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ESTIMATING NATURAL RATE OF INTEREST: THE CASE FOR AZERBAIJAN

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Estimating Natural Rate of Interest: The Case for Azerbaijan[1]

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Abstract

The natural rate of interest is widely used by central banks as a policy benchmark to determine the stance of the monetary policy. This study defines the natural rate of interest as the real short-term interest rate consistent with output at its potential and stable inflation. To estimate the natural rate of interest in Azerbaijan, the methodology by Laubach and Williams (2003) has been implemented. Kalman filter is applied to jointly estimate the natural rate of interest, potential output, and its trend growth rate, and examine the empirical relationship between estimated unobserved series for the period 2004:1 to 2023:2. The findings indicate that the natural rate of interest in Azerbaijan has averaged approximately 3.1 percent. The empirical results also reveal a slight decrease in the natural rate of interest over the sample period, mostly due to the slowdown in potential GDP growth.

Keywords: natural rate of interest, potential output, output gap, monetary policy

JEL: C32, E43, E52, O40

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I. Introduction

Azerbaijan is a small open economy and revenues from oil export has been a key driver of current account surplus. The country's GDP growth has been strongly linked to global oil prices leading to the periods of economic instability. Non-oil sector has emerged as a robust contributor to GDP growth in recent years. Inflation is mostly driven by the terms of trade and foreign price shocks due to the composition of the consumption basket.

To maintain inflation within the target level, which is 4±2%, Central Bank of the Republic of Azerbaijan (CBAR) enacted several measures aimed at reforming the operational framework of its monetary policy. These measures have notably contributed to the enhancement monetary policy transmission through the interest rate channel. Within this context, the fundamental role of interest rates as a tool has been emphasized. Since the short-term interest rate is one of the primary operational targets within the current monetary framework, the estimating the natural rate of interest is crucial task for the efficiency of the monetary policy decisions.

The idea of a natural rate was originally introduced by Wicksell (1898), which is defined as the level of the real interest rate consistent with stable commodity prices. Wicksell argued that any deviation of the real interest rate from its natural level would lead to an ongoing increase or decrease in the overall price level. The idea of a natural rate was further developed by Woodford (2003). In this study, the natural rate of interest is defined as the real short-term interest rate consistent with output, which converges to its potential and stable inflation. The difference between the real interest rate and the natural rate indicates whether monetary policy is expansionary or contractionary or neutral. The assessment of monetary policy stance is crutial for the formulation of monetary policy decisions. It shows if monetary policy is contributing to economic and financial developments that support the maintaince of price stability over the medium term.

The objective of this paper is to estimate the natural real interest rate for Azerbaijan. The study employs methodology developed by Laubach and Williams (2003) based on the Kalman filter to estimate the natural rate and potential growth. The specification of the model is different from the original Laubach and Williams model in two aspects. First, the oil price is omitted from the Phillips curve equation due to its indirect relation with the non-oil output. Being a nation abundant in oil resources, huge variations in oil prices impact the non-oil output through changes in budget expenditures. Second, in the Phillips curve equation, aggregated import price is replaced with the price of the fifteen main trading partners' CPI since the Azerbijani inflation is significantly

influenced by the price developments in these countries. Additionally, this study contributes to the existing literature on natural rate of real interest by providing estimates for the resource rich emerging market. The bulk of the existing literature regarding natural real interest rates has centered its attention on advanced economies.

There are several main findings to highlight. First, there is a slightly downward trend in estimated natural rates of interest toward the end of the sample, which is due to the decline in the estimated trend growth rate. We find that the relationship between the natural rate and trend potential output growth is modest. In addition, our estimate of the output gap shows the recession periods precisely. The empirical results also illustrate the assessment of monetary policy stance and its implications for the economy. The real interest rate gap has a divergent effect on the output gap. When the real rate gap was negative, the output gap tended to improve, and vice versa. During post-Covid periods, the level of the real interest rate falls below the natural rate, thus pointing to accommodative monetary policy conditions. However, starting from the second quarter of 2023, we observe a tightening of the monetary policy conditions.

The remainder of the paper is structured as follows. The second section provides a brief review of the literature, while the third section presents the empirical framework employed for the assessment of the natural rate in Azerbaijan. The results and their interpretation are described in the fourth section. The final section presents the conclusions.

II. Literature Review

The most widely used method for identifying the natural rate of interest in the literature is presented by Laubach and Williams (2003). It is based on a simple structural model in which the natural rate is a function of equilibrium real GDP growth. The model comprises two main equations. The first equation, derived from the Euler equation, establishes a connection between the output gap and the real interest rate. The second equation, known as the Phillips curve, links inflation to the output gap and relative price indicators. The previous studies employing Laubach-Williams's method find a declining trend in the natural rate of interest. According to the estimates, the natural interest rate for the United States was almost zero in 2016. Similar trends of declining natural rates were also observed by Holston *et al.* (2016) in Canada, the Euro Area, and the United Kingdom. They suggested that global factors such as secular stagnation could be significant contributors to diminishing trend, as these countries exhibited similar patterns. Importantly, this decline in the natural rate is consistent across different stages of economic development, affecting

both advanced and emerging market countries, as identified by Zhu (2016). Numerous studies have primarily focused on determining natural interest rates for developed economies, and only a limited number of studies focused on of the estimation of natural real interest rate for emerging markets and developing nations.

Besides the Laubach Williams approach, various other identification methodologies exist. Grui, Lepushynskyi, and Nikolaychuk (2018) employed the Quarterly Projection Model (QPM) to measure the natural interest rate specific to Ukraine, while Hledik and Vlcek (2018) adapted a QPM for the Czech Republic. Kreptsev *et al.* (2016) used semi-structural models, including the one by Laubach and Williams, to estimate the natural rate for the Russian Federation. Fuentes and Gredig (2007) and Magud and Tsounta (2012) applied a variety of methodologies such as consumption-smoothing models, uncovered interest rate parity condition (UIP), common stochastic trends between short-term and long-term nominal interest rates inspired by Basdevant et al. (2004), Taylor rules, and semi-structural models following Laubach and Williams to determine natural rates for Latin American economies, respectively. Carrillo *et al.* (2018) estimated the modified Laubach and Williams specification for a small open economy, while Us (2018) employed a model with time-varying parameters, utilizing an extended Kalman filter to account for Turkey.

In this study, I will refer to the Laubach and Williams methodology due to its structural framework and popularity among researchers and policymakers.

III. Empirical Methodology

i. Specification of the Model

The model used in this paper is based on the empirical framework of Laubach and Williams (LW, 2003). The authors suggest running the Kalman filter on a system of equations to jointly estimate the natural real interest rate, potential output growth, and output gap. The proposed model is a simple reduced-form New-Keynesian model, which jointly characterizes the behavior of inflation, and the output gap through modified IS and Phillips curves. In particular, the model takes the following forms:

$$\tilde{y_t} = a_{y1}\widetilde{y_{t-1}} + a_{y2}\widetilde{y_{t-2}} + \frac{a_r}{2}\sum_{j=1}^{2}\left(r_{t-j} - r^*_{t-j}\right) + \varepsilon_{1t} \qquad (1)$$

$$\pi_t = \sum_{i=1}^{4} b_{1i}\pi_{t-i} + b_2\tilde{y}_{t-1} + b_3\left(\pi_{t-1}^f - \pi_{t-1}\right) + \varepsilon_{2t} \quad (2)$$

$$r_t^* = cg_t + z_t \quad (3)$$

$$z_t = z_{t-1} + \varepsilon_{3t} \quad (4)$$

$$y_t^* = y_{t-1}^* + g_{t-1} + \varepsilon_{4t} \quad (5)$$

$$g_t = g_{t-1} + \varepsilon_{5t} \quad (6)$$

Equation (1) represents the output gap, which is defined as the percentage deviation of real non-oil GDP from its potential level. It is a function of its own lags, the lags in the real policy interest rate and the natural rate of interest differentials, and an uncorrelated error term. The output gap is positively affected by its own lags. The real interest rate gap has a negative impact on the output gap. Namely, tighter monetary policy reduces output gap by raising the real interest rate above the natural real interest rate.

Equation (2) describes the core inflation level. The core inflation is measured by the annualized growth rate of the consumer price index excluding the prices of goods and services regulated by the state, as well as seasonal agricultural products. It is determined by its own lags, lagged output gap, relative price, and uncorrelated error. The relative price variable includes the main trading partner's inflation measured as deviation from core inflation.

Equations (1) and (2) constitute the key measurement equations of the model in state space.

Equation (3) expresses the natural rate of interest. The economic theory imposed by LW implies that the natural rate of interest depends on the trend growth rate (g_t) and other determinants (z_t). *z* follows a stochastic process determined by equation (4).

Finally, equation (5) refers to potential output. It is assumed to follow a random walk with a stochastic drift *g* that itself follows a random walk (equation 6).

Equations (3)-(6) are the transition equations of the state-space model.

ii. Data

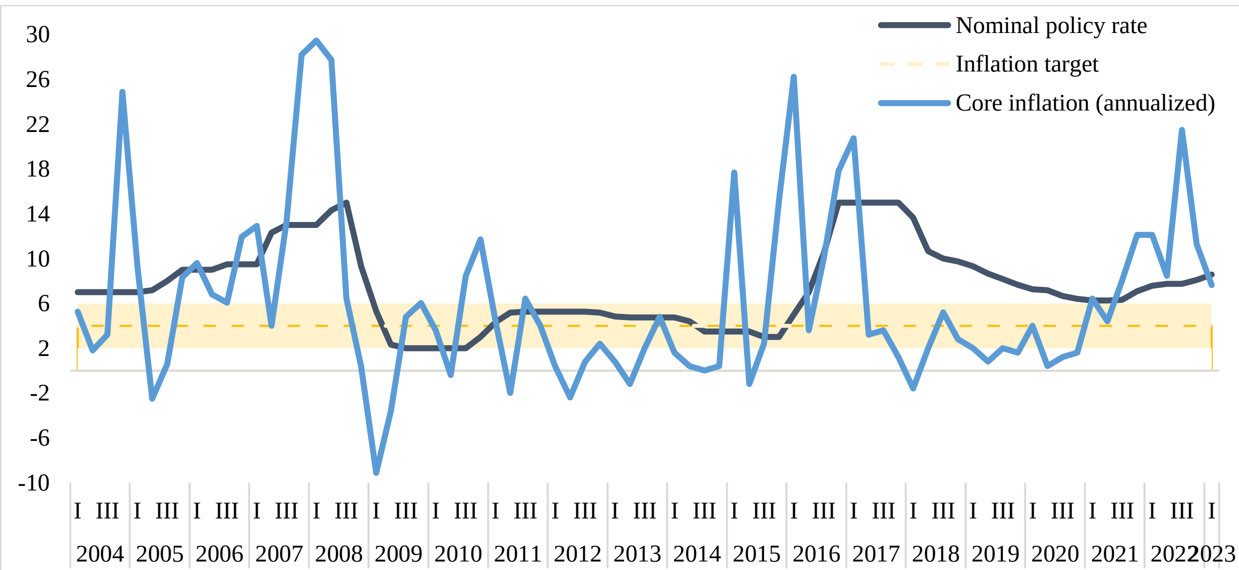
The estimation is based on the quarterly data over the period 2004:1 to 2023:2. The model contains data on real non-oil GDP, inflation, inflation expectations, and nominal interest rate. The variable *y* refers to the log of seasonally adjusted[3] real non-oil GDP at constant prices obtained

[3] Seasonal adjustment is made by the X-11 method.

from the State Statistics Committee of the Republic of Azerbaijan (SSCRA). The policy rate is the annualized nominal rate, with the quarterly figure computed as the average of the monthly values. The real interest rate is the difference between the nominal policy rate and inflation expectations generated from a univariate AR (4) model of inflation. The relative price variable included in the inflation equation is the main trading partners' CPI obtained from Central Bank of the Republic of Azerbaijan (CBAR) database. It is calculated as the weighted cpi of fifteen trading partners.

Figure 1 exhibits the dynamics of nominal policy rate and core inflation. The dynamic of core inflation is volatile during the estimation period while most of the time, the decision made by CBAR on policy rate is accommodative.

Figure 1. Nominal policy rate and core inflation dynamics in Azerbaijan, %



Source: CBAR & SSCRA

The methodology used to determine the lag lengths in equations (1) and (2) is consistent with LW. However, in the Phillips curve equation (equation 2), we opted for a shorter lag length than theirs due to the limitations posed by the sample size available for analysis.

iii. Estimation Methodology

The estimation methodology is the same as in LW. The estimations were made by the maximum likelihood method using Kalman filter. Since the potential growth and natural interest rate are unobservable and must be inferred from the data, the maximum likelihood estimated variances of these components are biased towards zero. The problem is known as "pile-up"

discussed by Stock and Watson (1998). To avoid such problem, first, Stock and Watson's (1998) median unbiased estimator is used to obtain the so-called ratios defined as:

$$\lambda_g = \frac{\delta_5}{\delta_4} \quad and \quad \lambda_z = \frac{\delta_3}{\delta_1} x \frac{a_r}{\sqrt{2}}$$

Here, λ_g is defined as a ratio of the standard deviations of the trend growth (δ_5) and the potential output (δ_4) and λ_z is defined as a ratio of the standard deviations of the term z_t (δ_3) and the output gap (δ_1) multiplied the ratio of the coefficient a_r in equation (1) and $\sqrt{2}$.
Then these ratios are imposed in the estimation of the remaining model parameters by maximum likelihood.

IV. Results

This section discusses the estimation results. The results from the maximum likelihood estimation of the model are reported in Table 1. The findings indicate that the output gap is a persistent process similar to the literature. The sum of the autoregressive parameters in the IS curve, a_{y1} and a_{y2}, is close to one. The coefficient relating the output gap to the real rate gap (a_r) is negative but statistically insignificant, which indicates that a positive real interest rate gap is indeed contractionary. In terms of the Phillips curve, the coefficient of the output gap (b_2) is negative and contradicts the standard economic theory. One possible reason for this is that the Phillips curve equation estimated using individual country data insufficiently captures the effect of foreign demand on domestic inflation (Wynne and Zhang, 2017). Lastly, for the natural rate equation, the link between the natural rate and the trend growth is relatively strong but statistically insignificant. The point estimate of the parameter c is 0.63.

Table 1: Parameter estimates of the model

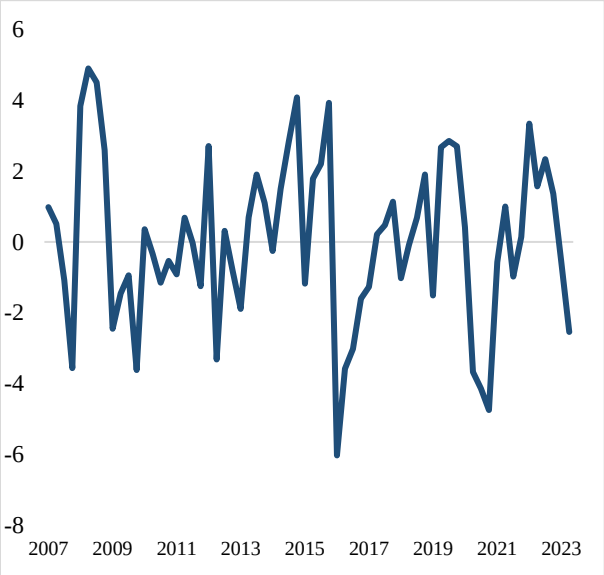
Parameter	Value
IS curve	
a_{y1}	0.861
a_{y2}	0.092
a_r	-0.009
Phillips curve	
$b_{1,1}$	0.950
$b_{1,2}$	-0.080

Parameter	Value
b_2	-0.001
b_3	0.343
Variances	
δ_y	2.842
δ_π	5.643
λ_g	0.110
λ_z	0.009

Source: Author's calculation

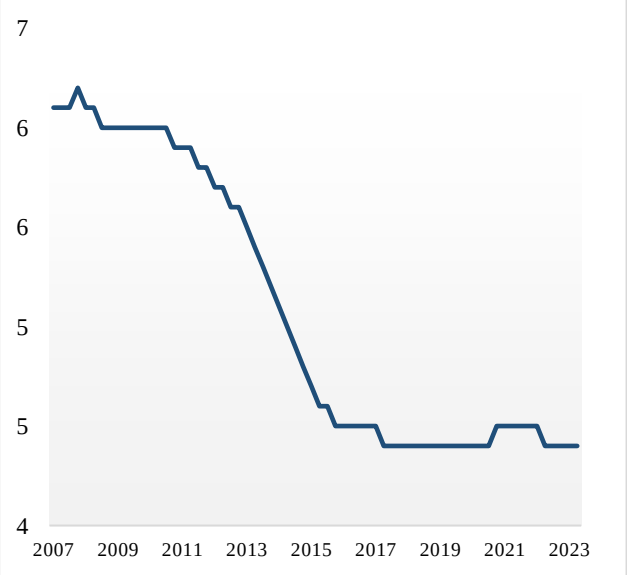
Figure 2 plots the estimation of non-oiloutput gap. It turns out that the estimated output gap picks up the business cycle turning points quite accurately. The output gap decreases significantly in each of the recessions. In particular, the output gap decreases most sharply during the oil crisis period followed by the post devaluation period, and post Covid-19 period.

Figure 2. Output gap, %



Source: Author's calculation

Figure 3. Trend growth rate, %



Source: Author's calculation

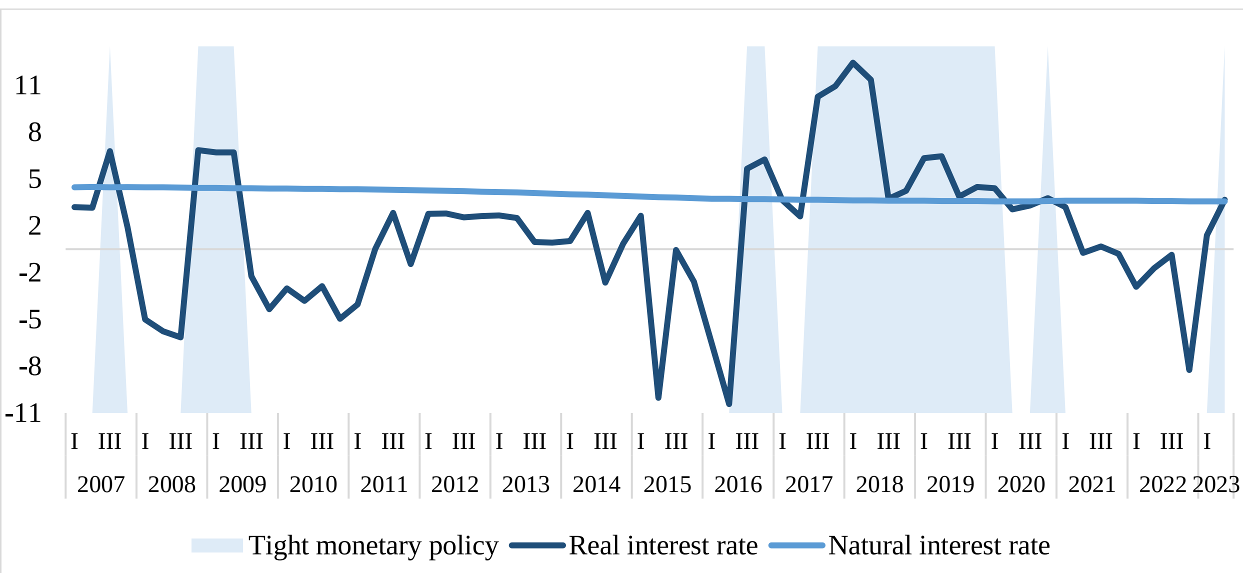
The estimation results show that there has been a modest downward trend in the natural rate of interest, akin to the single-country estimates of Laubach and Williams (2003). On average, the level of the natural rate of interest was 3.1% since devaluation, slightly above the average real interest rate (Figure 4). For the overall period, we find that potential growth has a downward sloping trend, which explains the decline in the natural rate of interest (Figure 3).

The estimation results also indicate the stance of monetary policy and its implications for the domestic economy (Figure 4). It is also useful to think in terms of the interest rate gap, defined as the difference between the observed real interest rate and the natural rate of interest while evaluating monetary conditions (Figure 5). A positive interest rate gap signifies tight monetary conditions, typically associated with weak demand and a negative output gap, and vice versa.

Over the observed period, there were six phases of monetary tightening: 2007/III, 2008/IV-2009/II, 2016/III-2016/IV, 2017/III-2020/I, 2020/IV, and 2023/II. Similarly, there were six periods of accommodative monetary policy: 2007/I-2007/II, 2007/IV-2008/III, 2009/III-2016/II, 2017/I-2017/II, 2020/II-2020/III, and 2021/I-2023/I.

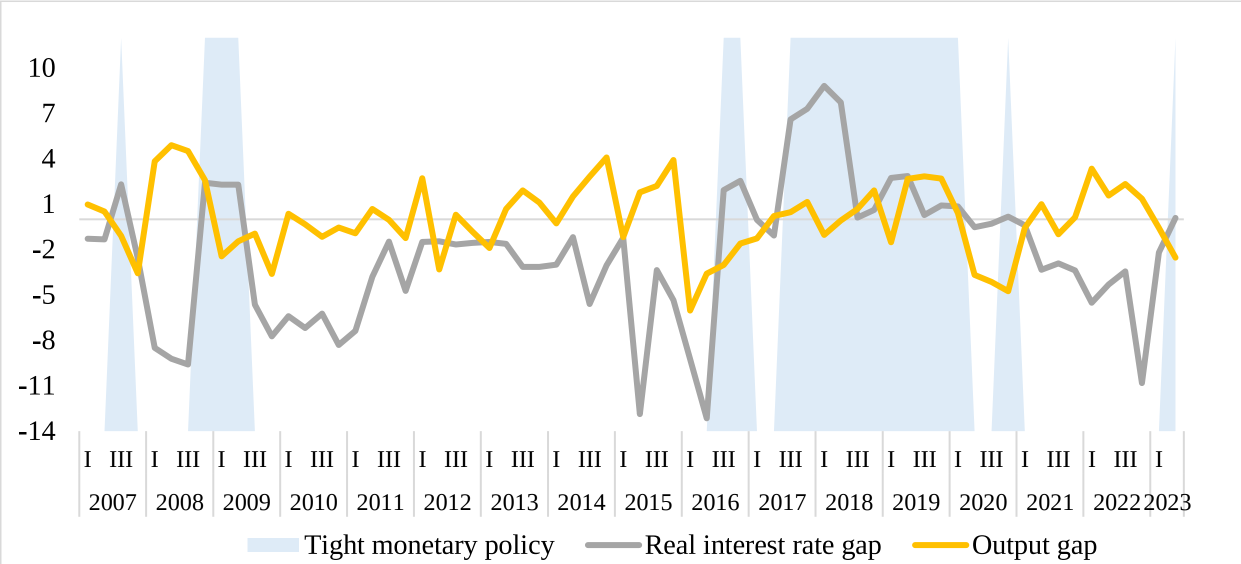
Focusing on specific periods, the pre-global financial crises (2007/IV-2008/III) and the post-COVID-19 recovery phase (2021/I-2023/I) were characterized by robust economic growth and strong demand. During these times, output gap was positive and the interest rate gap was negative, indicating accommodative monetary policy conditions. From late 2009 to early 2016, monetary policy remained accommodative, however, it was not accommodative enough, since output gap has been negative for the long time. Additionally, the devaluation phase, marked by high inflation due to increased import prices, contributed to tighter monetary conditions in late 2016.

Figure 4. Monetary Policy Stance, %



Source: Author's calculation

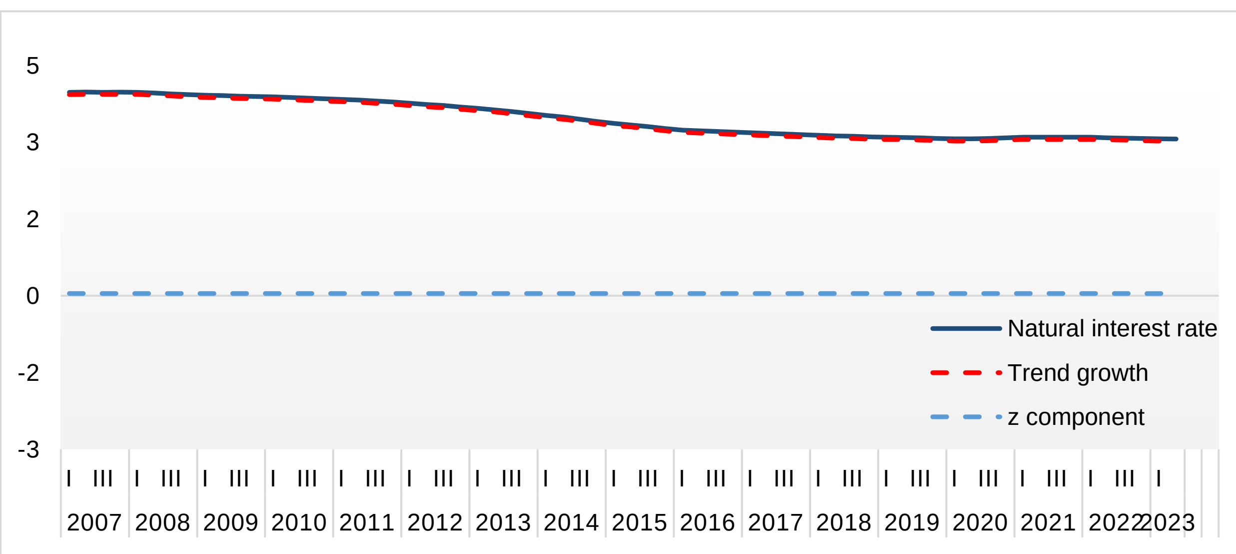
Figure 5. Output gap and real interest rate gap, %



Source: Author's calculation

The natural rate equation above shows that the natural rate is determined by two factors: the trend growth rate g_t and the other determinant z_t. Figure 6 displays the natural rate along with the contribution of each of the underlying determinants. Most of the fluctuation in the natural rate is determined by the trend growth rate while the other determinant (z_t) plays a rather limited role. This is because the trend growth rate typically accounts for the long-term changes in the economy, thus exerting a more significant influence on the natural rate's fluctuations. On the other hand, z_t is a less significant driver of long-term economic changes similar to the other studies.

Figure 6. Natural interest rate decomposition



Source: Author's calculation

It should be pointed out that the results are robust to the changes in the different specifications of restrictions in the variance of growth potential and the natural rate of interest.

V. Conclusion

The study presents the estimation of the natural rate of interest in Azerbaijan implementing the most widely used methodology developed by LW. The findings reveal that the estimated natural interest rate in Azerbaijan exhibits a slightly downward trend over the estimation period, mainly affected by the trend growth rate. Our estimate of the natural rate of interest in Azerbaijan is averaged approximately 3.1 percent since devaluation.

The study exhibits some important implications for the design and implementation of monetary policy by assessing the monentary stance through measuring the natural rate of interest. It shows that in the past, interest rates remained below the natural rate for prolonged periods, thus pointing to accommodative monetary policy conditions.

It's important to note that the assessment of the natural rate of interest is highly uncertain and influenced by a variety of factors and the sample period of the analysis. Therefore, it would be more useful to examine general trends rather than focusing on the specific point estimate to gain a broad understanding of how natural interest rates are changing. The estimates presented in this paper are also subject to some level of uncertainty, as they involve estimating an unobservable variable (the natural rate) by relying on another unobservable variable (potential output). Moreover, there may exist other factors that can have an impact on the natural rate of interest which is not considered in the paper. Hence, the improvement of the paper can proceed in these directions.

Besides, the natural rate of interest should also be estimated by other methods such as time-varying parameter model. This method takes into account that economic conditions, policies, and external influences, structural changes of the economy over time, most of which affect the equilibrium interest rate.

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