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SYSTEM DYNAMIC MODELLING OF INFLATION

Inflation is a socio-economic phenomenon, generated by the disproportion of production in various spheres of market economy. At the same time, inflation is one of the most acute problems of the current economic development of almost all countries of the world, especially in Ukraine. One of the goals of the National Bank of Ukraine is low and stable inflation. As prices rise, they start to affect the general cost of living for the public and the central bank takes the necessary measures to keep inflation within permissible limits.

In order to reduce the negative impact of inflation on the economy of Ukraine, and consequently on the quality of people's lives, it is necessary to know the inflation processes, factors that generate them, and to be able to prevent them. That is why we investigated the inflation model of Ukraine. The purpose of the project was to make the inflation model relevant to the Ukrainian economy.

Our task was to investigate the SFD of the New Keynesian Monetary Policy Model especially inflation part and apply it for Ukrainian data, identify and analyze the causes of inflation in Ukraine, understand the behavior of the inflation of Ukraine and compare it to the output variable of the model.

Model Structure. Since inflation accumulates over time and it takes time to see the change in inflation, we consider inflation as a stock. We know that stocks can change only through the flows. In our model, we have netflow Δ inflation that calculates difference between indicated and current inflation per adjustment time. This difference we called the gap between indicated and current inflation.

From the New Keynesian Phillips curve: Inflation in the current time depends on its value in the previous period, the central bank's target value in the next period, and the output gap in the current period.

The inflation equation is expressed as:

$$inflation_t = a1 * inflation_{t-1} + (1 - a1) * inflationtarget_{t+1} + \\ + b1 * outputgap_t \quad . \qquad (1)$$

This equation defines *indicated inflation* that adjusts over time in our model. Variables indicated inflation, inflation and Δ inflation creates negative feedback loop. Negative feedback loops act to bring the state of the system in line with a goal or desired state (Sterman, 2000). Our case brings inflation to indicated inflation. Indicated inflation is influenced by 4 exogenous factors such as *inflation target, output gap, parameters a1* and *b1*.

Central bank's inflation target is goal for inflation that a central bank publicly announces and commits to achieve over the medium term (2-3 years). The output gap is the difference between actual GDP and potential GDP. In our model output gap measured in terms of its percentage deviation from the potential GDP. We can show it as a formula:

$$100 * (GDP - Potential\_GDP * Normal\_Capacity\_Utilization) / (Potential\_GDP * Normal\_Capacity\_Utilization),$$

where normal capacity utilization is assumed to be 100 per cent of potential GDP.

The parameter a1 (0<a1<1) reflects the credibility of the central bank's monetary policy makers. If the Central Bank commits to an inflation target, is capable of reaching that target, and has demonstrated its capability well enough for its commitment to be credible, a1 will be close to zero, ideally zero from the perspective of policy makers. If a1=0, indicated inflation equals the central bank's inflation target plus the effect of the output gap. If a1=1, the Central Bank's target has no effect on inflationary expectations, and indicated inflation equals current inflation plus the output gap effect. The parameter b1 (b1>0) reflects the unitless output gap effect on inflation.

When indicated inflation is determined, the inflation adjusts towards that value over time. Adjustment time is speed with which inflation adjusts to indicated inflation. After one adjustment time, 63% of the initial gap is corrected. After two adjustment times, the state of the system is moved 86% of the way to the indicated value. After three adjustment times, the adjustment is 95% complete. Technically, the gap is never fully corrected; there is always some small fraction of the gap remaining at any finite time. However, for all practical purposes adjustment is complete after three to four adjustment times have passed when goal is constant value. But we have more complex process because indicated inflation is not a constant; it changes with the output gap and with prior inflation. Yet the seemingly separate impacts on indicated inflation are actually interrelated and have offsetting effects. An adjustment time constant of 1/3 year was selected because the full adjustment of the gap between inflation and its indicated value would occur in about one year after a change in the output gap.

The one year period for a full adjustment of inflation is suggested by empirical observations at the Bank of England: "The empirical evidence is that on average it takes up to about one year in this and other industrial economies for the response to a monetary policy change to have its peak effect on demand and production, and that it takes up to a further year for these activity changes to have their fullest impact on the inflation rate." (Bank of England, 1999).

Figure 1 represent the SDF of inflation model:

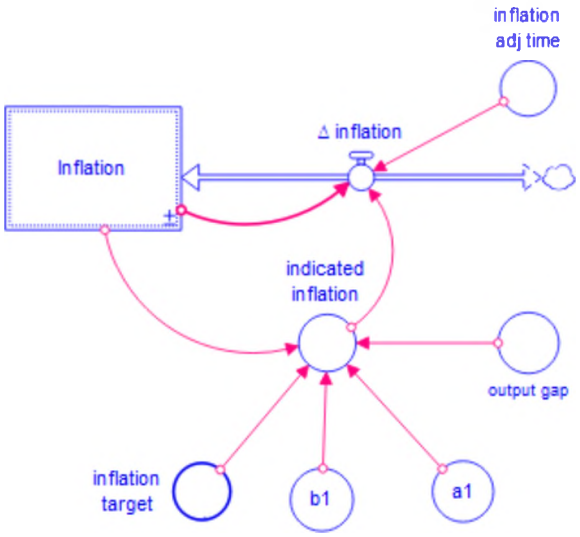

Figure 1. System dynamic model of inflation adjustment process

Historical background. Since the National Bank of Ukraine moved de facto to inflation targeting in 2016 we considered the time horizon for our study from 2016Q4 to 2018Q3. The time units of model are years. All data are quarterly. The data, which are used in this project, are mostly taken from the site of the National Bank of Ukraine – bank.gov.ua. All data don't include temporarily occupied territory of Crimea and the part of the anti-terrorist operation zone.

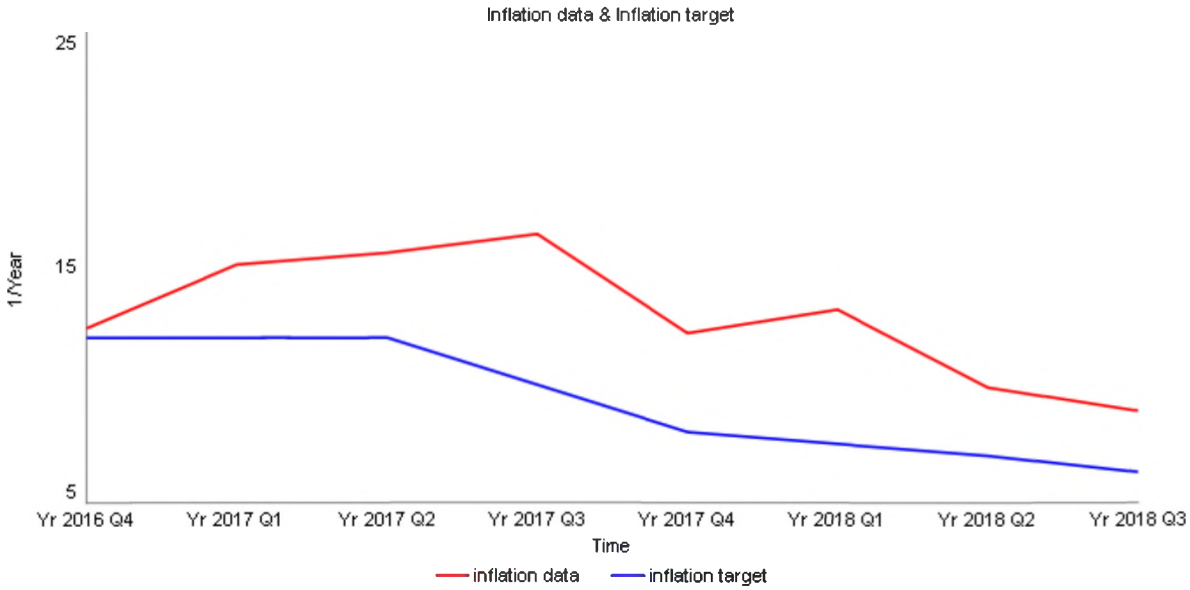

Figure 2. Dynamics of inflation and inflation target in Ukraine

The National Bank implemented the inflation target for 2016 at a level of 12% ±3 because of balanced fiscal and monetary policy. Reductions in inflation also contributed to cheapening grain prices on world commodity markets as a result of a record world harvest this year, slowing down imported inflation in a context of low exchange rate volatility and improving inflation expectations.

Inflation in 2017 was higher than the NBU's forecast, which is primarily due to the following factors: faster growth in raw food prices (large export volumes and a decrease in supply on the back of a decrease of livestock pushed prices for meat and dairy products upwards); higher production costs, and a revival of consumer demand (double the increase of the minimum wage at the beginning of the year); weakening of the hryvnia exchange rate. Starting in 2017Q4, inflation will decrease and approach the targeted level. The reduction of inflation will be conditioned by a rather tight monetary policy, the decay of the impact of a sharp rise in food prices, further slowing down of imported inflation in the context of relatively low exchange rate volatility, and a drop in the growth of raw food prices.

In first quarter of 2018, inflation remained above the targets. The main reason for the high inflation was the continuation of the rapid rise in food prices. This was due to a decrease in production volumes in agricultural products and intensive exports of food.. However, in order to reduce the increase in inflationary pressure, the National Bank has continued the cycle of tighter monetary policy - twice raised the discount rate. In the second-third quarters of 2018, consumer inflation is moderate slowed down. The decrease in inflation was due to the expansion of the supply of domestic and imported food products, as well as the decline in world food prices. However, the fundamental inflationary pressure remained significant, which is the result of a steady expansion of consumer demand, which is supported by high rates of increase in Ukrainian wages (28% more than in the previous year), which far exceeds the growth rate of the economy.

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