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# Argentine Agricultural Structure and Policy Implications

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**Abstract:** This paper uses 1940-80 time-series data and a multiproduct, multiinput aggregate translog profit function to estimate the structure of Argentine agricultural technology. Estimates of own-price supply elasticity ranged between 0 and 1.5, and derived demand elasticities were between -1 and -2. Given the authors' estimates of price wedges due to currency overvaluation, trade restrictions, and domestic taxes, the implications of eliminating any one of these policy-induced wedges would be to increase production of the various agricultural commodities from as little as 5 percent to as much as 100 percent.

## Introduction

Argentine agricultural output grew at a rate of about 1.4 percent per year between 1940 and 1972 (Cavallo and Mundlak, 1982), which is sluggish, given earlier rates of 1.8 percent during 1908-20 and 2.2 percent during 1920-40 (Schultz, 1956). It is also sluggish relative to growth in US agricultural output of 2.0 percent during the same period. Adjusting for factor use, total factor productivity in Argentine agriculture grew at a rate of only 0.6 percent during 1940-72, compared to 2.0 percent for the USA and 1.2 percent in the rest of the Argentine economy during the same period. Other studies have suggested that price and tax policies contributed to this sluggish growth. The purpose of this study is to provide further information on the effects of these policies on the production of various agricultural commodities.

The approach of this study is to specify and estimate a multiinput, multioutput model of the Argentine agricultural sector, so that the results can be used to examine the effects of price and tax policies in a comparative static framework. This model is developed using applied duality theory in a manner similar to previous studies of aggregate agricultural technology by Antle (1984), Lopez (1984), Shumway (1983), and Weaver (1983).

## Estimation of the Structure

### Model

The producer's variable profit function may be defined as:

$$(1) \pi(p, r; z) \equiv \max_{xy} \{py - rx; (y, x; z) \in T\},$$

where  $p$  is a vector of  $m$  output prices,  $r$  is a vector of  $n$  input prices,  $y$  is a vector of  $m$  output quantities,  $x$  is a vector of  $n$  input quantities,  $z$  is a vector of  $l$  fixed factors, and  $T$  is a closed, bounded, smooth, and strictly convex set of all feasible combinations of inputs and outputs; i.e., a production possibility set. In addition, technology is assumed to exhibit constant returns to scale. The profit function (1) is assumed to be convex, linearly homogeneous, and monotonic in prices. For this study of Argentine agriculture, a translog specification is used, which is a flexible functional form in the sense that it provides a local second-order approximation to any arbitrary functional form:

$$(2) \bar{\pi} = \alpha_0 + \alpha \bar{d} + \{(\bar{d}' \beta \bar{d})/2\}, \text{ where } \bar{\pi} = \ln \pi, \text{ and } \bar{d} = \begin{bmatrix} \bar{p} \\ \bar{r} \\ \bar{z} \end{bmatrix} = \begin{bmatrix} \ln p \\ \ln r \\ \ln z \end{bmatrix}.$$

Differentiating the profit function and invoking Hotelling's lemma yields a system of share equations:

$$(3) \quad \begin{aligned} M_i^* &= \alpha_i + \sum_{j=1}^m \beta_{ij} \bar{p}_j + \sum_{k=1}^n \beta_{ik} \bar{r}_k + \sum_{r=1}^l \beta_{ir} \bar{z}_r; \quad \forall i=1, \dots, m; \\ -M_h^* &= \alpha_h + \sum_{j=1}^m \beta_{hj} \bar{p}_j + \sum_{k=1}^n \beta_{hk} \bar{r}_k + \sum_{r=1}^l \beta_{hr} \bar{z}_r; \quad \forall h=1, \dots, n; \end{aligned}$$

where  $M_i^*$  is the share of profit accounted for by revenues for the  $i$ th output and  $M_h^*$  is the share of profit accounted for by expenses for the  $h$ th input. In more compact notation, (3) can be expressed as:

$$(4) \quad M = \alpha + \beta \bar{d},$$

where  $M$  is a column vector consisting of output shares and the negative of input shares.

## Data

Parameters of the Argentine agricultural supply and factor demand structure (4) are estimated using time series data for 1940-80. The seven aggregate output categories used are wheat, maize, grain sorghum, sunflower, linseed, soyabeans, and beef. The three variable input aggregates are labour (number in the labour force), capital (current value times imputed rate of return to capital), and an aggregate index of fertilizers, seeds, and chemicals. The inputs considered fixed within the annual observation interval are land and precipitation in the crop-producing region of the Pampas. A time trend was included as an index of technical change. All prices and values were deflated to 1960 pesos.<sup>2</sup> The six crops in this study used 93.5 percent of nonforage crop acreage planted in the first five years of the data period and 89.3 percent in the final five years. Including fruits and vegetables plus industrial commodities such as sugar, cotton, and tobacco in the value of agricultural production, the seven commodities here constitute about 60 percent of the value of all output.

## Estimation

In order to estimate the parameters of the profit function, a stochastic structure must be assumed for the equation system (4). Any deviations of the observed output supply and input demand quantities from their profit maximizing levels are hypothesized to be caused by random errors in optimization. The disturbances are assumed to be additive and normally distributed with zero means and a positive semidefinite variance-covariance matrix.

The estimation procedure used is Zellner's seemingly unrelated regression technique. Contemporaneous correlation of the residuals in different equations is plausible and can therefore be exploited by the technique. Given the large number of parameters, the system of equations was not estimated using the iterative seemingly unrelated regression method because the likelihood function tends to be unstable. The equations were restricted to satisfy the symmetry and homogeneity conditions. Of the 85 independent parameter estimates (Table 1), 13 are significant at the 1-percent level, and 26 at the 5-percent level. A check of the regularity conditions shows that monotonicity does not hold; i.e., not all predicted shares are positive. Tests also failed to support the hypotheses of symmetry, homogeneity, and homotheticity.

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Table 1-Parameter Estimates Restricted for Symmetry and Homogeneity\*

Dependent Variable	Price of:											Land	Rain	Time
	Intercept	Beef	Wheat	Maize	Sunflower	Linseed	Soyabean	Sorghum	Capital	Labour	Others			
Beef	6.432 (2.51)	1.165 (0.344)	-0.837 (0.217)	-0.410 (0.115)	-0.136 (0.093)	-0.099 (0.068)	-0.012 (0.040)	-0.133 (0.069)	0.099 (0.291)	0.266 (0.171)	0.098 (0.086)	0.0658 (0.122)	-0.0093 (0.179)	-0.057 (0.089)
Wheat	0.466 (1.97)		1.307 (0.206)	-0.477 (0.087)	-0.034 (0.066)	-0.119 (0.040)	0.028 (0.037)	-0.179 (0.043)	0.174 (0.223)	-0.034 (0.130)	0.171 (0.069)	0.208 (0.094)	-0.202 (0.140)	0.006 (0.071)
Maize	-1.446 (0.958)			0.884 (0.077)	-0.108 (0.043)	-0.038 (0.022)	0.004 (0.022)	0.012 (0.030)	0.093 (0.102)	0.002 (0.058)	0.038 (0.035)	-0.015 (0.041)	0.297 (0.063)	-0.282 (0.035)
Sunflower	-0.983 (0.656)				0.279 (0.044)	0.038 (0.024)	-0.009 (0.015)	0.006 (0.025)	-0.091 (0.074)	0.037 (0.048)	0.016 (0.024)	0.033 (0.031)	-0.045 (0.046)	0.012 (0.024)
Linseed	-0.336					0.089 0.013	0.007 0.045	0.062 0.062	0.002 0.002	0.016 0.016	0.066 0.066	-0.094 -0.094		
Soyabean	-0.359 (0.326)						0.050 (0.012)	-0.010 (0.011)	-0.059 (0.036)	-0.009 (0.021)	-0.017 (0.013)	0.021 (0.016)	-0.045 (0.023)	0.024 (0.013)
Sorghum	-0.153 (0.373)							0.248 (0.034)	-0.007 (0.038)	0.004 (0.033)	0.041 (0.017)	-0.046 (0.018)	0.030 (0.024)	0.016 (0.014)
Capital	-1.050 (2.967)								-0.099 (0.345)	0.001 (0.192)	-0.155 (0.096)	-0.164 (0.140)	-0.108 (0.211)	0.272 (0.104)
Labour	0.380 (1.65)									-0.224 (0.115)	-0.105 (0.054)	-0.095 (0.079)	-0.030 (0.118)	0.125 (0.059)
Others	-1.949 (0.856)										-0.089 (0.034)	-0.024 (0.040)	0.046 (0.061)	-0.022 (0.031)

\*Standard errors in parentheses.

### Elasticity Estimates

While the structure of equation (4), as estimated above, can be used to evaluate the effects of prices and fixed factors on the *mix* (shares) of outputs and inputs, elasticities must be derived to evaluate their effects on the levels of outputs and inputs. The elasticities can be obtained by differentiation of the share equations.<sup>3</sup> Table 2 shows the own- and cross-price elasticities calculated in this manner from the Table 1 parameter estimates, using the mean value of shares.

Table 2-Estimated Own- and Cross-Price Elasticities

Quantity of:	Price of:										
	Beef	Wheat	Maize	Sunflower	Linseed	Soyabean	Sorghum	Capital	Labour	Others	
Beef	1.17	0.10	0.08	-0.03	0.02	0.02	-0.02	-0.95	-0.26	-0.20	
Wheat	0.15	1.42	-0.15	0.10	-0.04	0.07	-0.12	-0.82	-0.53	-0.07	
Maize	0.22	-0.29	1.48	-0.11	0.02	0.04	0.12	-0.82	-0.48	-0.19	
Sunflower	0.22	0.58	-0.33	1.10	0.38	-0.03	0.14	-1.67	-0.23	-0.17	
Linseed	0.27	-0.26	0.08	0.49	-0.08	0.15	0.16	-0.62	0.08	-0.27	
Soyabean	0.78	1.75	0.57	-0.14	0.54	0.66	0.42	-2.96	-0.78	-0.85	
Sorghum	-0.19	-1.03	0.55	0.21	0.18	0.13	1.56	-1.11	-0.44	0.14	
Capital	1.08	0.65	0.34	0.23	0.07	0.09	0.10	-1.94	-0.49	-0.13	
Labour	0.63	0.89	0.43	0.07	-0.02	0.05	0.09	-1.03	-1.03	-0.07	
Others	0.83	0.21	0.29	0.08	0.10	0.09	-0.05	-0.48	-0.12	-0.97	

On the supply side, own-price elasticities fall between 0.7 and 1.5 except for linseed, implying a high degree of responsiveness to price. Outputs exhibit a substantial degree of complementarity, with 15 of the 21 cross-supply elasticities being positive. This result is intuitively plausible, as in this model a price increase for one commodity can stimulate additional purchases of variable inputs used jointly in the production of other commodities. Overall, the elasticities of output supply with respect to output prices indicate a considerable degree of flexibility exists in the choice of the output mix, even in the short run. The production of the various commodities is most responsive to the price of capital services (elasticities of -0.6 to -3.0), next most responsive to wages (elasticities of -0.1 to -0.8), and least responsive to the price of other inputs (elasticities of -0.1 to -0.8). These results

support the hypothesis that the agricultural sector would be substantially affected by policies such as credit subsidies and wage controls.

In general, own-price elasticities are higher than results obtained by Weaver (1983) for the Dakotas, Antle (1984) for the USA, and Shumway (1983) for Texas. Antle's multiproduct model for Egypt produced higher supply and input demand elasticities than the ones presented in this study, but it was based on a cross section of firms rather than the aggregate economy. Weaver's results implied complementarity among all outputs and among all inputs. Results are not as conclusive for the studies of Texas and the USA. Antle's estimates for Egypt indicate complementarity in input and output space.

Own-price elasticities for input choice are about -1 for labour and "other inputs," and -2 for capital. Negative cross elasticities were obtained in all cases, as in Weaver. From the perspective of a multioutput, multiinput technology, these results are consistent with limited substitution possibilities among inputs. Elasticities of virtually all variable inputs with respect to output prices are positive.

### Implications for Policy Effects on Argentine Agriculture

In this section, prices are assumed to be exogenous to the agricultural sector.<sup>4</sup> Therefore, the price wedges created by various policies can be characterized as simply exogenous price changes within the structure estimated above. Given an estimate of the price effect of a policy, equation (4) is then used with the coefficients of Table 1 to evaluate the effects of the policy on the mix (shares) of inputs and outputs. To evaluate effects on the levels of inputs and outputs, a similar linear elasticity model is used:

$$(5) \delta \begin{bmatrix} \ln y \\ \ln x \end{bmatrix} = \Sigma \delta \begin{bmatrix} \ln p \\ \ln r \end{bmatrix},$$

where  $\Sigma$  is the 10x10 matrix of price elasticities from Table 2. The use of this linear elasticity model introduces a considerable approximation error with large price shifts if the true model is one of constant elasticity supply and derived demand equations. However, since only crude estimates of the sizes of the price changes can be obtained, the approximation seems appropriate.

#### Estimates of Policy Price Wedges

Previous studies by Reca (1980), Cavallo and Mundlak (1982), and Mielke (1984) identify relevant policies and provide information about their price effects. The general effect of these policies has been to tax agriculture very heavily, but the types and sizes of the interventions have tended to be erratic, as the various political factions in the country have wrested control from one another over the past four decades. Hence, for this study, the nature of the interventions are summarized and price wedges that seem to be representative of the period are rather arbitrarily specified (Table 3).

The most significant interventions have been those related to trade, in the form of exchange rate controls, export taxes and restrictions on imports of agricultural inputs. A recent unpublished World Bank study estimated that overvaluation averaged 18 percent during 1960-80, which is lower than the estimates by Reca and Cavallo and Mundlak. Export taxes on the commodities included here have varied from no tax to 56 percent for grains and 30 percent for beef. Cavallo and Mundlak's study shows an average export tax on all agriculture of 29 percent during 1940-73. Examination of the time path of these taxes (Mielke, p. 19) suggests that figures of 10 percent for beef, 15 percent for soybeans, and 25 percent for other commodities are representative but still low estimates of the increases in prices if these export taxes were repealed. Finally, from discussions in Mielke and Reca, elimination of import taxes and import restrictions would decrease prices of

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Table 3—Estimated Changes in Prices Faced by Farmers Due to Elimination of Policies

Commodity	Export Tax	Import Restrictions	Policy Set Overvalued Currency	Domestic Taxes	Minimum Wages
	Percent				
Beef	10	0	18	0	0
Wheat	25	0	18	0	0
Maize	25	0	18	0	0
Sunflower	25	0	18	0	0
Linseed	25	0	18	0	0
Soyabean	15	0	18	0	0
Sorghum	25	0	18	0	0
Capital	0	-26	18	-18	0
Labour	0	0	0	-13	-10
Others	0	-26	18	-18	0

capital goods and other inputs (fertilizer, seed, and chemicals) by 26 percent.

Domestic policies of significance include the social security tax on labour, which raised wages by 13 percent (Reca indicates that this figure had risen to 40 percent by 1980); the minimum wage, which raised wages by 10 percent; and value-added taxes on capital and other inputs (Mielke, p. 9), estimated to be 18 percent.

Effects of Policies on Inputs and Outputs

The estimated price wedges associated with each of the policies identified above are summarized in Table 3. Not all of them were in effect in a given year, but most of the policies were in effect for much of the historical period. To obtain an estimate of their net impact on agriculture, the impact of eliminating all these wedges simultaneously is estimated by the use of equations (4) and (5), using the average values of the variables during 1940-80 as a base.

The use of equation (4) yields changes in profit shares. Profit shares can be easily converted to the more useful concepts of revenue shares (outputs) and cost shares (inputs). The changes in these shares associated with the price policy wedges are reported in Table 4.

Elimination of the wedges would reduce the relative size of the beef industry. Although these policies have held beef prices lower than world levels, grain prices were even more severely reduced (beef producers were apparently more successful in influencing the government than crop producers). As a result, elimination of all price wedges would reduce the relative size of the beef industry and increase that of each of the crops.

Elimination of all these wedges would decrease the price of capital and "other

inputs" by 26 percent and labour by 23 percent. However, given the high elasticity of demand for capital (about -2), capital would rise in its share of costs. The interventions have also increased the prices of labour and other inputs, but, given their lower elasticities of demand, the elimination of the wedges would result in a relative decrease in their share of costs.

The elasticities of Table 2 are used with equation (5) to estimate the quantity effects of selected policies. The effect of currency devaluation (elimination of the exchange rate controls in Table 3) would have been to increase beef production by 5 percent, soyabean

Table 4—Effects of Combined Interventions on Average Shares

	Profit Shares		Revenue/Cost Shares	
	Actual	without Intervention	Actual	without Intervention
<b>Outputs:</b>				
Beef	1.17	0.69	0.42	0.31
Wheat	0.82	0.73	0.29	0.33
Maize	0.43	0.40	0.15	0.18
Sunflower	0.14	0.19	0.05	0.09
Linseed	0.11	0.05	0.04	0.02
Soyabean	0.03	0.09	0.01	0.04
Sorghum	0.10	0.09	0.03	0.04
<b>Inputs:</b>				
Capital	-1.03	-0.87	0.57	0.70
Labour	-0.49	-0.31	0.27	0.25
Others	-0.28	-0.06	0.16	0.05

production by 14 percent, and other crops by similar amounts. Variable input use would have risen similarly (Table 5). The elimination of both export taxes and import restrictions would have had more dramatic effects, with increases in output ranging from about 47

Table 5—Estimated Effects of Policy Changes on Quantities

Commodity	Export Tax	Import Restriction	Policy Set Overvalued Currency	Domestic Taxes	Minimum Wages
	Percent				
Beef	17	30	5	24	3
Wheat	33	23	10	23	5
Maize	34	26	9	24	5
Sunflower	49	48	4	36	2
Linseed	15	23	-2	15	-1
Soyabean	96	99	14	79	8
Sorghum	37	25	8	23	4
Weighted output	27	29	7	25	4
Capital	47	54	9	44	5
Labour	43	29	18	33	10
Others	26	38	2	28	1
Weighted input	43	44	10	38	6

percent for beef to a tripling of soyabean output. The use of capital would have doubled, and labour and others would have increased more than 50 percent. The estimated effects of eliminating the value-added tax on capital and chemicals and the social security tax on labour are shown in column 4, Table 5. The effects on output and input use are more modest, but still dramatic, with increases ranging from 15 percent to 80 percent.

Elimination of minimum wages in agriculture would have had relatively minor effects (column 5).

These estimates of *mutatis mutandis* effects of interventions are in some cases quite large. The assumptions of the basic model, and therefore of these calculations, are that input supplies and product demands are perfectly elastic. To the extent that expansion would drive up input prices or drive down product prices, the effects of eliminating interventions would be *smaller* than those shown in Table 5. Furthermore, the use of Table 3 elasticities to calculate the shifts in Table 5 involves a linear approximation of the supply functions implied by the translog technology of Table 1, and this also exaggerates the output effects presented in Table 5. Because of these approximation errors in predicting large changes from current equilibrium levels, the results in Table 5 should be considered to be *upper bound estimates* of the effects of completely eliminating any one of the three wedges shown. For a partial reduction in the wedges, the responses shown may be quite accurate. Effects of the magnitude shown could certainly not be expected from the elimination of more than one wedge simultaneously. In any case, the results demonstrate that the various policies have certainly had dramatic effects in holding back agricultural output in Argentina.

## Conclusions

The results of this study have confirmed the influence of relative output prices, relative variable input prices, and quantities of fixed inputs on production decisions. The findings imply that Argentina's agricultural price policies have had substantial adverse effects on productivity. Evidence on the distortion of resource allocation as a result of government intervention in markets is offered by the analysis. Agricultural output in Argentina has been implicitly and explicitly taxed—the static effect being lower agricultural output.

## Notes

<sup>1</sup>World Bank; and Department of Economics and Business, North Carolina State University; respectively. With the usual disclaimers, the authors are grateful for valuable help and comments provided by Professors Antonio Besil, Domingo Cavallo, John Dutton, Paul Johnson, Luis Pellegrino, A.R. Gallant, and M.K. Wohlgenant.

<sup>2</sup>For additional descriptions and sources of the data, see Fulginiti (1986).

<sup>3</sup>See Sidhu and Baanante (1981) for details. The own-price elasticity of supply for crop  $i$ , for example, is  $n_{ii} = (\beta_i/M_i) + M_i - 1$ .

<sup>4</sup>Argentina is a small country in the world market for these commodities, and, since agriculture represents only 8-10 percent of GNP, that sector is a reasonably small user of capital, labour, and "other inputs."

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## DISCUSSION OPENING—Urs Egger (Department of Agricultural Economics, Swiss Federal Institute of Technology)

The authors present a model that permits simulation of the impacts of government intervention in markets in Argentina from 1940 to 1980. They conclude that agricultural policy had a dramatic effect in holding back agricultural output in Argentina. Considering how many agricultural policies discriminate against the agricultural sector in many countries, the result is not surprising. What is surprising are the positive cross-supply elasticities for most of the output categories, given the model's assumption of fixed input of land in production. Also, if the analysis had been continued into the 1980s, policy changes that diminish or remove some export taxes would have allowed a test of the model's qualities.



The paper should stimulate us to go a step further by asking what would happen if Argentine agricultural policy were changed in the way suggested by the paper. Increased prices would effect an increase in agricultural production. With limited time, only three major problem fields arising from such a change can be proposed for discussion: income distribution in agriculture, consumer prices and inflation, and export-oriented agriculture.

The impact of additional income as a consequence of increased output should be discussed. The structure of land tenure is not as unequal in Argentina as in other Latin American countries that have a relatively large share of medium-sized family farms. Nevertheless, 40 percent of the rural population have to live on 5 percent of the agricultural area. Considering the inflationary tendency, this large group will not have the necessary financial means for investment. Therefore, additional output would hardly improve income distribution in rural areas.

In 1985, about 80 percent of the population lived in urban areas. For several years, high rates of inflation were the daily reality in Argentina. The 1986 level of 82 percent per year marked the first time in the 1980s that the rate fell below 100 percent. Considering the importance of expenditures on food, the paper's proposed change of policy by raising food prices would affect the majority of the Argentine population in a negative way.

Another question is whether increased output would contribute to export performance. Fluctuating prices and effects of protectionist agricultural policies in industrial countries are major features of agricultural world markets. The export performance of Argentina's major export commodities—cereals and meat—strongly depends on the agricultural policies in the USA and EC. Therefore, increased output of those commodities can only be exported if import restrictions in those countries are removed or at least diminished. Also, the low price level on world markets caused by surpluses from industrial countries must be raised in order to be of interest for exports.

These remarks are intended to show the necessity of interpreting agricultural policy measures in their overall economic context, including foreign trade. An exclusive sectoral model involves the danger of evaluating certain policy measures differently than if their impacts were assessed as part of an overall economic strategy.

## GENERAL DISCUSSION—*Ralph D. Christy, Rapporteur* (Department of Agricultural Economics and Agribusiness, Louisiana State University)

A series of questions focused on the importance of nonprice policy in Argentine agriculture. How does the duality model account for credit policy? Since the time period of this study was lengthy (1940-80), how was land reform policy treated? How has price stabilization policy (as opposed to price support policy) been accounted for in the model?

One participant commented that the elasticity values were relatively high and speculated that perhaps the constraints imposed in the model pushed up the coefficients, which would provide erroneous policy prescriptions. The participant suggested that rather than imposing constraints, hypotheses should be tested.

In reply, Fulginiti stated that the model did not account for interest rates explicitly; the price of capital was used as an exogenous variable. Therefore, credit policy was not addressed directly. With respect to land reform, the same response applies. The data were annual observations, which should capture quality adjustments in land; however, distributional questions may not be reflected.

Fulginiti also noted that the elasticities were admittedly high. The homogeneity restriction was respected. The model was not designed to examine price theory, but it is a translog function (profit/production model). Therefore, the model does not allow for oversupply of factors. Introduction of instrumental variables may be possible. Although income distribution is an important issue, the objective of the paper does not necessarily include such questions.

Participants in the general discussion included V. Beker, G. Flichman, and O. Knudsen.