2.3. Evaluation of the effectiveness of monetary policy in Ukraine

Throughout the war period, the NBU's monetary policy was adaptive, focusing on crisis management and the stabilization of the financial system while laying the groundwork for post-conflict economic recovery. The unique challenges posed by the war necessitated a departure from conventional monetary policy practices, emphasizing the need for flexibility and responsiveness in central banking during times of crisis. Based on the information provided above, Ukraine followed a similar path to other countries when the NBU chose to peg the exchange rate of hryvnia to USD during the onset of the invasion. This move was made by the regulator to maintain stability in economic agents' expectations and thereby ensure macro-financial stability during the war. In addition, the fixed exchange rate played a vital role in controlling inflation [21, 24].

Foreign exchange interventions have become the main monetary policy instrument in Ukraine during the war. By imposing foreign exchange restrictions and intervening in the interbank market to cover the remaining foreign exchange deficit, the NBU was able to fix the exchange rate. Also, certain restrictions were imposed on some foreign exchange transactions and capital movements. In such a way, NBU wanted to prevent nonproductive capital outflows, thereby limiting foreign exchange demand.

At the same time, in the first several months of the full-scale invasion, the regulator decided to postpone its decisions regarding the central bank rate and left it at 10% till the beginning of June 2022, when the Board of the NBU raised the key policy rate to 25% [21].

At the beginning of the extensive Russian aggression, the NBU chose not to make any significant decisions regarding the key policy rate. The reasoning behind this decision was the immense psychological pressure caused by the full-scale invasion. As a result, altering the key policy rate was unlikely to have a positive impact on stabilizing expectations and encouraging the retention of hryvnia assets, particularly in support of the fixed exchange rate. Instead, the NBU focused its

monetary policy efforts primarily on guaranteeing the uninterrupted functioning of the banking system and payments within the economy.

The situation with inflation was worsening, as it was accelerating from February to May (from 10,7% to 18% respectively) due to the disruption of production and logistics [21]. Moreover, the persistently high global energy prices exerted significant inflationary pressure on consumer inflation, both directly and indirectly, through increased production costs. Furthermore, global inflation rates also recorded high values, exceeding 8% in the United States and euro area countries, which was further fueling the rise of domestic prices. Despite the gradual economic recovery, the upward inflation trend was expected to persist in the upcoming months. This may have worsened inflation expectations, influencing depositors to convert their hryvnia savings into foreign currency. To mitigate these negative effects, the NBU returned to an active interest rate policy.

The NBU's governing board has opted to maintain the key policy rate at 25% while also raising the required reserves ratios for banks. These actions were expected to promote greater appeal for hryvnia-based assets, reinforce the stability of the exchange rate, and gradually mitigate inflationary pressures. Furthermore, the choice to maintain the key policy rate at its current level is motivated by the need to uphold exchange rate stability. Additionally, it creates suitable circumstances for the persistent reduction of inflation and the alleviation of the most oppressive foreign exchange constraints.

As the Ukrainian economy was gradually adapting and the psychological shock of the conflict subsided, there was a need to change the approach to monetary policy. With low yields on hryvnia assets, there was an increased risk of dollarization of the economy and the financial system losing valuable resources. The depreciation expectations of households and businesses were also vulnerable to changes in the war situation, especially those on the frontline and other situational factors. To address these issues, the NBU decided to intensify its interventions to sell foreign currency. However, the difference in the cash market exchange rate and the official exchange rate widened, exacerbating the negative effects on the economy caused by multiple

exchange rates and restrictions on foreign exchange transactions and cross-border transfers.

The NBU admitted that the fixation of the exchange rate at USD/UAH 29,25 had a restraining effect on the cost of goods and services and influenced inflation and exchange rate expectations. Economic agents were adapting to the war, and consumer imports recovered faster than exports due to restrictions on seaports that were till July. During that period, The U.S. dollar strengthened markedly against most currencies, including reserve currencies, and the fixed exchange rate caused more imbalance in the economy and high pressure on international reserves. As a result, the members of the Monetary Policy Committee agreed that maintaining the exchange rate at pre-war levels was unjustified and that improvements in export logistics and imports justified a policy change. However, returning to a floating exchange rate was seen as premature, so a one-time adjustment of 25% was made to fix the exchange rate at a new level of USD/UAH 36,56 per USD. This adjustment was expected to reduce demand for noncritical imports, improve the competitiveness of domestic production, and stimulate exports. External financing and the exchange rate adjustment allowed international reserves to be maintained at a sufficient level (as of May 1, 2023, Ukraine had reached its historical value of USD 35,9 billion in international reserves, covering 4,9 months of future imports), strengthening the NBU's ability to control the exchange rate and inflation trends [21, 23, 24].

According to the recent situation with inflation in Ukraine, it has been decreasing at a great pace than predicted for the third consecutive month (as of April 2023, the annual consumer inflation dropped to 17,9%, which was much lower than in December 2022 – 26,6%; the rates of price growth were also lower than the trajectory outlined in the NBU`s Inflation Report published in January 2023). This decline is attributed to the significant supply of food, sufficient fuel reserves, and improvements in inflation and exchange rate expectations. The latter is mainly due to the NBU's consistent monetary policy that seeks to maintain exchange rate stability and increase the appeal of hryvnia savings.

The decrease in inflation is anticipated to persist, mainly because of the reduced expense of energy resources in the worldwide market, limited internal

demand, and the influence of the monetary policies implemented by the NBU. Considering the collective impact of these factors, alongside the significantly improved situation in the energy sector, the NBU has modified its inflation projection for 2023, lowering it from 18.7% to 14.8% [23].

At the same time, the notable decline in inflation every year is mainly due to the elevated reference point of the previous year, coupled with the mild winter climate that reinforced this pattern. Nevertheless, the strain on production expenses for businesses remains prominent, including the challenges of managing operations and adapting logistics networks amidst the ongoing conflict. As a result, the ongoing conflict remains a major source of uncertainty, which poses a significant risk to future inflation trends. That`s why NBU highlights the necessity to keep the key policy rate at a high value to bolster the impact of previous measures by the regulator and facilitate additional growth in the investment appeal of hryvnia savings.

In addition to it, the NBU has taken steps to strengthen the monetary transmission and increase interest rates on hryvnia deposits, including tightening reserve requirements (RR) for current accounts and demand deposits. Moreover, starting from February 11, 2023, banks can use a wider range of domestic government debt securities to cover up to 50% of their total required reserves. The NBU implemented this measure to encourage banks to actively participate in auctions held by the Ministry of Finance and help revive the domestic debt market, thereby avoiding direct funding of the budget deficit by the NBU in 2023 [21]. At the same time, these measures taken to immobilize liquidity may not be sufficient due to constant inflows of foreign exchange and government debt securities returning to the banking system. So, the question arises of what additional tools to protect hryvnia retail and corporate deposits from inflation and optimize the operational design of monetary policy to make hryvnia assets more attractive could be implemented. The members of the MPC also believe that NBU's measures to stimulate hryvnia term deposits and stabilize the foreign exchange market should create conditions for easing foreign exchange market restrictions, which adversely affect business activity.

From September 15, 2023, the National Bank has taken decision to decrease the central bank rate from 22% to 20%. The decrease of inflation allowed to decline

further the central bank rate. Furthermore, from October 27, 2023, the key policy rate was set at 16% [21]. Moreover, the NBU sees the possibility of an additional reduction in the central bank rate at the next meeting. At the same time, the expected trajectory of inflation limit the scope for softening the interest rate policy next year. A return to the cycle of lowering the key policy rate in 2024 will be possible only in the event of a significant reduction in the risks to exchange rate stability and inflationary dynamics.

Since the beginning of the full-scale russian invasion, the NBU has been constantly communicating its commitment to inflation-targeting combined with some extra measures needed to stabilise the foreign exchange market and banking system. At the same time, the successfulness of inflation-targeting depends greatly on the strength of the links between monetary policy instruments and the real economy. The importance of these links for an adequate macroeconomic environment constitutes the relevance of this research topic. Next step is to evaluate whether current monetary policy and inflation-targeting has been more successful in decelerating and decreasing the volatility of inflation compared with fixed exchange rate.

The general approach for modeling the causal relationships in a national economy follows the design of "a semi-structural, forward-looking New-Keynesian model of a small open economy" [54] that the NBU uses for medium-term forecasting of key macroeconomic variables. Also, the research of David Wheat [57] on modeling macroeconomics with system dynamics tools was a great source of inspiration for the development of this model. There are 8 sectors in the model. Each represents a part of a national or a foreign economy.

In Figure 2.3, the first three sectors are displayed. We start with the assumptions concerning domestic interest rates. It is assumed that inflation expectations are the same for all economic agents in an economy (which is an obvious simplification, but this is a simple model of a national economy) and for foreign investors too. The sum of the expected inflation and the required real interest rate is the required nominal interest rate in the economy. The normal real interest rate is assumed to be equal to 3% per year as the NBU estimates that the neutral real interest rate in a steady state for Ukraine is 3% [54]. The neutral rate is the normal

rate because at such a level, the monetary conditions are neither tight nor accommodating [53, 55].

Additionally, it is assumed that the real interest rate changes only if a central bank changes its policy rate. And the policy rate of a central bank is a goal for real interest rate in the economy.

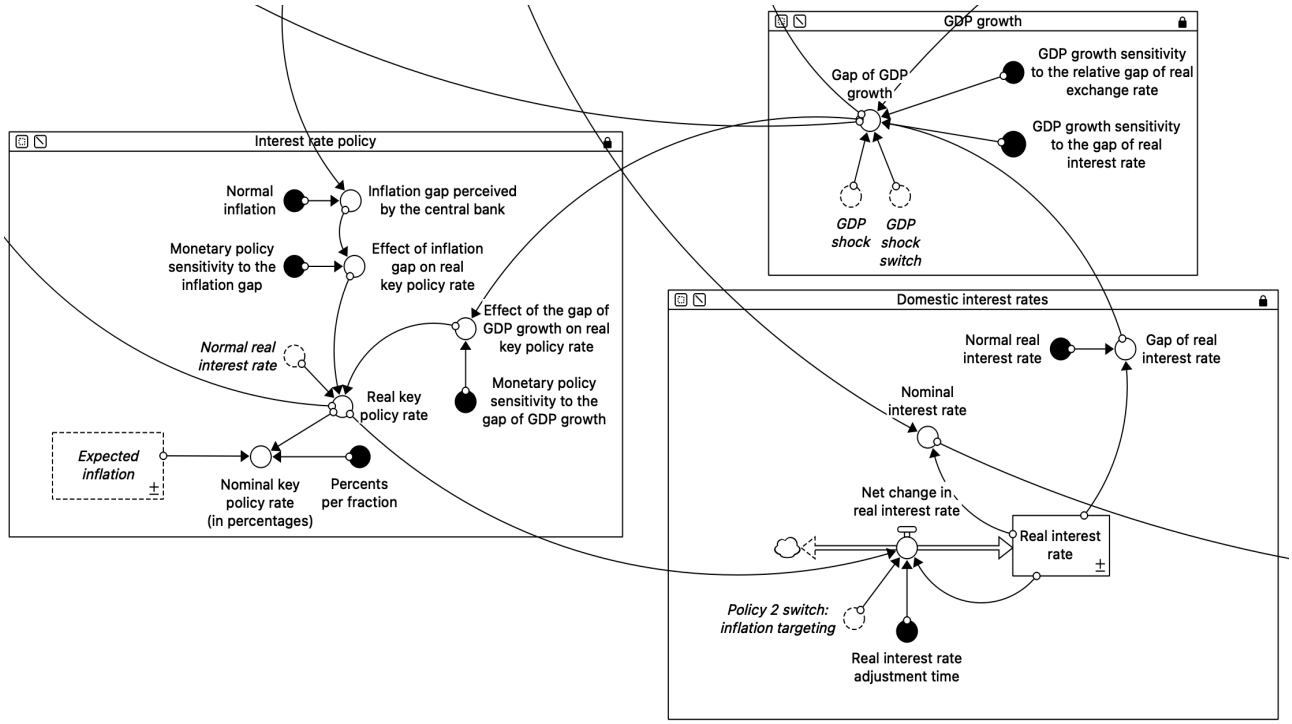

Figure 2.3. Interest rate policy, GDP growth and domestic interest rates sectors

Source: developed by authors in Stella Architect

In the GDP growth sector, real monetary conditions (real interest rate) and real conditions of international trade (real exchange rate gap) define the rate of change in GDP instantaneously. GDP growth sensitivities to the mentioned factors are assumed to be equal -0.035 and -0.065, respectively [54].

The interest rate policy sector represents a decision rule of a central bank. Monetary policy sensitivity to the gap of GDP growth is assumed to be equal 0.4. The lower bound for this parameter is equal to 0, because usually, central banks are not willing to increase the interest rates to react to the positive gap of GDP growth as there are debates about whether the actual rate of GDP growth is higher or lower than the growth of the potential GDP. The upper bound for this parameter cannot be higher

than the lower bound for monetary policy sensitivity to the inflation gap because price stability is the overriding goal of monetary policy. Monetary policy sensitivity to the inflation gap is assumed to be equal to 2 [54]. This parameter cannot be less than 1, because in emerging economies, the financial depth of the country is low, and it requires quite significant changes in interest rates to affect the real production and inflation. Also, because of high volatility, various risk premiums, and high dependence of domestic businesses, particularly of banks, on loans in foreign currency, the transmission of the changes in the key policy rate into market interest rates could be incomplete, which will increase the need of higher sensitivity of monetary policy to the inflation gap. The upper bound is around 3 because too high sensitivity of monetary policy to the inflation gap in real world might significantly restrain economic development, which would lead to dissatisfaction of the population with the policy of a central bank, which will cause the change of management in the central bank and less sensitive monetary policy. Normal inflation for the period under consideration (2016-2022) is assumed to be equal 13% annually. This value is higher than the current medium-term inflation target because the targeted rate of inflation has been gradually decreased in 2016-2019.

In the domestic prices sector (Figure 2.4) it is assumed that inflation sensitivity to the changes in the nominal exchange rate is -0.05 as in the paper on the quarterly projection model for Ukraine [54] a respective parameter in the core inflation specification is calibrated to be equal -0.05. Similarly, the inflation sensitivity to the gap of GDP growth is equal to 0.18, while inflation sensitivity to the relative real exchange rate gap is assumed to be equal -0.06.

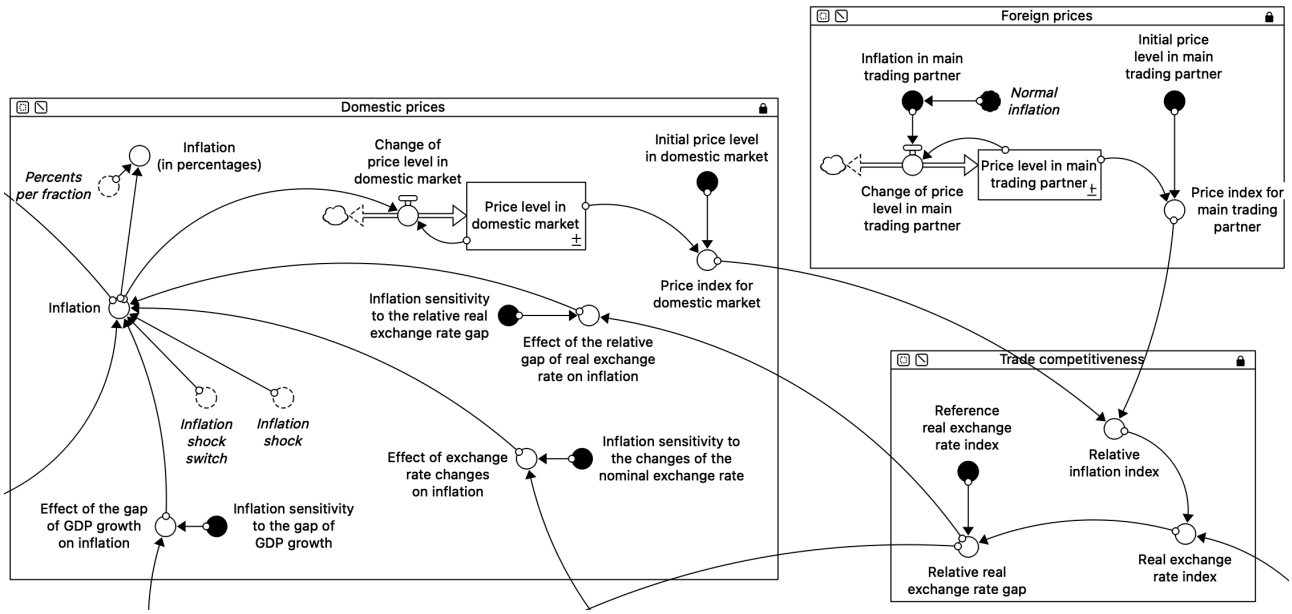

Figure 2.4. Domestic prices, foreign prices, trade competitiveness sectors

Source: developed by authors in Stella Architect

The most important component of the inflation formations sector (Figure 2.5) is the central bank credibility parameter. In the paper on the quarterly projection model for Ukraine [54], this parameter is assumed to be equal to 0.75. However, during the calibration, it was found that this value should be much lower, around 0.15. It makes more sense to assume that the central bank's credibility is closer to its lower bound as the central bank of Ukraine experienced a severe decrease in trust in 2014-2015 and there have been major changes in the regulations about the central bank and its mandate in Ukraine.

In the foreign exchange market (Figure 2.6) it is assumed that the nominal exchange rate sensitivity to the gap of nominal interest rate is around 0.25, because the effect of international flows of capital on the nominal exchange rate covers only one segment of the foreign exchange market and we are interested in the dynamics of this specific segment.

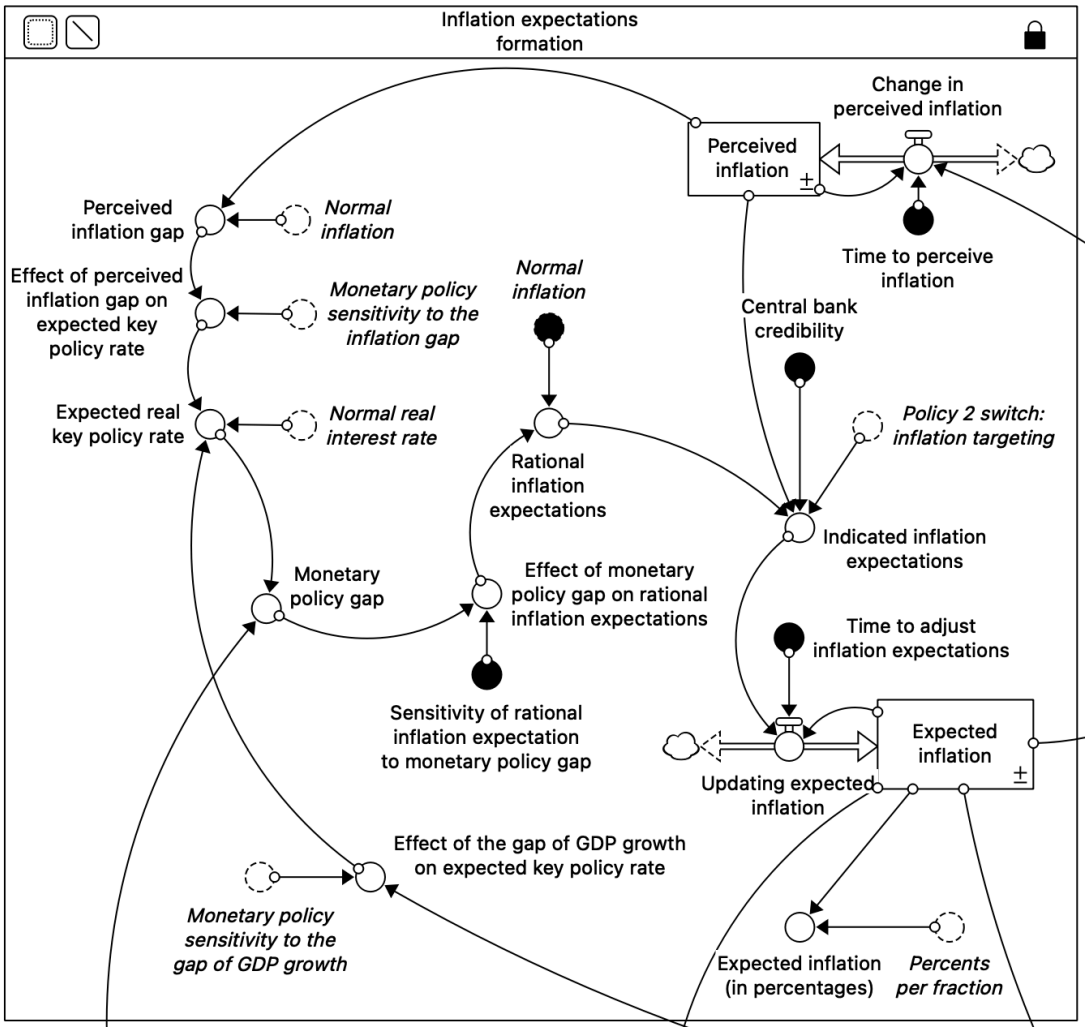

Figure 2.5. Inflation expectations formation sector

Source: developed by authors in Stella Architect

In this model the nominal exchange rate can change either because of international flows of capital or because of foreign exchange interventions by the central bank. This is a simplification, because there are other factors affecting nominal exchange rate like the revenues of exporters and the need for foreign currency to pay for imported goods. Because of the assumption that there are only 2 countries in the world of this model, the stock of the nominal exchange rate can also be considered a nominal effective exchange rate (NEER). The nominal exchange rate adjustment time is assumed to be equal to 1 year because Ukraine has a shallow financial market. Normal fraction for coverage of exchange rate volatility with foreign exchange interventions equals to 0.15 [54].

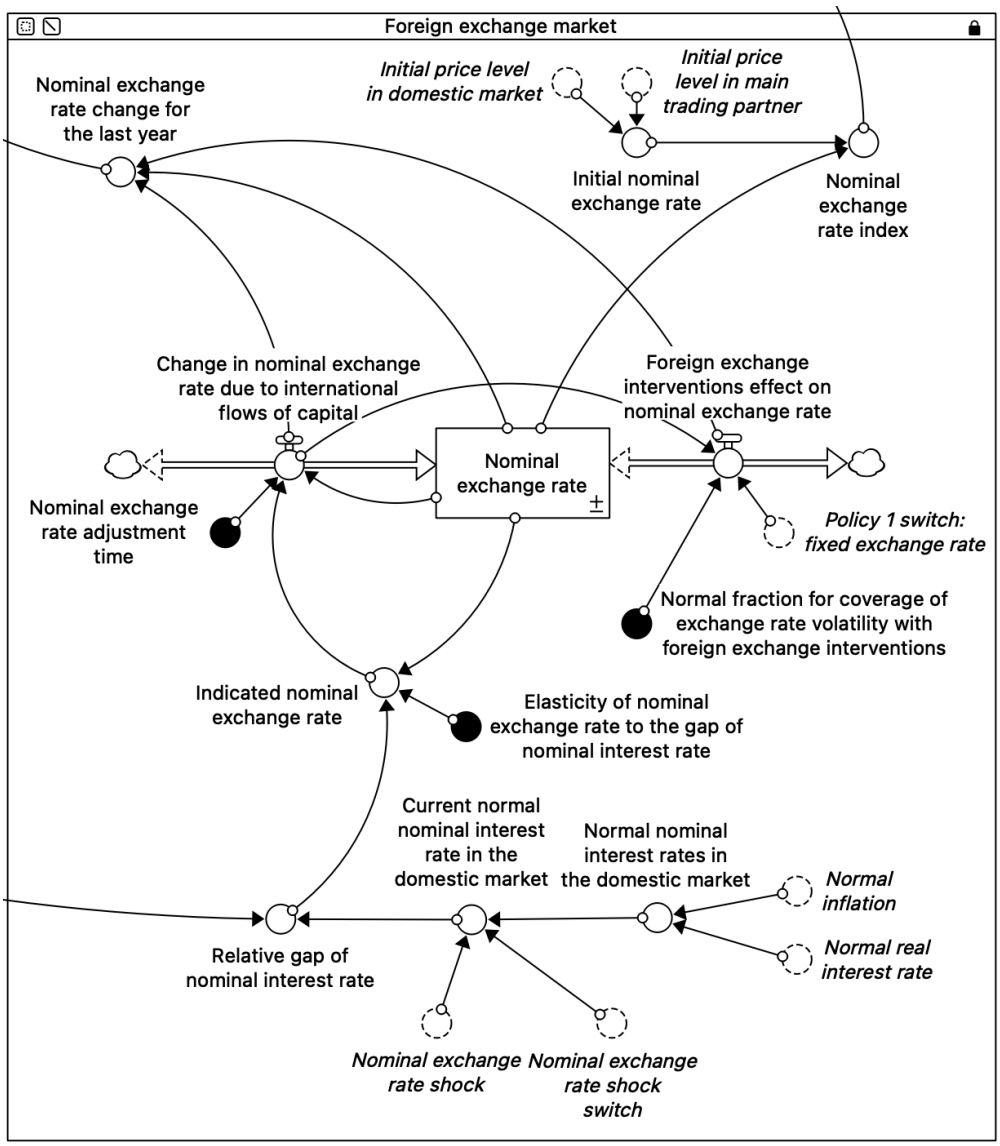

Figure 2.6. Foreign exchange market

Source: developed by authors in Stella Architect

Now that structure of the model is described, next step is to consider the dynamic hypothesis about the key structural relationships that drive the behaviour of our system. The most important feedback loops integrated in the model are summarised in the form of a causal loop diagram (Figure 2.7).

Self-fulfilling backward-looking expectations (R1). It is assumed that inflation expectations have persistent nature and are affected by the historical events which the population has seen. J. Sterman shows that expectations about prices tend to be primarily dependent on the past even when there is an abundance of complex methods for inflation forecasting [56]. At the same time, the actual price changes are

heavily dependent on inflation expectations, because manufacturers account for expectations when they set their prices.

Imported goods get relatively cheaper (B1). Ukraine is a relatively small economy, but at the same time it is extensively involved in international trade (the ratio of exports and imports to GDP has rarely fallen below 80% over the last few decades). Due to that, the inflation in the main trading partners of Ukraine affects the dynamics of prices in Ukraine through its effects on the relative trade competitiveness of foreign and domestic manufacturers. For example, if for a long period of time inflation stays higher in Ukraine than in the main trading partners, prices of goods and services of foreign firms will become very attractive for households in Ukraine. They will buy more imported goods and services and the general price level in the domestic economy will move towards the world price level.

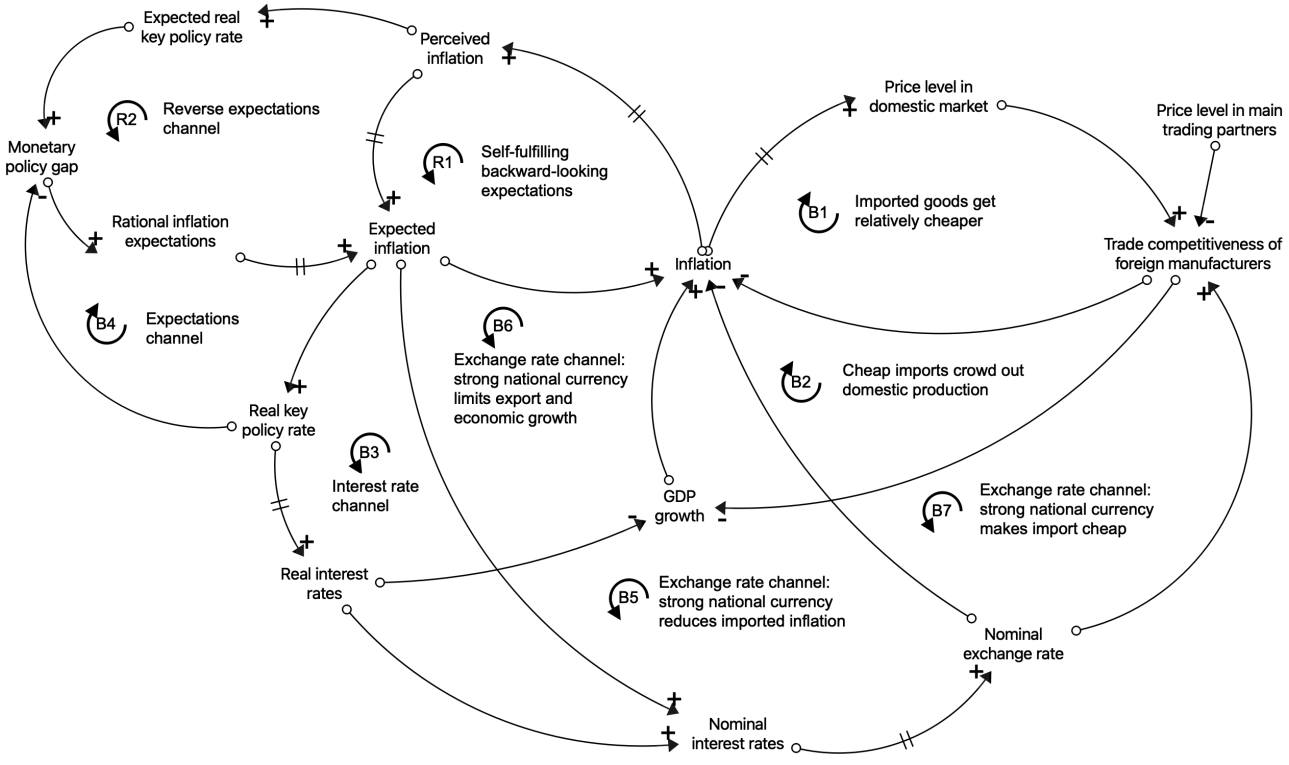

Figure 2.7. Causal Loop Diagram for key feedback mechanisms

Source: developed by authors in Stella Architect

Cheap imports crowd out domestic production (B2). This feedback loop is like B1, but here the influence of trade competitiveness on GDP growth is also considered. If we take the previously mentioned example of high persistent inflation in the domestic market, then we can also add that the increase in the demand for imported goods and services will decrease the demand for domestic ones. Also, exporters would not be able to sell as much as before in the foreign markets, because their prices became relatively high. As a result, GDP in the domestic economy will decrease and it will lead to a reduction in the demand-driven pressure on inflation.

Secondly, we need to discuss the feedback processes that are added when a central bank is using inflation-targeting monetary policy regime.

Interest rate channel (B3). When the forecasted inflation is higher than the inflation target, a central bank must increase its key policy rate. Real interest rates in the economy will increase as well because the key policy rate represents the cost of short-term borrowing for commercial banks. As a result, it will become more costly for firms to borrow money. Thus, investments will fall, and GDP growth will slow down. Slower GDP growth means less competition for resources in the domestic economy and smaller final demand, which would lead to a deceleration of inflation.

Expectations channel (B4). One of the key characteristics of inflation-targeting is public communication of the inflation target. A central bank is trying to convince the population that its actions will lead to the stabilization of inflation around the targeted rate in the medium term (1-2 years). And if a central bank is acting according to its vows, then the expected inflation will approach the inflation target.

Reverse expectations channel (R2). Conversely, if the actual actions of a central bank contradict the expected actions, inflation expectations will destabilize.

Exchange rate channel. It is assumed that higher interest rates in the domestic economy attract foreign investors, which is why the nominal exchange rate appreciates. This has a direct effect on inflation because the prices for imported goods become relatively lower (B5). At the same time, the appreciation of national currency increases the demand for foreign goods and services, which limits GDP growth (B6) and increases the proportion of relatively cheap imports in consumption (B7).

The structure of the model was developed as it was already mentioned based on the forecasting model that in its turn had been developed relying on modern mainstream macroeconomic thought. Rational inflation expectations were added to the sector of inflation expectations to make the expectations channel of the monetary transmission mechanism more explicit compared to the econometrics model. Most of the values for constant parameters in the model are taken from the quarterly projection model for Ukraine [54]. The values for other constant parameters are based either on assumptions or on the hand calibration of the model to historical data on inflation, inflation expectations, and the policy rate in Ukraine.

Next step is the model's sensitivity analysis, which is divided into 4 parts. The first three parts explore the sensitivity of key performance indicators to different values of individual parameters, and the parameters are separated into three groups because their involvement in the system behavior depends on the monetary policy regime that is used by a central bank. Also, policy sensitivity tests were conducted to explore the model sensitivity to constant parameters under different monetary policy regimes.

First parameters that are influencing the system independently of the monetary policy regime are considered. This group consists of constant parameters that stay active under each of the scenarios described in this article. That is why they were tested under all three scenarios to investigate the possible presence of leverage points that are independent of the monetary policy. Parameters were changed one at a time while other parameters remained the same for each of the tests in this part of the sensitivity analysis discussion. Stella's Model Analysis Tools were used with the following settings: Distribution – Uniform, Latin Hypercube sampling (Noise seed = 21), and 200 runs for each parameter under each scenario. The key results are presented in Table 2.3. The results indicate that the model is most sensitive to two variables: the adjustment time of inflation expectations and inflation sensitivity to the relative real exchange rate gap.

Table 2.3. Summary of results of the sensitivity tests for the parameters that are influencing the system independently of the monetary policy regime

Parameter [unit]	**Range**			**Sensitivity**	**Uncertainty about the actual value**
	Min	Used in the model	Max		
Time to perceive inflation [Year]	0.042	0.083	0.250	Numerical	Low
Time to adjust inflation expectations [Year]	1.000	2.000	4.000	High Numerical / Policy	High
GDP growth sensitivity to the relative gap of real exchange rate [(dmnl/Year)/(dmnl/Year)]	-0.400	-0.065	-0.010	Numerical	Average
Inflation sensitivity to the gap of GDP growth [(dmnl/Year)/(dmnl/Year)]	0.040	0.180	0.360	Numerical	Average
Inflation sensitivity to the relative real exchange rate gap [dmnl/Year]	-0.200	-0.060	-0.010	High Numerical / Policy	Average
Normal inflation [dmnl/Year]	0.010	0.130	0.250	Numerical	Average
Normal real interest rate [dmnl/Year]	0.015	0.030	0.060	Numerical	Average
Initial price level in domestic market [Units of national currency]	0.500	1.000	2.000	No	Low
Initial price level in main trading partner [Units of foreign currency]	0.500	1.000	2.000	No	Low

Source: calculated by authors in Stella Architect

The model shows both high numerical and policy sensitivity to the time to adjust inflation expectations parameter. This makes sense: if it takes longer to adjust inflation expectations then an ability of an exogenous shock to push inflation expectations higher would be limited (the reinforcing loop of self-fulfilling backward-looking expectation is weakened) and vice versa. Also, the results indicate that under inflation-targeting the development of inflation and inflation expectations

show enhanced oscillatory behaviour. This happens because the feedback loops that are added with inflation-targeting monetary policy regime force inflation to decelerate, while the actual monetary policy decisions are primarily dependent on the expected inflation which gets more volatile if there is a faster adjustment of the expectations. We could also see that under a combination of the monetary policy regimes (inflation-targeting and fixed exchange rate combined) oscillatory behavior is dampened. The reason for that is the fact that the fixed exchange rate makes the exchange rate channel of the monetary transmission mechanism inactive, which is why monetary policy becomes less effective in the deceleration of inflation. At the same time, it makes the deceleration of inflation smoother. There is also quite significant uncertainty about the real value of this parameter, which is why future research on this topic seems necessary.

The model shows both high numerical and policy sensitivity to the inflation sensitivity to the relative real exchange rate gap parameter. And similarly to the adjustment time of inflation expectations, under inflation-targeting monetary policy regime, the variation of this parameter affects the amplitude of oscillations of the key performance indicators. The reason for that is the dependency of the efficiency of the exchange rate channel of the monetary transmission mechanism on this parameter. A relatively large negative value of inflation sensitivity to the relative real exchange rate gap strengthens one of the balancing loops in the exchange rate channel, which is why monetary policy decisions affect inflation and inflation expectations faster.

Next step is to consider parameters that are introduced with inflation-targeting regime and stay active even if exchange rate is fixed (2 policy settings). This group consists of constant parameters that stay active either under a pure inflation-targeting monetary policy regime or under a combination of inflation-targeting with the fixed exchange rate regime. Parameters were changed one at a time while other parameters remained the same for each of the tests in this part of the sensitivity analysis discussion. Stella's Model Analysis Tools were used with the following settings: Distribution – Uniform, Latin Hypercube sampling (Noise seed = 21), and 200 runs for each parameter under each scenario. The key results are presented in Table 2.4.

Table 2.4. Summary of results of the sensitivity tests for the parameters that are introduced with inflation-targeting regime and stay active even if exchange rate is fixed

Parameter [unit]	**Range**			**Sensitivity**	**Uncertainty about the actual value**
	Min	Used in the model	Max		
Real interest rate adjustment time [Year]	0.250	0.500	1.500	Numerical	High
Monetary policy sensitivity to the gap of GDP growth [(dmnl/ Year)/(dmnl/Year)]	0.000	0.400	1.000	Numerical	Average
Monetary policy sensitivity to the inflation gap [(dmnl/Year)/ (dmnl/Year)]	1.000	2.000	4.000	High numerical / Policy	Average
GDP growth sensitivity to the gap of real interest rate [(dmnl/ Year)/(dmnl/Year)]	-0.400	-0.035	-0.010	Numerical	Average
Sensitivity of rational inflation expectation to monetary policy gap [(dmnl/Year)/(dmnl/Year)]	0.500	1.000	2.000	Numerical	High
Central bank credibility [dmnl]	0.000	0.150	1.000	High numerical	High

Source: calculated by authors in Stella Architect

Also, here we extend the number of key policy indicators and include the nominal key policy rate because this rate is the most important instrument of a central bank that is targeting inflation. The model shows relatively high numerical sensitivity to the monetary policy sensitivity to the inflation gap parameter under pure inflation targeting monetary policy regime. This is expected because higher monetary policy sensitivity to the inflation gap strengthens the link from the expected inflation to the real key policy rate, which is why the nominal key policy rate takes higher values faster and its effects on inflation appear faster as well.

Under the combination of inflation-targeting and fixed exchange rate high numerical sensitivity is observable only for the nominal key policy rate, while inflation and inflation expectations do not change that much as under pure inflation-

targeting. This is due to the inactivity of the exchange rate channel of the monetary transmission mechanism when the exchange rate is kept constant. In other words, even though the nominal exchange rate has already increased a lot, it does not affect inflation and inflation expectations that much. As a result, the deceleration of inflation is caused primarily by the loops that are not dependent on monetary policy.

The model shows relatively high numerical sensitivity to the central bank credibility parameter under pure inflation-targeting. This happens because increased central bank credibility makes both B4 and R2 feedback loops stronger. On the one hand, higher central bank credibility makes it easier to decrease inflation expectations as the population has trust in its central bank. On the other hand, inflation expectations become much more sensitive to monetary policy decisions and react faster to the discrepancies between the expected key policy rate and the actual one.

Finally parameters that become inactive if exchange rate is fixed were considered. This group consists of constant parameters that stay active only if the nominal exchange rate is allowed by a central bank to float. Parameters were changed one at a time while other parameters remained the same for each of the tests in this part of the sensitivity analysis discussion. Stella's Model Analysis Tools were used with the following settings: Distribution – Uniform, Latin Hypercube sampling (Noise seed = 21), and 200 runs for each parameter under only one scenario – inflation-targeting. The key results are presented in Table 2.5.

The results indicate that the model is highly numerical and to some extent behaviorally sensitive to the parameter of inflation sensitivity to the changes in the nominal exchange rate. This is a result of high uncertainty about the actual value of this parameter, especially during times of high macroeconomic volatility. As we can see from the sensitivity test, if this parameter is set to be equal to a relatively large negative value (-0.7), the inflation rate decreases fast after the end of the exogenous shocks because of a sharp increase of the nominal exchange rates that attract foreign capital in Ukraine, which is why the national currency appreciates. As a result, imported inflation slow down, and headline inflation slow down as well.

Table 2.5. Summary of results of the sensitivity tests for the parameters that become inactive if the nominal exchange rate is fixed

Parameter [Unit]	**Range**			**Sensitivity**	**Uncertainty about the actual value**
	Min	Used in the model	Max		
Nominal exchange rate adjustment time [Year]	0.500	1.000	1.500	Numerical	Average
Elasticity of nominal exchange rate to the gap of nominal interest rate [dmnl]	0.125	0.250	0.500	Numerical	High
Inflation sensitivity to the changes of the nominal exchange rate [(dmnl/Year)/(dmnl/Year)]	-0.700	-0.050	-0.010	High numerical / Behavioral	High
Normal fraction for coverage of exchange rate volatility with foreign exchange interventions [dmnl]	0.075	0.150	0.300	Numerical	Low

Source: calculated by authors in Stella Architect

Next step is to evaluate macroeconomic resilience under three monetary policy regimes: inflation-targeting, fixed exchange rate, a combination of inflation-targeting and fixed exchange rate.

The first simulation scenario represents the actual monetary policy used in 2015-2021. The graphs in Figure 6. show the comparison of the historical behaviour of the key performance indicators with the results of the simulation. Accounting for the role of exogenous inflationary shock in 2015, the model was able to reproduce the historical trends relatively well. But the simulated development of the nominal key policy rate shows higher ranges of fluctuations. It can be explained by the fact that, in reality, the central bank of Ukraine is not willing to increase its key policy rate above the range of 25-30% as the productive influence of such changes on inflation degrades on such levels of interest rates, which is why the central bank is forced to use its other instruments to affect prices.

In the first year of the simulation, we observe that in addition to exogenous shocks inflation also accelerates due to self-fulfilling backward-looking inflation

expectations, while it takes a long time for inflation to affect trade competitiveness and international trade, which is why B1 and B2 have small effects amid the crisis. At the same time, the nominal key policy rate is growing sharply as the central bank is trying to counteract the reinforcing loop of inflation expectations and deal with the aftermath of the exogenous inflationary shock for inflation expectations.

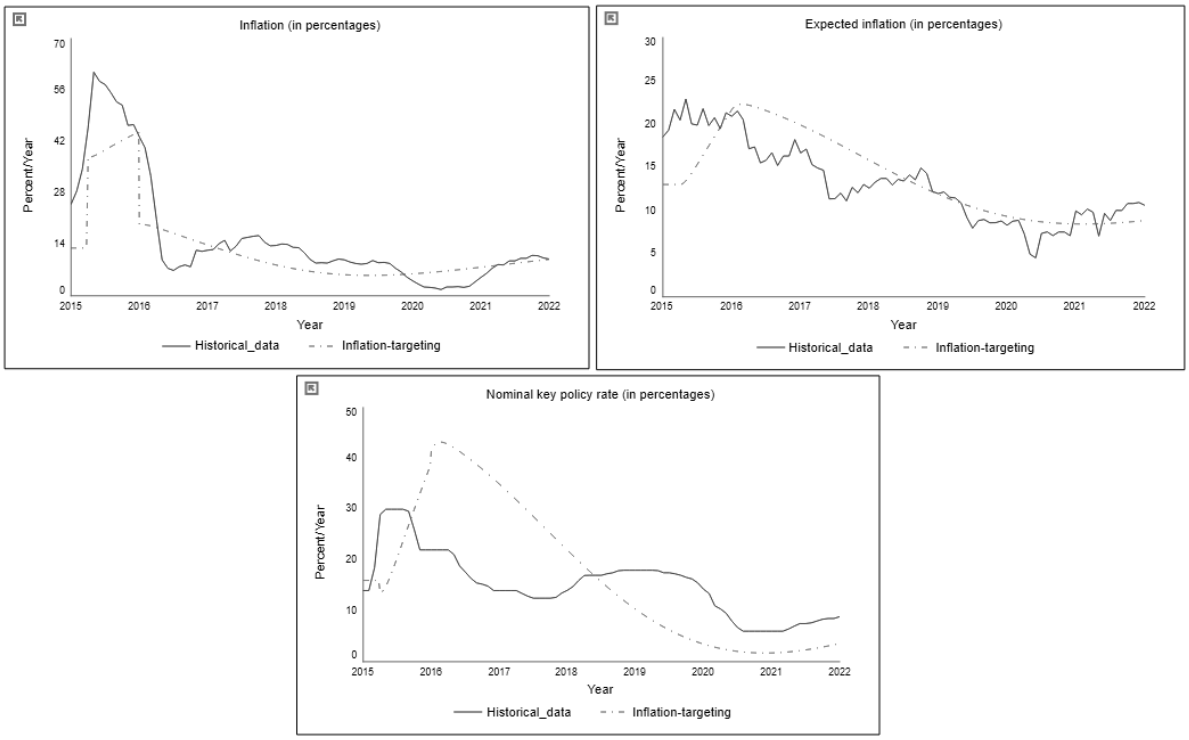

Figure 2.8. Behaviour of key performance indicators under inflation-targeting
Source: developed by authors in Stella Architect

After the exogenous shock is gone, the monetary transmission channels and the major balancing loops that are independent of the monetary policy start to decelerate inflation. But their effects have unequal delays, which is why in 2017 inflation is already lower than the initial normal level (13%) and still decelerating. It reaches the range of 5-6% in 2019 and starts to accelerate again as the monetary policy becomes expansionary. It should be noted that in the model the monetary policy has two goals: 1) stabilisation of inflation around its normal level (i.e., inflation target); 2) promotion of sustained economic growth when this goal does not contradict the first one. The same is observed in the real world. That is why, after inflation has been significantly decelerated, the second goal starts to grow in

importance for the central bank and the nominal key policy rate becomes even lower to stimulate the growth of GDP. As a result, by the end of the simulation inflation is around 10% per year and is close to its anchor i.e., inflation expectations (around 9%).

The role of the expectations channel is ambiguous. People judge the actions of the central bank by looking at the current inflation rate, while the central bank does not care and should not care that much about the currently perceived inflation rate which represents the past events, but about the future inflation as its policy is always future-oriented. In the model, this difference in anchors is captured by assuming that the central bank sets its key policy rate by looking at the inflation expectations which is a dynamic anchor for actual inflation, while the population judges the appropriateness of the nominal key policy rate by looking at the perceived inflation. As a result, during the simulation, the perceived (by the population) difference between the required key policy rate and the actual one (monetary policy gap) is very high in 2015: the central bank increases its key policy rate after it observes that inflation expectations get out of control, but such actions are viewed by the population as too weak and too delayed. On the other hand, in 2016-2020 the monetary policy is perceived to be too contractionary, which is why the future-oriented component of inflation expectations falls significantly.

Secondly, fixed exchange rate monetary policy regime scenario was simulated. If we consider the hypothetical situation in which in 2015 the central bank of Ukraine decided to adhere to its conventional policy of the fixed exchange rate, the development of key performance indicators would be different (Figure 2.9), though not too problematic. The graph of the key policy rate is not shown here as under the policy of fixed exchange rate a central bank is not trying to affect the interest rates in the economy, which is why the key policy rate becomes useless. It should also be mentioned that the key advantage of the fixed exchange rate monetary policy regime is the relative security it provides for the economic agents who hold assets nominated in the national currency. This is especially true during times of significant macroeconomic instability when there is a great risk of capital outflow from the country.

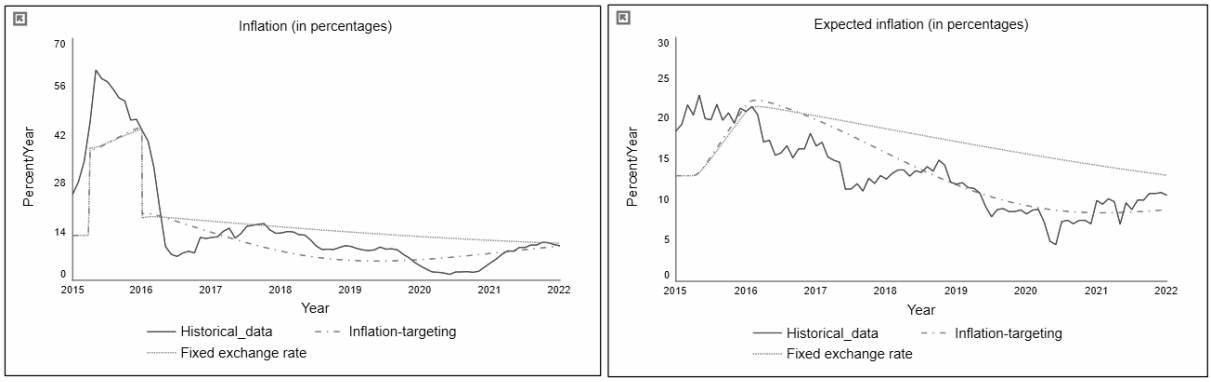

Figure 2.9. Behaviour of the key performance indicators under fixed exchange rate monetary policy regime

Source: developed by authors in Stella Architect

As can be seen, inflation and inflation expectations still converge to normal levels relatively fast. Even though all feedback loops that are added by inflation-targeting are turned off in this scenario, the influence of the accumulated over the crisis period gap of trade competitiveness forces the growth rate of domestic prices to slow down (B1 and B2 have a significant influence). Such results suggest that even though the chosen monetary policy regime was relatively efficient in the short and medium term, in the long-run active monetary policy has a relatively small effect on the overall price level. This is consistent with New Keynesian thought in macroeconomics.

Final step is to explore scenario of a combination of inflation-targeting and fixed exchange rate. This is an especially important scenario as currently (2023) NBU operates in a monetary policy setting that corresponds to this scenario. As it can be seen, the deceleration of inflation and the decrease of inflation expectations happen a little slower than under pure inflation-targeting. The reason for this is that the fixed exchange rate makes exchange rate channel (B5, B6, B7) of the monetary transmission mechanism inactive which is why the increased inflow of foreign capital into the domestic economy that follows the increase of the interest rates in the economy is not affecting the nominal exchange rate and does not help to slow down inflation in short and medium-term.

Interestingly, the key policy rate does not decrease as much by the end of the simulation as it did under pure inflation-targeting. This happens because due to the inactivity of the exchange rate channel the trade competitiveness of domestic manufacturers in the international market has not been worsened additionally to the effects of the exogenous shocks (inactive B6), which is why the GDP growth has been higher. Higher GDP growth prevented the central bank from further decreasing its key policy rate when expected inflation reached its normal range. Such results reveal a peculiar advantage of a combination of the fixed exchange rate with inflation-targeting: if a central bank of a small open economy is not willing to sacrifice economic growth for faster deceleration of inflation, it might use the fixation of the nominal exchange rate to "steal" some economic growth from the main trading partners by making the domestic manufacturers relatively more competitive in the international market.

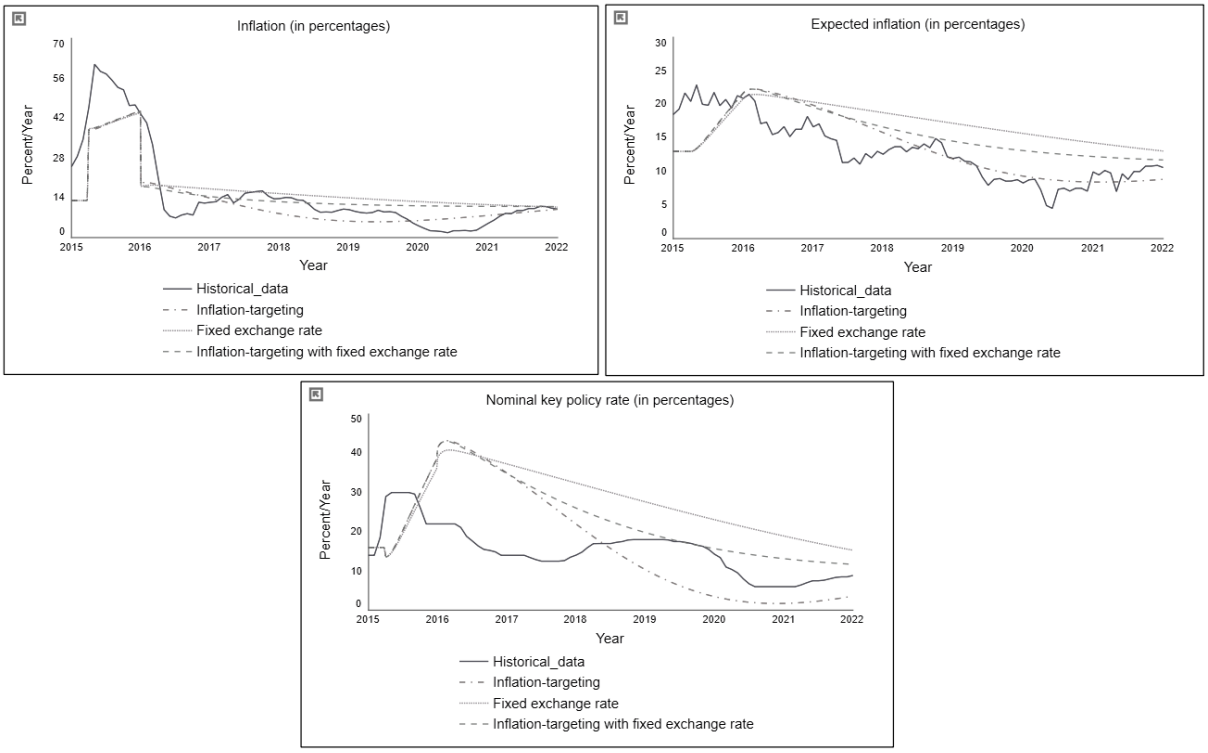

Figure 2.10. Behavior of key performance indicators under inflation-targeting with fixed exchange rate

Source: developed by authors in Stella Architect

Also, the results of the sensitivity analysis indicate that there is significant numerical sensitivity of the key performance indicators to the changes in inflation sensitivity to the relative real exchange rate gap under all three settings of the monetary policy. This parameter represents the degree of involvement of an economy in international trade and defines the speed of influence of foreign prices on domestic ones. Essentially, during the simulations, a high absolute value of this parameter helps inflation rates in domestic and foreign economies to converge to their normal value faster. That is why, even if there is no central bank in an economy, inflation could still be not very volatile if there are no barriers to international trade.

Model analysis revealed that under classical inflation-targeting (no fixed exchange rate) inflation and inflation expectation decrease the fastest. At the same time, the effect of monetary policy of any type on inflation deceleration has been found to be relatively insignificant in the medium- and long-term as it is the competition in the international trade that forces the prices in different economies to converge in the model. On the one hand, this conclusion stresses the importance of liberalization of international flows of goods, services, labor, and capital. On the other, it shows that model leaves outside of its boundary significant factors that should be accounted for to make a more comprehensive policy recommendation. In particular, the model does not consider technology and labor productivity differences between trading partners, and the positive structural changes in an economy that are triggered by a more transparent monetary policy (savings in the national currency become more popular, financial market develops faster due to a more predictable interest rate policy). Thus, further research aimed at the incorporation of these factors into the model seems necessary.

The main outcome recommendation is to return to the classical inflation-targeting without a fixed foreign exchange rate as soon as Ukraine wins the war. Also, it is crucial to develop the infrastructure and improve the regulatory conditions for the stock, bond, and mortgage markets to strengthen the monetary transmission mechanism.