Econometric Analysis of Supply Response and Demand for Basic Grains in El Salvador

A report for Chemonics International and the U S Agency for International Development

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SUMMARY

Basic grains are quite important in the rural economy and in the general population diet of El Salvador In spite of a booming economy in the 1990s, the real prices for basic grains continue to decline to record lows Demand and supply parameters are crucial information for effective policy making aimed at this sector

The major purpose of the study was to provide estimates of the consumer demand and supply response for four basic grains in El Salvador maize, red beans, rice, and sorghum A subsidiary objective was to train personnel of the Ministry of Agriculture and Livestock in the underlying econometric procedures and results Using 1975-97 data, the main findings are

(1) Although basic grain prices have severely dropped in relation to the consumer price index, these prices have *not* dropped in relation to the agricultural wage rate--the main component of the cost of production

(2) The estimated short run (long run) elasticities of area planted with respect to the expected prices are 0 077 (0 251) for maize, 0 136 (0 529) for red beans, 0 222 (0 296) for rice, and 0 269 (0 330) for sorghum

(3) The estimated price elasticities of demand are -0 553 for maize, -0 601 for red beans, -0 530 for rice, and -0 394 for sorghum Except for sorghum, all demands were found to be income inelastic

(4) Technology has played a strong role in increasing the productivity of rice but a rather weak role in the case of red beans

(5) The production of maize and beans are characterized by a high tendency to continue cultivation in spite of changing economic conditions

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Introduction

El Salvador has experienced the most significant advances in economic growth and urban poverty reduction in Central America in the 1990s, although in many respects the rural sector has been left behind Of particular importance to the economic health of the rural sector is the basic grain subsector (maize, beans, rice, and sorghum) because it uses approximately 70% of agricultural land and these grains constitute the staple diet of the Salvadorian population

In spite of the importance of basic grains both in agricultural production and in food consumption, there is lack of knowledge as to how changes in prices and other factors affect their production and consumption Such information is vital for better-informed policy making In particular, the price elasticities of supply and demand are vital components that affect *how much* production and consumption are affected by price policy decisions In addition, these elasticisties determine the welfare impact of pricing policy decisions and the impact of natural disasters such as *El Niño*

The main objective of this study was to develop and estimate a prototype supply-and-demand model to estimate the impact of changes in price and non-price variables across various basic grain subsectors (maize, beans, rice, and sorghum) A second objective was to strengthen the Ministry of Agriculture and Livestock's capacity to analyze past, present and future agricultural policies with respect to basic grains The second objective was accomplished through work with the consultant and through teaching and training modules

Trends in the Market for Basic Grains

Figures 1a-1d show the trends in the producer prices for four basic grains in El Salvador maize, beans, rice, and sorghum in the 1975-97 period Most noticeable is the drastic decline in real prices for all basic grains in El Salvador, as defined by producer prices deflated by the consumer price index This severe deterioration in the terms of trade for basic grains was highlighted in a recent report by the World Bank (1997) that clearly outlines its implications for rural poverty It is also interesting to note that, when deflated by the cost of labor (the main component of the cost of production), the deterioration in terms of trade is not apparent

Figures 2a-2d show the trends in consumption of basic grains and their sources (domestic or foreign) It is not surprising that the decline in real prices has translated into increases in consumption Obviously, imports of basic grains are playing an increasingly important role In fact, El Salvador now accounts for 55% of all imports of basic grains in Central America

FIGURE 1
REAL PRODUCER PRICES 1975-97

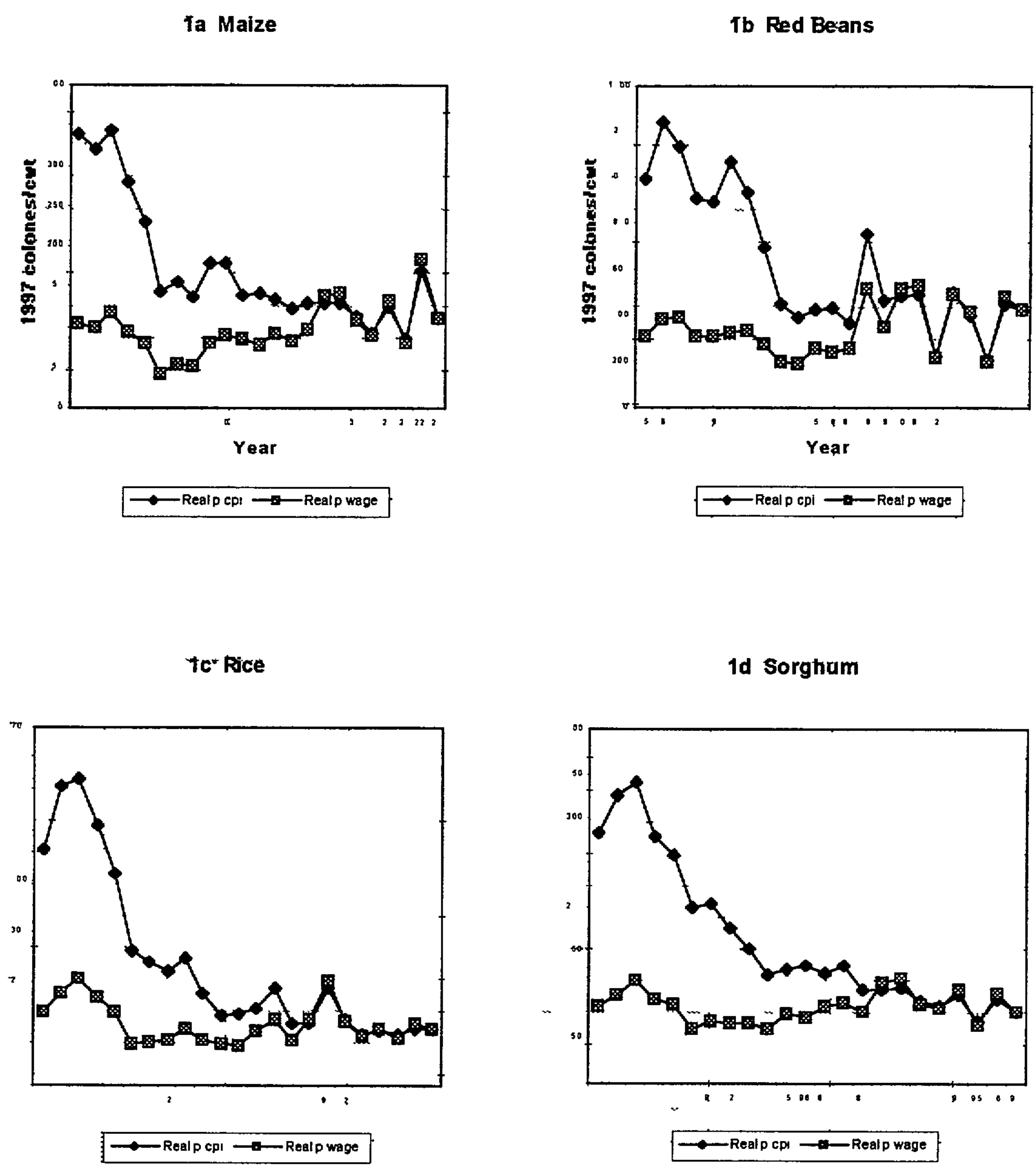
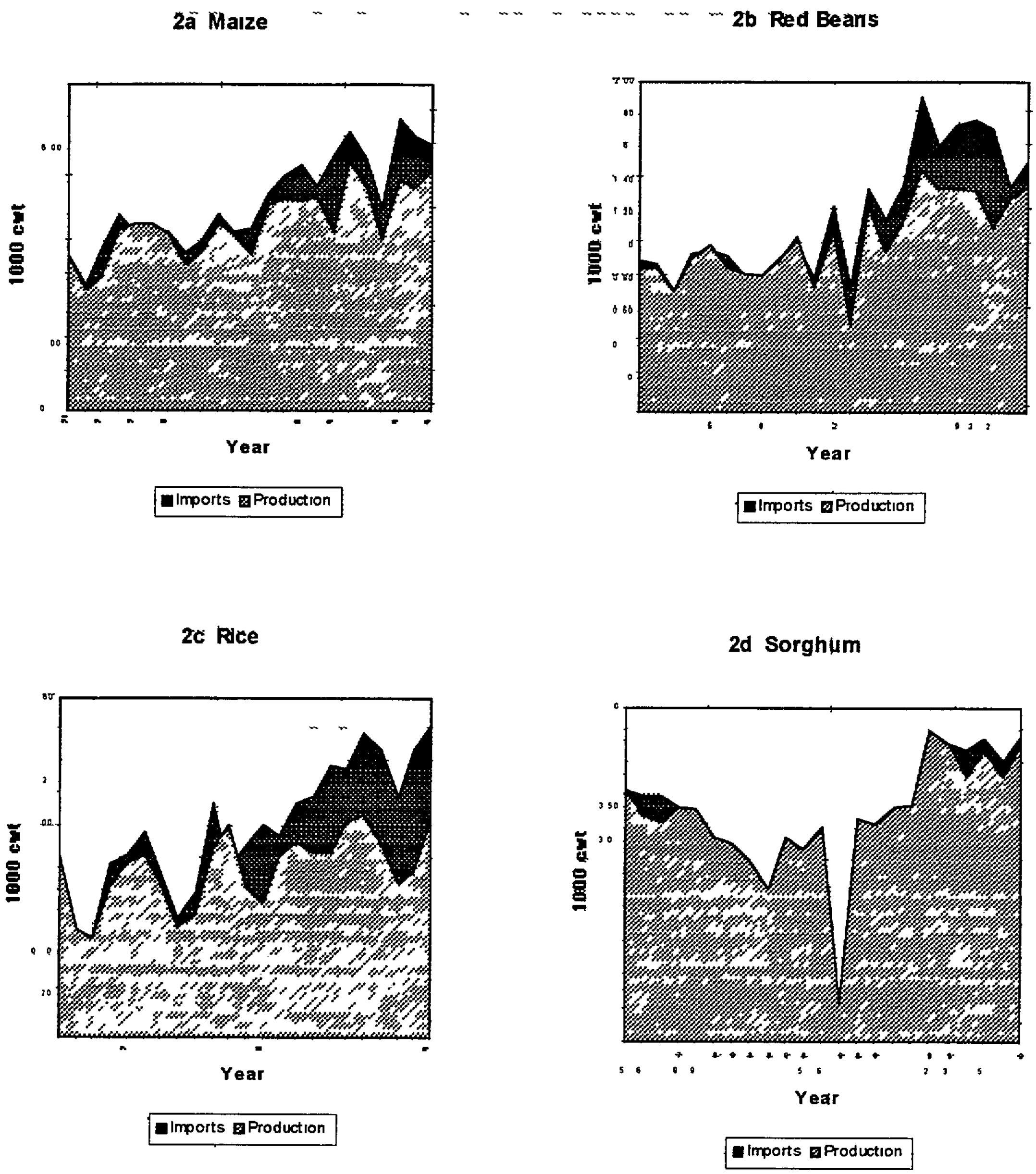


FIGURE 2
PRODUCTION IMPORTS
AND CONSUMPTION, 1975-97



An additional insight is obtained when decomposing production into the area cultivated (*manzanas*) and yield (*cwt per manzana*) Figures 3a-3d show the trends in area planted with the four basic grains It is interesting to note that both maize and beans show an upward trend in area cultivated in spite of the decline in real prices defined with respect to the consumer price index However, both the areas cultivated with rice and sorghum appear to be more random In fact, area cultivated in rice has declined in the 1990s, however, rice cultivation is now more concentrated in irrigated areas Yields are shown in figures 4a-4d The most striking trend is that rice has experienced the greatest gains in productivity while red beans had experienced the lowest

Model Specification

Following conventional specification of market models which include supply response, an econometric model can be specified with three behavioral equations to capture area cultivated, yield, and demand responses, plus an equation that represents market equilibrium The same model is specified for each of the four basic grains

Area Planted

Since basic grain production consists of two components, namely area planted and yield, the supply side of the market is divided into two representative equations The rationale behind this is that different timing and information are used for decisions regarding acreage and yield At planting time, growers do not know with certainty what prices they will receive at harvest time Hence, decisions on how many manzanas to plant must be based on *expected* rather than *actual* output prices

The number of manzanas planted is hypothesized to be a function of the expected price for the basic grain, cost of production, and area planted in the preceding year Since the cost production series reported by Ministry of Agriculture (MAG) (1979-96) was quite incomplete with apparent inconsistencies across the years under study, the wage rate applicable to basic grains was used as an index of these costs This is not an unreasonable substitution since labor accounts for over 40% of the total cost of production and over two-thirds of the variable costs

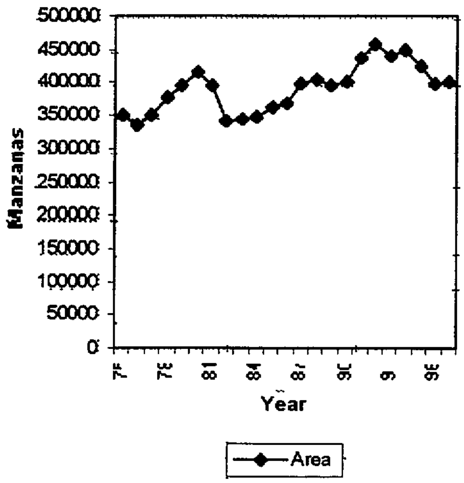
The influence of planted area in the previous year depends on the degree of partial adjustments producers make with respect to changing economic conditions as well as fixity of factors of production and psychological inducements to continue to produce certain basic grains Casual observation suggested a high degree of "tradition" in the cultivation of maize and beans and less inertia in the cultivation of rice and sorghum

Yield Response

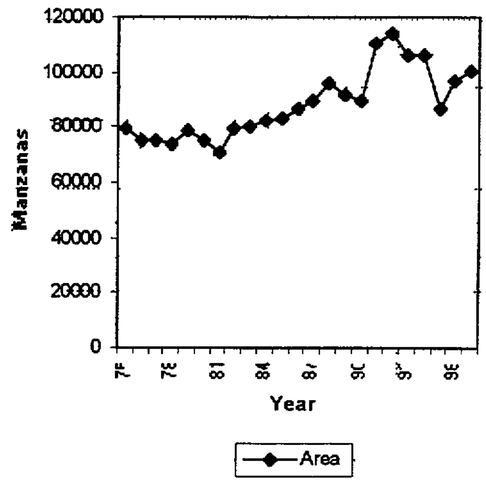
Basic grain yields are mainly affected by weather conditions throughout the production period and technology over the years After consultation with analysts from MAG, it was concluded that unlike some vegetable crops, yields of basic grains are not significantly affected by the

FIGURE 3 AREA PLANTED, 1975-97

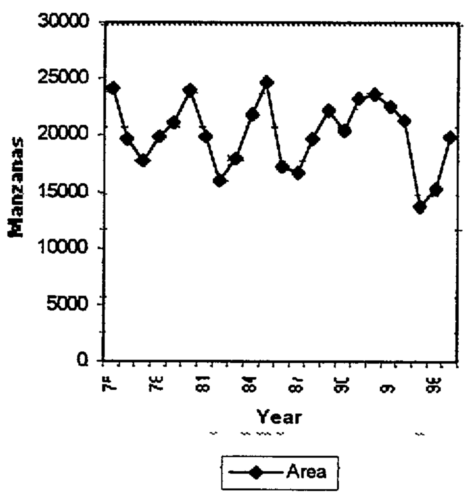
3a Maize



3b Red Beans



3c Rice



3d Sorghum

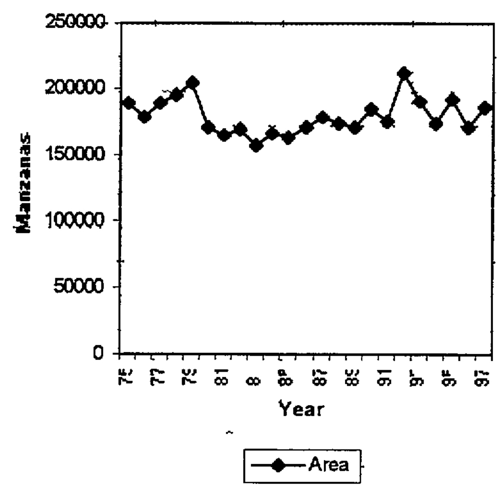
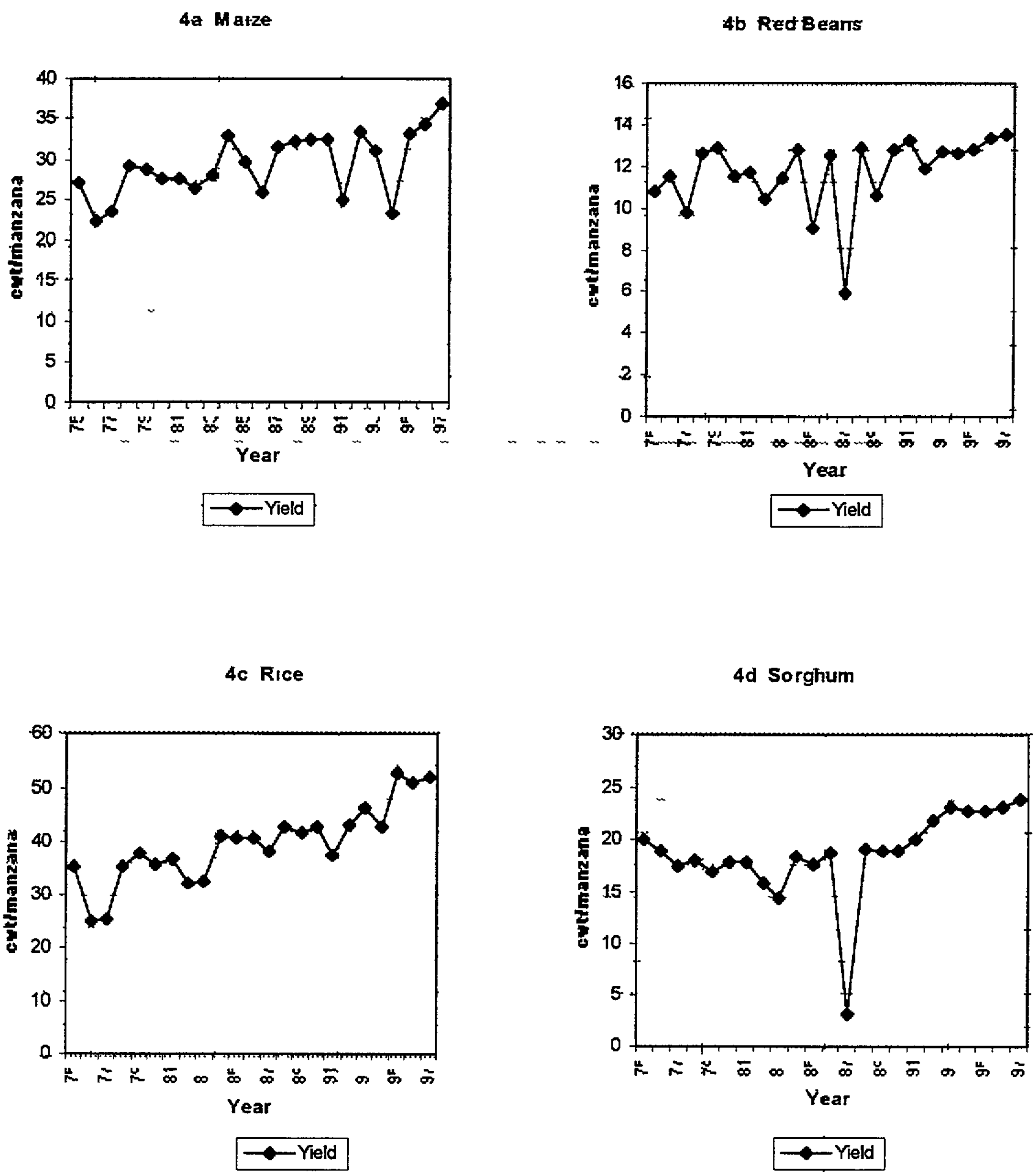


FIGURE 4 YIELDS 1975-97



output price or the price of inputs Once a technology bundle is adopted there is very little farmers can do to intentionally affect yields It is interesting to notice that yield risk caused by weather has diminished in rice production as the fluctuations of yield have been reduced through an increasing proportion of the crop being produced under irrigated lands

Demand

Farm level demand for basic grains is derived from consumers' demand Hence, following consumer choice theory, the quantity demanded of basic grains is stipulated to be a function of their price and consumers' income

The price of substitutes is not included since these grains have a unique place in the Salvadorian diet White maize, which is produced in El Salvador, goes into the production of corn derivatives such as pupusas and tortillas Yellow maize, which goes into animal feed and has other limited industrial uses, it is not a substitute (it is usually imported from the United States) This study is concerned only with white maize Red beans (*frijoles)* do not have a close substitute either Unlike other Central American countries, El Salvador does not have a strong tradition in the consumption of rice Its per capita consumption of rice is about one third of Costa Rica's or Nicaragua's Finally, sorghum (*sorgo* or *maicillo)* is mostly used for livestock feed

Demand can also be specified as being price-dependent instead of quantity dependent In this case, price is assumed to be determined by the quantity supplied into the market (quantity produced plus quantity imported minus quantity exported) and consumers' income This specification is common in perishable commodities such as fresh vegetables or for very short run analysis In preliminary estimation, these types of specification did not perform as well as a quantity dependent or the traditional specification The price flexibilities obtained under price dependent demands are nevertheless reported for comparison purposes, and the implied price elasticities are considered upper bounds of the true elasticities

Price Expectations

Area planted is an *ex ante* decision based on expected rather than actual prices Further, since expected prices are not recorded or observed, hypotheses have to be based on how expectations are formed Typically, agricultural economists have modeled expected output prices as being determined by past prices (Cobweb behavior, distributed lags, and adaptive expectation models) In other words, agents are supposed to react to recent past information in a naive manner—there is no use of current information or room for learning For traditional farmers this can be justified, given the cost of acquiring information Furthermore, a recent study by Ramos, Worman, and Hugo (1993) considered the Cobweb model appropriate for basic grains in El Salvador the price farmers expect is the price they received in the preceding period Nonetheless, such a model did not yield satisfactory results for red beans and sorghum

Alternatively, the Rational Expectations Hypothesis postulates that producers base their expectations on current market information This hypothesis has been applied to agricultural problems by Goodwin and Sheffrin (1982), and Shonkwiler and Emerson (1982) It is conceivable and even plausible that both types of expectations, using historical as well as current information, may take place in the market (Lopez, 1986) In the case of basic grains in El Salvador, it is plausible to assume behavior of a Cobweb type rather than the REH type In this report, both types of price expectation hypotheses were tested based on a model proposed by Lopez (1986) It was determined that the cobweb model was appropriate for maize, rice, and sorghum but that the REH was more suitable for red beans

A Market Model for Basic Grains

The econometric specification of the market model follows directly from the preceding discussion The behavioral equations to capture the above choices, are specified as follows

(1) $\ln A_t = \beta_{10} + \varepsilon \ln(P_t^* / L_t) + \beta_{12} \ln A_{t-1} + U_{1t}$

(2) $\ln Y_t = \beta_{20} + \beta_{21} W_t + \beta_{22} \ln T_t + U_{2t}$

(3) $\ln Q_t^d = \beta_{30} + \eta \ln(P_t / D_t) + \beta_{31} \ln(I_t / D_t) + U_{3t}$

(4) $Q_t^D = (A_t \; Y_t) + M_t - X_t$

where

ln	= natural logarithm operator
t	= year t subscript
A_t	= area of a basic grain planted
P_t^*	= expected price of the basic grain
A_{t-1}	= area planted in the previous year
L_t	= agricultural wage rate
Y_t	= yield per unit of land
W_t	= weather conditions
T_t	= a trend variable
Q_t^D	= quantity demanded
D_t	= the consumer price index
I_t	= consumer income
M_t	= imports
X_t	= exports
β_{ij}, U_{it}	= parameters and error terms

Equations (1) and (2) capture the supply side of the model while equation (3) captures the demand side Equation (4) represents the equilibrium condition where apparent consumption equals shipments from domestic and foreign sources net of exports In the case of El Salvador, imports predominate over exports

Homogeneity of degree zero is imposed in the equation for area planted by deflating the expected price with the agricultural wage rate (labor is the main component of production costs) Homogeneity of degree zero is imposed in the demand equation by dividing the basic grain price and income by the consumer price index The price used is the basic grain price at the producer level Thus, demand is meant to represent a derived demand at that level

Following Lopez (1986), the following model was estimated to determine the nature of price expectations

$$\text{(5)} \quad \ln A_t = \beta_{10} + \beta_{11}\left[\alpha \ln P_t^{reh} + (1-\alpha)\ln P_{t-1} - \ln L_t\right] + \beta_{12}\ln A_{t-1} + u_t$$

where P_{t-1} is the price received in the previous year, P_t^{reh} is the REH price forecasted following McCallum technique (1976), u_t an error term, α is a parameter that weights the relevance of the Cobweb model The test of interest is H_0 $\alpha = 0$ (Cobweb model) With 1975-97 data, one fails to reject this hypothesis at the 95% level of confidence for maize, rice, and sorghum but not for red beans where α was estimated at 0 874 with a t-ratio of 3 452

The Data

For data sources, this report relied primarily on data supplied by the Ministry of Agriculture and Livestock of El Salvador, especially by the Direccion General de Economia Agropecuaria (DGEA) and the Office of Agricultural Policy Analysis (OAPA) Sources also included *International Financial Statistics* of the International Monetary Fund (Gross Domestic Product and the consumer price index), *Politica Agricola* volumes II (by Pleitez) and III (by Ramos, Worman, and Hugo) of the Ministerio de Agricultura y Ganaderia for production, yields, imports and exports, and DGEA's reports on cost of production for the agricultural wage rate Production and trade in the 1990s were obtained from computer files supplied by the DGEA and OAPA Annual observations were collected for the 1975-97 time period

The effect of weather on yields was measured with a Stallings' index First, expected yields for maize, beans, rice, and sorghum were obtained by regressing yield on time and using the predicted values as expected yield Then a weather variable was measured as the ratio of actual to expected yield The four resulting weather variables were correlated and the alternative crop whose weather was the most highly correlated with a given basic grain was chosen in lieu of a grain's own weather variable Red beans and sorghum weather indices were interchanged, as were rice and maize indices to avoid spurious correlation The main advantage of using the Stallings' index instead of direct weather variables is that it is simpler to estimate In addition, this index includes not only the effects of various direct components of weather such as rainfall and temperature, but also indirect effects such as insects, disease, and pests (Stallings, 1960)

Once all variables of the model were operational, the structural model was estimated Ordinary Least Squares were used for equations (1) and (2) since they do not contain endogenous variables as explanatory variables A two-stage least squares (2SLS) technique was used to estimate equation (3) This method was preferred over a three-stage least square technique (3SLS) because it yielded more plausible results, probably because some of the required conditions for 3SLS to be efficient were violated (such as lack of complete specification of one of the equations in the system) All estimations were conducted with the SHAZAM software program The results are presented in Table 1

Results

The estimated coefficients of the structural model are presented in Table 1 In general, the results are plausible and conform to *a priori* expectations of signs and magnitudes

The price elasticisties of supply (as measured by the elasticity of area planted with respect to the expected price) are in the range of previous estimates for El Salvador or similar countries For maize in El Salvador, Ramos, Worman and Hugo (1993) find a short-run elasticity of area of approximately 0 0709 (vs 0 077 in Table 1) For rice, they find a short run price elasticity of 0 259 (vs 0 222 in Table 1) Unlike the results of Ramos, Worman and Hugo (1993), the elasticity for red beans is estimated at 0 136 (vs -0 0257) and for sorghum is estimated at 0 269 (vs 0 017) The implied long run elasticities of supply in Table 1 are 0 251 for maize, 0 529 for beans, 0 296 for rice, and 0 330 for sorghum Sullivan, Wainio, and Roningen (1989) report consensus supply elasticities of 0 22 for maize and 0 58 for rice for the Central American and the Caribbean region (vs 0 251 and 0 296 long run price elasticities in this report)

The price elasticities of demand are approximately -0 553 for maize, -0 601 for beans, -0 530 for rice, and -0 394 for sorghum In other words, the demand is price inelastic reflecting reluctance of consumers to change the quantity purchase in spite of price swings

Initially, the demand model contained lagged consumption as an explanatory variable However, this was only marginally significant in the case of maize In that case, the short run elasticity was estimated at -0 305 while the long run at 0 571, which is close to that reported in Table 1 Except for sorghum, all income elasticities were less than 0 5, reflecting normal but income inelastic goods Finally, the consensus demand elasticisties reported by Sullivan, Wainio, and Roningen for the Central American and Caribbean region are -0 30 for corn (vs -0 553 in Table 1) and -0 65 for rice (vs -0 530 in Table 1)

The magnitude and significance of the lagged area coefficients indicate that both corn and red beans are quite traditional crops with a strong tendency to continue to be cultivated in spite of price/cost conditions On the other hand, as discussed in the graphical analysis, the areas planted with rice and sorghum tend to fluctuate much more Finally, it should be noted that technology (as measured by a trend variable) has played a stronger role in raising rice productivity than in any other basic grain in El Salvador

Table 1 Estimated Parameters for the Market for Basic Grains in El Salvador

Equation	Variable	Parameter	Coefficients (T-Ratios)			
			Maize	Red Beans	Rice	Sorghum
Area	Intercept	β_{10}	3 876	2 606	7 134	9 607
			(3 11)	(2 125)	(4 011)	(5 168)
	$\ln(P_t^* / L_t)$	ε	0 077	0 136	0 222	0 269
			(2 28)	(2 163)	(2 167)	(4 099)
	$\ln A_{t-1}$	β_{11}	0 693	0 7428	0 251	0 184
			(7 16)	(6 652)	(1 407)	(1 896)
		R^2	0 720	0 742	0 215	0 496
Yield	Intercept	β_{20}	-1 774	-1 394	-6 052	-3 992
			(-1 66)	(-1 156)	(-6 375)	(-1 394)
	W_t	β_{21}	0 430	0 686	0 657	2 213
			(3 500)	(6 605)	(4 144)	(6 142)
	$\ln T_t$	β_{22}	1 008	0 708	2 034	1 046
			(4 297)	(2 646)	(9 664)	(1 644)
		R^2	0 577	0 682	0 830	0 635
Demand	Intercept	β_{30}	14 884	13 659	11 211	1 393
			(4 978)	(2 714)	(2 670)	(0 183)
	$\ln(P_t / D_t)$	η	-0 553	-0 601	-0 530	-0 394
			(-4 641)	(-3 275)	(-5 059)	(-1 621)
	$\ln(I_t / D_t)$	β_{31}	0 371	0 356	0 467	1 359
			(1 258)	(0 710)	(1 169)	(1 852)
		R^2	0 534	0 310	0 605	0 138

Notes N=23 (1975-97) The R^2 is the squared correlation coefficient between actual and predicted values The area planted and yield equations were estimated with OLS The demand equations were estimated with 2SLS

Table 2 reports the results of 2SLS estimation for (real) price dependent demand equations Hence, the coefficients are price flexibilities However, one can derive the own-price elasticities by inverting the price flexibility coefficient with respect to total quantity reaching the market The implied price elasticities are -0 817 for maize, -1 117 for beans, -0 600 for rice, and -2 481 for sorghum These coefficients are slightly larger than the direct elasticities for maize and rice (-0 553 and -0 530, respectively), twice as large for beans (-0 530), and six times as large for sorghum These can be considered upper bounds of the true elasticity estimates

The lack of consistency of the results in Tables 1 and 2 also show some of the shortcomings of the proposed model for the case of sorghum This grain is basically used for feed and industrial uses and its modeling should perhaps reflect some important factors capturing this aspect, such as the incorporation of final output prices (e g meats)

Conclusions

Empirical findings show that the area planted with basic grains in El Salvador is mainly affected by the expected price of output, the agricultural wage rate, and partial adjustment as measured by the coefficient of the lagged area planted The short run elasticities of area planted with respect to the expected grain price were approximately 0 077 for maize, 0 136 for beans, 0 222 for rice, and 0 269 for sorghum The implied long run elasticities were 0 251 for maize, 0 529 for red beans, 0 296 for rice, and 0 330 for sorghum The partial adjustment coefficient for both corn and beans confirm that these are "traditional" crops and points out the difficulty of response of these farmers to changing economic conditions The results also confirm that rice has been the only grain with dramatic increases in productivity due to technology

The price elasticities of demand were estimated at approximately -0 553 for maize, -0 601 for beans, -0 530 for rice, and -0 394 for sorghum These results confirm the notion that the demands for these grains are price inelastic From a supplementary model involving price-dependent demands and hence price flexbilities, the implied elasticities were estimated at -0 817 for maize, -1 117 for beans, -0 600 for rice, and -2 481 for sorghum Although these can be considered upper bounds, the results for sorghum seem quite unstable Unlike other basic grains, sorghum is significantly transformed through industrial uses, such as for animal feed Hence, its demand may require a different modeling approach

From these mainly technical results, it is difficult, if not inappropriate, to draw policy recommendations Nonetheless, the results clearly point out that maize and red beans should be in one category of basic grains (i e , traditional) while rice and sorghum represent a different category The results also confirm inelasticies both on the demand and the supply side, indicating the potential for severe price volatility However, an aspect that was not emphasized in the modeling was the explicit role played by international trade This would be one promising future direction of research Finally, with the severe declines in the terms of trade for basic grains in relation to the consumer price index, it is difficult to visualize alleviation of rural poverty if current trends continue Without the significant gains in productivity experienced with rice, an alternative might be to push for high value-added crops (such as vegetables) under appropriate institutional support These issues, however, are beyond the scope of this report

Table 2 Estimated Parameters for the Inverse Demand Functions

Variable	Coefficients (T-Ratios) Maize	Beans	Rice	Sorghum
Intercept	8 046	-0 063	10 323	-20 424
	(1 164)	(-0 008)	(1 073)	(-3 678)
$\ln Q_t^D$	-1 223	-0 895	-1 666	-0 403
	(-4 742)	(-2 986)	(-5 244)	(-1 923)
$\ln(I_t / D_t)$	1 016	1 179	1 093	2 279
	(2 970)	(2 173)	(1 917)	(4 831)
R^2	0 684	0 471	0 705	0 494
Implied Elasticities				
Price	-0 817	-1 117	-0 600	-2 481
Income	0 831	1 317	0 65	5 655

Notes N=23 (1975-97) The dependent variables are the producer prices deflated by the consumer price index These equations were estimated with 2SLS The R^2 is the squared correlation coefficient between actual and predicted values

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