Effect of Relative Price Changes of Top Principle Crops on Farm Land Allocation in Post-Soviet Russia: Do Prices Matter?

Ekaterina Vorotnikova, Serhat Asci, and James L. Seale, Jr.

The authors, respectively, are: PhD candidate, vorotnikova@ufl.edu, Postdoctoral Associate, sasci@ufl.edu, and Professor, jseale@ufl.edu, in the Food and Resource Economics Department, University of Florida.

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014.

Effect of Relative Price Changes of Top Principle Crops on Farm Land Allocation in Post-Soviet Russia: Do Prices Matter?

Abstract

After the collapse of the Soviet Union in 1991, Russian economy was on the way to becoming more market-based. While the broadening of market forces in Russian agriculture seems plausible, there is little empirical evidence to support the proportion that land allocation decision among grains and oil-seeds are in large determined by output prices for the crops. The crops are wheat, barley, oats, corn, rye, soybeans, rapeseed, and sunflower. In this chapter, a land allocation model developed recently by Vorotnikova, Asci and Seale (2013) is fit to post-Soviet data to determine if output prices for grains and oil-seeds significantly affect land allocation among these crops and by what magnitudes. We look at the effect of the relative export price changes on allocation of land among top eight top crops in agricultural production for Russia during the years 1992 to 2012. We have determined that most price responsive acreages are those of 1) soybeans, 2) corn, 3) sunflower, 4) wheat, 5) rye, 6) barley, and 7) other. Overall, we can conclude that Russian agriculture has become price responsive when it comes to the land allocation.

Key Words: Post-Soviet Union agriculture, land allocation, price responsiveness

Introduction

While under the Soviet Union regime, Russian agricultural production and land allocation was based on a commanded economy. After the collapse of the Soviet Union in 1991, the Russian economy was on its way to becoming more market-based. Further, the economy became more integrated into the global economy and on August 22nd, 2012, after 18 years of negotiations, Russia became the 156th member of World Trade Organization (WTO 2014).

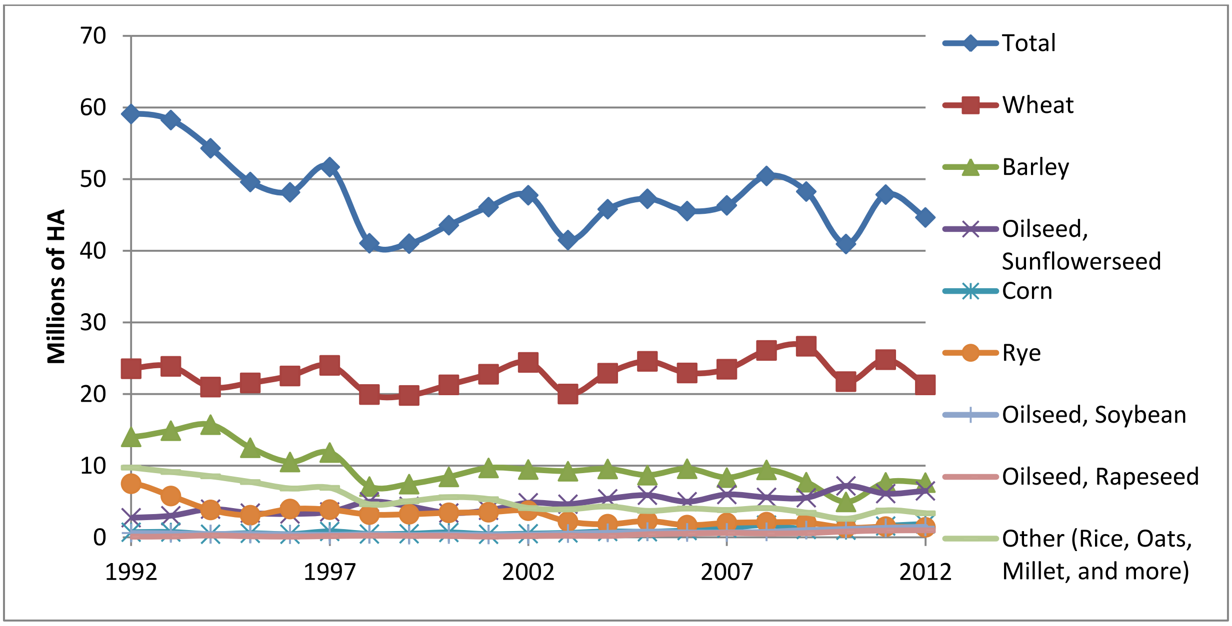
While the broadening of market forces in Russian agriculture seems plausible, there is little empirical evidence to support the proportion that land allocation decision among grains and oil-seeds are in large determined by output prices for the crops. In this chapter, a land allocation model developed recently by Vorotnikova, Asci and Seale (2013) is fit to post-Soviet data to determine if output prices for grains and oil-seeds significantly affect land allocation among these crops and by what magnitudes.

The model postulates that land is allocated among different crop based on total land in production and the output prices of the crops. For example, land allocated to a particular crop is expected to increase if the output price of that crop increases. Changes in total land in agricultural production can also affect the amount of land allocated to the different crops. Unlike the effects of output prices, the effects of changes in total agricultural land are not necessarily predictable based on economic theory, but maybe estimated and measured based on the models parameters.

The chapter is arranged as follows. First post-Soviet Russian data is presented and described in terms of grain and oil-seed land use, production, exports and prices. This is followed by a methodological section where the empirical model is presented and described. Data sources are reported followed by the presentation and discussion of parameter estimates. Based on the estimated parameters, price and land elasticities are calculated and discussed. Finally, interpretations and conclusions are drawn.

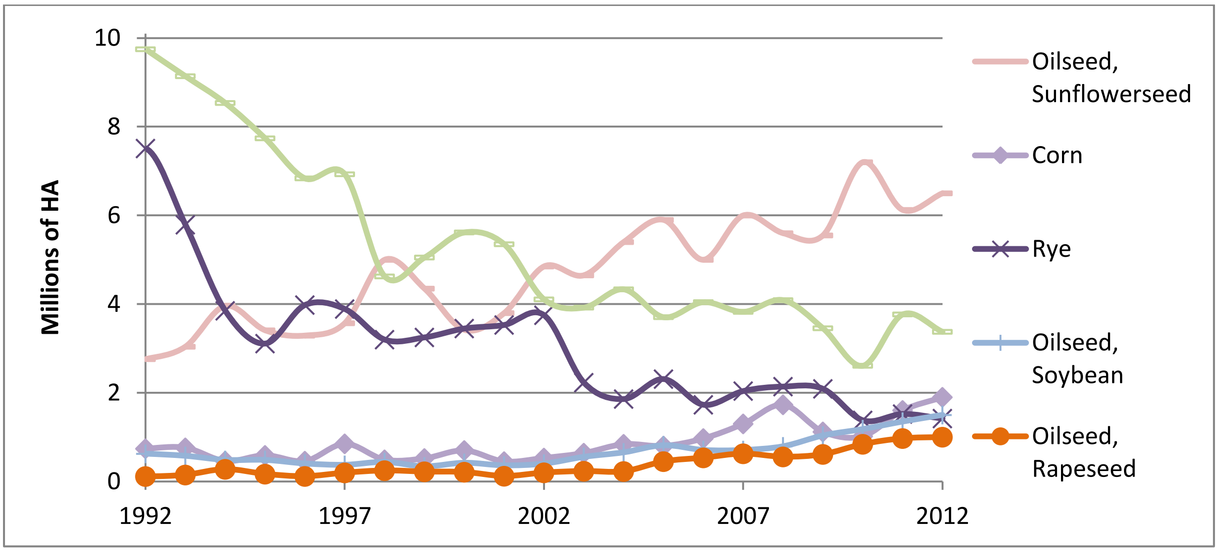
Post-Soviet Russia's Grain and Oil-seed Sector

While total land in grains and oil-seeds steadily declined from 1987 to 1998, it stabilized thereafter fluctuanting between 40 and 50 million hectares (Figure 1). The largest proportion of land is allocated to wheat, and the amount has been relatively stable through the period 1987-2012 fluctuating between 20 and 30 million hectares. This is not the case for the other grains and oil-seeds. Land allocated to barley decreased around 10 million hectares. Land use of crops with less than 10 million hectares are shown in detail in Figure 2.



Source: Based on data obtained from PSD-FAS
Figure 1. Land use for selected crops in Russia, 1992-2012.

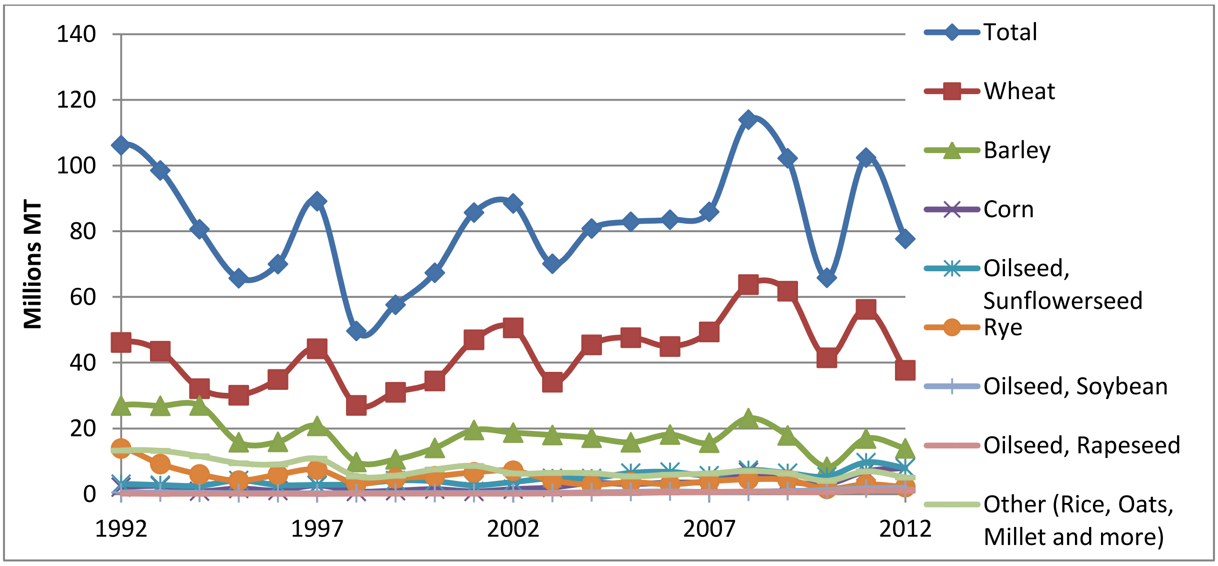
Significant decreases in acreage have occurred for oats, rye, and millet while acreage under sunflower, rapeseed, and corn has expanded, although from relatively low levels (Figure 2).



Source: Based on data obtained from PSD-FAS
Figure 2. Land use for crops of smaller production in Russia, 1992-2012.

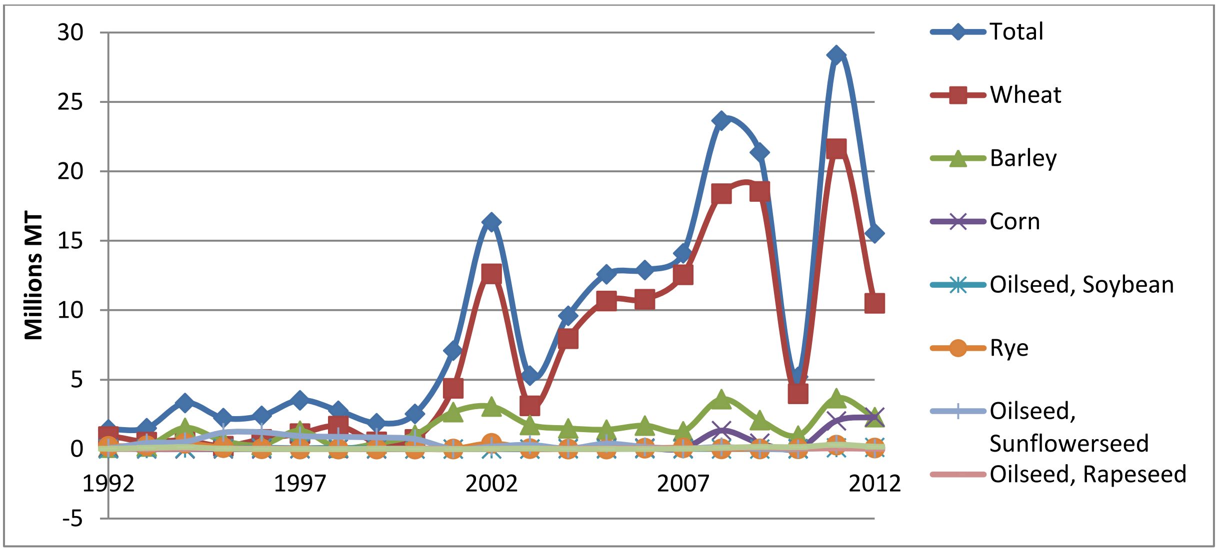
Wheat production is largest among these crops (Figure 3). While its fluctuation is larger than that of wheat land, it has remained relatively steady at about 40 million metric tons over the 1987-2012 period. Barley production follows a similar path as Barley land, decreasing from 1987-1998, then remaining relatively constant.

Corn production has increased five-fold over the period while production of rye, rice, and oats has declined.



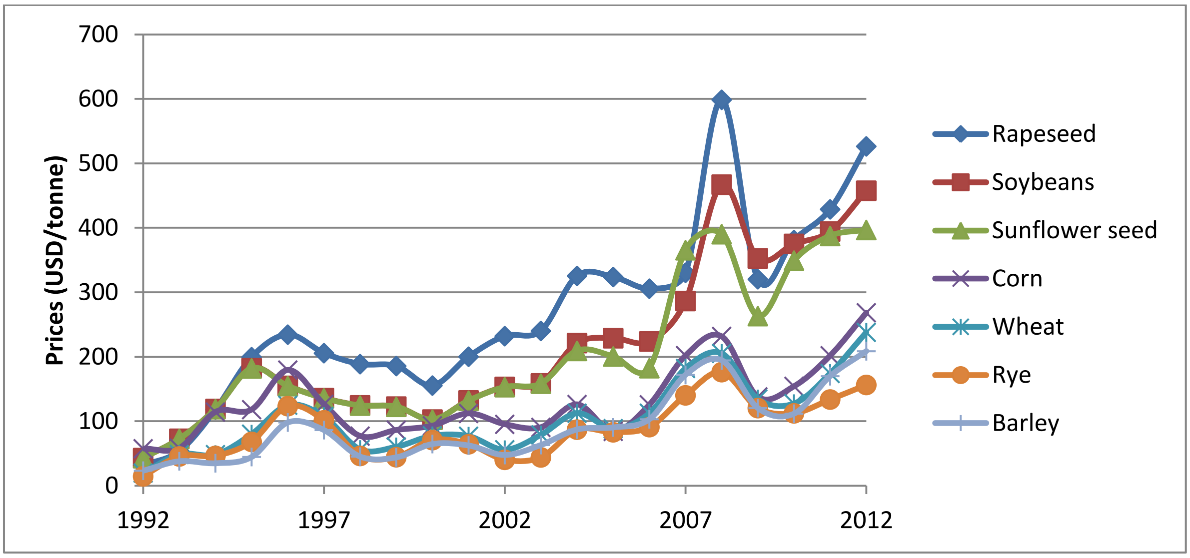
Source: Based on data obtained from PSD-FAS
Figure 3. Grain and oil-seed production in Russia, 1992-2012.

The most descriptive aspect of post-Soviet grains and oil-seeds is the increases in exports since 2001. Wheat has increased seven fold over this period (Figure 4). While starting from relatively low levels, the exports of corn and rye increased 461 and 29 times, respectively, from 2001 to 2012 (FAS, 2013).



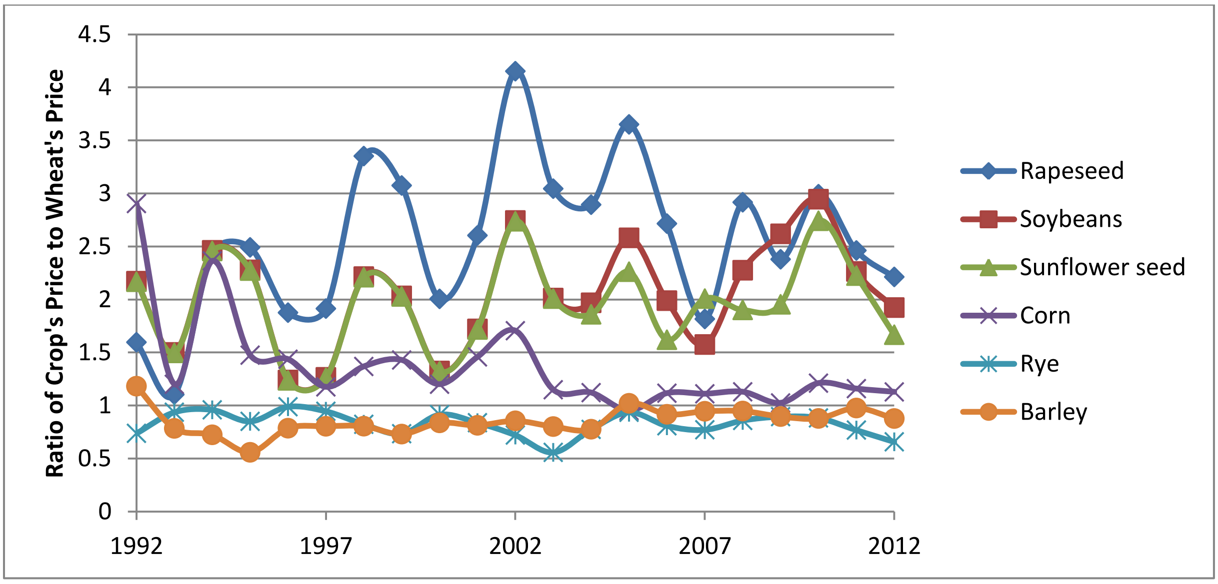
Source: Based on data obtained from PSD-FAS
Figure 4. Grain and oil-seed export of Russia, 1992-2012.

In regards to prices, prices of all crops have been going up steadily between 1998 and 2008. After 2008, however, prices of crops such as rapeseed, soybeans, and sunflower continued to go up with an increased pace, but after 2008 prices of crops such as corn, wheat, and rye have decreases pronouncedly, but recovered upward trajectory (Figure 5).



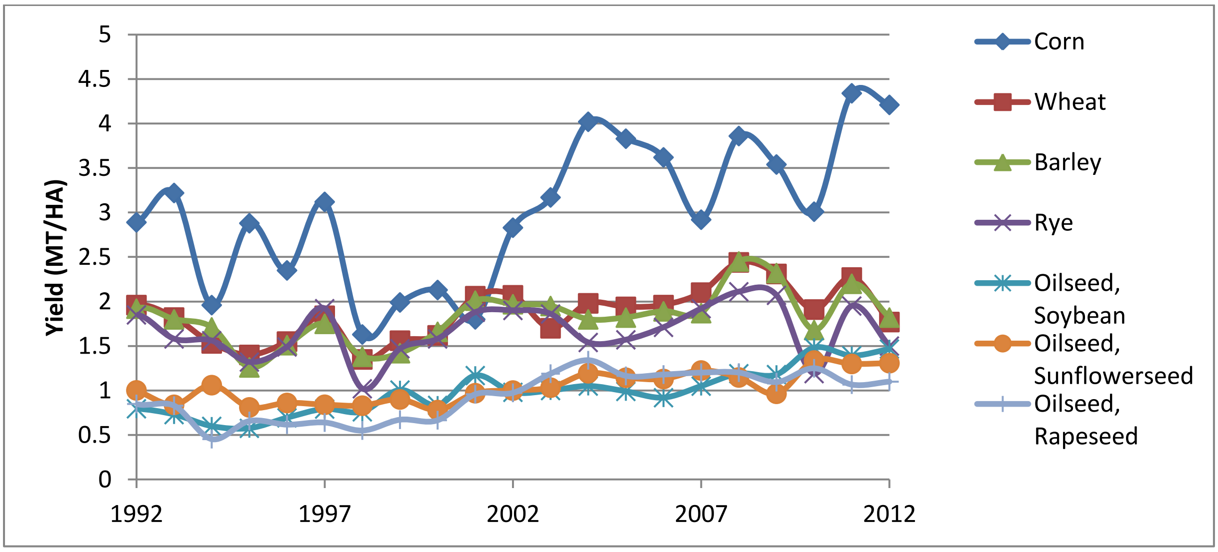
Source: Based on data obtained from PSD-FAS
Figure 5. Price changes of selected crops in Russia, 1992-2012

It is interesting to analyze prices of the crops relative to the price of wheat. Figure 6 presents a ratio of each crop's price divided by the price of wheat for 1992 to 2012. Rapeseed's to wheat price ratio has increased significantly from 2000 to 2005, but then declined steadily. This price ratio is the most volatile. Soybean to Wheat price ratio is also quite volatile with a slight upward trend after 2005, and so is that of Sunflower to Wheat. On the other hand, price ratios of Corn to Wheat has declined towards 2005, and then remained relatively stable. Price ratio of Rye to Wheat has declined slowly after 2005.



Source: Based on data obtained from PSD-FAS
Figure 6. Ratio of Each Crop's Price to That of Wheat in Russia, 1992-2012.

Increasing exports but contracting production and acreage comes as a surprise and is interesting especially in lieu of USDA's forecasts for Russian grain production and exports to increase into 2021 (Liefert et al. 2013). USDA's projections indicate that by 2021 grain area will increase by 5%, grain production by 22%, and Russian grain exports will rise by 82% relative to 2010 (Liefert et al. 2013). According to USDA, rising use of technology and increasing productivity will be the main drivers for Russia to reach its potential in agriculture. In regards to productivity, USDA forecasts that Russian grain yields are expected to rise by 17%; however, for the past decade the yield significantly increases only in rice and corn production while staying relatively flat for the rest of the grains including wheat (Figure 7).



Source: Based on data obtained from PSD-FAS
Figure 7. Yield as a productivity measure of selected crops in Russia, 1992-2012.

Clearly, there is a disconnect between the trend of contracting total land among the top grains, this anticipated expansion in production and exports. Thus, given such an interesting paradigm in Russian agriculture and its potential effect on world trade, this study looks at the effect of relative price changes onto the land allocation dynamics among the top eight grains produced in Russia (i.e. wheat, barley, corn, sunflower, rye, soybeans, rapeseed and other) for the years 1992-2012. Also, since production in some crops has expanded, yet the total land among the top crops has contracted, we suspect that the expansion might be happening at the expense of other grains. In particular, we are interested in whether output prices have significantly determined land allocation.

Methodology

The differential approach is one of the popular methodologies in consumer theory. Originally, differential models were developed by Barten (1964) and Theil (1965), and later modified by Theil (1977) for production theory. This approach has been extended to a perfectly competitive multiproduct firm (Laitenen and Theil 1978), then modified under the assumptions of homotheticity and input independence of a cost-minimizing firm (Theil 1979), and lastly improved for the supply response and input demand of a multiproduct firm, where an input is quasi-fixed (Livanis and Moss 2006). More recently, VAS (2013) develop a land allocation model based on the differential approach to producer theory for the multiproduct firm. At this study, we fit the model to post-Soviet data to examine the allocation of the quasi-fixed input factor, land, in production given the impacts of fluctuating crop prices.

The theoretical model is:

$$f_i d(\ln L_i) = \theta_i d(\ln L) + \sum_{j=1}^{n} \pi_{ij} d(\ln P_{ij}) \quad (1)$$

where Li is the quantity of land devoted to crop i, fi is the share of the total land allocated to crop i, Pi is the output price of crop j, $d(\ln L) = \sum_i f_i d \ln L_i$ is a Divisia index for land.

To operationally let $\bar{f}_{it} = (f_{i,t} + f_{i,t-1})/2$ and $d(\ln X_t) = \ln X_t - \ln X_{t-1}$ where *X* represents *L* and *P*, and ε_t be an error term. The empirical model is then

$$\bar{f}_{it} d(\ln L_i)_t = \theta_i d(\ln L)_t + \sum_{j=1}^{n} \pi_{ij} d(\ln P_{ij})_t + \varepsilon_t \quad (2)$$

which we refer to as the Rotterdam version of the land allocation model. Note that, the adding up conditions are: $\sum_i \theta_i = 1$ and $\sum_i \pi_{ij} = 0$. The homogeneity condition is: $\sum_j \pi_{ij} = 0$, and the symmetry condition is: $\pi_{ij} = \pi_{ji}$. The land volume elasticity and price elasticities (η_{ij}) of the land allocation equations are calculated by $\eta_i = \theta_i / f_i$ and $\eta_{ij} = \pi_{ij} / f_i$.

It is not necessary that θ_i is constant. One can hypothesis that θ_i, the marginal share, is equal to f_i, the average share, plus a constant parameter β_i. If one replaces $\theta_i = f_i + \beta_i$ in Equation (2), we obtain a version of land allocation model similar to the (CBS) model developed by Keller and van Driel (1985) and also Clements (1980), that is, Central Bureau of Statistics.

$$(3) \qquad \bar{f}_{it} d(\ln L_i - \ln L)_t = \beta_i d(\ln L)_t + \sum_{j=1}^{n} \pi_{ij} (d \ln P_{ij})_t + \varepsilon_t$$

We refer to his model as the CBS version of the land allocation model. The adding up conditions for the CBS model are as follows $\sum_i \beta_i = 0$ and $\sum_i \pi_{ij} = 0$.

Data

The data span the years 1992 to 2010. Acreage data are collected from the Production Supply and Distribution (PSD) dataset provided by Foreign Agriculture Services (FAS). Price data are collected from FAO. The data consist of the annual quantity and unit prices of the main grains of Russia: barley, corn, wheat, soybeans, sunflower seeds, rye, rapeseed plus three other crops whose quantities are summed to the category "other." This category contains the total land area for rice, oats and millet and the other price is calculated by dividing their summed production value by the summed production amount.

The model is estimated by dropping the other land equation to avoid singularity problem as described by Barten (1964), and we estimate all seven-grain equations with iterative seemingly unrelated regressions (SUR) to obtain maximum likelihood estimators. The estimation results are checked by replacing the dropped equations by another equation and the same results are obtained. This is accomplished by using the LSQ command in Time Series Processing (TSP) version 5.0.

Results

Parameter Estimation

We estimate three unrestricted parameterization of the differential land allocation model: Rotterdam, CBS and a general model consisting in parts of both Rotterdam and CBS. We impose homogeneity and symmetry conditions. Table 1 shows the log-likelihood values obtained from these estimations. The parentheses contain the number of free parameters for each estimation and the log-likelihood ratio test (LRT) statistics are provided below the estimation values. LRT is calculated by $-2[L(\theta^*)-L(\theta)]$, where $L(\theta^*)$ refers to the log value of the likelihood function when restriction is imposed while $L(\theta)$ is used for the unrestricted estimation. LRT is compared with critical value from a $\chi^2(q)$ distribution, where q is the difference of number of free parameters between restricted and unrestricted estimations. We compare three restrictions for our estimations. At first, we compare homogeneity imposed model with unrestricted model, and then symmetry imposed model with homogeneity imposed model both for Rotterdam and CBS. At last, we compare symmetry imposed models of Rotterdam and CBS systems with a general model that combines the two models (Barten 1993). The results show that we reject homogeneity for both models since LRTs for Rotterdam and CBS, respectively, 16.56 and 16.00, are greater than critical value 14.07 at the 5% significance level. We do not reject homogeneity at the 10% significance level for either model. We also reject symmetry restriction for both models. The LRTs, respectively, 35.47 and 35.37 for Rotterdam and CBS, are again greater than the critical value of 19.68 for $\chi^2(21)$

at the 5% significance level. Laitinen (1978) shows that asymptotic tests reject homogeneity more often that they should for samples with relatively small numbers of observations as the number of equations in the model increases. Laitinen developed an exact test, Hotelling's T-test for using in multivariate hypothesis testing for samples with few degrees of freedom. Based on the calculated Hotelling's T-test statistic of 1.35 for Rotterdam and 1.3 for CBS, which are less than the critical value of 2.77 for $F_{8,13}$ at 5% significance level, homogeneity should not be rejected. Meisner (1979) also shows the probability of rejecting homogeneity and symmetry when the number of goods (or equations) in the estimation increases. The low degrees of freedom decreases the power of asymptotic test. Since, we have a high number of goods in the estimations, we increase the probability of rejecting hypotheses although they should not be rejected. Unfortunately, unlike for homogeneity, an exact test for small samples has not been developed due to the complications from cross-equation restriction in symmetry tests.

Lastly, based on the LRT tests results we fail to reject both Rotterdam and CBS models by comparing them to a general model. LRT for Rotterdam is 1.04, and for CBS is 0.28, which are less than the chi-square critical value of 3.84 at the 5% significance level. This confirms that both models fit the data well and CBS model has a lower LRT than the Rotterdam's statistic.

Table 1. Test Results for the Log likelihood within Models

	Unrestricted Model (63[1])	Homogeneity Imposed (56[2])	$\chi^2(7)$ (95%)	Symmetry Imposed[2] (35[1])	$\chi^2(21)$ (95%)	General Model (36[1])[3]	$\chi^2(1)$ (95%)
Rotterdam	500.202	491.921		474.185		474.707	
-2[L(θ*)-L(θ)]		16.56	14.07	35.47	19.68	1.04	3.84
CBS	500.251	492.252		474.568		474.707	
-2[L(θ*)-L(θ)]		16.00	14.07	35.37	19.68	0.28	3.84

1) Number of free parameters for each estimation.
2) Both symmetry and homogeneity are jointly imposed.
3) Homogeneity and symmetry imposed log-likelihood value is provided for general model.

Table 2 demonstrates the coefficients for both the Rotterdam and the CBS models for eight top grains and oil seeds produced in Russia estimated by using the price and acreage data from 1992 to 2012. The parentheses below the coefficients include their asymptotic standard errors. In both models, we observe positive and statistically significant the land coefficients for wheat, barley, and other crops at the 1% level, except of barley in the CBS model, that is significant at 5% instead of 1% level. Next, in the Rotterdam model rye is positive and significant at 0.05 level, however, it is not significant in the CBS model. Interestingly, in Rotterdam model soybeans are positive and significant at the 10%, but in the CBS – at 5% level. Sunflower is not significant in the Rotterdam model; however, it is significant at 0.10 level in the CBS model.

Results suggest that, for one unit increase/decrease in total land, the acreage of wheat, barley, other crops, rye, and soybeans, according to the Rotterdam model, increase/decrease by 0.44, 0.32, 0.14, 0.07, and 0.01 units, respectively, while according to the CBS model - by 0.45, 0.31, 0.12, 0.05, and 0.02, respectively. Note that soybean acreage would increase the most followed by wheat acreage. The land coefficients in the CBS model are statistically significant for sunflower at 1% significance level, barley and rapeseed at the 5% significance level, respectively.

It is important to note is that due to the structure of the CBS model, its land coefficients in this particular configuration offer something that those of the Rotterdam model do not. As a general rule, the land coefficients for CBS greater than, equal to or less than zero indicate that land elasticity will be greater than, equal to, or less than unity, respectively. In our model, it means that the positive land coefficient for barley is an indication that a land elasticity, that is subsequently calculated based on the coefficient, is going to be higher than one while negative coefficients for sunflower and rapeseed mean that land elasticities will be lower than one. This has an implication for the way these crops compete for the additional land, which is discussed further in the elasticity section.

In the Rotterdam model, all own-price coefficients for crops are positive as expected and are statistically significantly at the 1% level for corn, wheat, soybeans, and sunflower. In the CBS model, same crops as in the Rotterdam model are statistically significant and only wheat coefficient is different than zero at the 5% level. These results indicate that land allocation decisions are in part determined by output crop prices, that prices matter.

Next, ten out of 28 cross-price coefficients are statistically significant in the Rotterdam model while nine are statistically significant in the CBS model. Although the magnitudes are the same for the wheat-soybean combination for both models, this coefficient is not statistically significant in the CBS model. In the Rotterdam model, corn-soybean, corn-rye, wheat-sunflower, and soybean-rapeseed coefficients are negative and statistically significant at the 1% level while wheat-soybean coefficient is also negative and significant at 10% level. This means that the crops in these combinations behave as compliments between each other. Soybeans–other crops and sunflower-rapeseed coefficients are positive and significant at 1%, corn-wheat coefficient is also positive and statistically significant at the 5%, while barley-rye and rapeseed-other crops coefficients are positive and significant at the 10% level, which indicates that these crops behave as compliments to each other in the pair specific combinations. The CBS model yields similar results for the exception of the sunflower-rapeseed and rapeseed-other crops that are statistically significant at the 5% level. Also, the significance of wheat-soybean combination is lost in the CBS model.

Table 2. Coefficients of the Rotterdam and CBS models – Russia from 1992 to 2010

Crops	Output Price Coefficients (π_{ab})								Land Coefficients (θ_i)	Land Coefficients (β_i) CBS
	Barley	Corn	Wheat	Soybeans	Sunflower	Rye	Rapeseed	Other Crops		
Rotterdam										
Barley	**0.013**	-0.001	-0.045	0.000	-0.003	0.026*	-0.001	0.010	0.318***	Na
	(0.028)	(0.005)	(0.028)	(0.003)	(0.010)	(0.015)	(0.003)	(0.015)	(0.053)	
Corn		**0.010*** **	0.014**	-0.005***	-0.002	-0.012***	0.000	-0.003	0.018	Na
		(0.003)	(0.006)	(0.001)	(0.003)	(0.004)	(0.001)	(0.004)	(0.011)	
Wheat			**0.099*** **	-0.005*	-0.037***	-0.013	-0.003	-0.011	0.436***	Na
			(0.037)	(0.003)	(0.012)	(0.018)	(0.003)	(0.018)	(0.060)	
Soybeans				**0.009*** **	-0.001	-0.002	-0.007***	0.010***	0.007*	Na
				(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	
Sunflower					**0.031*** **	0.011	0.006***	-0.006	0.008	Na
					(0.007)	(0.008)	(0.002)	(0.007)	(0.026)	
Rye						**0.004**	-0.001	-0.013	0.073**	Na
						(0.014)	(0.002)	(0.010)	(0.034)	
Rapeseed							**0.001**	0.005*	-0.005	Na
							(0.002)	(0.003)	(0.005)	
Other Crops								**0.007**	0.144***	Na
								(0.014)	(0.029)	
CBS										
Barley	**0.001**	0.000	-0.036	-0.001	0.002	0.025*	-0.001	0.011	0.313**	0.130**
	(0.029)	(0.005)	(0.028)	(0.003)	(0.010)	(0.015)	(0.003)	(0.015)	(0.057)	(0.055)
Corn		**0.010*** **	0.015**	-0.005***	-0.002	-0.013***	0.000	-0.004	0.026	-0.002
		(0.002)	(0.006)	(0.001)	(0.003)	(0.004)	(0.001)	(0.004)	(0.011)	(0.011)
Wheat			**0.081** **	-0.005	-0.040***	-0.012	-0.003	0.000	0.447***	-0.066
			(0.036)	(0.003)	(0.012)	(0.017)	(0.003)	(0.017)	(0.059)	(0.060)
Soybeans				**0.009*** **	-0.001	-0.003	-0.006***	0.012***	0.016**	-0.004
				(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.005)	(0.005)
Sunflower					**0.033*** **	0.010	0.005**	-0.006	0.053*	-0.092***
					(0.007)	(0.008)	(0.002)	(0.007)	(0.023)	(0.025)
Rye						**0.005**	-0.002	-0.011	0.026	-0.011
						(0.014)	(0.002)	(0.010)	(0.029)	(0.010)
Rapeseed							**0.001**	0.006**	0.002	-0.011**
							(0.002)	(0.003)	(0.005)	(0.005)
Other Crops								**-0.007**	0.122***	0.034
								(0.014)	(0.024)	(0.029)

Note: figures in parenthesis are standard deviations.
* - significant at 10% level; ** - significant at 5% level; *** - significant at 1% level.

Elasticity Estimation

Land and price elasticities for both the Rotterdam and the CBS models are provided in Table 3. All elasticities are computed from their respective coefficients at the sample mean for the entire sample. First, the land elasticities for seven out of eight crops are statistically significant. The land elasticities for barley, wheat, and other crops are significant at the 1% level and for soybean and rye at 10%. The elasticities for barley, rye and other crops are greater than unity while for wheat and soybeans they are less than unity. This is a confirmation to the land coefficients results in the CBS model that foreshadowed that the land elasticities for sunflower and rapeseed are less than unity. The results indicate that if land expands (contracts) by 1%, then the land quantity for barley, other crops, rye, wheat, and soybeans goes up (down) respectively by 1.54%, 1.31%, 1.17%, 0.89%, and 0.62%, respectively. In the CBS model, for the same crops, the land elasticities are: 1.63%, 1.31%, 1.18%, 0.86%, and 0.66%, respectively. In summary, the results show that barley, rye and other crops are the most responsive crops in terms of percentage changes to the expansion of total land because their land elasticities are greater than unity.

The model shows that the order of magnitude in percent change relative to 1% change in total land is 1) Barley, 2) Other, 3) Rye, 4) Corn, 5) Wheat, 6) Soybeans, 7) Sunflower, and 8) negative for Rapeseed. This corresponds well with the dynamics observed in Figures 1 and 2. For example, looking at the total land versus Barley, its land seems to follow trend in total land while wheat does not follow as closely. Rapeseed goes in the opposite direction, gaining land share when total land decreases, which warrants the negative sign of the land elasticity.

Table 3. Output Price and Land Elasticities of the Rotterdam and CBS Models – Russia from 1992 to 2010

Crops	Crop Prices								Land
	Barley	Corn	Wheat	Soybeans	Sunflower	Rye	Rapeseed	Other Crops	
Rotterdam									
Barley	**0.06**	-0.01	-0.22	0.00	-0.02	0.13*	0.00	0.05	1.54***
	(0.13)	(0.03)	(0.14)	(0.01)	(0.05)	(0.07)	(0.01)	(0.07)	(0.26)
Corn	-0.08	**0.58*****	0.82**	-0.30***	-0.09	-0.73***	-0.03	-0.17	1.05
	(0.31)	**(0.16)**	(0.37)	(0.06)	(0.19)	(0.26)	(0.08)	(0.25)	(0.67)
Wheat	-0.09	0.03**	**0.20*****	-0.01*	-0.07***	-0.03	-0.01	-0.02	0.89***
	(0.06)	(0.01)	**(0.08)**	(0.01)	(0.02)	(0.04)	(0.01)	(0.04)	(0.12)
Soybeans	0.02	-0.42***	-0.40*	**0.78*****	-0.06	-0.21	-0.56***	0.84***	0.62*
	(0.23)	(0.08)	(0.22)	**(0.22)**	(0.16)	(0.16)	(0.13)	(0.22)	(0.35)
Sunflower	-0.03	-0.02	-0.38***	-0.01	**0.32*****	0.12	0.06***	-0.06	0.08
	(0.10)	(0.03)	(0.12)	(0.02)	**(0.08)**	(0.08)	(0.02)	(0.07)	(0.27)
Rye	0.42*	-0.20***	-0.21	-0.04	0.18	**0.07**	-0.02	-0.20	1.17*
	(0.24)	(0.07)	(0.28)	(0.03)	(0.13)	**(0.22)**	(0.04)	(0.16)	(0.55)
Rapeseed	-0.11	-0.08	-0.47	-1.06***	0.99***	-0.22	**0.20**	0.76*	-0.77
	(0.48)	(0.20)	(0.52)	(0.25)	(0.33)	(0.39)	**(0.25)**	(0.45)	(0.77)
Other Crops	0.10	-0.03	-0.10	0.09***	-0.06	-0.11	0.04*	**0.06**	1.31***
	(0.13)	(0.04)	(0.16)	(0.02)	(0.07)	(0.09)	(0.03)	**(0.13)**	(0.27)
CBS									
Barley	**0.00**	0.00	-0.17	-0.01	0.01	0.12*	-0.01	0.05	1.63***
	(0.14)	(0.02)	(0.14)	(0.01)	(0.05)	(0.07)	(0.01)	(0.07)	(0.26)
Corn	-0.01	**0.58*****	0.88**	-0.28***	-0.13	-0.77***	-0.01	-0.26	0.89
	(0.31)	**(0.15)**	(0.36)	(0.06)	(0.19)	(0.25)	(0.07)	(0.25)	(0.67)
Wheat	-0.07	0.03**	**0.17****	-0.01	-0.08***	-0.02	-0.01	0.00	0.86***
	(0.06)	(0.01)	**(0.07)**	(0.01)	(0.02)	(0.04)	(0.01)	(0.04)	(0.12)
Soybeans	-0.12	-0.39***	-0.38	**0.76*****	-0.12	-0.23	-0.53***	1.03***	0.66*
	(0.25)	(0.09)	(0.24)	**(0.25)**	(0.18)	(0.17)	(0.14)	(0.24)	(0.38)
Sunflower	0.02	-0.02	-0.42***	-0.02	**0.34*****	0.11	0.06**	-0.06	0.05
	(0.11)	(0.03)	(0.12)	(0.02)	**(0.08)**	(0.08)	(0.02)	(0.07)	(0.26)
Rye	0.40*	-0.21***	-0.18	-0.04	0.16	**0.08**	-0.02	-0.18	1.18**
	(0.24)	(0.07)	(0.28)	(0.03)	(0.12)	**(0.22)**	(0.04)	(0.16)	(0.54)
Rapeseed	-0.22	-0.04	-0.53	-1.02***	0.86**	-0.24	**0.23**	0.95**	-0.75
	(0.48)	(0.20)	(0.51)	(0.27)	(0.34)	(0.38)	**(0.25)**	(0.45)	(0.76)
Other Crops	0.10	-0.04	0.00	0.11***	-0.05	-0.10	0.05**	**-0.06**	1.31***
	(0.13)	(0.04)	(0.16)	(0.03)	(0.07)	(0.09)	(0.03)	**(0.13)**	(0.26)

Note: figures in parenthesis are standard deviations.
* - significant at 10% level; ** - significant at 5% level; *** - significant at 1% level.

Second, own-price elasticities are displayed along the diagonals in Table 3. They provide a measure of the responsiveness of land quantity to changes in the own-price of the particular crop. In the Rotterdam model, own-price elasticities are significant for corn, wheat, soybeans, and sunflower at the 1% significance level while in the CBS model they are significant at the same levels for the same crops except for wheat, whose own-price elasticity's significance level drops to 5%. The results of the Rotterdam model indicate that if the price of soybeans, corn, sunflower, and wheat goes up (down) by 1%, the land quantity for these crops goes up (down) by 0.78%, 0.58%, 0.32%, and 0.20%, respectively. CBS model's results are also similar. The results indicate that the land quantity response to changes in soybean and corn prices is greater than those of wheat and sunflower.

Third, cross-price elasticities measure the land quantity responsiveness to the price changes in competing crops. In the Rotterdam model, the cross-price elasticities for corn-soybean, wheat-sunflower, rye-corn, and soybean-rapeseed combinations are negative and statistically significant at 1% while wheat-soybean cross-price elasticity is also negative and significant at 10%. This indicates that these crops behave as substitutes to each other in the pair-wise combinations when it comes to allocation of land already in production. On the other hand, cross-price elasticities of soybean –other crops and sunflower-rapeseed are significant at the 1%, corn-wheat is statistically significant at 5%, barley-rye and rapeseed-other crops are significant at 10% - all are positive cross price elasticities. This suggests that these crops behave as compliments.

Finally, the important aspect of the analysis is that the model allows to compare the relative price changes effect in one crop on the land share of another to that of the vice versa combination. Thus, for two crops that are substitutes, it is possible to identify which crop's prices have more influence on acreage of the other in particular combination of substitutes. For example, for a 1% upward/downward movement in corn price, land allocated to soybeans decreases/increases by 0.42%, but for a 1% price change in soybeans, the land share of corn changes only by 0.30%. This means that corn prices have more influence on soybeans land than the soybean prices on the acreage of corn. In turn, rye's price changes have more influence on corn's acreage than the other way around. If prices of rye increase/decrease by 1%, corn' acreages goes down/up by 0.73% (compared to 0.20% in reverse case). Thus, our result is more meaningful in the following connotation, as rye's prices drop by 1%, corn's acreage tends to go up by 0.73%. In wheat-soybean and wheat-sunflower combinations, wheat's prices have more influence on the land of the other two than the other way around. Specifically, if the price of wheat goes up/down by 1%, then the land quantity allocated to soybeans and sunflower decreases/increases by 0.40% and 0.38%, respectively. In comparison, wheat's acreage changes only slightly in response to 1% price change in soybeans and sunflower: decreases/increases by much smaller magnitude, 0.01% and 0.07%, respectively. In turn, rapeseed's acreage is a lot more sensitive to price changes in soybeans than the other way around. For 1% upward/downward price change in soybeans, rapeseed's acreage goes down/up by 1.06%, whereas for 1% price change in rapeseed, soybeans acreage responds by reversing only by 0.56%.

Discussion and Conclusion

A schematic diagram in Figure 8 graphically demonstrates the conclusions of the analysis. The dynamics between crops' prices and acreages relations are best represented by the cross-price elasticities. The are represented by the thick blue lines that distinguish crops that behave as compliments. The dotted red lines represent cross-price elasticity for crops behaving as substitutes. The directions of the lines represent which crop's price is more influential on the acreage of the other in a given two-crop combination, and only the highest magnitudes of the two possible elasticities is displayed. For example, rye price changes are more influential on corn's acreage than the other way around, thus, the direction of the red dotted line is from rye to corn, and rye-corn price elasticity is displayed instead of that of corn-rye. Rye's price changes have a significant influence on corn acreage, while corn competes for land with soybeans, and in turn, soybeans compete with rapeseed. Rye and barley as well as soybeans and other crops behave as complements when it comes to the land allocation. Wheat competes for land with both soybeans and sunflower, while sunflower and rapeseed as well as corn and wheat behave as complements in respective combinations when it comes to land allocation.

The responsiveness of crop's acreages to their own prices is one of the most important goals of the paper. Price responsiveness is captured best by the own-price elasticity measure, and it is represented by a thin circular line. Thus, most price responsive acreages are those of 1) soybeans, 2) corn, 3) sunflower, 4) wheat, 5) rye, 6) barley, and 7) other.

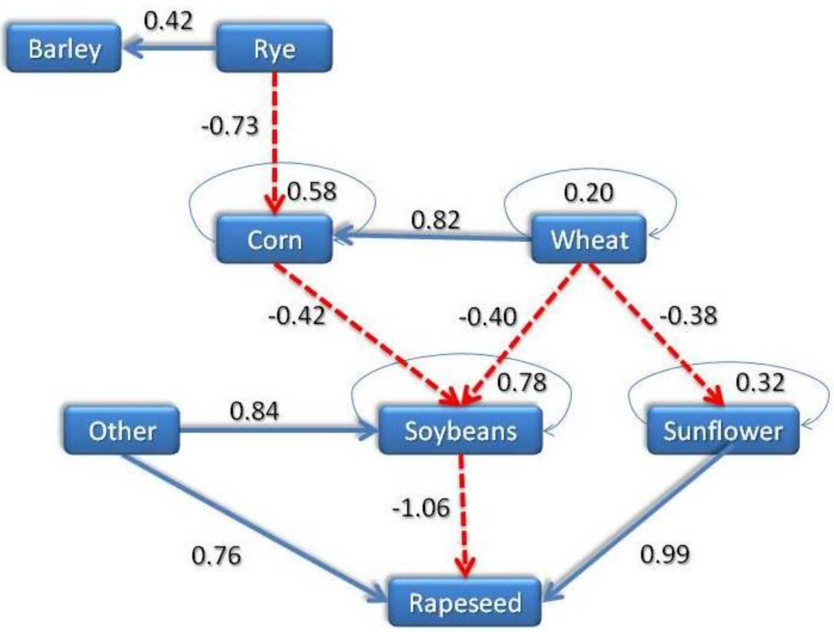


Figure 8. Elasticity Chart

Based on the full assessment of all results, we can confirm that wheat is still "king" for Russia as corn is "king" for the United States. The interesting dynamic is that in the U.S. corn competes with wheat pretty intensely; however, in Russia corn and wheat behave as compliments. This can be explained by a boom phase in the “boom-bust cycle” as characterized by Schmitz (1995). Indeed, the dynamics of corn production expansion in Russia, specifically, starting out from the low levels of production and growing rapidly, fits the description of the dynamics for such boom phase. Corn competes with rye and soybeans at this time because these two crops are more comparable for production size and acreage. However, if corn surpasses its current levels significantly, it is possible that eventually it will compete with wheat for land instead of complimentary behavior characteristic at this time. Furthermore, the fact that corn prices have been rising significantly until 2008, and then contracted after 2008 pronouncedly, yet corn acreage continues to expand after 2005 without any break in 2008 (Figures 5 and 6) signifies that corn is in the “boom” phase at this time.

In addition, given that corn is a feed grain in animal production, it is interesting to see that corn plantings expansion coincides with the expansion in animal production (Figure 8). Specifically, swine and especially poultry production have been expanding in Russia since 2000, and particularly rapidly after 2005. The production of poultry has been exponential. Figure 9 displays the dynamics of poultry, swine, and beef production, plotted on primary axis as compared to the acreage expansion of corn, plotted on the secondary axis, for the years 1985-2013. Beef production has been declining steadily throughout the entire time. It can be seen that the expansion of corn acreage after 2000 mirrors that of poultry and swine production.

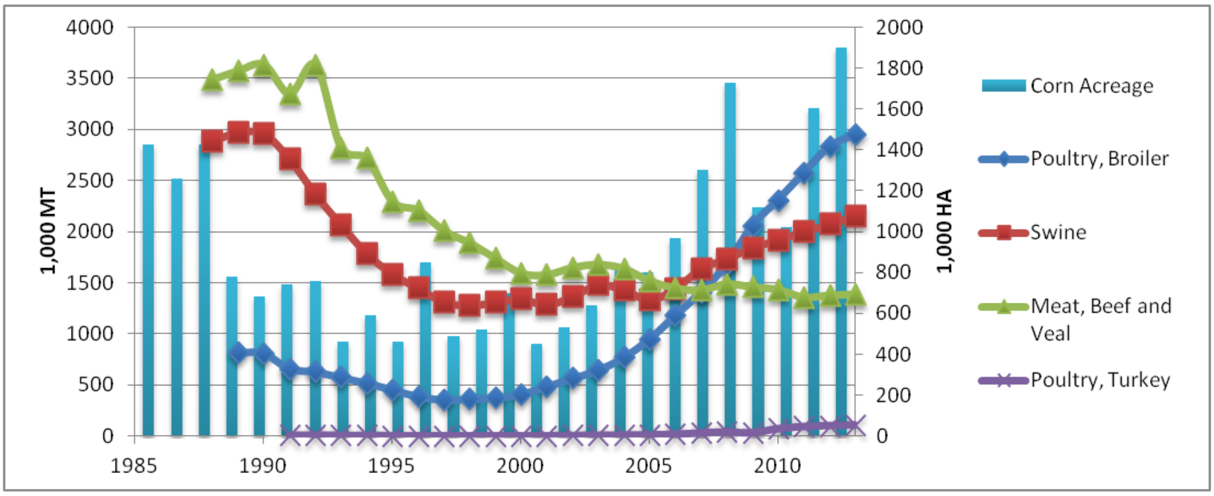


Figure 9. Poultry, Swine, and Beef Production and Corn Acreage 1985-2013

There is another angle of international importance to the dynamics between corn and wheat. As discussed by VAS (2013) in the U.S. corn is expanding at the expense of soybeans, wheat, and some other crops. This could possibly provide other countries including Russia a unique opportunity to step in to fill the gap in wheat production as wheat production contracts in the U.S. due to corn expansion.

Next, prices for rapeseed have been rising very significantly, and the acreage shows that farmers respond to it by increasing the land allocated to this crop. Rapeseed acreage has been rising steadily since 2005, and it competes with soybeans for land. This makes sense since two crops are oil crops. The acreage for sunflower seed, which is also an oil crop, has increased most significantly out of all crops. The land allocated to sunflower has been rising most steadily out of all crops since 1987. Prices for sunflower have increased most significantly since 1998. Sunflower competes for land with wheat.

In general, the land for corn, soybeans, and rapeseed has increased most significantly from 2005. Interestingly, this year coincides with Energy Policy Act of 2005 (EPA 2005) enacted by the U.S. government, which has resulted in structural changes in land allocation decisions in favor of corn and soybeans for the US farmers (Vorotnikova and Seale 2013). Another study by Vorotnikova and Seale has identified that EPA 2005 is hidden subsidy to corn producers that is a trade distorting. Thus, it is interesting to see at least from the preliminary results that some changes after 2005 can be seen not just in the U.S. agricultural sector, but in Russian as well, although such assertion is still to be statistically tested in our future works.

It is also interesting to mention that, if USDA's projections of 5% increase in total grain land are accurate, then according to the results of our model, Barley, other, rye, and wheat acreage would expand by 7.7%, 6.55%, 5.85%, 4.45%, respectively. Overall, we can conclude that Russian agriculture has become price responsive when it comes to the land allocation.

References

Barten, A.P. 1964. "Consumer Demand Functions Under Conditions of Almost Additive Preferences." *Econometrica* 32: 1-38.

Barten, A.P. 1993. "Consumer Allocation Models: Choice of Functional Form." *Empirical Economics* 18: 129–58.

Clements, K.W. 1980. "An Aggregative Multiproduct Supply Model." *European Economic Review* 13: 239–245.

Keller, W. J., and J. Van Driel. 1985. "Differential Consumer Demand Systems." *European Economic Review* 27: 375-390.

Laitenen, K., and H. Theil. 1978. "Supply and Demand of the Multiproduct Firm." *European Economic Review* 11: 107-54.

Laitenen, K. "Why is Demand Homogeneity So Often Rejected?" *Economics Letters* 1(1978): 187-191.

Livanis, G., and C.B.Moss. 2006. "Quasi-fixity and Multiproduct Firms." *Economics Letters* 93:228-234.

Meisner, J. F. "The Sad Fate of the Asymptotic Slutsky Symmetry Testing for Large Systems." *Economics Letters* 2(1979): 231-233.

Theil, H. 1965. "The Information Approach to Demand Analysis." *Econometrica* 33: 67-87.

Theil, H. 1977. "The Independent Inputs of Production." *Econometrica* 45: 1303-1328.

Theil, H. 1979. “A differential Approach to Input-Output Analysis.” Economic Letters 3: 381-85.

WTO – World Trade Oranization. 2014. Members and Observers http://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm (Access date February 2014).

Liefert, O., Liefert, W., and Luebehusen, E. 2013. “Rising Grain Exports by the Former Soviet Union Region. Causes and Outlook.” Economic Research Service, WHS-13A-01. February 2013

PSD-FAS. 2013. Production Supply and Distribution dataset provided by Foreign Agriculture Services (FAS).

Vorotnikova, E., S. Asci, and J.L. Seale, Jr. 2013. “Effect of Relative Price Changes of Top Principle Crops on U.S. Farm Land Allocation.” Paper presented at SAEA Annual Meeting February 2-5, Orlando, Florida.

Vorotnikova, E., and J.L. Seale, Jr. 2013. “Effects of Relative Price Changes on the land Allocation Dynamics among Top Staple Crops in the U.S. before and after the Energy Policy Act of 2005.” Paper presented at AAEA Annual Meeting August 4-6, Washington, D.C.