WP/20/87

IMF Working Paper

Estimating the Neutral Interest Rate in the Kyrgyz Republic

by Iulia Ruxandra Teodoru and Asel Toktonalieva

INTERNATIONAL MONETARY FUND

WP/20/87

IMF Working Paper

Estimating the Neutral Interest Rate in the Kyrgyz Republic

by Iulia Ruxandra Teodoru and Asel Toktonalieva

INTERNATIONAL MONETARY FUND

 WP/20/87

IMF Working Paper

MCD

Estimating the Neutral Interest Rate in the Kyrgyz Republic

Prepared by Iulia Ruxandra Teodoru[1] and Asel Toktonalieva[2]

Authorized for distribution by Mark A. Horton

June 2020

Abstract

This paper estimates the neutral interest rate in the Kyrgyz Republic using a range of methodologies. Results indicate that the real neutral rate is about 4 percent based on an average of models and 3.7 percent based on a Quarterly Projection Model. This is higher than in many emerging markets and is likely explained by higher public debt and an elevated risk premium, low creditor rights and contractual enforcement, and low domestic savings. The use of an estimate of the neutral interest rate provides useful guidance to monetary policy and enhances transparency and independence of the central bank. Our estimate provides a quantitative benchmark for the monetary policy stance in the context of a central bank that is building analytical capacity, integrating additional insights in its decision-making process, and working to improve its communication. Strengthening the monetary transmission mechanism will be critical to enhance the effectiveness of monetary policy, including by allowing more exchange rate flexibility to support the transition to a full-fledged inflation targeting regime, and reducing excess liquidity to enhance the credit channel, reducing dollarization and high interest rate spreads that adversely affect the transmission of the policy rate to the economy.

JEL Classification Numbers: E52, E58, E43

Keywords: neutral interest rate, monetary policy stance, Taylor rule, quarterly projection model, general equilibrium model

Author's E-Mail Address: iteodoru@imf.org and aselya.atb@gmail.com

---

[1] International Monetary Fund.
[2] Currently, University of Texas at Dallas, and previously, National Bank of the Kyrgyz Republic.

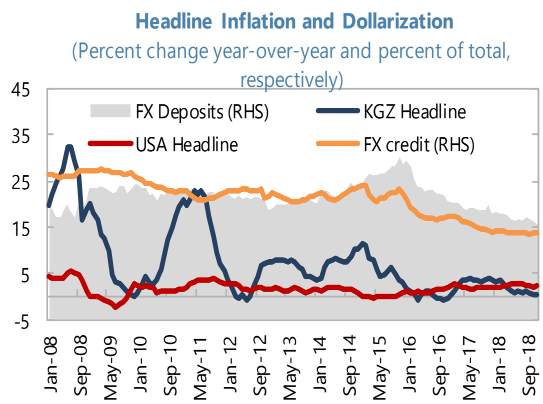
TABLE OF CONTENTS

I. INTRODUCTION[3]

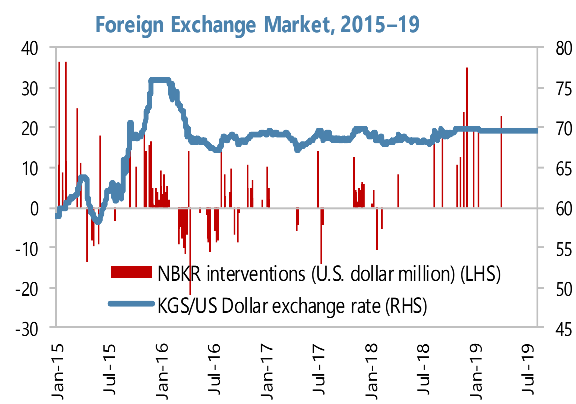
The National Bank of the Kyrgyz Republic (NBKR) is making steady progress to strengthen the monetary policy framework in the context of a move toward inflation targeting. In March 2014, the NBKR decided to move toward an inflation-targeting (IT) regime and use the policy rate as the instrument to keep inflation in the range of 5–7 percent in the medium term. The previous monetary-targeting regime, which targeted the monetary aggregate M2, had failed to lower inflation expectations or restrain inflation volatility.[4] Over the past few years, encouraging steps have taken place in the move toward the IT regime. These have included a substantial reduction of dollarization thanks to prudential rules (Figure 1, left chart) and a reduction of inflation, as well as absorption of surplus liquidity which has supported a closer alignment of short-term market rates to the policy rate. At the same time, importance is still attached by the public and financial market participants to stability of the nominal exchange rate, and FX interventions remain significant, although their frequency has been reduced over the past three years. They are mostly one-sided (selling FX). While the NBKR is targeting headline inflation, it is paying attention to core inflation too, in order to prevent the central bank from responding too strongly to temporary fluctuations in inflation (Figure 1, right chart).

Figure 1. Dollarization and Exchange Rate Developments

Dollarization has substantially declined while the inflation differential with the US almost disappeared



The KGZ/USD exchange rate has been stable over the past two years with less frequent but still sizeable foreign exchange interventions



Source: National authorities and authors' estimates.

---

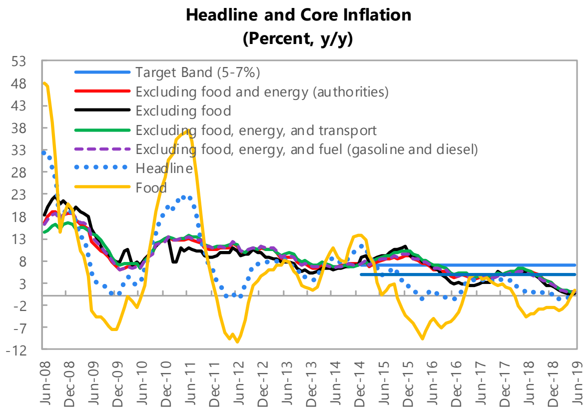
[3] Acknowledgements: We are grateful to Mark Horton, Christian Josz, Rossen Rozenov, Yaroslav Hul, Hynek Hrebicek and Jiri Lukac for insightful comments provided on the paper, and to the National Bank of the Kyrgyz Republic for the suggestions received on the QPM.

[4] According to Medina Cas, Carrion-Menendez and Frantischek (2011), one of the main advantages of the IT regime is its capacity to lower inflation without suppressing output. Countries with IT regimes are shown to have both lower inflation and inflation volatility relative to non-IT countries.

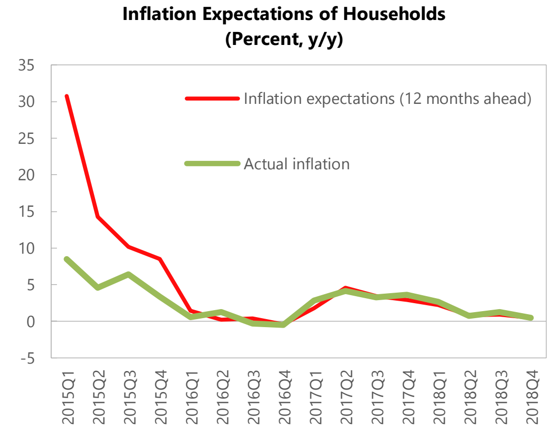
Inflation has come down as pass-through from shocks in 2015–16 has faded (Figure 2). Inflation has been below the NBKR's 5–7 percent target band since 2015 Q4, both due to falling food prices and low core inflation. This likely also reflects appreciation of the real effective exchange rate (REER), given that the items with the largest share in core inflation are imported, non-food products. Because of a stable som/$ exchange rate and REER appreciation, price increases for these items have slowed down. At the same time, household and firm inflation expectations have been closely aligned to actual inflation since 2016 rather than the inflation target. This suggests that agents have backward-looking expectations, and the exchange rate plays a role in the formation of expectations. Actual inflation is influenced by the stable exchange rate, and agents appear to be focused on exchange rate movements.

Figure 2. Inflation Dynamics

Headline inflation has been below the target range since 2015 Q4 due to lower core inflation and falling food prices



Inflation expectations have been very close to actual inflation since 2016



Source: National authorities and authors' estimates.

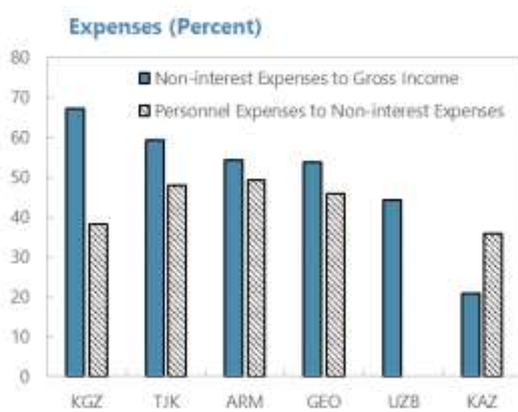
In the past several years, economic growth has slowed, and with high commercial bank lending rates, the NBKR is under pressure to support activity. Commercial bank lending rates—averaging 14 percent in real terms—and the lending-deposit interest rate spread—averaging 10 percentage points—are among the highest in the world, because of high bank operating costs, insufficient competition, credit risk, information asymmetries, and funding costs (Box 1.). Given these structural issues, changes in policy rates do not appear to translate into changes in commercial bank lending rates. Still, there is pressure on the NBKR to lower the policy rate to support the economy.

Box 1. Interest Rate Spreads

Interest rate spreads in the Kyrgyz Republic are relatively high from both a regional and global perspective. This constrains financial intermediation and hampers the effectiveness of the credit channel for monetary policy transmission. High interest rate spreads are likely one of the main reasons for the relatively low level of private investment, given that access to finance is a key constraint for firms.

High interest rate spreads are a reflection of a lack of competition and inefficiency in the banking system, as well as high credit risk and funding costs. Efficiency indicators suggest that noninterest costs are high compared to peers (67 percent of financial income) and personnel costs take up more than half of noninterest costs. At the same time, the concentration of the three largest banks (66.5 percent) is higher than in some of the regional peers. The Herfindahl-Hirschman bank concentration index (HHI) points towards increasing concentration since 2016. Econometric analysis (forthcoming IMF, 2020) finds that more competition, lower credit risk, and lower funding costs are key to lowering spreads. Lowering operating costs for small and medium-sized banks would also be critical to reduce their relatively higher spreads.

The Kyrgyz Republic has weaknesses in the rule of law and the depth of credit information and credit bureau coverage. Information on credit worthiness of borrowers is not easily available or sufficiently transparent to mitigate information asymmetries between banks and borrowers. This results in higher commercial bank lending rates and collateral requirements. Weaknesses in the rule of law and the overall business environment are reflected in weaker business and financial rankings of the country and may increase external funding costs.



	Strength of legal rights index (0=weak to 12=strong)	Depth of credit information index (0=low to 8=high)	Private credit bureau coverage (% of adults)	Rule of Law (-2.5=weak to 2.5=strong)
KAZ	6	7	59.3	-0.4
GEO	9	8	100	0.3
UZB	6	7	42.7	-1.1
KGZ	9	6	37.9	-0.9
ARM	6	8	80	-0.2
TJK	1	7	44.9	-1.3
AZE	8	8	41.5	-0.6
Average	**6.4**	**7.3**	**58.0**	**-0.6**

Source: World Economic Outlook database, Financial Soundness Indicators database, World Development Indicators, Worldwide Governance Indicators, and authors' estimates.

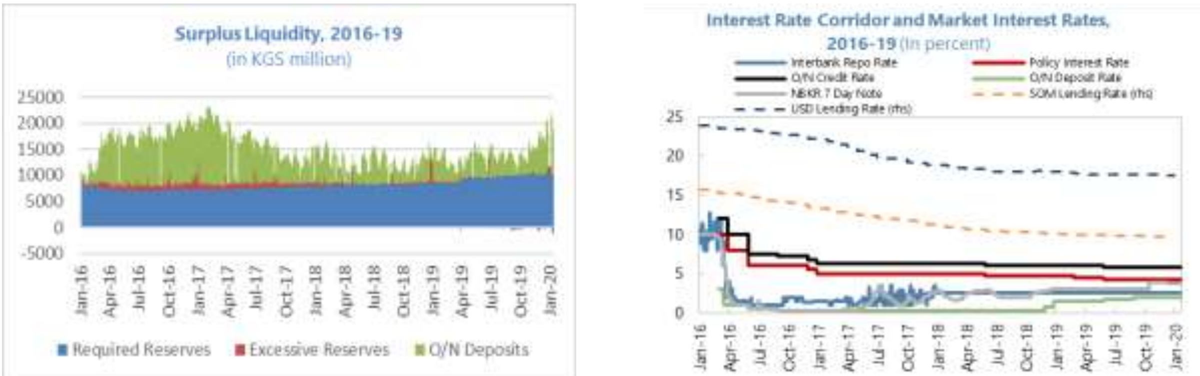
Policy rate decisions in the Kyrgyz Republic have mostly been based on a rule, with discretion employed in light of structural changes and external shocks. An estimate of the level of the neutral interest rate can provide guidance, as well as an indication of whether the monetary stance is accommodative, neutral, or restrictive. The NBKR uses a modified Taylor rule as part of a Quarterly Projection Model (QPM, see Section III.F.) to assess the monetary policy stance and guide its decisions on the policy rate. An interest rate above the neutral rate suggests a tight monetary policy stance, and when this is the case, economic slack will tend to increase. Growth will slow, the unemployment rate should rise, and the rate of inflation should be more muted or decline. By contrast, an interest rate below the neutral rate suggests an accommodative monetary policy stance, and when this is the case, economic slack will diminish, the economy will grow faster, the unemployment rate should decline, and inflation should increase. The challenge for the NBKR is managing this process and getting the balance right. The NBKR lowered its nominal policy rate twice in 2019—from 4.75 percent to 4.5 percent in February and 4.25 percent in May, based on its assessment that the output gap was negative and on signs of disinflationary pressures (headline inflation decelerated from 0.5 percent in December 2018 to -0.7 percent in February 2019 and was 0 percent in May 2019, while core inflation decelerated from 2.9 percent to 1.5 percent and 1 percent in the respective months). These reductions in the policy rate were also consistent with lower inflation expectations (see Figure 2).

Monetary policy transmission from the policy rate to money-market rates, and ultimately, to the real economy is weak in the Kyrgyz Republic. A still-high level of dollarization hinders the effectiveness of the transmission mechanism. Surplus liquidity in the banking system has been reduced (from to 13.2 bn KGS in Q1 2017 to 7.2 bn KGS in December 2019, Figure 3, left chart) through issuance of NBKR notes, but it remains high and at the short end, blurring the signal of the policy rate on the interbank market and the behavior of firms and households. Surplus liquidity because banks want to hold liquidity to self-insure in the context of a still inactive interbank market. The interest rate corridor measured as the range from the ceiling on the overnight (O/N) credit rate to the floor on the O/N deposit rate has changed multiple times (Figure 3, right chart): the O/N credit rate was lowered several times since 2016 moving in tandem with the policy rate, while the O/N deposit rate was raised recently with the aim to absorb excess liquidity from the market. At the end of 2018, the interest rate corridor was narrowed due to the higher O/N deposit rate, but it is still wide and asymmetric (the policy rate is near the top of the corridor). Given general lack of activity in the interbank market, the interbank interest rate has mostly stayed at the bottom of the interest-rate corridor. Further narrowing the interest-rate corridor by raising the O/N deposit rate is a prerequisite to bring short-term interest rates and the interbank rate closer to the policy rate.

Figure 3. Surplus Liquidity and Interest Rates Developments

Excess liquidity in the banking system has been reduced, but it remains high

The interbank rate has mostly stayed at the bottom of the interest rate corridor of the central bank



Source: National authorities and authors' estimates.

The objective of this paper is to estimate the neutral real interest rate for the Kyrgyz Republic. Section II reviews the literature on the neutral interest rate. Section III presents a description of methodologies and techniques used for estimation, including univariate filters, various dynamic Taylor rules, a General Equilibrium model following Laubach and Williams (2003), a time-varying VAR model (TVP VAR), and the QPM employed by the authorities for forecasting inflation. Section IV presents an additional analysis for overall monetary conditions. Section V presents the results. and section VI draws conclusions and makes recommendations for moving towards a full-fledged inflation targeting regime and improving the monetary policy transmission mechanism, as well as fiscal policy, structural reforms and financial sector policies to address high real interest rates and spreads.

II. Literature Review

Given that the neutral interest rate is a latent variable—an unobserved variable that must be inferred from the data, there are various methods to assess it. These differ not only in terms of methodology, but also in the definition of the neutral interest rate itself:

- The original definition came from Knut Wicksell (1898), who characterized the "natural rate of interest": "There is a certain rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor to lower them. This is necessarily the same as the rate of interest which would be determined by supply and demand if no use were made of money and all lending was effected in the form of real capital goods." Wicksell defined the natural rate of interest in three ways: (1) the rate of interest that equates saving and investment; (2) the marginal productivity of capital; and (3) the rate of interest that is consistent with aggregate price stability. These definitions imply that the natural rate is: (i) consistent with equilibrium; (ii) is a

characteristic of the economy in the long run; and (iii) is not fixed but fluctuates according to changes in technology that affect the productivity of capital.

- Taylor (1993) developed a representative policy rule with the feature that the federal funds rate in the United Sates rises if inflation increases above a target of 2 percent or if real GDP rises above trend GDP. If both the inflation rate and real GDP are on target, then the federal funds rate would equal 4 percent, or 2 percent in real terms. The 2 percent "equilibrium" real rate is close to the assumed steady-state growth rate of 2.2 percent. The response parameters (i.e. weights on inflation and the output gap) of the policy rule were both set to one half.

$$r = p + .5y + .5(p - 2) + 2$$

where r is the federal funds rate, p is the rate of inflation over the previous four quarters, and $y = 100(Y - Y^*)/Y^*$, where Y is real GDP and Y^* is trend GDP (equals 2.2 percent per year from 1984.1 through 1992.3).

This parameterization appeared to describe Federal Reserve behavior well in the late 1980s and early 1990s. Econometric evidence that appeared to support the stabilization properties of this rule generated substantial interest, and numerous central banks began to monitor this policy rule or related variants to provide guidance on decisions. By linking interest rate decisions directly to inflation and economic activity, "Taylor rules" offer a useful tool for studying and conducting monetary policy.

- Laubach and Williams (2003) operationalized Wicksell's concept by defining the natural rate as the real short-term interest rate consistent with the economy operating at its full potential once transitory shocks to aggregate supply or demand have abated. Their concept of the neutral interest rate takes a 'longer-run' perspective in that it refers to the level of the real interest rate expected to prevail five to ten years in the future, after the economy has emerged from any cyclical fluctuations and is expanding at its trend rate. They used a multivariate Kalman filter to jointly estimate potential output and the neutral rate in the U.S. The Laubach-Williams model was influential, and a number of subsequent papers have used their approach to estimate equilibrium interest rates.[5] [6]

[5] Pescatori and Turunen (2015) apply a Bayesian approach to the semi-structural model of Laubach and Williams to calculate the neutral rate in the US, while Krustev (2018) extends the model of Laubach and Williams by adding the financial cycle. Christensen and Rudebusch (2017) and Ajevskis (2018) use financial information and the term structure of interest rates to estimate the natural rate. These approaches are relevant mostly for developed economies with large financial markets.

[6] Pedersen (2015) argues that the estimation of the original Laubach and Williams (2003) model turns out to be problematic for the Danish economy, performs poorly on Danish data, and in general is not appropriate for a

(continued…)

- Dynamic Stochastic General Equilibrium (DSGE) and related New Keynesian models[7] entail a more rigorous framework, in which the natural rate is defined as the real interest rate that would prevail if all prices were flexible. There are conceptual differences in estimation of natural rates by Woodford (2003) and DSGE models on the one hand and Laubach and Williams (2003)-type models on the other. Woodford (2003), focused on a *short-run equilibrium rate*, arguing that offsetting high-frequency movements in the equilibrium interest rate should be a key consideration of monetary policy, to be supplemented by deviations from the equilibrium interest rate to achieve the central bank's inflation and employment stabilization goals. The short-run focus is in contrast to measures discussed in Laubach and Williams (2003) and Holston, Laubach, and Williams (2017), which emphasize the economy's *long-run* equilibrium interest rate. The key distinction is that a *short-run* equilibrium rate is one that stabilizes the economy period by period, whereas the *long-run* equilibrium is the value of the interest rate that will stabilize the economy down the road, in the long run. The time horizon in DSGE models is different, and hence, measures of the natural rate produced by such models typically exhibit higher volatility. However, despite conceptual differences, the methodologies can be viewed as complementary to one another.

- Most studies estimate neutral rates for developed economies, while a few investigations pursued neutral rates for emerging markets and developing countries. Grui, Lepushynskyi and Nikolaychuk (2018) use the QPM to estimate the neutral rate for Ukraine, and Hledik and Vlcek (2018) use a variant of the QPM for the Czech Republic. The QPM is a small, structural new Keynesian model, which can also be viewed as a more simple form of the DSGE models. Kreptsev et al (2016) use semi-structural models, including that of Laubach and Williams, for the Russian Federation. Fuentes and Gredig (2007) and Magud and Tsounta (2012) use a range of methodologies, including consumption-smoothing models and uncovered interest rate parity condition (UIPC), as well as a common stochastic trend between short-term and long-term nominal interest rates following Basdevant et al. (2004), Taylor rules, and a semi-structural model following Laubach and Williams to estimate neutral rates for Chile and for ten Latin American economies, respectively. Carrillo et al (2018) estimate the modified Laubach and Williams specification for the small open economy. Us (2018) estimates a model with time-varying parameters using an extended Kalman filter to account for the volatile nature of the Turkish economy.

---

small open economy. He solves the issue by extending the 2003 reduced-form model and applying Bayesian econometric techniques for the estimation.

[7] Gali (2002), Giammarioli and Valla (2003), Woodford (2003), Neiss and Nelson (2003), Lam and Tkacz (2004), Brand, Bielecki and Penalver (2018).

Table 1. Estimates of Neutral Real Interest Rate in Emerging Markets and Developing Economies

Grui, Lepushynskyi and Nikolaychuk (2018)	Ukraine	2-2.5
Hledik and Vlcek (2018)	Czech Republic	1.0
Fuentes and Gredig (2007)	Chile	2.8
Carrillo et al (2018)	Mexico	2.5
Kreptsev et al (2016)	Russia	2.5-3, with high uncertainty around estimates
Magud and Tsounta (2012)	Brazil	5.1 (4.5-5.7)
	Peru	2.0 (1.3-5)
	Colombia	2.3 (1.6-4.4)
	Costa Rica	3.5 (2.6-4.1)
	Dominican Republic	3.2 (1.7-4.2)
	Guatemala	2.8 (2.0-3.7)
	Paraguay	2.2 (1-3.8)
IMF Article IV Consultation (2018)	Georgia	2
IMF Article IV Consultation (2018)	Kazakhstan	4

Source: Authors' review of literature, see references.

III. Empirical Framework

A. Univariate Estimates

Univariate time series methods work well at estimating the neutral interest rate when inflation and economic activity are relatively stable. The simple mean of the policy interest rate over a long time-horizon—for example from June 2015 to December 2019—could be an approximation for the neutral rate. In this case, the neutral real rate for the Kyrgyz Republic would be 3.6 percent; the median is 3.75 percent. Another univariate statistical technique for measuring the neutral rates is to apply time-series filtering methods such as Hodrick-Prescott filtration. Under this approach, the neutral rate is 3.9 percent in December 2019. However, the Hodrick-Prescott filter is criticized for its end-point bias. Furthermore, there are arguments that the neutral rate is not constant over time and that univariate methods do not take into account

Neutral Real Rate
(Percent)

Source: Authors' estimates.

periods of unstable inflation or changes in economic structure.

B. Dynamic Taylor Rules

Dynamic Taylor rules link interest rate decisions directly to inflation and economic activity and can account for the speed and persistence of interest-rate movements. Magud and Tsounta (2012), Carrillo et al (2018), and Ajevskis (2018) use dynamic Taylor rules in their estimations of neutral rates. The Taylor rule in our estimates comprises the following equations:

$$r_t = r_t^* + \beta\,(\pi_t - \pi_t^*) + \theta\, y_t + \varphi\, reer + e_t$$

$$r_t^* = r_{t-1}^* + g_{t-1}$$

$$g_t = g_{t-1} + v_t$$

where r_t is the policy rate, r_t^* is the neutral nominal policy rate, $(\pi_t - \pi_t^*)$ are deviations from the inflation target, y_t is the output gap, *reer* is the real effective exchange rate gap (i.e. cyclical component of the *reer*), g_t is the growth rate of the state variable r_t^*, and v_t^2 is a stochastic disturbance term (with mean zero). All disturbance terms are assumed to be zero mean variables with constant variances.The model incorporates information on the output gap and on the deviation of actual inflation from the inflation target, as is standard in Taylor rule models. The exchange rate is included to account for an important transmission channel in emerging markets. The intercept in the Taylor rule can be interpreted as the neutral interest rate and is modelled as a random walk process. The results show that the real neutral level of the interest rate is 4.3 percent. If lagged values of the output gap and reer gap are considered, the neutral rate is 4.7 percent.

We estimate a modified Taylor rule by including the lagged component of the interest rate to account for the persistence of the monetary policy. In this case, the equation for the Taylor rule takes the following form:

$$r_t = \alpha\, r_{t-1} + (1-\alpha)(r_t^* + \beta\,(\pi_t - \pi_t^*) + \theta\, y_t + \varphi\, reer) + e_t^2$$

while the transition equations r_t^* and g_t are modelled as before. For simplicity, we calibrate the coefficient of monetary policy persistence α to 0.6 - the same value as the one in the QPM of Kyrgyz Republic. The results indicate that the neutral rate is similar to the estimate that does not include the persistence of the policy rate; if lagged values of the output gap and the reer gap are considered, the real neutral rate is higher—5.2 percent.

C. General Equilibrium Model

The small, semi-structural macroeconomic model of Laubach and Williams (2003) has been used extensively for estimations of neutral rates. Following their work, other studies applied either the standard model or a modified variant. This is because the Laubach-Williams model focuses on aggregate demand-supply equilibrium, without requiring complex theoretical foundations as is the case with DSGE models. Following mainly the work of Fuentes and Gredig (2007) and of Magud and Tsounta (2012), the approach in this study relies on an Investment-Savings (IS) equation that relates the output gap to its own lags and lags of deviations of the monetary policy rate from neutral levels, as well as a Phillips curve that relates inflation to the output gap. The model depends less on the structure of financial markets; however, it assumes that the monetary transmission channel works efficiently. The model consists of the following equations:

$$(y_t - y_t^*) = \sum_{s=1}^{S} a_s^y \,(y_{t-s} - y_{t-s}^*) + \sum_{v=1}^{V} a_v^r \,(r_{t-v} - r_{t-v}^*) + e_t^y$$

$$\pi_t = \sum_{p=1}^{P} \beta_p^\pi \;\pi_{t-p} + \sum_{q=q}^{Q} \beta_q^Y \left(y_{t-q} - y_{t-q}^*\right) + x_{1,t}'\beta + e_t^\pi$$

$$y_t^* = y_{t-1}^* + g_{t-1} + e_t^{y*}$$

$$g_t = g_{t-1} + e_t^g$$

$$r_t^* = r_{t-1}^* + e_t^r$$

where $(y_t - y_t^*)$ is the output gap, $(r_{t-v} - r_{t-v}^*)$ is the deviation of the real monetary policy rate from the neutral real rate, π_t is the inflation rate, $x_{1,t}'$ is a control variable for the inflation equation, respectively, that includes cyclical deviations of the real effective exchange rate. The control variables are included to account for the fact that the Kyrgyz Republic is a small open economy. All disturbance terms are assumed to be zero-mean variables with constant variances.

The model estimates two unobservable variables—the neutral real rate and potential output—using a Kalman filter. Unlike the original work of Laubach and Williams (2003), the neutral rate is modelled as a random walk process without drift; in the standard Laubach and Williams (2003) model, the neutral rate is estimated as the sum of the potential output growth rate and other determinants captured in an autoregressive process. The smoothness of the trend components is controlled by setting the restrictions on the sigmas, similar to Fuentes and Gerdig (2007) and Magud and Tsounta (2012):

$$\frac{\sigma_{y*}}{\sigma_g} = \lambda_1$$

$$\frac{\sigma_y}{\sigma_r} = \lambda_2$$

$\frac{\sigma_{y*}}{\sigma_g}$ is the variance of potential output divided by the variance of real output, and $\frac{\sigma_y}{\sigma_r}$ is the variance of output divided by the variance of the neutral interest rate. The lambdas are set to 14400, given use of monthly data. Using these restrictions, the model can be estimated by maximum likelihood using the Kalman filter algorithm. According to our general equilibrium model, the neutral real rate is 4 percent.

Table 2. Model Parameter Estimates

	Coefficient	Std. Error	z-Statistic	Prob.
α^y	0.38	0.00	82.22	0.00
α^r	0.00	0.01	-0.02	0.99
β^π	1.45	0.03	46.50	0.00
β^y	1.14	4.67	0.24	0.81
$x^{''}$	-0.06	0.02	-2.67	0.01
	Final State	Root MSE	z-Statistic	Prob.
y^*	9.33	0.06	148.19	0.00
r^*	3.98	1.04	3.81	0.00

Source: IMF staff calculations.

D. TVP VAR

Time-varying parameter vector autoregressive models (TVP VAR) provide another alternative way to measure the neutral interest rate. Contrary to the semi-structural macroeconomic framework of Laubach and Williams (2003), this approach can be viewed as a statistical technique that allows for non-linearity in relationships of economic variables. What distinguishes a TVP VAR from the standard VAR approach is that the parameters of the model (i.e. the lag coefficients and the variances of the economic shocks) are allowed to vary over time. Thus, this framework is capable of capturing a variety of nonlinear behaviors that are apparent in macroeconomic time series, such as asymmetric movements of variables over the course of the business cycle. Lubik and Matthes (2015) use a TVP VAR to estimate the natural rate for the U.S.; Brubakk, Ellingsen and Robstad (2018) apply a TVP VAR to estimate the neutral rate in Norway; Carrillo et al (2018) implement Bayesian Vector Autoregression (BVAR) with time-varying intercepts for Mexico. The model in this study can be represented in the state-space form as follows:

$$Y_t = \alpha_t + \sum_{j}^{L} B_{j,t}\, Y_{t-j} + v_t$$

$$\beta_t = \{\alpha_{t,}\, B_{j,t}\}$$

$$\beta_t = \mu + F\beta_{t-1} + e_t$$

A TVP VAR of order two is estimated for three variables: real GDP growth rate, short-term interest rate, and the inflation rate for the period of June 2010 - May 2019. Specifially the following equations are estimated in the observation equation:

$$GDP_t = \alpha_{1t} + beta_{1,1}GDP_{t-1} + beta_{1,2}infl_{t-1} + beta_{1,3}\,r_{t-1} + +beta_{1,4}GDP_{t-2} + beta_{1,5}infl_{t-2} + beta_{1,6}\,r_{t-2} + v_{1t}$$

$$infl_t = \alpha_{2t} + beta_{2,1}GDP_{t-1} + beta_{2,2}infl_{t-1} + beta_{2,,3}\,r_{t-1} + +beta_{2,4}GDP_{t-2} + beta_{2,5}infl_{t-2} + beta_{2,6}\,r_{t-2} + v_{2t}$$

$$r_t = \alpha_{3t} + beta_{3,1}GDP_{t-1} + beta_{3,2}infl_{t-1} + beta_{3,3}\,r_{t-1} + +beta_{4,4}GDP_{t-2} + beta_{5,,5}infl_{t-2} + beta_{6,,6}\,r_{t-2} + v_{3t}$$

where GDP, $infl$, and r stand for the real output growth, inflation and interest rate are collected in the matrice Y, and the betas are collected in the matrice B. We apply Gibbs sampling techniques and Carter-Kohn algorithm in the BVAR estimation. At each point t, the neutral rate is measured as the 24 month ahead in sample forecast of the interest rate. The results indicate that the neutral real rate is about 2.8 percent (Appendix III presents the coefficients).

E. Quarterly Projection Model

The QPM used at the NBKR for forecasting and policy analysis features rational expectations and an interest-rate rule. The QPM is a small structural new Keynesian model of a small open economy with a floating exchange rate. The model is linear and calibrated to match stylized facts of the Kyrgyz economy. It uses quarterly data for the period of Q1 2000 to Q1 2019. The model defines variables in terms of gaps (business cycles) and trends (long-term values) which are identified using a Kalman filter. Policymakers can affect business conditions in response to different shocks affecting the economy. For example, a supply shock caused by a low harvest which could raise food prices and then spill into core inflation can be supressed by an increase of the policy rate. In contrast, interest rates can be reduced to support the economy in response to a negative domestic or foreign demand shock. In addition, the results of policy interventions can be analyzed through the model's outcome. In the long-run, economic fundamentals are at their equilibrium values.

The QPM models the Kyrgyz economy, including remittances and gold production, and uses simpler models of the economies of its main trading partners and of the US economy as inputs for the Kyrgyz model. The model uses the steady states of trading partners, as well as historical data to model the gaps and trends mostly as an autoregressive process. The modeling of partners is simpler compared to the Kyrgyz economy. Key relations between variables are established: the Russian and Kazakh output gaps depend on the real oil price gap, and Kyrgyz remittances depend on Russian GDP; the US sector models the US economy, as well as the dynamics of real oil prices, food and gold prices. The

Chinese sector consists of autoregressive equations to set the dynamics of Chinese macroeconomic variables. The results from the external sector are then used to model the Kyrgyz economy. The Kyrgyz economy is modeled using gold and agriculture production. Kumtor, the biggest gold mining company, produces around 10 percent of the country's GDP, and gold constitutes about 40 percent of goods exports, while agriculture accounts for around 12 percent of the country's GDP.

The four key equations of the QPM include an aggregate demand curve, a Philips curve, a UIP condition and a Taylor rule:

Aggregate demand equation. The total output gap is decomposed into (i) the output gap without Kumtor and agriculture, (ii) the Kumtor output gap, and (iii) the agriculture output gap. Each output gap is modeled separately, and policymakers impact only output without Kumtor and agriculture:

$$y_t^{xk} = a_1 y_{t-1}^{xk} + a_2 E_t y_{t+1}^{xk} - a_3 rmci_t + a_4 y_t^* + a_5 qremit_t + a_6 fisc_t + e_t^y$$

where y_t^{xk} is the output gap without Kumtor and agriculture, $rmci_t$ - real monetary condition index, y_t^* - foreign output gap, $qremit_t$ - real remittances gap, $fisc_t$ - fiscal impulse. Output depends on foreign demand (the weighted output of Russia, Kazakhstan, China and the U.S.), the mix of monetary and fiscal policies, as well as on the past and future output. The value of the coefficients show the extent of the impact of each factor, and thus, the effectiveness of monetary policy and the transmission mechanism.

The uncovered interest rate parity (UIP). Under the assumption of full capital mobility, the nominal UIP relates the exchange rate dynamics with the domestic and foreign nominal interest rates differential, adjusted for the risk premium:

$$s_t = w1 * (E_t\, s_{t+1} - \frac{i_t - i_t^{us} - prem_t}{4}) + (1 - w1) * SC + e_t^s$$

$$SC = s_{t-1} + 2(\Delta z^{us} + \pi_{target} - \pi_{target}^{us})/4$$

$$E_t s_{t+1} = f_1 s_{t+1} + (1 - f_1)(s_{t-1} + \frac{2}{4}\left(\Delta z^{us} + \pi_{target} - \pi_{target}^{us}\right))$$

where s_t is the nominal exchange rate KGS per USD, i_t - domestic nominal interest rate, i_t^{us} - US nominal interest rate, $prem_t$ - country risk premium. SC stands for the smoothing parameter that reflects less sensitivity to the interest rate differential, and w1 is the weight placed on the pure UIP. The risk premium is expressed as:

$$prem_t = g_1\, prem_{t-1} + (1 - g_1) prem^{ss} + e_t^{prem}$$

In the absence of shocks, the dynamics of the risk premium are mostly determined by its past value, and the risk premium converges to the steady-state value of 4.5 percentage points in equilibrium. The country risk premium has significantly declined since 2000. This can be attributed partly to the decline of the public debt-to-GDP ratio from 122 percent in 2000 to the present 54 percent (which is still a large burden for the country).

Aggregate supply: inflation. The headline inflation index is the sum of three components: food inflation, core inflation, and inflation of administratively-set prices (e.g. utility services). Each component is modeled separately. Core inflation is a function of past and expected inflation, imported prices, and real marginal costs:

$$\pi_{xf,t} = b_1 E_t\, \pi_{xf,t+1} + b_2 \pi_{im} + (1 - b_1 - b_2)\pi_{xf,t-1} + b_3 rmc_{xf} + e_{xf}$$

where $\pi_{xf,t}$ is the ex-food inflation, π_{im} - foreign imported inflation, rmc_{xf} - ex-food real marginal cost. The real marginal costs include both the output gap (markup costs) and the real exchange rate gap.

Similarly, food inflation is sensitive not only to imported food prices but also to the agricultural output (harvest):

$$\pi_{f,t} = b_{1f} E_t\, \pi_{f,t+1} + b_{2f} \pi_{im\_f} + \left(1 - b_{1f} - b_{2f}\right)\pi_{f,t-1} + b_{3f} rmc_f - b_{4f} y\_agr_t + e_f$$

Taylor rule. The interest rate rule is a modified "Taylor principle" and relates the interest rate with the inflation gap (difference between expected inflation and inflation target), output gap, exchange rate gap, and the lagged interest rate. The central bank sets the interest rate to achieve the inflation target, and the lagged component shows the persistence of the monetary policy:

$$i_t^T = c_1 i_{t-1} + (1 - c_1)(itnd_t + c_2\, \pi_{gap,t} + c_3 y_t + c_4 s_{gr,t})$$

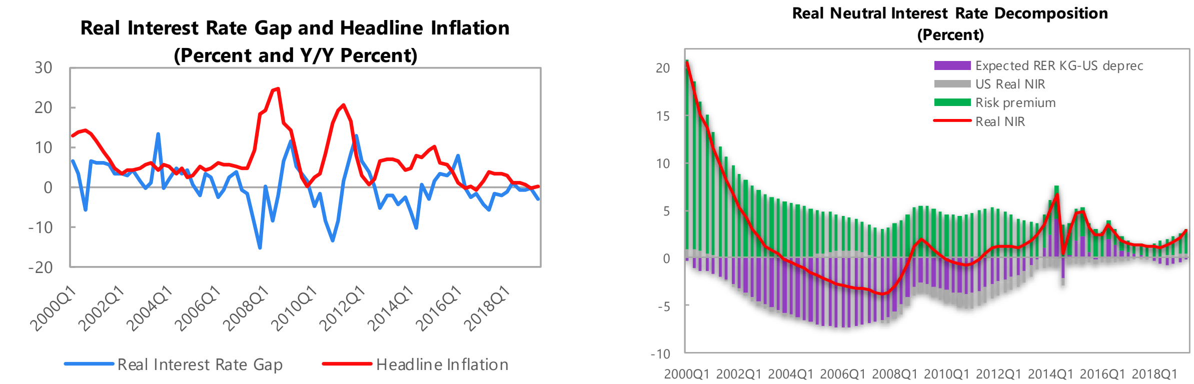
where i_t^T is the Taylor rule implied interest rate, $itnd_t$ - policy neutral rate, $\pi_{gap,t}$ - inflation gap, $s_{gr,t}$ - nominal exchange rate gap. The nominal neutral rate is a function of the real interest rate trend $rtnd_t$ and medium term expected inflation target $\pi_{target,t+4}$, while the real neutral rate from the real UIP is the sum of the risk premium *prem* (2.2 percent for Q1 2019; 4.5 percent is the steady state value), US neutral rate $rtnd^{us}$ (0.4 percent for Q1 2019) and the expected RER KG-US depreciation $exp\ \_z^{us}$ (-0.5 percent for Q1 2019):

$$itnd_t = rtnd_t + \pi_{target,t+4}$$

$$rtnd_t = exp\ \_z^{us} + rtnd^{us} + prem$$

The estimated real neutral rate from the QPM for the end-2019 is 3.7 percent. It is 4.5 percent for the steady state. Figure 4 depicts the real neutral rate decomposition and its dynamics since 2000.

Figure 4. Real Interest Rate Gap and Real Neutral Rate Decomposition



Source: Authors' estimates.

Table 3. Correlation Coefficients of Real Interest Rate Gap

	$lag=0$	$lag=1$	$lag=2$	$lag=3$	$lag=4$	$lag=5$
$corr(rgap_{t-lag}, r_t)$		0.5616	0.2702	0.0637		
$corr(rgap_{t-lag}, \pi_t)$	-0.2004	-0.4553	-0.5926	-0.6162	-0.3375	-0.1107
$corr(rgap_{t-lag}, \pi_{xf,t})$	0.0576	-0.0715	-0.2064	-0.3045	-0.3443	-0.3501
$corr(rgap_{t-lag}, \pi_{f,t})$	-0.2959	-0.5424	-0.6535	-0.6298	-0.2767	-0.0070
$corr(rgap_{t-lag}, y_t^{xk})$	-0.3231	-0.3353	-0.3102	-0.2618	-0.3014	-0.2475

Source: Authors' estimates.

Table 4. OLS Regression Results

	$lag=0$	$lag=1$	$lag=2$	$lag=3$
α	0.15	1.1**	1.5*	1.3**
β_1	0.95*	0.8*	0.76*	0.78*
β_2	-0.44*	-0.3*	-0.26*	-0.15**
R^2	0.91	0.83	0.80	0.76

The symbols *, **, *** denote the significance level at 1, 5 and 10 percent, correspondingly.

Source: Authors' estimates.

The real neutral rate in the Kyrgyz Republic is mostly determined by the risk premium and real exchange rate dynamics. Figure 4 shows that both inflation and the real interest gap exhibit high volatility. As a small open economy, the Kyrgyz Republic is vulnerable to external shocks. Observed inflation peaks from the end of 2007 to the first half of 2008 and again in 2011 were due to high food inflation for the first period, and high oil prices in 2008 and 2011, respectively. Low inflation in 2016 was accompanied by low oil prices, and was preceded by a tight monetary policy stance. Currently, the QPM results point to moderate inflation values together with a stimulative monetary policy. Table 3 shows the correlation of the interest rate gap (from the QPM) with the inflation and output gap at different lags. The correlation coefficients between the interest rate gap and inflation, as well as between the interest rate gap and output are negative at all lags. This outcome is consistent with the theory. An accommodative monetary policy aims to boost economic growth, resulting also in higher inflation pressures. Conversely, restrictive monetary policy stabilizes / lowers inflation, but also slows output growth. This implies a negative relation between the interest rate gap and the output gap and inflation rates. The interest rate gap is defined as the deviation of the real interest rate from its neutral rate, with a positive interest rate gap implying a contractionary monetary policy, and a negative interest rate gap implying an expansionary monetary policy. Interestingly, the correlation coefficient is higher for food inflation; given that food prices constitute a large part of the CPI basket (45–47 percent), they may spill into core inflation and explain the high correlation.

Following the work of Garnier and Wilhelmsen (2005), we estimate the following equation to assess the predictive power of the interest rate gap:

$$\pi_t = \alpha + \beta_1 \pi_{t-1} + \beta_2 rgap_{t-lag} + e_t$$

The results are shown in Table 4. The coefficient β_2 is negative and statistically significant at the one percent level up to two lags, negative and statistically significant at ten percent level for the third lag. The results indicate that the interest rate gap from the QPM estimation has a certain predictive and explanatory power for inflation.

IV. THE REAL MONETARY CONDITIONS INDEX

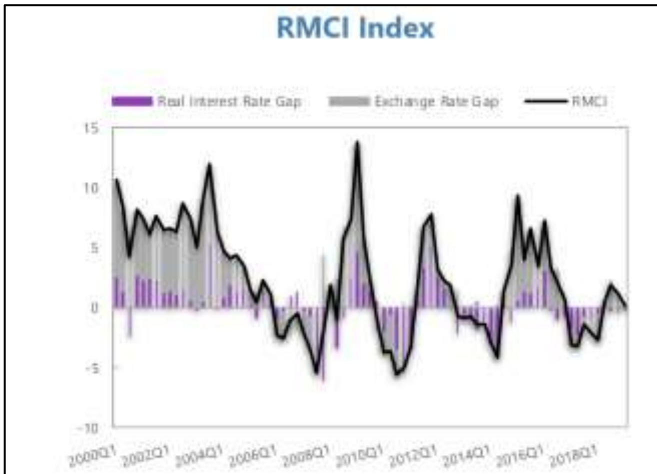
Given the transitional nature and structure of the Kyrgyz economy, the analysis of monetary conditions could be complemented by an indicator that includes the REER gap. A small, underdeveloped financial market and still-sizable excess liquidity in the banking system hamper monetary transmission through the credit and asset price channels, as might be expected for a developing economy. At the same time, the NBKR conducts FX interventions to limit disorderly market conditions. Thus, despite an evaluation that monetary policy has been accommodative, an economy might exhibit muted inflationary pressures and tight monetary and financial conditions due to a REER appreciation. The real monetary condition index (RMCI) can serve as an additional indicator of overall monetary conditions

in the Kyrgyz Republic.[8] Exchange rates influence aggregate demand, especially in small open economies. Thus, focusing on interest rates, with exchange rates playing a role as well may be important in understanding an economy's behavior, and so in policymaking. Given the openness of the economy, the exchange rate can exhibit excessive volatility. This will prompt the central bank to intervene in the FX market to smooth that volatility. For the NBKR, the RMCI index serves as an additional indicator of monetary conditions, and as a model-based policy guide between formal model forecasts, which can capture such effects on monetary conditions not captured otherwise in the Taylor rule of the QPM.

The index is composed of both the real interest rate and exchange rate gaps:

$$rmci_t = aa_1\, rgap + (1 - aa_1)(-zgap)$$

The parameter aa1 is set at 0.4. The weights on the interest rate and exchange rate reflect the relative effects of those variables on aggregate demand.[9] The parameter is calibrated based on the theoretical values: typically values are between 0.3 and 0.8, depending on the openness of the economy, with lower values for more open economies. The RMCI index is commonly used in the QPM style models of central banks in developing countries (i.e. the QPM of the Czech Republic sets the corresponding coefficient for the RMCI index to 0.6, according to Hledik, T. and Vlcek, J. (2018)). These values of the RMCI index imply a fairly efficient transmission mechanism from real exchange and interest rates to the real economy, with the exchange rate playing an important role due to the openness of the economy. From the historical simulation they did not appear to be very sensitive, keeping all else equal.[10] As depicted in the chart, monetary conditions were restrictive until the last quarter of 2018 when they turned to neutral. The restrictive monetary conditions were mostly due to the real exchange rate component.



Source: Authors' estimates.

[8] Instead of an RMCI index which combines interest and exchange rates as one index, some QPMs present the impact of the interest rate and exchange rate separately in the AD equation.

[9] Estimation of the relative weights involves a high degree of uncertainty.

[10] The properties of the model such as calibration and historical simulation are reported in Appendices I and II.

V. Results

In our estimates, the neutral real rate in the Kyrgyz Republic ranges from 2.8 to 5.2 percent and 3.7 based on the QPM (Table 5). The estimated neutral interest rate is subject to considerable uncertainty (see chart for QPM estimates). This is a more general problem and does not only reflect the quality of the data available for the Kyrgyz Republic. Even for advanced economies often there is no consensus on the appropriate measure of the neutral interest rate, and different estimation methods point to different results. The QPM estimates a real neutral rate of 3.7 for the end-2019. The real neutral rate is higher than in other emerging markets (1 percent in the Czech Republic (Hledik, Vlcek, 2018), 2 percent in Georgia (IMF, 2018), 2.5 percent in Ukraine and 2.5–3.5 percent in the Russian Federation (Grui, Lepushynskyi and Nikolaychuk, 2018), but similar to Kazakhstan's and Brazil's (in the 4-5.5 percent range).

Neutral Real Interest Rate

Source: Authors' estimates.

In more developed economies where the return on capital is lower, the neutral real rate tends to be lower. Thus, it is reasonable to expect that the estimates of the neutral rate in Kyrgyz Republic are higher compared to advanced economies or more financially- and economically-developed economies. Higher public debt and an elevated risk premium, institutional factors such as weak creditor rights and contractual enforcement (Box 1), low domestic savings and thus investment (Box 1), and a higher inflation target are among the factors which could lead to higher neutral rates. Furthermore, the statistical properties of the real interest rate gap show that it is negatively correlated with inflation, and thus has some explanatory power for inflation. For example, a negative interest rate gap implying an expansionary monetary policy will increase inflation, and the lags of the interest rate gap have also a statistically significant influence on inflation (see details in Table 3 of section III. E.).

However, the neutral rate alone might not be a sufficient indicator to assess monetary conditions, given the transitional nature and structure of the Kyrgyz economy. Thus, it should be accompanied by an indicator which includes the REER gap, or other macrofinancial variables, for a proper assessment. The RMCI points to restrictive monetary conditions from the REER appreciation since 2015.

Table 5. Kyrgyz Republic: Neutral Real Interest Rate, 2019

Method	Neutral Real Interest Rate (NRIR)
Univariate Filters	3.6
REER Augm Taylor Rule	4.3
REER Augm Taylor Rule (lagged r*, y and reer gaps)	5.2
General Equilibrium Model	4.0
TVP VAR	2.8
Average	**4.0**
QPM Q4 2019	3.7

Sources: National authorities and IMF staff estimates.

VI. Conclusion and Policy Recommendations

The neutral interest rate is one of the many unknowns with which monetary policy makers must contend. Since there is no single "correct" methodology to estimate the neutral rate, central banks will continue to operate on the basis of well-informed, but subjective judgement about latent variables such as the output gap and the neutral rate. This paper uses a number of methodologies commonly employed in the literature to estimate the neutral rate. Each model has its own theoretical restrictions in terms of the variables and model specifications. The purely statistical methods such as the mean or Hodrick-Prescott filter are a simple way to estimate the neutral rate, but might be less suited or reliable given volatile data of developing countries. A TVP VAR allows modelling of non-linear relations among variables, but the approach lacks an economic foundation. Laubach and Williams (2003)-related models provide a simple structural macroeconomic model for long-run equilibrium rate assessments, but have mostly been applied to the advanced economies. The QPM belongs to the more complex tools for estimation of the neutral rate. It has been the official benchmark model used by NBKR for macroeconomic forecasting and analysis since 2014. Given that the estimated output gap and neutral real interest rate are subject to considerable uncertainty, it is critical to consider the outcomes of several alternative models / rules and to analyze the sources of differences. Thus, besides estimates based on the QPM interest-rate rule, which is more complex, there may be merit in looking at simpler models for robustness checks.

The estimation of the neutral rate is an integral part of the assessment of the monetary policy stance in the Kyrgyz Republic. It is an official tool used by policymakers providing an analytical framework to guide monetary policy decisions and limit the scope of discretion. Despite challenges faced by the NBKR such as a still-high level of dollarization, liquidity surplus, high lending rates and spreads, and the resulting weak transmission mechanism, it is

essential to have a measure of the neutral rate given the transitional nature of the economy and as a step towards a full-fledged IT regime.

The NBKR has come under pressure to support economic growth given high real interest rates and spreads. These are likely due to high public debt and an elevated risk premium, institutional factors such as a weak rule of law and information asymmetries, low domestic savings and thus investment, and a higher inflation target. Thus, it would be important to maintain low fiscal deficits that do not exceed 2.5 percent of GDP (with scope to reduce the high wage bill and tax exemptions) to lower the level of public debt. This would help reduce the risk premium. At the same time, structural reforms to strengthen the rule of law and improve information on credit worthiness of borrowers to mitigate information asymmetries would reduce commercial bank lending rates. Improvement in the rule of law and the overall business environment can also lead to better business and financial rankings of the country and may reduce external funding costs. Further increasing competition among banks by leveling the playing field is key to reduce the high interest rate spreads. Smaller and medium-sized banks could reduce their average costs by potentially rationalizing expenditures on personnel or increasing access to finance by a greater share of the population. Absorption of smaller banks by larger and more efficient ones could potentially create synergies and economies of scale, helping to compress operating costs and reduce the spreads.

To advance towards a fully-fledged inflation targeting regime and enhance the effectiveness of monetary policy, action is needed in terms of the nominal anchor, liquidity management, and communication. Greater exchange rate flexibility is desirable, as it can reduce the perception that a low exchange rate is one of NBKR's main policy objectives, which would support establishing inflation as the undisputed monetary anchor. More flexibility would enhance the role of the exchange rate as a shock absorber and make market participants more cognizant of two-way risks in exchange markets, promoting the development and use of hedging facilities and the reduction of foreign currency mismatches, while more generally discouraging dollarization. In terms of monetary operations and liquidity management, efforts should continue to reduce excess liquidity to ensure the effective functioning of the interbank market and recognize the 7-day NBKR notes as the main liquidity instrument to be issued at a fixed rate (i.e., the policy rate), thereby increasing the issuance of 7-day NBKR notes. In terms of communication, it would be important to improve the explanation of monetary and exchange rate policy decisions (i.e. the rationale for the exchange rate stability and the timing and size of FX interventions), and to incorporate more forward-looking elements (i.e., inflation forecasts and medium-term inflation target range) in press releases and monetary reports.

VII. References

Ajevskis, V. (2018). The Natural Rate of Interest: Information Derived from a Shadow Rate Model. *Latvijas Banka Working Papers, 2/18*

Basdevant, O., Bjorksten, N., and Karagedikli, O. (2004). Estimating a Time Varying Neutral Real Interest Rate for New Zealand. *Discussion Paper No. 2004/01,* Wellington: Reserve Bank of New Zealand

Berg, A., Karam, P., and Laxton, D. (2006). Practical Model-Based Monetary Policy Analysis: A How-To Guide. *IMF Working Paper, 06/81*

Brand, C., Bielecki, M., Penalver, A. (2018). The Natural Rate of Interest: Estimates, Drivers, and Challenges to Monetary Policy. *ECB Occasional Paper Series, 217/18*

Brubakk, L., Ellingsen, J. and Robstad, O. (2018). Estimates of the Neutral Rate of Interest in Norway. *Norges Bank Staff Memo, 7*

Botha, B., Jager, S., Ruch, F. and Steinbach, R. (2017). The Quarterly Projection Model of the SARB. *South African Reserve Bank Working Paper Series, 17/01*

Carrillo, J.A., Elizondo, R., Rodriguez-Perez, C.A. and Roldan-Pena, J. (2018). What Determines the Neutral Rate of Interest in an Emerging Economy? *Banco de Mexico Working Papers, 2018-22*

Christensen, J.H.E., Rudebusch, G.D. (2019). A New Normal for Interest Rates? Evidence from Inflation-Indexed Debt. *Federal Reserve Bank of San Francisco Working Paper, 07/17*

Fuentes, R. and Gredig, F. (2007). Estimating the Chilean Natural Rate of Interest. *Central Bank of Chile Working Papers, 448*

Garnier, J.and Wilhemsen, B. (2005). The Natural Real Interest Rate and the Output Gap in the Euro Area. A Joint Estimation. *ECB Working Paper Series, 546/05*

Grui, A., Lepushynskyi, V., Nikolaychuk, S. (2018). A Neutral Real Interest Rate in the Case of a Small Open Economy: Application to Ukraine. *Visnyk of the National Bank of Ukraine, 243, pp. 420*

Hledik, T. and Vlcek, J. (2018). Quantifying the Natural Rate of Interest in a Small Open Economy – the Czech Case. *Working Paper Series, 7*

Holston, K., Laubach, T. and Williams, J. (2016). Measuring the Natural Rate of Interest: International Trends and Determinants. *Federal Reserve Bank of San Francisco Working Paper, 2016-11*

IMF (2018), Article IV Consultation for Kazakhstan, Selected Issues Paper, Using Interest Rate Rules to Inform Monetary Policy. *IMF Country Report No. 18/278*

Kamin, S., Turner, P. and Van't dack, J. (1998). The Transmission Mechanism of Monetary Policy in Emerging Market Economies: An Overview. *BIS Policy Papers, 3*

Kreptsev, D., Porshakov, A., Seleznev, S., Sinyakov, A. (2016). The Equilibrium Interest Rate: a Measurement for Russia. *Economic Research Working Papers, 13/16*

Krustev, G. (2018). The Natural Rate of Interest and the Financial Cycle. *ECB Working Paper Series, 2168/18*

Lam, J.P., Tkacz, G. (2004). Estimating Policy Neutral Interest Rates for Canada Using a Dynamic Stochatic General Equilibrium Framework. *Bank of Canada Working Paper, 04/9*

Laubach, T., Williams, J.C. (2003). Measuring the Natural Rate of Interest. *Review of Economics and Statistics, 85*

Laubach, T., Williams, J.C. (2016). Measuring the Natural Rate of Interest Redux. *Finance and Economics Discussion Series, 2016-011*

Lubik, T. A. and Matthes, C. (2015). Calculating the Natural Rate of Interest: A Comparison of Two Alternative Approaches. *Richmond Fed Economic Brief (Oct), 16*

Magud, N.E. and Tsounta, E. (2012). To Cut or Not to Cut? That is the (Central Banks) Question - In Search of the Neutral Interest Rate in Latin America. *IMF Working Paper, 12/243*

Medina Cas, S., Carrion-Menendez, A. and Frantischek, F. (2011). Improving the Monetary Policy Frameworks in Central America. *IMF Working Paper, 11/245*

Pedersen, J. (2015). The Danish Natural Real Rate of Interest and Secular Stagnation. *Danmarks Nationalbank Working Papers, 94*

Pescatori, A., Turunen, J. (2015). Lower for Longer: Neutral Rates in the United States. *IMF Working Papers, 135/2015*

Taylor, J. B. (1993). Discretion Versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy, Vol. 39, pp. 195-214*

Us, V. (2018). Measuring the Natural Interest Rate for the Turkish Economy. *International Journal of Central Banking, 14/1*

Wicksell, K. (1907). The Influence of the Rate of Interest on Prices. *Economic Journal, Vol. 17*

Wicksell, K., Geldzins und Guterpreise (1898). Interest and Prices, 1898, translated by R.F. Kahn, 193

Woodford, M. (2003). Interest and Prices: Foundations of a Theory of Monetary Policy. *Princeton : Princeton University Press*

APPENDIX I

Calibration of the QPM

The parameters in the QPM are calibrated. The steady states reflect either historical averages or expert judgment about future growth rates. The parameters are shown in table 6. Foreign inflation target are consistent with central banks' official targets (5 percent for domestic target, 4 percent for Russian target, 5 percent for Kazakhstan, and 3 percent for China). The steady states for the external sector (i.e. oil, food and gold) and foreign output growth rates are set based on WEO and country authorities' projections. The calibration is tested on the historical simulation and various filtration exercises.

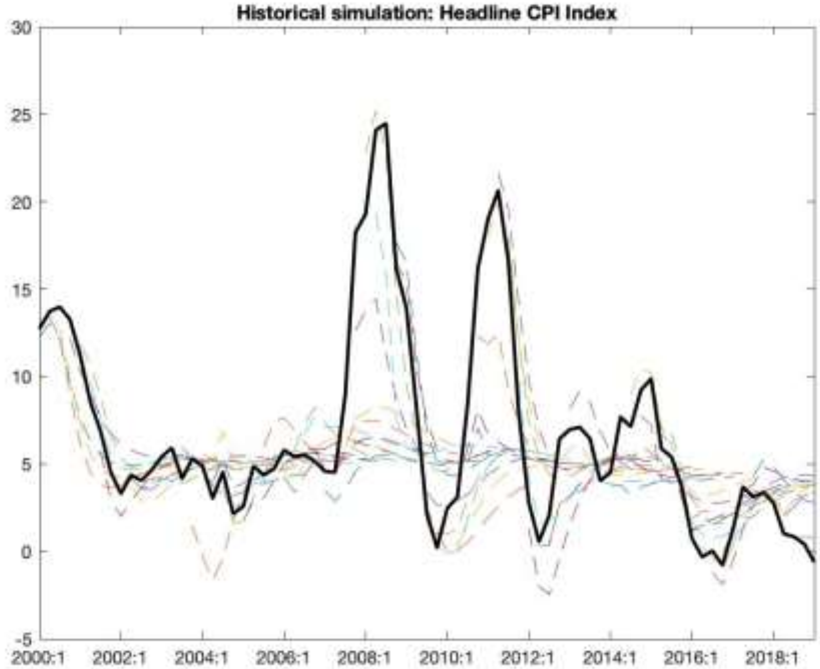
Table 6. Steady State Values of Parameters

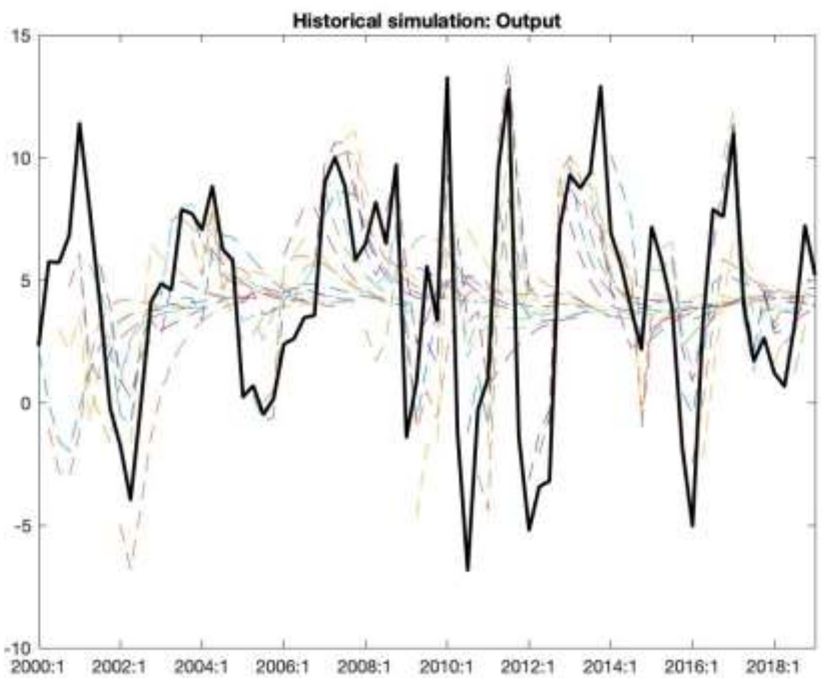
Variable	Value
Non-Kumtor output growth rate	4.5
Kumtor output growth rate	0
Agriculture output growth rate	2.0
Domestic inflation target	5.0
Food relative price trend	-0.25
Non-food relative price trend	0.25
Real effective exchange rate trend	-0.5
Risk premium trend	4.5
Real remittances growth	5.0
Russian real effective exchange rate trend	0
Russian inflation target	4.0
Russian GDP growth	2.0
Kazakh inflation target	5.0
Kazakh real effective exchange rate trend	0
Kazakh output growth	3.0
Foreign interest rate	0.5
US inflation target	2.3
Oil price change	0.5
Food price change	0.5
Gold price change	0.5
US output growth rate	2.0
Chinese real effective exchange rate	0
Chinese inflation target	3.0
Chinese output growth rate	5.5

Source: National authorities and authors' estimates.

Appendix II

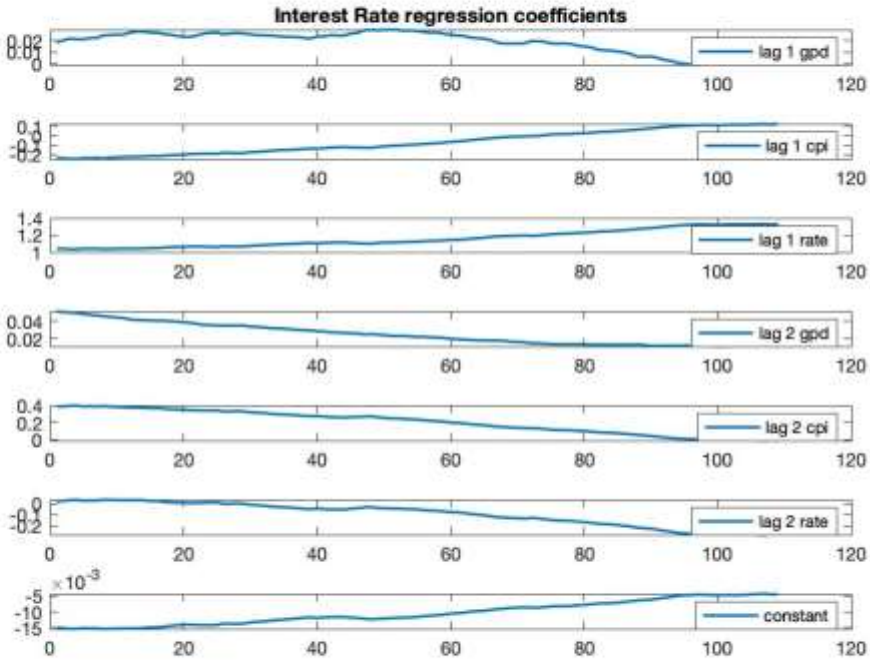
QPM Historical Simulation

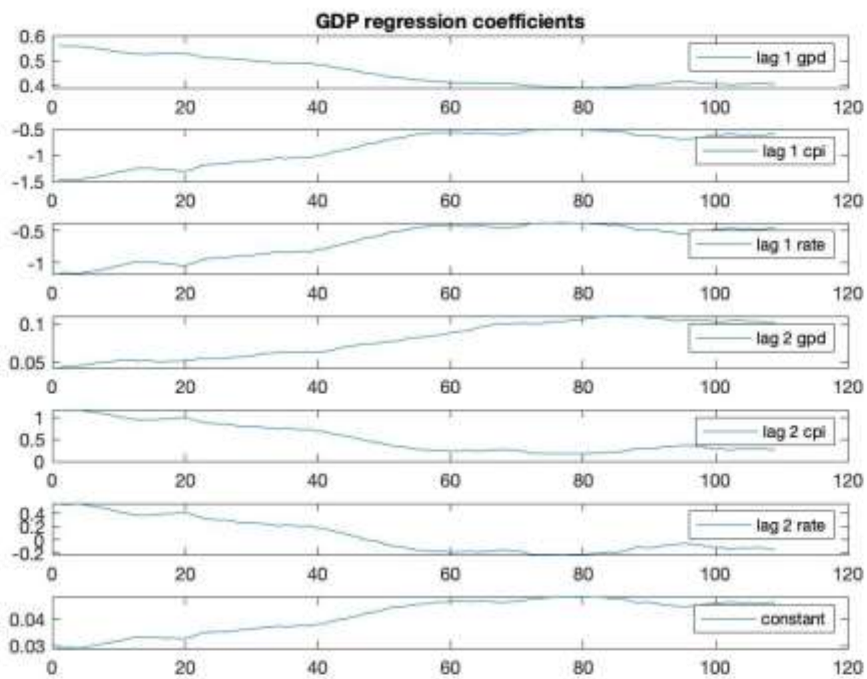


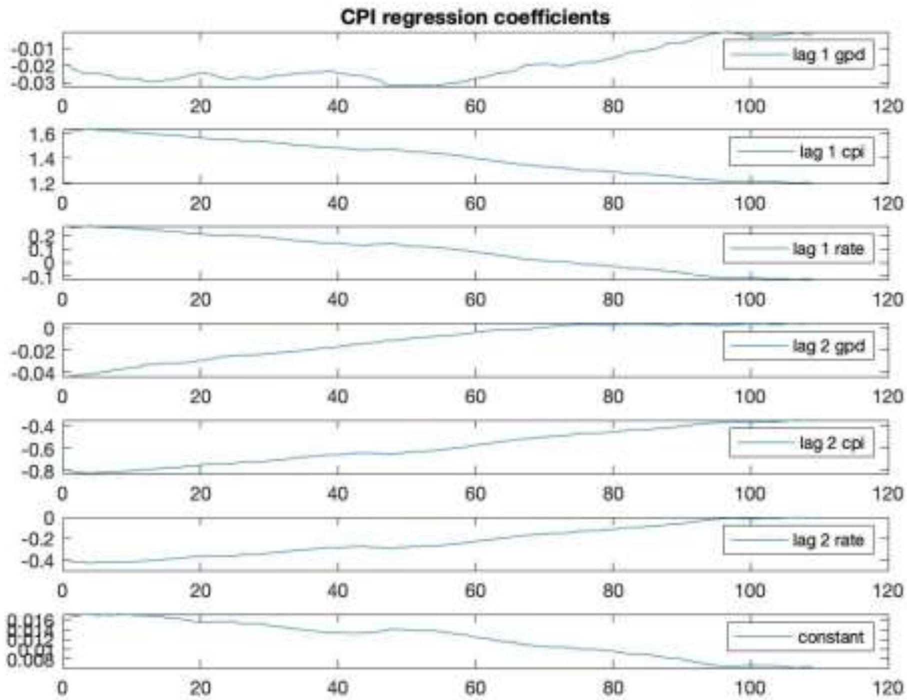


APPENDIX III

TVP VAR Coefficients






CPI regression coefficients
lag 1 gpd
lag 1 cpi
lag 1 rate
lag 2 gpd
lag 2 cpi
lag 2 rate
constant
0
20
40
60
80
100
120