National Bank of Ukraine

NBU Working Papers

02/2022

Endogenous Monetary Policy Credibility in Ukraine

Kateryna Savolchuk, Anton Grui

The NBU Working Papers

The NBU Working Papers present independent research by employees of the National Bank of Ukraine (NBU) or by outside contributors on topics relevant to central banks. The Working Papers aim is to provide a platform for critical discussion. They are reviewed internationally to ensure a high content quality. The opinions and conclusions in the papers are strictly those of the author(s) and do not necessarily reflect the views of the National Bank of Ukraine or of the members of the Board of the National Bank of Ukraine.

This publication is available on the NBU's website at **www.bank.gov.ua**.

Address:

9 Instytutska Street

01601, Kyiv, Ukraine

research@bank.gov.ua

Endogenous Monetary Policy Credibility in Ukraine

Kateryna Savolchuk[a], Anton Grui[a]

[a]National Bank of Ukraine

E-mail: Kateryna.Savolchuk@bank.gov.ua

Anton.Grui@bank.gov.ua

Abstract

In this paper, we introduce endogenous monetary policy credibility into a semi-structural New Keynesian model. The model is estimated based on data for Ukraine, which de facto adopted inflation-targeting at the end of 2015. We model credibility as a nonlinear function of two gaps – actual and expected deviations of inflation from its target. Credibility is asymmetric as above-target inflation reduces it more than below-target. We show how low policy credibility can make economic stabilization more costly, and expansionary policy – counterproductive. It can also generate the price puzzle. Furthermore, we estimate the historical path of monetary policy credibility in Ukraine.

Keywords: New Keynesian model, monetary policy credibility, inflation expectations

JEL classification: C51, E52, E58

1. Introduction

Monetary policy credibility reflects economic agents' perceptions of what a central bank does and whether it is able to achieve its objectives. The concept became essential for policymakers since many central banks have adopted inflation-targeting regimes to maintain low and stable inflation.

Lack of monetary policy credibility manifests itself in the economics agents' uncertainty and unanchored inflation expectations. In turn, this affects economic agents' decisions about future investment and saving, as well as the process of setting wages and prices. Lack of credibility entails a negative impact on output and inflation volatility. On the contrary, gains in credibility ensure the efficiency of monetary policy transmission mechanisms, help anchor inflation expectations, and reduce inflation volatility.

This paper introduces nonlinear endogenous monetary policy credibility into a semi-structural model of a small open economy. Without this proposed extension, this model is a simplified version of the Quarterly Projection Model in gaps, which many central banks use for policy analysis and macroeconomic forecasting.[1] The model is applied to Ukrainian data in the period of inflation targeting.

The proposed approach of modeling policy credibility closely relates to Lalonde (2005). However, our approach differs in several ways. First, the functional form of credibility is asymmetrical. Positive deviations of inflation from the target lead to greater credibility loss than negative deviations of the same size. Second, credibility is gained and lost only gradually. Persistent deviations of inflation from the announced goal destroy credibility more than short-lasting deviations. Third, a drop in credibility creates a positive inflation expectations bias, which generates additional upward pressure on expectations and, consequently, on inflation. The bias is modeled like in Isard et al. (2001).

In this paper, we show that the costs of economic stabilization strongly depend on initial levels of credibility. First, inflation stabilization after a supply shock is more costly for a central bank with a low level of credibility. Monetary policy should react more aggressively to avoid further erosion of credibility. Therefore, the economy incurs greater losses in economic activity. Second, we simulate asymmetric responses to contractionary and expansionary monetary policy shocks. In the case of initially low credibility, expansionary monetary policy shocks do not stimulate the economy. The central bank is forced to sharply raise the policy rate in response to accelerated inflation.

[1] For instance, the National Bank of Ukraine (Grui and Vdovychenko, 2019), the South Africa Reserve Bank (Botha et al., 2017), the National Bank of Georgia (Tvalodze et al., 2016), Central Bank of India (Benes et al., 2017).

Low levels of credibility can also explain the price puzzle. Biased inflation expectations make inflation temporarily increase in response to a contractionary monetary policy shock.

We estimate historical monetary policy credibility in Ukraine using the Kalman filter. We find that the National Bank of Ukraine (NBU) used to have a relatively low level of credibility in the first year of inflation targeting. However, it climbed to moderate levels in subsequent years.

The paper is organized as follows. Section 2 provides a literature review on monetary policy credibility. Section 3 presents recent monetary policy and inflation developments in Ukraine. The model's key equations and Bayesian estimation of parameters are presented in sections 4 and 5, respectively. Section 6 discusses model properties. Simulated historical credibility is offered in section 7. Section 8 summarizes the research.

2. Literature Review on Policy Credibility

Literature proposes several definitions of monetary policy credibility. One of the widely used definitions was introduced by Blinder (2000). The author states that "a central bank is credible if people believe it will do what it says." However, according to a survey conducted among central bankers and economists, the definition of credibility is different for the two groups of respondents. Central bankers tend to link the credibility to a degree of dedication to price stability more closely than economists do. Anyway, both economists and central bankers think that it is necessary for a central bank to "have a history of doing what it says it will do" to be credible.

Cukierman and Meltzer (1986) define credibility as a gap between what policymakers plan and what economic agents believe about those plans. The authors interpret credibility as a speed at which the public perceives changes in monetary policy objectives. According to this, a central bank is less credible if the public needs more time to perceive changes in objectives. Therefore, the longer it takes for the public to recognize changes, the longer it remembers events that happened a long time ago and the less weight economic agents attach to recent developments in shaping their expectations.

Both approaches agree that higher central bank credibility makes inflation expectations of economic agents more anchored to pre-announced targeted levels. Therefore, inflation expectations are an important workhorse for understanding the credibility concept.

Empirical and theoretical studies consider inflation expectations as a key factor in determining the inflation process. According to Mishkin (2007) and Bems et al. (2018), better-anchored inflation expectations decrease the persistence of inflation. Moreover, the effects of temporary shocks on inflation are reduced since the public does not overreact to variations in economic activity.

It is worth noting that "anchoring of inflation expectations is not a deus ex machina" (Mishkin, 2007). Monetary policy actions must be the driving force in changing the development of inflation expectations. A transparent policy and communication strategies are needed to manage expectations (Faust and Svensson, 2001, Bernanke et al., 2000). A better understanding of how the public forms inflation expectations can improve the central bank's ability to evaluate its credibility level and outcome of policy actions, as well as its ability to forecast inflation (Bernanke, 2007).

The importance of credibility in monetary policy was considered by Faust and Svensson (2001). They claim that a central bank with a low level of credibility should conduct a less expansionary policy compared to a central bank that enjoys a high level of credibility. In addition, as further loss of credibility is undesirable, a less credible central bank has smaller room to stabilize the economy.

Credibility is important for monetary policy to be efficient. Blinder (2000) suggests that it makes the disinflationary process less costly and helps keep low inflation once it has been achieved. Under certain assumptions, a fully credible central bank can even introduce disinflation without any negative consequences for employment. Therefore, credibility provides a possibility to minimize the cost of disinflationary policy and volatility of economic indicators.

Svensson (1993) proposes a way to test whether a policy is credible or not, but not a direct methodology to measure it. The author compares market real interest rates with target-consistent real yields to test credibility. The strong and weak concepts of credibility are considered, namely absolute credibility and credibility in expectations. In the case of the former, the public believes that there is a zero probability that the central bank will not achieve the target. In the case of the latter, there is some probability of not hitting the target. However, the author states that such an indirect approach to testing credibility can be simplified with the increased availability of survey data on expected inflation.

Furthermore, the literature offers several approaches to the direct measurement of credibility. King (1995) measures credibility as the gap between long-term inflation expectations and the inflation target. The author uses nominal and index-linked bonds for the empirical estimation of the public's long-term inflation expectations.

Generally, literature proposes to model credibility as an index that fluctuates in a range from 0 (no credibility) to 1 (perfect credibility). In addition, credibility is allowed to determine the process of expectation formation in the economy.

One of those approaches was introduced by Bomfim and Rudebusch (2000). They propose three mechanisms for establishing credibility: outcome, behavior, and announcement. According to the first and the second mechanisms, credibility is gained if a central bank managed to reach its target in the past and if future inflation is believed to be close to the target. According to the third, the central bank is credible if it announces a transparent goal for inflation. Based on the first two approaches, the authors measure credibility as a linear function of the gap between past or expected inflation and the announced monetary policy objective. They model the public's inflation expectations as a weighted sum of an inflation target and recently realized inflation, where relative weights depend on the credibility. Therefore, in forming inflation expectations, the public assigns a higher weight on a target if a central bank is credible.

Bomfim and Rudebusch (2000) used the proposed credibility index to compare the ability of "deliberate" and "opportunistic" policies to achieve disinflation. The deliberate policymakers take consistent actions to reach the announced inflation target. In contrast, opportunistic policymakers avoid deliberate action and wait for unexpected shocks to reduce inflation. Concrete actions of deliberate policy help gain credibility faster and reduce the sacrifice ratio.

The approach introduced by Bomfim and Rudebusch (2000) was extended by Lalonde (2005). The author defines credibility as a weighted combination of outcome and behavior credibility, and nonlinearly relates it to the distances of past and expected inflation to the target. The author considers credibility that can be symmetrically lost due to either upward or downward deviations of inflation from the target.

Isard et al. (2001) propose another approach to measuring credibility. They consider a two-stage regime-switching model, according to which the economy can be in a mode of either low or high inflation. They define credibility as a probability to stay in the low-inflation regime. According to them, credibility losses due to positive deviations of inflation from the target are higher compared to losses from the negative deviations.

Laxton and Diaye (2002) empirically confirm the assumption that variations in long-term interest rates are mainly caused by variations in inflation expectations. Based on this, the authors use long-term bond yields to measure monetary policy credibility for several industrialized countries. Similarly to Isard et al. (2001), they model credibility as the probability to stay in the low-interest rate regime. Therefore, if the long-term interest rate is low, then credibility is high and vice versa. They show that a crude measure of credibility improves the performance of out-of-sample forecasting.

Levieuge et al. (2018) compute credibility for a large set of emerging economies under IT regimes using survey-based inflation expectations. They define credibility based on the difference between agents' inflation expectations and the inflation target. The authors found that countries could suffer from a low initial level of credibility if they did not fully meet the preconditions for adopting an IT framework. In addition, they empirically confirm that higher monetary policy credibility negatively affects the variance of the short-term policy rate. Finally, they emphasize that the exchange rate is also affected by credibility. Lack of credibility leads to the vulnerability of the economy to speculative attacks.

Istrefi and Piloiu (2014) study inflation expectations in the US and the euro area. They indicate that policy-related uncertainty poses upside risks to professional forecasters. Higher uncertainty leads to both contracting economic activity and rising long-term inflation expectations.

Carriere-Swallow et al. (2016) find evidence that credibility substantially reduces the exchange rate path-through to prices.

Furthermore, several studies extend standard gap models with the time-varying process of monetary policy credibility. These models are a semi-structural representation of the New-Keynesian model of a small open economy. They are widely used among central banks with IT frameworks, particularly by the National Bank of Ukraine. For a conceptual overview of such a model for the Ukrainian economy (without time-varying monetary policy credibility), see Grui and Vdovychenko (2019).

Based on the index proposed by Isard et al. (2001), several authors incorporate endogenous monetary policy credibility in semi-structural models for different economies. Argov et al. (2007) consider the case of Israel, Benes et al. (2017) the case of India, and Chansriniyom et al. (2020) the case of Indonesia and the Philippines. They try to explain the behavior of these economies in periods of interest: a sharp drop in interest rates (Israel), capital outflow, exchange rate depreciation, as well as the volatility of financial markets (Indonesia) and high inflation (Philippines). The authors found that the extended model more accurately reproduces the development of economic variables in periods of a lack of credibility.

In addition, Alichi et al. (2008) extend a gap model with policy credibility. The authors note that unfavorable supply shocks make the disinflationary path more difficult in a less credible economy due to second-round effects. In addition, they emphasize the importance of timely monetary policy response. Delayed response leads to the destruction of credibility, de-anchoring of expectations, and more prolonged output losses. Therefore, stagflation is the price of a delayed policy reaction.

3. Monetary Policy and Inflation in 2015–2021

The NBU de facto adopted inflation targeting at the end of 2015 and pursued a disinflation agenda in 2016–2019. The policy regime switch occurred amid an inflation outbreak (Figure 1) caused by a major devaluation after a long period of the fixed exchange rate. Under inflation targeting, a short-term interest rate is the main monetary policy instrument, while the exchange rate remains floating. Foreign exchange interventions serve as an additional policy instrument.

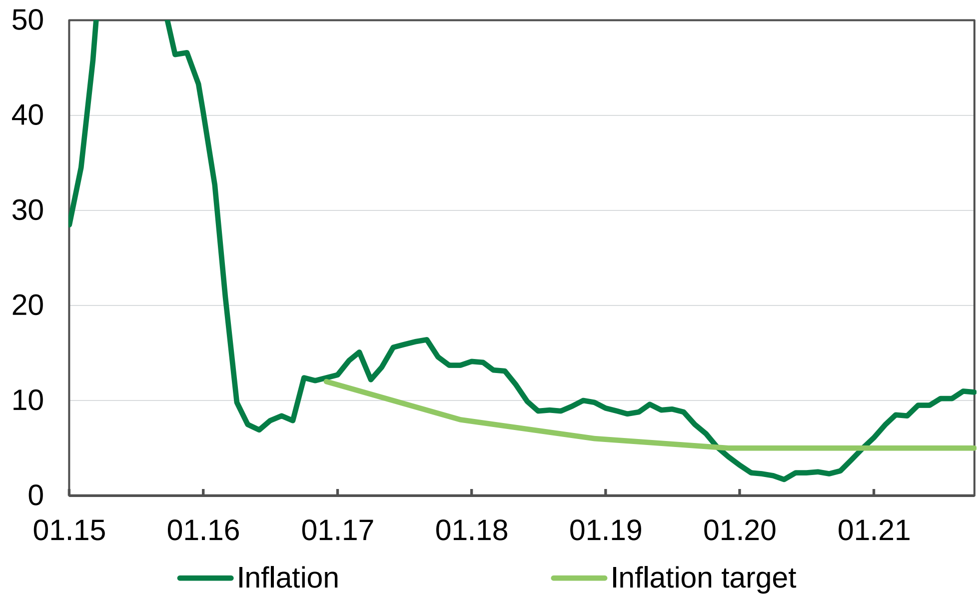

Figure 1. Inflation and Its Target, %, yoy
Source: National Bank of Ukraine

In 2014–2015, Ukraine was simultaneously hit by three crises, which intensified each other. First, the annexation of Crimea and the military conflict in 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 a 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.

The inflation target descended from 12±3% in 2016 to 5±1% in 2019. Gradual disinflation was needed to minimize negative consequences for economic growth and to adjust administratively regulated prices to market-justified levels.

The mid-term inflation target in Ukraine is 5±1%, which is relatively high in comparison with developed inflation targeters. This is for several reasons. First, a higher target helps anchor inflation expectations given historically high and volatile inflation in Ukraine. Second, the higher target is in line with the Balassa-Samuelson effect. Prices are expected to grow faster in countries that catch up in productivity with more advanced partners. Finally, the higher inflation target allows for more nominal interest rate flexibility during downturns.

Inflation quickly diminished to the target in 2016. However, it remained elevated in 2017–2018. It decreased to the mid-term target in 2019 and spent most of 2020 below the target amid the COVID-19 pandemic and subdued demand.

The inflation target variable in the proposed model follows official targets in 2016–2021. On the preceding horizon, it is assumed to be equal to 12%, which is close to the historic average of 12.2% in 2001–2015. The coefficients of the model are estimated using Bayesian techniques on the 2016–2021:3 sample.

Inflation expectations were gradually improving amid disinflation. After a peak in 2015, they decreased towards the announced inflation target albeit with a noticeable positive bias (Figure 2).

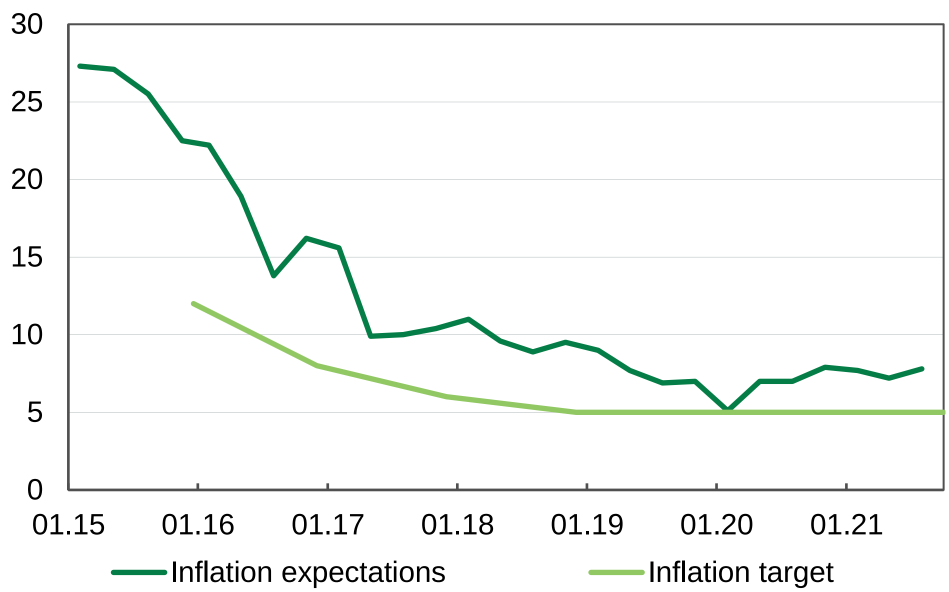

Figure 2. One-year Ahead Inflation Expectations of Non-Financial Corporations[2] and One-Year Ahead Inflation Target, %, yoy
Source: National Bank of Ukraine
Note: Both expectations and the target are one-year ahead. Therefore, for example, the value for expectations in August 2021 is what y-o-y inflation is expected to be in August 2022. The inflation target is respectively expected to remain at 5% for the following 12 months.

Inflation expectations remained above the target in 2016–2021. This is true even for the period of below-the-target inflation in 2020. Such persistency marks a positive bias in inflation expectations of non-financial corporations.

The convergence of the expectations to the target remarkably stalled at the end of 2017 and continued only in 2019. This indicates worsening monetary policy credibility due to a period of high

[2] About 600-700 responders pick among inflation intervals to answer the question of how much consumer prices will change in percentage over the next 12 months.

inflation in 2017 through the first half of 2019. Generally, the better the policy credibility, the closer to the target inflation expectations should be.

The Phillips curve in the proposed model is augmented with observed inflation expectations of non-financial corporations. The equation for the expectations contains three components. The first and the second ones are backward-looking and a forward-looking terms, which attribute some weights to the inflation target. They lose these weights and become equal to a combination of adaptive and rational expectations in case of zero policy credibility. The third term is a bias, which grows with low credibility. Inflation expectations are designed to approach the inflation target when credibility grows.

One-fifth of the consumer basket bears administratively regulated prices, which only weakly react to monetary policy. Prices for such goods and services are heavily regulated by central and local authorities. Among them are mostly utilities, excisable alcohol and tobacco, and transportation. The relatively high share of regulated prices is a legacy of the long period of the centrally planned economy in Ukraine.

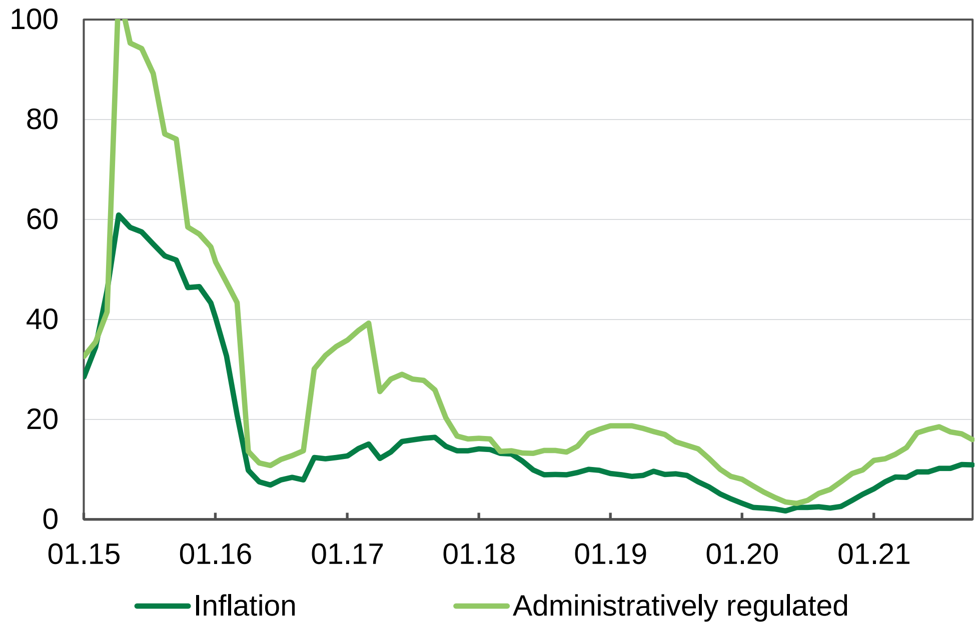

Figure 3. Inflation and Its Administratively Regulated Component
Source: National Bank of Ukraine

Administratively regulated prices were outpacing others in 2015–2021 (figure 3). Adjustments were needed to correct unsustainably low prices for utilities and to harmonize excise taxes with the corresponding rates in the European Union.

Growing prices for utilities were the main drivers of peaking administratively regulated inflation in 2015 and 2016–2017. Increasing tobacco excise taxes may keep the component high in the years to come (NBU, 2020).

The Phillips curve in the proposed model contains an administratively regulated component. It is modeled with an autoregressive process and treated as an exogenous variable.

4. **Key Equations of the Model**

This section presents the key equations of the semi-structural model of a small open economy. The model is in “gaps” – such models are widely used within inflation-targeting central banks. Gaps mean percentage deviations of actual values of variables from their trends. In the model, all gaps and trends are not directly observable. Instead, they are obtained using the Kalman filter and, for initial estimations, using the Hodrick-Prescott filter.

IS Curve

Output gap ($\hat{y}_t$) is modeled with an open economy investment-savings curve.

$$\hat{y}_t = \alpha_1 \hat{y}_{t-1} - \beta_1 * rmci_t + \delta_1 \hat{y}_t^* + \theta_1 \widehat{tot}_t - \mu_1 \widehat{prem}_t + \varepsilon_{1,t} \quad (1)$$

$$rmci_t = \gamma_1 \left(-\widehat{lr}_t\right) + (1 - \gamma_1) \hat{z}_t \quad (2)$$

To present the persistence of business cycle, the output gap is related to its own lagged value ($\hat{y}_{t-1}$).

The real monetary conditions ($rmci_t$) term reflects the impact of monetary policy on the domestic economy through interest rate and exchange rate transmission channels. The index is the weighted average of the real credit rate gap ($\widehat{lr}_t$) and the real effective exchange rate gap ($\hat{z}_t$). The decisions of economic participants about consumption and savings are captured by the real credit rate. A process of substitution of domestic goods by foreign ones and vice versa is reflected by the real effective exchange rate.

In addition, the foreign output gap ($\hat{y}_t^*$) and commodity terms-of-trade gap ($\widehat{tot}_t$) are included to capture the effects of trading partners’ demand on domestic goods.

Incorporation of the risk premium gap ($\widehat{prem}_t$) reflects negative effects that perceived sovereign risk poses to domestic investment and, consequently, demand.

The term $\varepsilon_{1,t}$ represents a demand shock.

Phillips Curve

Annualized quarterly inflation (π_t) is modeled with a Phillips curve.

$$\pi_t = \alpha_2(\pi4_t^e + \beta_2 rmc_t) + (1-\alpha_2)\pi_t^{admin} + \varepsilon_{2,t} \quad (3)$$

$$rmc_t = \gamma_2\hat{y}_t + (1-\gamma_2)\hat{z}_t \quad (4)$$

Inflation is determined by four-quarters-ahead inflation expectations ($\pi4_t^e$) and real marginal costs (rmc_t). The latter are presented as a weighed sum of output gap ($\hat{y}_t$) and real effective exchange rate gap ($\hat{z}_t$). These gaps are approximation of domestic producers' and importers' marginal costs, respectively.

In addition, the Phillips curve accounts for the impact of an administratively regulated inflation (π_t^{admin}).

In our setting, administrative inflation follows an autoregressive process.

$$\pi_t^{admin} = \ \alpha_3\pi_t^{admin} + (1-\alpha_3)\pi_t + \varepsilon_{3,t} \quad (5)$$

The terms $\varepsilon_{2,t}$ and $\varepsilon_{3,t}$represent supply and administrative inflation shocks, respectively.

Inflation Expectations

The four-quarters-ahead year-over-year inflation expectations are modeled as a weighed sum of backward-looking ($\pi4_{b_t}^e$) and forward-looking ($\pi4_{f_t}^e$) inflation expectations, as well as an inflation expectations bias. They are observed as the expectations of non-financial corporations.

$$\pi4_t^e = \alpha_4\pi4_{b_t}^e + (1-\alpha_4)\pi4_{f_t}^e + b_t + \varepsilon_{4,t} \quad (6)$$

Backward-looking inflation expectations ($\pi4_{b_t}^e$) are a weighed combination of a lagged inflation target ($\pi4_{t-1}^T$) and a lagged annual inflation ($\pi4_{t-1}$).

$$\pi4_{b_t}^e = c_t^o\beta_4\pi4_{t-1}^T + (1-c_t^o\beta_4)\pi4_{t-1} \quad (7)$$

Forward-looking agents, in turn, take into consideration future inflation target ($\pi4_{t+4}^T$) and model-consistent four-quarter-ahead inflation expectations ($\pi4_{t+4}$).

$$\pi4_{f_t}^e = c_t^a\beta_4\pi4_{t+4}^T + (1-c_t^a\beta_4)\pi4_{t+4} \quad (8)$$

The weights that both group of agents assign to inflation target depend on the stocks of outcome credibility (c_t^o) and action credibility (c_t^a), as well as on a parameter β_4. Both credibility stocks can range from zero (no credibility) to one (full credibility). In the case of perfect credibility, inflation expectations are more anchored. Parameter β_4 is the weight that agents assign to a target in the case of a fully credible monetary policy.

The term $\varepsilon_{4,t}$ represents an inflation expectations shock.

Our specification resembles those from behavioral macroeconomic models, e.g., De Grauwe and Ji (2020), where economic agents switch between forecasting rules based on their past performances. Forecasting rules in our model range from naïve (backward-looking) to underlying model (forward-looking) to fundamentalist (target). Weights before the rules depend on the time-varying monetary policy credibility.

Outcome and Action Credibility

Outcome credibility (c_t^o) reflects the perception of the central bank's past success in achieving the inflation target by backward-looking agents. Since credibility can be gained or lost only gradually, it depends on its lagged value (c_{t-1}^o). Outcome credibility responds to a signal (ξ_t^o).

$$c_t^o = \rho_1 c_{t-1}^o + (1-\rho_1)\xi_t^o \tag{9}$$

$$\xi_t^o = e^{-\frac{(\pi 4_{t-1} - \pi 4_{t-1}^T)^2}{2\theta^2}}, \tag{10}$$

where $\theta = \theta_2$ if $\pi 4_{t-1} - \pi 4_{t-1}^T \geq 0$ and $\theta = \theta_3$ otherwise, $\theta_2 < \theta_3$.

The signal to credibility nonlinearly depends on a gap between the past year-over-year inflation and inflation target ($\pi 4_{t-1} - \pi 4_{t-1}^T$), as well as on the parameter θ, which displays agents' sensitivity to inflation deviation from the target level. The lower is the value of the parameter θ, the more sensitive are agents to the gap between inflation and the target.

In our setting, the parameter θ depends on whether the deviation of inflation from the target is positive or negative. Negative deviation makes the parameter θ higher to ensure lower sensitivity of economic participants to below-target inflation. Therefore, the signal to credibility is asymmetrical: the loss in credibility is higher due to the positive deviation of inflation from the announced target.

The signal equals 1 if inflation matched the target level in the past ($\pi 4_{t-1} - \pi 4_{t-1}^T = 0$). If monetary policy has recently failed to reach its inflation objective, then signal to credibility is low. Loss in outcome credibility entails less anchored and more backward-looking expectations.

Above-target inflation reduces credibility more than below-target inflation. Therefore, positive deviations are costlier than negative ones. Chansriniyom et al. (2020) notes the intuitiveness of such approach. Public "penalizes" above-target episodes because price stability is more associated with low inflation than with high inflation. Furthermore, past economic crises in Ukraine were mostly accompanied by devaluations and inflation outbreaks.

The magnitude of credibility signal strongly depends on the values taken by the parameter θ (Figure 4). For example, if θ is 1.3, when inflation exceeds the target, and 2.6 otherwise, then a positive deviation of one percentage point leads to a signal of 0.74. In turn, a negative deviation of the same size leads to a 0.93 signal to credibility.

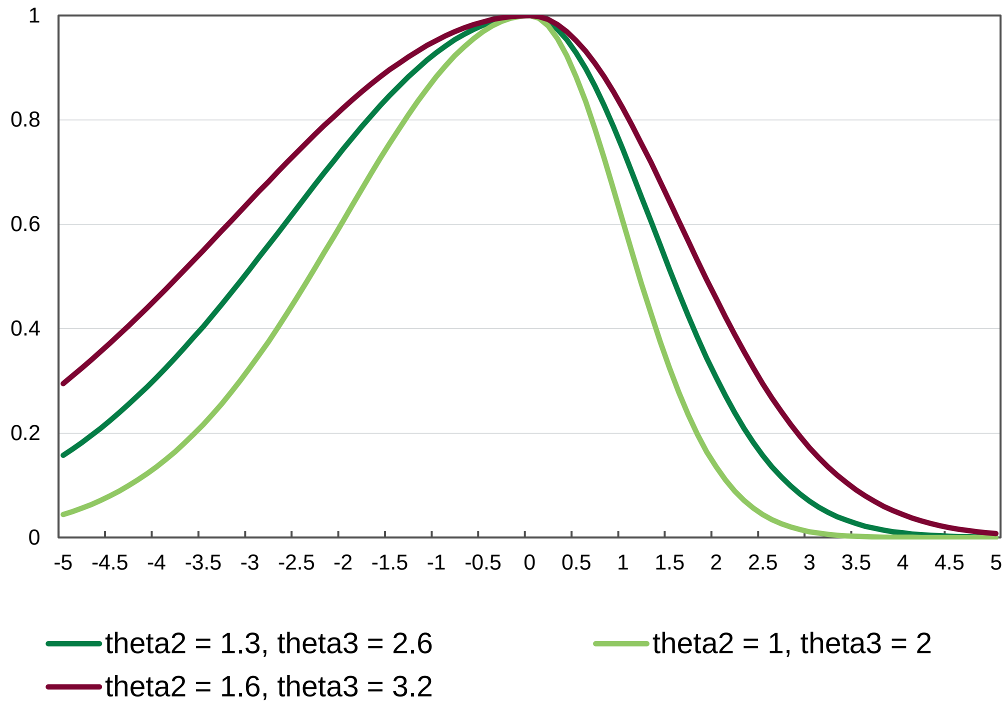

Figure 4. Effect of Parameter θ on the Signal to Credibility
Source: own calculations
Note: The parameter θ takes a value equal to θ_2 when deviation of inflation from the target is positive, otherwise θ is equal to θ_3.

Lower values of θ make economic agents more concerned about the deviation of inflation from the target. It results in a lower credibility signal. Higher parameter θ values mean lower sensitivity and higher signals to credibility.

In our model, the parameters θ_2 and θ_3 are calibrated to 1.3 and 2.6, respectively.

As was mentioned above, forward-looking agents consider action credibility (c_t^a) to shape their expectations. Concept of action credibility reflects agents' expectations about ability of monetary policy to match target in the future. Action credibility is modeled in the same way as the outcome credibility:

$$c_t^a = \rho_1 c_{t-1}^a + (1-\rho_1)\xi_t^a \quad (11)$$

$$\xi_t^a = e^{-\frac{(\pi 4_{t+4} - \pi 4_{t+4}^T)^2}{2\theta^2}}, \quad (12)$$

where $\theta = \theta_2$ if $\pi 4_{t+4} - \pi 4_{t+4}^T \geq 0$ and $\theta = \theta_3$ otherwise, $\theta_2 < \theta_3$.

However, in this case, the signal to action credibility is the function of the gap between four-quarters-ahead inflation expectations and the inflation target $(\pi4_{t+4} - \pi4^T_{t+4})$.

The signal to action credibility is higher if agents believe that the central bank will manage to achieve the inflation target. If action credibility is high, agents give more weight to the inflation target in forming their expectations.

Finally, overall monetary policy credibility (c_t) is the weighed average of outcome and action credibility.

$$c_t = \alpha_4 c^o_t + (1 - \alpha_4) c^a_t \tag{13}$$

Inflation Expectations Bias

As mentioned above, four quarters ahead inflation expectations $(\pi4^e_t)$ are affected by an expectations bias (14).

$$b_t = \rho_2 \, [c_t \pi4^{e,L}_t + (1 - c_t)\pi4^{e,H}_t - \pi4^T_t] \tag{14}$$

$$\pi4^{e,L}_t = (1 - \rho_3)\pi4^T_t \sum_{i=0}^{3} {\rho_3}^i + \rho_3^4 \pi4_t \tag{15}$$

$$\pi4^{e,H}_t = (1 - \rho_4)\pi4^{T,H} \sum_{i=0}^{3} {\rho_4}^i + \rho_4^4 \pi4_t \tag{16}$$

We assume that the economy can be in two inflation regimes: low and high. The first regime is associated with the target level $(\pi4^T_t)$, and the second – with a high inflation rate $(\pi4^{T,H})$, which is the average rate of inflation before the introduction of an inflation-targeting regime. Inflation expectations[3] in both regimes (equations 15, 16) are modeled as the weighted sum of inflation $(\pi4_t)$ and the inflation level associated with corresponding regime, $\pi4^T_t$ or $\pi4^{T,H}$.

[3] See Chansriniyom et al. (2020) for a detailed explanation of the formation of inflation expectations in the regimes of low and high inflation.

The inflation expectations bias is the difference between weighed sum of inflation expectations in two regimes and inflation target, where the weigh depends on credibility stock.

The logic of the inflation expectations bias is as follows: when past and expected inflation are on target, credibility is perfect ($c_t = 1$). Therefore, the bias is close to zero as inflation expectations in the low inflation regime converge to the target. On the other hand, when past and expected rates of inflation are substantially below or above the target, credibility is completely lost ($c_t = 0$). Then bias is positive as expectations are associated with the high inflation rate.

Our specification implies that any drop in credibility almost certainly leads to an upward bias of inflation expectations. It is fully in line with, among others, Isard et al. (2001). Positive bias arises from the fact that a portion of agents who experienced high inflation in the past will attach some probability to a return to a high inflation regime. Inflation on average used to be high in Ukraine prior to the adoption of inflation-targeting. Deteriorated faith in the ability of the NBU to meet its commitment results into rising inflation expectations.

Monetary Policy Rule

The monetary policy reaction function is represented by a Taylor rule in the following way:

$$i_t^P = \alpha_5 i_{t-1}^P + (1-\alpha_5)(\bar{r}_t^P + \pi_{t+1} + \beta_5(\pi_{t+1} - \pi_{t+1}^T) + \gamma_5 \hat{y}_t) + \varepsilon_{5,t} \quad (17)$$

To capture the fact that a central bank adjusts policy interest rate only gradually, current interest rate depends on its lagged value (i_{t-1}^P). Policy makers change interest rate in response to deviation of expected inflation from the target ($\pi_{t+1} - \pi_{t+1}^T$) and to output gap ($\hat{y}_t$).

In the long term, policy interest rate converges to its neutral level ($\bar{r}_t^P + \pi_{t+1}$), which is consistent with inflation on its target and zero output gap.

The monetary policy shock is presented by the $\varepsilon_{5,t}$ term.

Modified Uncovered Interest Parity

The nominal exchange rate (s_t) is represented by a modified uncovered interest parity (UIP) condition, which reflects assumption about no-arbitrage opportunities. An increase in the nominal exchange rate means a depreciation of national currency against the US dollar.

$$s_t = (1-\alpha_6)s_{t+1} + \alpha_6\left(s_{t-1} + \frac{2}{4}(\Delta\bar{z}_t + \pi_t^T - \pi_t^{*T})\right) + \frac{i_t^* - i_t + prem_t}{4} - \beta_6\widehat{tot}_t + \varepsilon_{6,t} \quad (18)$$

The first two terms represent expectations about the future nominal exchange rate. Expectations are modeled as a weighed combination of model-consistent (s_{t+1}) and myopic expectations. The latter are constructed as a function of the past exchange rate (s_{t-1}), inflation differential ($\pi_t^T - \pi_t^{*T}$)

and growth of the real exchange rate trend ($\Delta\bar{z}_t$). Myopic expectations present the views of agents about long-run economic fundamentals.

The nominal exchange rate is also related to foreign (i_t^*) and domestic short-term nominal interest rates (i_t), and the sovereign risk premium ($prem_t$).

According to the no-arbitrage opportunity, in equilibrium, economic agents do not gain an advantage by investing in domestic assets rather than foreign ones. Therefore, the risk-adjusted interest rates differential should be compensated by expected depreciation.

To capture the large share of commodities in foreign trade, the equation (18) is also account for the effect from the commodity term of the trade gap ($\widehat{tot}_t$).

The last term ($\varepsilon_{6,t}$) presents an exchange rate shock.

5. Estimation of Parameters

The parameters of the model are estimated with the Bayesian methods.

This approach was chosen for several reasons. First, the application of the Bayesian approach allows for incorporate priors about parameters. Therefore, both the views of experts and the data are used to make conclusions about the posterior values of the parameters. Second, Bayesian technique is helpful in dealing with short data sample.

The model has 62 parameters, 51 of them are estimated with the Bayesian approach. In most cases, the values of the parameters of the NBU's Quarterly Projection Model (Grui and Vdovychenko, 2019) are used as the mean priors.

Beta distribution priors are used for parameters that range from zero to one. Inverse gamma distributions are used as priors for other parameters, including standard deviations of shocks. Our priors are relatively lax to allow posterior modes to deviate from calibrated values. Priors for the Taylor rule and the UIP condition are tighter, however, which reflects higher confidence in parameters for policy variables (as opposed to them being inferred from the data). We do not run sensitivity tests to see how much the results are driven by the tightness of the priors.

The model is estimated for the period from 2016:1 to 2021:3. The estimation results of the main equations are reported in Table 1.

Table 1. Priors and Estimated coefficients

	Prior			Posterior
	Distribution	Mean	Std. deviation	Mode
Open economy investment-savings curve				
α_1	Beta	0.70	0.10	0.70
β_1	Inverse Gamma	0.10	0.10	0.05
δ_1	Inverse Gamma	0.50	0.10	0.55
θ_1	Inverse Gamma	0.15	0.10	0.08
μ_1	Inverse Gamma	0.10	0.10	0.05
γ_1	Beta	0.40	0.10	0.39
$\sigma(\varepsilon_{1,t})$	Inverse Gamma	1.00	1.00	0.24
Phillips curve and inflation expectations				
α_2	Beta	0.80	0.10	0.95
β_2	Inverse Gamma	0.40	0.10	0.38
γ_2	Beta	0.40	0.10	0.39
$\sigma(\varepsilon_{2,t})$	Inverse Gamma	1.00	1.00	0.48
α_3	Beta	0.60	0.10	0.6
$\sigma(\varepsilon_{3,t})$	Inverse Gamma	1.00	1.00	0.98
α_4	Beta	0.25	0.10	0.36
β_4	Beta	0.55	0.10	0.53
$\sigma(\varepsilon_{4,t})$	Inverse Gamma	1.00	1.00	0.39

Table 1 (continued). Priors and Estimated coefficients

Policy credibility and inflation expectations bias				
ρ_1	Beta	0.75	0.10	0.78
ρ_2	Beta	0.30	0.10	0.29
ρ_3	Beta	0.50	0.10	0.52
ρ_4	Beta	0.55	0.10	0.55
Taylor rule				
α_5	Beta	0.60	0.05	0.66
β_5	Inverse Gamma	1.50	0.05	1.27
γ_5	Inverse Gamma	0.40	0.05	0.40
$\sigma(\varepsilon_{5,t})$	Inverse Gamma	1.00	1.00	0.35
Uncovered interest parity				
α_6	Beta	0.50	0.05	0.60
β_6	Inverse Gamma	0.10	0.05	0.15
$\sigma(\varepsilon_{6,t})$	Inverse Gamma	1.00	1.00	0.35

Source: own calculations

Standard deviations of the shocks are relative. The ones in the Taylor rule ($\varepsilon_{5,t}$) and the UIP condition ($\varepsilon_{6,t}$) are of equal size, while the shocks in the Phillips curve ($\varepsilon_{2,t}$) and those in inflation expectations ($\varepsilon_{4,t}$) are slightly more volatile. Aggregate demand shocks ($\varepsilon_{1,t}$) demonstrate the lowest volatility. Standard deviation of the administrative inflation shocks ($\varepsilon_{3,t}$) is the largest.

6. Model Properties

In this section, we describe the impulse response functions of the key macroeconomic variables to various shocks. We will demonstrate how eventual economic stabilization depends on the starting point of credibility.

We distinguish several scenarios. The first one is an economy with full credibility at the beginning of the simulation. It can be disrupted, so credibility slightly declines in response to the shocks that hit the economy. Yet, inflation expectations remain quite anchored. The second one is an economy with an initially high credibility level of 0.8. The third and the fourth are economies with medium (0.5) and low (0.1) initial levels of credibility to monetary policy.

Sizes of the impulses for our simulations roughly correspond to estimated standard deviations of the shocks. They matter due to a non-linear nature of the model. All shocks are temporary and hit the economy in the first period. Before the shocks occur, all the variables are in equilibrium. The responses of all macroeconomic variables, including credibility, are presented as deviations from steady states. All simulations see credibility returning to its steady state of full credibility in the long term.

Supply Shock

Figure B.1 shows impulse response functions to the supply shock.

In the case of an initially fully credible monetary policy, economic agents are confident in the commitment of monetary authorities to low and stable inflation. Therefore, inflation expectations remain highly anchored even in the period of the shock. Such favorable conditions allow the central bank not to hike the policy rate much in response to higher inflation. Later, the policy rate is decreased slightly to support the economy in times of an appreciating real exchange rate. The nominal exchange rate soon depreciates.

Lower starting levels of credibility lead to higher biases in inflation expectations and more pronounced inflation spikes. Monetary policy is forced to react more aggressively, which leads to a temporarily appreciating nominal exchange rate and generates a deeper recession. Lack of credibility makes fighting inflation more costly.

A supply shock is the only shock in our simulations to be able to significantly harm initially full credibility. Others generate almost no credibility reduction.

Demand Shock

Impulse response functions to the demand shock are shown in Figure B.2.

Excessive demand creates a positive inflationary pressure. The central bank reacts with raising the policy interest rate. Nominal exchange rate temporarily appreciates, while output gradually returns to its potential.

Higher levels of monetary policy credibility allow less pronounced interest rate reactions, as inflation expectations remain more anchored and inflation – less volatile. In case of the demand shock, output stabilization does not much depend on credibility.

Monetary Policy Shocks

We use monetary policy shocks to illustrate modeled nonlinearities in economic reactions to inflationary and deflationary shocks. Figures B.3 and B.4 display impulse responses to positive and negative policy shocks, respectively.

Hawkish policy actions unsurprisingly lead to falling output and an appreciating nominal exchange rate. Lower levels of credibility require more aggressive policy movements, which cause more pronounced responses. Inflation does eventually fall as well. However, the timing of the decrease can be very different for different levels of credibility.

Medium and low levels of credibility allow us to generate the price puzzle. In an economy with not highly credible monetary policy, biased inflation expectations make inflation temporarily grow after a contractionary policy shock. The extreme case of low credibility makes inflation peak even higher than it fall afterwards. In contrast, full and high initial levels of credibility see inflation decrease (almost) immediately.

Dovish policy actions can boost the economy only in cases of high or full credibility. Nominal exchange rate depreciates, and inflation expectedly picks up.

Not credible monetary policy is not able to stimulate the economy as it is quickly forced to reverse its stance and fight an inflation outbreak. Biased inflation expectations highly increase inflation. Policy must react and becomes contractionary instead of expansionary. Low credibility even requires temporary nominal exchange rate appreciation.

Negative policy shocks have much larger absolute effects on inflation than positive ones. This nonlinearity is explained by most often non-negative bias[4] and the fact that credibility is lost quicker in case of inflation being above-target. Only perfectly credible monetary policy can lead to symmetric inflation responses to positive and negative policy shocks. Initially, fully credible policy comes close.

7. Results

This section provides estimates of historical monetary policy credibility fluctuations.

We use the Kalman filter to estimate unobservable credibility stock based on the model's observable variables. The nonlinear prediction step is used in the filter to capture model nonlinearities. The filter is simulated on the 2012–2021:3 historic horizon. It starts in advance of the adoption of the IT regime in order to obtain the initial values for the credibility stock.

[4] Negative bias can arise in case of highly credible monetary policy and simultaneously below-target inflation.

Figure 5 shows the model simulated outcome and action credibility stock, as well as their weighted average. Table 2 summarizes the development of credibility stock on different horizons.

In 2015, both action and outcome levels of credibility were low, which is consistent with a period of extremely high inflation. A year after that, action credibility sharply increased. This points to the NBU's successful disinflationary policy that took place in 2016 having helped to improve rational expectations. On the other hand, in 2016, outcome credibility remained quite low and peaked only in the first quarter of 2017. The peak coincides with the central bank's success in achieving the target in the previous quarter.

Outcome credibility decreased in 2017 and remained low until 2019, which is in line with above-target inflation. It was gained only in 2020, when inflation decreased and moved below the target level. Action credibility each time seems to both decrease and increase before the outcome credibility does.

The NBU's monetary policy used to have a relatively low level of credibility on the inflation-targeting horizon. However, it increased during the most recent past. The average value of credibility equals to 0.36. Excluding the period of high inflation in 2015, the average rises to 0.40. Since 2019, it climbs to 0.56. Action credibility is on all horizons above the outcome credibility.

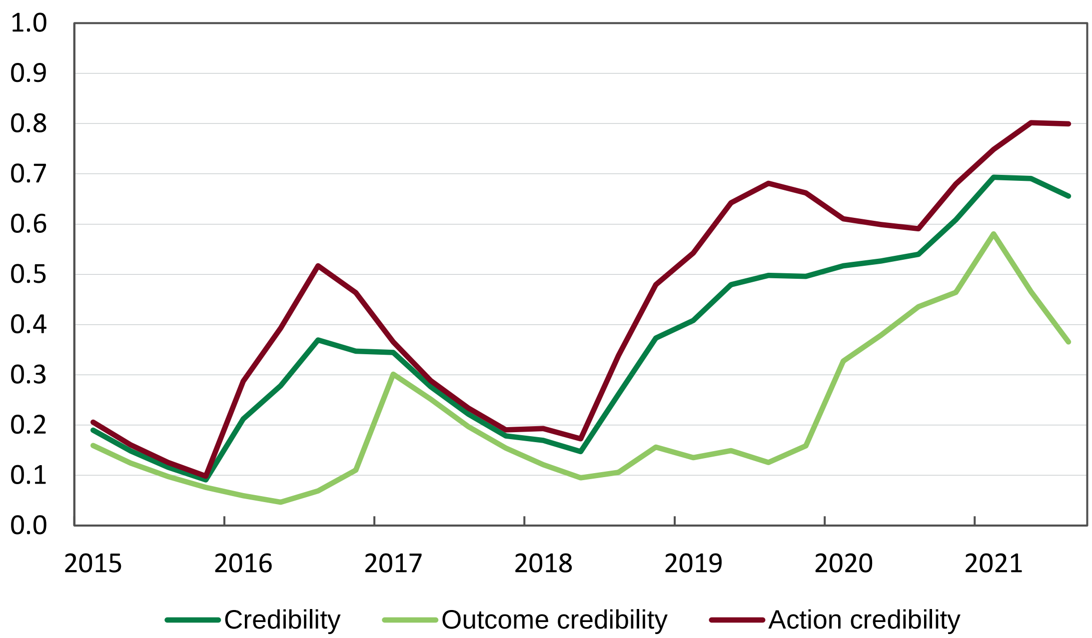

Figure 5. Model Simulated Credibility Stocks

Source: own calculations

Table 2. Average Values of Credibility Socks on Different Historic Horizon

	Since 2015	Since 2016	Since 2019
Outcome credibility	0.21	0.23	0.33
Action credibility	0.44	0.49	0.67
Overall credibility	0.36	0.40	0.56

Source: own calculations

8. Summary

Monetary policy credibility is important for inflation-targeting central banks to maintain price stability. It helps anchor inflation expectations and stabilize the economy. Higher credibility can be achieved with actual inflation or expected inflation, or both being close to the preannounced target. The effect is not symmetric as negative deviations from the target are less harmful than positive ones.

To account for the linkage between credibility and inflation expectations, we extend a New Keynesian model for a small open economy with an endogenous process of monetary policy credibility. Higher credibility leads to more anchored and less biased inflation expectations. We apply the model to the case of Ukraine, use surveyed inflation expectations, and measure credibility.

Model properties show that a higher level of credibility helps the central bank return inflation to the target level at a relatively lower cost. The volatility of other economic indicators is also minimized. Well-anchored and unbiased inflation expectations allow the monetary authority not to overreact to temporary shocks.

A low level of credibility creates problems for stimulating the economy as an expansionary monetary policy may send inflation soaring. It requires a quick policy reversal, which restricts economic activity. Moreover, low credibility generates the price puzzle, in which inflation temporarily increases in response to a contractionary monetary policy shock.

Our findings confirm the crucial role of credibility for the efficiency of the monetary policy transmission mechanism. High credibility and anchored inflation expectations facilitate each other in case monetary policy is consistently committed to achieving its main objective – keeping inflation close to the target.

The proposed model will become a good contribution to the NBU's modeling toolkit. First, it measures how monetary policy credibility changes in response to various economic shocks and policy actions. Second, it allows for accounting for credibility changes in designing policy scenarios.

Finally, model simulations indicate that the NBU started with a very low level of credibility in 2015, but gradually increased it over the years. In 2021, it stands above 0.6 on a scale from 0 to 1.

References

Alichi, A., Chen, H., Clinton, K., Freedman, C., Johnson, M., Kamenik, O., Kisinbay, T., Laxton, D. (2009). Inflation targeting under imperfect policy credibility. IMF Working Paper, 09/94. International Monetary Fund. https://doi.org/10.5089/9781451872415.001

Argov, E., Epstein, N. P., Karam, P. D., Laxton, D., Rose, D. (2007). Endogenous monetary policy credibility in a small macro model of Israel. IMF Working Paper, 07/207. International Monetary Fund. Retrieved from https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Endogenous-Monetary-Policy-Credibility-in-a-Small-Macro-Model-of-Israel-21231

Ascari, G., Florio, A., Gobbi, A. (2017). Transparency, expectations anchoring and inflation target. European Economic Review, 91, 261-273. https://doi.org/10.1016/j.euroecorev.2016.11.001

Bems, R., Caselli, F., Grigoli, F., Gruss, B. (2021). Expectations' anchoring and inflation persistence. Journal of International Economics, 132, 103516. https://doi.org/10.1016/j.jinteco.2021.103516

Benes, M. J., Clinton, K., George, A., Gupta, P., John, J., Kamenik, O., Laxton, D., Mitra, P., Nadhanael, G. V., Portillo R., Wang, H., Zhang, F. (2017). Quarterly projection model for India: Key elements and properties. IMF Working Paper, 17/33. International Monetary Fund. Retrieved from https://www.imf.org/en/Publications/WP/Issues/2017/02/13/Quarterly-Projection-Model-for-India-Key-Elements-and-Properties-44659

Bernanke, B. (2007). Inflation expectations and inflation forecasting. Monetary Economics Workshop of the National Bureau of Economic Research Summer Institute, Cambridge. Retrieved from https://www.federalreserve.gov/newsevents/speech/bernanke20070710a.htm

Blinder, A. S. (2000). Central-bank credibility: why do we care? How do we build it?. American Economic Review, 90(5), 1421-1431. https://doi.org/10.1257/aer.90.5.1421

Bomfim, A. N., Rudebusch, G. D. (2000). Opportunistic and deliberate disinflation under imperfect credibility. Journal of Money, Credit and Banking, 32(4, Part 1), 707-721. https://doi.org/10.2307/2601179

Bordo, M. D., Siklos, P. L. (2017). Central bank credibility before and after the crisis. Open Economies Review, 28(1), 19-45. https://doi.org/10.1007/s11079-016-9411-2

Botha, B., de Jager, S., Ruch, F., Steinbach, R. (2017). The quarterly projection model of the SARB, Working Paper, 17/01. South African Reserve Bank. Retrieved from https://www.resbank.co.za/en/home/publications/publication-detail-pages/working-papers/2017/8000

Carriere-Swallow, M. Y., Gruss, B., Magud, M. N. E., Valencia, M. F. (2016). Monetary policy credibility and exchange rate pass-through. IMF Working Paper, 16/240. International Monetary Fund. Retrieved from https://www.imf.org/external/pubs/ft/wp/2016/wp16240.pdf

Chansriniyom, T., Epstein, N. P., Nalban, V., Berg, A., Danninger, S. (2020). The monetary policy credibility channel and the amplification effects in a semi-structural model. IMF Working Papers, 20/201. International Monetary Fund. https://doi.org/10.5089/9781513557717.001

Cukierman, A., Meltzer, A. H. (1986). A theory of ambiguity, credibility, and inflation under discretion and asymmetric information. Econometrica: Journal of the Econometric Society, 54(5), 1099-1128. https://doi.org/10.2307/1912324

De Grauwe, P., Ji, Y. (2020). Structural reforms, animal spirits, and monetary policies. European Economic Review, 124, 103395. https://doi.org/10.1016/j.euroecorev.2020.103395

De Jesus, C. S., Lopes, T. R., Guimarães, S. D. (2017). Monetary policy credibility and inflation in an emerging economy. Economics Bulletin, 37(2), 778-789. Retrieved from http://www.accessecon.com/Pubs/EB/2017/Volume37/EB-17-V37-I2-P71.pdf

Faust, J., Svensson, L. E. (2001). Transparency and credibility: Monetary policy with unobservable goals. International Economic Review, 42(2), 369-397. https://doi.org/10.1111/1468-2354.00114

Grui, A., Vdovychenko, A. (2019). Quarterly Projection Model for Ukraine. NBU Working Papers, 3/2019. Kyiv: National Bank of Ukraine. Retrieved from https://bank.gov.ua/admin_uploads/article/WP_2019-03_Grui_Vdovychenko_en.pdf

Isard, P., Laxton, D., Eliasson, A. C. (2001). Inflation targeting with NAIRU uncertainty and endogenous policy credibility. Journal of Economic Dynamics and Control, 25(1-2), 115-148. https://doi.org/10.1016/S0165-1889(99)00071-8

Istrefi, K., Piloiu, A. (2014). Economic policy uncertainty and inflation expectations. Bank de France. Document de Travail, 511. Retrieved from https://publications.banque-france.fr/sites/default/files/medias/documents/working-paper_511_2014.pdf

King, M. (1995). Credibility and monetary policy: theory and evidence. Scottish Journal of Political Economy, 42(1), 1-19. https://doi.org/10.1111/j.1467-9485.1995.tb01142.x

Lalonde, R. (2005). Endogenous central bank credibility in a small forward-looking model of the US economy. Working Paper, 2005/16. Bank of Canada. Retrieved from https://www.bankofcanada.ca/wp-content/uploads/2010/02/wp05-16.pdf

Laxton, D., N'Diaye, P. (2002). Monetary policy credibility and the unemployment-inflation tradeoff: some evidence from 17 industrial countries. IMF Working Paper, 2002/220. https://doi.org/10.5089/9781451875218.001

Levieuge, G., Lucotte, Y., Ringuedé, S. (2018). Central bank credibility and the expectations channel: Evidence based on a new credibility index. Review of World Economics, 154, 493-535. https://doi.org/10.1007/s10290-018-0308-6

Mishkin, F. S. (2007). Inflation dynamics. International Finance, 10(3), 317-334. https://doi.org/10.1111/j.1468-2362.2007.00205.x

Svensson, L. E. (1993). The simplest test of inflation target credibility. NBER Working Paper, 4604. National Bureau of Economic Research. IMF Working Paper https://www.nber.org/system/files/working_papers/w4604/w4604.pdf

Tvalodze, S., Mkhatrishvili, S., Mdivnishvili, T., Tutberidze, D., Zedgenidze, Z. (2016). The National Bank of Georgia's Forecasting and Policy Analysis System. NBG Working Papers, 01/2016. National Bank of Georgia.

Appendix A
Data description

Variable	Source	Note
Real GDP	State Statistics Service of Ukraine (SSSU)	Data are in 2016 constant prices
Headline inflation	SSSU	Consumer Price Index
Administratively regulated inflation	SSSU	Administratively regulated inflation
Inflation target	NBU	Official target level
One-year ahead inflation expectations of non-financial corporations	NBU	Average value provided in response to the question of how much the consumer price index will change over the next 12 months (in percentage)
Key policy rate	NBU	NBU’s short-term interest rate on its main market operations
Interbank rate	NBU	Interbank interest rates without overdrafts
Commodity terms of trade	Thomson Reuters, own calculations	Weighted average of main commodity export and import prices
Real effective exchange rate	NBU	The weighted average of the domestic nominal exchange rate and the trading partners’ exchange rates divided by the corresponding consumer price indexes
Nominal exchange rate (UAH/USD)	NBU	Official exchange rate UAH per USD
Sovereign risk premium	cbonds.com, own calculations	Difference between yields to maturity of Ukrainian Eurobonds and US 10-year Treasuries
Foreign interest rate	Thomson Reuters	One-month LIBOR rate
World demand gap	National statistical offices, own calculations	The real GDP of the main trading partners

Appendix B

Figures

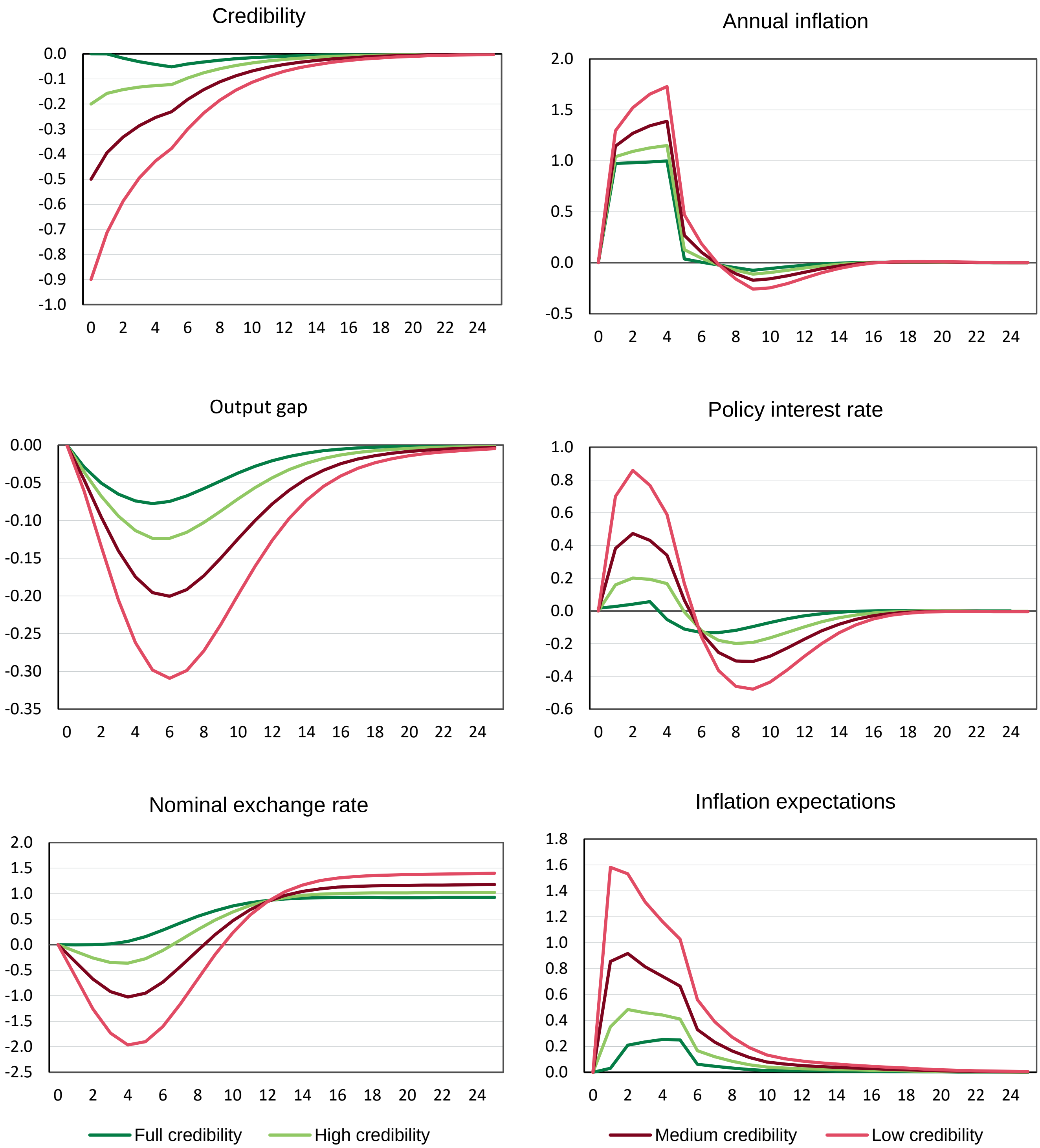

Figure B.1. Impulse Response Functions to Supply Shock, %

Source: own calculations

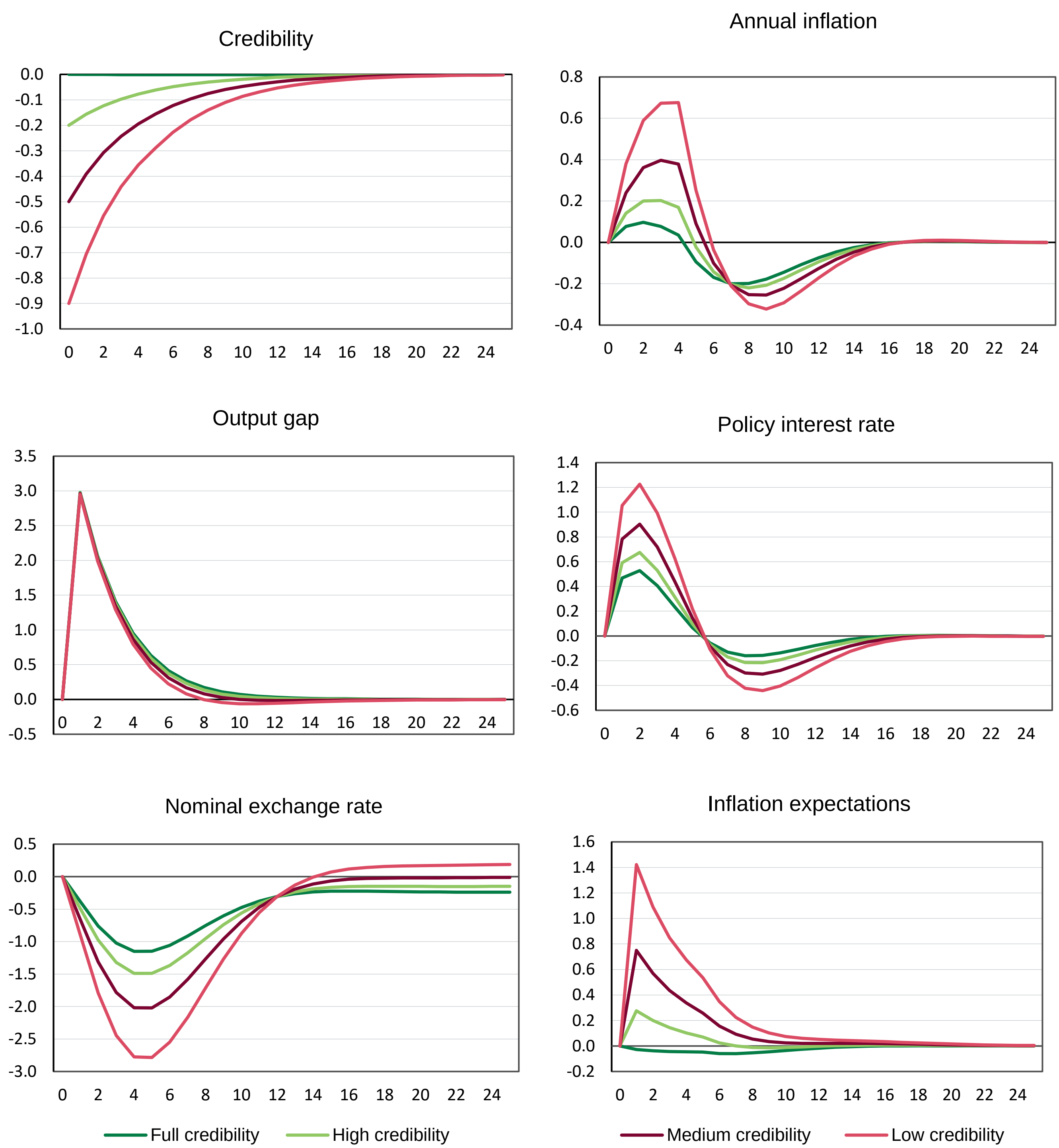

Figure B.2. Impulse Response Functions to Demand Shock, %

Source: own calculations

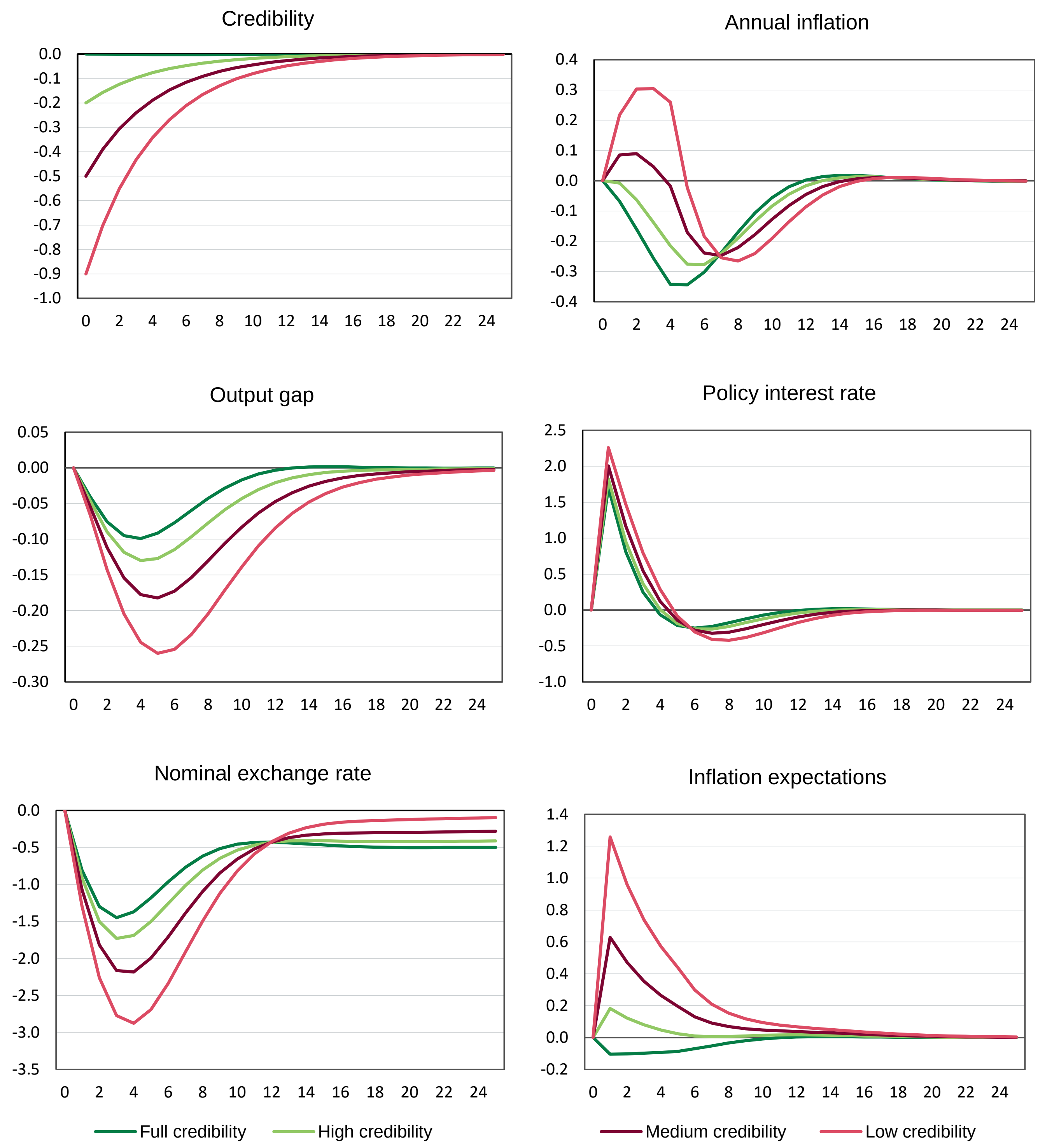

Figure B.3. Impulse Response Functions to Positive Monetary Policy Shock, %

Source: own calculations

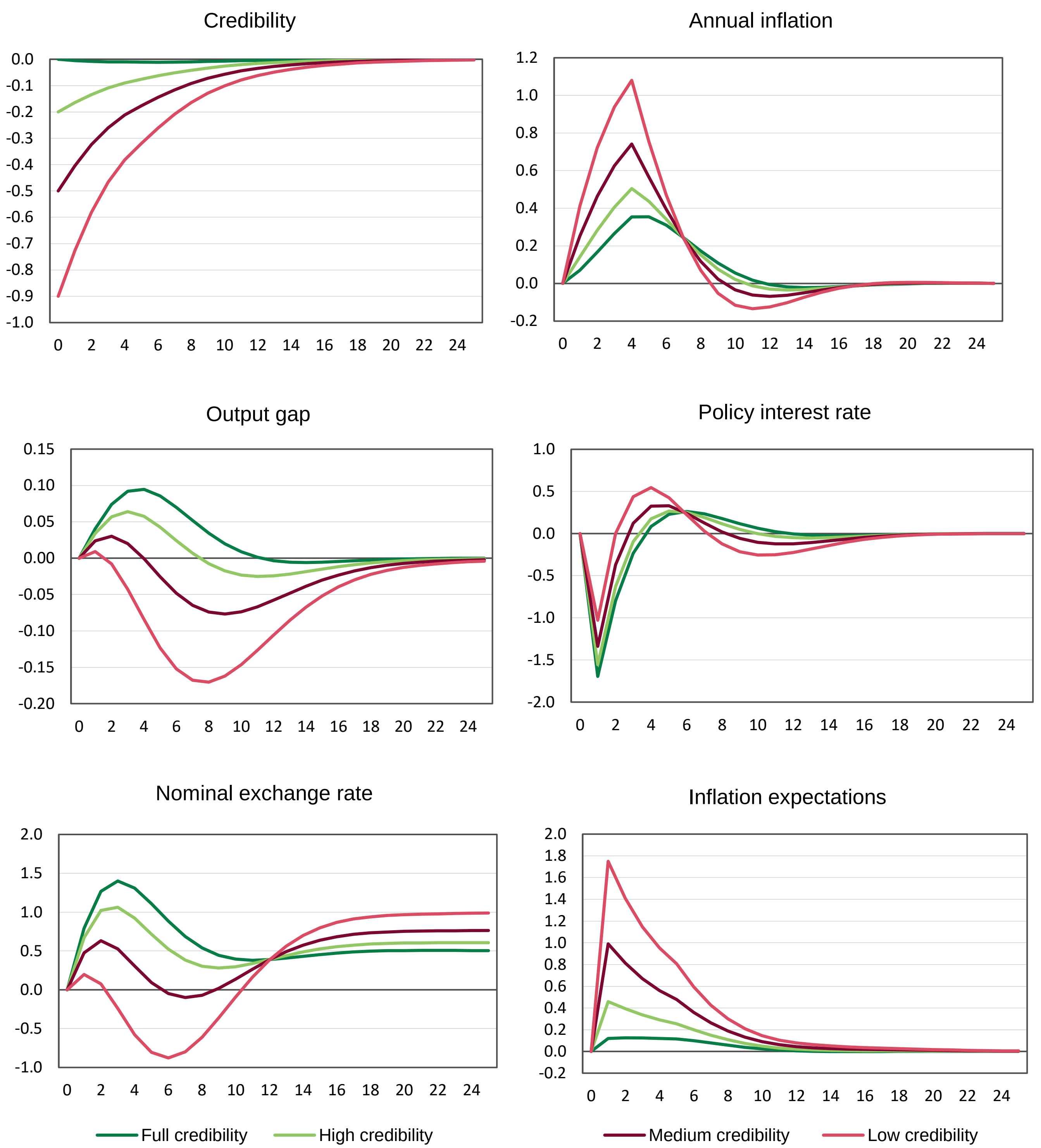

Figure B.4. Impulse Response Functions to Negative Monetary Policy Shock, %

Source: own calculations