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Choosing a Taylor Rule with Limited Data Availability: The Benchmark Approach[1]

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Abstract

In this paper, we propose and test a new methodology that aims to select the best performing monetary policy rule when macroeconomic data are very limited, as is often the case for developing countries. The methodology is based on calculating economic losses during the periods when a country implicitly followed an assumed rule and when its central bank exercised discretion. For countries with short data spans where such analysis is not possible, we propose adopting the rules that historically worked well for their peers. As an intermediate step, we develop a novel approach to the calculation of the equilibrium real interest rate for developing countries that accounts for their substantial risk premia and the expected real appreciation of the domestic currency. The methodology is then applied to Czechia, Hungary, Poland, and Ukraine to construct the optimal policy rate path and contrast it with the actual one.

JEL Classification Codes: E52, E58

Keywords: Taylor rules, monetary policy, real-time data, discretion

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1. Introduction

Monetary policy can be a key driver behind a successful economy. This fact makes designing optimal monetary policy crucial to the economy's performance, while raising the question about the best way to do it. Since the establishment of central banking, the prevailing approach has been to exercise discretion, which allows policymakers to make arbitrary decisions they feel are best given the economic situation.[6] However, in recent decades, a rules-based approach, which seeks to have monetary policy determined by a pre-specified "rule," has gained in popularity. Such policy rules aim to specify a particular set of actions that depend on variations in macroeconomic conditions in a country. The debate between discretionary monetary policy and rules-based monetary policy has resulted in many different opinions from Friedman (1960), Council of Economic Advisors (1962), Kydland and Prescott (1977) to Bernanke (2003), Mishkin (2017), and Taylor (2017) among many others.

The most famous and influential monetary policy rule was proposed by John Taylor in his 1993 paper (Taylor, 1993). This rule is often referred to as *the* Taylor rule. The Taylor rule aims to prescribe the ideal interest rate based on the deviation of inflation from the central bank's target (assumed to be 2% for the U.S.) and the deviation of GDP from trend or potential GDP, with weights assigned to each gap being equal to 0.5. The United States Federal Reserve regularly uses the Taylor rule as well as the so-called balanced-approach rule proposed by Yellen (2012) with the weight of the output gap coefficient being increased to 1.0 as a reference for monetary policy (Board of Governors, 2018). Other central banks have recently started referring to various Taylor-type rules as well (Kuroda, 2016; Jonsson and Katinic, 2017; Plantier and Scrimgeour, 2002; Singleton, 2010).

Designing the best rule for a particular economy is never easy. One popular way to do that is by developing a Dynamic Stochastic General Equilibrium (DSGE)-type model and trying out several monetary policy reaction functions in an attempt to find one that minimizes a particular metric, typically – macroeconomic volatility. This approach is not without flaws. First, if one is able to find the optimal rule, there is no guarantee that the underlying model of an economy is the right one. Second, even if it is correct, the Lucas (1976) critique points out that economic relationships change over time. Hence, even if you select the correct mathematical model of an economy, it will likely be wrong later in the future, and thus so will be the chosen rule. Finally, a DSGE-based analysis cannot test the performance of a rule versus discretion due to the inability to mathematically model discretion. Any attempt to do so will simply define yet another rule.

Another method to choose the best rule is proposed by Nikolsko-Rzhevskyy, Papell, and Prodan (2019, 2021). The authors rely on actual past economic data, rather than a mathematical model

[6] We would like to stress that the majority of central banks do utilize some policy rules while modeling monetary policy responses and forecasting macroeconomic variables. The banks' boards, however, are not legally bound to follow any rule, and are able to deviate from its recommendation at will, thus exercising discretion. With a rules-based approach, they would have been stripped of this freedom.

of an economy. As a first step, the authors hypothesize a loss function. Next, they evaluate the various monetary policy rules by calculating quadratic loss ratios: the loss in high deviations periods (when the actual funds rate is far from the one prescribed by a rule) divided by the loss in low deviations periods (when the funds rate is close to the prescribed one). Rules with higher loss ratios are preferred to rules with lower loss ratios because economic performance is relatively worse in high deviations periods than in the ones of low deviations. One of the major advantages of this method is that it actually allows the testing of various policy rules against discretion, defined as periods of high deviations.[7]

Thus far, this method has been exclusively applied to the U.S. economy. In the case of developing countries, this proposed method does have some limitations. Ideally, this method works best with long datasets that offer rich dynamics. However, for many of these developing countries, having a long dataset is simply not a reality. If we consider Ukraine as an example, prior to 2014, Ukraine's central bank, the National Bank of Ukraine, had not conducted independent monetary policy and its main objective was keeping the exchange rate constant. This strategy made any data prior to 2014 effectively meaningless, while also having disastrous effects on the Ukrainian economy. In 2014, following the illegal annexation of Crimea by Russia and the start of the war in the east of Ukraine, the hryvnia devalued dramatically, its exchange rate plunged UAH 8 to USD 1 in January 2014, to almost UAH 34 to USD 1 in February of 2015. At the same time, Ukraine's GDP fell more than 15% in 2014-2015. On a positive note, the NBU, having strengthened its independence, began inflation targeting, a monetary policy aimed at managing inflation. Additionally, the NBU stated that its main objective to the Ukrainian economy would be creating an "environment of low and stable inflation, as well as contributing to, within the NBU's remit, the country's financial stability" (National Bank of Ukraine, 2019).

Since Ukraine's data prior to 2014 are not viable, how could we determine if a rules-based monetary policy approach worked for Ukraine or any other developing nation with limited data availability? Even if we were able to determine that a rules-based approach would work – how does one pick the most effective rule? The methodology we propose to solve this problem is the *first* contribution of this paper. We start by selecting a set of "benchmark" countries whose socioeconomic characteristics are similar to the developing country in question (Ukraine). Another required condition is the availability of sufficiently long datasets for the benchmark countries to make it possible to apply the methodology of Nikolsko-Rzhevskyy, Papell, and Prodan (2019, 2021). After the methodology is applied and the optimal rule for those benchmark countries is

[7] The most important disadvantage of this approach, however, is that it does not produce any counterfactual results. While we can tell whether economic performance has been better during periods when the central bank adhered more closely to a rule, we cannot answer the question of whether economic performance would have been better had the central bank always followed a rule.

selected, we superimpose those results onto Ukraine's data in order to come up with our best possible educated guess for the optimal rule for the developing country.

Poland, Hungary, and Czechia are the benchmark countries we selected as they are economically and politically similar to Ukraine. All four countries are small open economies in Central and Eastern Europe. They have independent central banks and their own national currencies, the Polish Zloty, the Hungarian Forint, the Czech Koruna, and the Ukrainian Hryvnia, respectively. Ukraine, Poland, Hungary, and Czechia each have relatively similar populations (Ukraine has 41 million people, Poland – 38 million, Hungary – 9.8 million, and Czechia – 10.7 million) and GDP (Ukraine's GDP is estimated at USD 152 billion, Poland's at USD 594 billion, Hungary's at USD 155 billion, and Czechia's at USD 241 billion).[8] Arguably, the most important similarity among the four countries is that they all have experienced nearly identical changes in their exchange rate systems. Poland had a crawling band exchange rate system until 1999, and then adopted an independent float regime in 2000 (Maria-Dolores, 2005). Hungary had a crawling band exchange rate regime until 1999, which was changed to a managed float system in 2000. Czechia had a crawling band system until 1996, switched to a managed float in 1997, and then finally adopted an independent float exchange rate system in 2001. Moreover, central banks in those countries switched to an inflation targeting framework, in 1997 for Czechia Republic, and at the beginning of 2000s for Poland and Hungary. Ukraine has only recently switched to an inflation targeting framework, it happened in 2016. Therefore, if we were able to identify a policy rule that – had it been adopted – would have produced solid performance for the three reference countries while clearly overperforming discretion, we could reasonably expect it to work well for Ukraine as well. Finding optimal policy rules for Poland, Hungary, and Czechia is our *second* contribution to the literature.

In order to evaluate a policy proposed by a Taylor-type rule, one needs to know the equilibrium real interest rate. Taylor (1993) assumed it to be equal to two percent in the U.S. More recently, Laubach and Williams (2003) used Kalman filter for estimation, linking the neutral interest rate to the U.S. potential output growth rate, thus allowing it to vary in time. Despite being sometimes criticized, their approach remains the gold standard when calculating the equilibrium real interest rates for developed countries.[9] Small open economies (SOEs), however, often finance investment with external funds, which makes them dependent on the yield expectations on the international capital market. As a result, only a very small share of their neutral rates could be attributed to the potential growth rates (Grafe et al., 2018). This result makes the Laubach and Williams' approach, designed for developed countries, inapplicable to SOE. Hence, as our *third* contribution to the literature, we propose a novel approach that allows researchers to calculate neutral rates for SOEs, while taking into account the peculiarities of their economies. Our approach is based on

[8] Data for 2020 come from the IMF World Economic Outlook (April 2021).

[9] The methodology also attributes a large share of the neutral rate variation to an unobserved "other factor." According to Buncic (2021), its estimation is misspecified. On a sample since 2008, it leads to underestimated neutral rates in the U.S., the euro area, Canada, and the UK.

the concept that a small open economy accepts a price of capital determined by the global capital markets adjusted through risk premium and real exchange rate changes.

According to our methodology, real equilibrium interest rates in SOEs directly react to changes of their counterpart in the U.S., including its sharp decline after the global financial crisis (GFC). However, other factors may prove to be more important. First, all four investigated countries exhibit appreciating real exchange rates in 2000-2008. The real convergence of a SOE makes global investors more willing to buy its assets, which decreases the equilibrium interest rate. This appreciation trend reverted in 2009-2020. Second, equilibrium rates are sensitive to sovereign risk premia as investors require higher yields from more vulnerable countries. The premia in Poland and Hungary move in tandem as they spike during the GFC and the European Debt Crisis, and gradually decrease afterwards. The premium in the developed Czech economy is assumed to be equal to zero.

Our results show that when it comes to the inflation and output gap coefficients, it is best for a central bank to respond to both of them. For Poland, the optimal inflation and output gap coefficients should be around 0.7 to maximize the gain. For Hungary, the optimal inflation gap response coefficient is 0.5, while the output gap response coefficient is 0.9, thus implying a stronger response to real economic activity when compared to Poland. For Czechia, the combination of an inflation response coefficient of 0.3 with the output gap coefficient being anywhere between 0.9 and 1.0. When we superimpose the three benchmark countries' results to obtain our best recommendation for Ukraine, the suggested rule perfectly replicates the “balanced-approach rule'” popularized by Yellen (2012). This rule sets the inflation gap response coefficient at 0.5 (consistent with the classical Taylor 1993 rule), while using a twice-as-large coefficient of 1.0 for the output gap. Had the NBU utilized this rule, the economic losses would have been 39% lower than under an alternative discretionary approach. The results also suggest that the NBU was running a monetary policy that was broadly consistent with the optimal rule for Ukraine between 2016 and 2019. Deviations during the COVID pandemic in 2020 are explained by some inertia in the NBU’s interest rate. Moreover, low inflation and the pandemic-induced negative output gap were (correctly) assessed as temporary.[10]

In the next section, we go over the methodology. Then in section 3, we describe the data for all four countries, Poland, Hungary, Czechia, and Ukraine. In Section 4, we discuss the results for the benchmark countries as well as calculate the optimal rule for Ukraine. Section 5 is devoted to discussing the policy implications for Ukraine, and Section 6 concludes the paper.

[10] Note that our results should not be considered an immediate recommendation to any abovementioned central bank.

2. Methodology

2.1. Evaluating the Taylor Rules

Taylor (1993a) proposed the following monetary policy rule,

$$i_t = \pi_t + \alpha(\pi_t - \pi_t^*) + \gamma\hat{y}_t + R_t^* \quad (1)$$

where the target level of the short-term nominal interest rate is determined by the deviation of the actual inflation rate, π_t, from the target inflation, π^*, the deviation of real GDP from its potential level, $\hat{y}_t$, and the equilibrium level of the real interest rate, R_t^*. The original rule for the U.S. sets the inflation target and the real interest rate at two percent, while restricting the inflation and output gap coefficients to 0.5. In more modern setups, however, both R_t^* and π_t are assumed to be time-varying. Additionally, even for the U.S., there is no consensus on the optimal parameters of the rule, i.e., the values of α and γ. For instance, in 2012, Janet Yellen proposed an alternative to the Taylor rule, which is now known as the “balanced-approach rule,” or the “balanced rule.” While the Taylor rule places equal weight on deviations of inflation and GDP, the balanced rule places a 0.5 coefficient on inflation and a 1.0 coefficient on the output gap, twice as high as that of the 1993 Taylor rule. While the original and balanced (or output gap tilting) Taylor rules are relatively accepted and mainstream, as evidenced by their inclusion in the United States Federal Reserve Board’s semi-annual Monetary Policy Report, an inflation titling rule gives yet another alternative. Such rules provide policymakers with guidelines based on their preferred speed of returning inflation to the target after the deviation appears and the need to smooth the economic cycle. A faster return of inflation to the target implies higher short-term costs in terms of output volatility; however, it allows the central banks to gain credibility, which eases inflation management in the future. Less volatile inflation contributes to higher potential output growth.

However, when researchers compare the performance of different policy rules, they usually rely on the maximization of some welfare function (or minimization of loss function). For instance, when comparing the performance of all three types of rules, Nikolsko-Rzhevskyy, Papell, and Prodan (2021) found that an inflation titling rule, which places a 0.5 coefficient on the output gap and a 1.0 coefficient on the inflation gap, performed in the top quintile for all of their simulations for the U.S., thus outperforming 80%+ of other rules as well as discretion. To the best of our knowledge, no such simulation that tests the efficiency of various Taylor rules against each other and discretion is available for Poland, Hungary, Czechia that we use as benchmark countries for Ukraine.

Another common modification of the classical Taylor 1993 rule entails accounting for interest rate smoothing, first introduced by Clarida, Gali, and Gertler (1998). Indeed, it is common practice to include a lagged interest rate as an independent variable for estimating and conducting a positive policy analysis. However, doing so is problematic in a normative policy evaluation context because a lagged interest rate would perpetuate policy errors, making the concept of a deviation unclear.

Cochrane et al. (2020) discuss this issue with the first-difference rule included in the Monetary Policy Report. For this reason, we choose to keep the functional form of the rule as in Eq. (1).

Instead of restricting ourselves to considering only these or another small set of rules by fixing α and γ at particular values, in our counterfactual experiment we will allow them to vary between 0 and 1 in an attempt to find a combination that0 works best. To evaluate the rules based on how well they would have performed had the central banks actually used them, we need to define a loss function. While there are many different possibilities, one of the most popular choices is the quadratic loss function (Nikolsko-Rzhevskyy, Papell, Prodan, 2019; Woodford, 2003):

$$L_t = (\pi_t - \pi_t{}^*)^2 + \lambda(u_t - u_t{}^*)^2 \quad (2)$$

If a policy results in deviations of inflation, π_t, from the target level, π^*, and unemployment, u_t, from its natural rate, u^*, it suffers the penalties. The coefficient, λ, allows the two quadratic losses to contribute differently to the value of the loss function, L. In our benchmark specification, $\lambda = 1$. Following the previous research, we allow monetary policy to affect the economy – and therefore lead to a particular value of the loss function – with a lag. Typically, the lag is between a year and two years. Hence, in our baseline specification, the policy lag is set to six quarters.

To divide the sample into the rules-based periods and discretionary periods, we do the following: first, we use Eq. (1) to construct the suggested interest rate for each pair of the response coefficients, α and γ, that define a Taylor rule. Whenever possible, we use real-time data – data that are available to monetary authorities at the time they were making their decisions. Second, by subtracting the suggested interest rate from the actual central bank rate, we construct the deviations which we then turn into absolute deviations. When the absolute deviations are large, we can say that the central bank was deviating from this particular rule thus exercising discretion. When the deviations are small, the central bank acted as if it was following the rule. As a threshold that separates the two regimes, we use the median value of the absolute distance (as in Nikolsko-Rzhevskyy, Papell, and Prodan, 2019). This method has several advantages over other methods. The most notable advantage is regardless of the rule being tested 50% of the data points will be “rules” while the other 50% will be “discretion.” Since the value of the loss function is invariant to the choice of the rule, different rules simply relabel the rules-based and discretionary data points in the sample, while keeping their number and the cumulative loss constant.

Once we know which data points belong to each regime, we calculate an average value of the loss function during the discretionary states, and its value during the rules-based states. We then divide the former by the latter to obtain a “loss ratio.” The larger the ratio is, the more beneficial it is to stick to that particular rule. By varying the two response coefficients – α (the inflation gap) and γ (the output gap) – we will be obtaining different loss ratios, thus finding the pair of the coefficients that maximizes it.

2.2. Estimating R*

The majority of the variables in Eq. (2) are readily available or require trivial calculations to obtain. The exception is the intercept, ${R_t}^*$, at which the policy real interest rate settles when inflation is at its target and the output gap is zero. At this point, monetary policy must remain neutral with respect to the economy. Therefore, the interest rate at this level is known as a neutral real interest rate. This rate also serves as a threshold, against which one may judge whether the monetary policy is expansionary or contractionary.

Literature treats the neutral interest rate as an unobservable and time-variant variable. Laubach and Williams (2003) were first to provide Kalman filter estimates of the neutral rate, which popularized applications of statistical filters and state-space models. The authors link the neutral rate in the U.S. closely to the potential output growth rate. This approach is consistent with the intertemporal utility maximization problem in a closed economy or a global economy setup, where investments are constrained by savings.

However, SOEs often finance investments with external funds, which makes them dependent on the yield expectations on the international capital market. Grafe et al. (2018) calculate neutral rates for several SOEs, including Czechia, Poland, and Hungary. They find that very little, if anything, can be attributed to their internal potential growth rates. Instead, the authors decompose neutral rates into the neutral rate in the U.S., which is a common global factor for all SOEs, and an unobservable random-walk component, which stands for all other factors.

Baksa et al. (2013) consider the case of Hungary and propose deriving the neutral interest rates in SOEs using the interest rate parity condition. Then Grui, Lepushynskyi and Nikolaychuk (2018) exploited this approach for the case of Ukraine. According to their approach, the neutral rate in a SOE must compensate for the country's risk premium. Additionally, it should account for the expected real appreciation of the domestic currency. This approach is based on two opposing realities. Due to risk, investors require higher yields from more vulnerable countries. However, the potential for currency appreciation makes investors more willingly accept lower rates of interest. We have decided to follow this approach in our paper.

The domestic neutral interest rate (r_t^*) is calculated as a sum of its counterpart in the U.S. ($r_t^{*,US}$) and a sovereign risk premium trend ($prem_t^*$) diminished by an annualized real exchange rate appreciation trend (Δz_t^*). Unobservable risk premium and exchange rate trends are estimated with the Kalman filter. The choice of slow-moving trends instead of more volatile actual indicators is consistent with the medium-term concept of the neutral rate. It states that the latter is consistent with output at its potential level and inflation at its target when the effects of all cyclical shocks have dissipated.

$$r_t^* = r_t^{*,US} + prem_t^* - \Delta z_t^* \tag{3}$$

The neutral rate in the U.S. is estimated using the Laubach and Williams (2003) methodology. The estimates are published by the Federal Reserve Bank of New York. We take the "one-sided" values, which correspond most closely to the real-time estimates. These estimates are conditional only on current and past observations, however, the coefficients of the model are estimated with all available data. For our modeling purposes, we make the U.S. neutral rate follow a random walk plus noise:

$$r_t^{*,US} = r_{t-1}^{*,US} + \varepsilon_{1,t} \quad (4)$$

The sovereign risk premium is calculated as a difference between the J.P. Morgan Emerging Market Bond Index Plus (EMBI+), which tracks the performance of sovereign dollar-denominated bonds in emerging markets, and yields to maturity on the U.S. 10-year treasury bonds. The premium, $prem_t$, is decomposed into the trend, $prem_t^*$, and a cyclical gap, $\widetilde{prem}_t$. The former follows a random walk, while the latter – an autoregressive process, which reverts to zero. The autoregressive coefficient in the gap equation is calibrated at 0.6. The standard deviation of the innovations to the gap is modeled to be 6.7 times higher than of those to the trend.

$$prem_t = prem_t^* + \widetilde{prem}_t \quad (5)$$

$$prem_t^* = prem_{t-1}^* + \varepsilon_{2,t} \quad (6)$$

$$\widetilde{prem}_t = \alpha_3 \widetilde{prem}_{t-1} + \varepsilon_{3,t} \quad (7)$$

The logarithm of the real exchange rate to the U.S. dollar, z_t, is decomposed into the unobservable trend, z_t^*, and the gap, $\tilde{z}_t$, similar to the risk premium. The autoregressive coefficient in the gap equation is set equal to 0.6, while the innovations to the gap have 6.7 times higher standard deviation than the innovations to the trend. Note that real exchange rate changes Δz_t^* are annualized, thus multiplication by 4.

$$z_t = z_t^* + \tilde{z}_t \quad (8)$$

$$z_t^* = z_{t-1}^* + \varepsilon_{4,t} \quad (9)$$

$$\tilde{z}_t = \alpha_5 \tilde{z}_{t-1} + \varepsilon_{5,t} \quad (10)$$

$$\Delta z_t^* = 4(z_t^* - z_{t-1}^*) \quad (11)$$

The neutral interest rate is unobservable, and its estimation requires other unobservable components as inputs. Consequently, any neutral interest rate estimate is subject to uncertainty.

This uncertainty raises the question about the costs of incorrectly estimating the neutral interest rate for the monetary policy. Perrelli and Roache (2014) investigated a set of emerging market economies and claimed that these costs are low. Taylor-type policy rules ensure that any mistakes are partially corrected. Policymakers respond to observable outcomes, regardless of whether they are due to output or inflation shocks, or incorrect estimates of observable variables.

3. Data Description

3.1. Poland, Hungary, and Czechia

The data for Poland, Hungary, and Czechia required for working with Eq. (1) and Eq. (2) come from Federal Reserve Economic Data (FRED),[11] OECD Main Economic Indicators (MEI),[12] and the corresponding central bank publications. The policy variable, i_t, is the interbank rate downloaded from FRED except for Czechia, where the two-week repo rate is used with the data obtained from the central bank's website.[13] Unemployment data, u_t, were taken from FRED as well, while the natural rate of unemployment, $u_t{}^*$, was downloaded from MEI data; quadratic conversion was then applied to transform annual figures into quarterly data.

The output gap, y_t, for all the three countries is obtained by detrending real GDP (downloaded from FRED) in a semi-real-time mode (i.e. an expanding window) using the Hodrick-Prescott filter.[14] For each window, the latest cycle estimate is being recorded as corresponding to that window's end date. After Q1 2008 for Poland, Q4 2010 for Hungary, and Q3 2010 for Czechia, we used the central banks' official real-time estimates of the output gap, obtained from the corresponding Inflation Reports over those years.[15] These Inflation Reports also provided data on each country's inflation target, $\pi_t{}^*$. As a measure of actual inflation, π_t, we used the headline year-over-year consumer inflation for all the three countries. The National Bank of Czechia targeted core CPI rather than headline CPI prior to Q4 2001. Therefore, we replaced the index for Czechia on that horizon. Summary statistics are presented in Table 1.

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[11] https://fred.stlouisfed.org/

[12] https://stats.oecd.org/Index.aspx?DataSetCode=MEI

[13] https://www.cnb.cz/en/monetary-policy/instruments/

[14] To deal with the well-known end-of-sample problem of the Hodrick-Prescott filter, we follow Baxter and King (1999) and Clausen and Meier (2005) and base the calculation of the filter at the end of the sample on data including forecasts over the next 12 quarters.

[15] https://www.nbp.pl/homen.aspx?f=/en/publikacje/raport_inflacja/raport_inflacja.html (for Poland), https://www.mnb.hu/en/publications/reports/inflation-report (for Hungary), and https://www.cnb.cz/en/monetary-policy/inflation-reports/ (for Czechia).

Table 1. Summary Statistics for Poland, Hungary, and Czechia

	Average	St.Dev	Min	Max
Poland				
Policy rate i_t	6.76	6.28	1.00	24.50
Output gap y_t	0.27	1.37	-2.10	6.00
Inflation π_t	3.24	3.14	-1.21	13.57
Inflation target ${\pi_t}^*$	3.60	2.14	2.50	9.50
Unemployment u_t	12.66	4.18	5.08	19.99
Natural rate of unemployment ${u_t}^*$	9.83	2.88	5.00	13.39
Hungary				
Policy rate i_t	6.89	4.83	0.90	20.17
Output gap y_t	-0.29	1.87	-5.52	6.00
Inflation π_t	5.03	3.58	-1.06	17.03
Inflation target ${\pi_t}^*$	4.09	1.67	3.00	9.00
Unemployment u_t	7.28	2.35	3.43	12.00
Natural rate of unemployment ${u_t}^*$	7.83	0.99	6.34	13.00
Czechia				
Policy rate i_t	2.50	3.06	0.05	15.00
Output gap y_t	-0.41	1.42	-5.33	6.00
Inflation π_t	2.66	2.43	-0.39	13.30
Inflation target ${\pi_t}^*$	2.94	1.23	2.00	9.00
Unemployment u_t	6.25	2.13	2.00	12.00
Natural rate of unemployment ${u_t}^*$	6.10	1.41	3.81	13.00

3.2. Ukraine

The NBU provided the data on Ukraine's output gap and neutral real interest rate. In addition, the data on inflation expectations came from the NBU's survey of financial analysts. Lastly, we use the data on interest rate forecasts from Focus Economics.

Ukraine's inflation targeting regime was announced in August 2015, and the first inflation target was set for December 2016. In our assessment, we rely on data from Q1 2016 until Q4 2020. Summary statistics are presented in Table 2.

Table 2. Summary Statistics for Ukraine

Ukraine	Average	St.Dev	Min	Max
Policy rate i_t	14.61	4.23	6.00	22.00
Output gap y_t	-2.37	3.25	-12.00	0.47
Inflation π_t	10.16	6.43	2.07	30.79
Inflation target $\pi_t{}^*$	7.21	2.65	5.00	12.00
Inflation expectations of fin. analysts	8.26	1.98	5.50	13.10

4. Empirical Research Findings

4.1. Real Neutral Interest Rate

The results for Poland, Hungary, and Czechia are shown in Fig. 1, which depicts the neutral real interest rates as well as their components, following the methodology outlined in Section 2.2. The individual *R** components for Poland are also plotted separately from each other in Fig. 2. Similar charts for other countries are available upon request.

As expected, the neutral rates in SOEs change along with their U.S. counterpart. According to the estimates by Laubach and Williams (2003), the latter significantly decreased in the aftermath of the global financial crisis of 2008, and remained low since that crisis. This phenomenon is what we observe as well.[16]

[16] The values for H2 2020 were extrapolated with a random walk as NY Fed suspended posting regular updates, citing the extraordinary volatility related to the COVID-19 pandemic.

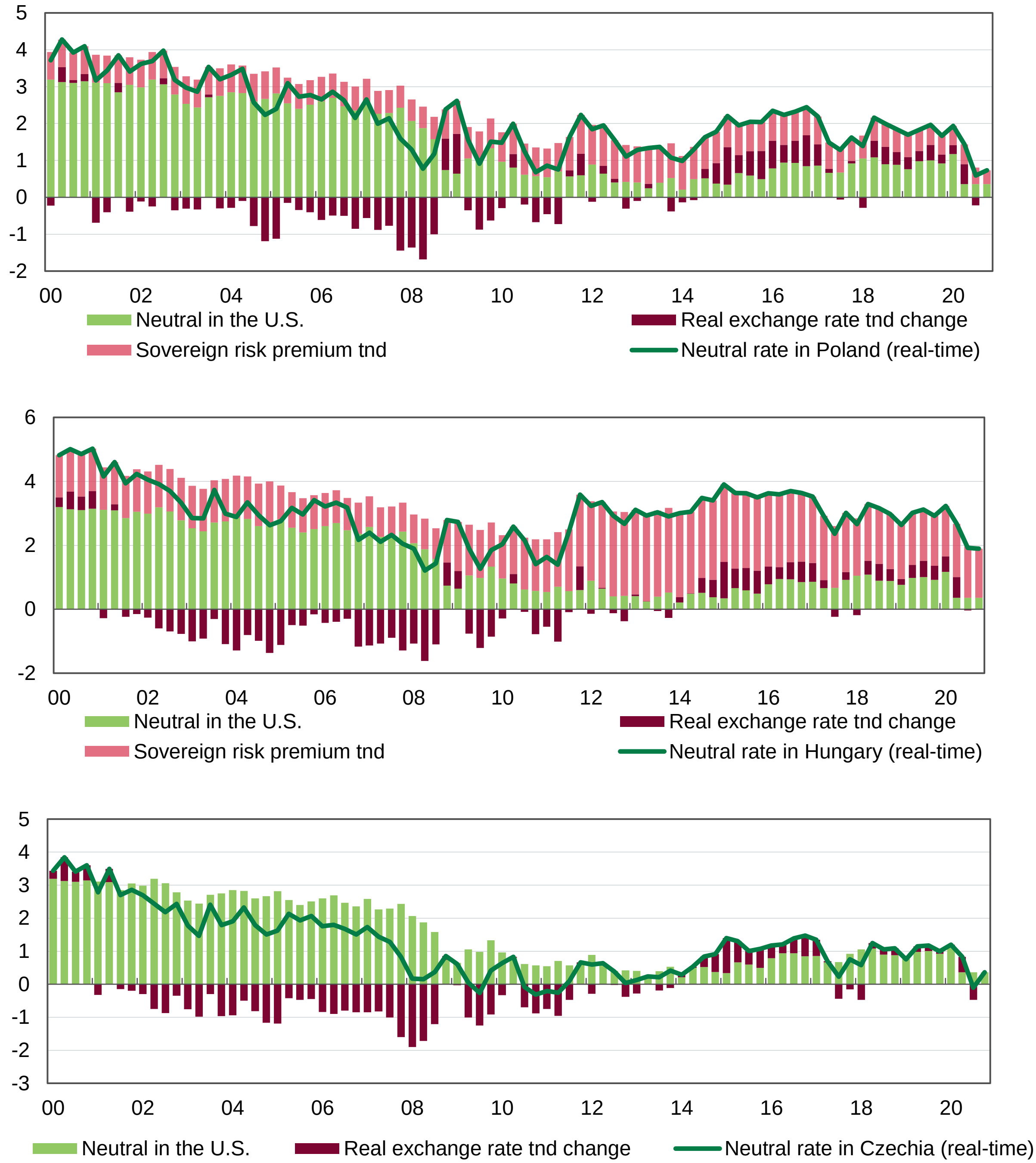

Figure 1. Real Neutral Interest Rates and Their Components for Poland (top), Hungary (middle), and Czechia (bottom)

The neutral interest rate may rise in case of a country's lower investment attractiveness as measured by its sovereign risk premium. The premium in Poland (the left-upper panel of Fig. 2) peaked twice in recent history – at the end of the global financial crisis and during the European debt crisis. Since those events, Poland's sovereign risk premium has been gradually decreasing.

Real-time trend estimates of the premium do not overreact to these temporary peaks. Additionally, it was steadily declining during 2013–2020. The situation in Hungary is similar. The premium in Czechia is considered to be equal to zero as the country is officially designated as an advanced economy and the EMBI estimates are not available. The data prior to 2005 are extrapolated with the Kalman filter as the information is not available for any of the three countries.

In 2000-2008, consistently appreciating real exchange rates led to a lower neutral interest rate for Poland. However, this trend stalled, and even partially reversed itself since that period of time. Real-time trend estimates seem to sluggishly follow observable exchange rate developments during both periods. The situation is similar in other economies under review, even though Ukraine displays stronger depreciation in 2014–2015.

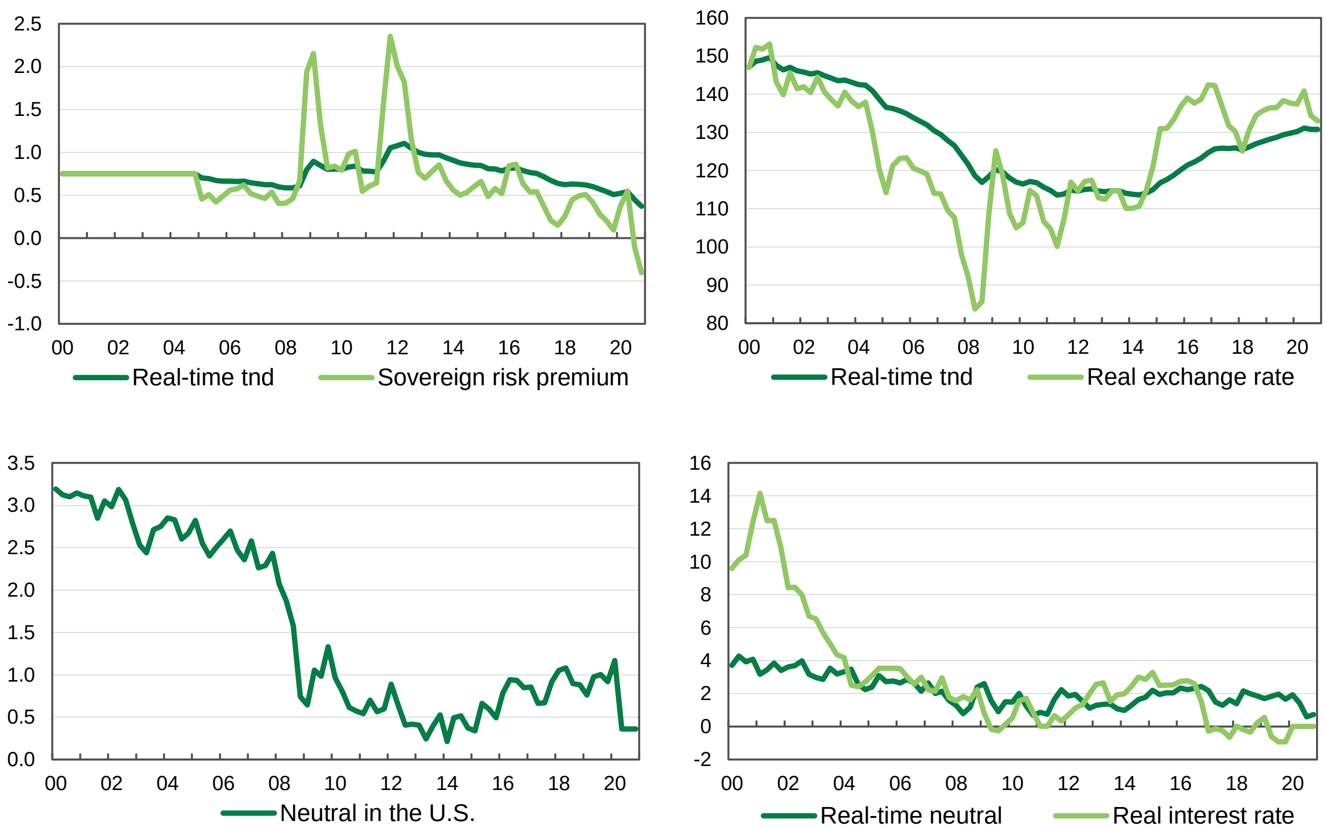

Figure 2. Poland's Real Neutral Interest Rate R* and its Subcomponents

Table 3 shows real-time estimates of the real neutral interest rate for Poland, Hungary, and Czechia. Those of Hungary and Czechia are lower, on average, in 2009–2020 than they were in 2000–2008. This rate decrease is consistent with the falling neutral rate in the U.S. However, the decrease is less substantial. The difference can be mostly attributed to changes to each country's real exchange rates that were appreciating until 2008, but have been depreciating ever since. Additionally, it can also be partially explained by the sovereign risk premium hikes during the European debt crisis.

Table 3. Real Neutral Interest Rate *R** before and after the Global Financial Crisis

	2000–2008	2009–2020
Poland	2.88	1.63
Hungary	3.23	2.84
Czechia	2.00	0.64
U.S.	2.62	0.70

Having constructed the R* series for Poland, Hungary, and Czechia, we have all the variables required to use Eq. (1). Hence, we can proceed with testing of the performance of the various policy rules for those countries to construct loss ratios. The results will show which combinations for the inflation and output gap coefficients would have been most beneficial for the economies of Poland, Hungary, and Czechia.

4.2. Assessing the Taylor Rule for Poland

We start by estimating our benchmark model for Poland. Following the literature (Nikolsko-Rzhevskyy, 2014, 2019, 2021), we assume a six-quarter lag between the moment when monetary policy changes take place and when the economy feels the effects of those changes. The loss function is defined by Eq. (2). As described in the methodology section, the inflation and output gap response coefficients in Eq. (1), α and γ, are allowed to vary between 0 and 1 with a discrete step of 0.1. For each pair of the response coefficients, we calculate the implied interest rate and compare it to the actual policy rate. Then we calculate the absolute difference between them. Each absolute difference series is then divided into the “rule-based” and “discretionary” periods depending on whether the absolute difference between the interest rate in a particular quarter was below or above its median value. As a result, exactly half of the data points are qualified as “rules-based” and the other half as “discretionary.” We calculate the average value of the loss function for each state separately – “rules” and “discretion.” Then, we divide this average loss value for the “discretionary” periods by its counterpart for the “rules” periods to obtain the *loss ratio*. If the ratio for a particular value of the inflation and output gap response coefficients is above one, this means that there are historical advantages to sticking to this rule. The larger the magnitude of this loss ratio is, the more beneficial it is to use this rule as opposed to the use of discretion.

The loss ratios for the different values of the inflation and output gap response coefficients for Poland are shown in Figure 3 below.

Inflation gap coefficient, α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
1.0	1.62	*1.78*	1.62	1.69	1.69	*1.79*	1.70	1.70	1.70	*1.85*	1.0
0.9	*1.81*	1.62	1.62	1.69	1.69	1.71	1.70	1.70	1.70	1.71	0.9
0.8	*1.74*	*1.82*	*1.72*	1.71	*1.75*	1.71	1.70	1.70	1.70	*1.77*	0.8
0.7	1.71	*1.79*	*1.72*	*1.72*	*1.73*	*1.90*	*1.94*	*1.89*	*1.89*	*1.77*	0.7
0.6	1.71	*1.79*	*1.72*	*1.72*	1.62	*1.73*	*1.89*	*1.89*	*1.79*	*1.80*	0.6
0.5	1.71	*1.79*	*1.79*	*1.72*	1.62	*1.73*	1.71	1.71	*1.74*	*1.86*	0.5
0.4	1.71	*1.79*	*1.79*	*1.72*	*1.72*	*1.73*	1.71	1.71	1.63	*1.77*	0.4
0.3	1.71	*1.79*	*1.79*	1.65	*1.72*	1.62	1.65	1.63	1.67	1.62	0.3
0.2	1.71	*1.79*	*1.79*	1.65	1.64	1.64	1.58	1.67	1.67	1.67	0.2
0.1	1.71	1.70	1.70	1.64	1.57	1.57	1.58	1.67	1.67	1.67	0.1
0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	

Output gap coefficient, γ

Figure 3. Heat Map of Loss Ratios for Poland

We can see several important results: first, regardless of which rule is being used, the ratios are always above one, meaning that all those rules appear to perform better than discretion. Rules in the lowest 5th quintile still result in about a 60% gain over discretion. Rules in the top 1st quintile are not much different, but still guarantee a gain of at least 79%. Second, it appears to be paramount to respond aggressively to inflation deviations. In fact, if the inflation response coefficient, α, is below 0.2, then regardless of the output gap response coefficient, γ, we will never reach the top two quintiles. Third, the best rule with the highest loss ratio of 1.94 is for $\alpha = \gamma = 0.7$, but we would stay in the top quintile even if the coefficients are slightly higher or lower. This rule – had the Bank of Poland used it – would have led to the best economic performance.

4.3. Assessing the Taylor Rule for Hungary

The next country we examine is Hungary. As it was the case for Poland, here, we vary the inflation and output gap response coefficients from zero to one in 0.1 increments. Then, we construct the loss ratios for each pair of α and γ and analyze them. The results are shown in Figure 4.

Inflation gap coefficient, α

	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
1.0	0.88	0.88	0.83	0.86	0.86	0.86	0.93	0.87	0.89	0.90	1.0
0.9	0.87	0.87	0.87	0.86	0.86	0.88	0.90	0.98	0.96	0.96	0.9
0.8	0.95	0.91	0.91	0.91	0.91	0.88	0.94	1.01	1.05	1.00	0.8
0.7	0.95	0.96	0.96	0.96	0.92	0.91	0.96	0.98	1.04	1.06	0.7
0.6	0.82	0.90	0.96	0.97	0.97	0.92	0.96	1.02	1.02	1.02	0.6
0.5	0.76	0.80	0.77	0.81	0.91	0.92	0.96	1.02	1.07	1.02	0.5
0.4	0.79	0.76	0.77	0.78	0.82	0.88	0.88	1.02	1.02	1.02	0.4
0.3	0.82	0.76	0.75	0.74	0.75	0.80	0.88	0.92	0.92	0.94	0.3
0.2	0.78	0.74	0.75	0.74	0.72	0.77	0.81	0.87	0.87	0.92	0.2
0.1	0.84	0.87	0.85	0.79	0.79	0.79	0.79	0.77	0.79	0.83	0.1
0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	

Output gap coefficient, γ

Figure 4. Heat Map of Loss Ratios for Hungary

For Hungary, the best combination of the inflation and output gap coefficients is 0.5 (lower than that for Poland) and 0.9 (higher than that for Poland). We will stay in the top quintile even for somewhat smaller and somewhat larger coefficients. The resultant benefit of using a rule rather than discretion is about 7 percent (the highest loss ratio is 1.07). Overall, there is no well-pronounced gain in economic performance from using the Taylor rules. Making a mistake of under-responding to inflation and output would put the policymakers in the bottom quintile, and might result in an up to 28% economic loss when compared to the optimal scenario.

4.4. Assessing the Taylor Rule for Czechia

The model for Czechia is parametrized the same way it is for Poland and Hungary. The results appear in Figure 5.

The model favors an inflation gap coefficient of 0.3 and an output gap coefficient of 0.9 or 1.0. In general, there always exists an inflation coefficient that will put the corresponding Taylor rule into the top quintile for every output gap coefficient. In fact, the classical rule where both coefficients are equal to 0.5 beats at least 80% of the alternatives. There also appears to be a substitutability between the inflation and output gap response coefficients: most combinations that belong to the top quintile appear to align along the main diagonal of the heat map matrix. Another important takeaway is that it is important for the Czech economy to aggressively respond to inflation. When the central bank fails to aggressively respond to inflation (α<0.3) then regardless of the output gap coefficient, the loss ratios fall into one of the two lowest quintiles. Those rules, however, still result in at least a 23% gain over discretion.

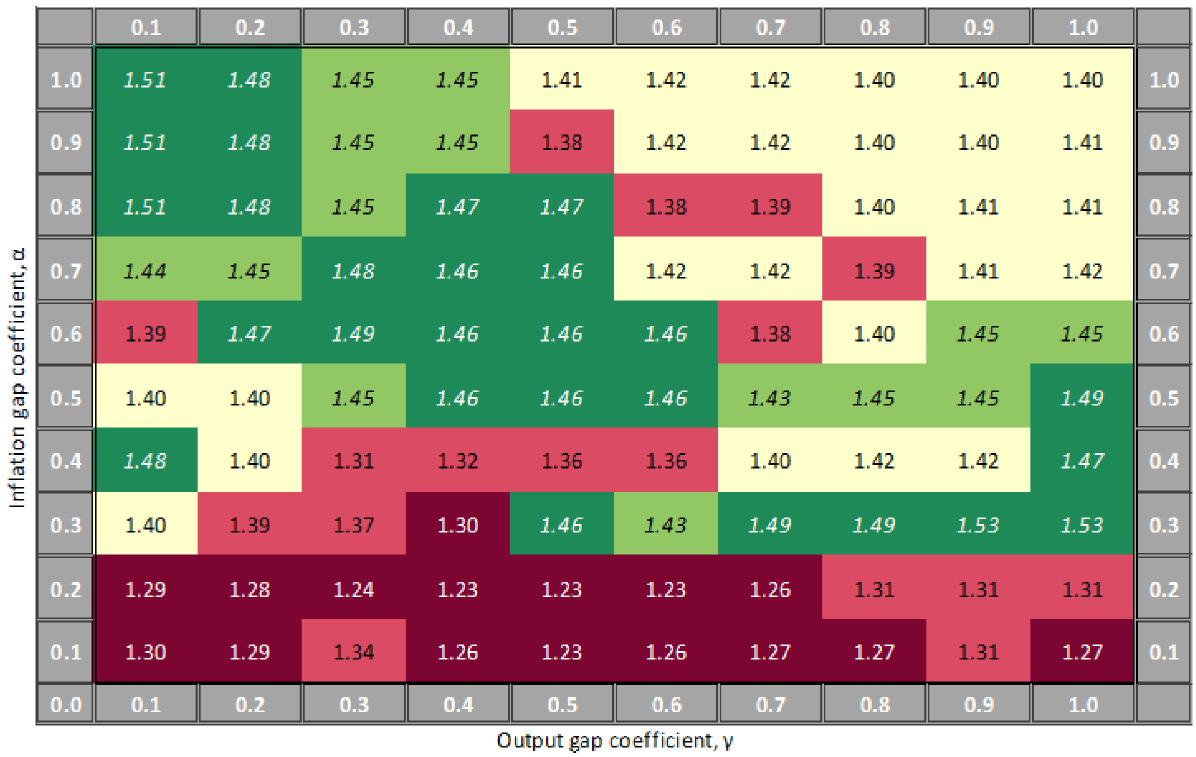

Figure 5. Heat Map of Loss Ratios for Czechia

4.5. Superposition of Benchmark Countries

As our next step, we create a superposition of the results for Poland, Hungary, and Czechia by overlaying the three heat maps over each other, calculating the product of the individual losses, and finding the geometric mean. This combined map allows us to investigate which rule or rules perform well, on average, for the three countries. Since in our study, Poland, Hungary, and Czechia serve as benchmark counties for Ukraine, this map will also provide insights for the optimal monetary policy in Ukraine. The geometric average of the three heat maps is presented below.

It looks like that the suggested rule for Ukraine appears to mimic that of Yellen (2012) with an inflation coefficient of 0.5 and an output gap coefficient of 1.0. This combination results in the loss ratio of 1.39, implying a 39% gain over using discretion. A slightly lower output gap coefficient or a lower or higher inflation gap coefficient would still keep the rule in the top quintile. In general, the optimal heat map for Ukraine most resembles that for Hungary, except that here, there are substantial potential gains from using the rules. The results also show the importance of first, a significant monetary response to inflation (low inflation response coefficients would put us into the bottom quintile) and second, a significant (ideally, close to one) output gap response coefficient.

Inflation gap coefficient, α

	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
1.0	1.24	1.28	1.23	1.25	1.23	1.25	1.26	1.28	1.30	1.34	1.0
0.9	1.30	1.26	1.24	1.25	1.23	1.26	1.27	1.29	1.32	1.31	0.9
0.8	1.28	1.30	1.29	1.29	1.30	1.27	1.27	1.32	1.32	1.32	0.8
0.7	1.28	1.30	1.29	1.29	1.29	1.32	1.34	1.34	1.37	1.35	0.7
0.6	1.21	1.26	1.30	1.29	1.27	1.28	1.33	1.34	1.35	1.37	0.6
0.5	1.20	1.23	1.24	1.26	1.25	1.28	1.29	1.32	1.35	1.39	0.5
0.4	1.22	1.22	1.19	1.21	1.21	1.26	1.31	1.33	1.30	1.35	0.4
0.3	1.18	1.20	1.19	1.15	1.27	1.24	1.28	1.30	1.34	1.33	0.3
0.2	1.13	1.13	1.12	1.11	1.11	1.16	1.18	1.24	1.25	1.26	0.2
0.1	1.11	1.08	1.10	1.08	1.09	1.10	1.13	1.17	1.19	1.19	0.1
0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	

Output gap coefficient, γ

Figure 6. The Recommendation for Ukraine (the geometric average of the three heat maps)

As our next step, we look at what the suggested rule for Ukraine we obtained by combining the results for the three benchmark countries would imply for the Ukrainian economy. Additionally, we will contrast the actual interest rate, set by the NBU over the available sample, to the one suggested by our rule.

5. Application to Ukraine

Applying a standard Taylor rule is not so straightforward for the Ukrainian economy, which is characterized by sharp disinflation (inflation target decreased from 12±3% in 2016 to 5±1% in 2019 and further) and sizable inflation shocks during the early years of inflation targeting. Macroeconomic volatility was further elevated by the pandemic in 2020. Additionally, just as it was the case for the benchmark economies, we need to solve the problem of appropriately measuring the variables that enter Eq. (1) as this is an essential step required to construct the implied rate.

First, the choice of the real neutral rate, *R**, depends on a number of assumptions around long-term values of main macroeconomic variables and may bring different outcomes. We rely on the official real-time estimates of the real neutral rate. Unlike the situation with Poland, Hungary, and the Czechia, where we had to estimate *R**, the series for Ukraine was provided by the NBU. These estimates were used by staff in providing monetary policy recommendations for the management, and thus do not depend on the policy preferences. However, they still might be a source of policy mistakes if they are consistently under- or overestimated. To validate the NBU estimates, we also provide the comparison between those estimates and the ones of market participants, surveyed by Focus Economics. The latter is calculated as a difference between long-term projections of the NBU rate and inflation target (see Figure 7). As can be seen, they match well and generally mimic each other's dynamics.

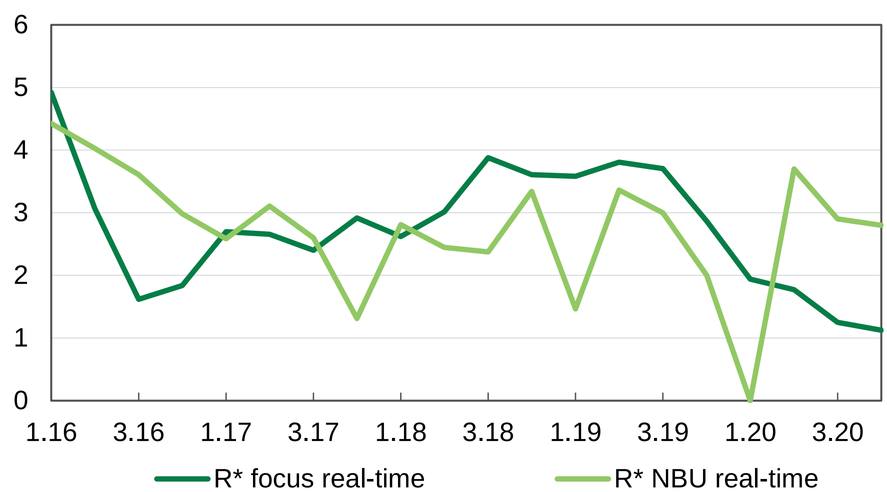

Figure 7. Real Neutral Interest Rate Estimates for Ukraine (NBU and market estimates)

Second, while a standard Taylor rule includes actual headline inflation as a measure of inflation expectations, such an approach in the case of Ukraine contains several drawbacks. Inflation in Ukraine is much more volatile compared to advanced economies and even with the majority of emerging markets. It is explained by poorly anchored inflation expectations, a high share of foods and other components with exaggerated price volatility, and the ongoing process of bringing some regulated prices to market levels. Thus, as a robustness check, in addition to the baseline specification that uses actual inflation, we also look at inflation expectations at the 12-months horizon. These expectations come from surveying financial experts by the NBU. The suggested rates using actual inflation and expected inflation, as well as the actual policy rate for Ukraine are shown in Figure 8.

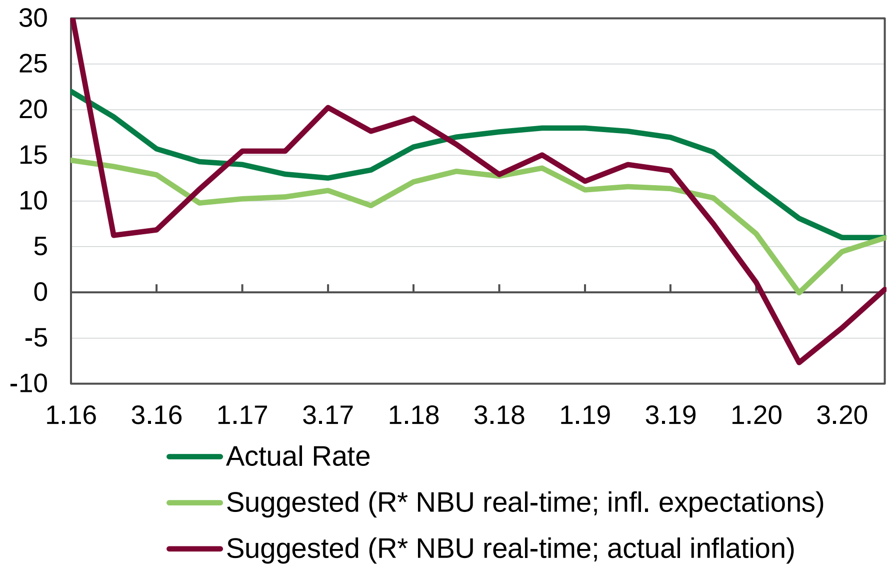

Figure 8. NBU's Key Policy Rate: Actual and Suggested by the Taylor Rule

Exploiting inflation expectations instead of more volatile actual inflation expectedly results in a more stable suggested path for the interest rate. It is interesting that this path was consistently biased downwards compared with the actual rate until the middle of 2020. Nevertheless, we cannot conclude that monetary policy was too tight on the whole horizon as inflation outcomes exceeded the targets on average. Instead, we consider this bias as the result of overconfidence of market analysts in the NBU's ability to quickly bring inflation down to the target. Moreover, pro-inflationary shocks turned out to be prevalent during that period.

The NBU's current reaction function relies on model-based expectations which are a weighted average of past inflation and a forward-looking component (see Grui and Vdovychenko, 2019 for details). As inflation almost permanently exceeded the future target from 2016 to the middle of 2019, it resulted in higher interest rates. Furthermore, during the first stage of inflation targeting, the NBU was much more aggressive in its reaction to inflation exceeding the target than to the negative output gap, essentially favoring price stability and accounting for the need to gain credibility to its monetary policy.

Despite the persistent bias, it seems that the NBU followed the changes in the suggested optimal path very closely. Moreover, there was a convergence of both interest rate paths (actual and suggested by the rule) in the second half of 2020, that may be a result of the start of inflation targeting period with stable inflation target (5±1%) after the initial disinflation period and actual inflation fluctuating relatively close to the target.

Relying on actual inflation in the policy rule brings the optimal interest rate, which is on average close to the actual interest rate set by the NBU. However, the suggested path was very volatile mimicking the vast fluctuations in actual inflation. One notable deviation started in the second quarter of 2020, when the suggested rate was consistently below the actual rate. This deviation suggests that while the NBU did respond to the COVID-19 crisis by lowering the policy interest rate, it did not lower it as much as the optimal rule would suggest. It can be explained by the fact that, just as many other central banks, the NBU also preferred some inertia in interest rates, thus including the autoregressive component in its interest rate reaction function which is absent in the standard Taylor rule (see Clarida, Gali, and Gertler, 1998 for an example). Moreover, the NBU considered the sharp inflation fall and the pandemic-induced negative output gap to be temporary. That turned out to be justified given an inflation surge in 2021.

Looking ahead, we expect that future interest rate decisions by the NBU will much more closely mimic the policy rule deemed optimal for neighboring countries. Our expectations ground on the stable inflation target after the initial stage of inflation targeting, and the economy returning to normal after the pandemic induced recession. The convergence of the NBU's actual rate with suggested path based on inflation expectations in the second half of 2020 has already provided some confirmation.

6. Conclusions

This paper makes several important contributions to the literature. First, it builds a framework that allows researchers and policymakers to develop the optimal monetary policy rule even when data availability is very limited. This methodology is applied to Ukraine whose central bank gained independence only after 2014 and did not start targeting inflation until 2016. The NBU never formally followed a policy rule and instead exercised discretion. Despite that, our results show that its actions closely resembled what the rule would have suggested in case it had been followed.

Second, as an intermediate result, the paper develops and implements a model that allows calculating the neutral real interest rate for small open economies. This calculation is a non-trivial task since unlike large economies, small open economies are affected by exogenous factors in a non-trivial way. For instance, they often rely on external financing. We apply our model to Poland, Hungary, and Czechia, and then calculate the time-varying neutral real interest rate for them.

Third, we analyze their monetary policy and backtest how various Taylor rules would have performed for Poland, Hungary, and Czechia Republic, had their central banks adopted them. We calculate the loss ratio for each set of parameters. This test allows us to find the best performing monetary policy reaction functions for each of the three countries.

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