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LAND ALLOCATION AMONG THE MAIN CROPS IN ARGENTINA: ESTIMATION OF PRICE AND LAND ELASTICITIES

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Abstract

In the past twenty years, there have been significant changes in land allocation among the main crops in Argentina. The aim of this paper was to analyze how those changes responded to variations in their relative prices in the short-term and quantify their responses. Additionally, it focused on understanding how the hectares devoted to a particular crop responded to changes in the total planted area. For this purpose a system of land allocation equations was estimated for the period 1980-2014. The results showed that the area planted with corn, soybean, sunflower and wheat responded to their own prices, being inelastic in all cases. A statistically significant and negative cross-price elasticity was observed for sunflower and corn. The other cross-price elasticities showed substitution for land use but they were not statistically significant. The land elasticities revealed to be elastic for wheat and inelastic for corn, soybean and sunflowers, while not significant for sorghum.
Keywords: *Differential Approach, Rotterdam Model, Agricultural production, Soybean.*
JEL Codes: *Q11; Q15; D24.*

1. Introduction

In the last twenty years, extensive agriculture in Argentina has undergone significant changes in its production structure as well as its tenure and land use system. The outstanding feature has been the predominance of soybean on land allocation (Capp and Mallach, 2012).

The transformations in the agricultural sector modes of organization and production have been directly related to the soybean production and commercialization changes since the mid 90s. The growing international demand for oil crops by developing countries, together with the incorporation of improvements such as technological packages including genetically modified seeds, herbicides and zero-tillage practices, shaped a structure of incentives for soybean in detriment of alternative crops. International trade, as well as domestic policies, also contributed to the soybean predominance. For instance, there were restrictions and bans to exports cereals; different government measures that interfere in the free marketing of domestically consumed grains, intended to keep low domestic prices as well as the imposition of artificially low administered prices that diminished the comparative profitability of activities such as dairy and beef cattle (reducing pastures land as well as feed grains production: corn and sorghum).

Between 1981 and 2014 the area planted with soybean increased at an average annual rate of 7.5%, while the area under corn, wheat, sunflower and sorghum only 0.08%. Taking these last four together, the area planted decreased to an annual rate of approximately 0.6% between 2000-2014 (MinAgri, 2014).

This process, in turn, was boosted by the strong growth of the local oil processing industry, which responded to the incentives offered by the processed products lower export taxes and good international prices. The complex became one of the most globally competitive, allowing Argentina to occupy first places in the soybean meal and oil exports. As a result soybean not only increased their share in the total cultivated land, but also pushed the expansion of the agricultural frontier into marginal areas (Bisang, 2003; Lanteri, 2008).

Therefore, the dynamics observed in land allocation among main crops in Argentina have been strongly linked to the evolution of soybean production and its responses to relative prices.

With respect to responses to prices several studies have approached the issue. Lema and Brescia (2001) estimated direct and cross price-elasticities of the main crops during the period 1959-2000 using a Vector Error Correction Model (VECM). The supply of all crops, except corn, turned out to be inelastic to their own prices. Meanwhile, Sonnet and Asís (2006) studied the phenomenon of soybean expansion between 1975 and 2004 with a Nerlovian model approach, incorporating risk variables. They found that cultivated land responded to the expected relative net income between competitive crops, with risk aversion to net income. Finally, Lanteri (2008) analyzed the long-term response of soybean planted area to changes in relative prices and other relevant variables in agricultural production, with a VEC model during the period 1974 to 2006. Differentiating by geographical area, the price elasticities for the whole country were greater than those encountered in a particular province. No updated studies have been found, despite the fact that the substitution seemed to have speeded up in the last decade.

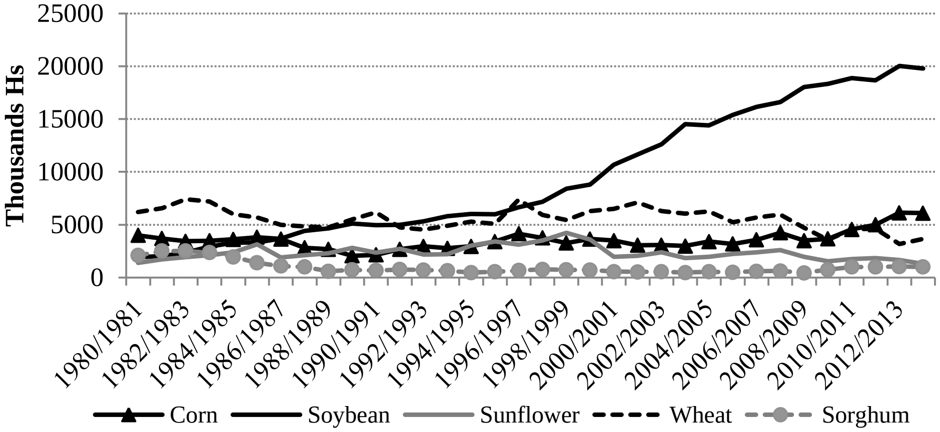
To fill the gap, this study aimed to estimate the short-term land allocation response to changes in relative prices among major Argentine crops. Additionally, it sought to understand how each crop planted area behaved relative to changes in the sum of the country cultivated area with the five major crops. To this purpose, the Seal, Vorotnikova and Asci (2014) recently developed land allocation model applied to United States (Vorotnikova, Asci and Seale, 2013), Russia (Vorotnikova, Asci and Seale, 2014) and China (Vorotnikova and Seale, 2014) was used.

Two points stands out as novel in the present research. First, the use of a microeconomic land allocation model of recent development in the literature applied to the case of Argentina; and secondly, as a corollary to the use of this model, the estimation of each crop land allocation response to variations in the total grain cultivated area.

The paper was structured as follows. Section two explains the characteristics of the data set and the dynamic of the main variables. It is followed by the model specification and methodological issues in section 3; and by the empirical results in section 4. The last section presents the conclusion and provides suggestions for future research.

2. Agricultural Land Use and Crop Prices in Argentina: A Summary

Land allocation among different crops in Argentina followed a defined pattern during the period 1981-2014, as shown in Figure 1. It has been characterized by relative stability in the hectares allocated to corn, wheat, sunflower and sorghum and the uninterrupted growth of soybean. The latter passed from 2 million hectares in the 1980/1981 crop season to nearly 20 million hectares in the 2013/2014 season; the trend speeded up from the mid 90s.



Source: Elaborated with data from the Ministry of Agriculture, Livestock and Fisheries of Argentina.

Figure 1. Land use for the main crops in Argentina (In hectares), 1980/2014

By sub-periods, there has been a decline in the planted area for all crops except soybean, from the 1996/1997 campaign until the end of the study period. In the case of corn and sorghum, the fall in the quantity of land allocated to them reversed since 2008/2009.

Table 1 shows the average annual growth rates of the five commodities. For the total period (1981-2014) growth rates for soybean, corn and sunflower were positive, and negative for wheat and sorghum. Soybean annual growth rate was by far the highest.

Table 1. Average annual growth rate of land use for principal crops in Argentina (%)

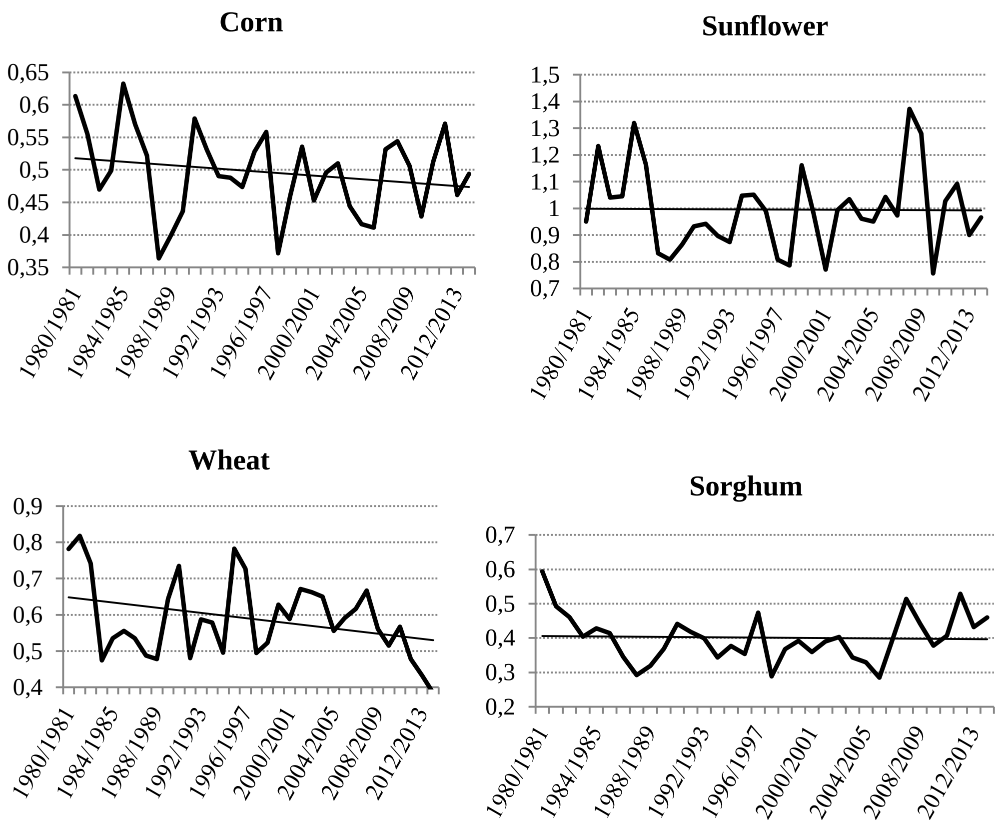
	Corn	Soybean	Sunflowers	Wheat	Sorghum
1981/1991	-5.44	10.21	7.73	0.51	-8.82
1991/2001	5.68	8.13	1.02	2.05	-0.47
2001/2014	5.15	4.97	-1.89	-2.87	6.68
1981/2014	**2.10**	**7.52**	**1.91**	**-0.35**	**-0.18**

Source: Elaborated with data from the Ministerio de Agricultura, Ganadería y Pesca.

The soybean planted area was the only one with positive growth rates in all sub-periods. In the case of sunflower and wheat, the area allocated to them grew between 1981 and 2001, decreasing from there on, while corn and sorghum presented an opposite behaviour.

Real prices of the main commodities in argentine pesos of 2013, except for wheat, with nominal prices deflated by the national consumer price index (CPI), had a similar behaviour throughout the analyzed period. Although significant variability was observed, there was a downward trend in real prices between 1980 and 2000, and a recovery later on. This was explained by the evolution of prices in Argentina: high inflation between 1980 and 1991, low inflation between 1992 and 2001, and a moderate but rising inflation between 2002-2014. This was accompanied by stable international prices of the main commodities during the 1980s and 1990s, and a significant increase since 2001, in the context of the strong growth of developing countries.

On other hand, the evolution of the exchange rate was also relevant in real price determination. The existence of a fixed exchange rate regime during the low inflation period, between 1992 and 2001, caused a significant revaluation of the local currency, negatively affecting the profitability of producer. This began to change when the system was abandoned in 2002, followed by a depreciation of the argentine peso against the US dollar. However, more recently, the exchange rate competitiveness was again significantly reduced.



Source: Elaborated with data from the FAO-BCRA-INDEC

Figure 2. Real Relative prices for the main crops in Argentina, 1980/2014

Relative real prices behaviour, in terms of each grain/soybean comparison, are shown in Figure 2. The trend was negative for corn and wheat, both commodities losing ground respect to soybean prices. No trend appeared in the relationship with sunflower and sorghum prices.

3. Methodology

3.1. Land Allocation Model: A Differential Approach

A land allocation model based on the Rotterdam differential approach, initially developed in the framework of consumption theory (Barten, 1964) and later extended to production theory (Theil, 1977), was adopted in this paper.

Laitinen (1980) provided an input allocation model in the framework of the two-stage choices of a multi-product firm; it minimized cost in the first stage obtaining demand input equations and then solved a maximization profit problem in order to get supply equations. Taking multi-product firms, Livanis and Moss (2006) extended the theoretical model with the presence of a quasi-fixed input. Seale et al. (2014) presented an adaptation in its empirical implementation, resulting in a linear specification of inputs allocation. For the analysis of agricultural land use in a multi-product approach, Vorotnikova et al. (2013; 2014) applied the Seale model, finding empirical evidence of acreage response to changes in relative prices for United States and Russia. In this paper, we used this model to study the Argentine case, selecting the most relevant agricultural crops planted in the country, mainly in the pampas region.

Let L_i be the agricultural land planted with crop *i*, p_i the price received by farmers, *L* the sum of the areas used for the selected commodities, and s_i the share of the area dedicated to crop *i*, then the linear input allocation model (Seale *et al.*, 2014) can be written as

$$s_i d(\ln L_i) = \theta_i d(\ln L) + \sum_{j=1}^{J} \beta_{ij} d(\ln p_j) \tag{1}$$

where $d(\ln L) = \sum_i s_i d \ln L_i$ is the so-called “Divisia index” for land. Considering discrete temporal data of acreage and prices, the empirical specification of (1) take finite differences, i.e. $d(\ln L_{it}) = \ln L_{it} - \ln L_{it-1}$, $d(\ln L_t) = \ln L_t - \ln L_{t-1}$ and $d(\ln p_{jt}) = \ln p_{jt} - \ln p_{jt-1}$. Additionally, for the share of the area s_i in a certain period of time *t*, an average is given by $\overline{s_{it}} = (s_{i.t} + s_{i,t-1})/2$ in order to capture the land shares between periods included in the dynamics. Then, the empirical version of (1) can be written as

$$\overline{s_{i,t}} d(\ln L_{it}) = \theta_i d(\ln L_t) + \sum_{j=1}^{J} \beta_{ij} d(\ln p_{jt}) + \upsilon_{it} \tag{2}$$

where υ_{it} corresponds to the random error of the model. For each crop *i*, an equation type (2) was identified, so a system of land allocation equations was estimated. Specifically, the system given by (2) was a version of the Rotterdam model, commonly used in the empirical analysis of consumption and input demand, but adapted to model the agricultural land allocation decisions (Vorotnikova, et al.2013: 8). In order to have consistency with the theoretical model (concavity), the following additional constraints were required

(i) Adding-up Conditions: $\sum_i \theta_i = 1$ y $\sum_i \beta_{ij} = 0$.

(ii) Homogeneity: $\sum_j \beta_{ij} = 0$.

(iii) Symmetry: $\beta_{ij} = \beta_{ji}$.

Once estimated the parameters involved in (2), i.e. $\left(\hat{\theta}_i, \hat{\beta}_{ij}\right)$, land and price elasticities were computed as follow:

$$\text{Land elasticities: } \hat{\eta}_i = \hat{\theta}_i / \overline{s_i} \tag{3}$$

and

$$\text{Own and Cross Price Elasticities: } \hat{\varepsilon}_{i,j} = \hat{\beta}_{i,j} / \overline{s_i} \tag{4}$$

where $\overline{s_i} = \sum_t \overline{s_{i,t}}$, i.e. the sample mean, throughout the period, of the biannual average shares of each crop in the total agricultural planted area ($\overline{s_{it}}$).

Some considerations about the model and their elasticities may be taking into account for economic interpretations. First, the model in statistical terms was a regression of the change (first difference) in the land share of certain crop on the change in total land (specifically, the sum of land advocated to the five crops considered) and the change in crops prices. So, the coefficients captured the short-run average response (year by year in the period 1980-2014) which was expressed as a unit change of acreages allocated to each crop associated with a unit change in total land (θ_i) or in prices ($\hat{\beta}_{i,j}$). Secondly, the elasticities showed the percent impact of land expansion and prices movements, and these depended on the land share of the certain crop in a specific year or selected period. Therefore, when the crop became more important in land occupation (i.e. greater share), the elasticity became lower. This implied that the economic interpretation of the calculated elasticities should have to be done in a careful manner, in the sense that the comparison between crops must consider the share of the land occupied by each. Finally, the cost or prices of agricultural inputs could be considered as in Vorotnikova and Seale (2013). But given that it takes degrees of freedom, a longer time series would be necessary in order to have a large enough sample to estimate the system. In countries with widely varying political and economic contexts, is difficult to find long time series to model the short-term dynamic of land use as a response to changes in selected crop prices. Therefore, following to Vorotnikova and Seale (2014) and Vorotnikova et al. (2014) for China and Russia respectively, in this paper only crop prices are incorporated in the land allocation system. The main disadvantage of not including input prices is the potential problem of omitted variable bias, which would be transferred to the estimated elasticities; in such instance, it would be more significant when the correlation between crop prices and input prices is higher.

3.2 Data and Estimation

The system was estimated using yearly data for the period 1980-2014. Crop planted area data came from the Ministry of Agriculture, Livestock and Fisheries of Argentina (Minagri, Argentina). They were compared with FAS-USDA agricultural area database, not founding significant differences. Producer Price data came from FAO, using the official exchange rate from Central Bank of Argentine Republic (BCRA) to convert to argentine pesos. The official figures not only showed exchange rate movements but also some policy effects, such as discounts generated by export taxes, which impacted on the effective nominal prices received by local farmers, and their incentives to allocate land. To convert them to real prices, they were deflated by the *CPI* (Consumer Price Index) from National Institute of Statistics and

Census (INDEC) until 2007, when the data was discontinued; and then by Price Consumer Index published by the Argentine Congress[1].

Real prices were collected for the country five major grain crops: corn, soybean, sunflower, wheat and sorghum. To solve the 'singularity problem', the sorghum equation was dropped in the system estimation; later on theoretical constraints (i)-(iii) were used for its parameters recovery. The four equations system was estimated by Zellner's Seemingly Unrelated Regressions (SUR) method via iterated maximum likelihood using STATA software. The two-step method was also used in order to compare results and check the ML estimates robustness.

4. Results and Discussion

4.1 Model Performance and Parameter Estimation

Before analyzing and interpreting the estimated model coefficients, likelihood ratio (LR) tests were performed to check the consistency of the theoretical constraints imposed by the (constrained) Rotterdam model. First, the system (2) was estimated without constraints (unrestricted model), and gradually homogeneity and symmetry are incorporated, constructing the statistic for the LR-test. Specifically, for each estimated model the log-likelihood was computed, and then if ℓ^* was the log-likelihood for the unrestricted model and ℓ^R was the log-likelihood for the restricted model (imposing constraints), the statistic $LR = -2[\ell^* - \ell^R]$ was computed; it followed, asymptotically under the null hypothesis, a Chi-Square distribution with $(k^R - k^*)$ degrees of freedom, where k^R and k^* were the number of free parameters in the restricted and unrestricted model, respectively. Table 2 presents the LR-test results, first comparing the unrestricted model respect to the model restricted with homogeneity. Then, this restricted model is contrasted with the full restricted model with homogeneity and symmetry. Comparing the statistics values with the theoretical chi-square values (taking in this case a significance level of 0.05), neither one could be rejected. Hence, the concavity imposed by the microeconomic theory was shown to be consistent with the empirical Rotterdam model proposed; it occurred even considering the low power of these asymptotic tests in relation to the small sample size for the number of equation to be estimated in the system.

Table 3 summarizes the estimation of the land allocation model (2). The R-squared and Chi2 statistics showed an acceptable goodness-of-fit for the estimated model. Land coefficients were significant and positive for the five crops included in the system. In particular, the results suggested that on average, given the relative prices, one additional unit (hectare) of total land (i.e. the total planted land with the five crops) was associated with an increase in approximately 0.11, 0.20, 0.11, 0.47 and 0.11 hectares of each of them: corn, soybean, sunflowers, wheat and sorghum planted, respectively.

So, in absolute terms, the model for the period 1980-2014 indicated that wheat and soybean were the crops more responsive (to fall and to rise) to expansions in the share of the planted land. Whereas soybean in terms of land occupation showed a similar trend, wheat has been much more volatile, hence a higher coefficient was revealed. The double-cropping system of wheat-soybean could have also influenced the results. In many regions of

[1] After 2007, the CPI was published by some Congress members as an average of CPI computed by various private consulting firms in Argentina. It reflected the inflation rates more realistically than the ones provided by the politically manipulated National Institute of Statistics and Census (INDEC).

Argentina, soybean and wheat are sowed in the same year, because wheat is a winter crop and soybean is a summer crop. This was possible due to some technologies, such as the use of zero- tillage practices and genetically modified seeds, among others. Therefore, if the total planted area increased by one unit, soybean and wheat were expected to be the more likely choices.

Table 2. Likelihood Ratio Test for LAR Model's constraints

Model	Log-Likelihood ($\ell \equiv \log L$)	d.f. (k)	LR-Test
Unrestricted	352.07	24	
With Homogeneity constraint	351.83	20	0.48 ($\chi^2_{0.05}[4] = 9.49$)
With Symmetry and Homogeneity constraints	349.54	14	4.58($\chi^2_{0.05}[6] = 12.59$)

Own-price coefficients were statistically significant at the 10% level in soybean and wheat, 5% significance level in corn and 1% significance level in sunflower. As expected, all of them were positive, except for sorghum, which exhibited a not statistically significant coefficient. In absolute terms, the major own-prices effects on land allocation decisions were for sunflower and soybean (0.07 and 0.08 by unit change in prices), followed by corn. In the case of wheat, the price effect was lower, in contrast to the findings with respect to the expansion of the total land. The role of wheat in the wheat-soybean annual land rotation may have influenced the price effect.

Table 3. Coefficient of the Land Allocation Model

	Corn	*Soybean*	*Sunflower*	*Wheat*	*Sorghum*
Land Coef.	0.1068* (0.0586)	0.2043** (0.0939)	0.1134* (0.0689)	0.4684*** (0.079)	0.1072** (0.0442)
Price Coef.					
Corn	0.0658** (0.0268)	-0.0169 (0.0218)	-0.0398*** (0.015)	-0.0082 (0.0176)	-0.0008 (0.0179)
Soybean		0.0706* (0.0409)	-0.0107519 0.022286	-0.0331 (0.025)	-0.009 (0.0166)
Sunflower			0.0804*** 0.0211	-0.0249 (0.0172)	-0.0049 (0.0111)
Wheat				0.0476* 0.0266	0.0187 (0.012)
Sorghum					-0.0031 (0.0177)
R-square	0.3282	0.1523	0.3283	0.6115	
Chi2	18.63	6.27	22.88	53.30	
Obs	34	34	34	34	34

Note: asymptotic standard errors in parenthesis. **statistically significant at the 1% level **significant at 5%* significant at 10%

The only significant cross-price coefficient was between corn and sunflower (at the 1% significance level) with the expected negative sign, indicating substitution between both crops in land allocation decisions. The other cross effects were predominantly negative but with lower and no significant coefficients.

Comparing the results of the same model applied to agricultural land allocation in other countries, such as China (Vorotnikova and Seale, 2014), Russia (Vorotnikova, Asci, and Seale, 2014) and United States (Vorotnikova and Seale, 2013), the land allocation Rotterdam model for Argentina performed very well. In the Russian and United States cases, homogeneity and symmetry were rejected. For China, there were not reported results about these restrictions. Despite considering different types of crops, more substitution relationships between crops were found in those countries; but similarly to the Argentine case, the own-price effects prevailed.

4.2 Land and Price Elasticities

Table 4 gives the elasticities computed using the coefficients of Table 3 and evaluated at the average shares of the period as in (3)-(4). Except for sorghum, land elasticities were statistically significant being elastic for wheat, inelastic for corn, soybean and sorghum, and approximately unitary for sunflower. On average, an expansion (contraction) of 10% in the total planted area increased (decreased) the land allocated to corn by 6.36% over the previous year, and similarly to soybean by 5.25%, to sunflower by 9.68%, to wheat by 16.98% and to sorghum by 8.98%, ceteris paribus. These results revealed that, as the total planted area increased in a given year, wheat and sunflower were the more responsive with respect to the previous year, taken as average for the total period.

The lower soybean land-elasticity was partially explained by the higher share of this crop in the total planted area, in such a way that the percentage change in a given year over the large portion of land already occupied resulted in a lower value.

Table 4. Land and Price Elasticities

$j =$	*Corn*	*Soybean*	*Sunflower*	*Wheat*	*Sorghum*
			Land: η_j		
	0.636** (0.349)	0.525** (0.242)	0.968* (0.577)	1.698*** (0.286)	0.898 (1.017)
			Prices: ε_{ij}		
$i =$					
Corn	**0.392**** (0.159)	-0.101 (0.129)	-0.237*** (0.089)	-.0487 (0.105)	-.0051 (0.107)
Soybean	-0.044 (0.056)	**0.182*** (0.105)	-0.028 (0.057)	-0.085 (0.064)	-0.025 (0.043)
Sunflower	-0.34*** (0.129)	-0.092 (0.19)	**0.687***** (0.18)	-0.213 (0.147)	-0.042 (0.095)
Wheat	-0.03 (0.064)	-0.12 (0.091)	-.0903 (0.062)	**0.172*** (0.096)	0.068 (0.044)
Sorghum	-0.017 (0.356)	-0.194 (0.329)	-0.098 (0.221)	0.371 (0.239)	-0.061 (0.352)

Note: asymptotic standard errors in parenthesis. **statistically significant at the 1% level **significant at 5%* significant at 10%

Own-price elasticities (presented along diagonal in Table 4) indicated how much the quantity of planted land changed (in percent) for each crop when its own price increased by 1 per cent. All crops had an inelastic response, being statistically significant at 1% level for sunflower, at 5% significance level for corn and at 10% level for soybean and wheat;

sorghum was not statistically significant. The results showed that, on average, the land used to plant corn, soybean, sunflower and wheat would increase by 3.92%, 1.82%, 6.87% and 1.72% respectively, if their respective prices went up by 10%. Sunflower turned out to be the most sensitive crop to its own price, followed by corn.

Negative cross-price elasticities revealed that the different crops were substitutes, i.e. they competed for the same land, so one percent increase in the price of one of them pushed down the quantity of land used in the alternative crop. However, only between corn and sunflower the cross-price elasticity resulted statistically significant at 1% level, with an asymmetric substitution effect. If the sunflower price went up by 1%, the land allocated to corn was reduced by 0.237%. On other hand, an increase of 1% in the corn price had a negative impact on the sunflower planted area by 0.345%, so the corn had a higher cross-effect on sunflower.

The elasticities presented in Table 4 were computed using the average shares for the overall period. Nevertheless, in Figure 1 can be appreciated that since 1997 the acreage allocated to soybean showed a considerable growth, giving a new distribution of land shares between crops. This would have justified the estimation by sub-periods, which was not possible for the series limited degrees of freedom. Instead, using the estimated coefficients for the entire period, Table 5 shows the elasticities computed at different ranges or intervals. The sorghum results were omitted for its lack of significance.

For the sub-period 1980-1997 soybeans had the larger land elasticities. It was the time when soybean expanded all over the country. Between 1997 and 2014 the soybean planted area was equivalent to that of the other four crops altogether; therefore, the soybean land elasticity decreased considerably, showing greater inflexibility (both downward and upward).

Table 5. Elasticities for the main crops by periods: 1980-1997 and 1997-2014

	Corn	*Soybean*	*Sunflower*	*Wheat*
Shares ($\overline{s_{it}}$) in %				
1980-1997	19.13	25.21	14.21	33.98
1997-2014	14.45	52.56	9.19	21.19
Land Elasticity: η_j				
1980-1997	0.558* (0.306)	0.810** (0.373)	0.798* (0.485)	1.378*** (0.232)
1997-2014	0.738* (0.405)	0.389** (0.179)	1.233* (0.750)	2.211*** (0.373)
Own-price Elasticity: ε_{ij}				
1980-1997	0.344** (0.139)	0.280* (0.162)	0.566*** (0.148)	0.140* (0.078)
1997-2014	0.455** (0.185)	0.134* (0.078)	0.875*** (0.229)	0.224* (0.125)

Note: asymptotic standard errors in parenthesis. **statistically significant at the 1% level **significant at 5%* significant at 10%

At the same time, in this period, the other crops increased their land elasticities due to their land share reduction. Sunflower and wheat were elastic, so when the sum of the five crops planted area went up (went down), the two crops responded more than proportionately in the same direction.

The estimated own-price elasticities were lower than unity in both sub-periods. Given the high growth of soybean in the period, these own-elasticities might seem low. However, it should be noted that 0.13% response in the land occupied by soybean to a change of 1% in its price represented a great change in absolute terms (i.e. hectares) compared with other crops, given its share in the total cropland.

Results obtained in this paper were coherent with those found in other studies of agricultural land use in Argentina, such as Lema and Brescia (2001) and Lanteri (2008). Consistency was found only in price elasticities, since they did not estimate land-elasticities. In particular, Lema and Brescia estimated non-structural log-log equations, using co-integration and error correction models for the period 1967-2000. Sorghum was not included. The short-term own price elasticities they found were 0.43 for corn, 0.24 for soybean, 0.42 for sunflower and 0.38 for wheat. Therefore, despite the significant methodological difference with the model used here, and the data period, the results were consistent.

Major differences were found with the Lema and Brescia cross-price elasticities since they only included some cross-effects (soybean-corn and soybean-wheat). They also estimated long-run elasticities, obtaining higher values as expected.

The Lanteri's study of soybean using co-integration techniques and VEC model for the period 1974-2006, reported a long-term price elasticity of 0.39 for soybean in Santa Fe province, and significantly higher for Argentina, between 2.24 and 5.24, depending on the model.

5. Conclusions

The growing expansion of soybean in Argentina has been accompanied by the reduction in the participation of other traditional extensive crops, such as corn, sunflower and sorghum. Instead of stabilizing, the area planted with soybean accelerated its growth at the beginning of the new millennium. Answers to questions such as how each crop planted area responded to its own price or to the total land used are needed to fully understand the developing path and its policy implications. Since no updated study was found to evaluate the on-going situation this research aimed to fill the gap.

An econometric model for the 1980-2014 period was fit with yearly data. Even though longer annual series were available, the Argentinean agricultural transformation has been so deep that would not be valuable for the present purpose. Despite of the limited number of observations, the results have been consistent with the economic expectations and the model presented an acceptable econometric adjustment.

In general, corn and soybean short-term land elasticities were lower than the unity. It indicated that as the sum of the land used for the five crops expanded (decreased) year by year, the share of each of them increased (decreased), with respect to the previous year, less than did the total expansion. The lower coefficient for soybean was mathematically understandable when one thinks that for its calculation the annual change was compared to an already large quantity of land occupied with the crop.

For land allocated to sunflower the response was almost the same (unitary), and for sorghum was not statistically significant.

The higher land elasticity for wheat needs further investigation. A hypothesis could be related to its use in the double-cropping wheat-soybean system in the Humid Pampas central region. As new land might have been incorporated to production, part of it could be used for wheat alone and another part for the wheat-soybean rotation, having increased its response year by year.

On the other hand, corn, soybean, sunflower and wheat price elasticities were all lower than unity, being sunflower the highest and soybean the lowest. This latter result leads to think that once the cultivation package was adopted by producers, the practice was uninterrupted despite changes in prices.

Cross price elasticities, on their part, were negative for sunflower and corn, indicating the strongest competition for the same land. Other coefficients were lower and not statistically significant. Therefore, at the end, we could interpret that land occupation responded more to the crop own prices than to their cross effects.

Several suggestions for future studies can be put forward. First, to include in the model some agricultural activities in addition to crops such as natural and artificial pastures (for dairy and beef cattle); furthermore, to differentiate regions or provinces, for their distinct ecological characteristics and modalities of production. Data availability is seen as the major obstacle to overcome both suggestions. Second, to add some environmental variables related to the activities to quantify their impact on the system as well as its sustainability. Lastly, to build different scenarios with differential export taxes on each commodity and how they would affect domestic prices and area planted. Effective agricultural policies designed with extensive knowledge of the sectors involved are urgently needed for the Argentine future take off.

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