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# Argentine Agricultural Policy in a Multiple-Output, Multiple-Input Framework

Lilyan E. Fulginiti
*University of Nebraska - Lincoln*, lfulginiti1@unl.edu

Richard K. Perrin
*University of Nebraska-Lincoln*, rperrin@unl.edu

# Argentine Agricultural Policy in a Multiple-Input, Multiple-Output Framework

**Lilyan E. Fulginiti and Richard K. Perrin**

This study shows that government interventions in Argentine agriculture substantially reduced the growth rate of output 1940–80. A multiple product, multiple input, aggregate translog profit function is estimated. Supply elasticity estimates range from zero for linseed to 1.6 for sorghum. Estimates of intervention wedges together with the estimated structure imply that export taxes, import restrictions, and domestic taxes each in isolation could have reduced aggregate output by as much as 25%–30%. These and other interventions increased beef as a share of outputs and increased the cost shares of purchased inputs and labor at the expense of capital inputs.

*Key words:* agricultural production, agricultural structure, Argentina.

Argentine agricultural output grew at a rate of about 1.4% per year between 1940 and 1972 (Cavallo and Mundlak, p. 13), which is a very sluggish growth rate, given earlier rates of 1.8% for 1908–20 and 2.2%, 1920–40 (Schultz). It also is sluggish relative to growth in U.S. agricultural output of 1.9% during the same period. Adjusting for factor use, total factor productivity in Argentine agriculture grew at a rate of only 0.6% during this period, compared to 1.2% in the rest of the Argentine economy (Cavallo and Mundlak) and compared to about 1.9% in U.S. agriculture (USDA).

A number of hypotheses have been offered to explain this sluggish growth, including heavy taxation of the agricultural sector, slow technological advance, and a lack of profit motivation among the dominant large landowner class. Empirical studies by Cavallo and Mundlak, Gluck, and Reca (1974) indicate that various price and tax policies have indeed significantly affected agricultural output. The purpose of the study reported here is to provide further evidence on this issue by simultaneously considering the effect of a number of such price and tax policies on the production of seven agricultural commodities and the use of three agricultural inputs in Argentina.

The approach of the study is first to specify and estimate a multiple-input, multiple-output model of the Argentine agricultural sector, based on 1940–80 time-series data. This model is developed using applied duality theory in a manner similar to previous studies of aggregate agricultural technology by Antle; Ball (1988); Shumway; Shumway, Saez, and Gottret; and Weaver. The resulting estimates of elasticities are then used to examine the effects of price and tax policies in a comparative static framework.

## The Economic Model

The producer's variable profit function may be defined as

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

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, the technology is assumed to exhibit constant returns to scale. The profit function as defined by

Lilyan Fulginiti and Richard K. Perrin are an assistant professor at Iowa State University and a professor at North Carolina State University, respectively.

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(1) is assumed to be convex, linearly homogenous, and monotonic in prices. If, in addition, the variable profit function is twice continuously differentiable with respect to prices, applying Hotelling's lemma yields the system of continuously differentiable output supply and input demand functions:

$$(2)\quad \frac{\delta\pi}{\delta p_i}(p, r; z) = y_i^*(p, r; z)\; i = 1, \ldots, m$$
$$\frac{\delta\pi}{\delta r_h}(p, r; z) = -x_h^*(p, r; z)\; h = 1, \ldots, n,$$

where $y_i^*$ and $x_h^*$ are profit-maximizing amounts of output $i$ and input $h$ given prices and fixed inputs.

For this study of Argentine agriculture, a translog specification is used which, as is well known, is a flexible functional form in that it provides a local second-order approximation to any arbitrary functional form.

In general,

$$(3)\quad \tilde{\pi} = \alpha_0 + \alpha\,\tilde{d} + \frac{1}{2}\tilde{d}'\,\beta\,\tilde{d},$$

where

$$\tilde{\pi} = \ln\pi$$
$$\tilde{d} = \begin{bmatrix}\tilde{p}\\ \tilde{r}\\ \tilde{z}\end{bmatrix} = \begin{bmatrix}\ln p\\ \ln r\\ \ln z\end{bmatrix}.$$

First-order differentiation of this profit function yields a system of share equations:

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

where $M$ is a column vector consisting of output shares and the negative of input shares, $\alpha$ is a vector, and $\beta$ is a matrix of the coefficients in equation (4).

Second-order differentiation of the profit function, with some manipulation of the results, yields response elastiticies [see Weaver's equation (19) for elasticities as functions of estimated parameters and estimated shares]. In the multiple-input, multiple-output case, the signs of these elasticities are not an indication of isoquant curvature because all other quantities are adjusting optimally to the price change as well.

The Hicksian measure of biases induced by technical change is used in this analysis. It is based upon marginal rates of substitution and must be measured between input pairs. Technological change is said to be Hicks $x_h$-saving, or $x_h$-neutral or $x_h$-using relative to $x_k$ if

$$(5)\quad B_{hk} = \delta\left(\ln\frac{x_k^*}{x_h^*}\right)\Big/\delta\tilde{z}\gamma \gtreqless 0,$$

where the variable $Z\gamma$ is arbitrarily designated as an index of technological change (Lau). A consistent estimator for this bias in the impact of technical change for the translog specification can be derived as

$$(6)\quad \hat{B}_{hk} = \frac{\hat{\beta}_{k\tilde{z}\gamma}}{M_k} - \frac{\hat{\beta}_{h\tilde{z}\gamma}}{M_h}.$$

## Argentine Agricultural Sector Data

Parameters of the agricultural supply and factor demand structure for Argentina are estimated using the functional form described previously, with time-series data for the years 1940–80. The seven aggregate output categories examined are wheat, corn, grain sorghum, sunflower, linseed, soybeans, and beef. The three variable input categories are labor, capital, and an aggregate of fertilizers, seeds, and chemicals. Land and precipitation are considered fixed within the annual observation interval. A third fixed input variable is time in years, which represents the index of technological change. This is equivalent to specifying exponential rates of output- and input-augmenting technological change. The trend variable could be a poor proxy for technical change if the change does not occur at a constant annual rate.

The seven commodities constitute over 70% of the value of all agricultural output in Argentina when industrial commodities such as sugar, cotton, and tobacco are included, along with fruits and vegetables. However, capital share is available only for the entire agricultural sector, and the land index is a quality-adjusted index which was available only for the entire sector. Any bias introduced by these approximations is probably small because of the consistently large fraction of total agricultural resources devoted to this set of commodities. The six crops used 94% of harvested crop acreage in the first five years of the data and 89% in the last five years, while beef used about six times the amount of land devoted to crops during most of this period.

Crop production data, in millions of metric tons, were obtained from Banco de Analisis y Computacion. Average crop prices received by farmers were obtained from Bolsa de Cereales, and were converted to 1960 pesos per quintal. Beef data, cash receipts, and farm price in pesos per kilogram, were obtained from Argentina Junta Nacional de Carnes and were also deflated to 1960 pesos, as are all other prices in the study.

Labor data consist of the number of workers in the agricultural labor force, and the average annual agricultural wage earnings including perquisites, taken from Cavallo and Mundlak (tables 25 and 26, extended to 1980 in a personal communication from Cavallo).

Expenditure on capital services is an aggregate of several categories: repairs and operation of motor vehicles and machinery, machine hire and custom work, electricity, interest on non-real estate debt, and depreciation on motor vehicles, machinery, and equipment. These expenditure data were taken from unpublished sources at the Ministry of Agriculture (SAG) and deflated. For the price of capital services, the procedure of Cavallo and Mundlak was used to calculate the real rate of return on capital in agriculture (though our numbers differ from theirs because of different aggregates of inputs and outputs). This rate is calculated as the ratio of the value of production (net of the values of labor and "other" inputs) to the value of agricultural capital including land. (Conceptually, this is similar to Ball's 1985 measure of the rate of return but without his deduction of depreciation, capital gains, and property tax from the value of production. The Cavallo-Mundlak procedure thus overestimates the Ball rate of return by an amount that would be nearly constant from year to year.) The rate of return we calculate averages .091, ranging from a low of .042 in 1949 to a high of .148 in 1973.

Expenditures on fertilizers, chemicals, and seeds for each of the six crops were available from SAG, though not in published form. These were aggregated across crops and inputs and deflated to provide the expenditure series for "other" inputs. A Tornquist-Theil price index for fertilizers, seeds, and chemicals was constructed using unpublished SAG price data for these inputs.

The land variable is a quality-adjusted index, calculated from Cavallo-Mundlak data (updated in private communication) as follows. The current value of agricultural land is taken as the difference between the capital stock in agriculture with land included and the capital stock with land excluded. This value is divided by a price index for land which consists of the Cavallo and Mundlak land price series. Precipitation, the second fixed input, was measured as millimeters per year for a number of weather stations in the Pampas.

## Estimation and Results

A stochastic structure must be assumed for the equation system (4) in order to estimate the parameters of the profit function. We assume that any deviations of the observed output supply and input demand quantities from their profit-maximizing levels are caused by random errors in optimization, and that these disturbances are additive with zero means and positive semidefinite variance-covariance matrix. This stochastic version of the share equations (4) is estimated using the seemingly unrelated regression technique of Zellner. The system was estimated with the linseed share eliminated; those coefficients are identifiable from the other parameters using the restrictions shown in table 1. The system was estimated with a single iteration because for the iterative method the likelihood function tends to be unstable with a large numbers of parameters as occurs here.[1] In addition, the absence of normality in the errors of the share equations favors the least-squares SUR approach as opposed to the maximum likelihood iterative SUR approach.

The equations were restricted to satisfy the symmetry and homogeneity conditions as shown in table 1. Table 2 presents the parameter esti-

[1] Personal communications from A. R. Gallant; see also Deaton. Their argument is as follows. With many equations and many parameters in the system to be estimated, the first-iteration parameter estimates are likely to fit one of the equations nearly perfectly. Successive iterations will quickly drive the variance-covariance matrix toward singularity, and the likelihood function turns unstable as the determinant of this matrix approaches infinity.

**Table 1. Symmetry and Homogeneity Conditions Imposed**

| | |
|---|---|
| Symmetry | $\beta_{ij} = \beta_{ji};\quad \forall i,j$ |
| | $\beta_{hk} = \beta_{kh};\quad \forall h,k$ |
| | $\beta_{ik} = \beta_{ki};\quad \forall i,k$ |
| Homogeneity in prices | $\sum_{i=1}^{m} \alpha_i + \sum_{h=1}^{n} \alpha_h = 1$ |
| | $\sum_{j=1}^{m} \beta_{ij} + \sum_{k=1}^{n} \beta_{ik} = 0;\quad \forall i = 1, \ldots, m$ |
| | $\sum_{j=1}^{m} \beta_{hj} + \sum_{k=1}^{n} \beta_{hk} = 0;\quad \forall h = 1, \ldots, n$ |
| | $\sum_{j=1}^{m} \beta_{rj} + \sum_{k=1}^{n} \beta_{rk} = 0;\quad \forall r = 1, \ldots, l$ |
| Homogeneity in fixed inputs | $\sum_{r=1}^{l} \beta_{ir} = 0;\quad \forall i = 1, \ldots, m$ |
| | $\sum_{r=1}^{l} \beta_{hr} = 0;\quad \forall h = 1, \ldots, n$ |

**Table 2. Parameter Estimates Restricted for Symmetry and Homogeneity**

| Dependent Variable | Intercept | Price of: Beef | Wheat | Corn | Sunflower | Linseed | Soybean | Sorghum | Capital | Labor | Others | Land | Rain | Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beef | 6.432 | 1.165 | −0.837 | −0.410 | −0.136 | −0.099 | −0.012 | −0.133 | 0.099 | 0.266 | 0.098 | 0.0658 | −0.0093 | −0.057 |
| | (2.51)[a] | (0.344) | (0.217) | (0.115) | (0.093) | (0.068) | (0.040) | (0.069) | (0.291) | (0.171) | (0.086) | (0.122) | (0.179) | (0.089) |
| Wheat | 0.466 | | 1.307 | −0.477 | −0.034 | −0.119 | 0.028 | −0.179 | 0.174 | −0.034 | 0.171 | 0.208 | −0.202 | 0.006 |
| | (1.97) | | (0.206) | (0.087) | (0.066) | (0.040) | (0.037) | (0.043) | (0.233) | (0.130) | (0.069) | (0.094) | (0.140) | (0.071) |
| Corn | −1.446 | | | 0.884 | −0.108 | −0.038 | 0.004 | 0.012 | 0.093 | 0.002 | 0.038 | −0.015 | 0.297 | −0.282 |
| | (0.958) | | | (0.077) | (0.043) | (0.029) | (0.022) | (0.030) | (0.102) | (0.058) | (0.035) | (0.041) | (0.063) | (0.035) |
| Sunflower | −0.983 | | | | 0.279 | 0.038 | −0.009 | 0.006 | −0.091 | 0.037 | 0.016 | 0.033 | −0.045 | 0.012 |
| | (0.656) | | | | (0.044) | (0.024) | (0.015) | (0.025) | (0.074) | (0.048) | (0.024) | (0.031) | (0.046) | (0.024) |
| Linseed | −0.338 | | | | | 0.089 | 0.013 | 0.007 | 0.045 | 0.062 | 0.002 | 0.016 | 0.066 | −0.094 |
| | (0.366) | | | | | (0.029) | (0.010) | (0.023) | (0.037) | (0.030) | (0.014) | (0.016) | (0.022) | (0.031) |
| Soybean | −0.359 | | | | | | 0.050 | 0.010 | −0.059 | −0.009 | −0.017 | 0.021 | −0.045 | 0.024 |
| | (0.326) | | | | | | (0.012) | (0.011) | (.036) | (0.021) | (0.013) | (0.016) | (0.023) | (0.013) |
| Sorghum | −0.153 | | | | | | | 0.240 | −0.007 | 0.004 | 0.041 | −0.046 | 0.030 | 0.016 |
| | (0.373) | | | | | | | (0.034) | (0.038) | (0.033) | (0.017) | (0.018) | (0.024) | (0.014) |
| Capital | −1.050 | | | | | | | | −0.099 | 0.001 | −0.155 | −0.164 | −0.108 | 0.272 |
| | (2.967) | | | | | | | | (0.346) | (0.192) | (0.096) | (0.140) | (0.211) | (0.104) |
| Labor | 0.380 | | | | | | | | | −0.224 | −0.105 | −0.095 | −0.030 | 0.125 |
| | (1.65) | | | | | | | | | (0.115) | (0.054) | (0.079) | (0.118) | (0.059) |
| Others | −1.949 | | | | | | | | | | −0.089 | −0.024 | 0.046 | −0.022 |
| | (0.856) | | | | | | | | | | (0.034) | (0.040) | (0.061) | (0.031) |

Note: Weighted mean square error for system = 1.598 with 297 degrees of freedom.
[a] Standard errors in parentheses.

mates of the restricted model. The table contains a total of ninety-five parameters, twenty of which are significant at the 1% level, twenty-six at the 5% level, and thirty-one at the 10% level. Eight of the ten own-price coefficients are significant at the 1% level. Durbin-Watson statistics for the restricted SUR equations ranged from 1.08 to 2.25, within the 5% levels of significance for forty-one observations and thirteen regressors.

In addition to the imposed properties of symmetry and homogeneity, monotonicity and convexity are additional properties of a profit function that cannot be satisfied globally with the translog function. However, they may hold at the specific data points used in estimating the function. Monotonicity is violated if predicted output shares are negative or predicted input shares are positive. For the restricted SUR estimates, monotonicity is satisfied at the average of the data points, and at 387 of the 410 data points (18 of the 23 negative share predictions occur at data points where the observed data share is zero or less than 0.01). Convexity is violated if own-price elasticities have the wrong sign. This condition is violated by the linseed elasticity of −.08 at the average of the data points, and it is violated at 32 of the 410 data points (19 of which are linseed elasticities).

While the structure of equation (4), as shown in table 2, 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 the effects on the levels of outputs and inputs. The elasticities can be obtained by differentiation of the share equations [see Weaver's 1983 equation (19) for elasticities as functions of estimated parameters and estimated shares]. Table 3 shows own-price and cross-price elasticities calculated in this manner from the table 2 parameter estimates, evaluated at the mean value of shares.

Own-price supply elasticities are between 0.7 and 1.5 except for linseed, which is slightly negative. These elasticities are larger than the 0.1–1.1 levels estimated by Weaver, by Ball, and by Shumway, Saez, and Gottret for similar commodities within the United States using similar methods. Of the twenty-one cross-supply elasticities, fifteen are positive indicating complementary relationships among the commodities. (Ball, Weaver and Antle and Aitah found all cross relationships to be complementary in their studies.) In other words, as the price for a commodity rises, new inputs are drawn into general production (note the input elasticities in response to product prices), causing an increase in the production of other products as well. Given the elasticities in table 3, the elasticity of beef supply in response to a general increase in all output prices is 1.41, compared with 1.42 for wheat; 1.49 for corn; 2.06 for sunflowers; and 0.8, 4.58, and 1.42 for linseed, soybeans, and sorghum, respectively. A general rise in product prices then, if not offset by higher input prices, would induce a relatively elastic response of aggregate output, but it would not affect all commodities equally.

Own-price input demand elasticities for capital, labor, and others are −1.94, −1.03, and −.97, respectively, again indicating a substantial degree of price responsiveness by Argentine producers. These levels are in the same range as those estimated by Ball, by Weaver, and by Antle and Aitah (all of whom used the translog), but are much higher than the −.08 to −.28 range estimated by Shumway, Saez, and Gottret, who used the normalized quadratic. The latter study showed all input cross elasticities to be positive, while the other three studies as well as this one

**Table 3. Estimated Own- and Cross-Price Elasticities**

| Quantity of: | Price of | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Beef | Wheat | Corn | Sunflower | Linseed | Soybean | Sorghum | Capital | Labor | 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 |
| Corn | 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 |
| Soybean | 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 |
| Labor | 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 |

show all of them to be negative, i.e., show inputs to be gross complements. It is useful to note the elasticity of response of a single input to a general increase in all input prices: −2.55 for capital, −2.13 for labor, and −1.56 for others. A general rise in input prices, with output prices constant, would thus tend to reduce the use of capital and labor much more than other inputs.

Finally, output elasticities with respect to input prices are in general negative. The sizes of these elasticities suggest that policies affecting credit and wages will have noticeable effects on output levels as well as input use. Further, the size of input elasticities with respect to beef, wheat, and corn prices suggests that input useage is responsive to output prices and policies that affect output prices.

The effect of technical change on relative levels of input use (bias) is revealed by comparing the time trend coefficients of each input share equation after dividing it by that input share [the terms in equation (6) above]. The estimates of these adjusted share trends (using average values of shares) are −.264 for capital, −.257 for labor, and .078 for others. Thus, technical change was biased most strongly in favor of "other" inputs and most strongly against capital. Expressed in traditional terms of pair-wise biases [equation (6)], the technical change was labor saving relative to others (.335) and capital saving relative to both labor (.007) and others (.342). This ordering of biases is consistent with the induced innovations hypothesis. Average annual price increases between the first and last five-year periods of the data were 6.8% for capital, 1.1% for labor, and 0.7% for others.

## Implications for the Effects of Policies

Relative stagnation of Argentine agriculture may in part result from policies that have raised the producer price of inputs and lowered the producer price of most outputs. In this section we examine the implications of the model for evaluating the impact of various government policies on the mix of outputs and inputs and on levels of production in Argentine agriculture. The relevant policies and their approximate price effects are identified first, and then the estimated coefficients are utilized to estimate their impacts.

### *Estimated Price Effects*

In general, the effect of a policy can be described as a percentage price wedge, that is, the difference between the demand price and the supply price, expressed as a percent of the equilibrium price. We make the assumption in this study that prices are indeed exogenous to the agricultural sector. (Argentina is a small country in the world market for these commodities, and, because agriculture represents but 7%–10% of gross national product (GNP), that sector is a reasonably small user of capital, labor, and "other" inputs.) Therefore, the price wedges created by various policies can be characterized as exogenous price changes for both inputs and outputs. We consider five kinds of policies which have affected prices paid or received by farmers: export taxes, import restrictions, exchange rate controls, domestic taxes, and minimum wages.

Ad valorem export taxes on crop and livestock products have been persistent and significant over the past forty years. Cavallo and Mundlak (pp. 59–60) report an effective average export tax rate of 29% on the entire agricultural sector from 1940 through 1972. Mielke (p. 6, p. 19) reports rates for particular commodities between 1958 and 1982. Based on data reported in these sources, we estimate conservatively that ad valorem export taxes resulted in average wedges of the following sizes: 10% for beef, 15% for soybeans, and 25% for the other crops (table 4).

Imports of machinery, chemicals, and fertilizers have been restricted both by tariff and nontariff barriers, and the restrictions have not been uniformly applied. Therefore, any estimate of the average price wedge imposed must be somewhat arbitrary. We accept Cavallo and Mundlak's estimate (p. 156) that the average tariff was 37%. With infinite elasticity of supply, prices of imported goods would fall by $(1-1/1.37) =$ 26% from actual levels if the tariffs were eliminated. This is a more conservative estimate of the price wedge than suggested by Mielke (who indicates, pp. 6–7, that tariffs alone during much of this period were 60% on machinery, seeds, and fertilizer), or by Sturzenegger (whose estimates, p. 225, of the implicit tariff coefficient for 1960–80 average 1.76).

Reca (1980) and Mielke both cite a World Bank study which estimated that overvaluation of the peso averaged 38% during 1968–74. Cavallo and Mundlak assert that 20% overvaluation is a reasonable estimate for the 1939–73 period. But the more recent World Bank study by Sturzenegger puts the figure at 18% for 1960–80; this estimate is utilized in this study.

Domestic taxes considered here include the value-added tax and social security taxes on la-

**Table 4. Estimated Farm Price Changes Due to Elimination of Policies**

| | Policy Set | | | | |
|---|---|---|---|---|---|
| Commodity | Export Taxes | Import Restrictions | Overvalued Currency | Domestic Taxes | Minimum Wages |
| | (price change in %) | | | | |
| Beef | 10 | 0 | 18 | 0 | 0 |
| Wheat | 25 | 0 | 18 | 0 | 0 |
| Corn | 25 | 0 | 18 | 0 | 0 |
| Sunflower | 25 | 0 | 18 | 0 | 0 |
| Linseed | 25 | 0 | 18 | 0 | 0 |
| Soybean | 15 | 0 | 18 | 0 | 0 |
| Sorghum | 25 | 0 | 18 | 0 | 0 |
| Capital | 0 | −26 | 18 | −18 | 0 |
| Labor | 0 | 0 | 0 | −13 | −10 |
| Others | 0 | −26 | 18 | −18 | 0 |

bor. The value-added tax has been 18% since it was introduced in the late 1970s to replace a number of other business taxes. Because no estimates of these other taxes are available, we assume that they, too, produced an average wedge of 18% on capital and "others" in prior years. Social Security taxes have been about 40% of wages in recent years (Reca 1980, p. 13, Sturzenegger, p. 36). These taxes do not apply to producers and nonsalaried family workers, however, who constituted two-thirds of the farm labor force in 1969 (Banco de Analisis y Computacion). We estimate that their average net effect has been to insert a 13% wedge in farm labor market (one-third of the current level of the tax). Following Reca, we estimate that minimum wages have inserted a 10% wedge in the farm labor market.

Other policies which might have introduced input and output wedges are official support prices and land taxation. After considering discussions of these policies by Reca and Mielke, it is doubtful that these policies have had significant effects on these markets over the forty-year span of our data. Agricultural credit subsidies may have been important, but there is little data on which to evaluate the price-wedge equivalent impact of these policies; thus, they are excluded from the analysis. It is clear that elimination of the policies we do consider would increase output prices and decrease input prices, with grains affected more than beef (beef producers apparently have been more successful than other producers in keeping export taxes low).

### *Predicted Share Effects of Policies*

To evaluate the effect of policy wedges on shares of inputs and outputs, we use equation (4) with the coefficients of table 2 as estimates of coefficients $\alpha$ and $\beta$. The change in the share vector $M$ equals $\beta$ times the change in $d$, with the wedge effects in table 5 being the changes in $d$. The predicted changes in profit shares resulting from elimination of wedges are reported in table 5. Because the profit share changes are difficult to interpret, these results also are presented in terms of revenue and cost share changes (table 6). Grains other than linseed would increase their share of output at the expense of beef. Capital would increase its share of inputs at the expense of labor and other inputs. This latter effect occurs, even though price reductions are about the same for the three inputs because of the relatively greater elasticity of capital and labor in response to all input prices as noted above.

### *Predicted Quantity Effects of Policies*

To predict the effects on the levels of inputs and outputs, we use a simple linear elasticity model similar to (4):

$$(7) \qquad \begin{bmatrix} \delta \ln y \\ \delta \ln x \end{bmatrix} = \Sigma \begin{bmatrix} \delta \ln p \\ \delta \ln r \end{bmatrix},$$

where $\Sigma$ is the $10 \times 10$ matrix of price elasticities from table 3, and the $\delta \ln p$ and $\delta \ln r$ are again the percentage price changes shown in table 4.

Two caveats are in order regarding the use of this linear elasticity model. First, the model assumes that both output and input prices are fixed. Thus, it overestimates quantity responses that would occur if output prices were to fall or input prices were to rise with expansion. Second, equation (7) is a linear approximation at a given point in price-quantity space. As such it over-

**Table 5. Average Profit Shares with and without Policy Interventions**

| | With Interventions (observed ave.) | Without Interventions[a] |
|---|---|---|
| Outputs: | | |
| Beef | 1.17 | 0.69 |
| Wheat | 0.82 | 0.73 |
| Corn | 0.43 | 0.40 |
| Sunflower | 0.14 | 0.19 |
| Linseed | 0.11 | 0.05 |
| Soybean | 0.03 | 0.09 |
| Sorghum | 0.10 | 0.09 |
| Inputs: | | |
| Capital | −1.03 | −0.87 |
| Labor | −0.49 | −0.31 |
| Others | −0.28 | −0.06 |

[a] Predicted from equation (4) and the price changes in table 5 with variables at sample mean.

**Table 6. Average Revenue and Cost Shares with and without Policy Interventions**

| | With Interventions (observed ave.) | Without Interventions[a] |
|---|---|---|
| Outputs: | | |
| Beef | 0.42 | 0.31 |
| Wheat | 0.29 | 0.33 |
| Corn | 0.15 | 0.18 |
| Sunflower | 0.05 | 0.09 |
| Linseed | 0.04 | 0.02 |
| Soybean | 0.01 | 0.04 |
| Sorghum | 0.03 | 0.04 |
| Inputs: | | |
| Capital | 0.57 | 0.70 |
| Labor | 0.27 | 0.25 |
| Others | 0.16 | 0.05 |

[a] Predicted from equation (4) and the price changes in table 5 with variables at sample mean.

estimates the quantity effect of price rises compared to curvilinear supply and demand functions. Despite these limitations, the linear elasticity model is useful in evaluating the relative magnitudes of the effects of various policies.

Trade-related policies (export taxes, import restrictions and currency overvaluation) have been by far the most important distortions affecting agricultural prices (table 4). Elimination of export taxes alone would have increased production from as little as about 15% for beef and linseed to 30% for wheat and corn and nearly 100% for the relatively minor crop of soybeans (table 7). The share-weighted average increase in production would be 27%. Elimination of import restrictions would have about the same overall effect on output (29%) but would have a larger impact on beef. The output effects of exchange rate devaluation would be more modest, ranging from no effect to an increase of 14% for soybeans, with a share-weighted average of 7%.

These estimates tend to corroborate the findings of the Cavallo-Mundlak study, which indicated that the combination of trade liberalization and exchange rate management would have produced increases of 30%–40% in per capita agricultural output over a twenty-year period. We find in addition that eliminating the value-added tax, social security tax, and other input taxes would increase average output by 25%, approximately the same level as for export taxes and import restrictions, with this effect being fairly uniform across commodities. Finally, the impact of eliminating minimum wages in agriculture would increase average output by only 4%.

**Table 7. Estimated Quantity Changes from Elimination of Policies**

| | Policy Set[a] | | | | |
|---|---|---|---|---|---|
| Commodity | Export Taxes | Import Restrictions | Overvalued Currency | Domestic Taxes | Minimum Wages |
| | (quantity change in %) | | | | |
| Beef | 17 | 30 | 5 | 24 | 3 |
| Wheat | 33 | 23 | 10 | 23 | 5 |
| Corn | 34 | 26 | 9 | 24 | 5 |
| Sunflower | 49 | 48 | 4 | 36 | 2 |
| Linseed | 15 | 23 | −2 | 15 | −1 |
| Soybean | 96 | 99 | 14 | 79 | 8 |
| Sorghum | 37 | 25 | 8 | 23 | 4 |
| Weighted output | 27 | 29 | 7 | 25 | 4 |
| Capital | 47 | 54 | 9 | 44 | 5 |
| Labor | 43 | 29 | 18 | 33 | 10 |
| Others | 26 | 38 | 2 | 28 | 1 |
| Weighted input | 43 | 44 | 10 | 38 | 6 |

[a] Predicted from equation (7) and the price changes in table 5 with variables at sample mean.

These increases in outputs are of course created by additional input use as shown in table 7. The ratio of weighted output change to weighted input change is 0.64 for each of the policy effects, a measure of the elasticity of production from variable inputs.

It is tempting to sum the effects of eliminating the various policies, which is technically correct given the linear elasticity model. However, the linear approximation errors referred to earlier would become so significant in the case of such large equilibrium displacements that little confidence could be placed on the quantitative results. The most that can be prudently concluded from this analysis is that the major policies affecting agricultural output are export taxes, import restrictions and domestic taxes, and that any one of these alone could have restricted average output by as much as 25%.

## Conclusions

This study examines Argentine agriculture to determine the possible impact of price-related policies in contributing to the relatively slow rate of growth of agricultural output since 1940. The study estimates a system of seven commodity supply and three input demand equations with a translog profit function specification. The profit function approach was satisfactory with regard to statistical significance and a priori plausibility of coefficients, although it satisfied neither monotonicity nor convexity properties over the entire data set. Estimated supply elasticities were 1.2 for beef, 1.4 for wheat, 1.5 for corn, and 0 to 1.6 for the minor crops. Estimated demand elasticities were −1.9 for capital and −1.0 for both labor and "other" inputs.

The responsiveness of both variable outputs and variable inputs to prices indicates that policies affecting price can have important quantitative effects. The major sets of such policies in Argentina in terms of price effects have been export taxes at 25% (10% for beef), import restrictions at 26% for capital and "other" inputs, currency overvaluation at 18% on tradable items, minimum wages at 10%, and other domestic taxes at 15%. Using the estimated elasticities from our model in a linear elasticity comparative statics framework, the aggregate (share-weighted) output effects of eliminating these sets of policies are 27% for export taxes, 29% for import restrictions, 7% for currency overvaluation, 25% for domestic taxes, and 4% for minimum wages. The approximation errors inherent in the linear model may lead to substantial overestimates at these levels of equilibrium displacement, but the results seem to corroborate the Cavallo and Mundlak conclusion that combined trade and exchange rate policies affected output by 30%–40% over a twenty-year period. In addition, the results show that the combined policies increased the share of beef in output by eleven percentage points, at the expense of crops (other than linseed), and decreased the input share of capital by 13% in favor primarily of nonlabor variable inputs.

If export taxes, import restrictions or domestic taxes had been eliminated between the first and last decades of our study, the resulting 25%–30% increase in production would have translated to an increased annual growth rate from 1.4% to 2.2% per year over the thirty-year interval. Such a growth rate would have been comparable to earlier levels in Argentine agriculture and would have exceeded the rate of growth in U.S. agriculture during the same period. Thus, we conclude that the price effects of various sets of policies in Argentina were sufficient to explain the relatively slow rate of growth of agricultural output.

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