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ABSTRACT/RESUME

Estimating a supply block for Poland

The supply-side framework and related measures of output and unemployment gaps play a leading role in the OECD analysis of short-term conjunctural conditions and long-term determinants of growth. To allow such diagnoses for Poland, this paper develops a comprehensive supply block in accordance with the OECD approach. The structural unemployment rate is derived from a Phillips-curve equation and, along with working age population, is combined with filter-based estimates of trend labour productivity, participation rates and hours worked per employee to generate measures of potential output. The performance of the model in capturing price pressures underlying the growth trajectory of the Polish economy is assessed, and measures of cyclically-adjusted general government net lending are provided. Based on the OECD autumn 2007 projections for 2008 and 2009, out-of-sample simulations derived from the Phillips-curve model suggest that CPI inflation is likely to continue to trend upward, exceeding the central bank's inflation target by a wide margin.

JEL codes: C53, E22, E23, E27, E52, P24
Keywords: OECD, Poland, macroeconomic modelling, production function, potential output, medium-term projections, structural budget deficit, transition economies.

Estimation du bloc offre pour la Pologne

Le bloc d'offre et les mesures associées d'écarts de production et de taux de chômage jouent un rôle de premier plan dans l'analyse des conditions conjoncturelles à court terme et des déterminants de la croissance à long terme faite par l'OCDE. Afin de permettre de tels diagnostics pour la Pologne, cette étude développe un bloc d'offre détaillé selon l'approche de l'OCDE. Le taux de chômage structurel est déduit à partir d'une équation de type Phillips et, conjointement avec la population en âge de travailler, est combiné à des estimations tendancielles de productivité du travail, de taux de participation et des heures travaillées par employé pour donner lieu à une mesure du niveau de production potentiel. La performance du modèle pour rendre compte des pressions de prix sous-jacentes à la trajectoire de croissance de l'économie polonaise est évaluée, et les mesures du déficit budgétaire ajusté du cycle sont fournies. Sur la base des projections de l'OCDE pour les années 2008 et 2009 réalisées à l'automne 2007, des simulations hors échantillon déduites à partir du modèle de la courbe de Phillips mettent en évidence que, selon toute vraisemblance, l'inflation IPC poursuivra sa tendance haussière, dépassant la cible d'inflation de la banque centrale de façon significative.

Classification JEL : C53, E22, E23, E27, E52, P24
Mots-clés : OCDE, Pologne, modélisation macroéconomique, fonction de production, production potentielle, projections de moyen terme, déficit budgétaire structurel, économies en transition.

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1. Introduction

The objective of this paper is to propose a consistent framework for modelling the supply side of the Polish economy in accordance with standard OECD methodology. The introduction of a fully-fledged supply block based on a production function should allow for a better assessment of the fiscal and monetary policy stance. It would also have the advantage of providing more reliable OECD estimates of potential growth. The production-function approach allows a precise quantification of the factors underlying potential output growth and thus can help to identify and assess relevant policy reform measures and to build illustrative scenarios. Both the Polish central bank (Fic *et al.*, 2005) and the European Commission (Denis *et al.*, 2006) now consider such an approach to be the reference method for the calculation of output gaps.

Previously, the supply block for Poland at the OECD was not based on the usual production-function framework due to data limitations. Potential labour productivity resulted from a direct de-trending of actual productivity based on univariate techniques that were also applied to derive trend participation rate and trend unemployment. Coupled with working-age population series, the latter two components provided an assessment of potential employment. This approach had the advantage of having a decomposition of several factors driving potential growth developments. Also, it had robust foundations for projection purposes. Typically, a benchmark value for the trend participation rate taking into account demographics and cohort effects was computed. Working-age population projections both over the short- and medium-term horizons were set in a transparent manner by using demographic assumptions. However, as that framework lacked several key components (the capital stock, the number of hours worked and estimates of an economically grounded structural unemployment rate), it provided only a partial view of

1. The paper was prepared when Franck Sédillot and Philippe Briard were staff members of the OECD's Economics Department. We thank Peter Jarrett, Vincent Koen, Annabelle Mourougane, Paul O'Brien, Alain de Serres and Andreas Wörgötter for useful comments and suggestions and the National Bank of Poland for making the data available. Special thanks go to Mee-Lan Frank for excellent technical preparation. The views expressed are those of the authors and do not necessarily reflect those of the OECD or its Member countries. The standard disclaimer applies.

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forces underlying potential output dynamics and thus lacked all-encompassing basis for policy recommendations. The aim of this study is to fill this gap.[6]

The information needed to establish a complete supply block for Poland was identified through a search for available data, collaboration with the National Bank of Poland (hereafter, the NBP) and a study of existing empirical evidence. This can be summarised under three headings:

- The economy-wide measure of the gross capital stock was provided by the NBP. This avoids making an exogenous assumption about its value for a given base year.[7] Moreover, with the benefit of an explicit capital-accumulation equation including six lags of gross fixed investment with different coefficients for each lag and a given value of the scrapping rate, it is now possible to compute the capital stock during the OECD's projection rounds and thus to calculate up-to-date potential output estimates for Poland. However, it should be underlined that it is only a gross measure of the capital stock. This is an important difference with the OECD's current method for most countries, which is based on capital services (Beffy *et al.*, 2006).[8]

- Henceforth, the number of hours worked can be explicitly considered in the analysis. Harmonised OECD data for Poland are available only since 2000. In order to establish a longer time series, the OECD data have been retropolated to 1995 with the help of the Labour Force Statistics (LFS) statistics supplied by the NBP.[9]

- The methodological framework adopted for computing the structural unemployment rate is similar to that used for other OECD countries; it is based on Kalman-filter estimates of a price-based Phillips curve and the measure derived can be interpreted as a Non-Accelerating Inflation Rate of Unemployment (NAIRU).

With the new data supplied by the NBP and longer time series available, the empirical work presented here proposes a first set of comprehensive estimates of potential output for Poland over the period from 1995Q1 to 2007Q3. Potential output is derived from a production function (*cf.* Annex 1.A1) including the capital stock, working-age population, structural unemployment rate and trend components of hours worked per employee, participation rate and total factor productivity. Hence, the contributions of trend labour productivity and total hours worked to potential GDP growth are clearly identified. Moreover, the output and unemployment gaps are computed and their relationship with CPI inflation is assessed. With the use of the resulting measures of slack, a first set of estimates of the cyclically-adjusted deficit is also provided and discussed. Finally, based on the OECD autumn 2007 projections of other variables (for

6. Identification of the supply block through the production-function approach is not a benchmark method in some other institutions. The IMF computes output gaps as the difference between real GDP and trend GDP from a Hodrick-Prescott filter, not only in empirical studies on Poland and other countries of the region (Allard, 2007), but also in its periodical assessment of the most advanced economies (IMF, 2007). The same methodology for calculating potential output is used by the Polish Ministry of Finance. As to the structural unemployment rate, the IMF relies on estimates provided by the OECD (IMF, 2007).

7. The European Commission exogenously sets the capital-output ratio at a constant value of 2 in 1995 for all New EU Member States (including Poland), except the Czech Republic (where a ratio equal to 3 is assumed).

8. Reliable estimates of the latter are not available for Poland, although research is under way at the NBP and the Central Statistical Office (GUS).

9. Using data of another country of the region as a benchmark for retropolating the missing time series would probably be a less desirable choice. In this respect, we note a difference with the European Commission data, where the number of hours worked for Poland has been calculated by considering trend hours for Hungary as a benchmark for the period from 1995 to 1999.

instance, the actual unemployment rate) and the underlying hypotheses (OECD, 2007b), the paper provides projections for 2008 and 2009 of the different components of the supply block and associated output and unemployment gap measures. Finally, out-of-sample projections are used for assessing the capacity of the Phillips curve model to predict price pressures in the Polish economy that appeared between 2006Q3 and 2007Q3 and to establish a baseline scenario for headline inflation in 2008 and 2009. The key results are as follows:

- The NAIRU follows the actual unemployment rate with a lag: after having declined to 12% in 1998, the NAIRU gradually increased up to 18% in 2004-05 and has been falling again since then to 14.5% in 2007q3. It is expected to reach an average of 12.8% in 2008 and 11.2% in 2009.

- Potential output growth has been mainly driven by trend labour productivity until 2005 and trend total hours worked since then, with a leading role played by changes in the NAIRU. This pattern is expected to continue in 2008 and 2009. Despite being smoother that the actual series, potential GDP still exhibits substantial volatility. The latter is estimated at 4.3% per year over the period 1996-2006; after having peaked at 5.5% in 2007, it is expected to decelerate to 5.3% in 2008 and 5.1% in 2009.

- The output and unemployment gaps provide consistent information about price pressures once disinflation had been achieved at the beginning of the current decade. The former indicator leads changes in inflation by one to two quarters, while the latter is more suitable for assessing price dynamics over the medium term. Both measures switched to "excess demand" territory in late 2005/early 2006, while CPI inflation rebounded from a low of 0.6% in 2006Q1 to 4.2% in February 2008. The output gap is projected to reach 2.1% and the unemployment gap 4.0% on average in 2008-09, generating increasing inflationary pressures.

- Out-of-sample projections derived from the Phillips-curve model correctly predict the inflation rate increase from a low of 1% in 2006 to 3.5% in 2007Q4. Moreover, according to the estimates, the price push should continue in 2008 and 2009 and exceed significantly the central bank's inflation target (2.5% ±1%). With a 50% probability, headline inflation is projected within a range of 3.3-6.1% in 2008 and rising further in the course of 2009 to reach 4.2–8.4% on average for the year. Important risks to these projections include, among others, the normal assumption in OECD Economic Outlooks that the exchange rate is unchanged, as well as the effects of recent hikes in (quasi–) regulated prices (energy, tobacco, rentals, heating and refuse collection).

- While actual and cyclically-adjusted fiscal deficits were both close to 4% in 2005, the improvement in the former to below 3% in 2007 was not fully reflected in the latter. The discrepancy between structural and actual expenditure estimated at 1% of GDP in 2007, is expected to have been driven by higher cyclical revenues than expenditures.

The paper proceeds as follows. Section 2 provides estimates of the structural unemployment rate, section 3 evaluates potential output growth and activity gaps and section 4 assesses the cyclically-adjusted budget balance. More technical material is given in annexes. Annex 1.A1 provides an overview of the main definitions underlying the production function methodology in use at the NBP and the one that is proposed here and presents the breakdown of potential output. Annex 2.A1 describes models developed by the NBP for calculating the NAWRU. Figures illustrating additional findings are presented in Annex 3.A1. Section 5 concludes the paper.

2. Estimating a NAIRU for Poland: results and overall discussion

Existing methods to estimate trend unemployment

Both the NBP and European Commission derive estimates of trend unemployment on the basis of a NAWRU concept.[10] Different techniques have been tried by the central bank. As a first approach, the NBP computed the structural unemployment rate using a quarterly version of the Elmeskov (1993) method, based on a wage Phillips curve relationship that relates the change in the growth rate of nominal wages to the unemployment gap. Subsequently, in late 2005 the central bank switched to a different estimation technique that prevailed up to 2006Q4. In this framework, the NAWRU indicator was computed through the Kalman filter from a Phillips curve equation. Since April 2007, the NAWRU used by the NBP for official projections has been deduced from a structural approach to modelling the labour market (Budnik, 2006) in which wage- and price-setting behaviour are separately distinguished.

The European Commission estimates for the new Member States are based on a "productivity-augmented" version of the Elmeskov (1993) method, in which the growth rate of nominal unit labour costs increases (decreases) whenever the unemployment rate is below (above) the NAWRU. However, the elasticity estimate for Poland reported in Denis *et al.* (2006) is very small. As a consequence, for the purpose of getting a reasonable path of the NAWRU rate, the unemployment gap elasticity of unit labour costs for Poland is assumed in the Commission's work to equal 2, a value close to the average for other new Member States.[11]

Estimating the NAIRU for Poland according to the OECD approach

One motivation for developing of a new approach to estimating the structural unemployment rate for Poland was to see whether the broad OECD framework adopted for most member states could be successfully applied in the case of Poland. To this end, a NAIRU was estimated from a Phillips-curve equation, using the Kalman filter technique. In the model, quarterly changes in year-on-year CPI inflation were regressed on its own lags, the unemployment gap and several variables aiming to capture temporary supply shocks, namely real non-oil import price inflation (weighted by the degree of openness of the economy), the change in real oil price inflation (weighted by a measure of the degree of oil intensity in production), the gap between potential and actual labour productivity and changes in total unit labour cost year-on-year increases. Before going further in the analysis, one should note that lags on inflation approximate the expectations-formation process, with the underlying assumption of purely backward-looking behaviour. This hypothesis might seem restrictive, but it is in fact in accordance with empirical evidence established by the NBP in this area (see Lyziak *et al.*, 2007). In this framework, only temporary supply-shock variables are included in the Phillips-curve specification and the NAIRU rate is assumed to implicitly capture the aggregate effect of all long-lasting shocks, without requiring these shocks to be explicitly modelled (Richardson *et al.*, 2000).

10. Throughout this study the unemployment rate measure is the one based on labour force survey (GUS's Quarterly Household Labour Force Survey), as opposed to the one based on claimant counts (from administrative registers).

11. The NBP and the European Commission use the same unemployment rate definition as the one considered here.

Box 1. **Estimation of the NAIRU for Poland**

As longer time series are now available, more elaborate methods based on reduced-form filter estimation techniques can be applied to derive the structural unemployment rate for Poland. In accordance with the OECD methodological standards, the NAIRU is estimated as a latent variable from a Phillips-curve equation, *via* a Kalman filter over the period 1995Q1-2007Q3.[1] The system of equations is of the form:

$$\Delta\pi_t = c_1\Delta\pi_{t-1} + c_2 ugap_t + c_3\Delta ulc_t + c_4\omega^m(\pi_t^m - \pi_t) + c_5 \log(pdy_t / pdypot_t) + c_6\,\Delta(\omega^{oil}\pi_t^{oil}) + c_7 dum1995q3 + c_8 dum1999q1 + \varepsilon_t^{\pi} \quad \text{(B1-1)}$$

where:

$$\Delta u_t^* = \theta\,\Delta u_{t-1}^* + \varepsilon_t^{u*} \quad \text{(B1-2)}$$

$$ugap_t = \alpha\Delta u^* + \phi_1 ugap_{t-1} + \phi_2 ugap_{t-2} + \varepsilon_t^{ugap} \quad \text{(B1-3)}$$

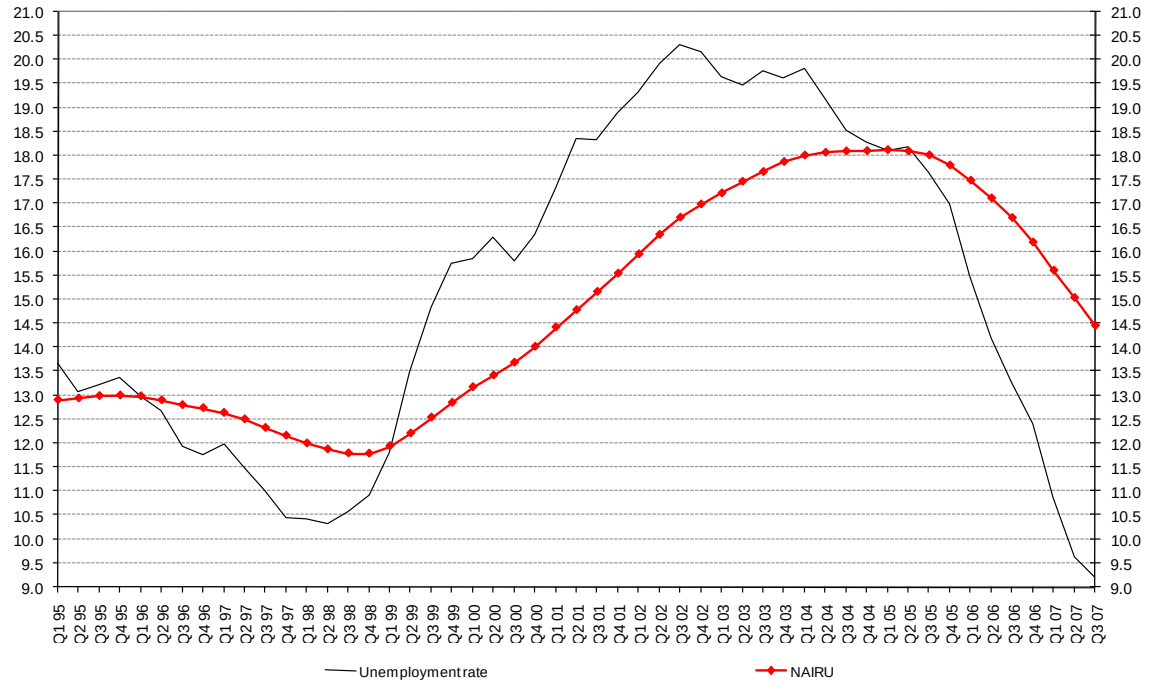
with $\varepsilon_t^{u*} \approx N(0,\sigma_{u^*}^2)$, $\varepsilon_t^{ugap} \approx N(0,\sigma_{ugap}^2)$ and $\theta < 1,\ \alpha > -1$ and correlations between the different ε_t being equal to 0. In equation (B1-1), Δ is the first-difference operator, π_t denotes year-on-year consumer price inflation, ulc_t year-on-year growth in total unit labour costs, u the unemployment rate, u^* the NAIRU and $ugap$ the unemployment gap, defined by $ugap_t = u_t - u_t^*$. π^m stands for year-on-year goods and services non-oil import price inflation and π^{oil} year-on-year oil price inflation (adjusted by changes in the exchange rate). These part inflations are respectively weighted by the degree of openness of the economy and the oil intensity of production denoted ω^m and ω^{oil}. Actual and trend labour productivity are denoted by pdy and $pdypot$ respectively. Both dummy variables aim to ensure the normality of the residual of the equation: $\varepsilon_t^{\pi} \approx N(0,\sigma_{\pi}^2)$. As a matter of clarification, in a first step the complete model (equations B1-1, B1-2 and B1-3) was estimated with a Kalman filter and then the NAIRU was derived from the estimates. Second, using the calculated NAIRU and the corresponding unemployment gap, the signal equation of the model was re-estimated (that is the Phillips curve or equation B1-1) by OLS, which yields the results reported in Table 1. The Phillips-curve specification includes only one lag of changes in the inflation rate as other lags came out statistically insignificant. Also, lagging the unemployment gap a quarter or including its first difference did not yield statistically significant results, but the introduction of the productivity gap contributed to the explanatory power of the model. Finally, equation (B1-3) describing the evolution of the unemployment gap is added in the system of equations. It follows the practice adopted in OECD's estimates for countries where the unemployment rate is subject to frequent and big changes, and where the Phillips-curve equation is relatively weak.

1. Data availability and quality concerns preclude extending the sample period before 1995 as, for instance, there is no official quarterly data for the GDP.

Figure 1 plots the estimated NAIRU and Table 1 provides a wide range of standard diagnostic tests aimed for testing the robustness of the Phillips curve. All variables have correctly signed and statistically significant coefficients at the 5% level, except the unemployment gap whose coefficient is significant only at the 10% level.[12] All specification tests are passed. In particular, there is no evidence of any significant serial correlation of the residuals. The Ramsey reset test and the relatively high value of the adjusted R-squared confirm that the equation is not mis-specified. Indeed, as Figure 3.A1.1 in Annex 3.A1 shows, when a static simulation of the model is performed, there is a high correspondence between fitted and actual CPI inflation values (the difference between the two being equal to the residuals from the estimation). All in all, these different elements provide sufficient evidence that the specification of the model is relevant from an economic as well as a statistical point of view.

In order to investigate further the robustness, the model has been simulated dynamically. Figure 2 plots dynamic simulations of CPI inflation over two sub-periods, 2003Q2-2007Q3 and 2005Q2-2007Q3, based on the OLS estimates of the Phillips curve (equation B1-1). The results are encouraging insofar as changes in the CPI index are correctly picked up, though it turns out that in both cases, the model tends to overestimate slightly the inflation rate at the end of the period.[13]

Figure 1. **NAIRU estimates from a Kalman filter**



Source: Own calculations.

12. The significance level of the unemployment gap is in fact close to the 5% threshold (the p-value is 7.1%). Moreover, the variable is significant at the 5% level when a shorter (1995Q1-2007Q2) time period is considered.

13. This gap is higher when dynamic simulations are performed when starting from 2000 or 2001, which reflects possible problems of regime shift related to changes in inflation dynamics, with the end of disinflation having been reached only since 2002-03.

Table 1. **Estimated Phillips curve and diagnostic tests**

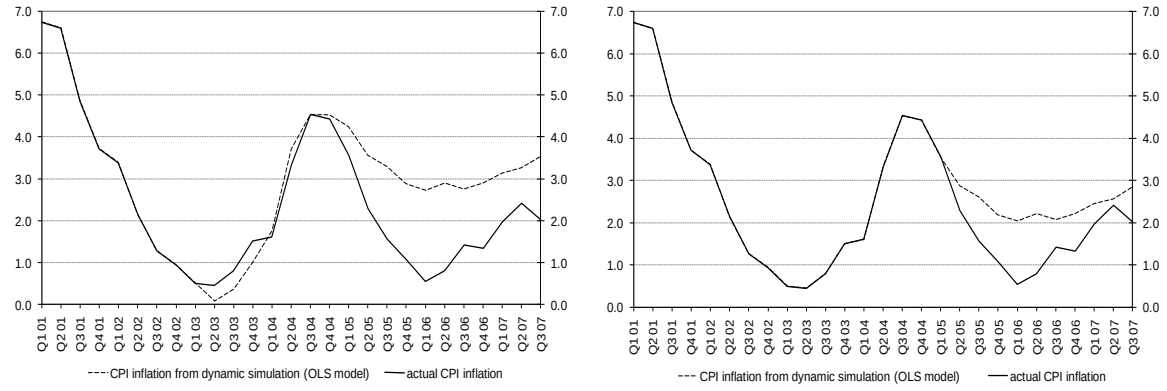
Sample	1995 Q1-2007 Q3	
Dynamics		
$\Delta\pi_{t-1}$	0.38	**(5.31)
Unemployment gap		
$u_t - u_t^*$	-0.08	*(-1.85)
Change in total unit labour cost growth		
Δulc_t	0.12	**(2.50)
Real non-oil import price inflation		
$\omega^m(\pi_t^m - \pi_t)$	0.16	**(2.64)
Factor productivity gap		
$\log(pdy_t / pdypot_t)*100$	0.27	**(3.43)
Change in oil price inflation		
$\Delta(\omega^{oil}\pi_t^{oil})$	0.17	**(4.50)
Sacrifice ratio	1.88	
Tests		
Durbin-Watson	2.24	
S.E.	0.67	
R2 adjusted	0.76	
Heterosked.	0.12	
Reset	0.34	
Normality	0.42	
Arch LM(1)	0.30	
Arch LM(4)	0.31	

Notes: OLS estimates with a NAIRU derived from a Kalman filter. The values in parenthesis are t-statistics. Test values are p-values; all tests pass at the 5 % level. * (**) denotes significance at 10% (5%) level.

Source: Own calculations.

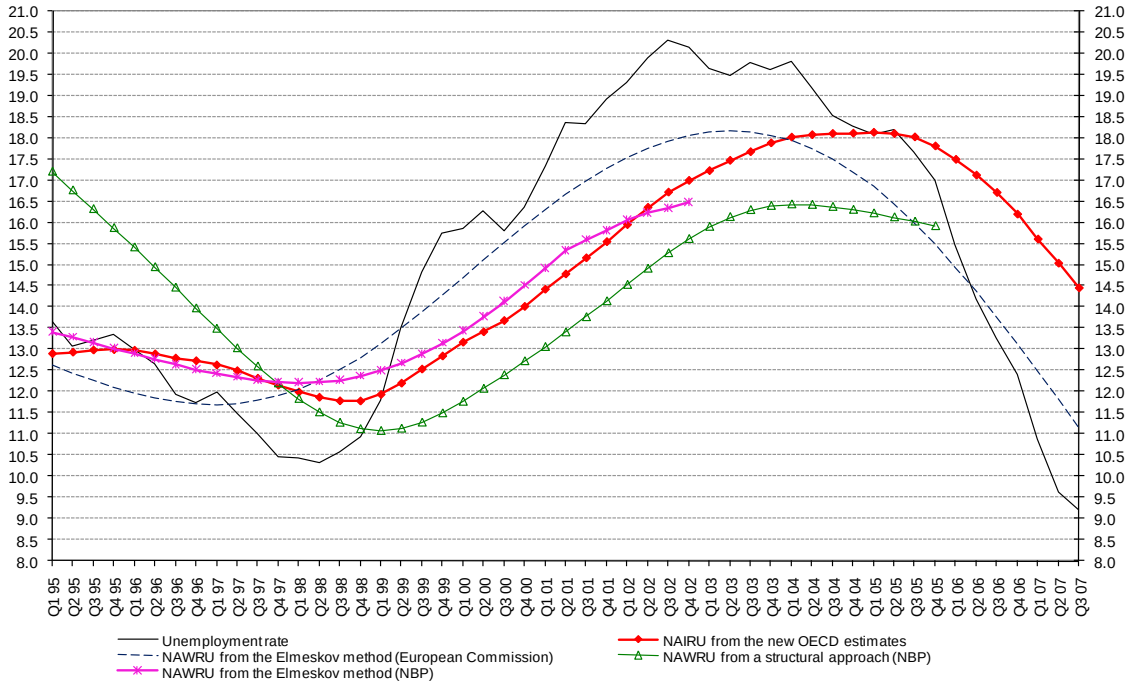
Figure 2. **Actual and dynamically simulated CPI year-on-year inflation rate**

2003Q2–2007Q3 **2005Q2–2007Q3**



Source: Own calculations.

Figure 3. **Different measures of the structural unemployment rate**



Note: European commission estimates are based on annual data and have been interpolated for the purposes of this study.

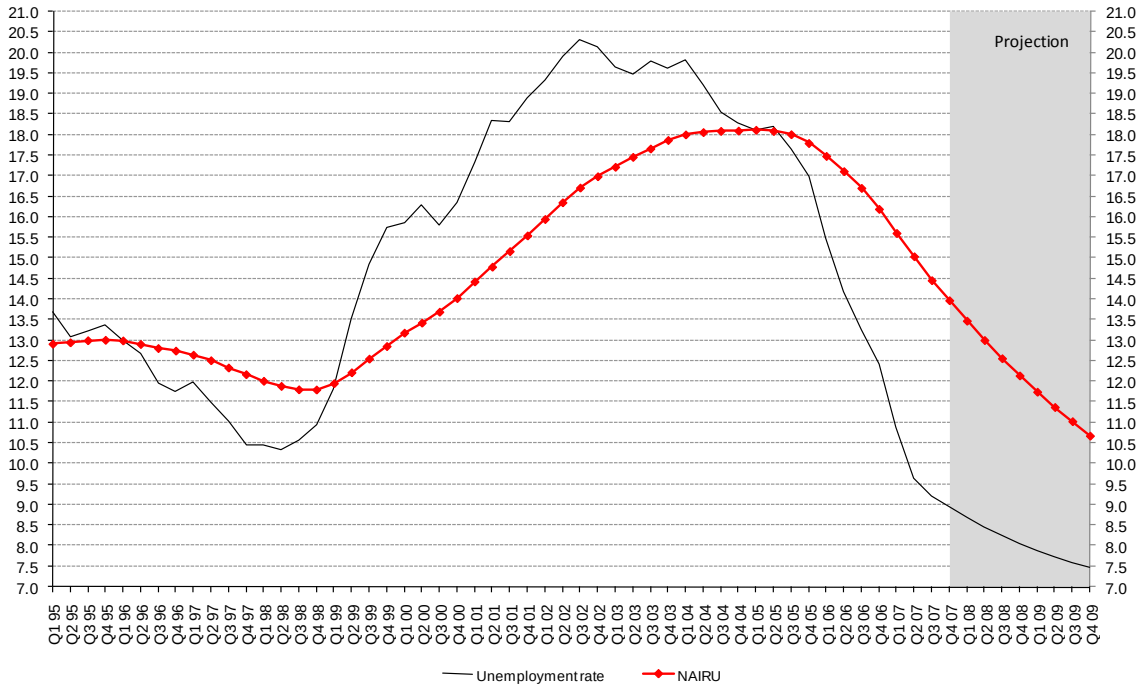
Source: Own calculations, LFS, OECD, Budnik (2006), Gradzewicz and Kolasa (2004) and European Commission (2007).

Possible forces underlying movements in the structural unemployment rate

Figures 3 compare the Kalman-filter based measure of trend unemployment with the NBP estimates discussed above and other available results. It appears that all the indicators share broadly similar profiles and follow with a lag the evolution of the actual unemployment rate. More particularly, the proposed new OECD estimate is close to the one obtained by the NBP with the Elmeskov method up to 2002 (Figure 3). In contrast, the structural method of measuring the NAWRU established by Budnik (2006) suggests a much higher level in the mid-1990s and a much lower one by the end of the 1990s (Figure 4). But according to its author, the purpose of the model was to capture alternating phases in the NAWRU changes rather than to pinpoint precisely its level. And even if this structural approach became the reference method used in the supply block of the main macroeconomic forecasting tool of the NBP (Fic *et al.*, 2005) as of April 2007, it is probable that such a strong variability in the NAWRU indicator has not been taken without making expert adjustments.

The extent of the decline observed in the late 1990s can be partly explained by specific labour market reforms (Budnik, 2006). In particular, the 1997 reform of the unemployment-benefit system would have led to a drop in the equilibrium unemployment rate. Benefits were differentiated in relation to individuals' work experience, the unemployed had to work longer to qualify for benefits, and average replacement rates were reduced. As a result, the percentage of unemployed who collected benefits was halved in only one year's time. However, the 1999 reform of the social insurance system would have had opposite consequences on the NAWRU, contributing to the rise observed in the first half of the 2000s. One feature of the reform was the restriction of public health-care insurance to employed and unemployed only. This move triggered higher flows of economically inactive to the relatively more attractive status of unemployed, thus exerting upward pressure on the structural rate of unemployment.

Figure 4. **Historical and projected level of actual and structural unemployment**



Note: OECD (2007b) projections for the actual unemployment rate.

Source: LFS and own calculations.

Some tentative explanations for the drop of the equilibrium rate of unemployment at the end of the sample period can also be cited.

- Training programmes for the unemployed financed, among others, through EU funds may have started to deliver positive outcomes.

- The internal mobility of the labour force, which is very low, may have increased with the strong economic upturn.

- The positive changes in the structure of unemployment that are currently under way, with a rising share of workers with better qualifications and stronger mobility, should push down the structural unemployment rate. However, large-scale emigration flows registered since Poland joined the European Union can be expected to increase the NAIRU if it mainly concerns highly skilled workers (NBP, 2007a and 2007b).

- According to the NBP, the recovery in the labour market is driven to a large extent by labour demand which, coupled with possible faster matching of qualifications to employers' needs and a more widespread use of flexible employment contracts, translates into a steady decline in the structural unemployment rate (NBP, 2007a).

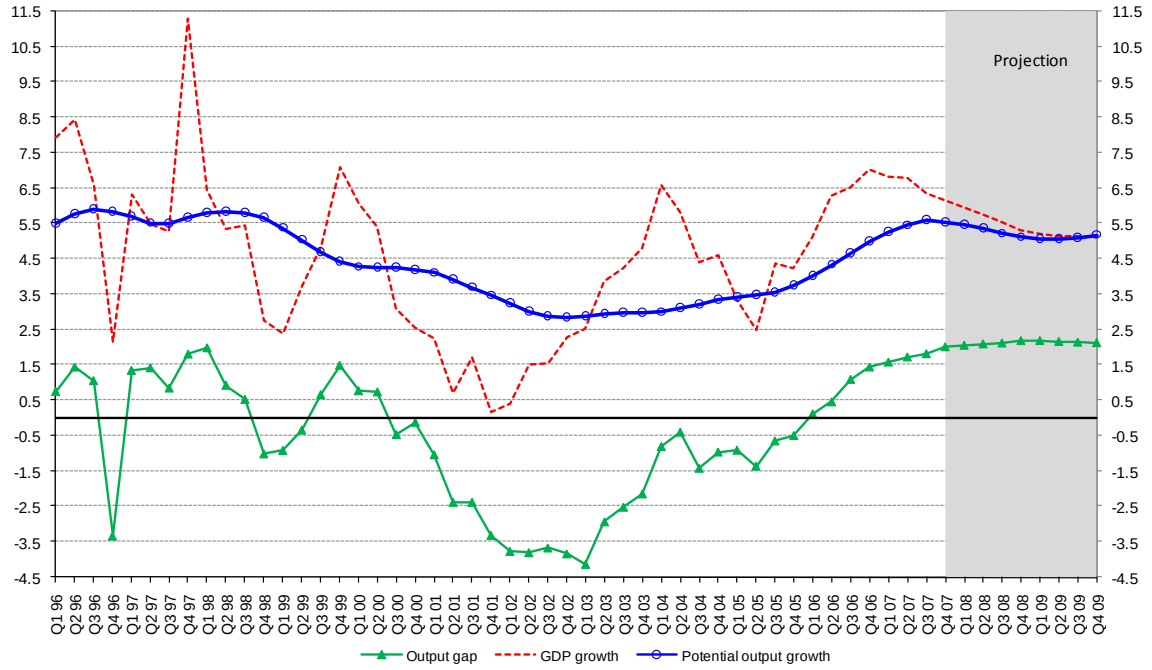
In the medium term, the drop in the equilibrium unemployment rate may be even deeper than that of the actual unemployment rate due to a rising share of younger workers in total unemployment, since they have a higher probability of finding a job (NBP, 2007a). Although checking the validity of this conjecture will be possible only with further empirical evidence, estimates of the model tend to corroborate the expectation of further declines in the near term. Kalman-filter estimates of the model allow one to

extrapolate the estimated time series behaviour of the NAIRU beyond the sample period under consideration (Figure 4). This exercise reveals a further reduction in the NAIRU, from 14.5% in 2007Q3 to 12.1% in 2008Q4 and 10.7% one year later. This trend is in accordance with latest estimates of the central bank reported in the February 2008 Inflation Report (NBP, 2008). Coupled with the slower decline in the unemployment rate that was projected for 2008 and 2009 in *Economic Outlook No. 82* (OECD, 2007b), this leads to the narrowing of the unemployment gap by 2 percentage points, from a high of 5.2% in 2007Q3 to 3.2% in 2009Q4.

3. Evaluating potential output growth and activity gaps

Given the NAIRU derived from the Kalman filter model and using the production function framework (*cf*. Annex 1.A1), one can compute the potential output of the Polish economy. Figure 5 compares estimates of the potential output growth rate with that of actual GDP and plots the output gap. After having reached 4.5% in 2006 and 5.5% in 2007, potential output growth is expected to moderate somewhat and amount to 5.3% in 2008 and 5.1% in 2009. With an estimated average growth at 4.4% over the 1996Q1-2007Q3 period, the variability of potential growth is quite sizeable, though substantially less so than that of actual GDP.[14] Nevertheless, Figure 5 illustrates that GDP has been growing above potential almost uninterruptedly since 2003. As a result, although the gap between actual and potential

Figure 5. **Output gap, actual and potential output growth**



Note: OECD (2007b) for actual GDP growth rate.

Source: Own calculations.

14. The extent of the variability in the growth rate of potential output (standard deviation of 1.1 percentage points against 2.3 percentage points for actual GDP) is one of the highest among OECD countries, but nevertheless similar to that of Ireland.

Table 2. **Estimates of various supply-side indicators**

	Proposed new OECD estimates				European Commission estimates						Ministry of Finance		
	Actual output growth	Potential GDP growth	Output gap	NAIRU	Actual output growth	Potential GDP growth		Output gaps		NAWRU	Actual output growth	HP trend growth	Output gap
						HP filter	PF method	HP filter	PF method				
2006	6.2	4.5	0.8	16.9	6.1	4.5	5.3	-1.2	0.3	14.1	6.2	5.3	-0.3
2007	6.5	5.5	1.8	14.8	6.5	4.5	5.9	0.7	0.9	11.5	6.5	5.5	0.6
2008	5.6	5.3	2.1	12.8	5.6	4.5	6.1	1.8	0.4	8.8	5.5	5.5	0.5
2009	5.2	5.1	2.2	11.2	5.2	4.4	6.3	2.6	-0.6	6.1	5.0	5.4	0.1

Source: Own calculations, European Commission (2007) and Ministry of Finance (2008).

output growth is projected to diminish in 2008 and to coincide at close to 5% in 2009, the output gap will remain positive at a value slightly exceeding 2% during the next two years.

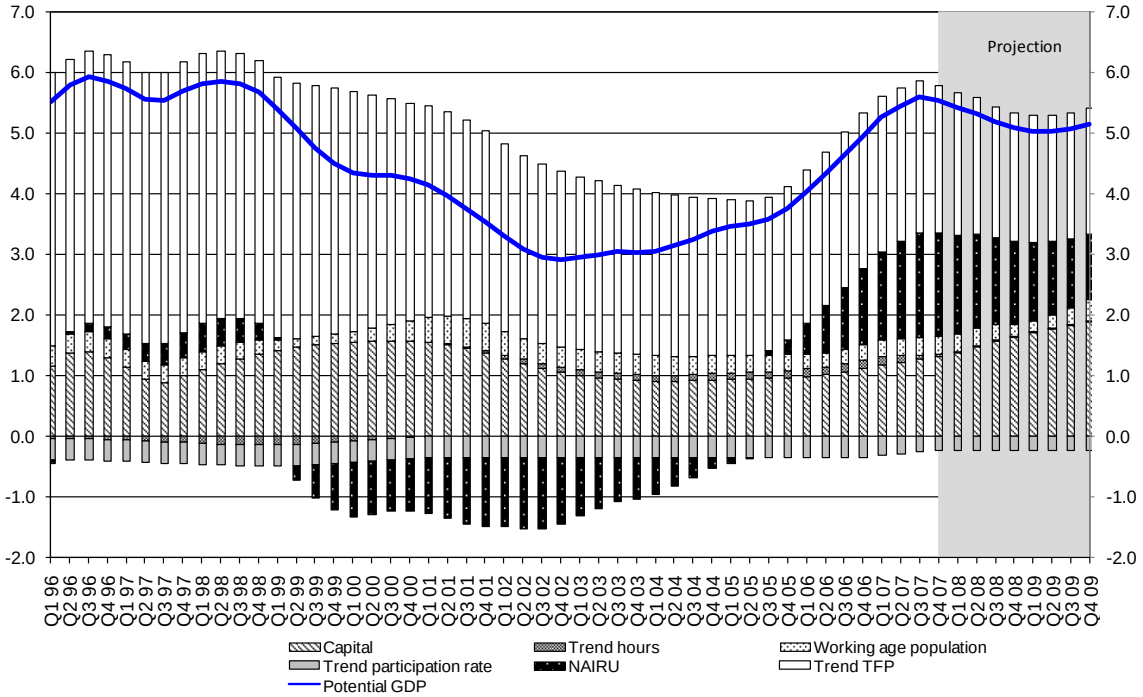
The estimates for 2006-09 are broadly consistent with those obtained by the IMF, European Commission and Ministry of Finance. Even so, some notable differences remain despite similar assumptions about actual output growth (Table 2). At end 2006, the IMF estimated potential GDP growth to be 4% (IMF, 2006). Using the same Hodrick-Prescott filtering technique, end-2007 estimates of the European Commission (2007) and the Ministry of Finance (2008) pointed to 0.5-1.5 percentage points more. Differences in definitions and assumptions about changes in the structural unemployment rate also account for discrepancies between the results when applying the production-function approach. While the proposed new OECD estimates suggest a deceleration of potential output growth from a peak of 5.5% in 2007, the European Commission calculations point to a further strengthening over the same period, driven by a much sharper decline in the structural unemployment.

Forces underlying potential-output growth

Figure 6 shows the decomposition of year-on-year changes in potential output growth, while Figure 3.A1.2 in Annex 3.A1 presents changes in the relative contribution of each component. Trend total factor productivity appears to be the main driving force behind the potential output growth rate, with an 85.5% contribution on average between 1996 and 2003, but following a decelerating trend since then. The second contributing factor is the capital stock whose contribution has hovered around 28% on average over the sample period, but a rise to above 30% is expected since mid-2008. The structural unemployment rate had a negative contribution of close to 6.5% on average from 1996Q1 to 2007Q3. It should be emphasised nevertheless that the recent evolution of potential output is mainly driven by sharp reversal in the contribution of unemployment from being negative (2003 to mid-2005) to strongly positive since then.

Table 3 provides an alternative decomposition of potential-output growth into growth of trend labour productivity (GDP per total hours worked in the economy) and potential total hours worked. The former is further disaggregated into two factors (capital deepening and trend increases in total factor productivity), whereas the latter is split between hours worked per employee, working-age population, the trend labour force participation rate and the structural unemployment path. On average over the 1996-2005 period, trend labour productivity increases exceeded potential GDP growth rate, with a very high contribution of trend total factor productivity. The contribution of total hours worked to potential output growth was slightly negative, driven by an equal contribution of the trend participation rate and the NAIRU, only partly offset by working-age population. However, as Table 3 indicates, the years 2006 and 2007 as well as projections for 2008 and 2009 contrast with these overall results, with a much stronger contribution of total hours worked to potential growth, predominantly driven by changes in the NAIRU.

Figure 6. **Decomposition of potential output growth rate**



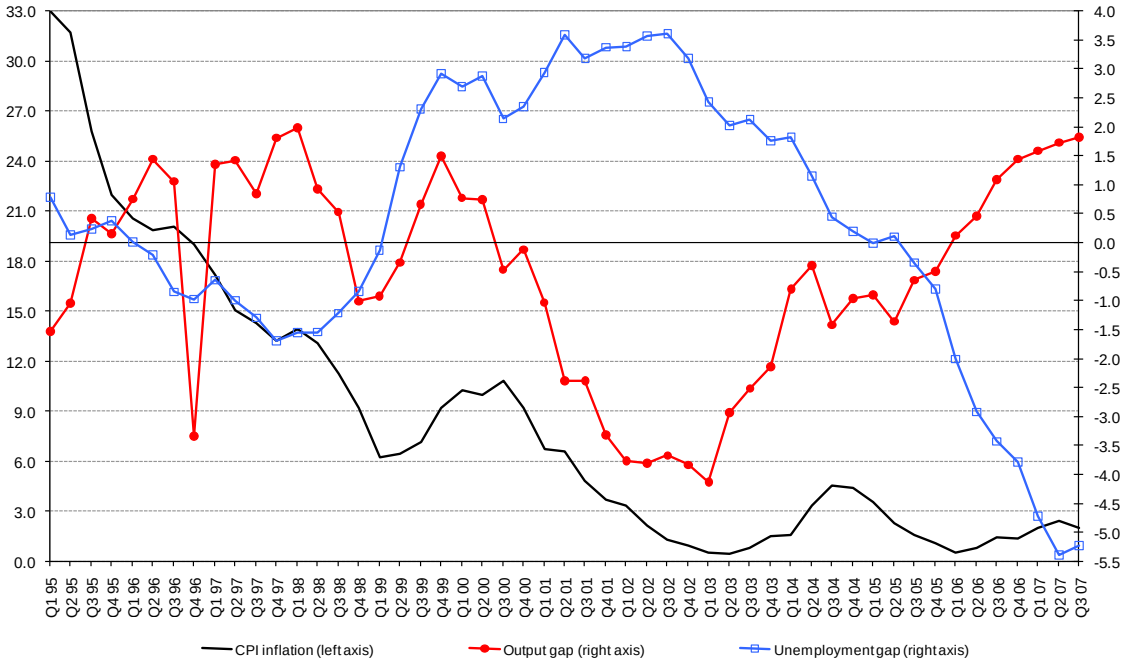
Source: Own calculations.

Table 3. **Decomposition of potential output growth**

	Potential GDP growth	Components of potential labour productivity: GDP per total hours worked			Potential total hours worked				
		Total	Capital deepening	Trend TFP	**Total**	Hours worked per employee	Working-age population	Trend participation rate	NAIRU
1996	5.8	**5.8**	1.3	4.5	**0.0**	-0.1	0.5	-0.6	0.1
1997	5.6	**5.3**	0.9	4.5	**0.3**	-0.2	0.5	-0.6	0.5
1998	5.8	**5.5**	1.1	4.4	**0.3**	-0.2	0.4	-0.5	0.6
1999	4.9	**6.1**	1.9	4.2	**-1.1**	-0.2	0.2	-0.5	-0.6
2000	4.3	**5.9**	2.2	3.8	**-1.6**	-0.1	0.4	-0.5	-1.4
2001	3.8	**5.3**	2.0	3.3	**-1.4**	0.1	0.7	-0.6	-1.6
2002	3.0	**4.8**	1.8	3.0	**-1.7**	0.1	0.5	-0.6	-1.8
2003	3.0	**4.2**	1.4	2.8	**-1.2**	0.2	0.5	-0.6	-1.3
2004	3.2	**3.8**	1.1	2.7	**-0.6**	0.2	0.5	-0.6	-0.6
2005	3.6	**3.5**	0.9	2.6	**0.1**	0.2	0.4	-0.6	0.1
2006	4.5	**3.1**	0.5	2.6	**1.4**	0.2	0.4	-0.6	1.4
2007	5.5	**2.8**	0.3	2.5	**2.6**	0.1	0.4	-0.4	2.5
2008	5.3	**2.9**	0.7	2.2	**2.4**	0.0	0.4	-0.4	2.3
2009	5.1	**3.2**	1.1	2.1	**1.9**	0.0	0.4	-0.4	1.8
Average 1996-05	4.3	**5.0**	1.5	3.6	**-0.7**	0.0	0.5	-0.6	-0.6

Source: Own calculations.

Figure 7. **Actual CPI inflation, output and unemployment gaps**



Source: Own calculations.

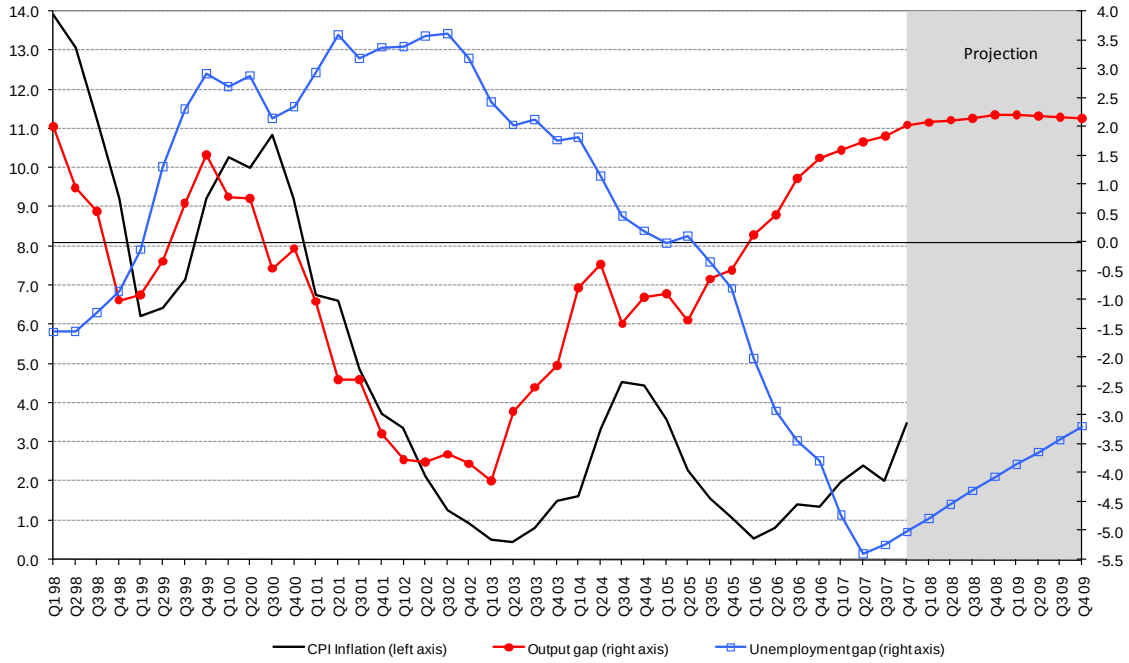
Estimating output and unemployment gaps and assessing their robustness

Let us now consider the relationship between the output and unemployment gaps and the inflation rate over the 1995Q1-2007Q3 sample period. Figure 7 juxtaposes the two indicators and the CPI inflation rate. The actual unemployment rate is higher than the structural unemployment rate and the output gap is negative on average. The latter is equal to –0.5% and the former 0.3%. This could reflect the decrease in the inflation rate from around 30% in 1995 to around 3.5% on average since 2000. Yet, having only a broad view of the overall 1995-2007 period might lead to inappropriate conclusions. Indeed, any significant relationship between different measures of output or unemployment gaps and the inflation rate is probably clouded by the protracted disinflation process throughout the 1990s. Whatever the estimates, it is difficult to detect a meaningful relationship between different definitions of activity gaps and CPI changes in the second half of the 1990s. For instance, the negative unemployment gap between 1996 and 1998 did not translate into a pause in disinflation, even though there was a small increase in unit labour cost growth between 1997 and 1998. Yet, there is one major exception as far as the level of the output gap indicator is concerned in 1998-99. As Figure 7 reveals, changing signs of the output gap led the U-shaped evolution in the inflation rate that occurred over this period.

A more straightforward picture emerges after the inflation rate permanently declined to one-digit levels at the beginning of the 2000s.[15] As shown in Figure 8, important and growing positive unemployment gaps and negative output gaps correspond to a downward slide in inflation from around

15. In principle, it would be interesting to know how the estimates would be affected if the model were run only over the period after disinflation was finished. However, the sample period would probably be too short to derive reliable estimates when considering data only as from 2002-03. This will be a fruitful extension for future work, when longer time series will be available.

Figure 8. **CPI inflation, output and unemployment gaps**



Source: Own calculations.

10% in 2000 to 0.5% in mid-2003. An overall rebalancing can be observed since that time, with different gaps closing progressively and switching signs in late 2005/early 2006. It is interesting to note that the transitory inflation shock that occurred around the time of Poland's EU accession in May 2004 happened as the output and unemployment gaps started to narrow. Thus, we cannot exclude the existence of a speed-limit effect during this episode. A more detailed analysis reveals that positive changes in the output-gap indicator in fact led the pick-up in the CPI index by a quarter or two. Moreover, the output gap broadly stabilised when the inflation rate peaked at above 4% in the second half of 2004 and then diminished in 2005.

The switch of the output gap into positive values in 2006Q1 coincided with a rebound in CPI inflation from an all time low and marked the beginning of an upward trend in price increases. Between 2006Q1 and 2007Q1 the output gap increased from 0.1% to 1.6%, while year-on-year headline inflation jumped from 0.6% to 2%, respectively. At the same time, the unemployment gap went sharply into negative territory, growing from –0.3% in 2005Q3 to –4.7% in 2007Q1. Thus, given the level and the extent of the widening of the unemployment gap, one could have expected a stronger pick-up in price inflation already in 2006. As a result, there might exist more or less pronounced lags in the inflation response to the NAIRU gap. Put differently, in the case of Poland it seems that this indicator is probably more sensitive for capturing changes in prices with several lags and over the medium term, while the output gap might be more informative about immediate short-term inflationary pressures, possibly leading them by a quarter or two.

Notwithstanding their exact sensitivity, both the output and unemployment gap indicators are consistent with price developments in 2007 as Figure 8 clearly reveals. The year-on-year inflation rate trended upward throughout 2007, moving from 2% in 2007Q1 to 3.5% in 2007Q4 and reached 4.2% in February 2008. Moreover, the latest available data and indicators (accelerating wage growth, rising unit labour costs, dramatic rise in capacity utilisation, labour shortages, etc.) reveal that a stronger inflationary push is in the pipeline. In view of this situation, the central bank increased its policy rate in seven steps of

0.25 percentage point from 4% in April to 5.75% in March 2008. It remains to be seen if these policy decisions will inverse or even stop underlying trends, given both the existing lags in the monetary policy transmission process and the scale of monetary tightening. However, the activity-gap measures estimated for 2008 and 2009 suggest, both in terms of their sign and cumulative value, that the pick-up in CPI inflation can be expected to continue in the coming quarters (Figure 8).

Out-of-sample projections of inflation using the Phillips curve

In order to corroborate the conjecture of growing price pressures in the Polish economy, dynamic out-of-sample simulations of the Phillips curve model were performed based on the OLS estimates of equation (B1-1). Six estimates of the model were made quarter by quarter starting from 2006Q2 with simulations computed over the subsequent quarters.[16] This allows an assessment of the predictive capacity of the model by comparing the latest actual price developments with those derived from the estimates as well as to forecast the central trajectory of inflation for 2008 and 2009. When carrying out the exercise, one should note that out-of-sample projections were achieved by taking autumn 2007 OECD projections (OECD, 2007b) for pre-determined variables. Therefore, should for example the unemployment rate evolve differently from what was projected, the inflation rate could deviate more or less importantly from the estimated path.[17] It is also worth mentioning that other risks to the projections include, among others, the exchange rate factor and recent hikes in (quasi–) regulated prices (energy, tobacco, rentals, heating and refuse collection).

Figure 3.A1.3 in Annex 3.A1 plots the projected trajectory of inflation for each out of the six out-of-sample simulations, while Figure 9 represents the average central projection for each quarter derived from the estimates.[18] The results are encouraging insofar as the model correctly predicts a pick-up in CPI inflation since mid-2006. For instance, the simulations yield a 3.5% rate in 2007Q4, identical to actual inflation. Moreover, there is a high likelihood that this trend will continue over the coming quarters with inflation dynamics evolving well above the upper end of the central bank's tolerance band for deviations (2.5% ±1%). In order to better assess the risk of overshooting the NBP's inflation target of 2.5%, various confidence intervals were calculated starting the simulation process from 2007Q2.[19] This yields a central projection for CPI price increases (see Figure 10) that in fact is close to the average path represented in Figure 9.[20] As plotted in Figure 10, there is a 50% probability that inflation will run in the 3.3-6.1% range in 2008 (3.3-6.8% in 2008Q4) and 4.2–8.4% in 2009 (4.7–9.4% in the last quarter). Only with large confidence intervals can CPI inflation be expected to be consistent with the central bank's inflation target (see also Table 4).

16. For instance, in a first step the model is estimated from 1995Q1 to 2006Q2 and out-of-sample projections are derived for 2006Q3 to 2009Q4; in the last (sixth) step the model is estimated from 1995Q1 to 2007Q3 and simulations are made from 2007Q4 to 2009Q4.

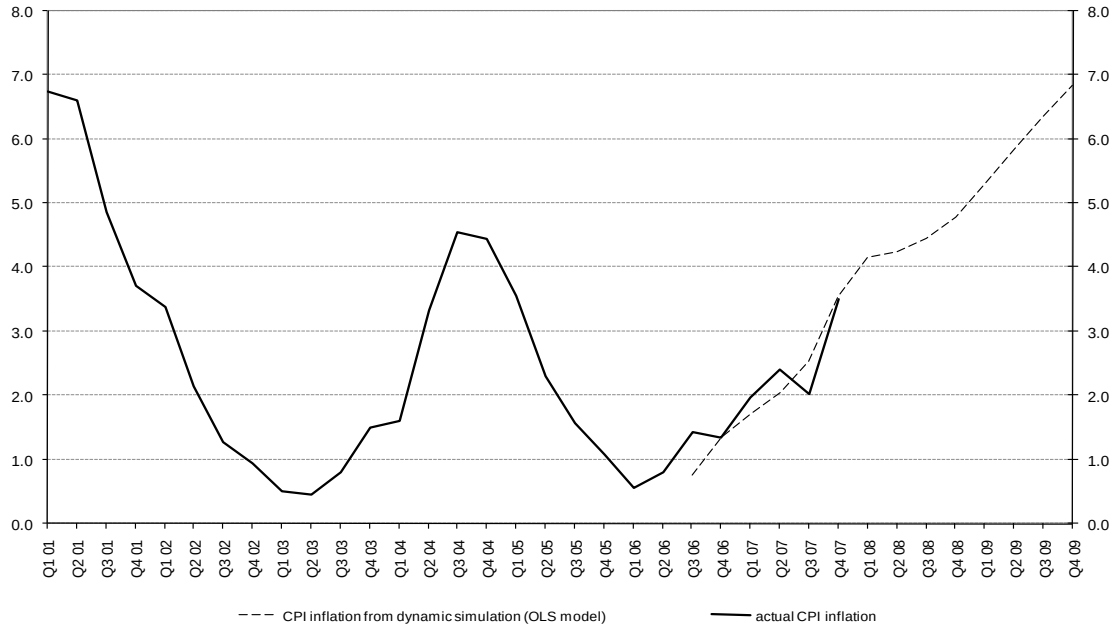
17. In the example under consideration, the higher the widening of the unemployment gap, the stronger the reaction in terms of projected CPI inflation.

18. From the theoretical point of view, adding one extra observation to the sample period brings additional information and improves the projection over the subsequent quarters, unless this observation is an outlier and deviates from the underlying trajectory. Rolling the estimates quarter by quarter and taking the average of projections for each quarter helps to mitigate this problem.

19. The trough in CPI inflation that occurred in 2007Q3 introduces a downward bias in projection (see the last panel in Figure Figure 3.A1.3 in Annex 3.A1), that is why the starting point for simulation purposes was brought forward by one quarter.

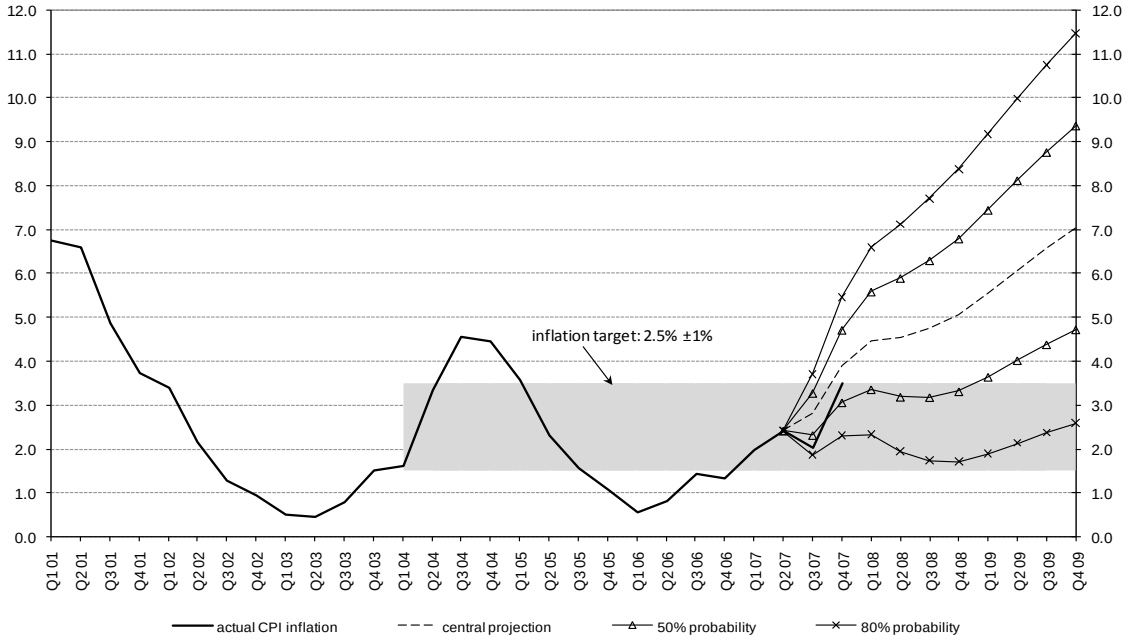
20. The gap between the two central projections does not exceed 0.2-0.3 percentage points on average in 2008 and 2009.

Figure 9. **Actual and projected CPI year-on-year inflation rate**



Source: Own calculations.

Figure 10. **Actual and fan chart of projected CPI year-on-year inflation**



Source: Own calculations.

Table 4. **Intervals for CPI inflation projections**

	Central projection	Intervals in which CPI inflation will remain with a given probability				
		30%	50%	60%	80%	90%
2007Q3	2.8	2.5–3.1	2.3–3.3	2.2–3.4	1.9–3.7	1.6–4.0
2007Q4	3.9	3.4–4.4	3.1–4.7	2.8–4.9	2.3–5.5	1.8–5.9
2008Q1	4.5	3.8–5.1	3.4–5.6	3.1–5.9	2.3–6.6	1.7–7.2
2008Q2	4.5	3.8–5.3	3.2–5.9	2.8–6.2	1.9–7.1	1.2–7.9
2008Q3	4.7	3.8–5.6	3.2–6.3	2.8–6.7	1.7–7.7	0.9–8.6
2008Q4	5.0	4.1–6.0	3.3–6.8	2.9–7.2	1.7–8.4	0.7–9.4
2009Q1	5.5	4.5–6.6	3.6–7.4	3.2–7.9	1.9–9.2	0.8–10.3
2009Q2	6.1	4.9–7.2	4.0–8.1	3.5–8.6	2.1–10.0	1.0–11.1
2009Q3	6.6	5.3–7.8	4.4–8.8	3.8–9.3	2.4–10.8	1.1–12.0
2009Q4	7.0	5.7–8.4	4.7–9.4	4.1–9.9	2.6–11.5	1.3–12.8
Average 2008	**4.7**	**3.9–5.5**	**3.3–6.1**	**2.9–6.5**	**1.9–7.5**	**1.1–8.3**
Average 2009	**6.3**	**5.1–7.5**	**4.2–8.4**	**3.7–9.0**	**2.2–10.4**	**1.1–11.5**

Source: Own calculations.

These findings are qualitatively consistent with market expectations, the NBP's estimates and views expressed by the MPC, though the extent of projected deviation from the target is probably higher than what the available evidence points to.

- Justifying the 0.25 percentage point interest rate hikes to 5.75% decided on at its meetings held at the end of June, August and November 2007 and in the three consecutive months of 2008, the MPC acknowledged that the probability of inflation running above the 2.5% target in the medium term was higher than the probability of inflation running below it.

- At the meeting held in November 2007, the MPC explicitly recognised that inflation will evolve above the central trajectory of the October's ECMOD model projection (NBP, 2007c), and this diagnosis was confirmed in a statement released in mid-December.

- The latest February 2008 NBP's ECMOD model projection indicated that the central path of inflation should reach 4.2% in 2008 and 3.7% in 2009 and thus remain well above the upper 3.5% tolerance band for deviations (NBP, 2008).

- Market participants have been revising their CPI projections upward.[21]

4. Estimates of the cyclically-adjusted budget balance

With output and unemployment gaps estimates at hand, it is possible to measure the cyclically-adjusted budget balance for Poland. To this end, the latest framework in use at the OECD has been applied, described in Girouard and André (2005). Recall that according to this approach, cyclically-adjusted general government net lending (ratio to potential output), b^*, is calculated from actual tax revenues adjusted by the ratio between potential output and actual output, while actual expenditures are weighted by the ratio of structural unemployment to actual unemployment, with relevant elasticities applied in each case:

21. For instance, by end January 2008, Merrill Lynch experts forecasted CPI inflation of 4.4% for 2008 (Bodys, 2008).

$$b^* = \left[\left(\sum_{i=1}^{4} T_i (Y^*/Y)^{\varepsilon_{t_i,y}} \right) - G(U^*/U)^{\varepsilon_{g,y}} + X \right] \Big/ Y^*, \quad (1)$$

where T_i stands for actual tax revenues for the i-th tax category, G denotes the actual current primary current government expenditures (*i.e.* excluding capital and interest outlays), X for non-tax revenues minus capital and net interest spending, Y (Y^*) the level of actual (potential) output, U (U^*) the level of actual (structural) unemployment, $\varepsilon_{t_i,y}$ the elasticity of the i-th category of tax with respect to the output gap and $\varepsilon_{g,y}$ the elasticity of current primary government expenditure with respect to the ratio of structural to actual unemployment. The values for different elasticities come from Girouard and André (2005) and amount to 1.39 for the corporate tax, 1.00 for personal and indirect taxes and 0.69 for social security contributions. As far as the current expenditure elasticity is concerned, the authors evaluate it at 0.024.

The gap between actual and cyclically-adjusted adjusted budget balances has been following a U-shaped evolution driven by changes in the unemployment and output gaps (Table 5).[22] Estimates for 2006 are worth a consideration as an improvement in actual net lending was coupled with a broadly unchanged structural component. The faster and sharper decline in registered unemployment as compared with the NAIRU implied less cyclical spending for unemployment benefits, while larger tax revenues were induced by a higher actual than potential GDP. With the output and unemployment gaps widening even further in 2007, the gap between general government net lending and its cyclically-adjusted component is expected to have reached 1% of GDP, mainly driven by cyclical revenues.

Table 5. **Actual and cyclically-adjusted government net lending**

	Net lending	Cyclically-adjusted net lending	Cyclical net lending (1)-(2) (5)-(6)	Cyclical revenues	Cyclical expenditure	Output gap	Unemployment gap
	(1)	(2)	(4)	(5)	(6)	(7)	(8)
1996	-4.9	-4.9	0.0	-0.1	0.0	-0.01	0.5
1997	-4.6	-5.3	0.6	0.4	-0.1	1.4	1.2
1998	-4.3	-4.6	0.3	0.2	-0.1	0.6	1.3
1999	-2.3	-2.3	0.0	0.1	0.1	0.2	-1.6
2000	-3.0	-3.0	-0.1	0.1	0.2	0.2	-2.5
2001	-5.1	-4.2	-0.9	-0.7	0.2	-2.3	-3.3
2002	-5.0	-3.5	-1.5	-1.2	0.2	-3.8	-3.4
2003	-6.3	-5.1	-1.2	-0.9	0.1	-2.9	-2.1
2004	-5.7	-5.3	-0.4	-0.3	0.0	-0.9	-0.9
2005	-4.3	-4.1	-0.3	-0.3	0.0	-0.8	0.3
2006	-3.8	-4.2	0.5	0.2	-0.2	0.8	3.0
2007	-2.8	-3.8	1.0	0.6	-0.4	1.8	5.1

Note: Some discrepancies may exist due to rounding.

Source: Own calculations and OECD (2007b) for net lending values.

22. In accordance with the Eurostat definition, net lending data are for private pension funds (OFE) classified outside the general government sector and thus include the budgetary costs of the 1999 pension reform.

Table 6. **Sensitivity analysis of cyclically-adjusted government net lending**

		Proposed new OECD estimates			European Commission estimates			
					Production-function method		HP filter method	
	Net lending	Cyclically-adjusted net lending	Output gap	UNR gap	Cyclically-adjusted net lending	Output gap	Cyclically-adjusted net lending	Output gap
1996	-4.9	-4.9	-0.01	0.5	-4.5	-0.9	-4.5	-0.9
1997	-4.6	-5.3	1.4	1.2	-4.9	0.7	-5.3	1.7
1998	-4.3	-4.6	0.6	1.3	-4.5	0.5	-5.2	2.3
1999	-2.3	-2.3	0.2	-1.6	-2.5	0.5	-3.3	2.6
2000	-3.0	-3.0	0.2	-2.5	-3.5	1.3	-4.0	2.8
2001	-5.1	-4.2	-2.3	-3.3	-5.1	-0.2	-5.1	-0.1
2002	-5.0	-3.5	-3.8	-3.4	-4.4	-1.6	-4.0	-2.7
2003	-6.3	-5.1	-2.9	-2.1	-5.8	-1.1	-5.1	-3.0
2004	-5.7	-5.3	-0.9	-0.9	-5.8	0.3	-4.9	-2.0
2005	-4.3	-4.1	-0.8	0.3	-4.1	-0.5	-3.3	-2.7
2006	-3.8	-4.2	0.8	3.0	-3.9	0.3	-3.3	-1.2
2007	-2.8	-3.8	1.8	5.1	-3.0	0.9	-3.0	0.7

Source: Own calculations, European Commission (2007) and OECD (2007b) for net lending values.

With this as a background, Table 6 compares the obtained estimates with those of the European Commission (2007). Some discrepancies remain, notably due to differences in measures of the unemployment and output gaps (the latter either derived from the production-function framework or using the HP filter) and the methodological approach applied for deriving the cyclically-adjusted budget balance. Indeed, instead of relying on equation (1), the European Commission estimates consist in adjusting directly net lending figures by the product of the output gap by and an aggregate measure of elasticities of individual budgetary items (European Commission, 2006).

5. Conclusion

This paper puts forward a new framework to analyse the supply side of the Polish economy based on the production-function method, in accordance with the standards adopted for other countries at the OECD. It is a timely opportunity to have such a tool for assessing fiscal and monetary policy developments in Poland. Indeed, the strong cyclical rebound in economic activity (6.2% in 2006 and 6.5% in 2007) raises concerns as to the balance between supply and demand and thus the capacity of the Polish economy to expand without inflationary pressures in the short term and pursue a non-inflationary growth path over the medium term. For instance, overestimating potential GDP may lead to central bank decisions that fall behind the curve. The output- and unemployment-gap measures identified in this study appear to yield useful indications for the conduct of monetary policy, although the latter might to some extent be more suitable for detecting medium-term trends in price dynamics rather than immediate short-term inflationary pressures. Yet out-of-sample projections derived from the Phillips-curve model that includes the unemployment gap clearly reveal that inflation should continue to trend upward in 2008 and 2009, a result that appears to be consistent with the expected level for the output gap. Potential output estimates provided in this study have also been used to provide a first set of structural budget balances. This is highly important from the policy perspective as an upswing phase of the business cycle also implies a risk of overestimating the underlying degree of fiscal improvement due to higher-than-expected tax revenues and lower-than-expected expenditure on unemployment benefits. As a result, the need of structural reforms might seem less pressing and fiscal consolidation efforts delayed.

Although potential output is an unobservable variable and its measure is surrounded by considerable uncertainty, a maximum effort has been made to establish a set of reliable estimates. Data and information provided by the National Bank of Poland made these investigations feasible and helped establish a benchmark for the resulting estimates, which is all the more useful as the existing empirical evidence for Poland is scant. However, if the scale of the emigration process and its impact on the working-age population and labour supply (and thus on unit labour costs) is not adequately taken into account or only with a lag, then more or less important revisions to past potential output estimates may occur. For instance, the last census in 2002 has already implied a downward level shift in the labour force since 2003. And the next one will probably uncover the scale of emigration in the post-EU accession period.[23] On the other hand, even if these developments have a negative impact on potential employment and thus on potential output growth, it might be the case that more refined measures of the capital stock (for instance, based on productive capital stock estimates) could prove to act as counteracting forces.

23. In a recently published survey on labour outflows from Poland after 2002, the GUS confirmed that LFS data are biased due to migration, but did not provide adjusted time series.

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Annex 1.A1

Overview of the main definitions underlying the production function methodology

Defining a production function for the Polish economy

The methodological framework applied by the central bank within the official projection tool – the ECMOD model (Fic *et al.*, 2005) – is based on a two-factor constant returns to scale Cobb-Douglas production function of the form:

$$Y_t = TFP_t \ (LF_t(1-U_t))^{\alpha} K_t^{1-\alpha}, \qquad \text{(A1)}$$

and is slightly different to that in use at the OECD and that is also resorted to in this paper:

$$Y_t = (TFP_t H_t POPT_t (LF_t / POPT_t)(1-U_t))^{\alpha} K_t^{1-\alpha}, \qquad \text{(A2)}$$

where Y_t is GDP, TFP_t total factor productivity, LF_t the labour force, K_t the capital stock, $POPT_t$ and $\left(LF_t / POPT_t\right)$ respectively the working-age population and the participation rate and H_t the average number of hours worked per employee. The output elasticity of labour and capital are represented by α and $1-\alpha$ respectively.

Under the assumption of constant returns to scale and perfect competition on the product market in the long term, the output elasticity of labour and capital can be calibrated at factor prices. One should note, however, that when computing the average wage share on the national accounts basis, there is a problem with unincorporated business income as it combines both, labour and capital factors' remunerations. Needless to say, that the calibration of α parameter is of primary importance for the overall result. For instance, the stronger α is, the lower the impact of the capital stock on GDP and the economy's potential. According to the ECMOD model, the central bank hypothesises that the α parameter in equation (A1) is equal 0.68, which is in line with international evidence. For comparison purposes, the European Commission hypothesis for Poland reported in Denis *et al.* (2006) is based on a broadly similar value of 0.65, while Gradzewicz and Kolasa (2004) evaluate the wage share as being equal to 0.55 on quarterly data over the period of 1995-2002. With this as background, standard OECD estimates of the labour elasticity with respect to output, similar to those performed for other member countries, yield a value of 0.64. This elasticity is subsequently applied in the model.

In April 2007, the central bank switched from a net to a gross measure of the capital stock. This change was due to some problems in getting plausible estimates of the depreciation rate, with the net capital stock showing unexpected variability. That is why this is the gross capital stock supplied by the central bank that is used for the purpose of building the supply block.

As a general rule, the whole-economy measure of the gross capital stock used at the central bank is computed through the perpetual-inventory method, taking into account the following lags' distribution describing the relationship between the completed fixed assets and the outlays incurred on them:

$$KEP_t = (1-\delta)KEP_{t-1} + 0.38I_t + 0.22I_{t-1} + 0.12I_{t-2} + 0.09I_{t-3} + 0.08I_{t-4} + 0.06I_{t-5} + 0.05I_{t-6}, \quad \text{(A3)}$$

where $K_t = (KEP_t + KEP_{t-1})/2$, I_t denotes seasonally adjusted quarterly gross fixed investment at constant prices and δ the scrapping rate. The scraping rate is constant, therefore a geometric survival law is assumed.

With regard to the number of hours worked, the official production-function method of the NBP considers only total employment data in modelling the labour supply. The new proposed approach developed here is based on the number of hours worked.[1] More specifically, quarterly LFS data from 1995 to 1999 linked to 2000 are used, and from 2000 onwards the OECD data produced on a harmonised basis by the OECD Directorate for Employment, Labour and Social Affairs.

As regards the working-age population and participation rates, central bank as well as OECD estimates are based on the LFS statistics. The NBP method relies on the number of persons aged 15 and over, as opposed to the 15 and over definition for the labour force and the 15-64 age bracket for the working-age population commonly applied by the OECD and which is also used in this study. Also, whatever the approach both adopted by the NBP or the OECD (and considered here), TFP_t is computed as a residual from solving out equations (A1) or (A2).

Breaking down the supply side of the Polish economy

According to the supply side of the ECMOD model, potential output is defined as follows:

$$Y_t^* = TFP_t^* (LF_t(1-U_t^*))^{\alpha} K_t^{1-\alpha}, \quad \text{(A4)}$$

The approach that is hypothesised here corresponds to the standard OECD framework based on Harrod-neutral technical progress with labour augmenting productivity:

$$Y_t^* = (TFP_t^* H_t^* POPT_t (LF_t/POPT_t)^* (1-U_t^*))^{\alpha} K_t^{1-\alpha}, \quad \text{(A5)}$$

where Y_t^* is the level of potential output, TFP_t^* trend total factor productivity, H_t^* trending hours per employee, LF_t the labour force, K_t the capital stock, $POPT_t$ and $(LF_t/POPT_t)^*$ respectively the working-age population and the potential participation rate, U_t^* the structural unemployment rate and α the output elasticity of labour.

The official NBP approach assumes that trend total factor productivity is generated by direct HP detrending of the TFP_t series. For the purpose of this study, it has been decided to stick to this convention (also adopted for other countries at the OECD) and thus to smooth total factor productivity with the HP filter.

1. The data are for the average number of hours worked per week in the main and additional job.

Finally, a few details should be given about the definition and the statistical treatment of the components of potential labour supply. Trending hours per employee (H_t^*) and participation rates $\left(LF_t / POPT_t\right)^*$ contained in equation (A5) are computed with the use of the HP filter. The LF_t variable in equation (A4) is an unsmoothed measure of the labour force.

Annex 2.A1

Models developed by the NBP for assessing the NAWRU

Estimates of the supply block made by the Polish central bank are based on a NAWRU (Non-Accelerating Wage Rate of Unemployment) definition of the structural unemployment rate. The NAWRU measure is preferred to the NAIRU indicator for modelling purposes. More specifically, as the ECMOD model is a structural tool, it allows for a feedback from the unemployment gap to wages and then from wages to inflation through unit labour costs. In order to assess the level of the NAWRU rate, several different methods have been tested by the central bank.

As a first approach, the NAWRU rate was computed using a quarterly version of the Elmeskov (1993) technique, based on a wage Phillips curve relationship relating linearly the acceleration or deceleration of the growth rate in nominal wages to the unemployment gap:[1]

$$\Delta^2 \ln(W_t) = -\alpha(\varphi(L)U_t - NAWRU_t), \qquad \text{with } \alpha > 0 \tag{B1}$$

where Δ is the first-difference operator, $\varphi(L)$ is a lag polynomial and L the lag operator. W_t and U_t are the levels of wages and unemployment, respectively.

Assuming the NAWRU to be constant between two consecutive quarters, one can calculate the α parameter by taking a first derivative (in discrete time) of equation (B1) with respect to the unemployment rate. Hence, equation (B1) can be rewritten as:

$$NAWRU_t = \varphi(L)U_t - \frac{\Delta^2 \ln(W_t)}{\Delta^3 \ln(W_t)} \Delta\varphi(L)U_t, \tag{B2}$$

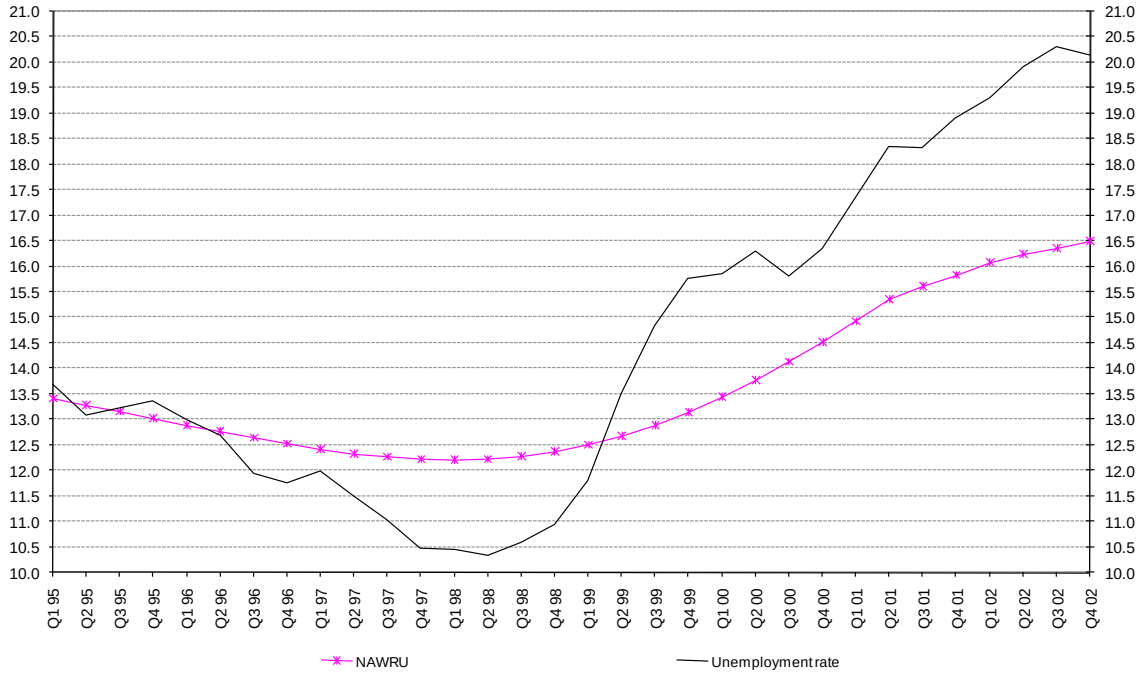
In order to take into account the delay with which the labour market situation impacts on changes in wages, Gradzewicz and Kolasa (2004) assume a lag polynomial of order four and a hypergeometrical distribution of $\varphi(L)$ coefficients. Figure 2.A1.1 plots the estimated smoothed series of the NAWRU rate found by the authors for the sample period from 1995 to 2002.[2]

In late 2005, the central bank decided to switch to a different estimation technique. The structural unemployment rate used in the ECMOD model up to 2006Q4 was derived from a wage Phillips curve with the help of the Kalman filter technique.

1. Equation (B1) is derived by assuming that in the labour market the expected real wage growth rate is a linear function of the unemployment gap and that economic agents have static inflation expectations.

2. Raw estimates are smoothed with the HP filter and for reducing the end of sample bias, an average level of approximately 16% was assumed for the NAWRU rate in 2002.

Figure 2.A1.1 **NAWRU from the Elmeskov (1993) method and the unemployment rate**



Source: Gradzewicz and Kolasa (2004).

Since April 2007, the NAWRU unemployment rate has been endogenised in the ECMOD model. It is now derived from a structural approach of the labour market, where firms are price setters and bargain with workers over both wages and employment levels. The model is detailed in Budnik (2006) and is based on the McDonald and Solow (1981) theoretical framework of a bargaining process between a union and a firm. From the empirical point of view, two co-integrating relations (interpreted as "price" and "wage" curves) describe firm-worker interactions. The structural rate of unemployment is determined provided that both co-integrating relations prevail. More specifically, the NAWRU is a function of the co-integrating vectors' parameters, variables present in "price" and "wage" curves, the stock of capital and the labour force (all variables are in logarithms):

$$nawru = (1-\alpha+\beta_1)^{-1}\left[tax\_wedge + price\_wedge + \theta_1 tot + benefits + reform99 + \right.$$
$$\left. + const + (1-\alpha)(aktyw-k) + \theta tfp - \delta\right] \qquad \text{(B3)}$$

where the corresponding definitions are as follows:

- α : elasticity of GDP to labour
- β_1 : semi-elasticity of wages to the unemployment rate
- tax_wedge = effective rate of revenues from social contributions paid by employers + effective rate of revenues from social contributions paid by employees + effective Personal Income Tax rate + effective rate of revenues from health insurance contributions
- $price\_wedge$ = consumer price index – GDP deflator

- tot = import deflator – GDP deflator
- $benefits = \beta_2 rp\_benefit + \beta_3 rp\_relief + \beta_4 (1 - d97q1)$: unemployment benefit replacement rate + social benefit replacement rate + level-shift dummy aiming to capture the impact of the unemployment benefit system reform in force since 1997Q1
- $reform99 = -\theta_2 (1 - d99q1)$: level-shift dummy aiming to capture the impact of the social insurance system reform introduced in 1999Q1
- $const = \beta_0 - \theta_0$: constant
- $aktyw$: labour force (from the LFS statistics)
- k : average capital stock over the sample period
- tfp: total factor productivity
- δ : ratio of the number of people employed in the agriculture sector to the total labour force

Based on equation (B3), the computed structural rate of unemployment is characterised by high frequency fluctuations mainly due to an important variability of fiscal time series. These are removed by applying the HP filter. Figure 2.A1.2 shows the estimated "raw" NAWRU measure, its filtered component and the actual unemployment rate over the period from 1995Q1 to 2005Q4.

Figure 2.A1.2. **"Raw" NAWRU, NAWRU from an HP filter and actual unemployment rate**

Source: Budnik (2006).

Figure 2.A1.3. **Unemployment compensation**

Source: Budnik (2006).

According to these estimates, in 1995 the equilibrium unemployment rate remained at the level of 16% and the registered unemployment rate at around 14%. Until 1999, both the structural and actual unemployment rates were decreasing and the negative unemployment gap was gradually narrowing. Budnik (2006) quotes two factors that lie behind these developments. First, the drop in the equilibrium unemployment rate is attributed to the reform of the unemployment benefit system introduced in 1997: benefits were differentiated according to work experience, the unemployed had to work longer to be eligible for benefits and replacement rates were reduced on average. As a result, the percentage of unemployed who collected unemployment benefits was halved in only one year's time (Figure 2.A1.3). The second important contributing factor is linked to terms-of-trade modifications following a marked reduction of import tariffs.

In the aftermath of the financial crisis in Russia in 1998, the Polish economy suffered from a negative foreign demand shock, which contributed to a progressive increase in the unemployment rate. However, the structural unemployment rate also started to rise progressively at the turn of the decade. The NAWRU bounced back from 12% in 1999 to hover around 16% in 2003. The unemployment gap widened until 2002, when the actual unemployment rate peaked at 20%. Several clues are put forward in Budnik's (2006) paper for explaining the upward movement in the NAWRU.

- The increase in the NAWRU at the end of the 1990s was probably an unintentional outcome of the far-reaching reform of the social insurance system introduced in 1999. Among other measures taken, the reform included changes in the health insurance system which restricted eligibility to healthcare insurance to employed and unemployed only (with the social insurance contribution of the latter covered by the government). As a consequence, this decision increased the relative attractiveness of the unemployed as compared with the economically inactive status and led to higher flows from the latter to the former category. Relevant parameters estimates confirm a negative net impact of the 1999 reform on the NAWRU.

- The restrictiveness of the unemployment-benefit system was partially loosened at the beginning of the current decade, leading to a rise in the replacement rate (Figure 2.A1.3).

- Some upward pressure on the equilibrium unemployment rate was exerted through shifts in relative prices, due to modifications in the price wedge between 2000 and 2001 (which could

have been induced by a delayed pass-through of effective indirect tax rate hikes) and to a terms-of-trade shock between 2002 and 2003 (due to a pronounced Zloty depreciation).

Starting in 2004, the NAWRU has showed a moderate downward movement as Figure 2.A1.2 plots. This downward movement has been linked to an acceleration of gross fixed investment, coupled with a small restraint of the unemployment benefit system's generosity. The strengthening of the Zloty has played in the same direction.

In this paper Budnik (2006) also tries to assess the long-run NAWRU, *i.e.* the structural rate of unemployment that would prevail had the inflation rate reached its steady-state level. In this approach, the NAWRU is a function of the real cost of capital and no longer depends on changes in the capital stock; it is also supposed to be determined by net foreign assets to GDP ratio, tax variables and the gap between domestic and foreign short term interest rates. More precisely, it is given by the following equation:

$$nawru^{*} = \beta_1^{-1}\Big[\, tax\_wedge^{*} - \theta_1\big(\eta_1(\gamma_1 nfa\_gdp + \gamma_2(i\_w3m - i3m\_ext) + \gamma_3 d04q2 - \gamma_0) - \eta_0\big) + \\ + benefits + reform99 + const + dummy + \left(\frac{1-\alpha}{\alpha}\right)(rucc - \ln(1-\alpha)) - \delta\,\Big] \tag{B4}$$

The steady-state tax wedge and price wedge are defined as follows, with the latter being pinned down by the level of indirect taxes:

$$tax\_wedge^{*} = tax\_wedge + price\_wedge^{*} + \theta_1 ggat\_tr \tag{B5}$$

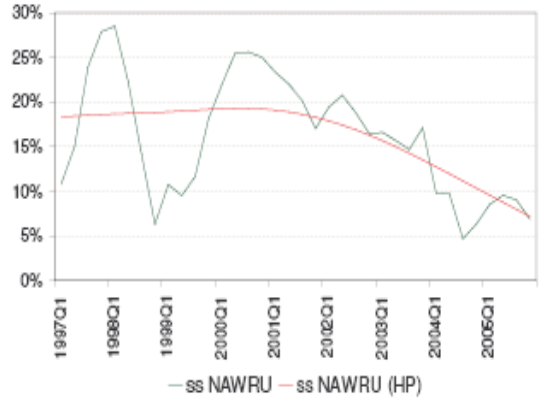
$$price\_wedge^{*} = \lambda(gvat\_tr + gext\_tr + ggam\_tr - gtr\_goods\_tr) + \nu_0 \tag{B6}$$

Additional as compared to equation (B3) definitions of variables are:

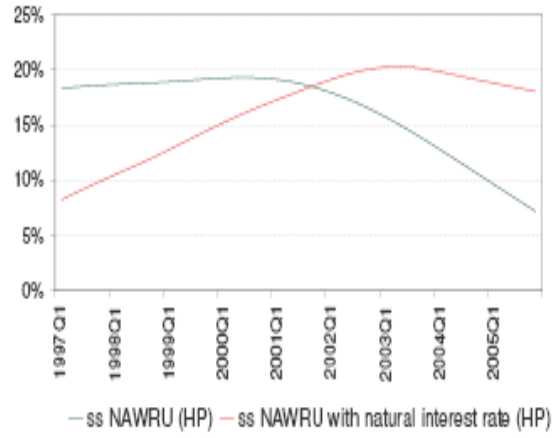
- nfa_gdp : net foreign assets to GDP ratio
- i_w3m : real three-month domestic money market interest rate
- $i3m\_ext$: real three-month foreign interest rate
- $\gamma_3 d04q2$: dummy variable standing for the positive shift in Polish trade competitiveness after joining the EU
- $rucc$: real cost of capital
- $ggat\_tr$: effective import tax rate
- $gvat\_tr$: VAT effective rate
- $gext\_tr$: effective excise tax rate
- $ggam\_tr$: effective gaming tax rate
- gtr_goods_tr : effective transfers to products

Figure 2.A1.4. **Steady-state NAWRU**

Steady-state NAWRU and its HP filtered component using a real 3-month money market interest rate



HP filtered components of steady-state NAWRUs using a real 3-month money market interest rate and a real natural interest rate



Source: Budnik (2006).

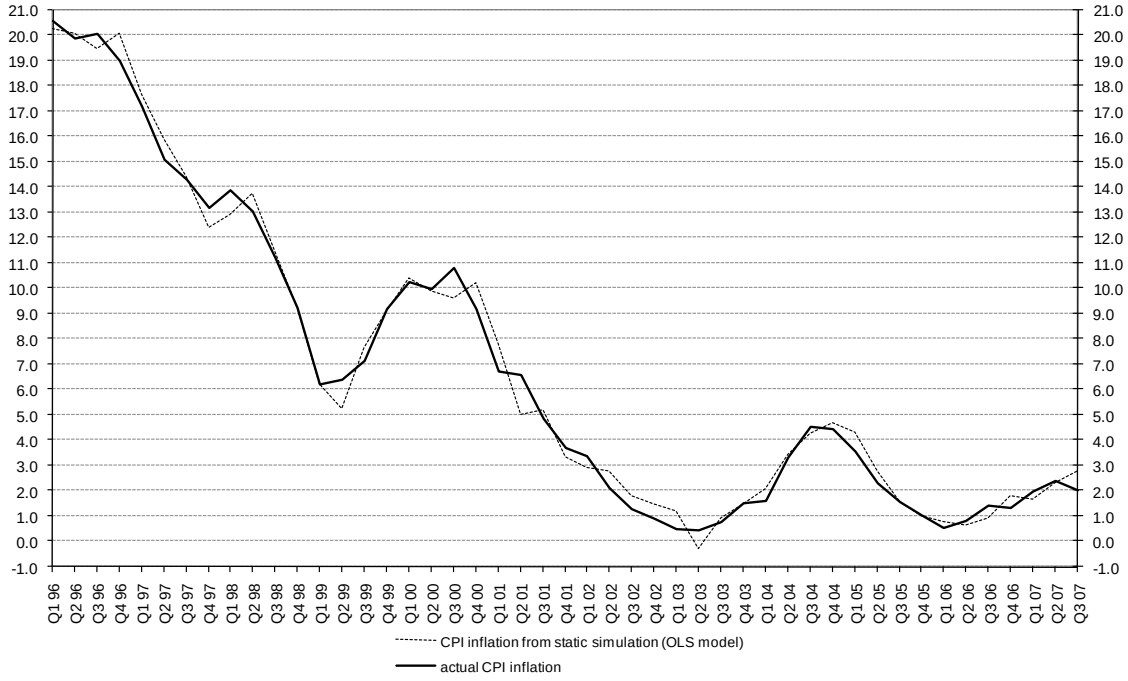
The left-hand side of Figure 2.A1.4 plots the estimated steady-state NAWRU and its HP filtered component. Budnik (2006) finds that changes in the user cost of capital, mainly linked to real interest rates, have been the main driver of the long-term structural unemployment rate. Thus, the high level of interest rates between 1998 and 2000 put an upward pressure on the NAWRU, and a progressive monetary policy easing has allowed its steady decline since 2001. Labour-market reforms at the end of the 1990s had also an impact on its profile, with a stronger restrictiveness of the unemployment benefit system exerting a downward influence in 1998 and 1999 as opposed to the social insurance system reform introduced in 1999 (*cf.* above). Finally, marked outflows of the labour force from the agriculture sector had also contributed to the high level of the long-run NAWRU at the beginning of the sample period.

However, the estimates of the steady-state NAWRU appear to be very sensitive, since using a real natural interest rate (equal to 4% for the whole period under consideration) instead of the real 3-month money-market interest rate in equation (B4) yields a rather different profile of the NAWRU as the right-hand side of Figure 2.A1.4 reveals.

Annex 3.A1

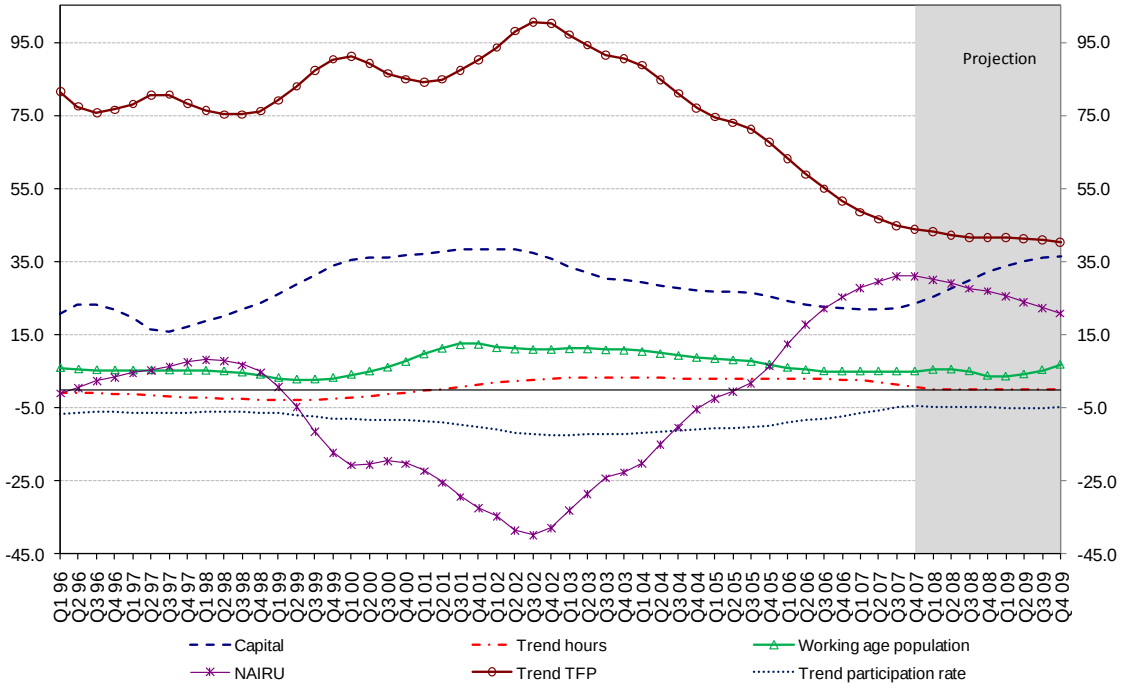
Figures illustrating additional findings

Figure 3.A1.1. **Actual and fitted CPI inflation issued from the Phillips curve model**



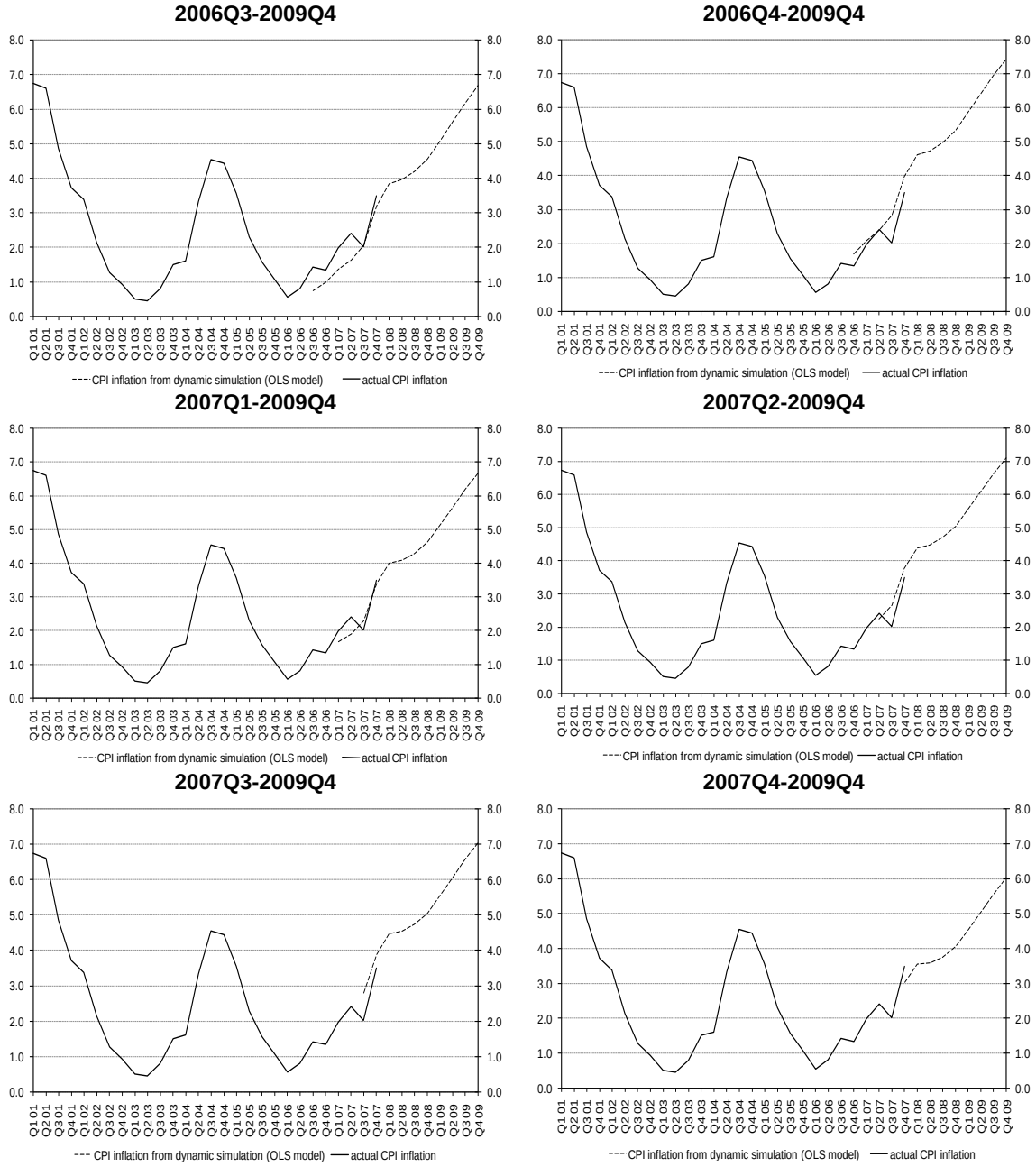
Source: Own calculations.

Figure 3.A1.2. **Relative contribution of each component to potential output growth rate**



Source: Own calculations.

Figure 3.A1.3. **Out-of-sample projections of inflation issued from the Phillips curve model**



Source: Own calculations.

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