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INFLATION TARGETING AS A TOOL FOR MAINTAINING PRICE STABILITY OF THE NATIONAL BANK OF UKRAINE

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Introduction. Inflation targeting is a tool for ensuring price stability in the economy and therefore requires harmonious coordination and communication among government institutions. At the same time, the central bank must adhere to a certain policy instrument, the established legal rules, which are fixed in its mandate, or act at its discretion. Nowadays, the most common rule of monetary policy is inflation targeting.

Aim and tasks. The purpose of the article is to explain the expediency of using the inflation targeting regime to keep inflation at a certain target level, which is determined by the central bank taking into account the current state of the economy.

Results. The theoretical model of Taylor is considered, which is based on inflation assessment in the form of a simple interest rate rule based on monetary policy instruments that ensure convergence of the inflation forecast to the target value in the medium term. The obtained results reflect the volatility of the indicators of the objective function in the data range of 2015 Q3–2021 Q2 and confirm the weight of the gap of variable values that are estimated to be insignificant (95%). Using the GMM method, the relationship between the indicators of the objective function and their impact on the inflation rate through the use of the inflation targeting regime was verified. In particular, the volatility of variables such as the inflation gap, short-term interest rate, output gap, and exchange rate gap and their impact on the target inflation rate was revealed on the time horizon of monetary policy. Smoothing out gaps in variables is one of the goals of the central bank's reaction function under the inflation targeting regime. The use of the GMM method confirms the validity of the application of Taylor's rule regarding the feasibility of choosing an objective function with predetermined variable parameters at different sampling intervals.

Conclusions. The increase in the volatility of variable parameters in the objective function of central banks under the inflation targeting regime is explained by global crises and the sensitivity of macroeconomic indicators to fluctuations in the economic situation. This is the main reason why central banks strictly follow the rules of monetary policy, which allow the timely smoothing of exogenous shocks in the economy.

Keywords: Taylor rule, gap output, central bank, inflation, targeting.

1. Introduction.

Monetary policy is a tool for ensuring long-term economic growth with low inflation and unemployment. At the same time, the central bank must either strictly adhere to a certain policy instrument in accordance with the established legal rules on the instruments or act with discretion. According to Kydland and Prescott (1977), mainstream economic theory emphasizes rules. Although both monetary policy regimes have advantages and disadvantages, the main feature of monetary policy rules is that they can be incorporated into the process of modeling the rational expectations of agents. Such analysis reduces errors in the process of making economic decisions regarding investment and consumption, and also improves the quality of economic growth.

Nowadays, inflation targeting is the most common rule of monetary policy of central banks. The main purpose of this rule is to prevent high inflation in the economy, which is a factor of macroeconomic instability. Under this regime, the central bank usually uses the key rate as a monetary policy tool to keep inflation at a certain target level, which usually fluctuates within a defined corridor. Most economists consider inflation targeting to be an effective monetary policy rule that ensures price stability and economic growth. According to the theory of Friedman and Schwartz (1963), monetary policy has a powerful influence on the welfare of economic agents and their behavior in conditions of uncertainty.

According to Taylor (1993) and Clarida (Clarida, 2000), inflation targeting by central banks can be approximated by a simple interest rate rule, according to which the central bank sets policy rates in response to an economically neutral rate in the economy. Although the central bank adheres to certain rules of monetary policy, there is still room for discretion, which can harm the realization of the rational expectations of economic agents. Using the inflation targeting interest rate rule, the central bank has certain advantages over target variables. If preferences change unexpectedly, they are not taken into account by agents as quickly and act as an exogenous shock to the economy.

Personnel changes in conditions of insufficient institutional independence is one of the reasons for changes in the preferences of central bank boards (Kyrylenko et al., 2021).

2. Literature review.

There are several ways in which changes in the parameters of monetary policy can be determined in the response function of central banks. First, the Taylor rule can be estimated for the sample distribution to check how the estimated parameters differ from each other in each sample. This method is presented in the following studies. For example, Judd and Rudebusch (1998) estimated the Taylor rule of the Federal Reserve System (FRS) using the least square method and distributed the samples according to the presiding members of the board. Their results demonstrate that the FRS weighed both inflation and the output gap. In turn, the FRS's response to the output gap is twice as large as that of Taylor (1993), whose output gap index was 0.5.

Clarida et al. (2000) using the generalized method of moments in sampling distributions find out that the weight of inflation was significantly higher than in previous periods. Orphanides A. (2004) also carried out a study of similar half-periods and found out that the main difference lies in the value of the output gap indicator in the total sample, since the pre-Volcker period is associated with a significantly higher weighted ratio of the GDP gap.

Martin and Milas (2013) using a least-square method on sample graph data from the UK found out that before the 2007 crisis, the weighted inflation gap was higher than after the crisis. Alternative approaches to the assessment of changes in monetary policy parameters are based on the assessment of the model of spatial states. Some studies use the Kalman filter (Kalman, 1960), for example, in the study of Cogley and Sargent (2001); Plantier and Scrimgeour (2002); Garbowski et al. (2019); Zayed et al. (2022).

The main results of the cited literature on the Taylor rule show that the parameters of monetary policy, which reflect the preferences of central banks to the output data of the objective function, change dynamically.

What is important is whether the inconsistency of monetary policy parameters can be considered a quasi-discretionary right?

On the one hand, central banks at present follow a certain policy rule (usually the Taylor rule); on the other hand, they react inconsistently to macroeconomic variables. If agents anticipate changes in the central bank's response, they take them into account in inflation expectations, so such changes cannot harm the stability of the economy. On the contrary, unforeseen changes in the parameters of monetary policy can significantly increase the fluctuations of the business cycle (Conrad and Eife, 2012; Sakun et al., 2021). Important findings for this discussion are found in Mandler (2007). In his opinion, one of the sources of agents' uncertainty is unpredictable changes in monetary policy parameters.

The research examines three main sources of inconsistency in monetary policy parameters. First, members of the central bank board have a limited term of office, and therefore their successors may interpret the application of monetary policy tools differently (Judd et al., 1998; Clarida et al., 2000). In addition, board members' attitudes toward monetary policy may change during their tenure, for example due to public pressure or changing academic and social trends. If the central bank is not sufficiently independent, the board members may also come under political pressure. Such pressures may have arisen during the COVID-19 pandemic, when economies faced a large-scale drop in output due to a manufacturing recession. Central banks that are under the influence of political pressure lose their independence in making decisions to achieve price stability of monetary policy in the medium term. As a result of political pressure, the current level of inflation is significantly higher than its target level. Second, central banks regularly update forecasting models, which can provide a better forecast than previous models. Thirdly, the source of changes in monetary policy parameters can be a change in the transmission mechanism of monetary policy. The need for the rigidity of the central bank's reaction to the level of inflation and the production gap largely depends on the inflationary expectations of economic agents. If the central bank successfully pegs inflation expectations to the level of the inflation target, it should not react harshly to the inflation gap, because inflation expectations independently ensure the desired level of inflation (Benati, 2008; Zhang, Osborn and Kim, 2008; Baxa et al., 2014).

3. Methodology.

In general, two main approaches are used to model the central bank's response function to the interest rate in the inflation targeting regime. The first approach proposed by Barro and Gordon (1983a, 1983b) theoretically derives the response function from the optimization of the central bank's loss function. The second approach is based on empirical estimates. As Taylor (1993) showed, central bank behavior can be approximated by a simple interest rate rule:

$$r_t^* = r\bar{\bar{r}} + \pi_t + 0{,}5(\pi_t - \pi^*) + 0{,}5x_t \quad (1)$$

where the target rate for the nominal discount rate r_t^* is set according to the deviation of inflation π_t from its target π^* and the output gap x_t together with the equilibrium real rate $r\bar{\bar{r}}$ in the economy.

Having replaced the parameters with specific data, equation (1) can be generally rewritten as follows:

$$r_t^* = \underline{r} + \xi_\pi(\pi_t - \pi^*) + \xi_x x_t \quad (2)$$

where $\underline{r}$ is the politically neutral rate (roughly reflecting inflation π_t and the equilibrium real rate $r\bar{r}$ (Fisher and Barber (1907); ξ_π and ξ_x are the central bank's weighting parameters for the inflation gap and the output gap, respectively. As a rule, central banks reflect delay in the implementation of monetary policy.Thus, their interest rate function is more accurately explained using the perspective version of equation (2):

$$r_t^* = \underline{r} + \xi_\pi(E\{(\Omega_t)\} - \pi^*) + \xi_x E\{x_{t+n}|\Omega_t\} \quad (3)$$

where Ω_t is the set of information available at time *t* when the central bank decides to set the interest rate, *n*-index is the horizon of monetary policy. The mathematical symbol *E* stands for the expectation of the future value of this variable. Thus, the expression $E\{(\Omega_t)\} - \pi^*$ is the expectation of the central bank regarding the inflation gap in the period *t*+*n*, taking into account the available information Ω_t.

If the central bank's inflation target has changed during the period under study, then the inflation target is also indexed by *t*:

$$r_t^* = \underline{r} + \xi_\pi(E\{\pi_{t+n}|\Omega_t\} - \pi_{t+n}^*) + \xi_x E\{x_{t+n}|\Omega_t\} \quad (4)$$

In addition, the central bank may prefer a gradual change in the discount rate. In this case, the central bank weighs the lagged interest rate. If a simple partial adjustment mechanism is applied (Clarida et al., 2000), then:

$$r_t = \rho r_{t-1} + (1-\rho)r_t^* \quad (5)$$

where r_t is the current discount rate; $\rho \in [0,1]$ is the smoothing parameter. If expression 5 is substituted into equation 4, we get:

$$r_t = (1-\rho)\left[\underline{r} + \xi_\pi(E\{\pi_{t+n}|\Omega_t\} - \pi_{t+n}^*) + \xi_x E\{x_{t+n}|\Omega_t\}\right] + \rho r_{t-1} \quad (6)$$

This is the most common specification used in the empirical literature on the Taylor rule. In addition, the parameters are not constant, as in equation 6, but constantly change over time:

$$r_t = (1-\rho_t)\left[\underline{r_t} + \xi_{\pi,t} E\{\widetilde{\pi_{t+n}}|\Omega_t\} + \xi_{x,t} E\{x_{t+n}|\Omega_t\}\right] + \rho_t r_{t-1} \quad (7)$$

where $E\{\widetilde{\pi_{t+n}}|\Omega_t\} \equiv E\{\pi_{t+n}|\Omega_t\} - \pi_{t+n}^*$ is the expected inflation gap t+n.

According to the research of Baxa et al. (2013), other variables related to central bank performance can be added to the equation. Since the National Bank of Ukraine occasionally uses currency interventions, it is necessary to check the value of the weight parameter for the exchange rate gap, which is determined as the difference between the exchange rate and the natural level of the exchange rate (long-term trend) in the economy (Feldkircher, Huber, Moder et al., 2016):

$$r_t = (1-\rho_t)\left[\underline{r_t} + \xi_{\pi,t} E\{\widetilde{\pi_{t+n}}|\Omega_t\} + \xi_{x,t} E\{x_{t+n}|\Omega_t\} + \xi_{\varepsilon,t} E\{\varepsilon_{t+n}|\Omega_t\}\right] + \rho_t r_{t-1} \quad (8)$$

where ε_{t+n} is the expected exchange rate gap; $\xi_{\varepsilon,t}$ is the weight parameter of the exchange rate gap.

Any political goals regarding long-term economic growth and the achievement of social development goals cannot in any way influence the political decision aimed at achieving the primary goal.

In accordance with the constitutional mandate, the officially announced response tools of the National Bank of Ukraine must be understandable, unchanging and clear. The central bank uses monetary policy tools only in response to deviations of inflation from its target:

$$r_t = (1-\rho)\left[\underline{r} + \xi_\pi(E\{\pi_{t+4}|\Omega_t\} - \pi_{t+n}^*)\right] + \rho r_{t-1} \quad (9)$$

In the process of analysis, it should be checked whether the National Bank of Ukraine is really focused on inflation targeting, adding output and exchange rate gaps to the reaction function. If the parameters of the response to these variables are estimated to be insignificant, then the empirical analysis shows that the National Bank of Ukraine is indeed complying with its constitutional mandate to maintain price stability. On the other hand, if these variables are statistically significant, then the central bank also focuses on the secondary objectives of monetary policy, although this may harm the achievement of price stability.

In order to assess inflation targeting and the fulfillment of the constitutional obligation regarding price stability during certain periods of monetary policy, we will identify the most frequently used tools of the National Bank of Ukraine's response to shocks in recent years. This analysis is particularly interesting because of the findings that unexpected changes in monetary policy parameters exacerbate business cycle fluctuations.

Thanks to the empirical approach proposed by Clarida et al. (2000), Frömmel and Schobert (2006), as well as the estimation of the generalized method of moments (GMM) at different sampling intervals, it was possible to track changes in monetary policy parameters in the studied period. The generalized method of moments (GMM) was proposed by Hansen (1982). According to this method, the sample is given by a certain distribution with parameters. At the same time, the number of moments of the distribution and the number of parameters equal to the corresponding moments of the sample are calculated. Let w_t be a vector *(h x 1)* of variables observed at time *t*. Let's suppose that θ denotes an unobserved and unknown *(a x 1)* vector of coefficients, and $h(\theta, w_t)$ is a *(r x 1)* vector function.

Then, θ_0 determines the true (population) value of θ.

The method of generalized moments estimates a model where the expected value of the function of the true parameter vector θ_0 satisfies the condition:

$$\mathrm{E}\{h(\theta_0, w_t)\} = 0 \quad (10)$$

Let's suppose that $y_T = (w'_T, w'_{T-1}, \dots, w'_1)'$ will be a $(Th \times 1)$-vector that includes all observations of the sample of size T. Then we can get the sample mean vector-functions for period t:

$$g(\theta, y_T) = \frac{1}{T}\sum_{i=1}^{T} h(\theta, w_t) \quad (11)$$

GMM chooses θ in such a way that the sample moment $g(\theta, y_T)$ is as close as possible to the zero moment of the population. Formally, the selection procedure is performed in the following scalar minimization problem:

$$Q(\theta, y_t) = arg[g(\theta, y_T)]' W_T [g(\theta, y_T)] \quad (12)$$

where $Q(\theta, y_t)$ denotes the vector function of the optimal θ that solves the above minimization problem, and W_t is the sequence of the positive definite weight matrix.

Let S denote the asymptotic variance of the sample mean value $h(\theta_0, w_t)$, which is given as:

$$S = T \times E\{[g(\theta, y_T)][g(\theta, y_T)]'\} \quad (13)$$

The optimal value of the weight matrix W is given by the inverse matrix of the asymptotic variance S, and therefore, the optimization problem in expression 3.3 can be rewritten as follows:

$$Q(\theta, y_t) = arg[g(\theta, y_T)]' S^{-1} [g(\theta, y_T)] \quad (14)$$

If the conditions are met, the GMM does not contradict the given parameters. The estimates found by this method are asymptotically normal and efficient with the correct choice of the weight matrix W_t.

Due to the possible endogeneity of the regressors, we will use the GMM parameter estimate for the instrumental variables approach, where regressors with lags *t-1* and *t-2* are used as instruments.

Having a linear model, it can be presented in vector form:

$$y_t = z'_t\beta + u_t \quad (15)$$

where $z_t - (k \times 1)$ is a vector of explanatory variables, y_t is the dependent variable, $\beta - (k \times 1)$ vector of unknown parameters, $u_t -$ probable error. Endogenous explanatory variables can cause a biased estimate because $E\{z_t u_t\} \neq 0$. Let x_t denote instrumental variables that are correlated with z_t and not with u_t .

It should be noted that instrumental variables are a special case applicable to the GMM estimator, where the vector of unknown parameters $\theta = \beta$, and the vector of observed variables $w_t = (y_t, z'_t, x'_t)'$. Then the vector function is determined as:

$$h(\theta, w_t) = x_t(y_t - z'_t\beta) \quad (16)$$

Converting the theoretical model in equation (8) into an econometric model, excluding unobserved forecast variables, we obtain:

$$r_t = (1-\rho_t)\left[\underline{r_t} + \xi_{\pi,t}\widetilde{\pi_{t+n}} + \xi_{x,t}x_{t+n} + \xi_{\varepsilon,t}\varepsilon_{t+n}\right] + \rho_t r_{t-1} + \epsilon_t \quad (17)$$

where ϵ_t is the error in period *t*.

The variability of parameters over time is tested using two separate subsamples. In each of them, the parameters are considered constant over time. Thus, the estimation equation does not include time-varying parameters:

$$r_t = (1-\rho)\left[\underline{r} + \xi_\pi\widetilde{\tilde{\pi}_{t+n}} + \xi_x x_{t+n} + \xi_\varepsilon\varepsilon_{t+n}\right] + \rho r_{t-1} + \epsilon_t \quad (18)$$

The corresponding parameter transformation formed: $\varpi_r \equiv (1-\rho)\underline{r}, \omega_\pi \equiv (1-\rho)\xi_\pi$, $\psi_x \equiv (1-\rho)\xi_x$, $\psi_x \equiv (1-\rho)\xi_x$ and $\omega_E \equiv (1-\rho)\xi_\varepsilon$ ensures the linearity of the model:

$$r_t = \psi_r + \psi_\pi\widetilde{\tilde{\pi}_{t+n} +} \psi_x x_{t+n} + \psi_E E_{t+n} + \rho r_{t-1} + \epsilon_t \quad (19)$$

According to Baxa et al. (2014), the policy horizon n is two (n=2). The policy horizon is typically 4-6 trimesters, but estimating such a distant horizon disproportionately increases the forecast error compared to a lower policy horizon. Thus, as it is suggested by Baxa et al. (2014), the policy horizon is equal to 2. After estimation, we apply the inverse transformation to obtain the initial parameters in equation 17. The inverse transformation is calculated as follows:

$$\underline{r} = \frac{\psi_r}{(1-\rho)}, \xi_\pi = \frac{\psi_\pi}{(1-\rho)}, \xi_x = \frac{\psi_x}{(1-\rho)} \quad (16)$$

4. Results.

Let us consider the statistical data used to estimate the Taylor rule, reflecting changes in the inflation targeting policy of the National Bank of Ukraine in the data range 2015 Q3 - 2021 Q2. Table 1 provides descriptive statistics for the interest rate, output gap, inflation gap, and exchange rate gap for the period 2015 Q3-2021 Q2.

Table 1 Statistical analysis of the data sample.

Statistics	Value	Standard deviation	Minimum value	25th percentile	75th percentile	Maximum value
Interest rate	3.16	2.795	-0.3871	1.471	3.634	13.251
Inflation gap	-0.05	2.096	-4.387	-1.442	0.892	7.251
Output gap	0.0034	0.801	-6.383	-0.176	0.19	2.86
Exchange rate gap	-0.017	1.443	-4.879	-0.647	0.424	5.901

Source: according to the Baxa et al. (2014).

4.1. Short-term interest rate.

To display the dynamics of changes in interest rates of the National Bank of Ukraine, we will use time series from the OECD database on short-term interest rates, at which short-term (3-month) borrowing between financial institutions or short-term (3-month) government bonds sold at the market are carried out. Values are calculated as average daily rates, measured as a percentage. This variable is directly related to the interest rate policy of the NBU and acts as a sufficient indicator of the directive exchange rates of the central bank. It has been empirically proven (Podpiera, 2008) that the directive scheme of interest rates can distort estimates, as it does not always adequately reflect the real state of economic development.

Table 1 shows the descriptive statistics of this variable. Among the given variables, this is the most variable indicator (see standard deviation). Although the maximum value was determined to be 13.25%, the average value was 3.116%. Table 2 shows the comparative descriptive statistics of the two half-periods. It should be noted that the average value of the short-term interest rate decreased from 4.392 in the 2015 Q3 - 2018 Q4 sample to 1.79 in the 2019 Q1-2021 Q2 sample. In addition, the volatility of the short-term interest rate has decreased, as it is indicated by the standard deviation. Thus, the National Bank of Ukraine managed to stabilize interest rates at a lower level. The sample is divided into subsamples 2019 Q1 – 2021 Q2 to monitor changes (Table 3).

Table 2. Statistical analysis of subsample data 2015 Q3 – 2018 Q4.

Statistics	Value	Standard deviation	Minimum value	25th percentile	75th percentile	Maximum value
Interest rate	4,392	3,312	-0,3871	2,254	6,807	13,251
Inflation gap	-0,014	2,639	-4,387	-1,512	1,425	7,251
Output gap	0,003	0,381	-1,496	-0,147	0,125	1,402
Exchange rate gap	-0,01	1,854	-4,879	-0,701	1,081	5,901

Source: according to the Baxa et al. (2014).

Table 3. Statistical analysis of subsample data 2019 Q1 – 2021 Q2.

Statistics	Value	Standard deviation	Minimum value	25th percentile	75th percentile	Maximum value
Interest rate	1,790	1,074	0,1	0,657	2,62	3,645
Inflation gap	-0,116	1,341	-2,891	-1,343	0,794	4,129
Output gap	0,004	1,082	-6,383	-0,234	0,345	2,86
Exchange rate gap	-0,044	0,845	-2,011	-0,526	0,33	2,678

Source: according to the Baxa et al. (2014).

4.2. Inflation gap.

The inflation gap is calculated as the difference between actual inflation and the inflation target set by the National Bank of Ukraine. The size of the inflation gap can be determined on the basis of inflation time series. The time series measures changes in the consumer price index (CPI) in the current period to the previous period. The inflation target indicators of the National Bank of Ukraine are shown in Table 4.

Table 4. Target inflation indicators of the National Bank of Ukraine

Year	Inflation target, %
2016	12 (+/-3%)
2017	8 (+/-2%)
2018	6 (+/-2%)
2019	5,8 (+/-1%)
2020	5,5 (+/-1%)
2021	5 (+/-1%)

Source: based on National Bank of Ukraine (2021).

The de facto inflation targeting regime was introduced in mid-2015 by announcing targets for the end of 2016. According to the National Bank of Ukraine's estimates, the horizon of monetary policy is 9-18 months. For all periods, the inflation target is set as an interval. This procedure should help reduce the inflation forecast error. For example, when the inflation target is close to zero, the central bank is not interested in stimulating economic growth. To calculate the inflation gap, let us assume that the central bank has set the inflation target as the average of these intervals. As Table 1 shows, the inflation gap is the second most volatile variable, as it is indicated by the standard deviation. Unlike the short-term interest rate, the inflation gap did not change significantly in the subsamples. However, its volatility decreased from 2.639 in the 2016 Q3 - 2018 Q4 subsample to 1.341 in the 2019 Q1 - 2021 Q2 subsample (Tables 2, 3). This shows that the introduction of inflation targeting contributed to price stabilization.

4.3. Output gap.

The output gap is defined as the difference between actual output and potential (long-term) output in the economy. Output in the economy is determined by the time series of real gross domestic product (GDP). In the study, it is advisable to use the time series of seasonally adjusted real GDP, calculated according to the expenditure approach and indexed to the base period of 2015. The output gap time series is calculated using the Hodrick-Prescott filter (Hodrick and Prescott, 1997) for real GDP in the time series. To obtain the output gap in the form of a percentage difference it is necessary to logarithmize the trend of potential GDP and subtract it from the logarithm of real GDP. It should be noted that in the first sub-sample 2016 Q3 - 2018 Q4, the output gap was less volatile than in the second sub-sample 2019 Q1 - 2021 Q2 (Tables 2, 3). This is due to the global lockdown and production stoppage due to Covid-19.

4.4. Exchange rate gap.

Taylor's rule implies a test of the hypothesis that the National Bank takes into account the exchange rate in the process of making a decision to establish an exchange rate policy regime. The main problem is how to determine the exchange rate gap. If the central bank has a fixed exchange rate regime and sets a fixed exchange rate, then the problem is solved simply.

In such a situation, the target value of the exchange rate indicator is subtracted from the actual value of the exchange rate. The resulting value is the exchange rate gap.On the contrary, in 2020 during the unconventional policy of currency interventions in the 1st quarter the National Bank targeted the UAH/USD exchange rate at UAH 27 by the end of the year.

Nevertheless, this policy did not mean that interest rates would be affected by the exchange rate gap, as the NBU aimed to maintain low interest rates and low exchange rate volatility to help return inflation to the 5.5% target (Figure 1). Therefore, it is not advisable to choose a clear target that will constitute the gap of the exchange rate.

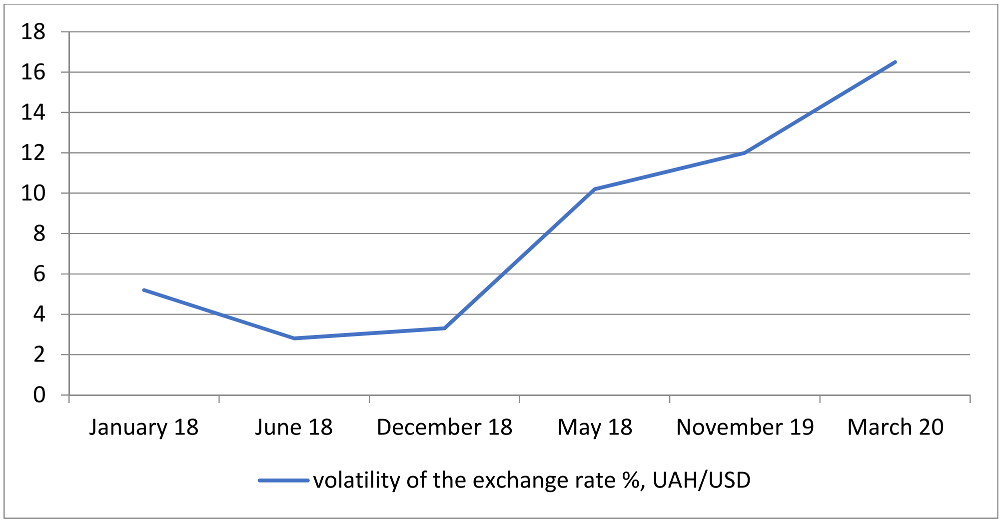

Fig. 1 Monthly volatility of the exchange rate %, UAH/USD.

Source: based on National Bank of Ukraine (2021).

The Hodrick-Prescott filter can be used (Hodrick and Prescott, 1997) to display the long-term trend of the exchange rate gap. To obtain the exchange rate gap as a % deviation, it is necessary to subtract the logarithm of the expected exchange rate trend from the logarithm of the actual exchange rate. In contrast to output gap volatility, exchange rate volatility was significantly higher in the first subsample period 2016 Q3 - 2018 Q4 (Tables 2, 3). Higher volatility was caused by a number of factors, in particular, the abandonment of the fixed exchange rate regime and the transition to a floating exchange rate determined at the interbank foreign exchange market. The result was the devaluation of the hryvnia in February 2015, but later the hryvnia began to strengthen.

Table 5 shows the results of the GMM estimation of the model obtained by equation 18. The estimations were carried out on four samples. The reliability of t-tests is ensured by the use of the Newey and West (1987) heteroskedasticity covariance matrix with autocorrelation (HAC).

Table 5. GMM estimation of results (HAC-robust).

Indexes	Dependent variable			
	Interest rate			
	(1)	(2)	(3)	(4)
ρ	0,831*** (0,073)	0,877*** (0,036)	0,756*** (0,121)	0,609*** (0,133)
$\underline{r}$	5,414*** (1,609)	5,947*** (1,306)	0,717* (0,394)	1,241*** (0,151)
ξ_π	1,974*** (0,422)	2,638*** (0,635)	0,209 (0,156)	0,468*** (0,148)
ξ_x	-2,348 (2,415)	-1,620 (4,421)	-1,689 (1,221)	-0,057 (0,176)
ξ_E	0,247 (0,514)	0,437 (1,310)	0,451 (0,620)	-0,193 (0,322)
Observations	24	14	10	8
R^2	0,925	0,925	0,392	0,873
Adjusted R^2	0,922	0,920	0,338	0,860
Residual Std. Error	1,176	1,364	0,574	0,264
J-statistic	2,364	2,781	1,251	2,201
Prob(J-statistic)	0,500	0,427	0,741	0,532

*p<0,1; **p<0,05; ***p<0,01

Note: (1) Estimated results for entire data range 2015 Q3-2021 Q2; (2) Evaluation of subsample results 2015 Q3-2018 Q4; (3) Evaluation of subsample results 2019 Q1-2021 Q2; (4) Evaluation of subsample results 2019 Q1-2020 Q4.

Source: based on Newey and West (1987).

From Table 5 it follows that at the 95% significance level for all four samples, the weight of the exchange rate gap and the output gap are insignificant, which means that the National Bank of Ukraine fulfills its constitutional duty to maintain price stability. Secondary objectives are only of interest when the primary objective is achieved.

J-statistics show that the choice of t − 1 and t − 2 lag variables of the inflation gap, output gap, and exchange rate gap, as well as t−2 and t−3 lag variables of the interest rate is exogenous, and therefore, these variables are effective instruments. The evaluation of results (1) is performed on the entire data range 2015 Q3 - 2021 Q2. The model predicts the process of generating interest rate data with quite a good quality. The estimation of the results (2) is taken only in the range of the first subsample 2015 Q3 - 2018 Q4.

The model is also quite sufficient. In contrast, the unsystematic shock to the key variables caused by the production shutdowns due to the Covid-19 pandemic seriously harms the predictions of model (3), which is estimated on the subsample 2019 Q1 - 2021 Q2. The assessment of results (4) is complicated by obtaining reliable estimates after the 2020 crisis. Perhaps, to obtain reliable estimates, it would be more expedient to exclude the period from the 1st quarter 2020 till the IV quarter 2020, which is analyzed in model (4), where only the subsample from the 1st quarter 2019 till the IV quarter 2019 is evaluated

The estimated smoothing parameter ρ is quite high, which indicates that the National Bank conducts the policy of changing the discount rates quite smoothly (except for crisis periods, when a sharp increase in the discount rate is a vital necessity to curb the spiral of inflation). For the first subsample, the parameter ρ is the highest in the model (2), which means a decrease in the smoothing behavior of the National Bank's interest rates in the period 2019 Q1-2020 Q4 model (4).

The policy-neutral rate $\underline{r}$, which represents the long-run equilibrium nominal interest rate, declined significantly between the two half-periods, from 5.947% in the 2015 Q3-2018 Q4 subsample to 1.241% in the 2019 Q1-2020 Q4 subsample.

This decrease is partly caused by inflation approaching its target value, as well as the general growth of the money supply. The influence of the National Bank on the size of the inflation gap ξ_{π} decreased from the value of 2.638 in the first sub-sample 2015 Q3-2018 Q4 to 0.468 in the third sub-sample 2019 Q1-2020 Q4. Thus, the National Bank reacted to the observed inflation gap with a soft interest rate policy, lowering the interest rate by several percentage points compared to the first sub-sample. At first glance, it may appear that the central bank has lost its vigilance in maintaining price stability, but this is not the case, as prices remained stable throughout the period, despite the smaller weight of the inflationary gap. The main reason for the decrease in this indicator is anchored inflationary expectations in the economy.

5. Discussion.

The conducted assessment of the Taylor rule reflecting changes in the inflation targeting policy of the National Bank of Ukraine in the data range 2015 Q3 - 2021 Q2 proved that the response parameters to the above variables are estimated to be insignificant (95%). This shows that the NBU clearly adheres to its constitutional mandate to maintain price stability. Thanks to the use of the generalized method of moments (GMM) at different sampling intervals, it was possible to track changes in the parameters of the monetary policy of the National Bank over the policy horizon 2015 Q3 - 2021 Q2. For the convenience of monitoring changes, the sample is divided into two subsamples: 2015 Q3 - 2018 Q4 and 2019 Q1 - 2021 Q2. Among the above variables, the short-term interest rate turned out to be the most volatile indicator, as it is evidenced by the standard deviation (2.795). Consequently, the National Bank managed to lower interest rates, which had a positive effect on the dynamics of inflation.

The inflation gap is the second most volatile variable, as it is indicated by the standard deviation (2.096). The reduction in the volatility of the inflation gap over the policy horizon indicates that the introduction of inflation targeting contributed to price stabilization.

Smoothing the output gap is one of the goals of the central bank's reaction function under the inflation targeting regime. In Ukraine, GDP volatility is lower than other variables included in the objective function, which corresponds to the goal of "...supporting sustainable economic growth." The output gap is the least volatile indicator, as it is evidenced by the standard deviation (0.801). This is due to the global lockdown and stoppage of production due to Covid-19. Exchange rate volatility was significantly higher at the policy horizon as indicated by the standard deviation (1.443). This is explained by a number of factors, in particular, the abandonment of the fixed exchange rate regime and the transition to a floating exchange rate determined under the influence of supply and demand in the interbank foreign exchange market.

6. Conclusions.

Central banks have a constitutional mandate to implement monetary policy in the economy. Strict adherence to the rules and instruments of monetary policy can support stable economic growth. In influencing economic processes in the economy, central banks use traditional and non-traditional instruments that have received wide support in practice. The inflation targeting regime is one of such tools.

The consistency of monetary policy is the key to achieving the planned goals, which allows economic agents to take into account changes in the monetary policy of the central bank in a timely manner and include them in their rational expectations for making effective decisions. Unexpected changes in monetary policy parameters increase fluctuations in the business cycle and uncertainty in the economy. This is the main reason why central banks strictly follow the rules of monetary policy, which allows timely smoothing of exogenous shocks in the economy. The study confirms the expediency of applying the Taylor rule when implementing the inflation targeting regime.

Analysis of the main parameters of monetary policy shows that the preferences of central banks change according to the output data of the objective function. The latter includes the following variables: inflation gap, short-term interest rate, output gap and exchange rate gap.

The following conclusions can be drawn on the basis of the results of GMM model estimation.

First, this method confirms the validity of the application of Taylor's rule regarding the feasibility of choosing an objective function with predetermined variable parameters at different sampling intervals. Second, the J-statistics show that the choice of t−1 and t−2 lag intervals for the given variables (inflation gap, GDP gap, and exchange rate gap), as well as t−2 and t−3 lag variables of the interest rate are exogenous, and therefore, these variables act as effective tools. Third, the evaluation of the model results is performed on the entire data range of 2015 Q3 - 2021 Q2. Fourth, the presence of unsystematic fluctuations for key variables in the model on the horizon for 2019 Q1 - 2021 Q2 indicates the presence of shocks caused by the recession of production in connection with the COVID-19 pandemic. Fifth, the high value (0.877) of the estimated smoothing parameter ρ for the first sub-sample indicates that the National Bank conducts a balanced policy of changing discount rates. Sixth, the politically neutral rate $\bar{r}$ has significantly decreased between the two half-periods (from 5.947% (2015 Q3-2018 Q4) to 1.241% (2019 Q1-2020 Q4). This decrease gradually brings the inflation indicator closer to its target value. Seventh, the value of the inflation gap ξ_π decreased from 2.638 (2015 Q3-2018 Q4) to 0.468 (2019 Q1-2020 Q4). Therefore, the National Bank, responding to the inflation gap, lowers interest rates to stimulate aggregate demand in the economy. This has a positive effect on inflationary expectations of economic agents and makes monetary policy more predictable.

REFERENCES

Barro, R. J., & Gordon, D. B. (1983a). A positive theory of monetary policy in a natural rate model. Journal of political economy, 91 (4), 589–610. https://doi.org/10.1086/261167

Barro, R. J., & Gordon, D. B. (1983b). Rules, discretion and reputation in a model of monetary policy. Journal of monetary economics, 12 (1), 101–121. https://doi.org/10.1016/0304-3932(83)90051-X

Baxa, J., Horváth, R., & Vašíček, B. (2013). Time-varying monetary-policy rules and financial stress: Does financial instability matter for monetary policy? Journal of Financial Stability, 9(1), 117-138. https://doi.org/10.1016/j.jfs.2011.10.002

Baxa, J., Horváth, R., & Vašíček, B. (2014a). How does monetary policy change? Evidence on inflation targeting countries. Macroeconomic Dynamics, 18 (3), 593–630. https://doi.org/10.1017/S1365100512000545

Benati, L. (2008). Investigating inflation persistence across monetary regimes. The Quarterly Journal of Economics, 123 (3), 1005–1060. https://doi.org/10.1162/qjec.2008.123.3.1005

Clarida, R., Galí, J., & Gertler, M. (2000). Monetary policy rules and macroeconomic stability: evidence and some theory. The Quarterly journal of economics, 115 (1), 147–180. https://doi.org/10.1162/003355300554692

Cogley, T., & Sargent, T. J. (2001). Evolving post-world war II us inflation dynamics. NBER macroeconomics annual, 16, 331–373. https://doi.org/10.1086/654451

Conrad, C., & Eife, T. A. (2012). Explaining Inflation-Gap Persistence by a Time-Varying Taylor Rule. Journal of Macroeconomics, Forthcoming, University of Heidelberg, Department of Economics, Discussion Paper No. 521. http://dx.doi.org/10.2139/ssrn.1703350

Feldkircher, M., Huber, F., Moder, I. (2016). Modeling the evolution of monetary policy rules in cesee. Focus on European Economic Integration, 1, 8–27.

Friedman, M., & Schwartz, A. J. A. (1963). Monetary history of the United States, 1867-1960. Princeton, N.J.: Princeton Univ. Press (for Nat. Bur. Econ. Res.).

Frömmel, M., & Schobert, F. (2006). Monetary policy rules in central and Eastern Europe (Tech. Rep.). Diskussionsbeitrag.

Garbowski, M., Mironova, D., Perevozova, I., Khrushch, N., & Gudz, I. (2019). Influence of IPO on macroeconomic security of countries. Journal of Security and Sustainability Issues, 8(4), 841-853. http://doi.org/10.9770/jssi.2019.8.4(24)

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators. Econometrica: Journal of the econometric society, 50(4), 1029–1054. https://doi.org/10.2307/1912775

Hodrick R. J., & Prescott E. C. (1997). Postwar US business cycles: an empirical investigation. Journal of Money, Credit and Banking, 29(1), 1-16. https://www0.gsb.columbia.edu/faculty/rhodrick/prescott-hodrick1997.pdf.

Judd, J. P., & Rudebusch, G. D. (1998). Taylor's rule and the fed: 1970-1997. Economic Review. Federal Reserve Bank of San Francisco, 3–16.

Kalman, R. E. (1960). A new approach to linear filtering and prediction problems. Journal of Basic Engineering, 81(1), 35–40.

Kydland, F. E., & Prescott, E. C. (1977). Rules rather than discretion: The inconsistency of optimal plans. Journal of political economy, 85 (3), 473–491.

Kyrylenko, V., Kulaga, I., Tkachenko, O., & Khokhych, D. (2021). Independence of central bank: new challenges. Financial and credit activities: problems of theory and practice, 4(39), 4–11. https://doi.org/10.18371/fcaptp.v4i39.238455.

Mandler, M. (2007). The Taylor rule and interest rate uncertainty in the US 1955-2006. Giessen: University of Giessen.

Martin, C., & Milas, C. (2013). Financial crises and monetary policy: Evidence from the UK. Journal of Financial Stability, 9(4), 654–661. https://doi.org/10.1016/j.jfs.2012.08.002

Newey, W. K., & West, K. D. (1987). Hypothesis testing with efficient method of moments estimation. International Economic Review, 28(3), 777–787.

Orphanides, A. (2004). Monetary policy rules, macroeconomic stability, and inflation: A view from the trenches. Journal of Money, Credit and Banking, 36(2), 151–175.

Plantier, C., & Scrimgeour, D. (2002). Estimating a Taylor rule for New Zealand with a time-varying neutral real rate. Reserve Bank of New Zealand Discussion Paper Series DP2002/06, Reserve Bank of New Zealand.

Podpiera, J. (2008). The role of ad hoc factors in policy rate settings. Economic Modeling, 25 (5), 1003–1010. https://doi.org/10.1016/j.econmod.2008.01.005

Sakun, A., Perevozova, I., Kartashova, O., Prystemskyi, O., & Mokhnenko, A. (2021). Innovative Paradigm of Management Accounting and Development of Controlling in the Entrepreneurship. Universal Journal of Accounting and Finance, 9(4), 548-564. https://doi.org/10.13189/ujaf.2021.090403

Taylor, J. B. (1993). Discretion versus policy rules in practice. In Carnegie Rochester conference series on public policy, 39, 195–214.

Zayed, N. M., Mohamed, I. S., Islam, K. M. A., Perevozova, I., Nitsenko, V., & Morozova, O. (2022). Factors influencing the financial situation and management of small and medium enterprises. Journal of Risk and Financial Management, 15(12), 554. https://doi.org/10.3390/jrfm15120554

Zhang, C., Osborn, D. R., & Kim, D. H. (2008). The new keynesian phillips curve: from sticky inflation to sticky prices. Journal of Money, Credit and Banking, 40(4), 667–699. https://doi.org/10.1111/j.1538-4616.2008.00131.x