6. How Core Inflation Reacts to the Second Round Effects

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Abstract

In order to evaluate the second round effects on core inflation, an econometric model based on auto-regressive vector technique was built. The way the core inflation reacts to the changes of oil and food prices on international markets, is an important matter for monetary policy. Another important issue for monetary policy is outlined by the internal markets, and mainly the way the core inflation responds, accordingly, to the changes of the fuel and food prices. The payoff of these changes on core inflation is a priori considered to be significant. The paper tests the above-mentioned hypothesis and the results of the study justify the impact of changes in oil and food prices on core inflation.

Keyword: core inflation, second round effects, commodity price, autoregressive vector, exchange rate, transmission mechanism, inflation.

JEL Classification: E31, E52

1. Introduction

The actuality of the current research is determined by the fact that continuing food and oil prices increase on international markets have a considerable impact on long-term prices in Republic of Moldova. The large share of food products in the consumption basket and a poor anchorage of inflation expectations, hinder the disinflation process. For this reason, the current research studies the impact on core inflation of food and

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oil price increase on international markets. Core inflation is intended to be the indicator that allows to perceive the inflation tendency for the long-term period. Finally, the shocks to food prices and fuel prices on international markets will affect not only the food and fuel prices in CPI, but also the core inflation, that will involve the reaction of tightening the monetary policy to reduce inflationary expectations, even in the absence of pressure from the aggregate demand.

2. Theoretical Background and Literature Review

2.1 Literature review

This topic has been extensively studied in the relevant specialty literature. Literature reviews that are published on this topic of interest have shown that changes in the commodity prices led to inflation. The most important researches were performed by Hafer (1983), Garner (1985), Defina (1988), Webb (1989), Furlong (1989), Cody and Mills (1991), Kugler (1991), and Trivedi and Hall (1995).

At the same time, studies by Garner (1995) and Bloomberg and Harris (1995) find that some commodity prices have not been reliable leading indicators of inflation since about the mid-1980.

In his papers Bernanke and others in (1997), Hooker (1999), Laxton (2002) describe in detail the effects of rising oil prices on international markets on economic activity and prices. According to their research, if the core inflation does not react to oil price increases on international markets, the monetary authorities shouldn't tighten the monetary policy.

According to S. Cecchetti and R. Moessner (2008) due to a high increase in commodity prices, increases in prices all over the world were recorded. According to their point of view, increased commodity prices in advanced countries did not affect the evolution of core inflation, due to low weight of food products in CPI and a strong anchoring of inflation expectations. Increase of core inflation from the rise in commodity prices is observed in developing countries, which are characterized by a high share of food CPI of around 30 percents is also specific for Republic of Moldova, leading to this research and to the identification and estimation of the second round effects on core inflation.

In his research Dospinescu (2010) indicates that there is a long-term tendency of the CPI, which is reflected by the irreversible changes in relative prices.

2.2 Measurement of core inflation

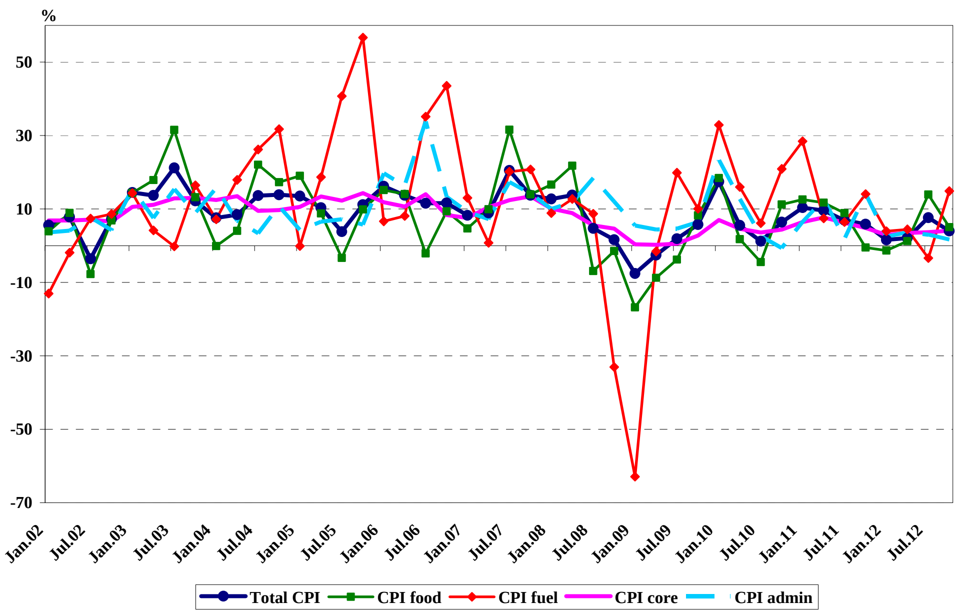
The evolution of prices of goods and services is reflected by several statistical indicators, such as, the consumer price index, industrial production price index, GDP deflator etc.

The Consumer Price Index (CPI) - is an indicator of the evaluation, which characterizes and provides an estimate of the evolution of prices of goods bought and used tariffs to meet the needs of the population living in a certain period to a fixed period.

The Consumer Price Index is divided into four general components that progress to identify more clearly the origin of the shocks affecting inflation: core inflation, food prices, regulated prices and fuel prices (figure 1).

Figure 1

Evolution of quarterly increases of the CPI components



Source: National Bureau of Statistics

The core inflation index is a measure reflecting persistent sources of inflationary pressures allowing inflation trend to charge for the effects of temporary and transitory influences that are eliminated. The calculation of this index, according to this methodology is performed by removing the effects of inflation overall transient shocks like changes in prices and tariffs from changes in goods and services with regulated prices, adverse weather conditions affecting food supply, changes in the price for some products and seasonal variations in international prices of fuel.

Core inflation index is calculated by the excluding method, according to the following equation:

$$I_{IB} = \frac{\sum_{i=1}^{n} p_i * ip_i - \sum_{j=1}^{m} p_j^{ex} * ip_j^{ex}}{\sum_{i=1}^{n} p_i - \sum_{j=1}^{m} p_j^{ex}} \tag{1}$$

Where: IIB – core inflation index;

p_i – weight of good or service in CPI basket;

ip_i – price index of good or service in CPI basket;

p^{ex}_j – weight of good or service excluded from CPI basket;

ip^{ex}_j – price index of good or service excluded from CPI basket;

i – goods and services entering in CPI basket;

j – goods and services that are excluded from CPI Basket for calculation IIB;

n – number of goods and services entering in CPI basket;

m – number of goods and services that are excluded from CPI basket for calculation IIB.

3. Empirical Analysis

3.1 Data

Starting from the basic objective and proposed tasks for the determination and quantification of second round effects on core inflation, given the basic techniques and statistical methods used, the phenomenon has been studied from two aspects: firstly, the impact of international oil and food prices on core inflation, taking into account the evolution of the exchange rate, in nominal terms, related with trading partners and the money in circulation; secondly, taking into consideration the fact that core inflation does not include products and services with increased volatility prices, such as food and fuel prices, the impact of food price and domestic fuel price variations on core inflation has been estimated.

In an economy with inflation targeting the monetary policy regime, exchange rate is floating, therefore both, the exchange rate and internal and external factors, influence the rate of inflation. Fluctuations in international oil prices can be identified on domestic market by domestic fuel prices; and the growth of international food prices is reflected on the domestic markets by domestic food prices, through the cost of imports. Taking into account the monetary policy transmission mechanisms, the change of the base rate creates fluctuations in the exchange rate, which affects the current level of inflation, and the inflationary expectations. Cyclical fluctuations of money supply and demand may also have an impact on inflation.

Therefore, the below listed variables were used to estimate the second round effects of oil and food prices: Urals 32[5] oil prices, international food prices (FAO)[6], core inflation, money in circulation and the nominal effective exchange rate. Time series of the aforementioned variables were defined as first-order differences of the natural logarithms seasonally adjusted, tested for the presence of seasonality (deseasonalised when needed, using X-12-ARIMA model).Thus we stationarized data by using their log-first-differences.

3.2 Methodology

To investigate the impact of international oil and food prices on core inflation more formally, we use vector auto regression (VAR) models. Application of the VAR models

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[5] U.S. Energy Information Administration

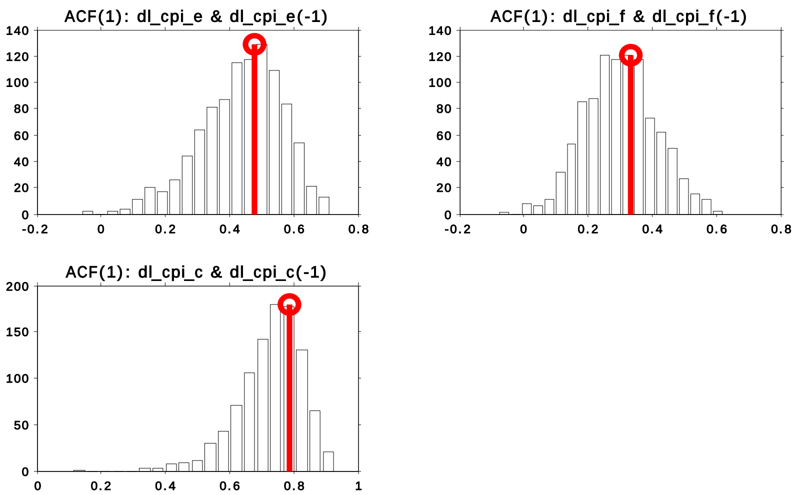
[6] Food and Agriculture Organization of the United Nations

in empirical analysis was introduced for the first time by Sims[7] in 1980. This type of model is based on the assumption of equations simultaneity, which means that all studied processes are analyzed from the perspective of an endogenous system. VAR type models are a form of non-structural econometric modeling, where data rather than theory, identifies the dynamic of the model. The restriction of the models, meaning the exclusion of some model parameters is criticized by Sims, according to which, if a set of variables are simultaneous, they should be treated equally, should not be made a priori division of variables into endogenous and exogenous. The alternative popularized by Sims is that in the VAR model, all variables are treated as endogenous, thus avoid the corruption of the model with arbitrary identification restrictions. Nevertheless, in the research of economic processes it is very appropriate to be set some restrictions, which are normally required, especially for the structure and economic meaning of the variables. In this way the model provides a flexible framework for analyzing economic processes. Therefore, relationships that are based formally or informally on economic theory, are established between variables.

In order to determine the number of lags for the VAR model and for testing the correlation between variables the bootstrapping method was applied. According to Figure 2, the red bar represents the correlation/autocorrelation of variables, and the histogram represents the probability distribution of correlation/autocorrelation between these variables in the time series additional created using the bootstrapping method

Figure 2

Autocorrelations for lag one for CPI components



Source: Author's calculation

Where **dl_cpi_e** – quarterly growth of domestic fuel prices;

dl_cpi_f – quarterly growth of domestic food prices;

[7] C.A. Sims, "Macroeconomics and Reality" Econometrica, vol. 48, 1980

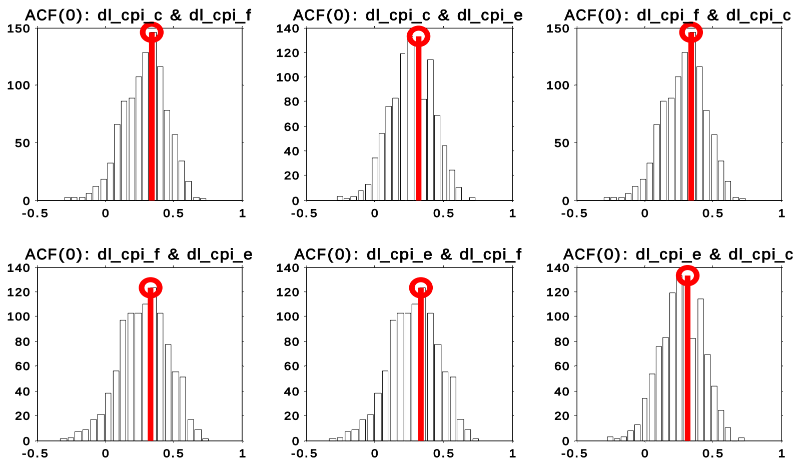
dl_cpi_c – quarterly growth of core inflation.

The analysis of the results identifies a strong persistence of core inflation. The persistence of fuel and food prices in CPI is low. These coefficients are obtained based on effective data and are justified by the results of the applied method.

According to Figure 3, a strong correlation between core inflation and food prices is being observed (the correlation coefficient being about 0.4), but given the persistence of core inflation it is anticipated that the influence of these factors can't to be so strong. The coefficient of correlation between food prices and core inflation, on one hand, and fuel prices and core inflation, on the other hand, is well substantiated by the bootstrapping method.

Figure 3

Cross correlations of order 0

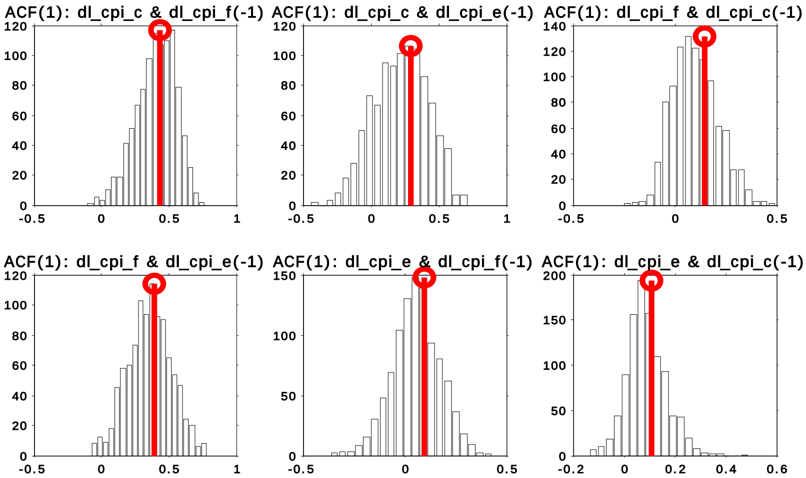


Source: Author's calculation

The correlation between the variables represents a significant step for this analysis; it justifies to a certain extent and the need for this restriction, which was performed on variables used in the model. The increase of core inflation is better correlated with increases in food prices in the previous period, than with those in the same period (Figure 4). The correlation of core inflation with fuel prices is also related to fuel prices from previous periods, as in the same period as well.

Figure 4

Cross correlations of order 1



Source: Author's calculation

4. Results

4.1. The impact of oil and food prices on international markets on core inflation.

In order to determine the impact of the changes in international food and oil prices on core inflation an econometric VAR structured model was used:

$$y_{1,t} = \alpha_1 + \alpha_2 y_{1,t-1} + \alpha_3 y_{1,t-2} + \xi_1 \tag{2}$$

$$y_{2,t} = \beta_1 + \beta_2 y_{1,t-1} + \beta_3 y_{1,t-2} + \beta_4 y_{2,t-1} + \beta_5 y_{2,t-2} + \xi_2 \tag{3}$$

$$\begin{aligned} y_{3,t} &= \phi_1 + \phi_2 y_{1,t-1} + \phi_3 y_{1,t-2} + \phi_4 y_{2,t-1} + \phi_5 y_{2,t-2} + \phi_6 y_{3,t-1} + \\ &+ \phi_7 y_{3,t-2} + \xi_3 \end{aligned} \tag{4}$$

$$\begin{aligned} y_{4,t} &= \mu_1 + \mu_2 y_{1,t-1} + \mu_3 y_{1,t-2} + \mu_4 y_{2,t-1} + \mu_5 y_{2,t-2} + \\ &+ \mu_6 y_{3,t-1} + \mu_7 y_{3,t-2} + \mu_8 y_{4,t-1} + \mu_9 y_{4,t-2} + \xi_4 \end{aligned} \tag{5}$$

$$\begin{aligned} y_{5,t} &= \gamma_1 + \gamma_2 y_{1,t-1} + \gamma_3 y_{1,t-2} + \gamma_4 y_{2,t-1} + \gamma_5 y_{2,t-2} + \\ &+ \gamma_6 y_{3,t-1} + \gamma_7 y_{3,t-2} + \gamma_8 y_{4,t-1} + \gamma_9 y_{4,t-2} + \gamma_{10} y_{5,t-1} + \\ &+ \gamma_{11} y_{5,t-2} + \xi_5 \end{aligned} \tag{6}$$

Where:

y_1 - quarterly growth of oil price on international markets;

y_2 - quarterly growth of food prices on international markets;

y_3 - quarterly growth of money in circulation;

y_4 - nominal effective exchange rate;

y_5 - core inflation index;

$\alpha_1,...,\alpha_3;\beta_1,...,\beta_5;\phi_1,...,\phi_7;\mu_1,...,\mu_9;\gamma_1,...,\gamma_{11}$ - matrix of coordination

$\xi_1,...,\xi_5$ - matrix of error vectors;

$\xi_1,...,\xi_5$ is a stochastic multivariate process which is normal distributed with mean zero and positive co-variation matrix equation defined for each part of the model

$$\xi_1,...,\xi_5 \sim N\left(0, \sigma_{\xi_1,...,\xi_5}\right) \tag{7}$$

The model contains restrictions on elasticity coefficients as to adjust to the economic theory and to reduce the incorporated parameters, which improve the estimated model. According to the imposed restrictions, the domestic variables (core inflation, money in circulation and the nominal effective exchange rate) don't affect international oil and food prices, just as the food prices on international markets (FAO)[8] do not influence oil prices (Urals 32)[9].

Integration tests on the log of the international oil and food prices, money in circulation, real effective exchange rate and core inflation indicate that these series have unit roots. Based on the data for the period 2002:1 to 2012:4 and using an Augmented Dickey-Fuller test, we find that all series are stationary in log-first differences (see Appendix, Table 3).

According to the impulse response function of the above described model (for its matrix of correlation, see Appendix, Table 1), the impact of international oil and food prices on core inflation is not very high (Figure 5), but a relatively high influence on the exchange rate and money in circulation is observed.

Based on the estimated coefficients in the VAR model we can estimate the cumulative impact on core inflation (see Appendix, Figure 10). The core inflation will achieve a cumulative increase of 0.053 percentage points over 12 quarters, as a result of a positive shock of 1.0 percent in oil price on international markets.

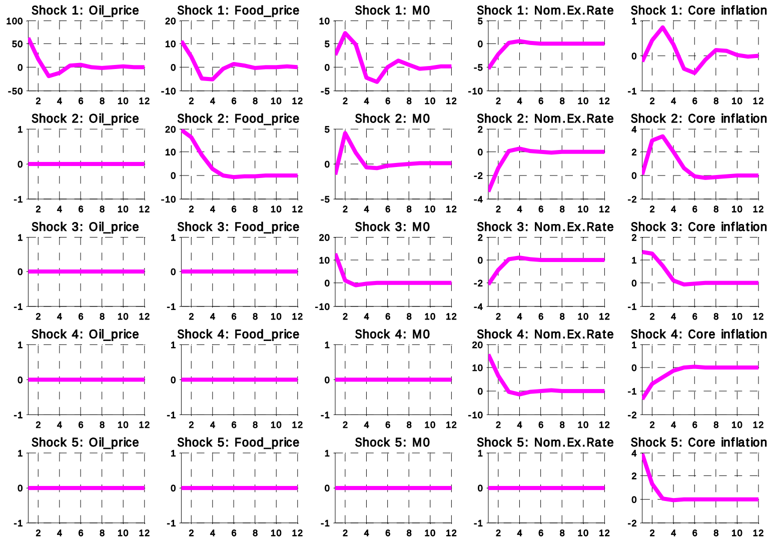
The cumulative increase in core inflation is 0.15 percentage points, following a 1.0 percent shock to food prices on international markets (see Appendix, Figure 11). This cumulative response will be recorded in core inflation over 8-12 quarters.

Figure 5

[8] Food and Agriculture Organization of the United Nations

[9] U.S. Energy Information Administration

The transmission of oil and food prices on international markets on core inflation



Source: Author's calculation based on NBS, FAO, NBM data

Following the current analysis, a moderate impact of international oil and food prices on core inflation is observed. This impact may be caused by the volatility of the nominal effective exchange rate and money supply, which mitigates the effects of imported inflation on core inflation in the transmission of impulses from the exogenous variables.

4.2. The impact of fuel and food prices in the CPI on core inflation.

The weak effects from fluctuations in international oil and food prices on core inflation are not a surprise. But, considering the fact that they have significant impact on fuel and food prices in the CPI index, monetary policy should be restricted as a result of exogenous shocks. Interesting question is how much the fluctuation in fuel and food prices on domestic market creates oscillations on core inflation. To determine the extent of influence a new model was created, a vector auto-regressive (VAR) type as well, including fuel and food prices from CPI, the core inflation excluding the prices of telecommunication services and drugs.

So, the VAR model used to determine the second round effects of fuel price fluctuations and domestic food inflation assumed that core inflation oscillations don't have a considerable effect on fuel and food prices.

The used VAR model can be written in the form:

$$y_{1,t} = \alpha_1 + \alpha_2 y_{1,t-1} + \alpha_3 y_{1,t-2} + \xi_1 \quad (8)$$

$$y_{2,t} = \beta_1 + \beta_2 y_{1,t-1} + \beta_3 y_{1,t-2} + \beta_4 y_{2,t-1} + \beta_5 y_{2,t-2} + \xi_2 \quad (9)$$

$$\begin{aligned} y_{3,t} &= \gamma_1 + \gamma_2 y_{1,t-1} + \gamma_3 y_{1,t-2} + \gamma_4 y_{2,t-1} + \gamma_5 y_{2,t-2} + \\ &+ \gamma_6 y_{3,t-1} + \gamma_7 y_{3,t-2} + \xi_3 \end{aligned} \quad (10)$$

Where:

y_1 – growth of index of fuel prices;

y_2 – growth of index of food prices;

y_3 – index of core inflation;

$\alpha_1,...,\alpha_3;\beta_1,...,\beta_5;\gamma_1,...,\gamma_7$ – coordination matrix;

$\xi_1,...,\xi_3$ –vector of errors matrix;

$$\xi_1,...,\xi_3 \sim N\left(0, \sigma_{\xi_1,...,\xi_3}\right) \quad (11)$$

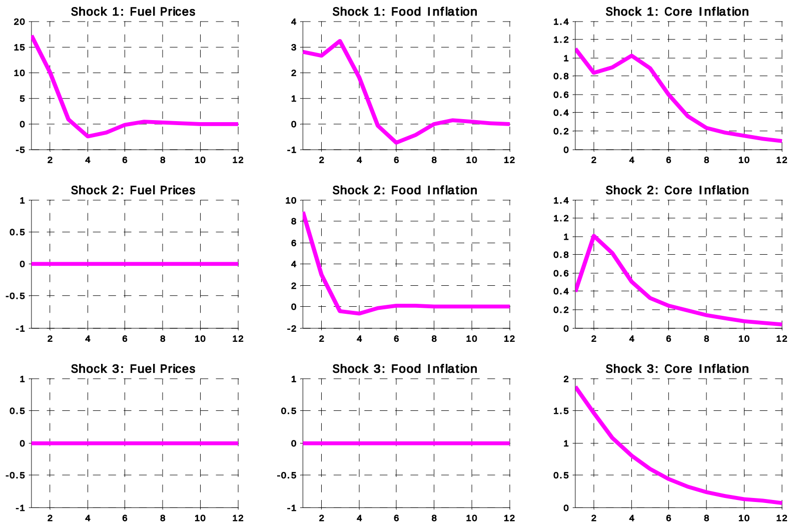
Errors are assumed to be normally distributed stochastic processes with zero mean and specific positive variance.

The model uses the following assumptions: The increase of fuel prices is only determined by previous evolution with lags and is not influenced by evolution of food prices and core inflation (for its matrix of correlation see Appendix, Table 2), The growth of food prices is determined by food price fluctuations with lags and variations of fuel prices with the same lags. Core inflation is determined by its evolution with lags and by the evolution of fuel and food prices with lags. Based on the data for the period 2002:1 to 2012:4 and using an Augmented Dickey-Fuller test, we find that all series are stationary in log-first differences (see Appendix, Table 3).

The growth of fuel prices (see Figure 6) has a positive effect on both food prices and core inflation. Due to an increased persistence of core inflation (see Appendix, Figure 14), the shock will close over 8-10 quarters, and a core inflation shock doesn't affect a food and fuel prices. In case of occurrence of a positive impulse in the amount of a standard deviation of food prices, core inflation will also record a positive response. It is assumed that fuel prices will not record oscillations (see Appendix, Figure 13). The way the variables react to a shock in fuel prices is represented in Appendix (see Figure 12), according to which, oscillations created by the shock are closed over 8 quarters.

Figure 6

Transmission mechanism of fuel prices and domestic food prices on core inflation

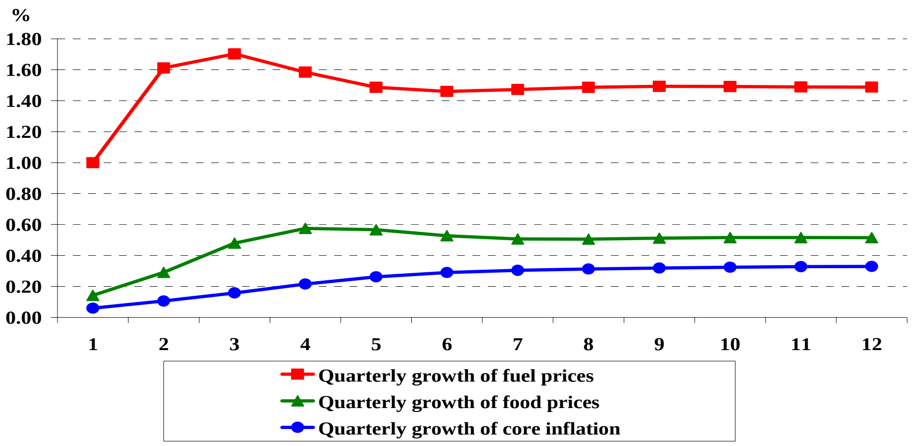


Source: Author's calculation based on NBS

Based on the data derived from the VAR model, the cumulative impact from the increases in fuel and food prices on Core CPI inflation can be determined.

Figure 7

Cumulative impulse response function to a shock in fuel prices



Source: Author's calculation

As anticipated, the growth of fuel prices in CPI, has a significant effect on the increase of core inflation (Figure 7). An increase of 1.0 percentage points has a cumulative impact of 0.33 percentage points on core inflation on the medium term, food prices also being affected by an increase of 0.5 percentage points.

On the basis of the restrictions imposed to the model, the increase of food prices in CPI, will not create oscillations in fuel prices (Figure 9), having only effects on core inflation. An increase of 1.0 percent in food prices will cause an increase of 0.28 percent of it. This impact will be recorded over 9 quarters of the impulse occurrence.

Cumulative impact of an increase in food inflation on headline inflation is 0.46 total (Figure 8)[10] , over a period of 12 quarters, and is calculated based on the equation:

$$\begin{aligned} \Delta cpi_{total} &= \left(\Delta cpi_{food} * w_{food}\right) + \left(\Delta cpi_{fuel} * w_{fuel}\right) + \\ &+ \left(\Delta cpi_{core} * w_{core}\right) \end{aligned} \tag{12}$$

Where:

Δcpi_{total} – headline inflation;

Δcpi_{food} – growth of food prices;

Δcpi_{fuel} – growth of fuel prices;

Δcpi_{core} – core inflation;

w_{food} – weight of food prices in the CPI;

w_{fuel} – weight of fuel prices in the CPI;

w_{core} – weight of core inflation in the CPI;

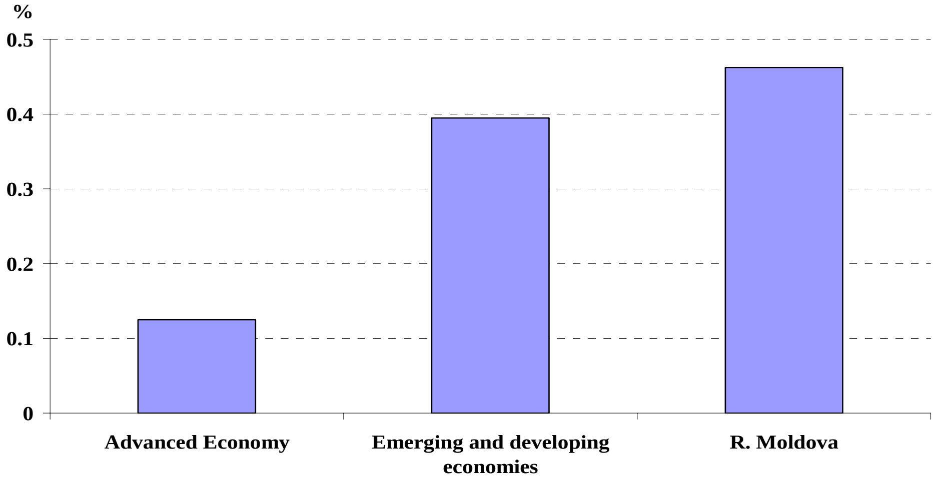
Given that a food price increase does not generate fluctuations in fuel prices, Δcpi_{fuel} =0. The impact on overall inflation will be calculated based on increases in food prices and core inflation.

The significant impact on total inflation is determined by the large share of food in CPI. According to the estimations from World Economic Outlet, October edition, in developing countries this impact is greater than in countries with advanced economies as a result of higher share of food and a weak anchoring inflation expectation.

[10] For highly developed and developing countries the parameters are imprecise estimated, median is reported accordingly. Cumulative impact for countries with advanced economies and developing countries is calculated for a period of five years. In case of the Republic of Moldova is calculated for a period of three years. However, the data can be compared given that after 3 years in R.M. the system actually is stabilizing.

Figure 8

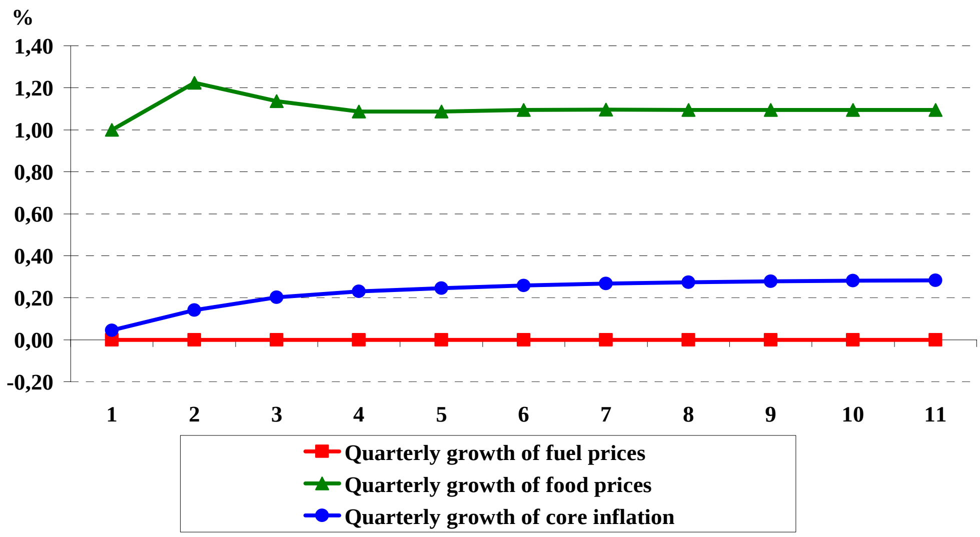
The impact of local food price increases on headline inflation



Source: Author's calculation and World Economic Outlook, "Slowing Growth, rising risks" IMF, September 2011 chapter 3, p.112

Figure 9

Cumulative impulse response function to a price shock (of 1.0 percent) to food



Source: Author's calculation

5. Conclusion

The analysis confirms the existence of second round effects on core inflation due to the changes in fuel and food prices. However, the magnitude of the transmission depends on the approach chosen to estimate it. If the impact of international prices (in U.S. dollars) on core inflation is analyzed, then the elasticity is lower than in the case of the analysis of an analogue transmission, but from the local prices (in CPI). Reduced transmission for the first approach can be explained by the distortion estimation as a result of the blurring effects from the intermediate variables (especially nominal effective exchange rate and monetary aggregates). Encouraging is that some estimated coefficients are similar to those of developing economies, estimated in the work of other authors. Namely, the cumulative shock impact (to stabilize the system) of 1.0 percent in food prices on the total CPI is 0.46 percent, for developing countries - 0.39 percent.

According to our estimates, the standard deviation of food prices increase in CPI is 1.4 percent, cumulative elasticity coefficient is 0.28, and this would imply a cumulative impact on core inflation of 0.4 percentage points, 12 months away from the produced shock. Standard deviation increase in fuel prices is equal to 2.2 percentage points; the coefficient of elasticity - 0.33, core inflation recordes a cumulative growth - 0.7 percentage points. In the case when there were simultaneous growths in the standard deviation of the food and fuel prices, core inflation would rise by 1.12 percentage points. Because of these increases, the total inflation will have a 0.97 percentage point's higher level.

It involves systematic monitoring of these effects on core inflation with the advent of several statistics on the variables in the model, in order to improve this study and its development.

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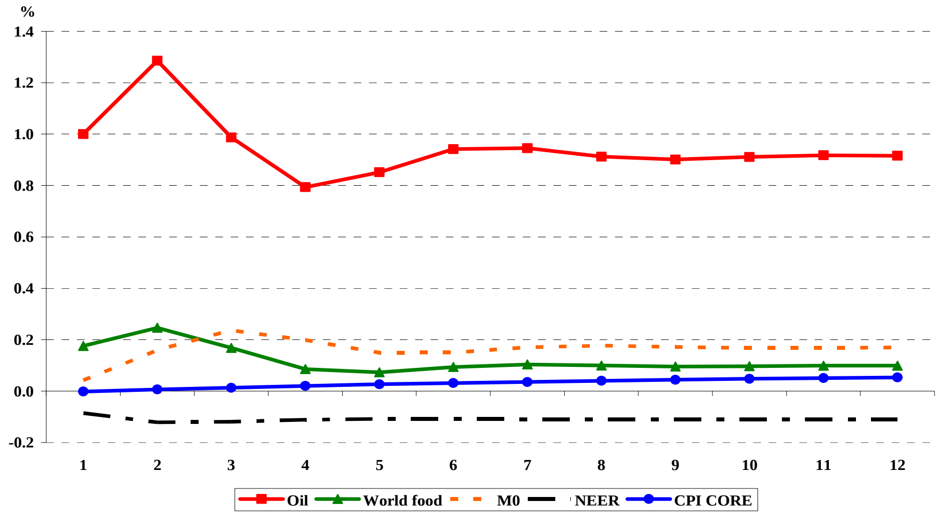
Appendix

Figure 10

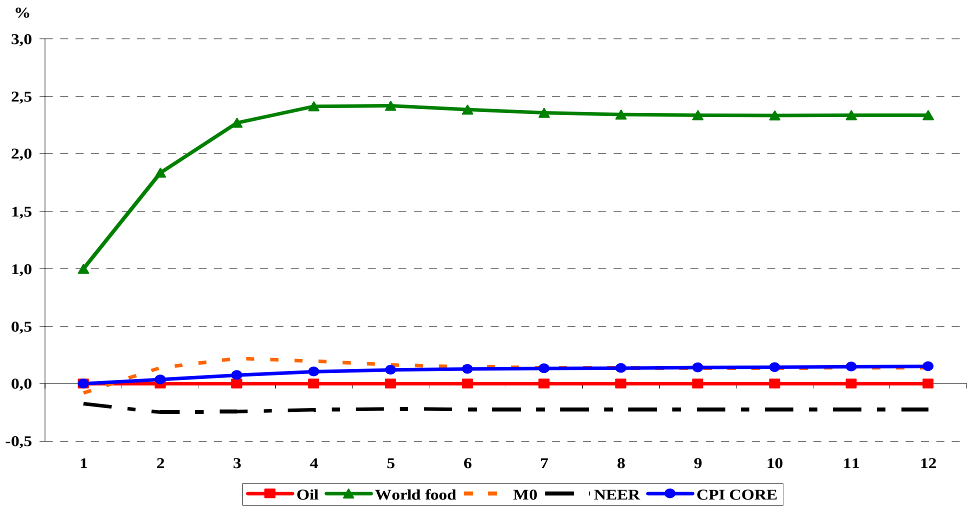
Cumulative impulse response - Shock to the international prices of oil



Source: Author's calculation

Figure 11

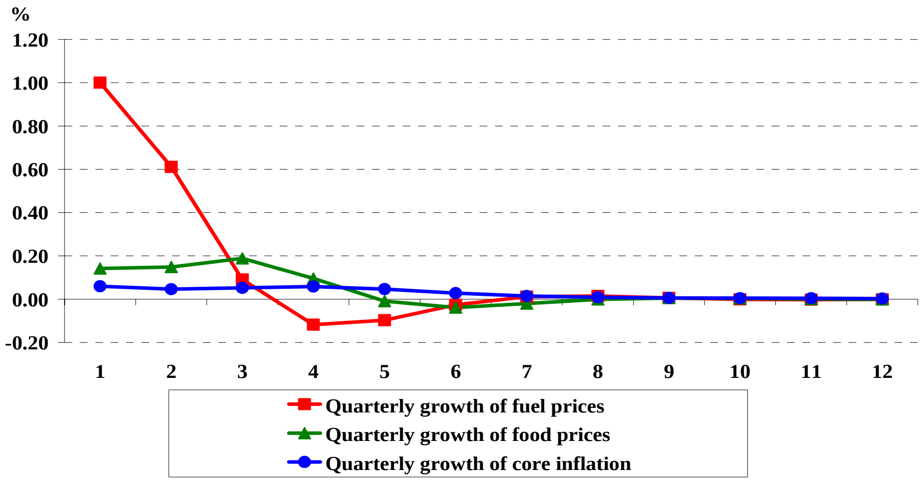
Cumulative impulse response - Shock to the international food prices



Source: Author's calculation

Figure 12

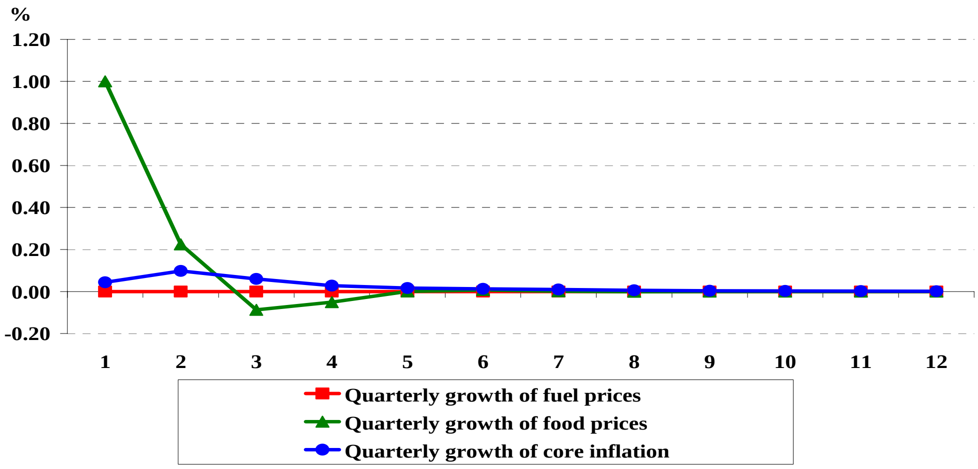
Impulse response function- Shock to the domestic prices of oil



Source: Author's calculation

Figure 13

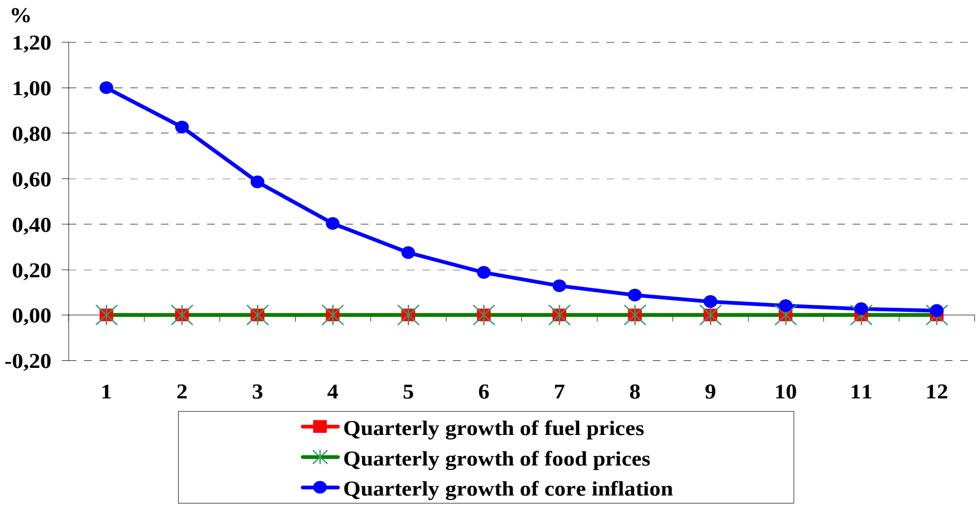
Impulse response function - Shock to the domestic food prices



Source: Author's calculation

Figure 14

Impulse response function - Shock to Core



Source: Author's calculation

Table 1

Matrix of coordination

	Oil prices	Food prices	M0	Nom. Ex. Rate	Core inflation
Oil prices	0.3008	0	0	0	0
Food prices	-0.0677	0.8066	0	0	0
M0	0.0829	0.1926	0.0725	0	0
Nom. Ex. Rate	0	0	0	0.4095	0
Core inflation	-0.0034	0.0371	0.0661	-0.0303	0.6931

Source: Author's calculation

Table 2

Matrix of coordination

	Fuel prices	Food prices	Core inflation
Fuel prices	0.5851	0	0
Food prices	0.0976	0.3397	0
Core inflation	-0.0139	0.0791	0.7789

Source: Author's calculation

Table 3

Dickey-Fuller test

Null Hypothesis: D(OIL PRICE,2) has a unit root Exogenous: Constant Lag Length: 10 (Automatic based on SIC, MAXLAG=13)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.395355	0.0000
Test critical values:	1% level	-3.476805	
	5% level	-2.881830	
	10% level	-2.577668	
Null Hypothesis: D(FOOD PRICE,2) has a unit root Exogenous: Constant Lag Length: 0 (Automatic based on SIC, MAXLAG=13)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-17.38737	0.0000
Test critical values:	1% level	-3.473382	
	5% level	-2.880336	
	10% level	-2.576871	
Null Hypothesis: D(M0,2) has a unit root Exogenous: Constant Lag Length: 5 (Automatic based on SIC, MAXLAG=13)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.83374	0.0000
Test critical values:	1% level	-3.475184	
	5% level	-2.881123	
	10% level	-2.577291	
Null Hypothesis: D(Nom. Ex. Rate,2) has a unit root Exogenous: Constant Lag Length: 7 (Automatic based on SIC, MAXLAG=13)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.995026	0.0000
Test critical values:	1% level	-3.480038	
	5% level	-2.883239	
	10% level	-2.578420	

Null Hypothesis: D(Core inflation,2) has a unit root
Exogenous: Constant
Lag Length: 8 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.586182	0.0000
Test critical values:	1% level	-3.476143	
	5% level	-2.881541	
	10% level	-2.577514	

Null Hypothesis: D(FUEL PRICES,2) has a unit root
Exogenous: Constant
Lag Length: 4 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.20686	0.0000
Test critical values:	1% level	-3.474874	
	5% level	-2.880987	
	10% level	-2.577219	

Null Hypothesis: D(FOOD PRICES,2) has a unit root
Exogenous: Constant
Lag Length: 7 (Automatic based on SIC, MAXLAG=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.509071	0.0000
Test critical values:	1% level	-3.475819	
	5% level	-2.881400	
	10% level	-2.577439	

*MacKinnon (1996) one-sided p-values.

Source: Author's calculation