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MODELLING OF EXCHANGE RATE EFFECTS AND COMPLIMENTARIES BETWEEN AGRICULTURE AND INDUSTRY IN UKRAINE

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This paper examines links between the exchange rate, agricultural and industrial outputs in Ukraine. This is estimated using monthly data for the 2001−2015 period. Results provide evidence that there is a positive spillover from agriculture to industry, being in line with modern arguments on the role of agricultural sector in economic growth (infrastructural spillovers, rural income effects, provision of resources for an industrialized economy). However, industrial output squeezes out agricultural production in the short run. Depreciation of the nominal (real) exchange rate has an expansionary effect on industrial output, but it is harmful for agriculture. From a policy perspective, the results suggest that agriculture-supporting policies should be productive in the industrialization context either.

Keywords**:** agriculture, industry, nominal (real) exchange rate, Ukraine

1. Introduction

Ukraine is a country with well-recognized comparative advantages in the agriculture, with land and climate suitable for agricultural production. As of 2014, agriculture accounted for a third of the total exports, including processed goods. Since 2012, relative stability of agricultural production is in a sharp contrast to a deep plunge in industrial output. Though high world food prices could have propped up demand for Ukraine’s agricultural production over the 2010–2013 period, recent downward price developments potentially have been of an opposite effect. To make things even worse, there has been a large depreciation of exchange rate to the tune of 90 percent since February 2014, not to mentioning an armed conflict in two eastern regions of Ukraine. These and other challenges notwithstanding, prospects for development of Ukraine's agriculture are rather optimistic. Macroeconomic model for Ukraine's economy AGMEMOD envisages a stable growth in production of wheat, corn, barley, sunflower and rapeseed at least till 2025 [10]. However, it is not clear whether agriculture can serve as a true engine of country's economic growth in general and industrial output in particular. As argued for transitional economies in Central and Eastern Europe and Central Asia by Gylfason [6], heavy dependence on natural resources and agriculture may result in rent seeking, policy failures (e.g., inflation), disincentives for education, external trade, and saving, thereby retarding economic growth.

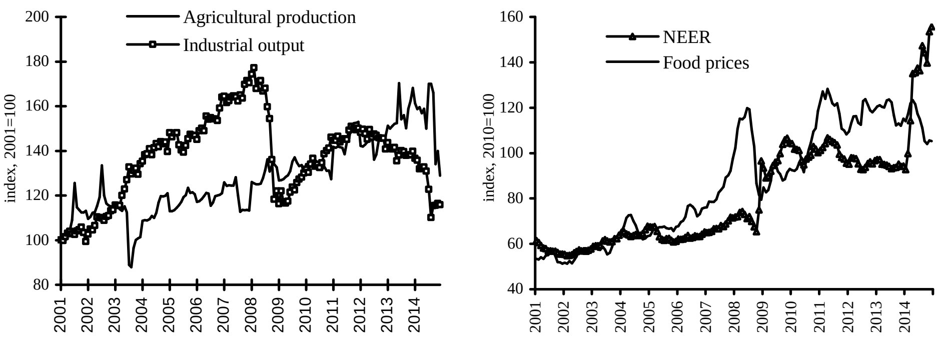


Figure 1. Ukraine: selected macroeconomic indicators, 2001–2014
Source: Ukraine's State Statistical Committee (www.ukrstat.gov.ua)

Recent empirical studies have yielded ambiguous evidence and there remains a lack of consensus on the effect of agriculture on economic development in general and industrial output in particular [2]. While most of empirical studies support the assumption that agricultural development is a precondition to industrialization [5], there are several arguments in favor of agriculture-led growth: (i) complementarity between investment in agriculture and the accompanying creation of infrastructure and institutions in other sectors, (ii) rising of rural incomes, with an expansion of market for consumer goods produced by domestic manufacturers, (iii) provision of resources for transformation into an industrialized economy, and (iv) alleviating of the foreign exchange constraint. Even for countries with a middle-level income, empirical studies provide strong evidence indicating that agriculture is an engine of economic growth [2]. For example, Taiwan had been successful in stimulating agricultural production and then converting it into accelerating growth in the nonagricultural sector [12]. However, in the process of agricultural development and expansion of exports it is important not to get trapped in the low-quality segment of the agro-food market with a decreasing competitiveness performance, as it has happened in Bulgaria and Romania [1].

The remainder of this paper is structured in the following way. A brief survey of theoretical issues is provided in the next section. Empirical methodology is outlined in the third section. The empirical results are explained at length in the fourth section, followed by the conclusions in the fifth and final section.

2. Literature survey

It is a dominant theme in the developmental literature that an increase in the industrial output is associated with a declining role of agriculture. Low agricultural productivity is a major obstacle for acceleration of economic growth. For example, Gollin et al. [5] propose a two-sector model with modern industry and less productive agriculture. The agricultural good is produced by a traditional technology ($\bar{a}$ units per unit of time) and a modern technology:

$$Y_{at} = A_a (1+\gamma_a)^t N_{at}, \tag{1}$$

where A_a is a total-factor-productivity (TFP) parameter that is assumed to be country-specific, γ_a is the constant exogenous rate of technological change in the modern agricultural technology that is common across countries, N_{at} is employment in the agricultural sector. The agricultural TFP parameter is affected by country policy and institutions, both climate and the quantity and quality of land per person. As the economy cannot substitute away from agricultural output, a distortion to agricultural activity actually leads to a counterproductive allocation of resources. Once equality $A_a (1+\gamma_a)^t \geq \bar{a}$ is satisfied, agricultural production switches from the traditional technology to the modern technology, and labor flows out of agriculture at a rate of γ_a. Based on data of 62 countries for the 1960–1990 period, it is empirically established that there is a negative relationship between agricultural productivity and the share of employment in agriculture.

Matsuyama [11] with a two-sector model of endogenous growth and learning-by-doing in the manufacturing sector demonstrates that there is a positive link between agricultural productivity and economic growth for the closed economy case, but it is just the opposite for the open economy case. If there is no foreign trade, an exogenous increase in agricultural productivity releases labour for manufacturing employment thus accelerating economic growth. For the open economy case, an economy with less productive agriculture allocates more labour to manufacturing and thus will grow faster. If there is no offsetting changes to relative prices, the productive agricultural sector squeezes out the manufacturing sector, with the economy being deindustrialized over time.

Causality can run from industry to agriculture as well. Yang and Zhu [19] propose a model implying the industrial development is a precondition for the modernization of agriculture, as it is necessary to bring the price of industrial products relative to agricultural products below a certain threshold, thus making it profitable for some farmers to adapt modern technology that uses industry-supplied inputs, such as manufactured farm implements and machinery, chemical fertilizers and high-yield seed varieties. In contrast, traditional technology uses labour and land only, with diminishing returns to labour. As agricultural modernization takes place, TFP growth in industry is reinforced with TFP developments in agriculture, contributing directly to agricultural labor productivity growth through the use of industry-supplied inputs, and thus facilitating structural change.

Arguments in favor of complementarity between industrial and agricultural sectors had been raised with strength in the 1960s by Schultz [14] and reinforced in many studies since then [13]. First, implementation of modern technologies in agriculture leads to productivity gains which in turn allow for redistribution of labour force in favour of industry [4; 16; 19]. For 23 Asian, Latin American and OECD countries over the 1963–2005 period, it is found that a decrease in the share of agriculture in total labour force is explained by a higher productivity, not by such alternative explanations as less efficient technologies, labour market deformations, labour migration or institutional obstacles [17].

Second, a favorable multiplier effect could emerge due to several mechanisms: (i) an increase in industry supplies, (ii) higher purchasing power of rural population (it is helpful in the expansion of demand for domestic industrial goods and services), (iii) a decrease in domestic food prices (it allows for a competitive level of industrial wages), (iv) an increase in budget revenues (it could be contributive to financing of infrastructural projects in the countryside), (v) weakening of the foreign exchange constraint due to export of agricultural goods (it is important for access to imported investment goods and raw materials). Agriculture may be a slower-growing sector, but it has large mass that implies not only a large output but also large economic inputs [13].

Third, better employment prospects in the countryside and higher incomes lead to accumulation of human capital, thus strengthening incentives for productivity. A similar effect could be achieved due to a higher level of social capital as a by-product of expansion in agricultural production [8]. An increase in income of farmer's households can be a factor behind higher savings, with better conditions for nutrition, lower inflation and elimination of poverty contributing to higher quality of labour force [2]. There is no evidence that policies that discriminate against agriculture have been beneficial for long-term economic growth [3].

As remarked by Mao and Schive [12], agricultural-led growth does not mean that agriculture would hold an increasing share in the economy, or that resources would flow only one way between the agricultural and nonagricultural sectors. It is about a more balanced pattern of development through stable prices, more equitable income distribution, less regional dualism, and probably a higher degree of social stability. The example of Taiwan is much telling. Initially, since the beginning of 1950s an accelerated growth of local agriculture contributed to industrial developments in the field of labor-intensive products, such as radios, bicycles, sewing machines, and machine tools, which quickly became competitive in international markets. A favorable reverse causality had emerged over time, when investment boom in computer industries allowed for policies to alleviate the burden of taxes, reduce fertilizer prices, and eventually abolish the rice-fertilizer barter system, with an increase of new investment in agricultural infrastructure and research and development.

The direction of exchange rate effects on agriculture is far from being unambiguous, as a positive demand-driven impact on exports could be neutralized by adverse supply-side effects [9]. For example, appreciation of exchange rate is responsible for an adverse effect on agriculture in Africa [13]. For Ukraine, it is found that the long-run exchange rate elasticity of export demand seems to be rather weak, although the exchange rate depreciation strongly contributes to demand for agricultural exports in the short-run (except foodstuffs) [15].

3. Empirical methodology

For empirical analysis, monthly dataset is used. The sample covers the period 2001:1–2014:12. Unfortunately, earlier observations are not available. This implies that the time span is rather short which could have implications for our results. Agricultural and industrial outputs have been taken from the Ukraine's State Statistical office (www.ukrstat.gov.ua) while the nominal (real) exchange rate has been obtained from the IMF's *International Financial Statistics* database (www.imf.org). All variables enter in logs, as it is common in order to improve statistical properties of the time series, with agricultural and industrial output series being seasonally adjusted.

There are such problems in analyzing data on the relationship between agricultural and nonagricultural growth as unavailability of important data (for example, for the small- and medium-size enterprises stimulated by agricultural growth) or complex lags in response to the various stimuli [14]. From the latter perspective, the use of vector autoregressive methodology is an obvious choice. Our empirical approach consists of two steps. First, we estimate impulse response functions and variance decompositions using a structural vector autoregressive (SVAR) model. Second, some robustness tests are conducted with an alternative measure of the exchange rate effects.

Our specification of the SVAR includes monthly data on agricultural production ($agro_t$), industrial output (ind_t), nominal effective exchange rate (e_t), and world food prices ($pfood_t$) (Fig. 1). Agricultural production has been on a steady upward trend till the beginning of 2014, with a sharp drop in production since then. There are two structural shifts in industrial output in 2008-2009 and 2014 which coincide with two large devaluations at these periods of time. Consequently, a dummy variable is used to control for the effects of the 2008–2009 world financial crisis and economic turbulence of 2014. As logarithmic transformation is meant to improve the fit, it is justified on the ground of a standard production function like the Cobb-Douglas model as well.

The use of a VAR addresses the potential endogeneity between the variables. For instance, while it is possible for agricultural production to impact Ukraine's industrial output, it is not ruled out that causality is running the opposite way. It is also likely that both variables respond to changes in exchange rate.

Comparing with the conventional Cholesky decomposition results which depend on the ordering of the variables, specification of the structural model allows for a more precise identification of causal links. For example, a two-way causality between agricultural and industrial sectors can be accounted for in order to test contradicting predictions of competitive two-sector growth models.

Assuming infinite vector moving average representation of $A_0 X_t = A(L) X_{t-1} + B\varepsilon_t$, the reduced-form of the VAR model is as follows:

$$X_t = A_0^{-1} A(L) X_{t-1} + A_0^{-1} B\varepsilon_t = C(L) X_{t-1} + u_t, \quad (2)$$

where X_t is a $N \times 1$ vector of the endogenous variables, $A(L)$ is a polynomial variance-covariance matrix, L is the lag operator, $C(L)$ is a matrix representing the relationship between lagged endogenous variables, ε_t is a $N \times 1$ vector of normally distributed, serially uncorrelated and mutually orthogonal white noise disturbances, and u_t is $N \times 1$ vector of normally distributed shocks that are serially uncorrelated but could be contemporaneously correlated with each other.

The specification of our SVAR is as follows (in terms of the contemporaneous innovations):

$$pfood = u_1, \quad (3)$$

$$agro = a_1 pfood + a_2 ind + u_2, \quad (4)$$

$$e = b_1 pfood + b_2 agro + u_3, \quad (5)$$

$$ind = c_1 agro + c_2 e + u_4, \quad (6)$$

All variables in equations (3)–(6) represent the first stage VAR residuals. It is assumed that innovations to the world food prices are contemporaneously uncorrelated with innovations to other variables (equation (3)). Agricultural production is affected by the world food prices and industrial output (equation (4)).

The former link reflects the realities of export-oriented agricultural sector while the latter relates Ukraine's agricultural production with domestic industrial output. While it is quite natural to assume a positive relationship between agricultural production and world good prices ($a_1 > 0$), the relation to industrial output is rather ambiguous ($a_2 <> 0$), as it is implied by competitive theoretical models.

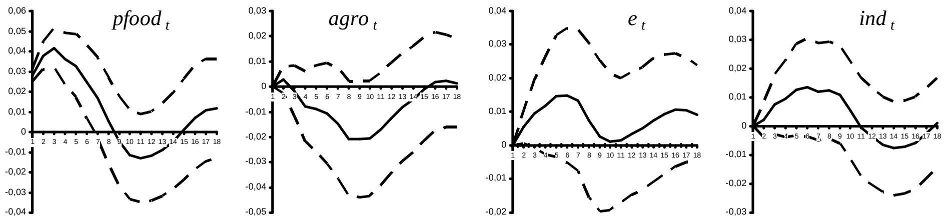
An exchange rate is a function of either world food prices or agricultural production (equation (5)). As higher value for agricultural exports should contribute to the supply of foreign exchange, an increase in agricultural production is expected to strengthen the demand for domestic currency thus reinforcing a tendency for the exchange rate appreciation ($b_1, b_2 < 0$).

Finally, industrial output is a function of agricultural production and shocks to a nominal (real) exchange rate (equation (6)). Both relationships are not clear ($c_1, c_2 <> 0$), being dependent on country-specific characteristics. For example, production in agricultural and industrial sectors can be complementary if the former provides inputs for the latter, but the link is likely to be of the opposite sign if both sectors compete for financial resources. If industrial output depends on imported inputs of different kind (petroleum, chemicals, fertilizers, seeds etc.), the depreciation of the exchange rate is almost certainly to be restrictionary; otherwise an opposite outcome is more likely.

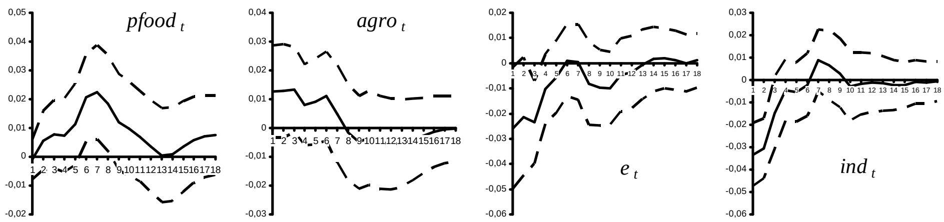
For computational purposes, EViews 6.1 program is used. We include eight lags into the SVAR model, as suggested by the Akaike criterion. Although there might be some concerns about nonstationarity of industrial output and exchange rate series, using sufficient number of lags to remove serial correlation and make the errors I(0) used to be enough for the purpose of impulse response analysis. As the unit root tests indicate stationarity of residuals, thus minimal requirements of adequacy are met. It is worth noting that the information in levels is not lost, as it would have been the case with first differencing the time series.

4. Empirical results and discussion

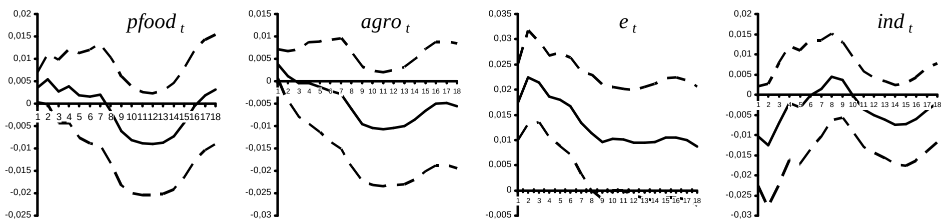
Impulse responses functions that show the predictable response of each variable after a shock to another variable in the system are presented in Fig. 2. Table 1 reports the portion of the forecast error variance decomposition (FEVD) in the endogenous variable at different forecast horizons that is attributable to innovations in other variables (the dominant shock is in bold type). Shocks to world food prices are corrected over half a year period. Although impulse response functions suggest some relations with Ukraine's agricultural and industrial outputs, the portion of both variables in FEVD is rather small. However, the direction of $agro_t$ and ind_t effects on world food prices is consistent with the pattern of sectoral spillovers. As increase in the Ukraine's agricultural production is supposed to put a downward pressure on the world food prices, just the opposite is likely to hold for industrial output effects assuming a substitution between foreign and domestic demand for agricultural goods.



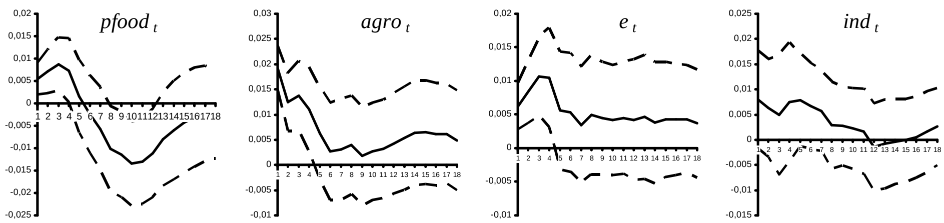
a) determinants of world food prices;



b) determinants of agricultural production;



c) determinants of nominal exchange rate;



d) determinants of industrial output;

Figure 2. Impulse response functions
Note: the solid line is the point estimate, while the dotted lines represent a two-standard error confidence band around this point estimate

As suggested by the impulse response analysis, there is complementarity between agricultural production and industrial output, but it is observed against the backdrop of a transitory adverse effect of industrial output shocks upon agriculture. The decline in agricultural production could be a consequence of the relocation of investments in favor of the industry. Industrial output shocks explain 50 to 33 percent of variation in the agricultural production. The influence of shocks to agriculture upon industrial output is even stronger, with weights ranging from 58 percent to 36 percent at three and eighteen month horizons respectively.

Table 1. Forecast error variance decomposition

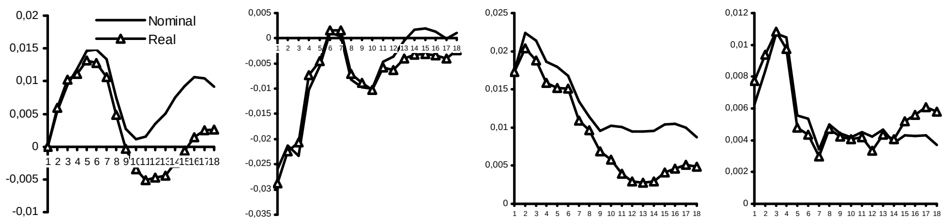
Impulses	Responses	Forecast horizons			
		3	6	12	18
World food prices (*pfood*)	*pfood*	**95**	**83**	**69**	**62**
	agro	0	3	15	18
	e	3	8	8	11
	ind	2	6	8	9
Agricultural production (*agro*)	*pfood*	2	12	25	27
	agro	11	14	12	13
	e	**37**	**32**	**29**	**28**
	ind	**50**	**41**	**34**	**33**
Nominal effective exchange rate (*e*)	*pfood*	3	3	8	9
	agro	1	1	12	15
	e	**77**	**84**	**70**	**66**
	ind	**19**	**12**	**10**	**11**
Industrial output (*ind*)	*pfood*	**13**	**12**	**35**	**34**
	agro	**58**	**49**	**34**	**36**
	e	**18**	**22**	**18**	**19**
	ind	10	16	13	14

As expected, higher world food prices contribute to an increase in agricultural production with several month lag but this effect is gradually phased out approximately in a year. On impact, industrial output increases, then declines gradually over about half a year to the minimum response, and finally recovers to its initial level. Our SVAR estimates suggest a rather complicated sectoral pattern of foreign price effects in the Ukraine's economy. It is interesting that contribution of the world food prices to the conditional variance of the agricultural production is lower if compared with their contribution to changes in the industrial output, 2 to 27 percent against 13 to 34 percent, respectively.

There is an asymmetrical response of agricultural and industrial sectors to exchange rate shocks. Exchange rate depreciation is likely to have a transitory contractionary effect on agricultural production while there is a clear positive impact upon industrial output, although the response is not significant in the long run. Exchange rate shocks account for about 37 to 28 percent of the variation in Ukraine's agricultural production at different time horizons and about 20 percent of variation in industrial output. Our findings are very much in line with those for African countries [9; 13] and point to a greater role of supply shocks in the short run. Among other factors, this might partially explain the slowdown in agricultural production that has been observed since the beginning of 2014 (Fig. 1).

Among other results, a shock in the world food prices is associated with an immediate short-lived depreciation of the exchange rate which is followed by a six month-long period of gradual weakening of the impulse response. However, the response function starts to decline steeply for the following five months, reaching maximum of the exchange rate appreciation around the 11th month. The response to an agricultural production shock shows a similar pattern. It is likely that a favorable world price shock is associated initially with a higher demand for foreign exchange in order to buy imported supplies necessary for the expansion of agricultural production in expectation of higher export receipts. If combined both world food prices and agricultural production account for 20 to 24 percent of exchange rate variance at twelve and eighteen month horizons.

In order to check the robustness of abovementioned results, we replaced a nominal exchange rate with the real exchange rate. Results suggest that the pattern of exchange rate effects on agricultural and industrial outputs is identical (Fig. 3). There is a difference between two indicators of exchange rate in that the real exchange rate seems to converge to long-run neutrality at the initial level while a nominal exchange rate stabilizes at a lower steady-state level. Both nominal and real exchange rates initially overshoot in response to a depreciation shock suggesting some nominal inertia in the Ukraine's economy. Other impulse responses are quite similar to those in Fig. 2, thus providing some extra support for robustness of empirical results.



a) world food prices; b) agriculture; c) exchange rate; d) industry;

Figure 3. Impulse response functions for exchange rate effects

As expected, the use crisis dummy variable reveals that the 2008–2009 world financial crisis and similar developments in 2014 had contributed to a depreciation of the exchange rate and a decline in industrial output. At the same time, it is worth noting that crisis developments seem to be neutral in respect to agricultural production. Consequently, it is possible to argue that the agriculture has had a stabilizing role in the Ukraine's economy, in addition to its stimulating effect on industrial output.

6. Conclusions

Overall the analysis allows clearly identify the pattern of relationships between agricultural and industrial sectors in Ukraine. There is a short-lived crowding out of agriculture by industrial output while there is a favourable and more persistent causality running from the former to the latter. For agricultural production, the fraction of variance decomposition which can be attributed to industrial output, gradually declines from 50 to 33 percent. On the other hand, shocks to agriculture explain 58 to 36 percent of variance decomposition in industrial output. From a policy perspective, the results suggest that agriculture-supporting policies should be productive in the industrialization context either. Both sectors – agricultural and industrial – are influenced by the world food prices but in a different way. On the whole, growth in the Ukraine's agriculture seems to be significantly foreign demand driven.

Exchange rate effects are not homogeneous across agricultural and industrial sectors suggesting different sector-specific relative price mechanisms. Exchange rate depreciation is restrictionary for agriculture while being expansionary for industry. It is likely that growth in both agriculture and industry contributes to the exchange rate appreciation (both shocks explain between 20 and 25 percent of variance of exchange rate on the aggregate). The impulse response analysis suggests also that a surge in the world food prices is another factor behind strengthening of the exchange rate. Realignments of a nominal exchange rate are inertial, with a new steady-state being obtained approximately in a year.

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