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Monetary Policy Transmission in Georgia: *empirical evidence*

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Monetary policy transmission in Georgia: *empirical evidence*

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Abstract

The strength of monetary policy transmission mechanism is what defines central banks' ability to influence a real economy and overall prices. This is what we analyse empirically within this paper. Namely, using structural vector autoregressions and based on data since 2009 when the NBG switched to an inflation targeting regime, we estimate the strength of interest rate and exchange rate channels in Georgia. The results suggest that both are relatively strong. Namely, an increase in interest rates seems to generate all three: smaller output gap, exchange rate appreciation and, consequently, lower inflation, underlining the improved transmission mechanism since the estimates from a decade ago. The reaction of inflation to an interest rate change peaks after 4 quarters, in line with other studies as well as the NBG's communication. Moreover, a variance decomposition analysis shows that inflation is mostly driven by supply shocks with demand shocks having only a negligible effect. In principle, this may be in line with the presumption that it is the central bank's systematic reaction function that neutralizes the effects of demand shocks on inflation, leaving the supply side as the major driver of inflation data.

JEL Codes: C13, E43, E52, F31

Keywords: Monetary policy; Transmission mechanism; Structural vector autoregressions; Inflation targeting.

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1. Introduction

Since the last century, monetary policy has become a widespread tool to smooth business cycles. Events of the 1960s have led to a loss of eminence of fiscal policy as a business cycle management tool due to concerns about effects of enlarging budget deficits and sluggishness of spending decisions to act as a stabilizer (Mishkin, 1995). Despite contemporary theory almost unanimously recognizing that monetary policy affects the real economy – referred to as monetary policy transmission mechanism (MPTM) – economists still actively debate, *how strongly* decisions of monetary authorities influence real variables like output and prices. Mishkin (1995) identifies four main general transmission channels: interest rate, asset prices, credit and exchange rate channels.

Despite an almost uniform theoretical description of transmission channels in general, the exact form and, more specifically, a measure of pass-through vary in each country. Bernanke and Gertler (1995) regarded monetary transmission as a "black box" and argued in favor of an empirical investigation of what happens amidst the process. Since then, much research has been done and currently a vast body of empirical literature exists, which tries to examine transmission mechanisms. The process differs amongst developing and developed countries though. The former type normally exhibits weaker interest rate and bank lending, as well as asset price channels due to lack of development of a financial system, together with a strong exchange rate channel, as a result of either high share of imported goods in consumption, or substantial degree of financial dollarization (Egert and Macdonald, 2009; Mishra and Montiel, 2012). Hence the need to have separate estimates for developing countries like Georgia. This is a topic of this paper – empirically estimating the strength of monetary policy transmission in Georgia.

National Bank of Georgia (NBG) adopted Inflation Targeting Regime in 2009, since which it announces the medium-term inflation target and uses the policy (refinancing) rate as the main policy instrument (NBG, 2021). By announcing the inflation target and decisions about the monetary policy rate, the NBG affects interest and exchange rates on the domestic financial markets as well as expectations of economic agents. All of these changes affect the spending behavior of Georgian households and companies, leading to changes in output and inflation. Therefore, in order to make correct decisions about the level of the policy rate (and, hence, achieve price stability more efficiently) the NBG needs to have empirical estimates of monetary policy transmission (i.e. to measure the quantitative impact of policy on real variables and inflation). Several studies scrutinized monetary policy transmission in developing and transition countries. Moreover, several authors analyzed interest rate and exchange rate channels in Georgia (Samkharadze, 2008; Bluashvili, 2013; Mdivnishvili, 2017), however new data has come out since then and financial dollarization has edged down, along with gradual development of domestic currency capital market. This paper aims to update the estimates and investigate the monetary policy transmission channels in the Georgian economy. More specifically, the research will assess the significance of interest and exchange rate channels.

Following the research of Christiano et al (1999) and Bernanke and Gertler (1995) the paper employs a structural vector autoregressive (SVAR) model with contemporaneous restrictions. The logic of this approach is to build an empirical model, which replicates the structure of an economy by restricting the coeval relationship between economic variables. Utilizing quarterly time series from the first quarter of 2009 to the fourth quarter of 2020, the research estimates SVAR with four endogenous variables. These include TIBR as a monetary policy instrument, Nominal Effective Exchange Rate (NEER) and annual CPI inflation rate. In addition, distinctive from other studies on Georgian MPTM, the study uses output gap (the deviation of actual output from its estimated potential level) as a measure of excess aggregate demand. To assess the transmission channels, impulse response functions of each variable and variance decompositions of forecast errors are analyzed.

The results suggest the existence of a relatively strong interest rate channel. Furthermore, the exchange rate channel plays a significant role in transmitting policy rate decisions to inflation but has a weaker effect on the output gap. The latter result can be a reflection of the net export channel being partly neutralized by the balance sheet effects coming from relatively high financial dollarization. On the other hand, interest rate changes affect all three output, exchange rate and inflation significantly, underlining the improved transmission mechanism since the estimates from a decade ago. The reaction of inflation to an interest rate change seems to peak after 4 quarters – a result in line with other studies as well as the NBG's communication. The response of the exchange rate to interest rates is also quite big. Overall, these results suggest that the monetary policy transmission (interest rate and exchange rate channels) in Georgia is relatively strong, unlike before adopting the inflation targeting regime.

Variance decompositions show that monetary policy shocks are generating only a small part of variations in either inflation or output. In case of inflation, supply shocks seem to be the major driver with output gap (demand) shocks having only a negligible effect. In principle, this may be in line with the presumption that it is the central bank's systematic reaction function that neutralizes the effects of demand shocks on inflation, leaving the supply side as the major driver of inflation. On the other hand, most of the variation in output is picked up by demand shocks.

The rest of the research is structured in the following way: the second section presents a review of relevant literature about monetary policy transmission mechanisms and their empirical estimates in emerging market economies. The third section describes the formal empirical methodology, as well as data and its characteristics used to estimate the model. The fourth section gives the diagnostics of the variables and estimated model as well as the results of impulse responses and variance decomposition analysis of both main and alternative models, as well as discusses and interprets them. The final section summarizes the paper, emphasizing potential weaknesses of employed empirical approach and policy recommendations.

2. Literature summary

2.1. Monetary policy transmission mechanisms

In an inflation targeting setting, the NBG conducts monetary policy by setting a monetary policy rate and anchoring inflation expectations by it. Mishkin (1995) proposes that four main transmission channels assist changes in the policy rate to affect prices and output. These are interest rate, asset price, credit and exchange rate channels.

In Georgia, currently, the asset price channel (a policy rate affecting financial, e.g. bonds, and non-financial, e.g. housing, prices) is deemed non-significant, due to underdeveloped capital and stock markets (Baiashvili, 2015). Therefore, the other three channels (interest rate, credit and exchange rate) are considered as a potentially effective path for the transmission of monetary policy decisions.

In case of the interest rate channel, a rise in the monetary policy rate leads to an increase in market interest rates (namely deposit and loan rates). Due to short-run price rigidities, changes in nominal interest rates also affect real interest rates. The latter in turn influence loan and deposit demand of households and firms, leading to reduced investment as well as consumption (as borrowing slows down and *propensity* to save increases). The process settles at reduced aggregate demand, consequently lower output and lower inflation.

The credit channel operates through changes on the supply side of banking. For instance, raising the monetary policy rate boosts interest rates on loans, as noted above. Therefore, borrowers' riskiness will be marginally higher (due to higher debt service burden) and banks would reduce the supply of credit by tightening credit standards. At the same time, higher interest rates mean, companies prefer to invest in riskier projects (moral hazard) to receive higher profit. This also induces banks to tighten credit conditions. Lower credit supply translates into reduced investment/consumption and, subsequently, lower aggregate demand and inflationary pressure.

The exchange rate channel is also a significant part and plays a big role in emerging market economies and developing countries. The decisions of the NBG to, for example, increase the policy rate raises interest rates on domestic currency assets, making them more attractive to investors, compared to foreign currency assets. Therefore, the demand for them, as well as GEL will surge upward, appreciating the exchange rate. This will clearly affect inflation as well.

Tvalodze et al (2016) argue that there are four major sub-channels, through which monetary policy decisions can affect inflation. First of all, appreciation of GEL lowers prices of imported goods. As, in small open economies, imported goods take a notable portion of the consumption basket, the decline in imported prices will directly contribute to the reduction in the overall inflation rate. Secondly, appreciation of NEER also causes an appreciation of *real effective* exchange rate. It reduces prices of imported factors of production, lowering marginal costs of domestic firms that use import as an intermediate good. The process translates into lower prices for domestic goods, putting downward pressure on inflation as well. Third, real appreciation affects the level of net exports. It makes prices of exported goods higher for foreigners and prices of imported goods cheaper for domestic consumers (increasing imports and worsening net exports). These means lower demand for domestic goods and therefore downward pressure on prices as well. Finally, the balance sheet effects of exchange rate appreciation are also noteworthy. Effective appreciation, other things equal, also means the GEL/USD exchange rate appreciates as well. In a highly dollarized country, like Georgia, where a significant part of loans is denominated in USD, appreciation of a domestic currency against the USD reduces the cost of servicing USD debt and, hence, aggregate demand is influenced positively. At the same time, lower costs of servicing USD loans imply smaller production costs for those firms that borrowed in USD, giving them a possibility to reduce prices as well.

In short, monetary policy decisions are transmitted through three main transmission channels: interest rate, exchange rate, and credit channels. The NBG, like many others, also considers the expectations channel, as an important way a decision of the central bank affects real variables. Notably, a rise in the policy rate reduces inflationary expectations that further pushes real interest rates up and thus contributes to strengthening of other channels discussed above.

2.2. Empirical literature

An extensive body of empirical literature is devoted to the examination of quantitative measures of monetary policy transmission channels. Methods span from a single country dynamic equation and vector autoregressive estimation to scrutinizing panel data for a number of countries. Various papers exploited VAR methodology for studying monetary policy transmission, in both developed and low-income, emerging, and transition countries. Christiano et al (1999) reviewed the literature about the effect of an exogenous monetary policy shock. They stressed that the main method used to identify the consequences of the shock is vector autoregressions. Once identifying assumptions of monetary policy shocks are isolated, the impulse responses of variables to a monetary policy shock in the VAR model is the same as a response to a shock in structural economic models. In other words, a simple structural VAR is a plausible substitute to structural economic models in studying monetary policy transmission empirically.

Multiple authors implement the aforementioned methodology to assess the transmission channels of monetary policy in low-income and emerging market economies. Mishra et al (2016) examine the effectiveness of bank lending channels for the Indian economy, using the SVAR model. Authors inspect monthly data spanning from April 2001 to December 2014. The model includes repo rate, industrial production index gap, headline CPI, REER gap, and commercial bank lending rate. The study finds that pass-through from the policy rate to the lending rate exists but is incomplete and the shock fails to be transmitted to aggregate demand and inflation from the lending rate. Furthermore, the paper explores the existence of an exchange rate channel with the right form but minuscule size, which is explained by the active intervention of the Indian Central Bank on the foreign exchange market, hindering the transmission of monetary policy.

Paper by Mishra and Montiel (2012) reviews the empirical evidence of monetary policy transmission in low-income countries. Authors suggest that lack of a sufficient link with the international financial markets, complemented with underdeveloped domestic stock and bond markets and intensive intervention in the foreign exchange market translate into weak transmission from monetary policy rates to bank lending rates and aggregate demand.

Egert and Macdonald (2009), similar to the aforementioned study, inspect the literature concerning the monetary policy transmission specifically in CEE transition countries, providing conclusions about an exchange rate, credit, and asset price channels. According to the authors, evidence shows that monetary policy has a significant effect on the exchange rate, but the strength of a transmission from the exchange rate to inflation has been exhibiting a diminishing behavior. Incapacitated stock and bond markets, in addition to the dominance of foreign investment, make asset price channel relatively negligible. Therefore, the price of financial assets, changed by a monetary policy shock has little effect on real variables. At the same time, the abovementioned conditions in conjunction with a concentrated banking system dampen the operating capacity of the credit channel.

There exists a limited number of studies examining monetary policy transmission mechanisms both qualitatively and quantitatively for the Georgian economy. The first research to have explicit estimates of transmission channels has been conducted by Bakradze and Billmeier (2007). The paper tried to uncover whether the economic environment of Georgia had been favorable for implementing the inflation-targeting framework. Authors first discuss the elements of the economic environment, stating that monetary policy effectiveness might be dampened by the high level of financial dollarization and a weakly developed financial market. Then they conduct empirical analysis using five-variable VAR, including real GDP, CPI, currency in circulation, level of international reserves, and NEER. The authors find that a reaction of output to currency in circulation is weakened by the credit channel, while the exchange rate channel aggravates it. In addition, the transmission of the shock to prices mostly happens through bank lending channel. They also emphasize the importance of having a short-term interest rate as a policy instrument to have a better empirical estimate of the interest rate channel.

Continuing in the flavor of the aforementioned study, Samkharadze (2008) analyses monetary policy transmission channels for the Georgian economy, based on monthly data from June 2002 to May 2007. The main objective of the study is to assess, how the exchange rate channel evolved after the “Rose Revolution”, and estimate interest rate and bank lending channels additionally. The paper uses standard VAR models with Cholesky decomposition, as well as alternative structural identification schemes to study impulse response functions. The model includes five variables: real GDP, CPI, M1 monetary aggregate, domestic lending rate, and NEER. In order to investigate the bank lending channel, an alternative model is estimated, where the domestic lending rate is substituted by total bank loans. The research asserts that in the estimation period there is significant effect of the interest rate channel (transmission from the lending rate to inflation). In addition, the study confirms the strong exchange rate transmission channel that is a typical characteristic of emerging market economies, although the exchange rate pass-through is still estimated to be smaller than other similar studies.

Following the development of domestic financial markets and implementation of an inflation-targeting regime, Bluashvili (2013) reestimated the monetary transmission mechanism, concentrating on interest rate and exchange rate channels. The study employs a standard VAR model with quarterly data, spanning from 2004Q1 to 2013Q2. Using Cholesky decomposition, together with an alternative structural identification, impulse responses of a monetary policy shock are studied. In contrast to the previous studies, the paper uses growth rates of real GDP and CPI inflation, together with monetary policy index, interest rate on short-term loans, and NEER. Results indicate statistical significance and effectiveness of interest rate channel as well as traditional strength of the exchange rate channel that is explained by a high degree of dollarization and a large share of imported goods into consumption basket. Both recursive and structural identifications yield similar outcomes.

Utilizing new data from 2009 to 2017, Mdivnishvili (2017) attempts to estimate monetary policy transmission channels, overviewing financial development and openness indicators. The research uses Principal Components Analysis and a Structural VAR model. The first method confirms that monetary policy has a significant effect on aggregate demand. SVAR model uses 5 variables, including real GDP growth, CPI inflation, domestic lending rate, Tbilisi interbank rate, and NEER. Monthly time series are seasonally adjusted, spanning from May 2010 to December 2017. The paper finds that transmission through bank lending channel has a relatively small but significant effect on GDP and inflation. At the same time, monetary policy shock of one unit causes a decline in inflation and GDP by 0.8% and 1.5% respectively. At the same time, transmission through the exchange rate channel is also significant, reducing inflation by 0.2%.

3. Methodology

3.1. Econometric model

The study aims to examine, how decisions of the NBG about the policy rate are transmitted to inflation and output. To this end, the paper uses the Vector Autoregressive methodology, suggested by Christiano et al (1999) to disentangle the effects of monetary policy shock on real variables. Del Negro and Schorfheide (2011) argue that VAR models "turn out to be one of the key empirical tools in modern macroeconomics". While we recognize the importance of caution when it comes to pure correlations (as in reduced-form VARs), having a structural perspective in an empirical exercise (as in structural VARs) could actually turn out to be very useful in policy deliberations.

VAR was introduced by Sims (1980) as a simple and more concise alternative to traditional large structural models. The typical VAR model is a system of multivariate linear equations, where each endogenous variable depends on its own lags and lags of other endogenous variables. A reduced-form VAR model has the following form:

$$B(L)\ Y_t = CX_t + u_t$$

where Y_t is the vector of endogenous variables, X_t – the vector of exogenous variables; $B(L) = I_n - B_1 L - \cdots - B_p L^p$ – is the matrix polynomial in the lag operator, C – the matrix of coefficient of exogenous variables and u_t – is the vector of reduced form residuals, following the zero-mean white noise process (Kilian and Lütkepohl, 2017), so the covariance matrix of the process has the following form:

$$E(u_t u'_\tau) = \begin{cases} \sigma_u, if\ \ t = \tau \\ 0, if\ t \neq \tau \end{cases}$$

Despite its usefulness in certain applications, reduced form VAR just presents dynamics within the data without explicitly specifying any economic logic (Cooley and LeRoy, 1985). Therefore, it is more convenient to impose structural restrictions on the contemporaneous relationships between endogenous variables. According to Christiano et al (1999), the imposition of identifying restrictions gives the structural shocks to residuals the same interpretation as shocks in structural models.

The typical SVAR is represented by the following equation:

$$A(L)Y_t = DX_t + \varepsilon_t$$

where Y_t – is the vector of endogenous variables, X_t – is the vector of exogenous variables, $A(L) = A_0 - A_1L - \cdots - A_pL^p$ – is the matrix polynomial in the lag operator for the structural VAR, A_0 – is the matrix of contemporaneous coefficients, and ε_t – is the vector of structural shocks, typically considered as a white noise process.

If A_0 is invertible, then multiplying structural VAR by A_0^{-1}, respective reduced-form VAR can be obtained:

$$A_0^{-1}A(L)Y_t = A_0^{-1}DX_t + A_0^{-1}\varepsilon_t \Rightarrow B(L)\ Y_t = CX_t + u_t$$

where $B(L) = A_0^{-1}A(L)$, and structural and reduced form errors are related by $u_t = A_0^{-1}\varepsilon_t$. In order to recover effects of structural shocks from reduced form residuals, knowledge of A_0 matrix is required. To estimate elements of A_0 matrix and thus satisfy rank condition for SVAR, Kilian and Lütkepohl (2017) propose to apply $\frac{n(n-1)}{2}$ restrictions on contemporaneous relations between endogenous variables, i.e. equating $\frac{n(n-1)}{2}$ elements of matrix A_0 to 0, diagonal elements of which are normalized to 1. The identification results in a just-identified system.

The research estimates the four-variable structural VAR model. It contains the following vector of endogenous variables: $Y_t = (\widehat{Y}_t, \pi_t, i_t, e_t)$. $\widehat{Y}_t$ represents output gap, π_t – annual inflation rate, i_t – monetary policy indicator (TIBR index), e_t – annual change in the nominal effective exchange rate. The respective order of variables is suggested by Bernanke and Blinder (1992). This structure guarantees that the output gap and inflation are not influenced by the monetary policy shock in the same period.

Estimated VAR is required to be stationary fundamentally. The VAR process is stationary and stable, if roots of the characteristic polynomial of the lag operator $A(L)$ lie outside the unit circle, i.e. inverse roots are inside the unit circle. In other words, $\det(A_0 - A_1L - \cdots - A_pL^p) \neq 0$. The stability of the model ensures that the first and second moments of the process are time-invariant (Kilian and Lütkepohl, 2017).

Following the imposition of structural restrictions on a matrix of contemporaneous coefficients, the estimated VAR can be used to calculate impulse response functions and variance decomposition of forecast errors. Substituting consecutively longer lags of the vector of endogenous variables and applying Wold Theorem leads to Vector Moving Average, VMA(∞)

representation of reduced-form VAR process, which is multiplied by $A_0 A_0^{-1}$ to obtain the VMA form of respective structural VAR:

$$Y_t = \mu + \sum_{i=0}^{\infty} \Phi_i u_{t-i} = \mu + \sum_{i=0}^{\infty} \Phi_i A_0 A_0^{-1} u_{t-i} = \mu + \sum_{i=0}^{\infty} \Theta_i \varepsilon_{t-i}$$

Furthermore, due to the assumption of stationarity, the impulse response of the endogenous variable j in the period i to the structural shock to variable k can be inferred as

$$\theta_{jk,i} = \frac{\partial y_{j,t+i}}{\partial \varepsilon_{k,t}} = \frac{\partial y_{j,t}}{\partial \varepsilon_{k,t-i}}$$

The impulse response represents how each variable reacts to the shock to each variable in time. In addition, the research will analyze the variance decomposition of forecast errors of the respective SVAR. This measure demonstrates what fraction of forecast error of each variable is due to each structural shock in every period. By analyzing both impulse response functions and variance decompositions of shocks, estimates and patterns of monetary policy transmission mechanisms can be inferred.

3.2. Identification

Considering the four-variable structural VAR model, described above, imposing identifying restrictions on a matrix of contemporaneous coefficients is essential. The standard approach is to use recursive ordering with the Cholesky decomposition (Sims, 1992; Bakradze and Billmeier, 2007; etc.), where A_0 is block-lower triangular. Such an approach might produce a price puzzle though (Sims, 1992) when inflation (in the short-run) increases in response to a contractionary monetary policy shock. This fact is possibly due to improper identification of a structural shock.

Considering the above discussion, this study implements the non-recursive identification strategy, widely applied in MPTM analysis (Sims and Zha, 1998). The study follows the subsequent scheme of structural restrictions:

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 \\ a_{31} & 0 & 1 & a_{34} \\ a_{41} & a_{42} & a_{43} & 1 \end{pmatrix} \begin{pmatrix} u_{\hat{y}} \\ u_{\pi} \\ u_i \\ u_e \end{pmatrix} = \begin{pmatrix} b_{11} & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 \\ 0 & 0 & b_{33} & 0 \\ 0 & 0 & 0 & b_{44} \end{pmatrix} \begin{pmatrix} \varepsilon_{\hat{y}} \\ \varepsilon_{\pi} \\ \varepsilon_i \\ \varepsilon_e \end{pmatrix}$$

The matrix A_0 has exactly 6 restrictions, making the model just-identified. They are the result of respective assumptions:

- Output gap does not react to any structural shock, besides its own, in the same quarter;

- Inflation responds only to the shock to the output gap and its shock concurrently;
- Monetary policy indicator (TIBR) does not react to inflation in the same period;
- The exchange rate contemporaneously reacts to all structural shocks.

Therefore, the monetary policy shock is identified as a structural shock to the TIBR rate. Successive impulse responses are inferred, considering the aforementioned contemporaneous restrictions.

3.3. Data

With the aim to estimate the model, the paper utilizes quarterly data, obtained from the NBG and National Statistics Office of Georgia and spanning from the first quarter of 2009 till the fourth quarter of 2020. The sample consists of 48 observations in total. Earlier data are excluded from the study because of the absence of inflation targeting regime before 2009 and data on the monetary policy instrument. The model includes four main endogenous variables: output gap, annual inflation rate, Tbilisi Interbank rate index (proxy for monetary policy rate), and annual change in the nominal effective exchange rate.

The output or GDP gap is typically defined as a difference between actual and potential outputs (IMF, 2013) and is a good indicator of the stance of an economy within business cycles. Potential output or full-employment output itself is the amount of goods and services that is produced at full capacity utilization (when all factors of production are fully utilized) without pressuring inflation. Potential output is a theoretical concept and is not observable, so it needs to be estimated. The widespread and simplest method to calculate potential output is the Hodrick-Prescott Filter (HP filter). The filter entails the assumption that the real GDP series is composed of trend and cyclical parts. The trend component is the measure of potential GDP, while the cyclical component shows the fluctuation of the series as a result of the business cycle (Hodrick and Prescott, 1997). Trend component is calculated by solving the following minimization problem:

$$\min_{Y_t^*} \sum_{t=1}^{T} (Y_t - Y_t^*)^2 + \lambda \sum_{t=1}^{T} [(Y_{t+1}^* - Y_t^*) + (Y_t^* - Y_{t-1}^*)]^2$$

Because paper uses quarterly data, the smoothing parameter is set to be $\lambda = 1600$. As Blagrave et al (2015) argue, HP filter is broadly applied in developing countries.

We acknowledge that the method is not based on an economic theory. But it is cross-checked with other more structural approaches to estimating potential output for Georgia and it still provides an adequate-enough approximation of the potential output. For estimation purposes, quarterly data on real GDP is used from 1996Q1 till 2020Q4. Data is seasonally adjusted, using X-12 methodology, developed by U.S. Census Bureau. After applying the HP filter, the output gap is calculated as a percentage deviation of real GDP from potential (trend) GDP. To deal with the end-point bias of the abovementioned statistical method, the (at the time of writing, forecasted) value of GDP for the first quarter of 2021 is added as the last observation. In the model, observations for the first quarter of 2009 till the fourth quarter of 2020 are utilized.

The annual inflation rate is calculated, as a percentage change in CPI compared to the same quarter of the previous year. The nominal effective exchange rate index is also seasonally adjusted and included in the model in logarithmic form. Tbilisi Interbank rate index (TIBR) is taken as an indicator of a monetary policy stance. The monetary policy rate has not been selected as a monetary policy indicator due to its irregular nature (irregular pattern of change). In the interbank market financial intermediaries “trade short-term liquidity” (NBG, 2020). The market is directly and strongly influenced by decisions of the central bank on the policy rate, as it has a critical role in monetary transmission. Therefore, TIBR is a good indicator of a monetary policy stance.

Except for the aforementioned endogenous variables, several exogenous variables are used. The emergence of COVID-19 has severely impacted economies, creating a worldwide economic crisis. Hence, an additional dummy variable $dcov$ is included, which takes into account the aforementioned economic disturbance and takes the value of 1 from the second quarter of 2020 till the end of the sample and 0 otherwise. Secondly, to control for the large exchange rate depreciation in 2015 (post-taper tantrum, huge oil price shock and regional conflict), another dummy variable $d15$ is added, which takes the value of 1 in all quarters of 2015 and 0 otherwise.

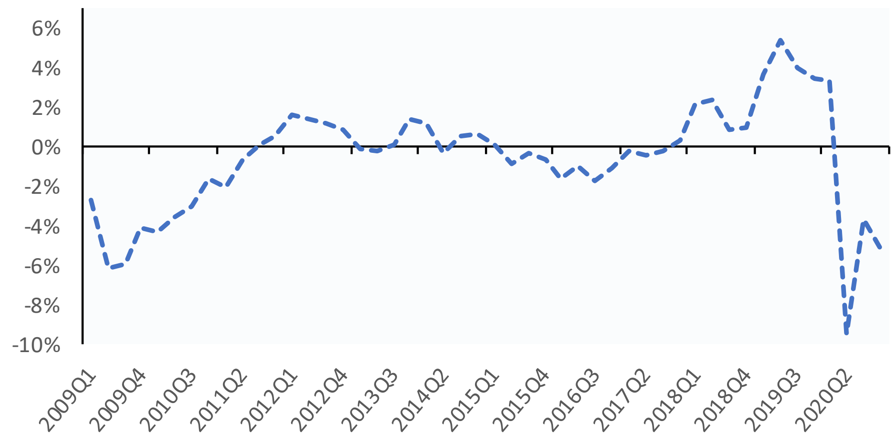
Table **1** presents summary statistics of endogenous variables. Average and median values of the output gap are negative, meaning that throughout the sample period actual output was below potential GDP more frequently, partly thanks to COVID-19 recession (see also Figure 1). A large spread between minimum and maximum values with a high level of standard deviation suggests that in the sample period Georgian economy has been affected by several severe shocks.

Table 1. Descriptive statistics of endogenous variables

Variables	Number of observations	Mean	Median	Minimum	Maximum	Standard deviation
Output gap	48	-0.57	-0.22	-9.96	5.24	2.87
Annual inflation		3.99	3.29	0.03	13.32	2.99
100*dlog(NEER)		0.88	0.01	-13.45	14.05	6.30
TIBR		5.98	6.56	2.03	9.06	1.80

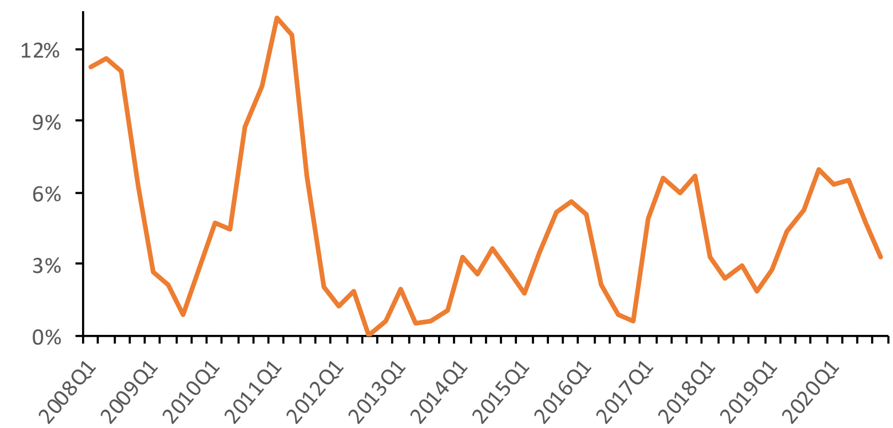
Source: Authors’ calculations

Figure 1. Output gap (based on the HP filter) in Georgia



Source: Georgian Statistics Office; authors' calculations

Figure 2. Inflation rate in Georgia



Source: National Bank of Georgia

Inspecting the inflation rate leads to similar conclusions. High variability in data is noticeable. Average inflation, similar to the median is around 3-4%. Combining all the information with the pattern of series, it is possible to conclude that the outset of the inflation targeting regime has been characterized by a high level of inflation, which has been stabilized thereafter (Figure 2).

The mean and median TIBR rate are around 6-6.5 percent. Unlike inflation and output, the TIBR series exhibit relatively small variability. On the other hand, while the median value of an annual change in NEER is close to zero – meaning that most of the times NEER is remaining unchanged – variation in the annual change in NEER is considerably larger than that of inflation and output gap (indicated by the twice as large standard deviation). Such fluctuations of the series stipulate that the Georgian economy is highly vulnerable and responsive to external shocks (Figure 7).

4. Results

4.1. Preliminary analysis

The stability and efficiency of the VAR model require endogenous variables to be stationary. In order to examine the presence of a unit root, Augmented Dickey-Fuller and Phillips-Perron tests are applied (Table 2).

Following the inspection of the graph, both trend and intercept are included in both tests, alongside four lags, since the data is of quarterly frequency. In case of TIBR rate, tests are conducted with intercept only since no trend is observed on the graph. ADF test implies that the output gap is stationary at a 5% significance level. The result is reinforced by Phillips-Perron test. Similarly, the inflation rate has no unit root at a 5% significance level. PP test yields the analogous outcome, but at 10%. Both tests suggest that Tbilisi Interbank rate is not stationary in level form. However, the series are stationary in its first difference form.

Despite its non-stationarity, TIBR is still utilized in the model in the level form. Abstaining from the first difference allows the straightforward formulation of a monetary policy shock, that is the shock to TIBR, not the shock to a change in TIBR. In addition, Sims et al (1990) assert that the estimation of a VAR with variables given in levels makes it possible to take into account the cointegration between variables.

Augmented Dickey-Fuller and Phillips-Perron tests deem NEER in logarithms as a process with a unit root. Differencing transforms the series into a stationary process.

Table 2. Unit root test results

	ADF test		PP test	
Variables	Level	First Difference[1]	Level	First difference[1]
Output Gap	-2.9725**		-3.1274**	
Inflation Rate	-3.8350**		-2.83487*	
TIBR	-2.3334	-4.5874***	-1.6344	-3.4228**
Log(NEER)	-2.224147	-3.9654**	-1.820955	-3.1407**

[1] Annual difference is used, where variable is differenced by its own value from the same quarter of the previous year.
* Significance at 10% level
** Significance at 5% level
*** Significance at 1% level

Source: Authors' calculations

4.2. Diagnostics of the VAR model

The main model for the research is the four-variable structural vector autoregressive model, where the vector of endogenous variables consists of the output gap, inflation, TIBR rate, and NEER with the respective order.

Firstly, the appropriate lag order is determined, examining various information criteria (Table 3). An optimal number of lags in VAR minimizes the following information criteria: Akaike information criteria (AIC), Schwarz information criteria (SIC), and Hannah-Quinn information criteria (HQC). Each measure differs in how strictly it penalizes the additional lag in the model. Akaike information criteria suggests 4 as an optimal lag length. Other information criteria

(Bayesian, Hannah-Quinn) propose to have 1 as an appropriate lag order. Models with 1,2 and 4 number of lags yield the qualitatively identical and theoretically correct results. Therefore, since the sample size is small, 1 is selected as a final order of lags.

Table 3. Lag order selection criteria

Lag	Log Likelihood	LR	FPE	AIC	BIC	HQ
0	-351.944	-	1500.42	18.66379	19.17566	18.84744
1	-248.855	169.1717*	17.49477	14.19769	15.39204*	14.62621*
2	-232.873	22.94806	18.35644	14.19863	16.07546	14.87202
3	-211.668	26.09904	15.59527	13.93168	16.491	14.84994
4	-187.861	24.41699	12.69540*	13.53134*	16.77315	14.69448

Source: Authors' calculations

The selection of the number of lags is followed by studying the stability of the estimated system. All inverse roots of the characteristic polynomial are situated within the unit imaginary circle (Figure 8), substantiating the fact that the estimated VAR model is stable. The diagnostics further proceeds with the examination of autocorrelation in residuals. Breusch-Godfrey LM test of serial correlation cannot reject the null hypothesis of no serial correlation for all lags (Figure).

White test for heteroscedasticity is applied to investigate the homoscedasticity of the residuals. White LM test suggests that there is no heteroscedasticity since the null hypothesis of homoscedasticity cannot be rejected (Figure 10). Finally, the Jarque-Berra test is employed for the residual normality. Both Skewness and Kurtosis are neglected. As a result, the calculated Jarque-Berra statistics imply the normal distribution of residuals.

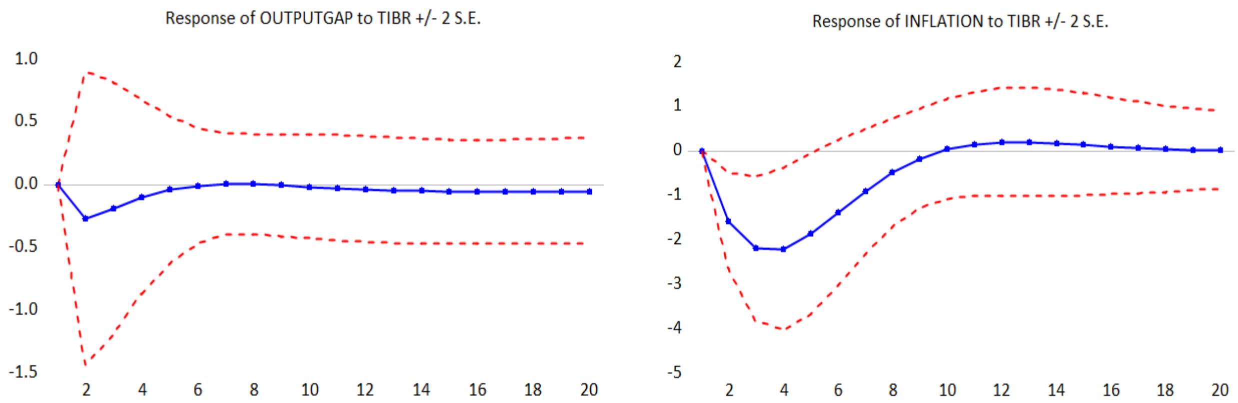
Therefore, the diagnostic tests suggest that the model is stable and residuals exhibit the characteristics of the white noise process.

4.3. Discussion of the results

Typically, in order to trace dynamic effects of a monetary policy shock on output gap, inflation and nominal effective exchange rate, i.e. to obtain the quantitative measure of monetary policy transmission, the standard impulse response functions are used. Monetary policy shock is identified as an exogenous 1 percentage point (pp) increase in Tbilisi Interbank rate.

Figure 3 shows that 1 pp shock to TIBR leads to a moderate decline in the output gap. The maximum decline is reached in the second quarter, when the output gap is reduced by 0.26 pp. In other words, contractionary monetary policy reduces actual output below potential, slowing down the economy. Following the trough, the output gap starts to stabilize and return back to the initial level.

Figure 3. Responses of output gap and inflation to a monetary policy shock



Source: Authors' calculations

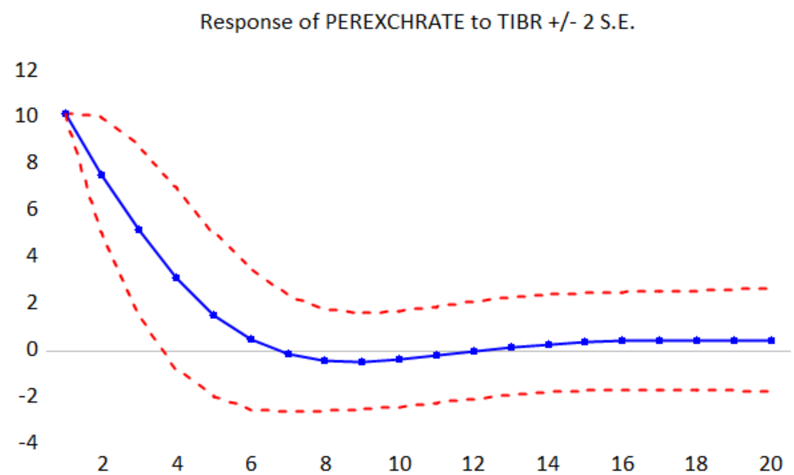
The pattern of the impulse response of inflation to the monetary policy shock exhibits similarities to the output gap. 1 pp positive shock to TIBR reduces CPI inflation gradually. More specifically, inflation reaches its lowest level after 4 quarters – showing 2.2 pp decline in the inflation rate in the 4th quarter. This reaction of inflation is quite strong and it could be related to a slowdown in demand as well as an also strong reaction of the exchange rate in response to TIBR (see the discussion below). In the succeeding periods the impulse responses of inflation start to stabilize and return to its initial value. The full effect of monetary policy decisions being revealed only after 4 quarters seems in line with theory as well as NBG's communication of its monetary policy. Friedman (1972) points towards a similar transmission lag.

Scrutinizing impulse responses above, it is apparent that the interest rate channel plays an important role in the transmission of monetary policy decisions. Changes in monetary policy seem to first influence the output gap, or the aggregate demand, and then slowly translate into the reduction in inflation. Results are consistent with the inflation targeting regime, currently operating in Georgia. It is conspicuous that the transition to this new regime made the interest rate channel stronger, compared to the previous period, when the channel played a negligible role in transmission (Bakradze and Billmeier, 2007; Samkharadze, 2008).

Examination of the exchange rate channel, at the cost of slight double counting, could be divided into the inspection of transmission from interest rate to exchange rate and from exchange rate to output and inflation. Figure 4 shows the effect of monetary policy on the nominal effective exchange rate. 1 pp positive shock to TIBR leads to an immediate large appreciation of NEER in the first quarter by about 10%. In the following quarters the effect of the shock gradually dies out but the appreciation relative to the initial condition still persists even after 4 quarters. So, in the short run exchange rate strongly reacts to the TIBR shock in a way that is consistent with theoretical predictions. An increase in lari interest rates makes Georgian lari assets more attractive, i.e. interest rate differential widens, which leads to expansion of demand for the Georgian currency, resulting in its appreciation.

Hence, the first leg of the exchange rate channel is strong – if anything, the question is whether it is too strong. 1 pp increase in the monetary policy rate causing a 10% jump in the exchange rate indeed seems like a very large change. Apart from a potential model misspecification issue that is, in general, always possible, the reason why the empirical estimates show such a picture could be related to long-term interest rates. Namely, our impulse responses may actually be showing reactions to changes in longer-term interest rates as well – since TIBR is close to being a unit root process, a shock to it simulates a scenario of higher TIBR for quite a while. This, along the lines of expectations hypothesis, can result in similarly higher long-term rates, which can affect the exchange rate much more strongly than short-term rates. More specifically, simple UIP calculations would suggest that 1 pp increase in a domestic currency 10-year interest rate is approximately equivalent to a 10% (expected) change in the exchange rate (for given risk premia and foreign currency interest rates).

Figure 4. Response of NEER to a monetary policy shock



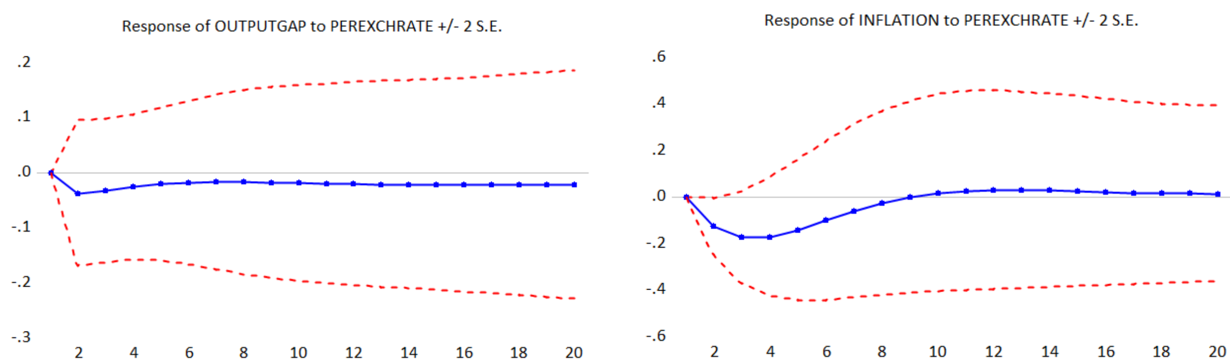
Source: Authors' calculations

Following a change in the exchange rate, 1 pp increase in NEER (Figure 5) produces a decline in the output gap by 0.04 pp in the second quarter. After the initial decline, the extent of the effect deteriorates. The direction of the shock response is theoretically correct (i.e. showing a traditional net export channel), but the statistical significance, as well as magnitude is quite negligible, compared to the reaction of the same variable to the monetary policy shock. Appreciation of the domestic currency should be followed by a decline in net exports due to reduced external demand and, more importantly, higher imports. Subsequently, output should decline, which is portrayed by the deterioration in the output gap. But, reaction of the output gap to an increase in NEER is significantly more sluggish, almost imperceptible.

Weaker output reaction can be a reflection of two things. First, there could be a reverse causality issue. Namely, in the data, output could be, for example, declining because of a negative external demand shock, which simultaneously depreciates the exchange rate – hence, in the data, we would be seeing both a drop in output as well as exchange rate depreciation, creating an impression as if depreciation caused output to decline. This issue may weaken the visibility of the effect we are trying to capture. Second, insignificant reaction of output to the exchange rate can also be a reflection of two opposing channels – i.e. net exports VS financial dollarization. Carranza et al (2009) suggest that in highly dollarized open economies influence of the exchange rate on net exports is hindered by the balance-sheet effects due to foreign currency denominated debt. In short, in our impulse responses, even though the exchange rate appreciation leads to a reduction in net exports, it also lowers the cost of debt denominated in a foreign currency, affecting spending behavior of households and production capacity of firms positively. Therefore, the traditionally signed response of output is less visible in the presence of financial dollarization. And Georgia is a relatively highly dollarized economy (loan dollarization is about 50-55% in 2021). Despite these two issues, the sign of the output gap change is still in line with the net export channel.

The reaction of the inflation rate to the exchange rate shock (Figure 5) is negative (in line with expectations). Appreciation of NEER by 1% leads to a decline in annual inflation by 0.13 pp in the second quarter and the effect reaches the maximum in the third quarter when the inflation declines by almost 0.2 percentage points. Following the initial shock, the variable steadily converges to its initial value. While the magnitude does not seem large, taking the strong reaction of the exchange rate to TIBR into account, one can argue that the exchange rate channel is still strong.

Figure 5. Responses of output gap and inflation to NEER

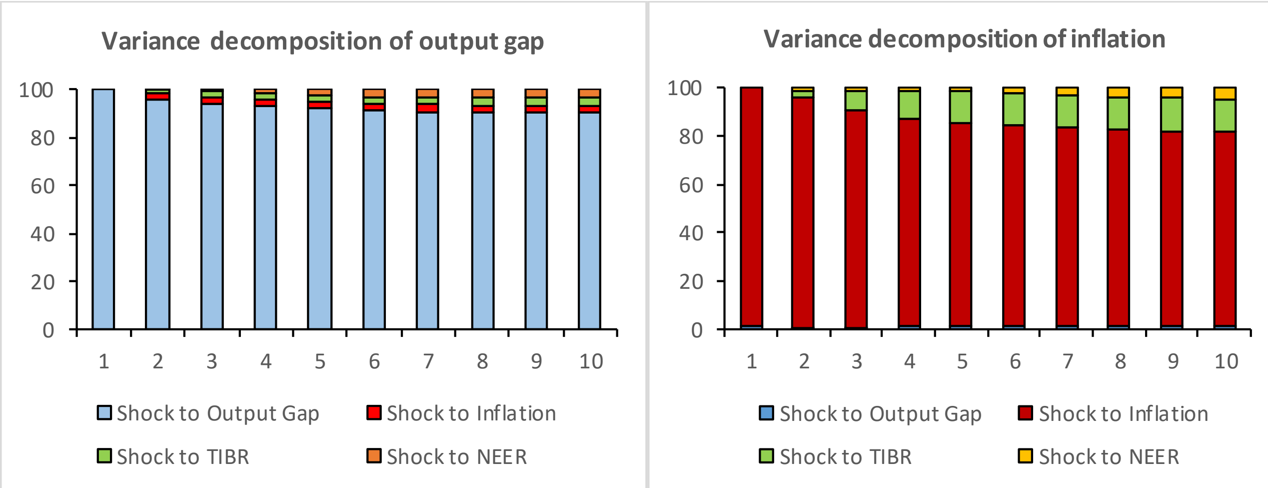


Source: Authors' calculations

The variance decompositions of the variables show how the variation in each variable is explained by different shocks. For example, the variation in the output gap (Figure 6) is mainly explained by its own (i.e. demand) shocks throughout the first 10 quarters. The share declines steadily, but even at the end of the 10th quarter, it still explains 90% of the overall variation.

Regarding the variation in inflation (Figure 6), it is mostly explained by its own (i.e. supply or cost-push) shocks. TIBR rate shocks also play a relatively important role in explaining the variation of inflation, as its share grows and reaches its maximum after 5 quarters, but overall remains small part of the picture (with 13% of the overall variation explained by it). The nominal effective exchange rate has the third-largest share that is consistent with the impulse response analysis. The output gap (demand) shocks cannot explain the inflation variation. Theoretically, it could be that the central bank neutralizes the effects of demand shocks on inflation, so that the output gap doesn't show up in inflation variation. Hence, supply shocks remain as a key driver of inflation variability.

Figure 6. Variance decompositions of output gap and inflation



Source: Authors' calculations

4.4. Robustness checks

As a robustness check to the main SVAR, impulse response functions from the alternative model have also been considered. The same VAR with the same variables and identical structural identification has been estimated with 4 lags. The number of lags has been chosen following the suggestion made by AIC.

Impulses responses from the alternative model are similar to the original SVAR. Output gap and inflation react to the monetary policy shock in the same manner. So the strength and importance of interest rate channel is confirmed by the alternative model.

The similar trends to the original model are observed in the exchange rate channel as well. NEER responds well to the monetary policy shock, while reaction of output to the exchange rate shock is weak and insignificant. Inflation reacts to the exchange rate shock with moderate, but significant magnitude. Therefore, similar to the first SVAR, exchange rate channel is significant, but has a bit smaller role.

In short, the alternative model yields qualitatively and quantitatively comparable results. However, due to the limited number of observations, as well as small degrees of freedom, explanatory power of the latter model is limited. Large number of lags produce a backward-looking model and together with the small sample may result in cyclical and volatile impulse responses. Other small changes in the specification also do not alter the final results much.

5. Conclusion

This paper empirically investigates two main channels of monetary policy transmission in Georgia: the interest rate channel and the exchange rate channel. The study employs quarterly time series, spanning from the first quarter of 2009 until the fourth quarter of 2020. Following the previous studies, the paper utilizes a structural vector autoregressive model with contemporaneous restrictions, using the four main endogenous variables: output gap, CPI inflation, short-term money market rate as a monetary policy indicator, and nominal effective exchange rate. The research scrutinizes impulse response functions of the variables to orthogonal policy shocks to estimate the dynamic effects of monetary policy decisions on output and inflation. Furthermore, the variance decomposition is also employed to assess what part of variability in endogenous variables is explained by different types of shocks.

The research finds that the interest rate channel plays an important role in the transmission of monetary policy to inflation and output, which is a favorable feature for the country employing an inflation-targeting regime. 1 pp exogenous rise in interest rate leads to a decline in the output gap by 0.26 pp and a reduction in inflation by 2.2 pp after 4 quarters. This in line with expectations about the transmission lags of monetary policy actions.

The exchange rate channel shows that 1 pp shock to TIBR leads to an appreciation of NEER by 10%. We conjecture that such a big response could be due to the effects of monetary policy on long-term interest rates (with long-term rates having a much bigger impact on the exchange rate than short-term rates). Then the shock is transmitted to the output gap and inflation. Namely, 1% appreciation of the exchange rate reduces inflation by almost 0.2 pp within 3 quarters, while the output reacts very weakly. Sluggishness of the response of output gap is a typical characteristic of highly dollarized economies, where net export channel is partly neutralized by the balance sheet channel (meaning that lower liability dollarization could be useful in increasing the effectiveness of monetary policy). With these results, one may argue that the effectiveness of the exchange rate channel is superior in the short-run (e.g. import prices), while in the following periods the interest rate channel dominates the monetary policy transmission.

The variance decomposition shows that TIBR shocks explain the second largest part of the variation in output gap throughout the medium term and its role is stronger for the variability of the inflation, but even there it explains only 13% of overall variation. Shocks to other variables have even less contribution. As a result, the fluctuations in the output gap are mainly driven by demand shocks, while the inflation in Georgia is mostly changing in response to supply shocks. One possible reason for this could be that the central bank is neutralizing the impact of demand shocks on prices, while it allows the effects of supply shocks.

While the results seem robust to some alternative specifications and are in line with theory, the paper still suffers from some shortcomings. First, relative to HP filters, structural model estimates or more advanced filtering methods (e.g. Kalman filter) seem superior for estimating potential output. Second, given the short time series and, hence, relatively wide confidence bands, results of the VAR and its impulse responses should be interpreted cautiously.

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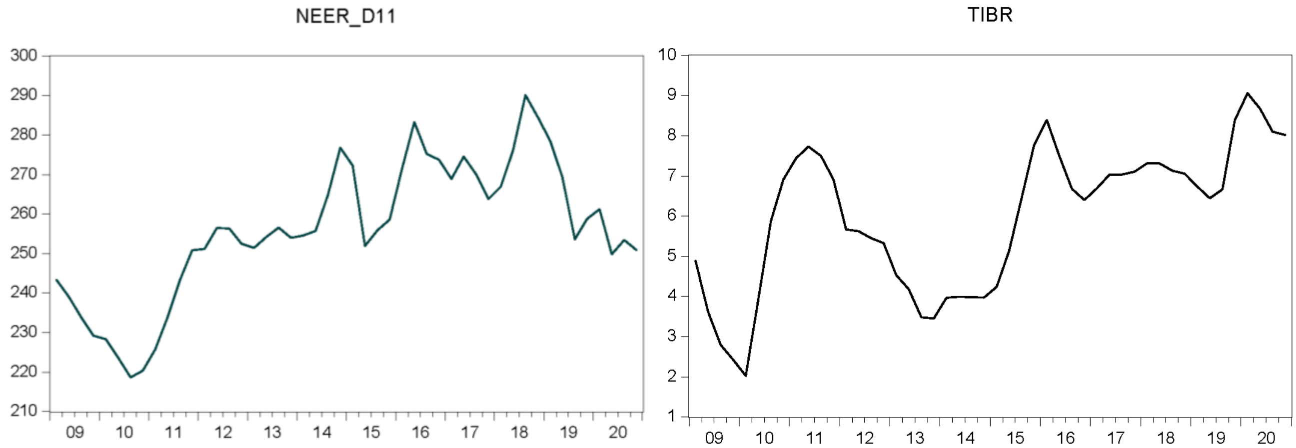
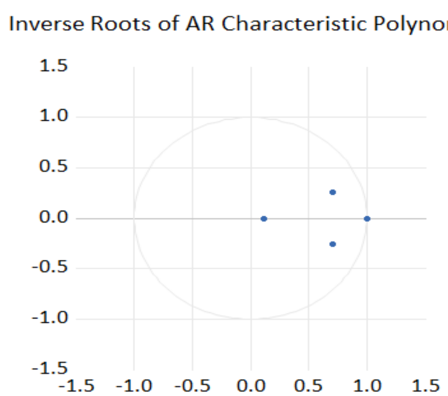
Appendix

Figure 7. NEER and TIBR



Source: National Bank of Georgia

Figure 8. Inverse roots of characteristic polynomial



Source: Authors' calculations

Figure 9. Serial corellation test

VAR Residual Serial Correlation LM Tests
Date: 10/24/21 Time: 14:14
Sample: 2011Q2 2020Q4
Included observations: 39

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	24.86521	16	0.0722	1.657838	(16, 77.0)	0.0739
2	19.25460	16	0.2557	1.239793	(16, 77.0)	0.2587
3	22.08064	16	0.1406	1.446871	(16, 77.0)	0.1430
4	23.57109	16	0.0993	1.558922	(16, 77.0)	0.1012
5	18.12530	16	0.3166	1.158972	(16, 77.0)	0.3197

Figure 10. Heteroskedasticity and normality tests

VAR Residual Heteroskedasticity Tests (Levels and Squares)
Date: 05/12/21 Time: 10:20
Sample: 2007Q1 2020Q4
Included observations: 39

Joint test:

Chi-sq	df	Prob.
377.7945	360	0.2491

Individual components:

Dependent	R-squared	F(36,2)	Prob.	Chi-sq(36)	Prob.
res1*res1	0.990964	6.092735	0.1507	38.64760	0.3509
res2*res2	0.989680	5.327790	0.1703	38.59752	0.3530
res3*res3	0.949377	1.041873	0.6075	37.02569	0.4214
res4*res4	0.972258	1.947015	0.3973	37.91806	0.3819
res2*res1	0.961920	1.403347	0.5028	37.51487	0.3996
res3*res1	0.937993	0.840395	0.6841	36.58171	0.4417
res3*res2	0.988500	4.775229	0.1880	38.55149	0.3549
res4*res1	0.990192	5.608916	0.1626	38.61750	0.3522
res4*res2	0.959079	1.302071	0.5286	37.40408	0.4045
res4*res3	0.853964	0.324868	0.9417	33.30460	0.5975

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Date: 10/24/21 Time: 14:16
Sample: 2011Q2 2020Q4
Included observations: 39

Component	Skewness	Chi-sq	df	Prob.*
1	0.010179	0.000673	1	0.9793
2	0.605949	2.386632	1	0.1224
3	0.269011	0.470385	1	0.4928
4	0.262028	0.446281	1	0.5041
Joint		3.303971	4	0.5083

Component	Kurtosis	Chi-sq	df	Prob.
1	4.225804	2.441716	1	0.1181
2	3.733415	0.874084	1	0.3498
3	2.591447	0.271238	1	0.6025
4	3.810795	1.068257	1	0.3013
Joint		4.655295	4	0.3245

Component	Jarque-Bera	df	Prob.
1	2.442390	2	0.2949
2	3.260716	2	0.1959
3	0.741623	2	0.6902
4	1.514537	2	0.4689
Joint	7.959267	8	0.4375

*Approximate p-values do not account for coefficient estimation

Source: Authors' calculations

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