	8.7167	5.8111	20.11
2004	8.7500	5.8333	21.02
2005	8.8889	5.9259	20.10
2006	8.7857	5.8571	21.02
2007	8.8889	5.9259	20.45
2008	8.8608	5.9072	19.72

Source: Own calculations based on SOEP data.

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