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Between russian Invasions: The Monetary Policy Transmission Mechanism in Ukraine in 2015-2021[1]

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Abstract

This report evaluates the monetary policy transmission mechanism in Ukraine during the early years of inflation targeting. It assesses both the overall strength of the policy interest rate transmission, and its channels. Furthermore, it addresses the stabilizing role of forward guidance, foreign exchange interventions, and monetary policy credibility.

The National Bank of Ukraine abandoned its fixed exchange rate regime in 2014 in response to an economic crisis ignited by the initial invasion by russia. Under inflation targeting, the short-term interest rate became the main monetary policy instrument, while the exchange rate remained floating.

The full-scale russian invasion in 2022 forced the National Bank of Ukraine to temporarily shelve its policy interest rate, fix the exchange rate and impose administrative restrictions. However, it remains committed to returning to conventional inflation targeting when economic conditions normalize. This report could become a point of reference for future policy decisions by the Ukrainian central bank.

JEL Classification Codes: E37, E43, E52.

Keywords: monetary policy transmission mechanism, inflation targeting, interest rate channel, exchange rate channel, expectations channel

[1] We highly appreciate comments from Tomasz Lyziak.

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Summary

Central banks have to possess an in-depth understanding of the monetary policy transmission mechanism in order to make effective policy decisions. Moreover, market participants also need to understand it, so as to understand the central bank's decisions.

This study aims to assess the transmission mechanism in Ukraine, and to summarize the research conducted by the National Bank of Ukraine (NBU) on selected aspects of this mechanism. It is the second comprehensive mechanism overview since the NBU adopted inflation targeting in 2015.[2] The updated report covers more topics and includes an overall assessment, along with semi-structural models.

The assessment covers the years from 2015 to 2021 – the period between the two russian invasions. These were the early years of inflation targeting in Ukraine. The NBU abandoned the fixed exchange rate in 2014 and pursued a disinflation agenda. The inflation target was reduced from its initial 12±3% to the current 5±1%.

The monetary policy regime switch occurred amid a triple crisis, the components of which exacerbated each other. As Savolchuk and Grui (2022) put it: "First, the annexation of Crimea and the military conflict in (the) Donbas created a macroeconomic crisis. The economy fell into recession. Second, a worsening current account and dwindling international reserves resulted in a currency crisis. The fixed exchange rate regime was abandoned, and the devaluation was followed by high inflation. Third, a banking crisis was caused by the long practice of oligarchic banking. It led to a growth of non-performing loans and a withdrawal of deposits. Further lending to the economy was subdued.

In 2016-2019, the economy was recovering. The banking system was cleansed, and lending slowly resumed. Inflation, exchange rate, and output growth were relatively stable. However, the risks associated with an escalation of the military conflict remain."

From 2015 to 2021, the monetary policy in Ukraine remained conventional. The short-term interest rate acted as the main policy instrument, while foreign exchange interventions were used as an additional one.

In late February 2022, russia escalated the military conflict into a full-scale invasion. As of the time of writing, active hostilities continue.

[2] The first is documented in Zholud et al. (2019).

The NBU was forced to impose administrative restrictions that rendered ineffective its market policy instruments, including the policy interest rate. However, as an NBU press release from 3 March 2022 notes: “After Ukraine is freed from russian invaders and the economy is back to operating on market-driven principles, the NBU will return to its traditional inflation-targeting mode, with a floating exchange rate.”[3]

This report is organized as follows: In Section 1, we give an overview of the theoretical foundations of monetary policy transmission, its channels, and the relevant features of Ukraine’s small open economy.

- A standard classification distinguishes several separate channels through which the policy changes are transmitted. The most important are the interest rate and the exchange rate channels. The credit channel can be influential due to market imperfections. The asset price channel is insignificant due to the underdevelopment of the stock and real estate markets. Inflation expectations, if anchored, can also help stabilize inflation.
- The transmission mechanism is shaped by the structural characteristics of the economy and its openness to the rest of the world. The Ukrainian financial system is bank-centric and has many state-owned banks. Lending in 2021 was yet to recover after the crisis of 2014-2015. Both of these factors impede the interest rate channel. On the other hand, high openness means the exchange rate channel is relatively strong.

Section 2 presents the main quantitative results – namely assessments of the general mechanism with semi-structural models, transmission to market interest rates, exchange rate transmission, the dynamics of inflation expectations, and the role of explicit forward guidance.

- The transmission mechanism’s general strength, and its lags, are evaluated with a set of New Keynesian semi-structural models, including ones that are regularly used for macroeconomic forecasting and informing monetary policy. All of the models indicate falling inflation in response to a contractionary policy shock. However, low monetary policy credibility can delay and subdue the effect. Separately, moderate foreign exchange interventions can help stabilize inflation.
- The wholesale overnight credit interest rate has quickly adjusted to the NBU’s policy rate since the adoption of inflation targeting, when it became an operational target of monetary policy. The transmission to retail deposit rates is slower, and not always complete. Rates for business generally display better transmission than the ones for the general public. The transmission to credit rates for businesses is the strongest for large borrowers and in banks with foreign capital. Government bond yields strongly react to policy rate changes. However, transmission was poorer amid the COVID-19 crisis.
- The exchange rate channel is of particular importance in Ukraine. Both exports and imports have high elasticities to the real effective exchange rate. The exchange rate pass-through

[3] NBU (2022).

to consumer prices is high. Moreover, it is asymmetric and non-linear, with the absolute effect from moderate depreciation being lower than that from significant depreciation, but higher than that from appreciation.

- The inflation expectations of various economic agents surveyed over 2016-2021 gradually improved, indicating growing monetary policy credibility. Still, they retained an upward bias. Exchange rate shock explains the high amount of variation in businesses' expectations, while inflation and the output gap play less important roles.
- Since 2019, the NBU has provided forward guidance in the form of policy interest rate projections. These seem to influence market forward interest rates, especially in the short term. Over a more extended period, the impact of the term premium increases.

1. Theory and Structural Factors Affecting the Transmission Mechanism

This section of the report considers the theory behind the monetary policy transmission mechanism and its historical evolution. We also discuss the structural characteristics of the Ukrainian economy, which are essential for the functioning of the transmission mechanism, and the relative strengths of the individual transmission channels.

The NBU de facto adopted inflation targeting in 2015 following a long period of the fixed exchange rate regime. The transition occurred amid a “perfect storm” of a russian invasion, and currency and banking crises. We encourage the reader to learn more about the broad macroeconomic picture of the early years of inflation targeting and of the period preceding it in Section 3 of Grui (2020).

1.1. Theoretical Introduction

An inflation-targeting central bank uses its short-term interest rate as a key policy tool to stabilize consumer inflation. The transmission from changes in the key policy interest rate to changes in inflation is called the transmission mechanism of monetary policy.

Traditional macroeconomic models, especially IS-LM ones,[4] involve an instant and complete signal transition from the key rate to macroeconomic variables, such as inflation and output. At the same time, many empirical studies, both in developed and emerging markets, show that transmission has a time lag and very often is not complete. Economic responses depend on several conditions, both external (e.g., sources of changes in the exchange rate) and internal, dependent on the central bank (e.g., the direction of the key rate change).

The monetary transmission mechanism is how monetary policy decisions affect asset prices and general economic conditions. There are two main reasons for studying it:

1. Understanding how monetary policy affects the economy is vital for assessing the current monetary policy stance.
2. To make monetary policy decisions, policymakers must have the most accurate economic assessment of the impact of their policies on economic activity and inflation.

Some economists (Bernanke and Gertler, 1995) noted that the monetary transmission mechanism is similar to a black box. The mechanism of a step-by-step signal transmission is obscured, and the observer sees only the initial change and the result.

[4] The IS-LM model shows the relationship between interest rates and real output. IS stands for "investment–saving" and LM for "liquidity preference–money supply".

Nevertheless, we can differentiate several possible ways or “channels” through which the initial change can be transmitted. There are usually three main neo-classical channels of influence (Ireland, 2010):

- **interest rate channel** – through interest rates on loans and deposits, which causes agents to change their consumption/savings/investment behavior
- **exchange rate channel** – due to changes in exchange rates
- **asset price channel** – due to changes in stock market valuations of asset values (or alternatives).

These channels are called neo-classical because they operate in a classical economic environment of perfect markets. In addition to these three channels, there are transmission channels that arise from market imperfections. The most important among them is the **credit channel**, which links tighter monetary policy to even higher borrowing costs due to imperfections in the credit market, such as information asymmetry.

The **interest rate channel** describes how the policy interest rate affects market interest rates, and subsequently output and consumer prices. Inflation targeting central banks typically control short-term money market interest rates. However, they also influence longer-term ones with forward guidance and through the term structure of interest rates. Longer-term interest rates, such as rates on bank loans and deposits, along with yields on government debt securities, are more relevant for consumption and investment choices and thus for the overall economy.

According to the **exchange rate channel**, raising the policy interest rate attracts foreign capital. Other things being equal, it is expected to strengthen the domestic currency in line with the uncovered interest parity. Exchange rate movements have implications for export competitiveness and import prices. Thus, the exchange rate influences inflation directly through import prices, and indirectly through aggregate demand. A central bank might choose to smooth excessive exchange rate fluctuations with foreign exchange interventions.

The **asset price channel** relies on the changing prices of such assets as real estate or stocks. A higher interest rate leads to lower asset prices, thus influencing economic agents’ wealth and, consequently, their investment and consumption decisions. This channel works in economies with developed stock and real estate markets. For this reason, it currently has little weight in Ukraine.

One can also differentiate a separate **inflation expectations channel**. It is among the most critical factors shaping monetary policy transmission. First, economic agents ground their financial decisions on real interest rates, which are nominal ones adjusted by inflation expectations. In turn, expectations are influenced by recent economic developments and policy actions. Second, anchored expectations help inflation-targeting central banks stabilize inflation and allow more room for maneuver in response to various economic disturbances.

Finally, the **credit channel** is linked to information asymmetry, as borrowers know their situation better than lenders. A higher interest rate worsens the balance sheets of both banks and their borrowers, while also reducing the bank's appetite for risks. This makes banks less inclined to issue new loans. As a result, a tight monetary policy decreases the supply of bank credit in addition to reducing the demand for it (interest rate channel).

1.2. Structural Characteristics

The policy transmission mechanism and its individual channels are shaped by the structural conditions of the country's financial system and its openness to the rest of the world. First, the financial system defines the interest rate channel of the transmission mechanism. The former is bank-centric in Ukraine, and was struck by the banking crisis in 2014-2015. Second, financial and trade openness affects the strength of the exchange rate channel.

In this section, we describe Ukrainian structural conditions and compare them with those of Poland – a relatively similar developing, yet more advanced neighboring country in Eastern Europe with an independent central bank that pursues inflation targeting. The data for Poland is taken as an average of biennial data from 2006 to 2018, from Chmielewski et al. (2020).

1.2.1. Interest Rate Channel

The Ukrainian banking system has undergone significant changes. After the crisis in 2014-2015, many banks were removed from the market due to their involvement in related-party lending and money laundering. Some other banks could not meet new requirements under the Basel III convention. The cleansing of the market decreased the number of banks from 180 in 2013 to 113 in 2015, and the number continued to fall in subsequent years. The banking system's assets to GDP ratio also decreased.

High asset ratios of state-owned banks, the biggest banks, or banks with foreign capital may impede the interest rate transmission channel. The latter implies reliance on external funds. The former two imply lower market competitiveness and higher concentration. Moreover, state-owned banks are more likely to buy government debt obligations.

Ukraine has had a large share of state-owned banks since 2016, when PrivatBank (the largest bank by the volume of assets) was nationalized. The state's share of the market is considerably above that of Poland, which leads to worse transmission.

Table 1. Factors Affecting the Interest Rate Channel

	2015	2016	2017	2018	2019	2020	2021	Poland 2006-2018[4]
Banking System Assets as a share of all financial assets (%)[1,3]	76.9	79.4	79.1	78.4	76.5	75.6	73.0	
Number of Banks[1]	113	99	84	78	75	73	71	
Total Bank Assets to GDP (%)[1,3]	63.0	53.4	62.9	54.3	49.8	52.7	45.4	
Assets share of state-owned banks (%)[1]	28.6	50.6	58.3	59.0	60.4	55.6	49.7	24.9
Assets share of banks with foreign capital (%)[1]	36.3	33.9	29.6	28.1	27.2	28.9	30.5	61.2
Assets share of 5 biggest banks (%)[1]	56.0	54.9	62.5	63.3	65.2	60.9	55.3	46.2
Herfindahl Index (%)[1,3]	8.7	8.6	11.9	9.7	10.0	10.8	9.6	6.9[5]
Share of NPLs (%)[1]			54.5	52.8	48.4	41.0	30.0	7.4
Share of NPLs of Households (%)[1]			53.5	46.0	34.1	27.9	17.7	
Deposits (% of GDP)[1]	36.0	33.3	30.1	26.2	26.9	32.1	29.8	45.1
Credits (% of GDP)[1]	49.4	41.9	34.1	30.1	24.4	22.6	20.7	46.6
Bank deposits to liabilities (%)[1,3]		74.8	78.1	78.8	84.8	85.4	85.2	
Share of credits in enterprise investments (%)[2]	7.3	7.1	5.3	6.7	7.0	6.6	4.7	
UAH Government debt bonds owned by banks (%)[1,3]	9.5	28.6	38.9	40.1	33.7	47.6	48.7	
UAH Government debt bonds owned by the NBU (%)[1,3]	87.8	67.9	57.4	56.5	46.8	37.7	33.2	
Inflation (5-year average, %)[2,3]	14.6	16.2	19.0	20.8	16.7	9.0	8.5	2.1

Source: [1]NBU; [2]DSSU; [3]own calculations; [4]Chmielewski et al. (2020); [5]ECB, average in 2016-2020.

The five biggest banks in Ukraine control a more significant part of the market than the five largest ones in Poland do. The top five consists of four state-owned banks and a foreign-capital bank, which oligopolize the market. We have also calculated a Herfindahl Index representing a concentration of assets (higher values mean more oligopoly). The concentration in Ukraine is higher than in Poland in relative terms.

The asset share of foreign capital banks has decreased over the last six years. It is lower than in Poland, which means there is higher overall reliance on domestic funding. Deposits are the dominant funding source for banks.

Non-performing loans (NPLs) have a long-lasting impact on the financial system. They block bank reserves, which decreases further lending. This hinders interest rate transmission to domestic demand. However, a higher share of NPLs can improve transmission to retail banking interest rates, as loans are issued predominantly to the most trustworthy entities with minimal risk premiums.

Traditionally, the share of NPLs grows during and after a crisis, which can be seen in the case of Ukraine, where it grew after the crisis in 2014-2015. The share decreased in 2017-2021. The process continued during the coronavirus crisis in 2020. A declining trend can be observed for both UAH and foreign currency loans. The high share of foreign currency NPLs is a legacy of the Global Financial Crisis of 2008 (GFC), due to a notable exchange rate devaluation. Households whose income is predominantly in UAH have a higher share of NPLs overall, with the bulk of these NPLs being in USD. However, this share decreased threefold in 2017-2021, as a result of a ban on households obtaining new foreign currency loans.

In 2020, Ukraine’s banks approved strategies for managing their NPLs, allowing their sale and writing off. The share of NPLs in Ukraine in 2021 was more than four times higher than in Poland. Its reduction would improve the financial system’s health and boost further lending.

Interest rate transmission relies on the volumes of private sector deposits and loans in the banking system. Their shares to GDP decreased in 2015-2021, even though deposits rebounded in 2019-2021. Both shares remain significantly lower than in Poland. Moreover, they are partially in foreign currency (see table 2), and many of the loans are non-performing.

Only a modest share of corporate investment is funded with bank loans, further hindering interest rate transmission to domestic demand. Businesses mostly take loans for operational activities, and these tend to be short-term – thus increasing transmission to interest rates.

Domestic government bonds are the most traded financial instrument in Ukraine. In 2015, most of them were owned by the NBU due to fiscal dominance. However, the share decreased in 2015-2021 as the NBU was prohibited from directly financing the state budget. Most of the new bonds are owned by the banking sector. However, the shares of other owners are also increasing. The percentage of non-residents surged in 2019 before stabilizing in 2020-2021, improving market liquidity (table 2).

In line with the standard New Keynesian model, the strength of monetary policy's impact on the real economy and prices is determined by price rigidity. If prices are rarely changed, monetary policy shocks strongly affect real quantities but have a low impact on prices. Antonova (2019) indicates that the frequency of price changes in Ukraine is much higher than in Poland (as estimated in Macias and Makarski, 2013). This result is consistent with higher average inflation in Ukraine and suggests limited monetary policy transmission to economic activity, but strong transmission to prices.

Table 2. Factors Affecting the Exchange Rate Channel

	2015	2016	2017	2018	2019	2020	2021	Poland 2006-2018[4]
Imports (% of GDP)[1]	55.3	56.2	55.9	54.0	49.1	40.8	42.5	45.2
Exports (% of GDP)[1]	52.7	49.3	48.1	45.3	41.0	39.2	40.9	45.1
Share of imports in consumption basket (%)[2]			35.2	35.3	35.0	34.5	34.1	12.5
Share of commodities in exports (%)[2]	73.0	74.2	74.9	74.8	75.9	75.7	77.2	
Share of imports in exports (%)[2,3]	35.7	34.5	34.5	33.4	29.8	27.1		
Deposits dollarization (%)[1]	44.9	46.0	44.0	40.7	39.0	37.1	31.8	11.1
Loans dollarization (%)[1]	56.0	49.5	43.9	42.8	36.9	36.9	28.4	28.8
UAH Government debt bonds owned by non-residents (%)[1]	0.6	0.2	0.8	1.0	16.1	9.8	9.7	
Credibility (%)[1]	13.9	16.4	20.5	26.0	37.6	37.1	38.3	

Source: [1]NBU; [2]DSSU; [3]own calculations; [4]Chmielewski et al. (2020).

1.2.2. Exchange Rate Channel

Ukraine is a small open economy, which makes it exposed to external shocks and exchange rate fluctuations. The import-to-GDP and export-to-GDP ratios have decreased over the last six years and are currently close to Poland's. However, the share of imported goods in the consumption basket is much higher.

Commodities (primarily agricultural products, base metals, and iron ore) make up a large share of Ukrainian exports. Moreover, exporters use a lot of imports as inputs. In such a situation, the sensitivity of exports to the exchange rate decreases. Commodity exporters do not adjust prices in line with changes in the exchange rate, while other exporters enjoy smaller benefits from a weaker exchange rate due to higher costs of imports.

The share of loans and deposits in foreign currency has decreased over the last few years. This is strengthening both the interest rate channel, as an increasing number of financial operations are conducted in hryvnias, and the exchange rate channel, as the wealth effects from exchange rate fluctuations are reduced. However, deposit dollarization remains much higher than in Poland.

We can observe a rapid increase in the share of non-residents in the ownership of government debt securities. In 2019, Ukraine made it easier for foreign investors to buy them, as it joined an international securities depositary. Higher capital mobility increased transmission from the interest rate to the exchange rate.

The NBU's credibility increased in 2015-2021.[5] Low credibility can destabilize inflation expectations and increase exchange rate pass-through to prices. Similarly, the pass-through rises if inflation is on average high.

2. Main Results

This part of the report presents our analysis of the main features of the monetary policy transmission mechanism in Ukraine. First, we assess its general strength and its lag with a set of New Keynesian semi-structural models. Then we delve into specific links, i.e., the transmission to market interest rates, the exchange rate channel, and the developments of inflation expectations.

2.1. Transmission as Seen by Semi-Structural Models

In this subsection of the report, we refer to semi-structural models, which have stronger theoretical foundations than the econometric models in the rest of the report. They are used to assess the strength and lags of monetary policy transmission and to analyze the role of foreign exchange interventions and monetary policy credibility.

2.1.1. Models Used to Analyze the Monetary Policy Transmission Mechanism

This subsection introduces the three quarterly semi-structural models used for monetary policy analysis at the NBU. All of them are New Keynesian models of a small open economy built around four central macroeconomic relationships: the aggregate demand curve, the Phillips curve, the uncovered interest parity, and the Taylor-type monetary policy rule. However, they each emphasize different aspects of monetary policy transmission.

[5] Business Outlook Survey respondents are asked "What is your assessment of the NBU's actions?" The share of those who trust the NBU's actions is used as a proxy for credibility.

The Quarterly Projection Model (QPM) is the core macroeconomic model used at the NBU to assist its policymaking. It is used to produce regular macroeconomic forecasts and inform monetary policy decisions. The QPM focuses in particular on heterogeneity in consumer prices. It includes separate Phillips curves for the four inflation components: core, raw food, administratively regulated, and petrol. The model coefficients are mostly estimated with Bayesian techniques on a time sample beginning in 2015. Priors are chosen in accordance with benchmarks found in the literature, internal assessments, and the need to match them with the characteristics of the Ukrainian economy. The model is regularly used for policy advice. It reflects institutional expert judgments on monetary policy transmission. A detailed description of the QPM can be found in Grui and Vdovychenko (2019).

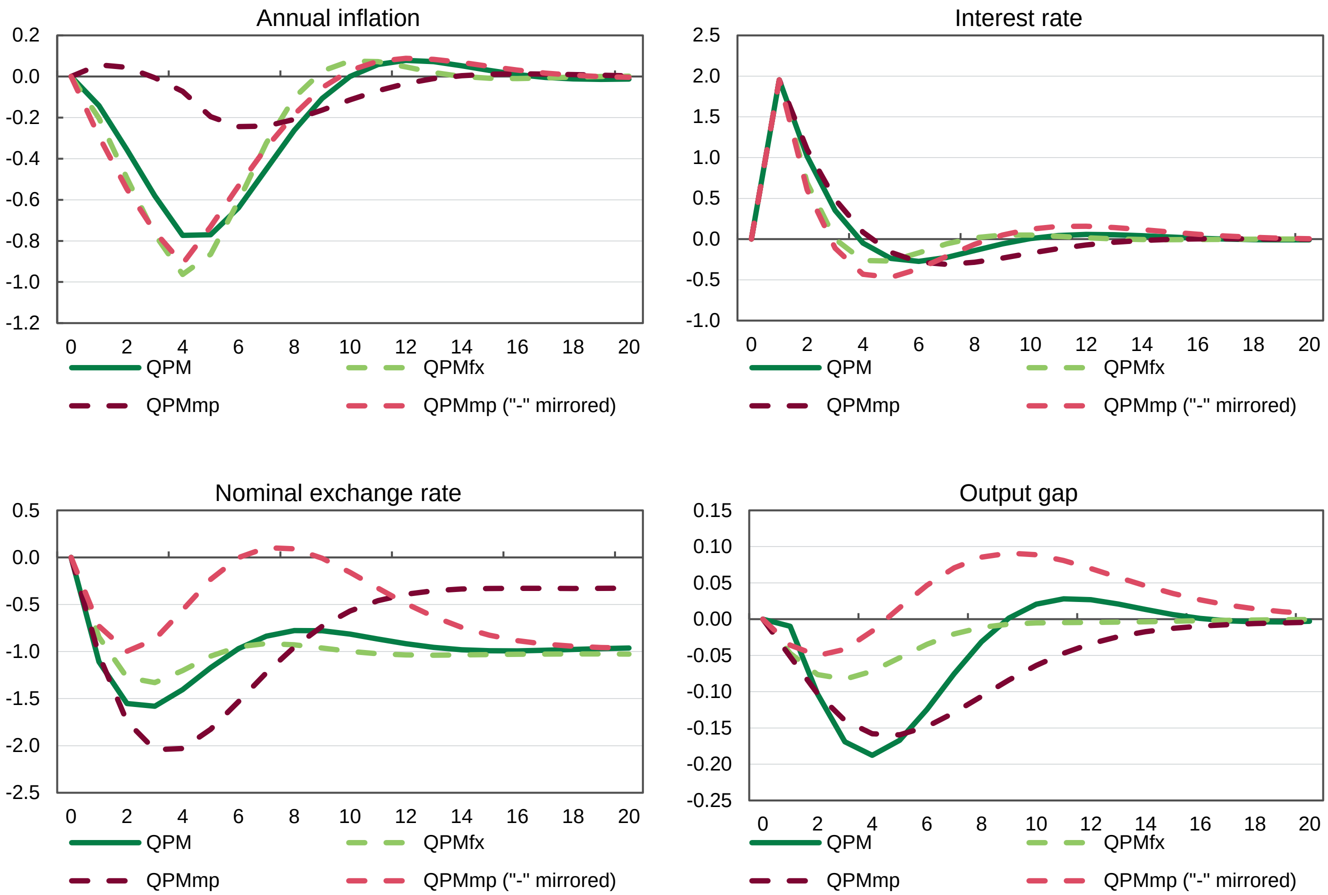
The second model is named QPMfx for its emphasis on the NBU's foreign exchange (fx) interventions. It is a satellite model that modifies uncovered interest parity to gauge how interventions can help maintain price stability under inflation targeting. Interventions are modeled as an automatic smoother of exchange rate movements. Their strength can be calibrated with model parametrization. The model coefficients are mostly estimated with Bayesian techniques on the 2015-2020:Q1 sample. Section 2.1.3. demonstrates the role of foreign exchange interventions in inflation stabilization. A detailed description of the QPMfx is available in Grui (2020).

The third model is called QPMmp, as it models time-variant monetary policy (mp) credibility. This satellite model modifies the Phillips curve to reflect the role of endogenous policy credibility in policy transmission. Credibility is modeled as a nonlinear function of the deviations of actual and expected inflation from their targets. In turn, higher credibility makes inflation expectations more anchored and reduces their bias. The majority of the coefficients in the QPMmp are estimated with Bayesian techniques on the 2016-2021 sample. Section 2.1.4 offers insights into the role of credibility in monetary policy transmission. Detailed information about the model is available in Savolchuk and Grui (2022).

2.1.2. Impulse Response Functions

To assess the strength of, and lags in policy transmission, we simulate impulse responses to a monetary policy shock with the three semi-structural models. The policy interest rate increases for one quarter and then moves following a monetary policy rule. No other shocks hit the economy for the duration of the simulations. All responses are normalized to have the same immediate response of the policy interest rate. The size of the shock is roughly in line with historical volatility.

The results shown feature two different simulations with the QPMmp. One is for a contractionary policy shock, and another is for an expansionary shock, which is mirrored for presentational purposes. QPMmp is the only model presented here with asymmetric responses to positive and negative economic shocks. At the beginning of each simulation, monetary policy credibility equals 0.6 out of 1, which is close to its estimated values in 2020-2021. Lower credibility leads to higher inflation expectations bias (more details in section 2.1.4).



Source: Own calculations.

Note: Quarterly data. QPM impulse response functions differ from what was published in Grui and Vdovychenko (2019) due to a slightly updated model structure and revised coefficients.

Figure 1. Impulse Response Functions to a Monetary Policy Shock – Results from Semi-Structural Models

Most of the simulations are qualitatively similar to each other. Tightened monetary policy leads to a nominal appreciation that troughs in the second or the third quarter. Output reaches its bottom in the period from the second to the fifth quarter, with the QPM indicating the fourth quarter after the interest rate increase. In most cases, the maximum effect on inflation occurs in the fourth quarter of the simulation.

The QPM and the QPMfx produce quantitatively similar simulations of the nominal exchange rate. Both are for the two years between the two simulations created with the QPMmp. The QPMfx output gap is also in between the two QPMmp output gaps for the whole duration of the simulation. However, the QPM-generated output gap displays a more pronounced response in the first year. This reflects the expert judgment about a more substantial monetary policy influence on the real economy than historically.

According to the QPMmp, inflation temporarily increases after the contractionary policy shock. This is due to the biased inflation expectations generated by imperfect policy credibility. Moreover, the consequent inflation decrease is not pronounced, which is consistent with biased inflation expectations. Most of the effect comes from the initially low level of credibility, which is further held back by the policy shock. Responses with the QPM and the QPMfx have a larger magnitude, and are close to the QPMmp's mirrored response to an expansionary policy shock.

2.1.3. The Role of Foreign Exchange Interventions

According to the Monetary Policy Strategy of the NBU (NBU, 2018), the bank uses foreign exchange interventions as an additional monetary policy instrument. The NBU intervenes in the foreign exchange market to accumulate international reserves, smooth hryvnia exchange rate volatility, and support the transmission of the key policy interest rate. This subsection considers the stabilization effect of the interventions on the main macroeconomic variables.

Moderate exchange rate management is effective in a small open economy with a high exchange rate pass-through and imperfectly anchored inflation expectations. It helps stabilize inflation and allows for less aggressive policy interest rate movements. Strong exchange rate management can increase these volatilities. However, the volatility of the output gap demonstrates almost no variation in response to various degrees of exchange rate management.

Table 3 presents simulated unconditional standard deviations of the main macroeconomic variables. They were obtained using the QPMfx model for four degrees of exchange rate management (pure floating, moderate management, strong management, and pegged exchange rate). Stronger management makes the exchange rate less volatile at the cost of heavier interventions.

The degrees of management are differentiated by the form of UIP equation. Pure UIP is associated with no foreign exchange interventions and a purely floating hryvnia. Moderate management introduces a backward-looking component to the UIP equation. Its weight is estimated according to the 2015-2020:Q1 historical period, which is consistent with the actual interventions of that time by the NBU. Strong management increases the weight of the backward-looking component. A very high weight effectively reduces the equation to a random walk (with drift), interpreted as a pegged exchange rate. All other coefficients of the model for the purposes of simulations are kept constant as they were estimated according to 2015-2020:Q1 data.

Table 3. Unconditional Standard Deviations of Main Macroeconomic Variables

	Nominal exchange rate, q-o-q	Interventions	Output gap	Inflation, q-o-q	Policy interest rate
Pure floating	1.32	0.00	1.00	1.07	1.16
Moderate management	1.00	1.00	1.00	1.00	1.00
Strong management	0.64	1.16	1.00	1.08	1.32
Pegged exchange rate	0.01	1.24	0.99	1.22	2.01

Source: Grui (2020).

Note: Values are normalized to the baseline case of moderate management.

The effect of interventions on inflation volatility is U-shaped. Moderate exchange rate management helps stabilize inflation, while strong management or even a pegged exchange rate can make it more volatile. A similar and more pronounced effect is observed for the policy interest rate. A heavily managed exchange rate can deprive monetary policy of a critical transmission channel.

The output gap shows almost no reaction to exchange rate management regimes changes. Heavier interventions do not help stabilize the real economy.

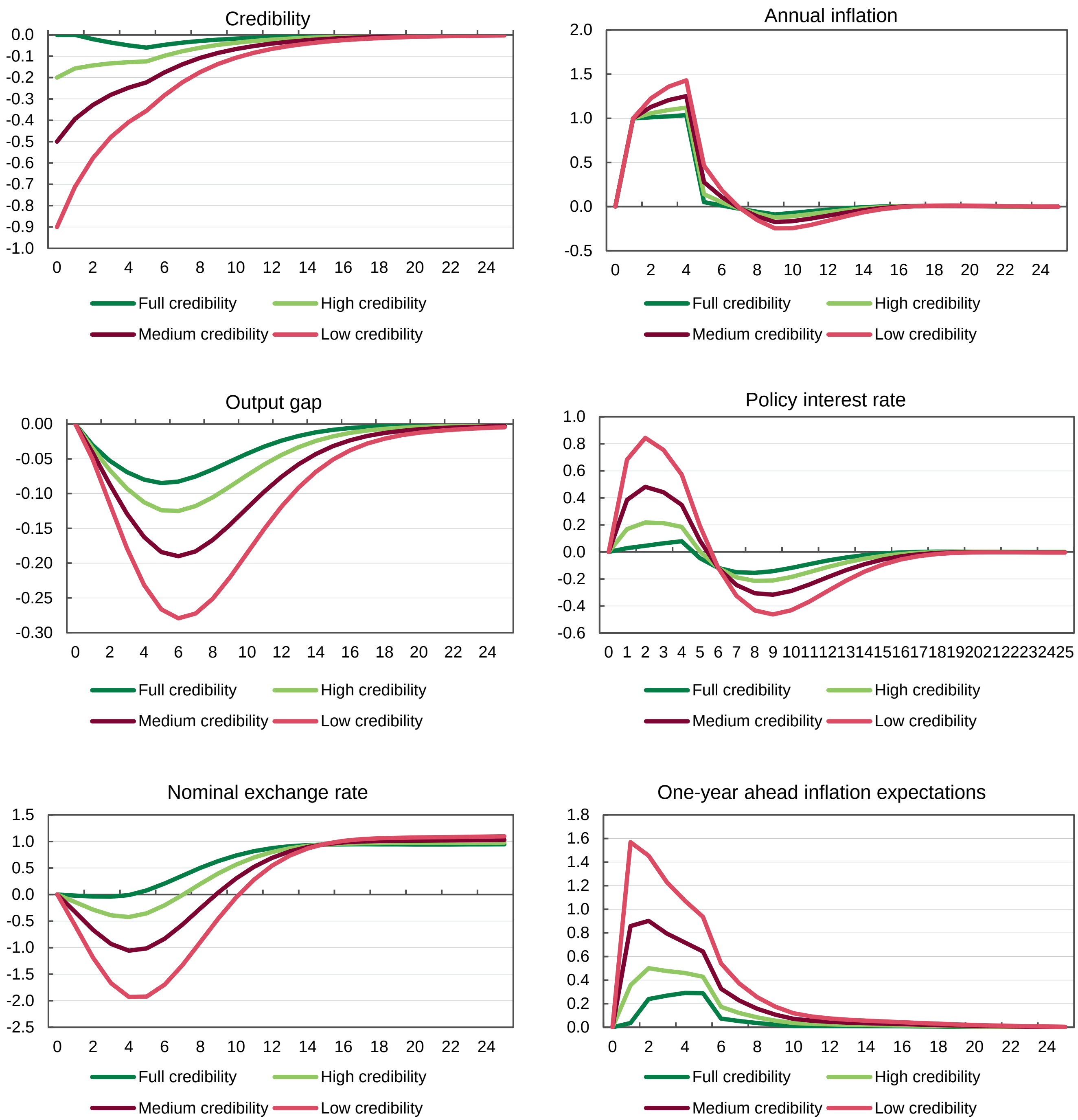
2.1.4. The Role of Monetary Policy Credibility

Monetary policy credibility is indispensable for a central bank that aims to anchor inflation expectations. It helps stabilize the economy after shocks, and promotes monetary policy transmission. This subsection describes the role of credibility in stabilizing inflation.

The QPMmp models credibility as an endogenous index that fluctuates between zero and one, where one indicates perfect credibility and unbiased inflation expectations. Credibility is gained when inflation is close to the target or is rationally expected to be close to the target in the future. It is lost otherwise. Above-target inflation leads to greater losses of credibility than below-target.

Credibility determines the degree of inflation expectations anchoring to the pre-announced target – it influences the size of the coefficient in front of the target in an inflation expectations equation. Furthermore, low credibility generates a persistent positive inflation expectations bias, which puts additional pressure on inflation.

Figure 2 shows impulse response functions to a supply shock across various levels of credibility. All responses are normalized to have the same inflation reaction in the first period.



Source: Savolchuk and Grui (2022), own calculations.

Note: Quarterly data.

Figure 2. Impulse Response Functions to a Supply Shock – Results from the QPMmp

High credibility allows the central bank not to overreact to the shock. Inflation expectations remain fairly anchored as agents have trust in the central bank's ability to manage inflation. Economic activity slowdown is limited. The policy interest rate soon decreases, and the nominal exchange rate depreciates.

Less favorable initial credibility creates a positive bias in expectations, which transmits into higher inflation. The central bank is forced to react more aggressively to bring inflation back to the target and avoid further credibility loss. A more pronounced policy response dampens demand and temporarily appreciates the nominal exchange rate.

2.2. Interest Rate Transmission

This section presents results for the pass-through from the NBU policy rate to interest rates in hryvnia. We assess the transmission to the interbank credit market, retail banking – both for households and non-financial corporations – and to government bond yields on the secondary market. Furthermore, we differentiate between interest rates for loans depending on firm size and the ownership of bank capital.

We use the Autoregressive Distributed Lag (ARDL) model, following Pesaran and Shin (1999), to study the transmission from the NBU policy rate to market interest rates. The ARDL model tests relationships in a single equation for time series data and allows for reparameterization as an error correction model (ECM) to test for cointegration. The estimated model is the following.

$$\Delta y_t = c_0 + \alpha(y_{t-1} - \theta x_{t-1}) + \sum_{i=1}^{p-1} \psi_{y_i} \Delta y_{t-i} + \sum_{i=0}^{q-1} \psi_{x_i} \Delta x_{t-i} + \epsilon_t \qquad (1)$$

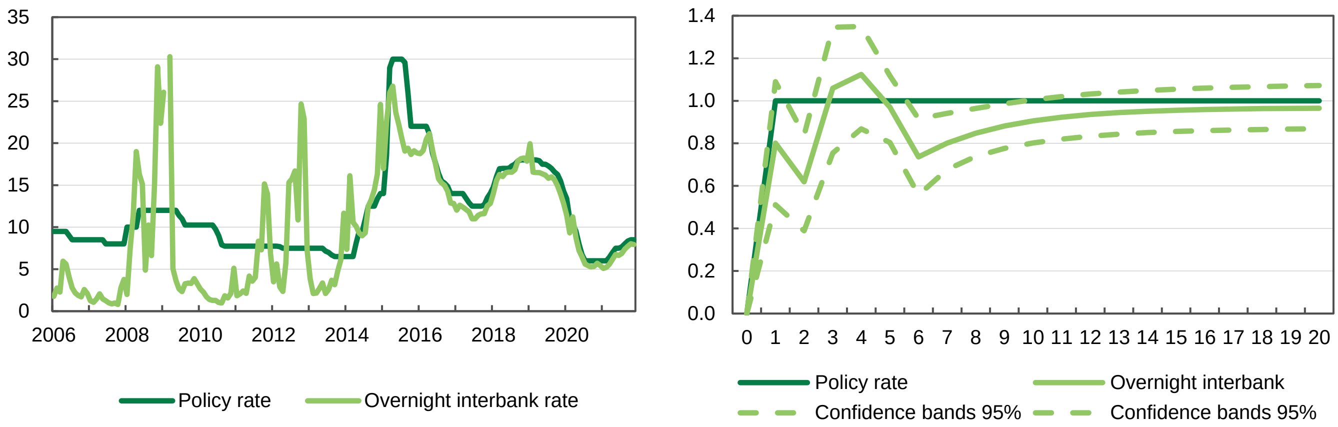
Here y_t represents the dependent variable, and x_t the explanatory variable. As can be seen, it allows an arbitrary structure of lags that is selected optimally. The long-term coefficient is θ, and α is the error correction parameter. The specification allows for a constant term, c_0. The short-term coefficients are given by ψ. To choose the optimal number of lags, we use the Bayesian Information Criterion.

Using the model, we build Impulse Response Function graphs and corresponding 95% confidence bands to investigate transmission dynamics in different markets.

2.2.1. Transmission to the Interbank Credit Market

The policy rate is highly correlated with overnight interbank rates in hryvnia, even though there are short-term deviations, as shown in Figure 3. These deviations are particularly notable in the earlier part of the sample. The series are cointegrated, i.e., they have a long-term relationship. The money markets have been adjusting to the NBU policy rate since the adoption of inflation targeting in 2015, when interbank rates became an operational target of the NBU's monetary policy. A Wald test finds a structural break in the behavior of spreads after 2015. The short-term interest rate became the main monetary policy instrument of the NBU only in 2015. No important market operations were tied to a specific rate before that time. These economic and statistical factors lead to the necessity to split the sample before and after 2015 for further analysis.

Note that the pre-inflation targeting sample is shown only for illustrational purposes. Only the 2015-2021 sample is examined in this section.



Source: NBU's own estimations.

Note: Monthly data; impulse response is for 2015-2021.

Figure 3. Policy Rate and Interbank Overnight Interest Rate

The estimated coefficients from the model are given in Table 4. Over the long term, there is full transmission after 2015, which is indicated by the long-term coefficient's statistically insignificant difference from one. The error adjustment coefficient suggests that some portion of the long-term deviation is wiped out after each month. The impulse response indicates that after 2015, the interbank rate quickly converges to the NBU policy rate to attain full transmission after several months. This comes from the nature of the cointegration between rates. The overnight rate is tightly bounded by the NBU thanks to the monetary policy's operational design.

The long-term coefficient before 2014 is not statistically different from either one or zero. We interpret it as no full transmission.

Table 4. Policy Rate and Interbank Overnight Interest Rate

	Until 2014	Since 2015
1-month response	0.38	0.83
	(0.31)	(0.18)
Error correction	-0.23	-0.28
	(0.06)	(0.05)
Long-term	1.63	0.96
	(1.42)	(0.05)
Full transmission?	No	Yes

Source: NBU, own estimations.

Note: Standard errors in parenthesis.

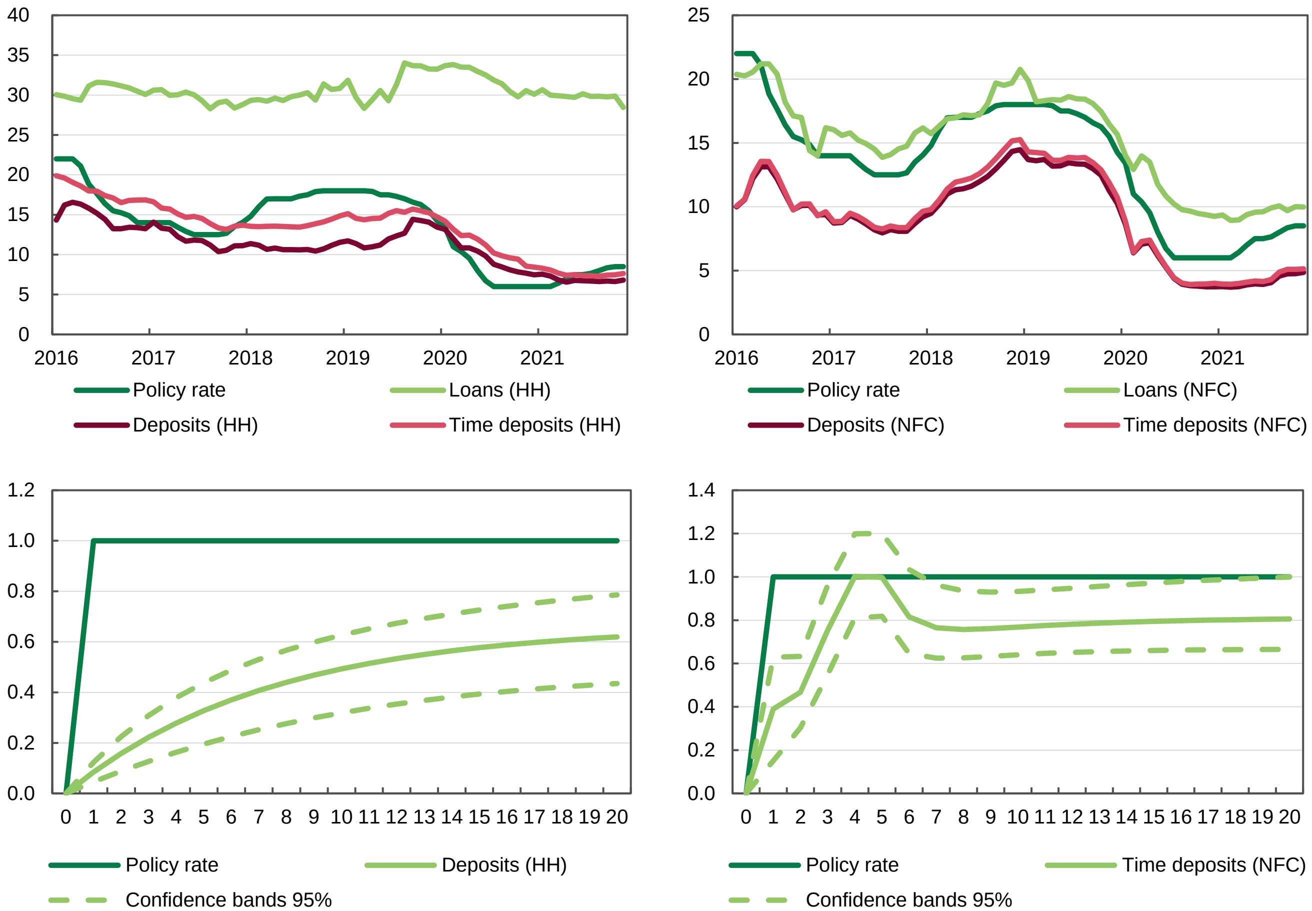
2.2.2. Transmission to Retail Banking Rates

This subsection analyzes the transmission from the policy rate to retail rates in commercial banks. We pay attention to the differences between the household (HH) and nonfinancial corporation (NFC) rates.

A visual inspection of Figure 4 suggests that the rate in domestic currency that households obtain on loans does not co-move with the policy rate and stays reasonably constant over the sample period. This reflects a low share of mortgages, a high risk perception of consumer loans, and other non-price factors. A cointegration test shows that this series is not cointegrated with the policy or overnight interbank rates. Thus, household loans are omitted from further analyses.

The rates on deposits and time deposits for households do indeed co-move with the policy interest rate, and the respective error correction coefficients are statistically significant (Table 5). However, the long-term coefficients for household deposits show that the transmission is incomplete. It might be impeded by high market concentration (see section 1.2.1.).

Transmission to time deposit rates for non-financial corporations (NFCs) is more robust. Despite the coefficient being less than 1, transmission is full, with 95% confidence bands. However, there is a significant negative spread with the policy rate.



Source: NBU, own estimations.

Note: Monthly data.

Figure 4. Policy Rate and Retail Banking Rates for Households and non-Financial Corporations

Transmission to the rates on loans to NFCs is incomplete, and is mainly due to loans to large corporations (see section 2.2.3.). The relatively high share of NPLs and low lending overall ensures that loans are issued to the most trustworthy NFCs with low risk premia. Moreover, firms mostly take short-term loans for operational activities, the interest rates of which are better correlated with the policy rate (see section 1.2.1.).

Table 5. Policy Rate and Retail Banking Interest Rates ECM Coefficients

	Households		Nonfinancial corporations		
	Deposits	Time deposits	Deposits	Time deposits	Loans
1-month response	0.07	0.06	0.36	0.4	0.14
	(0.05)	(0.02)	(0.14)	(0.15)	(0.04)
Error correction	-0.11	-0.09	-0.11	-0.11	-0.21
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
Long-term	0.7	0.69	0.78	0.8	0.68
	(0.08)	(0.1)	(0.08)	(0.09)	(0.06)
Full transmission?	No	No	No	Yes	No

Source: Own estimations.

Note: Standard errors in parenthesis.

2.2.3. Transmission to Corporate Loan Rates Depending on the Size of the Corporation

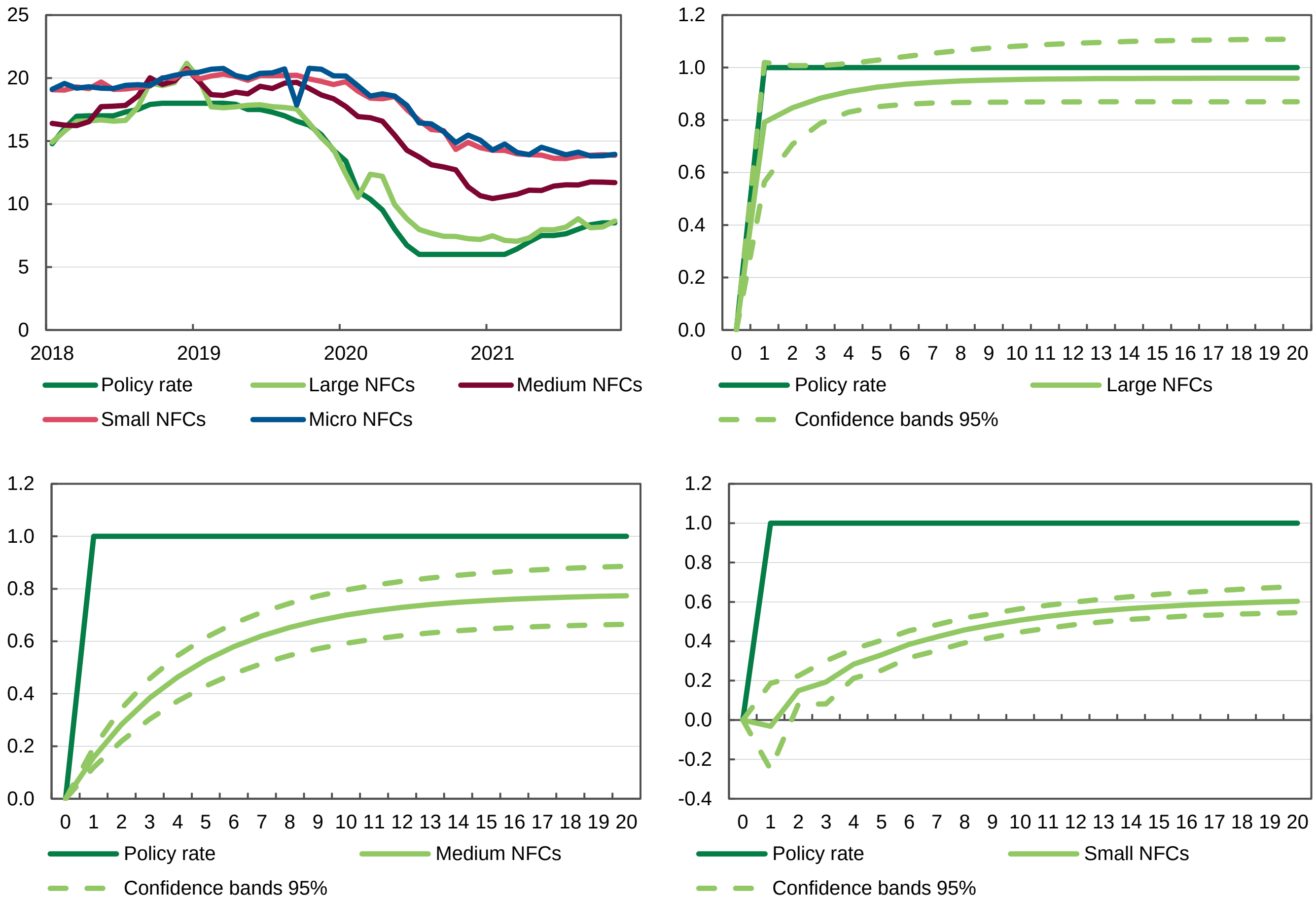
Figure 5 shows interest rates on loans to non-financial corporations split by their sizes. A larger size grants more robust transmission and lowers spreads over the policy rate (Table 6). Large firms get their funding practically at the policy rate. In contrast, transmission for smaller firms is incomplete.

Table 6. Policy Rate and Corporate Loan Rates Depending on Corporation Size ECM Coefficients

	Large NFCs	Medium NFCs	Small NFCs	Micro NFCs
1-month response	0.79	0.15	-0.03	-0.08
	(0.12)	(0.02)	(0.14)	(0.16)
Error correction	-0.46	-0.2	-0.26	-0.3
	(0.1)	(0.03)	(0.04)	(0.05)
Long term	0.96	0.77	0.61	0.63
	(0.04)	(0.06)	(0.04)	(0.06)
Full transmission?	Yes	No	No	No

Source: Own estimations.

Note: Standard errors in parenthesis.



Source: NBU, own estimations.

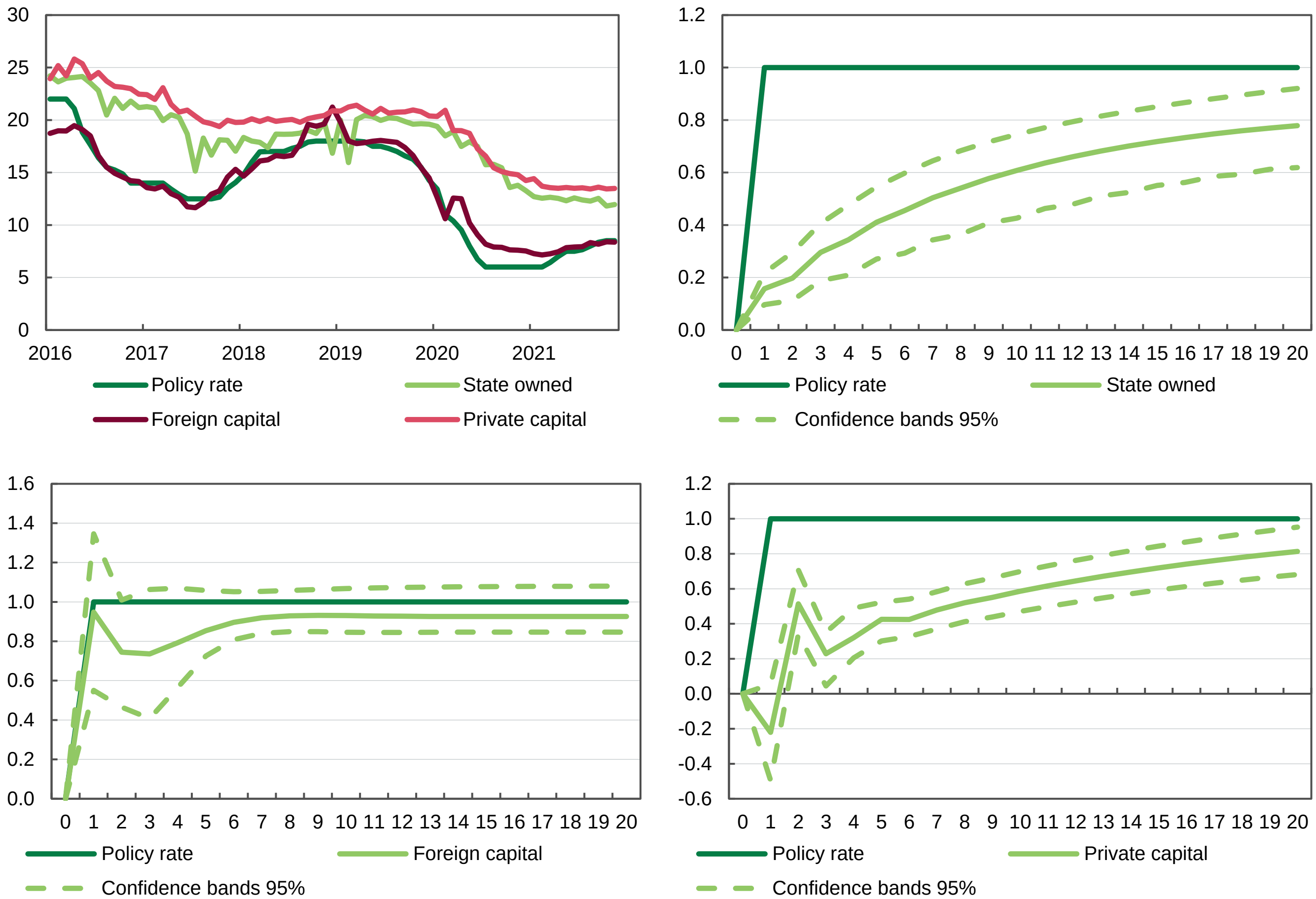
Note: Monthly data.

Figure 5. Policy Rate and Corporate Loan Rates Depending on the Size of the Corporation

2.2.4. Transmission to Corporate Loan Rates Depending on Bank Capital Ownership

Figure 6 shows rates on corporate loans decomposed by types of bank capital. Banks deemed to have state capital are those that are over 75% directly or indirectly controlled by the state. PrivatBank is excluded from the analysis as it changed ownership at the end of 2016 and exhibited non-market interest rates during those times. Banks with foreign capital are those whose controlling stakes belong to a foreign bank or banking group. We exclude banks with russian capital. Private capital banks are those in which the ultimate owners of at least 50% of the authorized capital are resident private investors.

Long-term transmission is partial for banks with majority state capital and for private banks (Table 7). On the other hand, transmission is full for foreign-capital banks, which show an almost instant reaction to changes in the policy rate. Foreign banks mostly credit large NFCs, rather than small firms or households.



Source: NBU, own estimations.

Note: Monthly data.

Figure 6. Policy Rate and Corporate Loan Rates Depending on Bank Capital Ownership

Table 7. Corporate Loan Rates Depending on Bank Capital Ownership ECM Coefficients

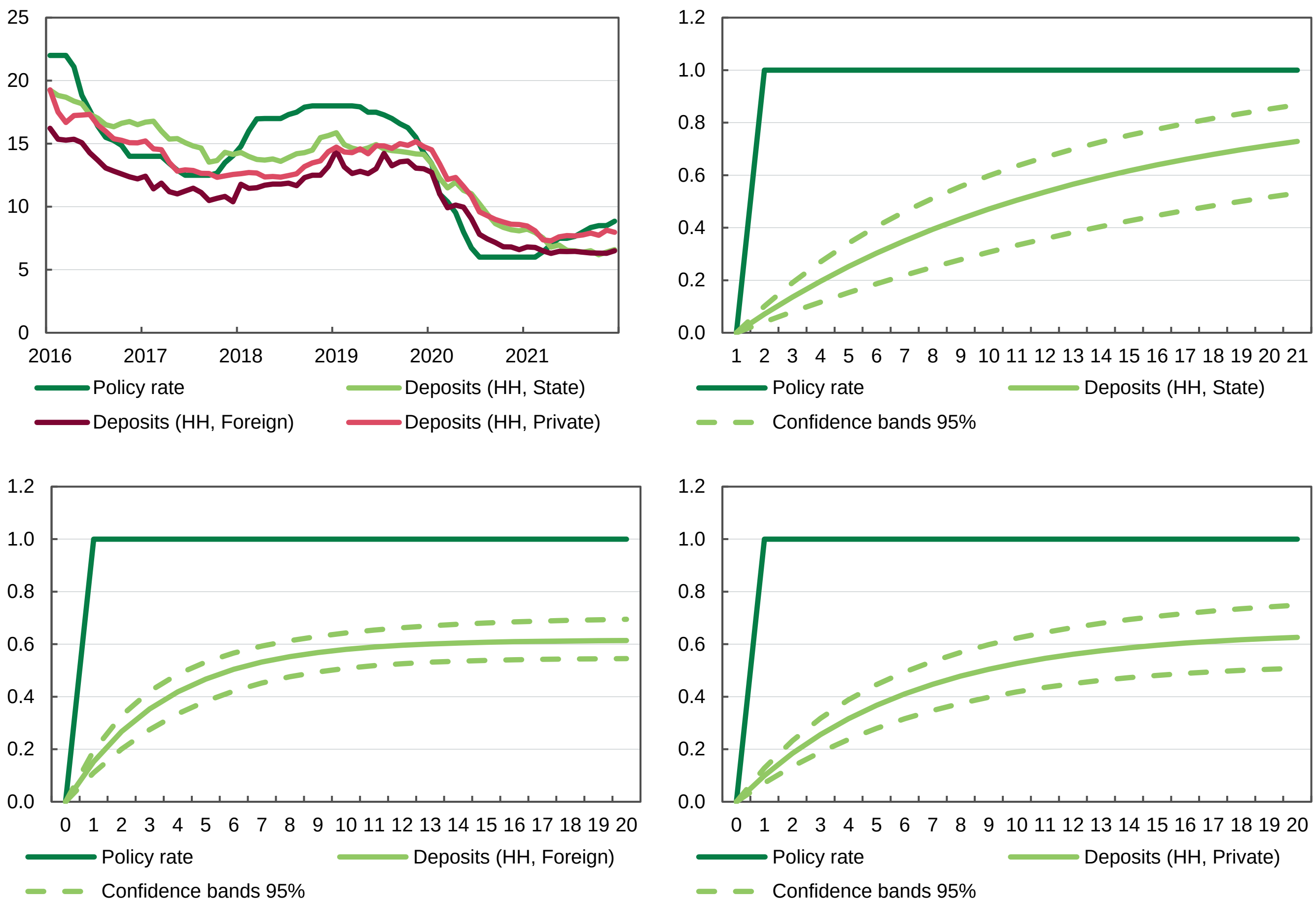
	State capital	Private capital	Foreign capital
1-month response	0.15	-0.22	0.94
	(0.03)	(0.14)	(0.2)
Error correction	-0.18	-0.12	-0.31
	(0.03)	(0.02)	(0.06)
Long-term	0.85	1.03	0.92
	(0.09)	(0.12)	(0.04)
Full transmission?	Yes	Yes	Yes

Source: Own estimations.

Note: Standard errors in parenthesis.

2.2.5. Transmission to Household Deposit Rates Depending on Bank Capital Ownership

The dynamics of deposit rates for households differ according to the bank capital's source. Most foreign banks have additional space to keep the rate lower than state or private banks due to their higher credibility among consumers. This translates to only partial transmission of monetary policy shocks, as shown in Figure 7.



Source: NBU, own estimations.

Note: Monthly data.

Figure 7. Policy Rate and Household Deposit Rates Depending on Bank Capital Ownership

Table 8. Household Deposit Rates Depending on Bank Capital Ownership ECM Coefficients

	State capital	Private capital	Foreign capital
1-month response	0.07	0.10	0.15
	(0.02)	(0.02)	(0.02)
Error correction	-0.08	-0.15	-0.25
	(0.01)	(0.02)	(0.04)
Long-term	0.91	0.65	0.62
	(0.12)	(0.08)	(0.04)
Full transmission?	Yes	No	No

Source: Own estimations.

Note: Standard errors in parenthesis.

2.2.6. Transmission to Yields on Government Bonds on the Secondary Market

Figure 8 depicts yields on government bonds with various maturities on the secondary market. Visual inspection indicates sound transmission from the policy interest rate since 2016, which worsened in 2020, when the interest rate was particularly low. This resulted from a disbalance in demand/supply due to high risk perceptions by domestic and foreign investors. Moreover, we can see spikes corresponding to the beginnings of crises, such as the COVID-19 at the beginning of 2020.

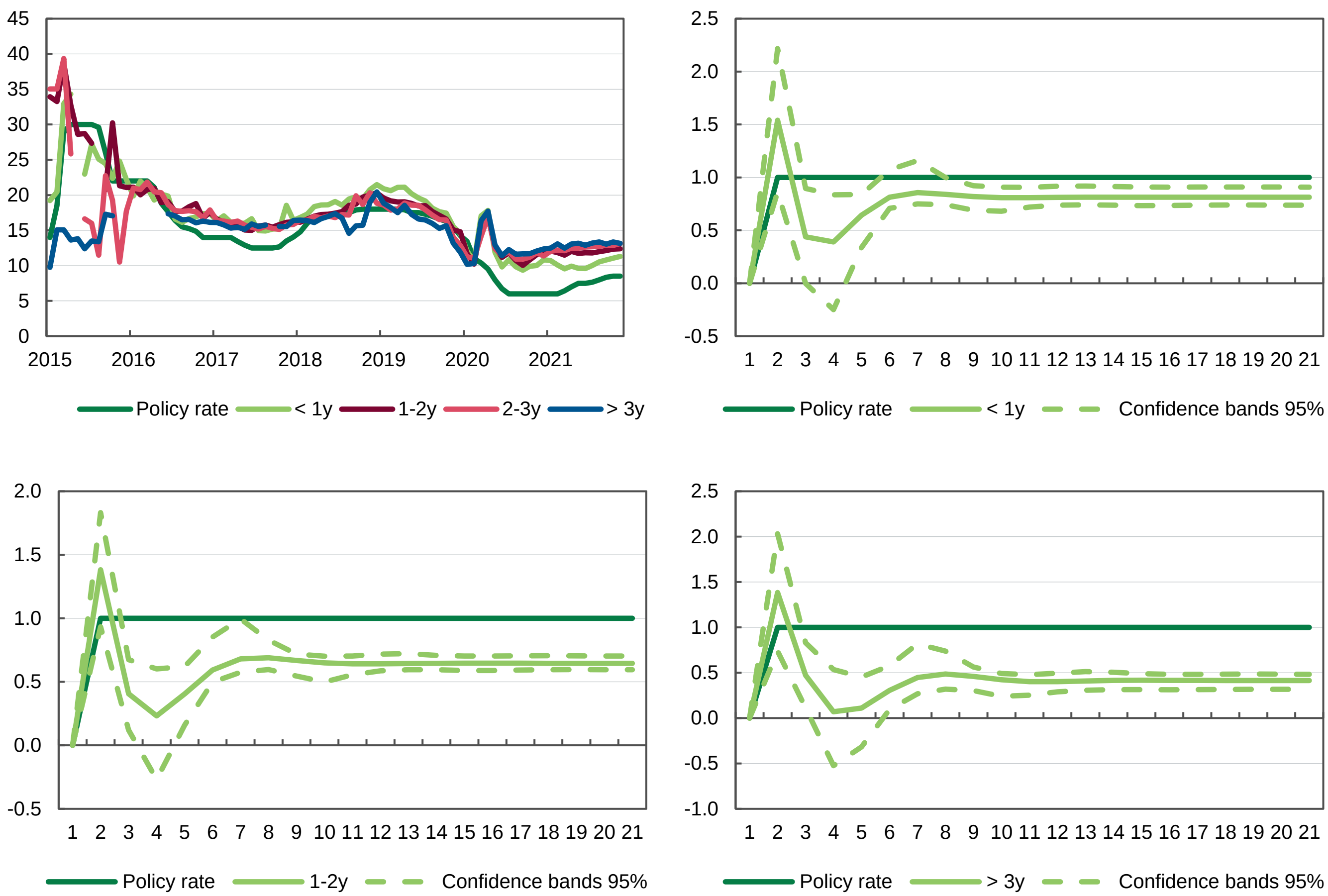
Table 9 presents formal econometric estimations. The transmission is close to being full for bonds with maturities of less than one year. The rates for bonds with longer maturities demonstrate weaker transmission, as longer maturities are influenced mainly by inflation expectations and monetary policy credibility. The estimations were conducted on the sample since 2016.

Table 9. Policy Rate and Yields on Government Bonds

	< 1 y	1-2 y	2-3 y	> 3 y
1-month response	1.54	1.38	1.13	1.38
	(0.41)	(0.27)	(0.37)	(0.39)
Error correction	-0.63	-0.55	-0.57	-0.59
	(0.11)	(0.10)	(0.13)	(0.11)
Long-term	0.81	0.65	0.58	0.41
	(0.05)	(0.03)	(0.04)	(0.04)
Full transmission?	No	No	No	No

Source: Own estimations.

Note: Standard errors in parenthesis.



Source: NBU, own estimations.

Note: Monthly data.

Figure 8. Policy Rate and Yields on Government Bonds

2.3. Exchange Rate Transmission

This subsection analyzes how the exchange rate impacts exports and imports, and its pass-through to consumer prices.

2.3.1. Impact of the Exchange Rate on the Real Economy

Real effective exchange rate (REER) movements can be caused by various shocks with varied outcomes for the trade balance. Therefore, REER elasticities for exports and imports are shock-dependent. This section follows Arias et al. (2018), imposing a structure on the shocks with a SVAR model with zero and sign restrictions.

To obtain the REER elasticities of exports and imports, we run a BVAR with sign and zero restrictions using quarterly data between 2003 and 2020. The model contains seven variables: logs of real exports, imports and GDP, REER, the short-term interbank interest rate, the real GDP index of trading partners, and the commodity terms of trade index.

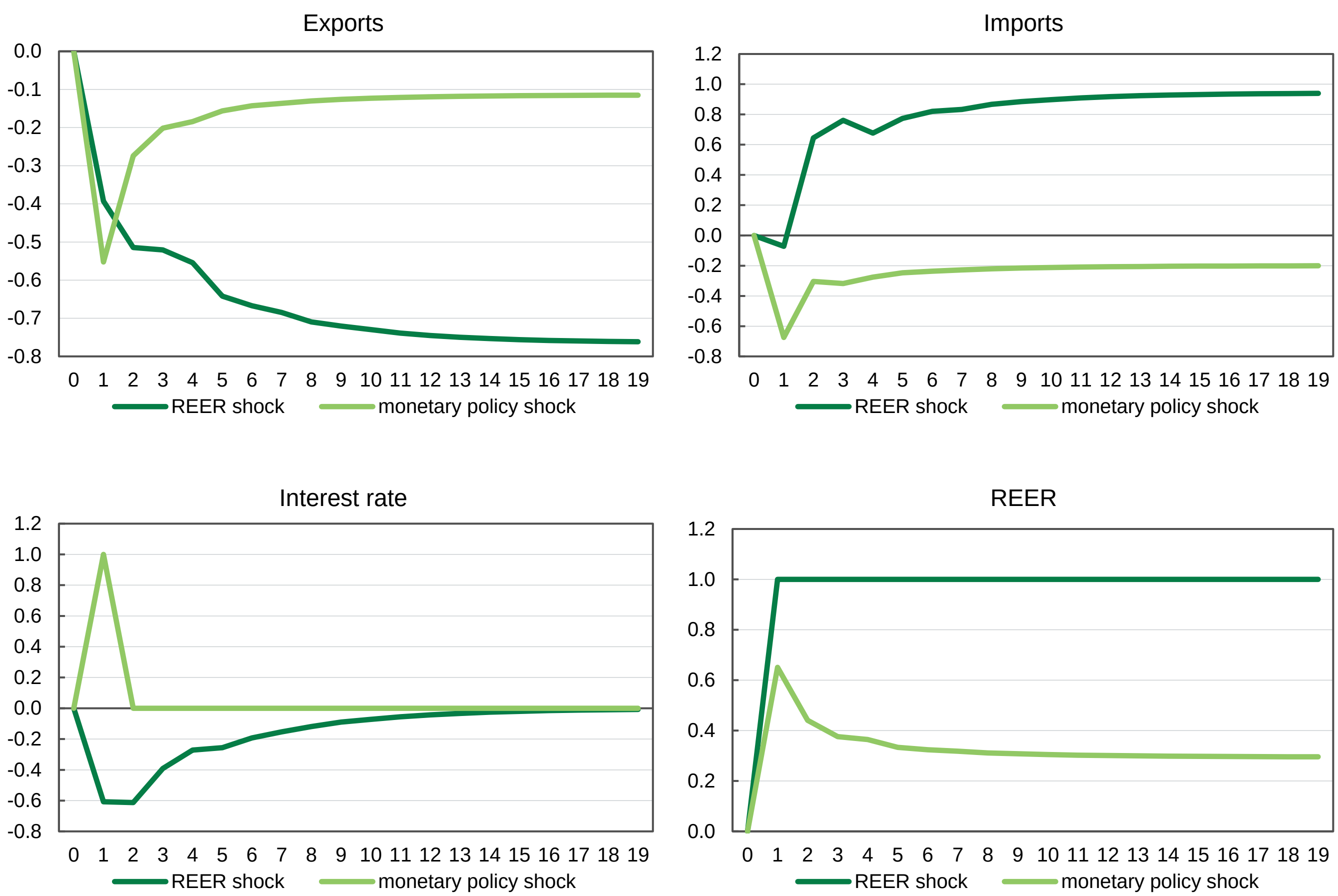
Exports and imports were taken in real terms, as provided by the State Statistics Service of Ukraine (SSSU). The commodity terms of trade index was calculated on the basis of NBU data on the structure of Ukraine's exports and imports and the dynamics of the prices for the relevant commodities.

The short-term interbank interest rate was introduced into the model as a proxy for the monetary policy stance. It has been greatly influenced by the key policy rate of the NBU since the adoption of the inflation targeting regime in 2015. Before that, the interbank interest rate was shaped by the monetary aggregate targeting policy and unsterilized FX interventions by the NBU.

Commodity terms of trade and the GDP developments of Ukraine's trading partners cannot be considered fully endogenous variables. We applied block exogeneity restrictions. The global economy and external markets impact the Ukrainian economy, but there are no effects in the opposite direction.

We estimated the model with four lags, where all variables except the interest rate were transformed into quarterly log differences. The BVAR was estimated by imposing the independent Normal Inverse Wishart prior. Structural shocks were identified according to Rubio-Ramírez et al. (2010) and Arias et al. (2018). Sign and zero restrictions were imposed on IRFs at impact, identifying the shocks of domestic supply, domestic demand, REER, monetary policy, world demand, and commodities terms of trade. Zero restrictions in our specification were applied to isolate the reaction of world GDP and commodities terms of trade from the impact of internal shocks on the Ukrainian economy. A detailed methodology and a literature review are available in Annex A.

Figure 9 illustrates the cumulative impulse response functions of real exports and imports to the monetary policy and REER shocks. The cumulative responses were divided by cumulative responses of the policy interest rate and the REER, respectively. Therefore, the values at the end of the responses can be interpreted as long-term elasticities.



Source: Own estimations.

Note: Quarterly data.

Figure 9. Cumulative Responses of Export and Import Growth to 1% REER Appreciation and a 1 p.p. Increase to the Interest Rate

On a 5-year horizon, export and import elasticities to REER are -0.76 and 0.94, respectively. The estimated elasticity of exports is relatively close to that obtained in Bussière et al. (2010) (-0.75) but differs from the result of Isard and Faruqee (1998) for emerging markets (-0.53). The REER elasticity of imports in our results is approximately 0.96 against 0.53 in Bussière et al. (2010) and 0.69 in Isard and Faruqee (1998).

Reacting to a 1% appreciation of the REER, exports gradually decline to reach a magnitude of minus 0.76% in the long term. This reaction reflects the loss of price competitiveness by exporters. REER appreciation boosts imports as it makes relative prices more favorable for importers.

Imports react with a lag because of the depressing impact of REER appreciation on overall economic activity.

A monetary policy shock reduces domestic demand in an economy and appreciates REER via the UIP condition. Exports react negatively because of real appreciation. Imports go down because of the drop in domestic demand and exports. A significant share of imports is used as an input for producing exports. Therefore, a reduction in the latter reduces demand for the former.

Table A. 3 in Annex A presents the forecast error variance decomposition of endogenous variables included in BVAR. The analysis says that REER and monetary policy shocks play a minor role in the developments of exports and imports. At the same time, about one-third of the export and import forecast error variances are explained by global environment shocks (world demand and commodities terms of trade shocks). An even stronger result is seen for real GDP, where about half of the forecast error variance is explained by global shocks.

2.3.2. Exchange Rate Pass-Through to Consumer Prices

This section investigates the exchange rate pass-through (ERPT) mechanism, which is particularly important for monetary policymaking in a small open economy. On the one hand, flexible exchange rates are supposed to insulate the real economy from adverse external shocks and allow an independent monetary policy to be conducted. On the other hand, if the risks associated with exchange rate volatility remain high, a central bank’s goal of price stability might be threatened.

The literature on ERPT to consumer prices in advanced and emerging economies is rich and comprehensive. Many studies provide ERPT estimates for different countries and find that ERPT is heavily heterogeneous across economies (e.g., McCarthy, 2007; Campa and Goldberg, 2005). There is also strong evidence that domestic prices respond asymmetrically to depreciations and appreciations (e.g., Pollard and Coughlin, 2004). Moreover, exchange rate pass-through might be nonlinear with respect to the size of exchange rate changes, the inflation environment, business cycle, and exchange rate volatility (e.g., Taylor, 2000; Bailliu and Fujii, 2004; Goldfajn and Werlang, 2000). While these studies customarily defined ERPT as the effect of a single exchange rate shock on prices, recent research also finds that the relationship between exchange rate changes and inflation may depend on the composition of the shocks to an economy (e.g. Comunale and Kunovac, 2017).

Several studies provide ERPT estimates for Ukraine over different samples, employing a range of analytical frameworks. Korhonen and Wachtel (2006) study ERPT to consumer prices in CIS countries. The authors use the VAR approach and impulse response analysis, and estimate ERPT to consumer prices in Ukraine at a level of 0.63-0.64. Compared to other CIS countries, the results for Ukraine are relatively high. Following a similar approach, Beckmann and Fidrmuc (2013) provide ERPT estimates for seven CIS countries and confirm the results of a high level of pass-through in Ukraine. They extend their analysis to measure the U.S. dollar and Euro ERPT separately, and find that Ukrainian prices are much more sensitive to the U.S. dollar exchange rate changes (0.45) than to that of the Euro (0.25). Novikova and Volkov (2012) employ a VEC framework and find that long-run ERPT to core inflation in Ukraine is at a level of 0.35-0.47. Faryna (2016) estimates nonlinear ERPT using an ARDL model and finds that consumer prices in Ukraine are mainly sensitive to large depreciations (0.2-0.4), while being statistically insignificant for small depreciations and appreciations. Moreover, ERPT increases when there is a high inflation environment and an economic slump.

This section aims at estimating the exchange rate pass-through to consumer prices in Ukraine, taking into account potential nonlinearities concerning the size and direction of exchange rate changes. The ERPT herein is defined as the percentage change in consumer price levels following a 1% shock to exchange rate. First, we estimate a battery of short-term inflation equations that include alternate control variables and different inflation and exchange rate lag lengths. We compute a median dynamic ERPT from the distribution of estimated coefficients. Second, a linear ERPT is estimated over an entire sample (i.e., 2014:M1-2021:M4) and in a rolling four-year window to explore the stability of estimated coefficients over time. Lastly, in a similar fashion, we estimate inflation equations, distinguishing between appreciations, moderate depreciations, and big depreciations (above 10% quarterly).

The results are as follows. First, we find that ERPT in Ukraine was high throughout the currency crisis in 2014-15 and amounted to about 0.5-0.6. This period can also be characterized by a high inflation environment, economic slump, and considerable exchange rate variability. However, ERPT declined substantially and amounted to about 0.3 over a period of moderate exchange rate fluctuations. Moreover, controlling for the size and direction of exchange rate changes, we find that ERPT in Ukraine is asymmetric and nonlinear. In particular, ERPT from a moderate depreciation is twice as high as from appreciation (0.2 versus 0.1), while big depreciations of over 10% pass-through to prices with a rate of 0.55.

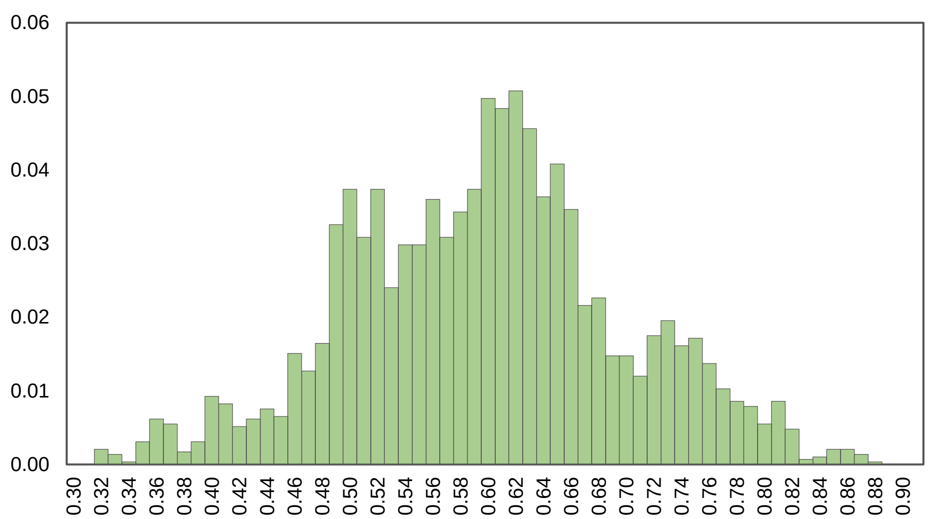
Our analytical framework follows the well-recognized “pricing-to-market” approach (see Dornbusch, 1987; Krugman, 1986). It estimates short-term inflation equations via an Autoregressive Distributed Lag Model (ARDL) of the following form:

$$\Delta p_t = c + \Gamma \sum_{i=1}^{p} \Delta p_{t-i} + \Theta \sum_{j=0}^{q} \Delta x_{t-j} + \Phi Controls_t + e_t \qquad (2)$$

where Δp_t stands for log differences of CPI; Γ – a vector of autoregressive coefficients; Δx_{t-j} – log differences of the exchange rate (hryvnias per US dollar) with corresponding coefficients in vector Θ; $Controls_t$ – control variables including demand conditions (real wage index, trade turnover, consumer confidence index), commodity prices (IMF commodity price index), and foreign inflation (derived from the real and nominal effective exchange rate series); Φ – is a matrix of coefficients for control variables.

Our sample includes monthly data over the period from 2014:M1 to 2021:M4 (88 observations). All time series are seasonally adjusted using the X-11 method. Due to the limited number of observations, we estimate a battery of model specifications that include alternate measures of control variables (quarterly and semi-annual log differences at time t and t-1, and HP filtered series with lambda 2 and 4 at time t and t-1). The lag length of inflation and exchange rate is chosen according to SIC, which has a higher penalty for including insignificant lags than AIC. We limit the number of lags for inflation (p) and exchange rate (q) to 4 months. Nonetheless, instead of choosing a single best specification, we estimated four models with the lowest SIC to explore the sensitivity to lag exclusion. In total, we estimated about 3,000 models and computed ERPT as a dynamic multiplier that includes both the exchange rate and persistence coefficients.

Figure 10 shows the distribution of the estimated linear ERPT coefficients. The median ERPT is about 0.6, varying from 0.3 to 0.9. These numbers are somewhat higher compared to the latest estimates in Faryna (2016). However, it should be noted that our results are based on seasonally adjusted data and different estimation samples. If the seasonally unadjusted exchange rate is used, the median ERPT falls to 0.3-0.4, depending on the sample. This result corresponds to the existing findings in the literature.



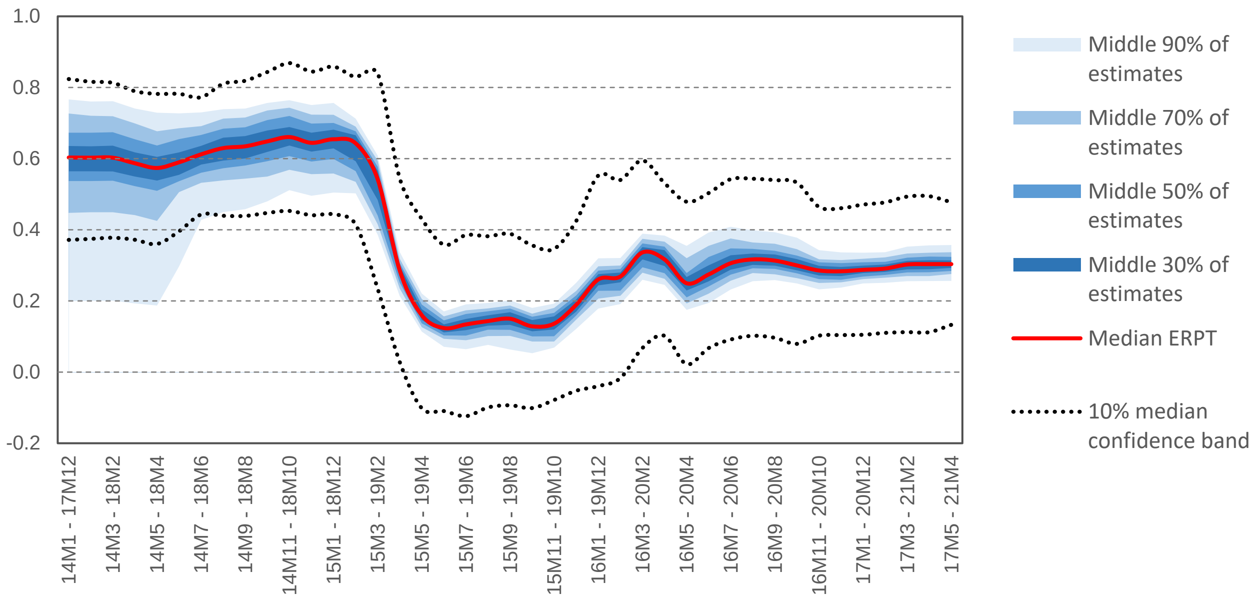
Source: Own estimations.

Figure 10. Distribution of Estimated Exchange Rate Pass-Through Coefficients

To explore whether ERPT has changed over time, we simulated a battery of models over a four-year rolling window. We computed a rolling median ERPT dynamic coefficient and a rolling median 90% confidence band based on the estimated standard errors, similar to the previous exercise.

The results show that ERPT reduced substantially from 0.6 to 0.3 after the period of a currency crisis in Ukraine (see Figure 11).

Noteworthy, the reduction in ERPT coincides with the introduction of the inflation targeting framework. Although our analysis does not take it into account explicitly, there is strong evidence in the literature that ERPT decreases after the adoption of inflation targeting, which might be explained by the improvement of central bank credibility and anchoring inflation expectations (see, for example, Nogueira, 2006).



Source: Own estimations.

Note: Monthly data.

Figure 11. Time-Varying Exchange Rate Pass-Through

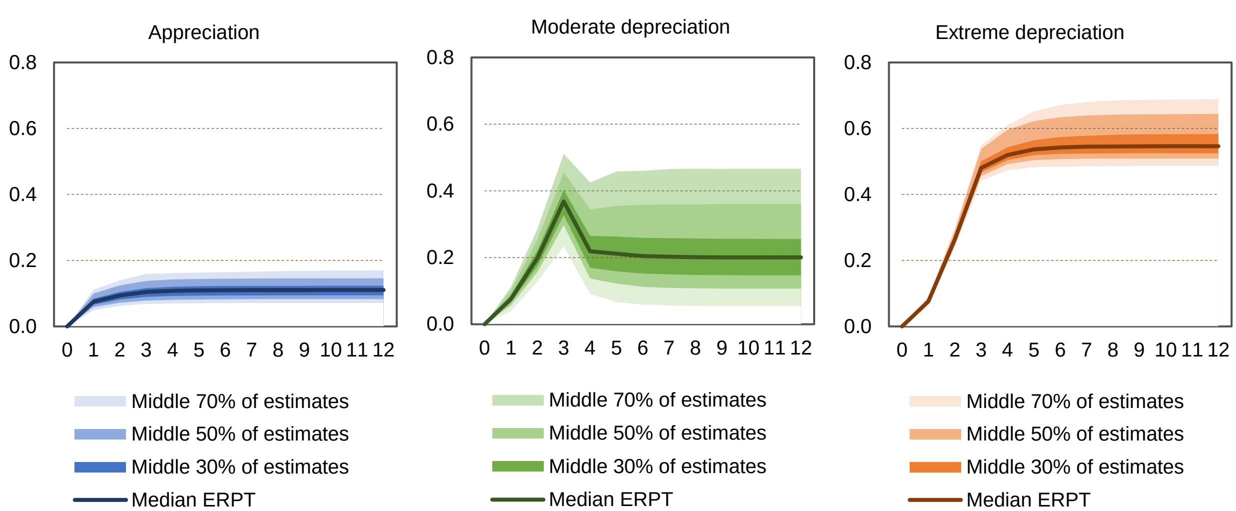
We then compared how the rolling ERPT coefficients were associated with the specific characteristics of corresponding periods (see Table 10). A simple correlation analysis indicates that higher ERPT estimates are observed in periods when there is a high inflation environment, economic slump, and considerable exchange rate variability. Moreover, ERPT increases if depreciations are more frequent than appreciations, and if exchange rate changes are large.

Considering the above-mentioned insights, we repeated the estimation of a battery of inflation equations, distinguishing between exchange rate changes of different sizes and directions. We divided the exchange rate series into quarterly appreciation and depreciation periods using dummy variables. After that, we divided the depreciation period into periods of moderate and extreme (above 10% monthly FX change) fluctuations. We computed ERPT coefficients for a battery of inflation equations as dynamic multipliers for each specific period, see Figure 12.

Table 10. Correlations Between ERPT Estimates and Specific Period Characteristics

		C0	C1	C2	C3	C4	C5	C6	C7	C8
Median ERPT	C0	1.00								
Mean monthly FX change	C1	0.81	1.00							
Mean monthly FX depreciation	C2	0.86	0.99	1.00						
Mean monthly FX appreciation	C3	0.85	0.82	0.85	1.00					
Standard deviation of FX changes	C4	0.91	0.95	0.97	0.89	1.00				
Mean annual inflation	C5	0.72	0.88	0.87	0.81	0.86	1.00			
Standard deviation of inflation	C6	0.66	0.81	0.79	0.74	0.8	0.98	1.00		
Cumulative demand slump	C7	0.68	0.71	0.71	0.49	0.66	0.44	0.41	1.00	
Share of depreciation episodes	C8	0.72	0.94	0.91	0.82	0.89	0.93	0.91	0.59	1.00

Source: Own estimations



Source: Own estimations.

Note: Monthly data. The shaded areas replicate the distribution of estimated coefficients of a battery of about 3,000 models. The figure does not include confidence bands based on estimated standard errors.

Figure 12. Dynamic ERPT from Appreciation, Moderate and Extreme Depreciation

The results suggest that depreciations of more than 10% (m-o-m) pass through to CPI at the rate of 0.55, which is in line with time-varying analysis. Moreover, all the estimated coefficients for extreme depreciation are strongly significant in 98% of the estimated models. Moderate depreciations, in turn, pass through to prices at a rate of 0.2 on average. However, the variation in estimated coefficients is much higher and statistically significant only in about 10% of the battery of models. Finally, ERPT from appreciations averages to about 0.1. However, the variation of coefficients is small – most do not statistically differ from zero.

To sum up, the exchange rate pass-through to consumer prices in Ukraine is highly unstable and strongly depends on the estimation approach and sample. The estimated battery of inflation equations of various specifications provides evidence that ERPT is asymmetric and nonlinear with regard to the size and direction of exchange rate changes and the macroeconomic environment. We provide some evidence that the degree of ERPT increases in periods of extreme depreciations, and when there is a high inflation environment, an economic slump, and considerable exchange rate volatility. The complexity of the estimation using volatile aggregated data calls for the use of microdata to better understand the degree and determinants of exchange rate pass-through in the pricing decisions of firms.

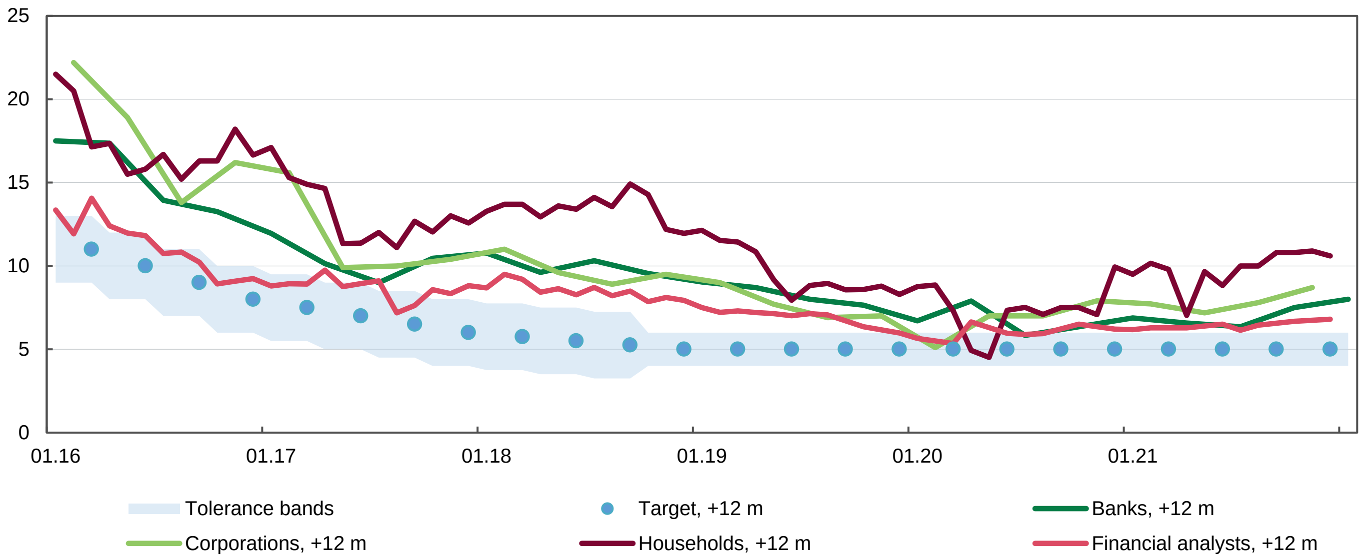
2.4. Inflation Expectations in the Transmission Mechanism

Inflation expectations play an essential role in the monetary policy transmission mechanism. First, economic participants consider their expectations when planning future investments and savings, setting wages and prices. Second, anchored expectations make for easier inflation stabilization, allowing more profound policy reactions to economic cycle fluctuations. This subsection analyzes how inflation expectations are formed and how well they are anchored.

2.4.1. Formation of Short-Term Inflation Expectations

The NBU analyses quantitative short-term inflation expectations of banks, corporates, households, and financial analysts. The expectations of all economic agents are collected through various surveys. Agents are asked how much the consumer price index will change over the next 12 months. About 700 corporates and 24 banks are surveyed every quarter, and about 1,000 households are surveyed monthly. The survey of financial analysts is linked to the Monetary Policy Committee meetings eight times per year, and the number of respondents ranges from 7 to 13. All agents, apart from financial analysts, choose an answer from an offered list of intervals. Analysts report their numerical forecasts. The average value provided in response to the question is taken as a measure of expectations. Data for financial analysts and households are available from mid-2014. In the case of corporates and banks, the data cover samples from the beginning of 2006 and late 2012, respectively.

The short-term expectations of all groups of agents have gradually improved since the introduction of inflation targeting (Figure 13). However, they systematically remain above the announced target. Household expectations typically exceed those of other agents and are much more volatile.



Source: NBU.

Note: Quarterly data.

Figure 13. One-Year Ahead Inflation Expectations and One-Year ahead Inflation Target

Note the considerable difference between the expectations of banks and financial analysts, which has two potential explanations. The first one lies in the methodological differences between the surveys described above. The second one is that most surveyed financial analysts are professional forecasters, while representatives of surveyed banks are credit managers, for whom inflation forecasting is not their main function.

To analyze how inflation expectations are formed, we estimate single-equation models. One-year ahead inflation expectations ($\pi^{e}_{t+4|t}$) are explained by past annual inflation rate (π_{t-1}), one-year ahead inflation target ($\pi^{tar}_{t+4|t}$) and the NBU's one-year ahead inflation projections published at period t ($\pi^{proj}_{t+4|t}$)[6]. In addition, the models include annual changes in the real interest rate (Δr_{t-1}), the index of key sectors' output (Δy_{t-1}) and the nominal effective exchange rate (Δe_{t-1}).

$$\pi^{e}_{t+4|t} = \alpha_0 + \alpha_1 \pi_{t-1} + \alpha_2 \pi^{tar}_{t+4|t} + \alpha_3 \pi^{proj}_{t+4|t} + \alpha_4 \Delta r_{t-1} + \alpha_5 \Delta y_{t-1} + \alpha_6 \Delta e_{t-1} + \varepsilon_t \qquad (3)$$

[6] The NBU's inflation projection is highly correlated with current inflation, so it is included in the models as residuals of the regression, in which projections are explained by current inflation.

The models are estimated on quarterly data. Ex-post real deposit interest rate is used for corporations and households, and ex-post real interbank rates for financial analysts and banks. The aggregation of monthly data into quarterly frequency is carried out by taking the last observation.

The results are shown in Figure 14. Households' expectations demonstrate the highest sensitivity to past inflation changes, while the impact on the expectations of other agents is half as weak. Almost all agents take the inflation target into account. Although financial analysts display relatively low attention to the announced target, they attach the highest weight to published inflation forecasts. Households respond to the NBU's forecasts, albeit the inflation target doesn't have a significant impact on their beliefs. There is also no significant impact of inflation projections on banks' expectations.

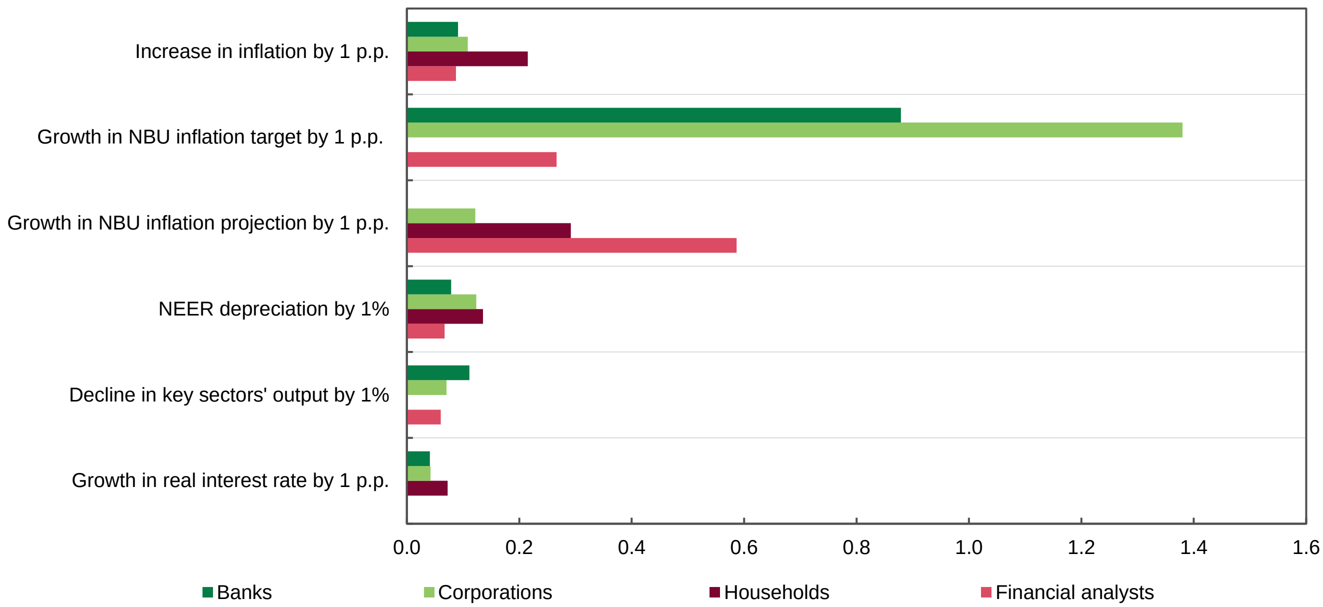
All agents adjust their forecasts in response to exchange rate changes. In addition, all but households respond to observed changes in key sectors' output: agents increase their expectations to lower output. The latter may indicate agents' supply side view of inflation (Candia et al. 2022). Finally, all agents, except financial analysts, tend to increase their expectations in response to a higher interest rate, which may suggest a signaling effect from a monetary policy shock (Melosi, 2017).

To summarize, economic agents pay attention to the NBU target and inflation forecast. The results affirm that a transparent policy and communications with the public strongly affect the process of inflation expectation formation.

In addition, we estimate structural VAR models to analyze what determines agents' forecasts. The models consist of five endogenous variables: one-year ahead inflation expectations ($\pi^e_{t+12|t}$), inflation (π_t), output gap ($\hat{y}_t$), annual change in the nominal effective exchange rate (Δe_t) and nominal interest rate (i_t).

$$BX_t = A_0 + \sum_{i=1}^{n} A_i X_{t-i} + \varepsilon_t \tag{4}$$

Where $X_t = [\pi^e_{t+12|t}, \pi_t, \hat{y}_t, \Delta e_t,\ i_t]$; B, A_0 and A_i are the structural coefficients, and ε_t is a structural shock with $E(\varepsilon_t) = 0$, and $cov(\varepsilon_t) = \Omega$, Ω is a diagonal matrix. Information criteria are used to determine the optimal lag length n. The impulse response functions are calculated using Cholesky decomposition, with the ordering of variable as in X_t.



Source: Own estimations.

Note: The models are estimated on a sample from 2015 to 2021. Values with p-values above 0.3 are omitted.

Figure 14. Response of One-Year-ahead Inflation Expectations to Different Impulses

This section presents only findings for corporations' expectations, as we did not find any proper results for other groups: inflation expectations often respond to shocks in "wrong" ways. Such results can be related to a limited number of observations. We will repeat the same analysis for those groups when more data is available.

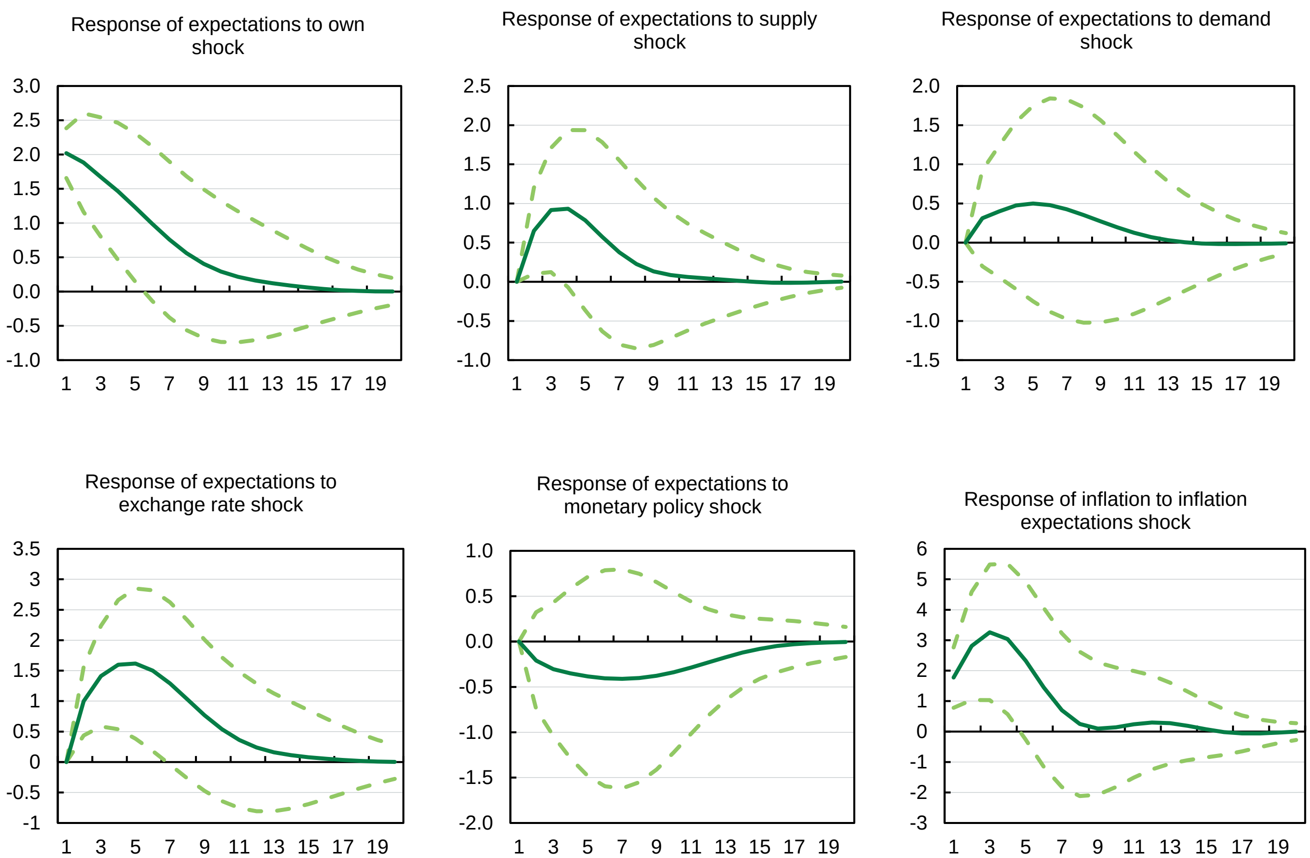
The SVAR model is estimated on a sample from 2006 to 2021. The number of lags is chosen to be two according to most information criteria.

Figure 15 shows the impulse response functions of the SVAR model for corporations. Economic agents respond to supply and nominal exchange rate shocks by raising their expectations. The strength of the response to the latter shock is higher than to the former. Both responses are statistically significant and last roughly an equal amount of time. A demand shock positively affects inflation expectations, while an increase in the interest rate lowers them. The impact of both shocks is not statistically significant. Finally, the effect of the expectations on inflation is strong and statistically significant.

Figure 16 shows the share of the variance of corporations' inflation expectations, decomposed into contributions from their own shocks and the shocks of other variables.

The results suggest that the proportion of the variability of inflation expectations due to their own shock is 46% over two years. Exchange rate shocks determine 38% of the total movements in expectations over the same horizon. The inflation and output gap play a less critical role. After two years, they explain 9% and 4% of expectations volatility, respectively. The contribution of the monetary policy shock to the changes in expectations is 3% over two years.

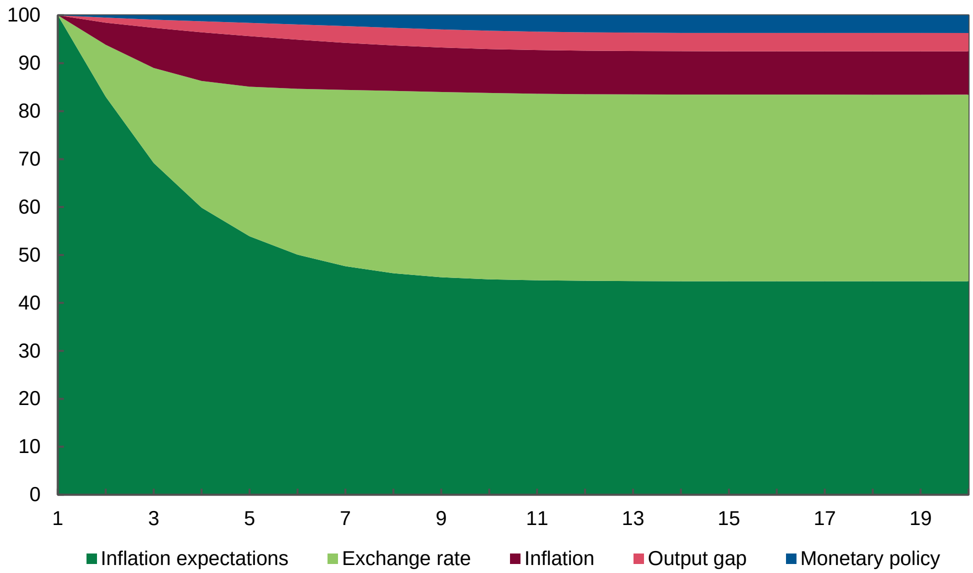
The SVAR approach indicates a more prominent role of the exchange rate in shaping short-term inflation expectations than the single-equation approach. This might be because the single-equation approach does not capture the indirect effects of the exchange rate on inflation expectations through other variables. Monetary policy shocks in the SVAR approach also induce impulse responses with “correct” signs.



Source: Own estimations.

Note: Quarterly data. The size of the shocks is equal to one standard deviation. Dashed lines indicate the 95% confidence intervals.

Figure 15. The Impulse Response Functions of SVAR Model for Corporations’ Inflation Expectations



Source: Own estimations.

Note: Quarterly data.

Figure 16. Variance Decomposition of Corporation's Inflation Expectations

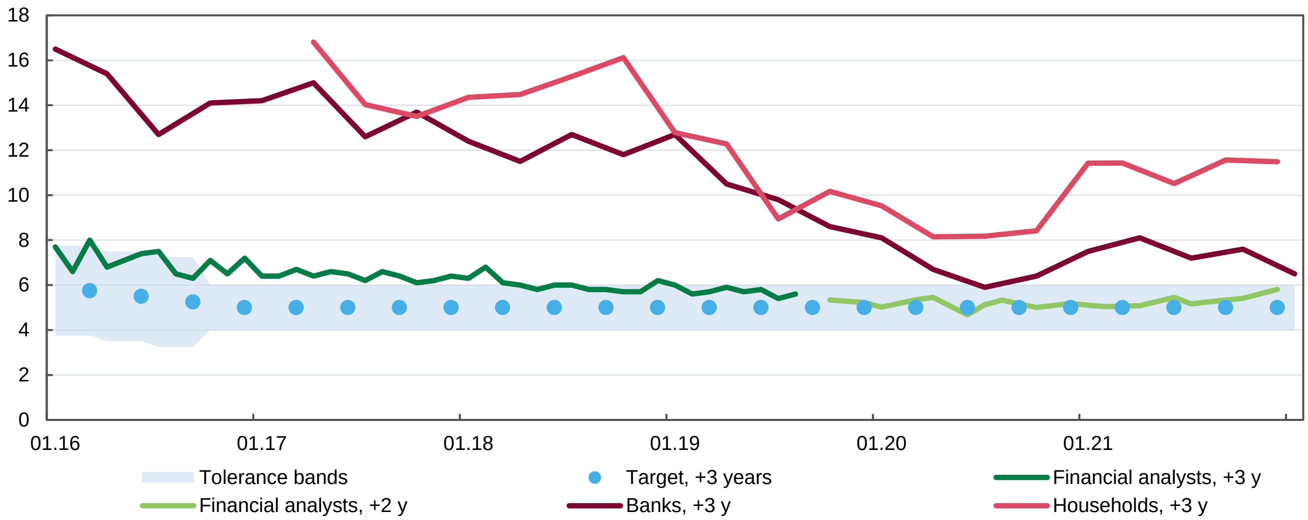
2.4.2. Anchoring Inflation Expectations

The extent to which inflation expectations are anchored can be used as a measure of monetary policy credibility and the efficiency of the transmission channel. Well-anchored inflation expectations are required to maintain price stability.

To analyze the anchoring of expectations, we use medium-term (two and three years ahead) and short-term (12 months ahead) expected inflation rates.

The medium-term inflation expectations of financial analysts indicate a high degree of anchoring. These expectations are stable and fluctuate around the target level (Figure 17). In contrast, households' and banks' expectations are unanchored. They are still higher than the target, despite having improved significantly since the introduction of IT. The medium-term expectations of banks and households are very similar to their short-term expectations. The correlations are 0.89 and 0.98, respectively.

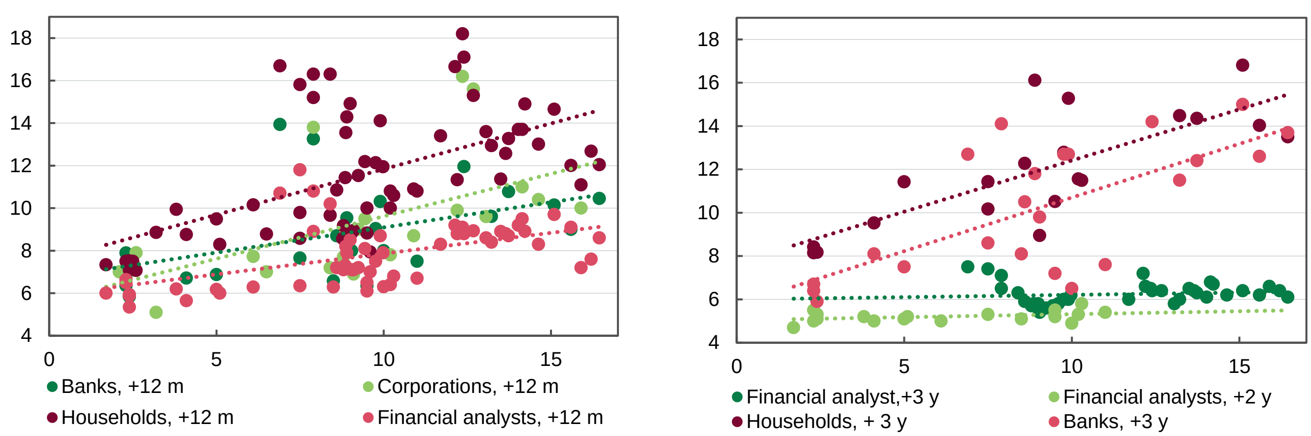
Figure 18 demonstrates the sensitivity of agents' expectations to inflation. The slope of the regression indicates the strength of the impact of inflation on expectations. For short-term expectations, it varies from 0.2 for financial analysts to 0.43 for households. For medium-term inflation expectations, the slope is nearly zero for financial analysts and about 0.47 for households and banks.



Source: NBU.

Note: Quarterly data. At the end of 2019, the relevant survey question for financial analysts was changed to ask about how much the consumer price index will change over the next two years rather than three years.

Figure 17. Medium-term Inflation Expectations



Source: NBU, own estimations

Note: Quarterly data. The graph covers the period from mid-2016 to 2021. Inflation corresponds to the annual inflation rate known at the time of the survey.

Figure 18. Sensitivity of Inflation Expectations to Inflation

2.5. Projected Interest Rate Path Transmission

In July 2019, the NBU started publishing its projected policy interest rate path as part of its macroeconomic forecast, becoming only the eighth inflation-targeting central bank to do so.[7] The following section presents results regarding the transmission of the path to yields on hryvnia domestic government debt securities.

The forecast is published quarterly in the NBU's Inflation Report and in press releases on monetary policy decisions that take place a week before the publication of the Inflation Report. Along with the traditional forward guidance, which often consists of verbal cues about future intentions, the key policy rate forecast enables market participants to draw conclusions about the NBU's further policy, which, in turn, translates into a more substantial impact of the key policy rate on market interest rates.

We compare market forward rates with respective projected policy rates. For instance, the f(2,1) rate is the forward rate that would allow an investor to buy a one-quarter government bond two quarters from now. It is compared with official three-quarter-ahead projections of the policy interest rate, cb(2,1).

Forward rates are not directly observed in Ukraine. They are derived from the term structure of spot rates using the following formula. For comparability with the policy rate (the main operation of which is the placement of certificates of deposit for 14 days), spot and forward interest rates are adjusted to a 2-week accrual of interest.

$$f_{T-1,1} = \left[\left(\frac{(1+r_T)^{\frac{T}{4}}}{(1+r_{T-1})^{\frac{T-1}{4}}}\right)^{4\times\frac{14}{365}} - 1\right] \times {}^{365}/_{14} \quad (5)$$

The effective spot rates r_T are measured as weighted average yields on hryvnia domestic government debt securities, which are traded on the secondary market starting from the day of the monetary policy announcement and for seven days after it. The data allow us to divide the bonds into several groups by their maturity: 0-1 quarters, 1-2 quarters, 2-3 quarters, 3-4 quarters, 1-1.5 years, 1.5-2 years, and 2-2.5 years. The spot rate r(0,1) and the following forward rates are thus derived: f(1,1), f(2,1), f(3,1), f(4,2), f(6,2), and f(8,2).

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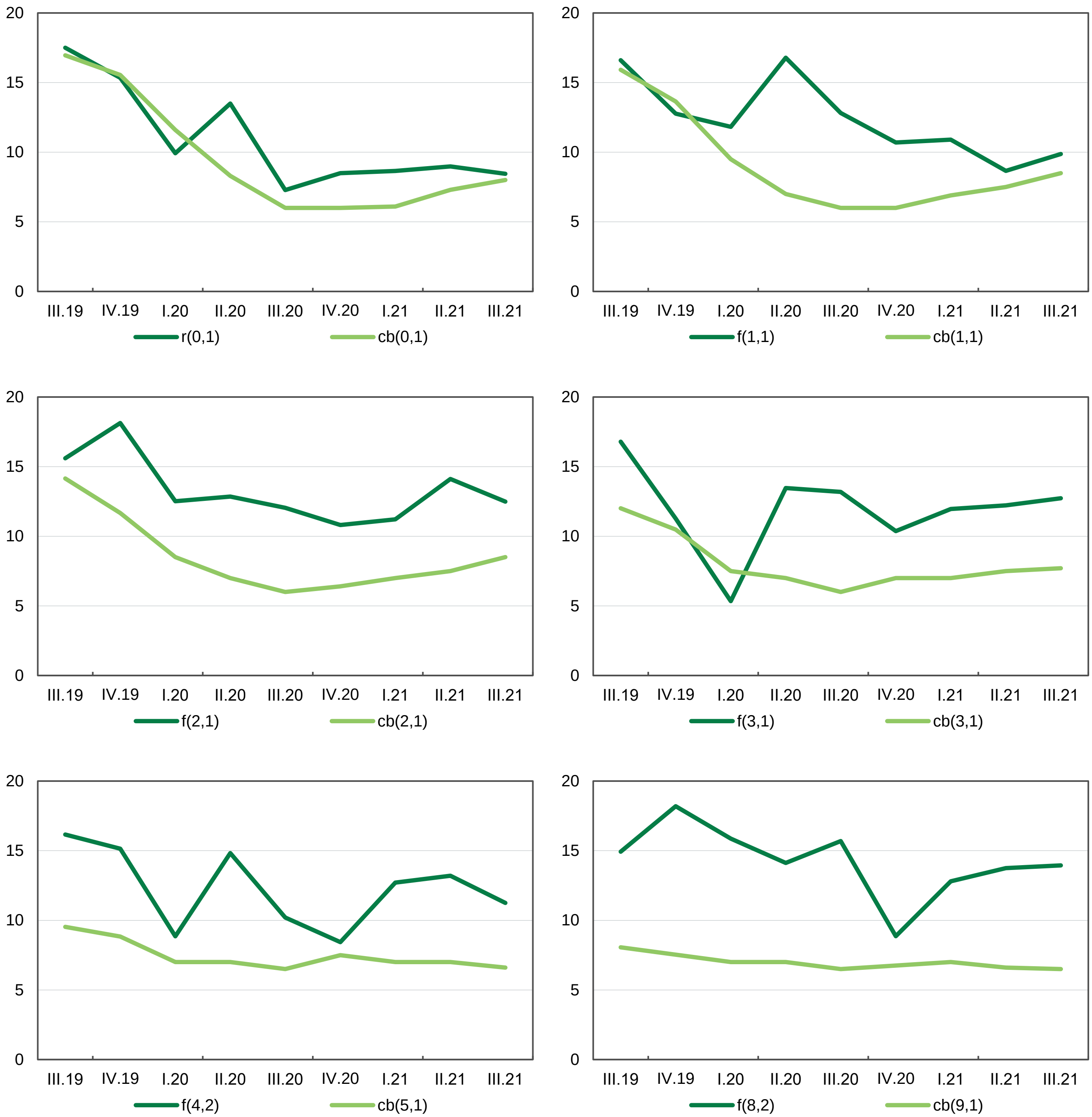
[7] The other seven banks are the National Bank of Georgia, the Reserve Bank of New Zealand, Norges Bank, the Bank of Israel, the Central Bank of Iceland, Czech National Bank, and Sveriges Riksbank. The Central Bank of russia began publishing the interest rate forecast later.



Source: NBU, own estimations.

Note: Quarterly data.

Figure 19. Projected Policy Rates and Market Spot and Forward Rates on Hryvnia Domestic Government Debt Securities

One-quarter market rates r(0,1) closely followed one-quarter ahead projections of the key policy rate cb(0,1), which declined from 17% in Q3 2019 to a low of 6% in H2 2020, and then increased to 8% in Q3 2021 (Figure 19). However, there was a notable spike in market rates in Q2 2020, which is related to uncertainty around COVID-19, which led to a capital outflow from emerging markets. Similar COVID-related spikes are observed for most forward rates as well.

The transmission seems to be present, although we are not providing any formal tests. There are, however, numerous occurrences of spikes and falls in the forward rates, which are attributed to COVID-19 uncertainty, demand/supply dislocations, and other factors. The term premium also comes into effect.

More distant forward rates are volatile, but do follow downward sloping trends. This is in line with decreasing policy interest rate projections.

The term premium, which we define here as the difference between market rates and key policy rate projections, seems to be increasing for more distant forward rates. Average term premiums for various projection horizons are shown in Table 11.

Table 11. Term Premiums Across Projection Horizons

Quarters after policy decisions	1st	2nd	3rd	4th	6th	8th	10th
Average term premium, p.p.	1.4	3.3	4.8	3.9	4.9	5.9	7.5

Source: Own estimations.

Conclusions

This report comprises several studies of the monetary policy transmission mechanism and its particular links. It aims to assess the potency of monetary policy since the adoption of inflation targeting in late 2015. The analysis was undertaken mainly using data for 2015-2021 – the initial years of the new monetary policy regime, which saw significant structural transformations of the Ukrainian economy.

We have established that monetary policy has a solid overall impact on the economy. Other things being equal, a tighter monetary policy leads to an appreciation in the nominal exchange rate, subdued aggregate demand, and falling prices. The maximum effect on inflation is reached around the fourth quarter after a policy shock. Low monetary policy credibility, however, can decrease and delay the impact.

The mechanism's interest rate, the exchange rate, inflation expectations, and credit channels were also investigated separately.

The interest rate channel. The wholesale interbank credit interest rate is tightly linked to the policy rate thanks to the operational design of monetary policy. Further transmission to retail banking rates is stronger for nonfinancial corporations than for households. It is especially strong for loans to large corporations by foreign-owned banks.

Interest rate transmission is restrained by relatively high banking sector concentration and a large share of state-owned banks. It is expected to improve as the financial markets develop.

The exchange rate channel. Exchange rate movements have been shown to significantly influence both real economic activity and consumer prices. The influence is strengthened by the high share of imported goods in the consumption basket, but weakened by prevailing commodities in exports. The share of non-residents that hold government debt securities significantly increased in 2019, which improved the transmission from the interest rate to the exchange rate.

The exchange rate pass-through to consumer prices is asymmetric, as depreciations have higher effects than appreciations. Moreover, it is non-linear – stronger depreciations are more impactful. These characteristics make the coefficient time-variant.

The high pass-through and shallow financial markets make moderate foreign exchange interventions an effective additional monetary policy tool for smoothing out exchange rate volatility, and for achieving general macroeconomic stability. However, heavy exchange rate management could make inflation more volatile, depriving monetary policy of a vital transmission channel.

The inflation expectations channel. The inflation expectations of various economic agents improved amid disinflation in 2016-2019. Along with them, improved monetary policy credibility. Expectations remained relatively anchored in the sense that they did not respond much to inflation deviations from its target.

However, in 2020-2021, inflation expectations retained an upward bias above the official target. Low monetary policy credibility might increase the bias, making a contractionary monetary policy less effective in decreasing inflation, while also making an expansionary policy less effective in increasing output.

Prospective areas of study include using large datasets with microeconomic data for banks and non-financial corporations. That would help identify supply-side factors affecting the issuance of new loans and the effect of interest rates on individual investment decisions. We also leave the assessment of the credit channel for future research. An empirical evaluation of the uncovered interest parity condition in Ukraine is among other interesting topics.

Further research should account for the evolving strength of the mechanism. The early years of inflation targeting have surely brought changes to various transmission channels. They can be captured with time-varying-parameter and Markov-switching models.

The russian invasion of 2022 created a structural break, which will have to be accounted for.

A separate important research topic relates to accessing the effectiveness of the administrative restrictions and unconventional policy measures undertaken by the NBU during the war.

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Annex A. Sign-Restricted BVARs for Volumes of Exports and Imports

The empirical estimation of export/import elasticities with respect to price changes (the REER in our case) is challenging. A standard VAR treats exports/imports and the REER as endogenous variables, and does not distinguish between underlying structural shocks that caused unexpected changes in international trade and prices. The conventional way of dealing with this issue is to apply sign and zero restricted BVARs, which allow the identification of shocks hitting the economy. The output of this approach is a set of shock-specific responses of the analyzed variables.

A sign-restrictions scheme was used in Bussière et al. (2010) to estimate on a country-by-country level the long-run REER elasticities of exports and imports for a sample of 21 countries (including seven emerging markets economies). They used quarterly data from 1979 to 2007 for five key time series: exports, imports, GDP, REER, and oil prices, all in real terms and in logs. The REER shock was identified by the positive feedback of imports and the negative reaction of exports.

In Chmielewski et al. (2020), BVARs were used to estimate export/import elasticities with respect to different measures of relative prices (including REERs based on CPI, PPI, and unit labor cost). BVARs for exports included Polish export volume, Poland's participation in global value chains, external demand weighted by the structure of Polish exports, world prices weighted by the structure of Polish exports, Polish short-run interbank interest rate, and some measure of the exchange rate. To identify the system of equations, the authors imposed sign and zero restrictions, which denoted the shocks of global demand, global supply, global prices, global value chains, domestic monetary policy, and the exogenous exchange rate shock resulting in the appreciation of the Polish zloty. A similar approach was applied to the estimation of import elasticity.

The sources of current account fluctuation in Ukraine were investigated in Nikolaychuk and Shapovalenko (2013). The authors applied a sign-restricted VAR to obtain an empirical estimate of current account reactions to different types of shocks. The VAR contained terms of trade index, relative output, trade balance, and the REER as endogenous variables and covered quarterly data from 2001 to 2012. The VAR was firmly identified as a system of four endogenous variables, containing four identified shocks: terms of trade shock, demand shock, supply shock, and REER shock.

BVARs with a sign or zero restricted impulse response functions are also popular in exchange rate pass-through (ERPT) studies. Forbes et al. (2018) directly incorporate the underlying shocks that cause exchange rate fluctuations when evaluating how these fluctuations pass-through to imports and consumer prices. They developed a SVAR framework for a small open economy and applied it to the UK. The authors use a sign and zero restrictions to identify the shocks of demand, supply, monetary policy, the nominal exchange rate, and global economy. It is shown that prices respond differently to exchange rate movements depending on what caused them. For example, the ERPT is low in response to domestic demand shocks and relatively high in response to domestic monetary policy shocks. In Comunale and Kunovac (2017), the same methodology was applied to estimate the ERPT for the euro area and separately for its four members – Germany, France, Italy, and Spain.

Sign and zero restrictions imposed to identify the shocks are shown in Table A.1. We identify a standard set of shocks, which closely correspond to the transmission mechanism of the QPM – the core macroeconomic model of the NBU. All restrictions have a duration of one quarter.

Table A.1. Sign and Zero Restrictions on BVAR IRFs

	Exports	Imports	GDP	REER	IR	GDP of trading partners	CTOT
Supply shock			↑	↓		0	0
Demand shock		↑	↑	↑	↑	0	0
REER shock			↓	↑	↓	0	0
MP shock			↓	↑	↑	0	0
World demand shock			↑			↑	
CTOT shock	↑			↑			↑

Source: Own estimations.

A supply shock is usually treated as a productivity boost leading to short-term price drops. That is why the REER depreciates. However, productivity growth should cause the REER to appreciate in the long run according to the Balassa-Samuelson effect. Because of this ambiguity regarding the impact of supply shocks on the REER, we leave long-run effects unrestricted.

A demand shock is associated with a positive correlation between output and inflation. Monetary policy reacts in a counter-cyclical manner, while the REER appreciates because of inflation hikes and an appreciation in the nominal exchange rate in response to interest rate growth. An increase in domestic demand usually deteriorates the current account. To account for that, we imposed a positive sign restriction on the reaction of imports.

The REER’s own is considered to be driven by an appreciation in the nominal exchange rate. It undermines the external competitiveness of the economy and reduces output. The pass-through effect from the nominal appreciation slows down inflation. Thus, the policy interest rate decreases. A monetary policy shock is identified when a higher interest rate is associated with a GDP drop and an appreciation of the nominal exchange rate.

A global demand shock boosts domestic output. A commodity terms of trade shock assumes that the price of an exported commodity increases. The improved current account has a positive effect on GDP. The inflow of foreign currency due to higher exports leads to an appreciation of the nominal exchange rate. The REER appreciates because of the prevailing effects of the nominal exchange rate.

We estimate BVARs with four lags and use two types of priors: Minnesota (a full VAR) and independent Normal Inverse Wishart (INIW). Minnesota priors are used to grid search for the most appropriate hyperparameters based on the maximization of the marginal likelihood for the model. This procedure cannot be repeated for INIW priors because it is impossible to derive the marginal likelihood of these models. That is why we applied optimized hyperparameters for Minnesota priors to the BVAR with INIW priors (Table A.2).

Table A.2. Optimized Hyperparameters

Hyperparameter	Value
Auto-regressive coefficient	0.20
Overall tightness (λ_1)	0.20
Cross-variable weighting (λ_2)	0.55
Lag decay (λ_3)	1.30
Exogenous variable tightness (λ_4)	100
Block exogeneity shrinkage (λ_5)	0.001

Source: Own estimations.

The overall tightness hyperparameter (λ_1) says that the prior on the first-lag coefficients of endogenous variables in each VAR equation is rather flat. According to λ_3, coefficients for lags of higher orders quickly converge to zero with high certainty. The cross-variable weighting hyperparameter (λ_2) means that cross-variable lag coefficients go to zero with higher confidence than for the endogenous variable's own lags. The hyperparameter on exogenous variable tightness (λ_4) means that there is some uncertainty around constant terms in VAR equations, as they are only exogenous components of the model. Finally, the block exogeneity shrinkage hyperparameter (λ_5) reflects our assumption on the one-side effects of the world economy on Ukraine. To get posterior distributions of BVAR parameters, we made 20,000 draws with 18,000 burn-in iterations.

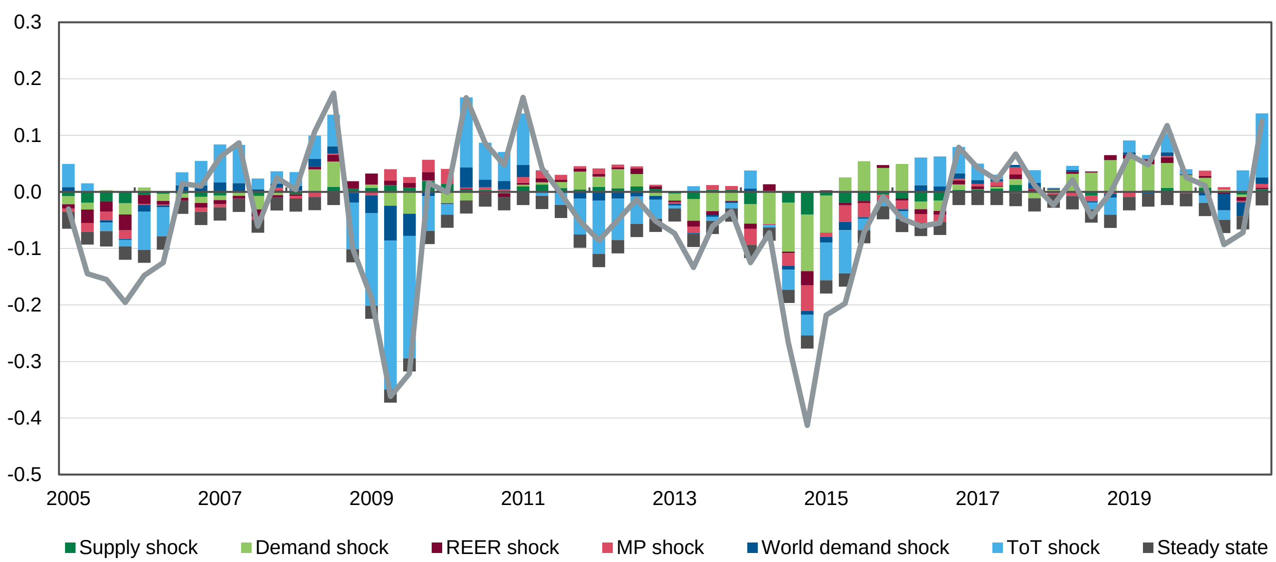
Table A.3. Forecast Error Variance Shares Explained by Different Shocks (average for 40 quarters)

	REER shock	Monetary policy shock	Global shocks (World GDP+CTOT)
Exports	5.1%	6.3%	35.1%
Imports	7.6%	7.7%	35.7%
GDP	2.2%	5.9%	49.6%

Source: Own estimations.

The exercise with forecast error variance decomposition (Table A.3.) demonstrates that REER and monetary policy shocks do not provide much insight into the real variables of primary interest. The global economy plays a major role in explaining the forecast error variances of exports, imports, and GDP.

The historical decompositions of export and import fluctuations (Figures A.1 and A.2) confirm the previous conclusion about the importance of the shocks of terms of trade and world GDP.

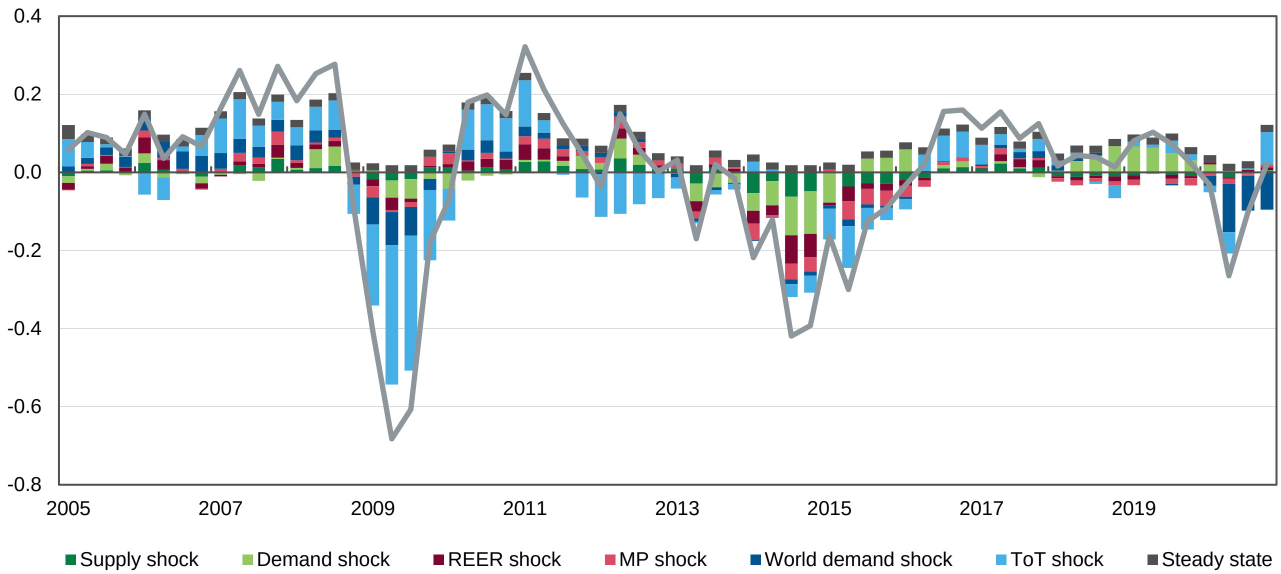


Source: Own estimations.

Note: Quarterly data.

Figure A.1. Historical Decomposition of Year-on-Year Changes in Ukrainian Exports[8]

[8] Figures A.1 – A.2 demonstrate the contribution of each of the six shocks to y-o-y changes in exports and imports. These historical decompositions of the variables are the posterior medians of the 2000 historical decompositions obtained from the saved iterations of the estimation algorithm. This is the reason why shock contributions do not sum up properly to the actual values. The same features of historical decompositions can be found in Comunale and Kunovac (2017) or Chmielewski et al. (2020).



Source: Own estimations.

Note: Quarterly data.

Figure A.2. Historical Decomposition of Year-on-Year Changes in Ukrainian Imports