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Elasticity of Agricultural Prices in Russia: An Empirical Study of Energy and Monetary Channels

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ABSTRACT

In this paper, we investigate long- and short-term direct and indirect impact of changes in oil prices (including shocks to exchange rate) and bank lending policy (interest rate channel) on prices of six groups of agricultural products in Russia (buckwheat, potatoes, oat, wheat, rye, barley). In this paper, Granger causality approach is applied to test long-run interlinkages with monthly data from January 1999 to October 2015. For testing the response of agricultural prices to sudden shocks in oil prices, exchange rate and interest rates for agricultural loans in the short-run, we use impulse-response techniques. The results of impulse response analysis show that agricultural prices are not particularly sensitive to changes in oil prices, exchange rate of Russian ruble and banks' interest rates in short-run, except for imported and not subsidized commodities. In the long-run, Granger causal relationship test shows same results.

Keywords: Agricultural Commodity, World Oil Prices, Exchange Rate, Interest Rate, Granger Causality Test, Impulse Response Analysis
JEL Classifications: F31, Q1

1. INTRODUCTION

Due to technological development, and slow population growth in the world, the prediction of Paul Samuelson about large-scale food crisis did not come true. During the 1990s and the first half of the 2000s a large proportion of agricultural prices remained relatively stable. However, due to natural disasters, catastrophes and other technological and environmental factors, agricultural prices have increased substantially. The prices for such agricultural commodities as grain crops and wheat has doubled in the past few years. According to data provided by the International Monetary Fund (IMF), the IMF's index of internationally traded agricultural products increased by 130% from January 2002 to June 2008 and 56% from January 2007 to June 2008 (Keith, 2008).

Russia is a one of major producer and consumer of a wide range of agricultural products. As one of the important players in the global markets of energy and agricultural products, Russia is very sensitive to changes in the prices of agricultural products, not to mention the oil prices. The sharp rise in prices of some crops, not to mention the general trend of rising prices in the agro-industry in the world markets, was due to a lack of supply and high production costs (Figure 1).

For example, the price of buckwheat reached in June 2008 long-term peak and amounted to nearly 7600 rubles per tonne. Compared with the previous year, the growth amounted to almost 30%. In the period from 2010 to 2012, the average price of buckwheat in Russia amounted to 25,000. A similar trend of rising prices of agricultural products is inherent to other cultures. Although the peak of growth of prices for buckwheat and wheat beginning in 2010s passed, the price growth is gradually recovering and gaining momentum. Frequent oscillations in agricultural prices have an impact on many other groups of the consumer goods. So, for example, price of pork in Russia during the boom years rose by 45% in 2008 and 82% in the period of 2010-2012. Rising grain prices pushed up the cost of pork production in terms of costs for fattening (Federal Service of State Statistics of Russia).

So, the rise in prices on world agricultural markets leads to disruption of the economic balance, balance in many countries, with particular impact on developing countries. On the one hand, high food prices improve economic condition of exporting countries, positively affecting the balance of payments, as in the case of the USA, Canada and partly Russia. On the other hand, the number of countries-net importers of agricultural products is three times more than the number of countries net exporters (von Braun, 2008). As a consequence, importers suffered significant losses during crises. The amount of expenses and crisis payments from the authorities has been substantially increased to cover cyclical effects.

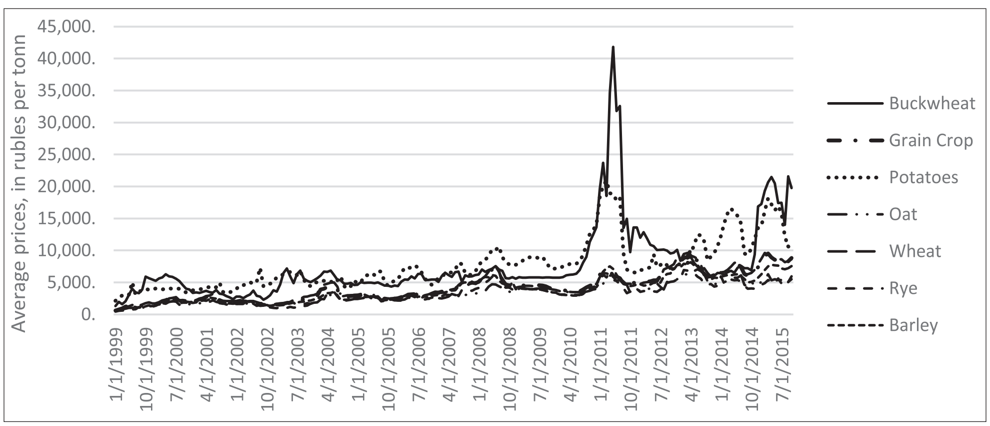
Thus, the rise in world food prices is not only good for the exporting countries, but also is a curse. A rise in global prices is pushing manufacturers to increase prices in domestic markets, thereby putting pressure on the household sector. Thus, according to the Food and Agriculture Organization (FAO), developing countries dependent on agricultural imports, are forced to pay additional costs in the amount of 324 billion US dollars in connection with growth of world prices for food. (FAOSTAT). In terms of sustainable growth trend of food prices, authorities of many countries are asking themselves a question about the factors influencing formation of tendency to their growth.

For example, Abbott et al. (2008) put forward an idea that there were three main variables, which are also recognized by most economists, namely the abundance of demand, the US dollar and the dependence of agriculture from energy industry. Among these three determinants, it is believed that the increased energy prices play a decisive role and affect food prices through direct and indirect channels. World oil prices skyrocketed to 140 US dollars per barrel by the end of the 2000s with about 20$/barrel in the late 1990s (Figure 2).

Hanson et al. (1993) conducted a study on the linkages between energy and agricultural prices in importing countries, using model of input-output, and found that an increase in oil prices increases the cost of crops. The increase in oil prices leads to an increase in costs in the fixed capital, and also creates an additional shed in transportation costs. On the other hand, the sharp rise in oil prices stimulates ethanol production - The main substitute of oil. Then the expansion of demand for biofuels causes higher agricultural prices. Many countries start stimulating and supporting programs for production of ethanol, which indirectly increases demand for agricultural products. For example, according to the Renewable Fuels Association, USA, as the largest producer of ethanol, has allocated around 25% of crops for its production, thereby increasing the growth of prices for the crop. Moreover, Harri et al. (2009) found that because most oil transactions is held in US dollars, and the price of agricultural commodities on domestic markets is established in national currency, another indirect channel for growth in the price of food is the exchange rate of the national currency (Figure 3).

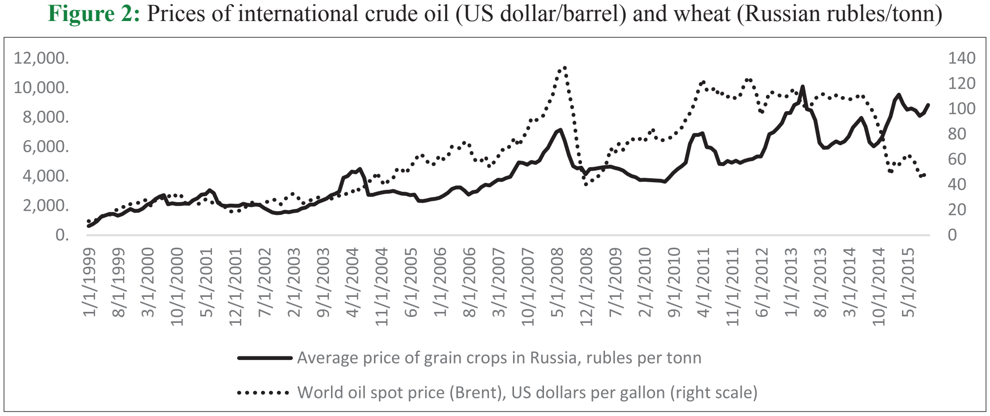
Impairment or strengthening of the national currency affects the export price and the price of the purchase from the exporting countries. For example, the devaluation of the Russian ruble will

Figure 1: Price dynamics of main agricultural commodities in Russia (RR/tonn)



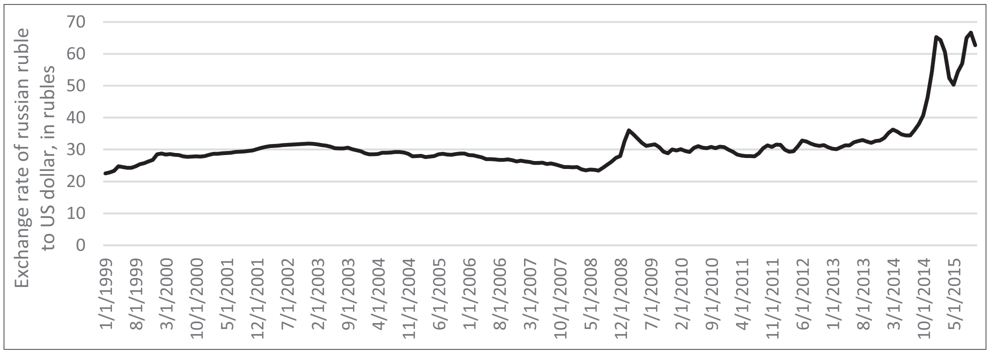
Data Source: Federal Service of State Statistics of Russia

Figure 2: Prices of international crude oil (US dollar/barrel) and wheat (Russian rubles/tonn)



Data Source: IEA Report and Federal Service of State Statistics of Russia

Figure 3: Exchange rate of Russian ruble to US dollar



Data Source: Bank of Russia

make agricultural products cheaper in comparison with other countries-exporters in the short-term. As equilibrium restores, new equilibrium price level will be set at a higher level on the national market. Conversely, the strengthening of the Russian ruble will make the agricultural products more expensive, than in other countries, thereby reducing demand for products from Russia. The reduction of domestic demand in turn will bring the prices to a new equilibrium level.

Thus, it can be assumed that the existing knowledge about direct and indirect channels of influence of oil prices on agricultural prices in developing countries is uncertain and depends on many factors. In this article, we will discuss direct and indirect channels of transmission from oil prices to agricultural prices in the short- and long-term.

It is believed that monetary factors such as money supply and interest rates also have an impact on agricultural prices. For example, increased cost of banking agricultural loans may lead to increased costs and expenses for farmers and agricultural enterprises, which will ultimately lead to an increase in the selling price. On the other hand, many countries actively promote protection of the agricultural sector and subsidize interest payments on loans. This, in turn, may reduce elasticity of agricultural prices to monetary shocks in the sector.

For a longtime, however, it was believed that because of the neutrality of money in the long-run, changes in money supply and/or interest on bank loans cannot provide redundant (overshooting) impact on prices in agricultural sector in the short-run. However, experience has shown that shocks in the monetary sector play an important role.

When choosing agricultural variables for analysis we agree with the view of Baffes (2007), according to which prices of individual agricultural goods is preferable to using an average of prices for all agricultural products. We apply Granger causality test and impulse response analysis to test long-run and short-run effects respectively. Understanding of the relationships between oil prices and domestic agricultural prices will allow the national authorities of countries, both exporters and importers of agricultural products to establish optimal monetary and sectoral policies to support agro sector. A sufficient level of production and supply of food is the key and guarantee of food security. Major manufacturers and farmers will then be able to adjust their operating policies and expectations, thereby reducing exposure to risks from changes in the volume of demand and fluctuations in the exchange rate.

2. LITERATURE REVIEW

The apparent coincidence of the parallel growth of oil prices and agricultural prices has attracted attention of many researchers worldwide. As a rule, most of their attention was paid to either the study of the relationship between agricultural prices and biofuel, or fluctuations in the exchange rate.

In some outstanding works, indicate the relationship between crude oil prices and agricultural prices. Esmaeili and Shokoohi (2011) found that oil prices have an indirect effect on agricultural prices. Campiche et al. (2007) investigated the co-variability between crude oil prices and a number of agricultural crops during the period from 2003 to 2007. Diagnostics through Johansen co-integration test allowed making a conclusion about the absence of co-integration for the period from 2003 to 2005. However, the prices of grain and soybeans were in co-integration with oil prices in the period from 2006 to 2007. Shocks in oil prices can explain only a small proportion of changes in agricultural prices to food crisis in 2006-2007, while in the post-crisis period, the role of oil prices as the explanatory variable increases (Wang et al., 2014). Nazlioglu (2011) found the existence of a stable causal relationship between oil and grain prices. In a similar study, Yu et al. (2006) analyzed the relationship between oil prices and vegetable products. The results of the Johansen co-integration test showed that the impact of oil prices on prices of agricultural goods is statistically insignificant for the studied period.

In the study, Baffes (2007) argues that there is a relationship between oil prices and 35 international agricultural traded goods for the period from 1960 to 2005. After determining the regression equation, the author claims that if oil prices remain high for some time, an agricultural boom is likely to last longer than in the absence of growth in oil prices. In addition, Baffes suggested to use individual prices for agricultural products in order to optimize the quality of regression models. Du et al. (2010) found that shocks in oil prices lead to a spike in agricultural prices due to increased linkages between the agricultural and energy sectors. The authors of this study used weekly prices of futures for oil, grain and wheat from 1998 to 2009 and applied a Bayesian Markov Monte Carlo method.

The last two studies speak in favor of the existence of significant correlation between agricultural and oil prices. However, a number of researchers come to alternate conclusions. For example, Zhang and Reed (2008) found that changes of agricultural prices in China are not the result of changes in world oil prices.

In addition, it should be noted that there are alternative linkages between oil prices and agricultural prices. So, Abbott et al. (2008) suggested that an increase in the current account leads to a depreciation of the US dollar, making exports more attractive than imports (exchange rate channel).

Currently, given the scale of international trade, the exchange rate is perhaps a key factor in determining the macroeconomic situation, not to mention attractiveness of the national economy. However, decades ago, the role of exchange rate in domestic markets for obvious reasons was underestimated. And it was not until 1974, when the brilliant work of Schuh (1974) on the role of exchange rate in agricultural trade has appeared. In this study, the author assumed that the overvalued dollar has reduced exports, due to the appearance of additional costs in importing countries. Kost (1976) conducted a study of theoretical bases used to assess the impact of exchange rate changes on commodities' trade volumes in the national economy. At the end, he came to conclusion that there are limits to how price and volume can change in response to changes in the exchange rate. At the same time, Vellianitis-Fidas (1976) conducted a cross-sectional study using stepwise ordinary least squares (OLS) method using data of different time periods. Kost (1976) and Vellianitis-Fidas (1976) in the end came to conclusion that the depreciation of the US dollar was not the cause of high prices in 1972-1973. Chambers and Just (1981) used regression analysis in order to test Granger causality between money supply and agricultural exports and lending rates. The results of the study were in line with other authors, and showed that the money supply (the value of the US dollar) plays a role in the volume of agricultural trade.

On contrary, Batten and Belongia (1984) defended the view that the exchange rate is insignificant and plays no special role. In their opinion, the cornerstone of demand for exports is the changing income of households in the importing countries. Chambers (1984) developed a theoretical model to assess short-term effects of changes in monetary policy on the agricultural sector. He also developed a vector autoregression (VAR) model for the resolution of statistical problems with the calculations. Kwon and Koo (2009) investigated reasons for the decline of food prices using the method proposed by Toda and Yamamoto (1995) - Granger causality test. The authors concluded that agricultural prices are influenced by exchange rate and oil prices through various channels, which is confirmed by previous empirical studies of the Abbott et al. (2008).

Until the 1980s it was believed that monetary factors do not affect agricultural prices due to neutrality of money in the long-run. However, large-scale validation of this hypothesis on empirical data has led to the emergence of overshooting hypothesis, which states that changes in money supply and interest rates can have a real impact on agricultural prices in the short-term (Frenkel, 2008). For example, Bordo (1980) studying short-term elasticity of agricultural prices, found that there is a relationship between monetary variables and agricultural prices in the long-term. A feature of the relationship is related to the adaptation of agricultural prices to shocks in the monetary sector taking into account the duration of contracts. Bessler (1984), on the basis of the analysis of prices for agricultural products in Brazil, using VAR analysis, showed existence of Granger causality of agricultural prices from the money supply in the long-term. Devadoss and Meyers (1987), using Sims' VAR technique found that there agricultural prices are sensitive to changes in monetary factors in the short-term. Saghaian et al. (2002) showed that agricultural price are elastic to changes in the monetary environment in the short-term and adjust faster than industrial prices. Asfaha and Jooste (2007) based on the vector error correction model, built using data for agricultural prices in South Africa, found that the hypothesis of neutrality of money is not confirmed in agricultural economics, in contrast to the hypothesis of overshooting. However, Tegene (1990), after analyzing the data of agricultural prices in the United States during the period from 1934 to 1987, using VAR model, came to the conclusion about the lack of a clear and statistically significant dependence of agricultural prices from changes in money supply and interest rates. To similar conclusions based on the analysis of data for agricultural sector of Pakistan come Mushtaq et al. (2011): In the short-term, shocks to the money supply and interest rates do not affect prices for agricultural commodities in the short-run.

Given the above, it should be noted that the history of the development of views on the question of relationship between agricultural prices, oil prices, interest and exchange rates is quite long, and opinions are sometimes are diametrically opposed. With this in mind, the authors present a review of relevant literature in Table 1.

3. MATERIALS AND METHODS

3.1. Research Methods

Engle and Granger (1987) developed a two-step test, which involves testing for the presence of unit root and to determine whether there is long-term, steady relationship between the variables y_t and x_t (co-integration relationship).

Step 1: Estimate the equation with the OLS method:

$$y_t = A_1\, y_{t-1} + \ldots + A_p\, y_{t-p} + Bx_t + \varepsilon_t$$

After calculating the non-equilibrium error, we get the co-integrating regression.

Step 2: Test the stability of the residual error obtained from Step 1. If the residual error is a stationary series, then variables y_t and x_t are considered to have the long-term stable relationship.

Testing stationarity of time series is a prerequisite for the regression analysis and the construction of VAR model. Among others, the most common is the augmented Dickey-Fuller (ADF) test, which we apply in this study to ensure stationary character of the used time series.

Table 1: Summary of relevant literature

Author	Commodity	Method	Oil prices, exchange rate-role
Johnson et al. (1977)	Wheat	Deterministic short run forecasting model	Important
Chambers and Just (1979)	General agriculture	Critique of exchange rate treatment	Somewhat important
Collins et al. (1980)	Wheat, corn, soybeans and cotton	Simple analytic method	Overly restricted in models
Chambers and Just (1989)	Wheat, corn, soybeans	Dynamic three stage least squares	Important
Chambers and Just (1981)	Agricultural versus non-agricultural sector	VAR	Important in the short run
Bessler (1984)	Brazilian agricultural prices	VAR	Important
Batten and Belongia (1986)	General agriculture	Standard expression for export determination	Not important
Orden and Fackler (1989)	General agriculture	Non-recursive structurally identified model	Inconclusive
Robertson and Orden (1990)	Agricultural prices	VAR and VEC	Play a role
Henry et al. (1993)	Beef cattle	Time series based on Bayesian VAR	Important
Babula et al. (1995)	Corn	Both structural econometric models and time series methods	Not important
Vellianitis-Fidas (1976)	General agriculture	OLSs and time series	Not important in 1972-1973
Author	**Commodity**	**Method**	**Monetary factors-role**
Bordo (1980)	Agricultural prices	VAR	Significant in long-run
Bessler (1984)	Brazilian agricultural prices	VAR	Significant in long-run
Devadoss and Meyers (1987)	Agricultural prices	Sims' VAR technique	Significant in short-run
Saghaian et al. (2002)	Agricultural prices	VAR	Significant in short-run
Asfaha and Jooste (2007)	Agricultural prices	VECM	Significant in short-run
Tegene (1990)	Agricultural prices	VAR	Not significant
Mushtaq et al (2011)	Wheat	VAR	Not significant in short-run

VAR: Vector autoregression, VEC: Vector error correction, VECM: Vector error correction model

3.1.1. Johansen co-integration test

With all the simplicity of use of the test for the presence of unit root, there are some restrictions hidden in the very mechanism of the test. The assumption of linearity must be fulfilled for building a linear model for estimation by the OLS method. In order to eliminate these problems, Johansen (1988) proposed a new method based on VAR model. First, it is necessary to build VAR model:

$$y_t = A_1\, y_{t-1} + ... + A_p\, y_{t-p} + Bx_t + \varepsilon_t$$

In which each component of y_t is non-reposeful series and it is integrated of order 1. x_t is a fixed exogenous vector, indicating the constant term, trend term and other certain terms. ε_t is a disturbance vector of k dimension.

After doing the calculus of finite differences, we can get:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \epsilon_t$$

$$\Pi = \sum_{i=1}^{p} A_i - I,\ \ \Gamma_i = -\sum_{j=i+1}^{p} A_j$$

We can obtain the $I(0)$ process after doing the transformation of the finite difference of $I(1)$ process. As a consequence, when Πy_{t-1} is the vector of $I(0)$, y_t is a stationary process.

3.1.2. Granger causality test

The basic idea of the Granger causality test consists of adding a lagged variable to the equation and test to determine whether this variable causes a lagged effect. If so, we can talk about the presence of causality according to Granger. The co-integration tests can only show whether there is long-term equilibrium relationship. However, to identify causal relationships one needs additional research methods. One of these is the Granger test.

We can test for the absence of Granger causality by estimating the following VAR model:

$$Y_t = a_0 + a_1 Y_{t-1} + \ldots + a_p Y_{t-p} + b_1 X_{t-1} + \ldots + b_p X_{t-p} + u_t$$

$$X_t = c_0 + c_1 X_{t-1} + \ldots + c_p X_{t-p} + d_1 Y_{t-1} + \ldots + d_p Y_{t-p} + v_t$$

Then, testing H_0: $b_1 = b_2 = \ldots = b_p = 0$, against H_A: "Not H_0," is a test that X does not Granger-cause Y.

Similarly, testing H_0: $d_1 = d_2 = \ldots = d_p = 0$, against H_A: "Not H_0," is a test that Y does not Granger-cause X.

In each case, a rejection of the null hypothesis (H_0) implies there is Granger causality.

3.2. Materials and Data Processing

The basis of statistical data for the study are monthly world oil prices, value of exchange rate of the Russian ruble/USD, bank lending rates for agricultural loans and monthly domestic prices of buckwheat, barley, potatoes, wheat, oats, rye and grain crops for the period from January 1999 to October 2015. The choice of this time span is due to the relative stability of agricultural prices during the 1990s. Since the end of 1990s, agricultural prices began to grow at a significant pace. In this study, we are interested in whether shocks in oil prices, lending rates and dynamics of the exchange rate are able to explain the upward trend in agricultural prices.

Variable "oil prices" represents the average monthly spot prices for crude oil (Brent) in Europe. Data is obtained from the statistical database of the US Energy Information Administration. Variable "exchange rate" is the value of the Russian ruble to the US dollar at the beginning of each month. Data is obtained from the statistical database of the Bank of Russia. Data on monthly average interest rates for agricultural loans is obtained from the database of the Bank of Russia. Data on monthly prices for agricultural goods is obtained from the database of the Federal Service of State Statistics of Russia (www.gks.ru).

To conduct time-series analysis, all variables are transformed into logarithms. To evaluate variables we use the method of descriptive statistics. To identify and formally assess the relationship between variables, we use simple correlation analysis. To study sensitivity of agricultural commodities' prices to shocks in oil prices, interest rates and the exchange rate of the ruble in short- and long-run, we turn to regression analysis, which involves the construction of unrestricted VAR model based on stationary time series, testing the model for heteroscedasticity of the residuals, autocorrelation as well as stability. Based on the model, we measure elasticity of variables in the short- and long-run by testing for the presence of co-integration and Granger causality, as well as using impulse response analysis.

4. RESULTS AND DISCUSSION

Descriptive statistics for variables are presented in Table 2. According to data of descriptive statistics, the exchange rate has the minimum value of standard deviation (0.1926). Standard deviation of interest rates is low as well (0.2492). In the case of oil prices, the standard deviation from the trend (0.6136) represents the maximum value of the entire sample. Specific behavior of the exchange rate and low volatility relative to other variables is because that throughout the 2000s in Russia the exchange rate was under the control of monetary authorities and restrained within the legislative boundaries. In this regard, significant exchange rate fluctuations were excluded. The transition in recent years to the regime of free exchange rate undoubtedly has increased the volatility. In case of interest rates, low deviations level can be explained by the fact that most of agricultural loans are granted by commercial banks, controlled (through equity share) by the state and interest rates are not elastic to market shocks (in cases of some banks, lending operations for agricultural business are even lossmaking).

In contrast, oil prices are characterized by the maximum value of the standard deviation, which suggests significant volatility. The same is true for the prices of agricultural goods. This feature is explained by the fact that oil prices are set on the world market and represent the ratio of supply and demand, as well as their dynamics.

If we turn to the results from simple correlation analysis (Table 3), we can detect a number of significant, at first glance, correlations. First, there is a significant linear relationship between the prices of various agricultural products. For example, the correlation between barley and wheat tends to 1 (0.981), and the correlation between barley and rye is 0.961. Thus, a sudden shock in the price of one commodity can lead to changes in the price of other goods, traded on the market.

Table 2: Descriptive statistics

Measure	LB	LBW	LCO	LER	LIR	LO	LP	LR	LW
Mean	8.0819	8.74862	3.98155	3.41162	2.667985	7.964022	8.834587	7.949375	8.216834
Median	8.06747	8.68075	4.09207	3.37831	2.60269	8.02871	8.82221	8.03923	8.24052
Maximum	9.00927	10.6411	4.88824	4.19863	3.54674	8.86433	9.94734	8.84220	9.17124
Minimum	6.24290	7.17141	2.32922	3.11307	2.18605	6.49237	7.66806	6.14081	6.41499
Standard deviation	0.57465	0.56022	0.61637	0.19264	0.24922	0.52122	0.46394	0.55946	0.54896
Skewness	−0.4004	0.65850	−0.4017	2.28912	0.93768	−0.38130	0.32609	−0.76340	−0.28542
Kurtosis	1.65133	2.24920	1.08606	2.32986	1.82590	1.36464	1.66224	2.17513	1.66764
Sum	1632.56	1767.22	804.274	689.147	538.933	1608.73	1784.58	1605.77	1659.80
Sum square deviation	66.3752	63.0833	76.3623	7.45920	12.4845	54.6060	43.2646	62.9120	60.5740
Observations	202	202	202	202	202	202	202	202	202

L in each name of the variables denotes the logarithm (i.e., LB: Logarithm of prices for barley, LBW: Logarithm of prices for buckwheat, LCO: Logarithm of prices for crude oil, LER: Logarithm of exchange rate, LIR: Logarithm of average interest rates for agricultural loans, LO: Logarithm of prices for oat; LP: Logarithm of prices for potatoes, LR: Logarithm of prices for rye, LW: Logarithm of prices for wheat)

Table 3: Correlation matrix

Variable	LB	LBW	LCO	LER	LIR	LO	LP	LR	LW
LB	1.000								
LBW	0.775	1.000							
LCO	0.866	0.667	1.000						
LER	0.423	0.479	0.122	1.000					
LIR	−0.479	−0.38	−0679	0.208	1.000				
LO	0.965	0.759	0.883	0.436	−0492	1.000			
LP	0.840	0.795	0.756	0.502	−0423	0.865	1.000		
LR	0.961	0.708	0.863	0.339	−0447	0.954	0.789	1.000	
LW	0.981	0.750	0.816	0.476	−0427	0.949	0.814	0.946	1.000

LB: Logarithm of prices for barley, LBW: Logarithm of prices for buckwheat, LCO: Logarithm of prices for crude oil, LER: Logarithm of exchange rate, LIR: Logarithm of average interest rates for agricultural loans, LO: Logarithm of prices for oat; LP: Logarithm of prices for potatoes, LR: Logarithm of prices for rye, LW: Logarithm of prices for wheat

The results of correlation analysis also show the presence of a linear relationship between the prices of agricultural goods and oil prices. For example, it can be considered a strong correlation between oil prices and the prices of rye and oat (0.863 and 0.883, respectively). However, this correlation may be misleading and the results cannot be considered fully reliable because of serial correlation issue.

The picture with the exchange rate looks not so clear. The degree of linear correlation between exchange rate and prices of agricultural products can be considered, at best, medium (0.3-0.5). This speaks in favor of the absence of a significant dependence of agricultural prices from exchange rate fluctuations. The reasons for this correlation may be the fact that Russia is a major international agricultural exporter. Therefore, shocks to exchange rate do not have a significant impact on domestic prices. However, it is important to remember that Russia is not a net exporter. The import channel affects a number of agricultural products included in the sample. In case of crop failure or inadequate supply the share of import of certain goods increases (for example, in the case of buckwheat).

Speaking of interest rate and its correlation with agricultural prices it is quite important to notice that the correlation is negative and medium at best (0.3-0.4). This observation could be explained by the fact that in good times demand for agricultural commodities increases pushing the prices upward. Increasing demand affects demand for loans. Rising returns in agriculture decreases risk expectations of creditors. Therefore, risk premium in interest rate decreases and *viz*. However, cyclic volatility of risk premium is low and medium strength correlation might be misleading.

Since the way of stochastic is different at each time point of the non-stationary series, general stochastic of the series is hard to capture. There is also the probability of obtaining spurious regression.

Thus, to resolve the problem with the non-stationarity of time series, it is necessary to test for the presence of unit root. The results of ADF and Phillips–Perron tests are presented in Table 4. The results show that the maximum order of integration is 1 ($d = 1$). This means that the first-differenced variables with constant and trend are stationary. Obtained differentiated variables are used to build the VAR model.

Building a VAR model involves determining the optimal number of lags. In our case, the Akaike information criterion equals 2. Consequently, we built a model based on the use of time lag of 2 months to determine the relationship in the short-term. The results of the diagnostic testing of the model for heteroscedasticity of residuals, autocorrelation, serial cross-correlation, and stability are presented in Table 5. As can be seen from Table 5, the model is stable, heteroscedasticity and serial correlation of residuals in the model are absent.

The model is used to determine the level of sensitivity of control variables (the price of agricultural goods) to shocks in oil prices and the exchange rate in the short-run and we use it to test for stable long-run linkages, applying Johansen and Granger tests. Results of Johansen co-integration test are presented in Table 6.

Johansen test results show the presence of co-integration between a number of equations, which allows presuming the existence of a long-term relationship between a number of them. However, the results of Johansen test can be accepted only if they are viable, and identified relationships meet the requirement of stability. For testing the last one, we use the AR roots graph (Figure 4). Since the inverse roots are all depicted in the unit circle, we can say that the VAR model is stable and does not affect the standard deviation in impulse response function.

The long-run causality test confirms the presence of a number of long-term relationships between the variables. Thus, in contrast to simple correlation analysis, Granger test (Table 7) shows the

Table 4: Results of the group unit root test

Test in:	ADF		PP	
	Statistic	P**	Statistic	P**
Levels				
Intercept	8.4421	0.9392	7.9174	0.9021
Intercept and trend	7.3459	0.3187	5.4482	0.3685
First-difference				
Intercept	770.82	0.0000**	745.54	0.0000**
Intercept and trend	749.75	0.0000**	720.58	0.0000**

**Denotes statistical significance at the 5% level of significance. ADF: Augmented Dickey-Fuller, PP: Phillips-Perron

Table 5: Results of unrestricted VAR model diagnostic testing

Type of test	Results		
	Lags	LM-stat	P value
VAR residual serial correlation LM test	1	100.1202	0.0736**
	2	92.8017	0.1743**
Stability condition test	All roots lie within the circle. VAR satisfies stability condition		
Heteroscedasticity (white test)	0.1497*		
VAR residual cross correlation test	No autocorrelation in the residuals		

**Denotes acceptance of null hypothesis (H_0: There is no serial correlation). *Denotes acceptance of null hypothesis of homoscedasticity. VAR: Vector autoregression, LM: Logarithm of prices for wheat

Table 6: Results of Johansen co-integration test

Hypothesized number of CE(s)	Eigen value	Trace statistics	0.05 critical value	P
None*	0.288922	245.3806	197.3709	0.0000
At most 1*	0.235629	177.8679	159.5297	0.0034
At most 2	0.167601	124.6651	125.6154	0.0571
At most 3	0.152614	88.34322	95.75366	0.1451
At most 4	0.110686	55.55455	69.81889	0.3961
At most 5	0.084663	32.32808	47.85613	0.5941
At most 6	0.057397	14.81240	29.79707	0.7921
At most 7	0.013876	3.108501	15.49471	0.9618
At most 8	0.001725	0.341757	3.841466	0.5588

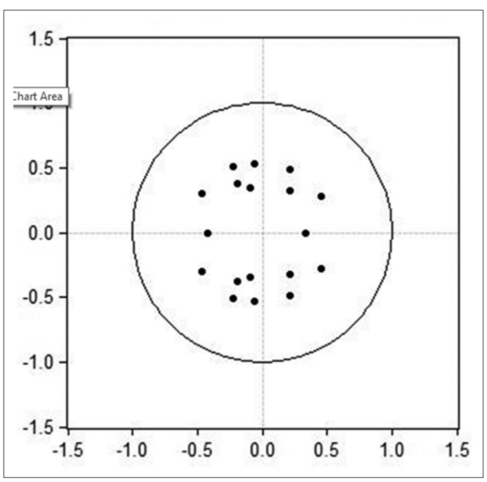
Trace statistics indicate 2 co-integrating equations at the 0.05 level. *Denotes statistical significance at the 5% level of significance presence of a long-term relationship between the exchange rate and the prices of buckwheat. At the same time, the Granger causality between exchange rate and other agricultural commodities is missing. This result is explained by the fact that for most of agricultural products, Russia is a net exporter and the channel of exchange rate has no significant impact on prices in the agro-industry. In the case of buckwheat, Russia is both a producer and importer. In case of droughts, crop failures, artificial panics in the agricultural market ("Buckwheat mania" of 2010-2011, crop failure of 2013), as well as increasing production costs and restriction of free pricing, lead to a loss of competitiveness of domestic producers. In 2014-2015, significant role in increasing domestic prices has played a sharp and strong depreciation of the ruble.

The absence of Granger causality from oil prices to agricultural commodities is also due to the exporting status of Russia. No need for import of crude oil reduces sensitivity of domestic agricultural price fluctuations to the world market.

Thus, in the group of agricultural commodities, on which Russia is a net exporter, sensitivity to shocks in oil prices and exchange rate tends to zero. For those agricultural goods that are imported (e.g., buckwheat), the channel of the exchange rate manifests itself in the long-run.

Results of Granger causality test for interest rates show that interest rates actually affect domestic prices on rye and wheat in the long-run. In case of other agricultural commodities no significant effect has been found. Explanation for this long-run causality can be simply explained by dependence of agricultural entities from lending. A spike in interest rates leads to adaption of domestic prices in future periods. Some industries are more "lending sensitive" than others because of absence of interest rates' subsidies, e.g.,

Figure 4: Inverse roots of AR characteristic polynomial



To assess the link between agricultural prices, oil prices, interest and exchange rates in the short-run, we turn to impulse response analysis. This technique allows us to assess sensitivity of control variables to shocks in oil prices and exchange rate in the short-run on the basis of the constructed VAR model. The results of impulse response analysis are presented in Figures 5-7.

The results of impulse-response analysis mostly confirm the overall results of the Granger test. In the short-term and in the long-term sensitivity of buckwheat prices to shocks in the exchange rate is manifested. In the case of oil prices statistically significant sensitivity of agricultural prices to shocks is not observed. This feature may take place due to import independence of Russian on energy raw materials.

Interest rates, as in the case of long-term causality, shows that rye is sensitive to shocks in interest rates. Short-term responses of wheat prices to changes in interest rates is not observed. This feature is explained by the fact that much of wheat is traded with long-term contracts and price volatility in the short-run has no significant effect on them. In case of other agricultural commodities, sensitivity to shocks in interest rates is not observed. This may be due to the state policy of subsidizing interest payments on a number of agricultural crops. In general, results of the research are consistent with the theory of international trade.

5. CONCLUSION

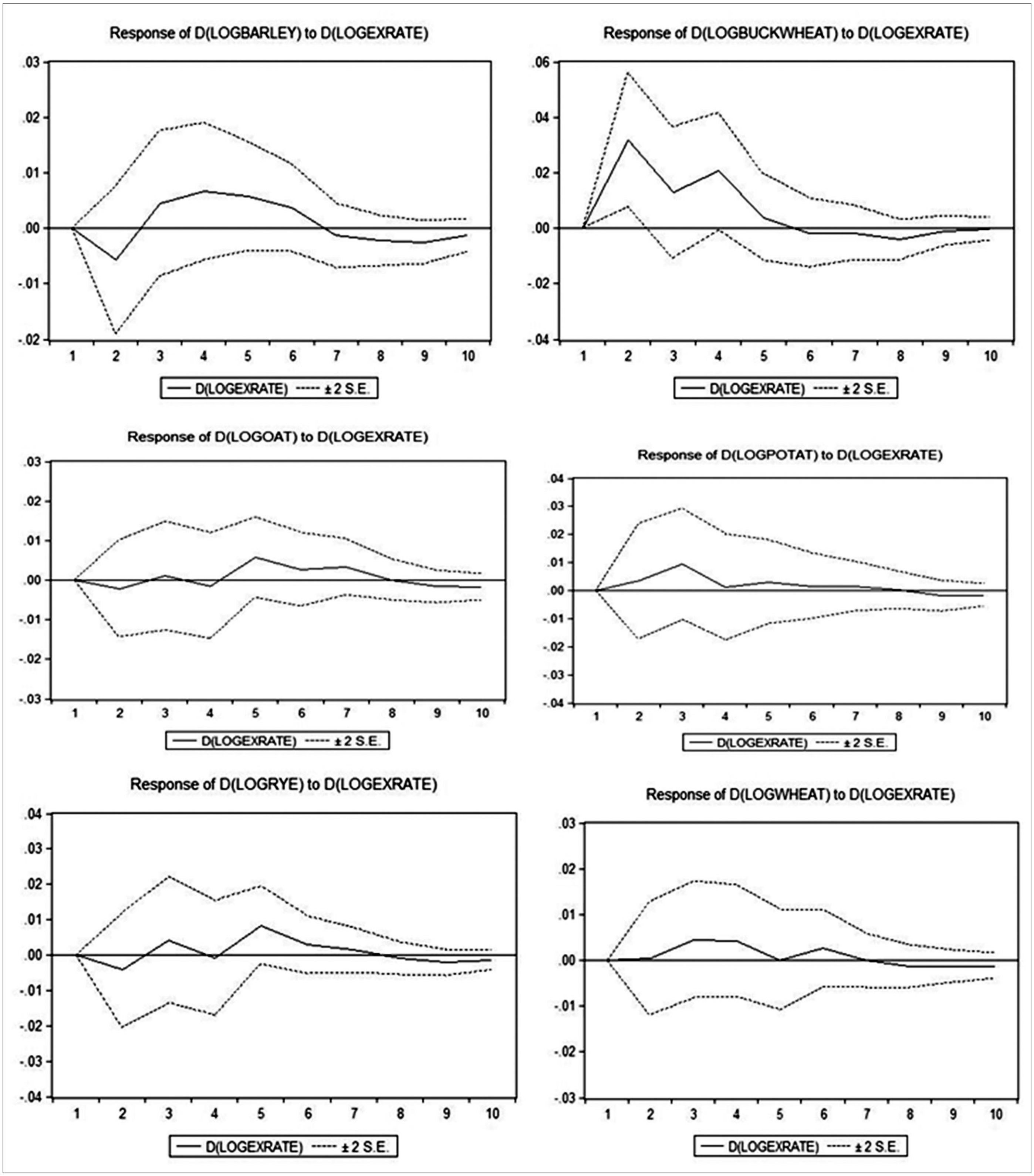
This study focuses on the analysis of relationships and determining sensitivity of agricultural prices to oil prices, interest and exchange rates. The definition of the character of interrelations in the national economy is important to ensure macro-economic wellbeing and food security. A clear understanding of the links between agricultural prices, oil prices, lending and exchange

Table 7: Results of long-run Granger causality test

Variable	LB	LBW	LCO	LER	LIR	LO	LP	LR	LW
LB		0.221	0.305	1.868	2.516	2.127	0.336	0.586	0.991
LBW	2.203		3.959	10.879*	0.653	0.159	1.704	0.463	1.285
LCO	1.066	0.626		2.241	7.491	3.148	2.618	2.534	0.626
LER	5.279	2.669	4.318		5.642	1.070	1.398	0.575	4.672
LIR	0.861	1.358	0.640	7.458		2.981	2.665	0.478	3.904
LO	16.743*	0.267	3.190	0.433	3.030		5.978*	11.380*	0.749
LP	4.108	1.633	0.021	0.581	0.701	1.307		1.660	1.363
LR	9.509*	1.190	3.127	0.232	10.236*	0.535	0.496		5.847*
LW	9.438*	0.639	0.545	1.550	8.357*	0.365	0.450	3.447	

*Denotes statistical significance at the 5% level of significance and rejection of null hypothesis of no Granger causality. LB: Logarithm of prices for barley, LBW: Logarithm of prices for buckwheat, LCO: Logarithm of prices for crude oil, LER: Logarithm of exchange rate, LIR: Logarithm of average interest rates for agricultural loans, LO: Logarithm of prices for oat, LP: Logarithm of prices for potatoes, LR: Logarithm of prices for rye, LW: Logarithm of prices for wheat

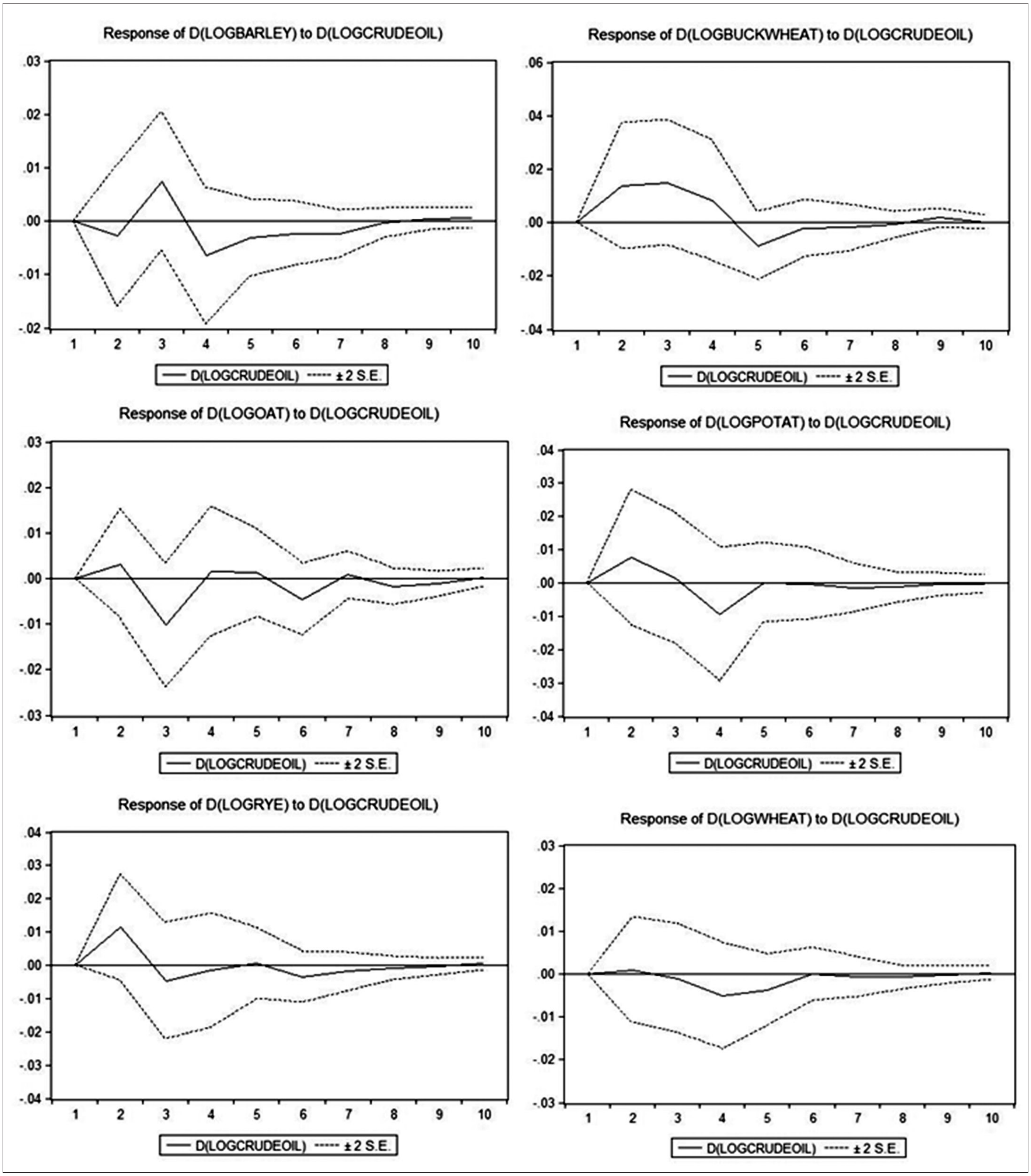
Figure 5: Response to one-standard deviation of the exchange rate



rates is a key prerequisite for the formation of optimal monetary and fiscal policy. Analyzing sensitivity of Russian agricultural market to shocks in world oil prices and exchange rate, we come to conclusion that the status of an exporter of agricultural products significantly protects the national economy from the effects of adverse shocks. Adverse effects, stemming from shocks to interest rates are mitigated through long-term contracts and subsidizing policies in some cases. However, casual linkage between interest rates (monetary factor) and agricultural prices holds true in the long- and short-run, thereby giving additional support to overshooting hypothesis.

However, at the same time, changes in oil prices, lending and exchange rates are not sufficient to explain an increase in domestic

Figure 6: Response to one-standard deviation of world oil price

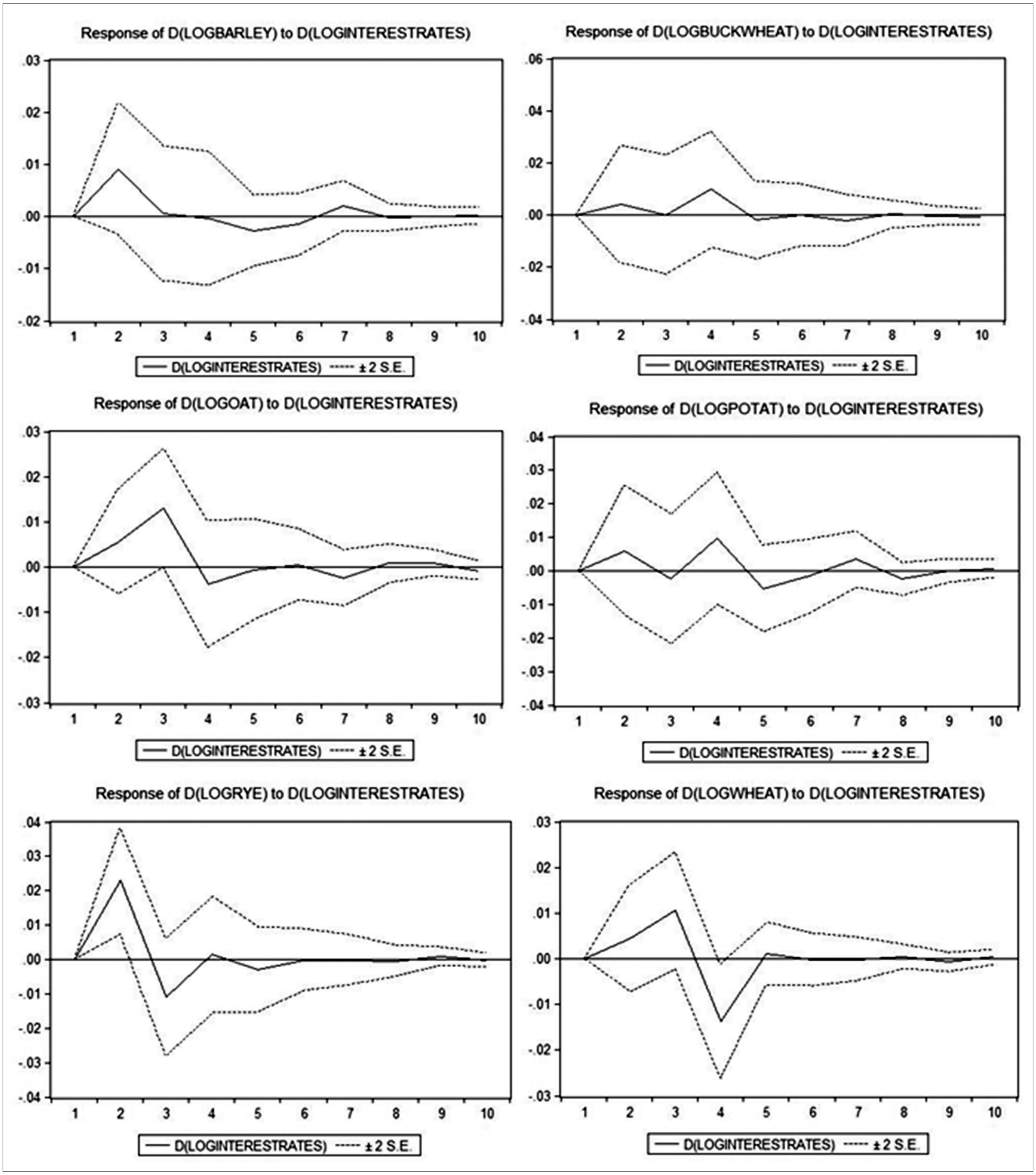


agricultural prices, which could be the subject of further research.

In the case of importer's status (for Russia-import of buckwheat), sensitivity to exogenous shocks of exchange rate (under condition of free market pricing) increases dramatically, which creates a threat to food security and welfare of the population. Removing subsidy policies and establishing market pricing for agricultural loan could be another challenge for the national economy.

Thus, an additional argument is given to the position according to which the transmission channel of exchange rate plays a significant

Figure 7: Response to one-standard deviation of interest rate



role in pricing mechanism of agricultural products, as well as for monetary factors affecting agricultural prices.

REFERENCES

Abbott, P.C., Hurt, C., Tyner, W.E. (2008), What's Driving Food Prices? Farm Foundation. Issue Reports, July 2008. Available from: http://www.ageconsearch.umn.edu/bit-stream/37951/2/FINAL%20WDFP%20REPORT%20 7-28-08.pdf.

Asfaha, T., Jooste, A. (2007), The effect of monetary changes on relative agricultural prices. Agrekon: Agricultural Economics Research, Policy and Practice in Southern Africa, 46(4), 460-474.

Babula, R.A., Ruppel, F.J., Bessler, D.A. (1995), U.S. corn exports: The role of the exchange rate. Agricultural Economics, 13, 75-88.

Baffes, J. (2007), Oil spills on other commodities. Access and Download Statistics, 32, 126-134.

Bank of Russia Official Web Site. Available from: http://www.cbr.ru.

Batten, D.S., Belongia, M.T. (1984), The recent decline in agricultural exports: Is the exchange rate the culprit? Federal Reserve Bank of St. Louis Review, 66, 5-14.

Batten, D.S., Belongia, M.T. (1986), Monetary policy, real exchange rates, and U.S. Agricultural Exports. American Journal of Agricultural Economics, 68, 422-427.

Bessler, D.A. (1984), Relative prices and money: A vector autoregression on Brazilian data. American Journal of Agricultural Economics, 66, 25-30.

Bordo, M. (1980), The effect of monetary changes on relative commodity prices and the role of long-term contracts. Journal of Political Economy, 61, 1088-1109.

Campiche, J.L., Bryant, H.L., Richardson, J.W., Outlaw, J.L. (2007), Examining the Evolving Correspondence between Petroleum Prices and Agricultural Commodity Prices. In: Proceeding of the AAEA Meeting, Portland, OR, July 29, August 1.

Chambers, R.G. (1984), Agricultural and financial market interdependence in the short run. American Journal of Agricultural Economics, 66, 12-24.

Chambers, R.G., Just, R.E. (1979), A critique of exchange rate treatment in agricultural trade models. American Journal of Agricultural Economics, 61, 249-257.

Chambers, R.G., Just, R.E. (1981), Effects of exchange rate changes on U.S. agriculture: A dynamic analysis. American Journal of Agricultural Economics, 63, 32-46.

Chambers, R.G., Just, R.E. (1989), Estimating multioutput technologies. American Journal of Agricultural Economics, 71, 980-995.

Collins, K.J., Meyers, W.H., Bredahl, M.E. (1980), Multiple exchange rate changes and U.S. agricultural commodity prices. American Journal of Agricultural Economics, 62, 656-665.

Devadoss, S., Meyers, W.H. (1987), Relative prices and money: Further results for the United States. American Journal of Agricultural Economics, 69, 838-842.

Du, X., Hayes, D.J., Yu, C. (2010), Dynamics of biofuel stock prices: A Bayesian approach. American Journal of Agricultural Economics, 93, 418-425.

Engle, R.F., Granger, C.W.J. (1987), Co-integration and error correction: Representation, estimation, and testing. Econometrica, 55, 251-276.

Esmaeili, A., Shokoohi, Z. (2011), Assessing the effect of oil price on world food prices: Application of principal component analysis. Energy Policy, 39, 1022-1025.

FAOSTAT: Food and Agriculture Organization of the United Nations, [DB/OL]. Available from: http://www.faostat.org.

Federal Service of State Statistics of Russia. Available from: http://www.gks.ru.

Frenkel, J. (2008), The Effect of Monetary Policy on Real Commodity Prices. Chapter in “Asset Prices and Monetary Policy”. NBER Research. p291-333.

Hanson, K., Robinson, S., Schluter, G. (1993), Sectoral effects of a world oil price shock: Economy wide linkages to the agricultural sector. Journal of Agricultural and Resource Economics, 18, 96-115.

Harri, A., Nalley, L.L., Hudson, D. (2009), The relationship between oil, exchange rates, and commodity prices. Journal of Agricultural and Applied Economics, 41, 501-510.

Henry, G., Peterson, E.W.F., Bessler, D., Farris, D. (1993), A time-series analysis of the effects of government policies on the U.S. beef cattle industry. Journal of Policy Modeling, 15, 117-139.

Johansen, S. (1988), Statistical analysis of co-integration vectors. Journal of Economic Dynamics and Control, 12, 231-254.

Johnson, P.R., Grennes, T., Thursby, M. (1977), Devaluation, foreign trade controls, and domestic wheat prices. American Journal of Agricultural Economics, 59, 619-627.

Keith, C. (2008), The role of recent developments with a focus on feed grain markets and market prospects: A review of recent development with a focus on feed grain markets and market prospects. Supporting Material for a Review Conducted by Kraft Foods Global, Inc., of the Current Situation in Farm and Food Markets, June 19, 2008.

Kost, W.E. (1976), Effects of an exchange rate change on agricultural trade. Agricultural Economics Research, 28, 99-106.

Kwon, D., Koo, W.W. (2009), Price transmission channels of energy and exchange rate on food sector: A disaggregated approach based on stage of process. In: Agricultural and Applied Economics Association 2009 AAEA and ACCI Joint Annual Meeting, Milwaukee, Wisconsin, July 26-29. 2009.

Mushtaq, K., Ghafoor, A., Ahmad, F. (2011), Impact of monetary and macro economic factors on wheat prices in Pakistan: Implications for food security. The Lahore Journal of Economics, 16(1), 95-110.

Nazlioglu, S. (2011), World oil and agricultural commodity prices: Evidence from nonlinear causality. Energy Policy, 39, 2935-2943.

Orden, D., Fackler, P.L. (1989), Identifying monetary impacts on agricultural prices in VAR models. American Journal of Agricultural Economics, 71, 495-502.

Robertson, J.C., Orden, D. (1990), Monetary impacts on prices in the short and long run: Some evidence from New Zealand. American Journal of Agricultural Economics, 72, 160-171.

Saghaian, S., Reed, M., Merchant, M. (2002), Monetary impacts and overshooting of agricultural prices in an open economy. American Journal of Agricultural Economics, 84, 91-103.

Schuh, G.E. (1974), The exchange rate and U.S. agriculture. American Journal of Agricultural Economics, 57, 1-13.

Tegene, A. (1990), The impact of macroeconomic variables on the farm sector: Some further evidence. Southern Journal of Agricultural Economics, 7, 77-86.

Toda, H.Y., Yamamoto, T. (1995), Statistical inference in vector autoregressions with possibly integrated processes. Journal of Econometrics, 166, 225-250.

Vellianitis-Fidas, A. (1976), The impact of devaluation on U.S. agricultural exports. Agricultural Economics Research, 28, 107-116.

Von Braun, J. (2008), Rising food prices: What should be done? Eurochoices, 7, 30-35.

Wang, Y., Wu, C., Yang, L. (2014), Oil price shocks and agricultural commodity prices. Energy Economics, 44, 22-35.

Yu, T., Bessler, D.A., Fuller, S.W. (2006), Cointegration and causality analysis of world vegetable oil and crude oil prices. In: American Agricultural Economics Association 2006, Annual Meeting, July 23-26, Long Beach.

Zhang, Q., Reed, M.R. (2008), Examining the Impact of the World Crude Oil Price on China‘s Agricultural Commodity Prices: The Case of Corn, Soybean, and Pork, In: _2008 Annual Meeting_, Feb 2–6, 2008, Dallas,Texas.