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ENERGY IN DEVELOPING COUNTRIES SERIES

Alcohol Fuels and the Agricultural Sector

William Ramsay
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The views expressed in this paper are those of the authors and should not be interpreted as representing the views of either A.I.D. or Resources for the Future.

INTRODUCTORY NOTE

The need for liquid fuels, especially fuels suitable for internal combustion engines, is of the highest priority for developing areas as well as for the industrial countries. About two-thirds of total commercial energy consumption in developing countries is derived from petroleum and petroleum products. Some of this consumption could be supplied by other fuels, such as coal and wood for generating electricity or providing mechanical energy. But there is at present no practical alternative to liquid fuels in most of the transport sector.

Special attention in this connection has been devoted to alcohols, in particular ethanol or grain alcohol. The technology for grain alcohol production is well developed. In addition, many developing countries already cultivate suitable feedstocks for ethanol, especially sugarcane.

Despite these attractions, biomass ethanol production does not offer a general solution to the energy problems of developing countries. In addition to the practical difficulties in creating successful agro-industry-energy systems, there is the important question of the benefits forgone from the alternative uses of available land and other factors, such as machinery, labor and fertilizer. Nevertheless, in some countries surplus land and other factors do exist. In other countries fuel alcohol could compete successfully with other crops.

Countries considering a fuel alcohol program must examine the trade-offs between using agricultural resources for fuel alcohols or other crops, or, put another way, between continuing to import petroleum and petroleum products and maintaining traditional production. In general, one can predict that the competition of new fuel alcohol programs with other agricultural products will raise prices both for crops and for the economic factors that go into crop production. However, since the interactions between land, labor, and capital and the substitution of some crops for others is quite complex, it is impossible to make firm predictions, and

very difficult even to see the chains of cause and effect that lead to different outcomes.

William Ramsay and John E. Jankowski, Jr. in "Alcohol Fuels and the Agricultural Sector" investigate the effect of an alcohol fuels program on prices and quantities in the agricultural sector of a developing country. A simple computer model is developed that examines new equilibria of agricultural supply and demand as part of a simplified simulation of an agricultural sector. If used with care, this model may shed some light on important policy issues, and should direct the decision maker to the sorts of questions that must be resolved before an alcohol program can be entered with confidence that positive results will follow.

We believe that this "food vs. fuel" problem is an important topic. Therefore, we have sponsored both this paper and other work in this area under the general sponsorship of the ARDEN (AID-RFF Development and ENergy) Cooperative Agreement No. AID/DSAN-CA-0179 with the Office of Energy of the U.S. Agency for International Development. Other related ARDEN work includes two companion papers, "Fuel Alcohol: Some Economic Complexities in Brazil and the United States," by Shafiqul Islam and William Ramsay (RFF Discussion Paper D-73G) and "Foreign Trade Imbalance and the Food Crisis: Anticipated Results of an Aggressive Program of Alcohol Fuel Production in Costa Rica," by R. Celis et al (RFF Discussion Paper D-73H). In addition, another study is in progress on the Brazilian PROALCOOL program and its effects on agriculture.

We issue this report on work in progress with the multiple purposes of informing the policy community of our results, of stimulating research elsewhere, and of eliciting comments on our own efforts.

Milton Russell
Director, Center for
Energy Policy Research

A MODEL FOR INVESTIGATING THE IMPACT OF ALCOHOL FUELS PROGRAMS ON AGRICULTURAL SECTORS IN DEVELOPING NATIONS

Introduction

Biomass fuels are one of the great hopes for the world in trying to get through the difficult transition from fossil fuels in the decades ahead. In many developing areas, they have the special advantage that they may already exist in the form of forest or field crops that can be readily used for energy purposes, or in the form of crop or animal wastes that are also useable. Of special interest is the production of alcohols, either ethanol or methanol, from woody crops or starches and sugars. In particular, the production of ethanol from sugarcane, corn, sweet sorghum, cassava, and other sugar and starch products is a completely commercially feasible process that has been used for millenia to produce beverages.

Because many governments in developing areas are interested in the alcohol fuel option, the effects of alcohol fuel programs on agriculture and on the national economy as a whole are of the utmost importance. The difficulty is that alcohol fuels can be expected to raise other prices all along the line. Prices of land, labor, and capital items (e.g., fertilizer, farm implements, etc.) will all tend to increase as the alcohol program competes with them for scarce inputs. The result will tend to be a rise in the prices of other agricultural commodities and of course a rise in the price of sugar or starch that is itself supplying the alcohol. These pressures of the alcohol program on land use and prices may also prevent governments from carrying out particular types of public policies, such as policies encouraging the growth of export crops or stimulating the cultivation of food crops to feed the local population. These special policy problems could be considered separately; indeed, impacts on foreign exchange, employment, etc., can be very complex (Islam and Ramsay, 1982). However, the problem of rising prices for the agricultural sector as a

whole will form the key piece in the puzzle of all these "food versus fuel" problems. An alcohol program will inevitably show its impacts through price pressures on both producer and consumer goods, and national policy decisions about the program can best judge its impacts through the changing prices in the market.

Models

In order to determine the effect of alcohol fuels programs on the local economy, an economic model of some sort is needed. Various models of agricultural sectors have been used in the past to examine policy decisions. Both linear and nonlinear programming models have been utilized to examine costs of price support measures, land retirement, and other U.S. agriculture policy initiatives (Heady and Hall, 1968). Simulation models of the econometric type have been used to look at agricultural energy production (Tyner and Bottum, 1979). In the context of developing areas, linear programming models have been used recently to predict the effect of alcohol fuels programs on a particular region of Costa Rica (Celis and coauthors, 1982) and of Brazil (Rask and Adams, 1980). In addition, a simulation model of a "perturbed" input-output sort called POLYSIM, has been utilized to predict the effects of alcohol fuels policies on the U.S. agriculture sector (Hertzmark and coauthors, 1980).

For the particular problem faced here, which is to enable energy planners in developing areas to make practical assessments of the effects of alcohol fuels on their economies, it was felt that a particular type of model would be desirable. This model would have to take into account the fact that the effects of large alcohol fuels programs, especially on small countries, could be rather large. Perturbation approaches are only suited to handling small percentages of deviations from a baseline. That is, an alcohol program in the United States, even of about 1 billion gallons of alcohol a year, involves a relatively small percentage of our total corn crop, and therefore can be sensibly treated as a small perturbation of the existing market. However, in other countries, the amount of sugarcane used for new alcohol programs will greatly exceed present sugarcane production, and a perturbation approach is not appropriate. At the same time, the fact that requisite agricultural data are lacking in many areas in developing countries can be taken to support the view that any planning

model should be relatively simple and straightforward, without too many different parameters. Econometric type models necessarily require a great deal of data and therefore would not be so suitable for use with a restricted set of data and parameters. In addition, it is difficult or impossible in such models to trace cause and effect, a connection which might be extremely useful for policy purposes. As far as linear programs are concerned, they are by nature not particularly well designed for handling large non-linear changes. In practice, a small linear programming model will turn out to be very sensitive to choices of parameters. If this over-sensitivity is to be decreased, it is usually only at the cost of adding many more constraint equations and therefore building up a large and expensive model with all its problems and costs. With this in mind, building on earlier work by Hertzmark and others (Hertzmark and coauthors, 1980), we have devised here a simple model of a modified cobweb-type in order to provide relatively quick and straightforward assessment of alcohol fuels programs.

BILYSON model

The model, which is described in more detail in the appendix, is designed to mock up the return to equilibrium of the farm sector under the impact of a government-initiated demand for a sugar or starch crop for alcohol production. The economic model depends on a demand curve of constant elasticity which may, however, be bounded by infinitely elastic segments where a government-imposed floor or ceiling price or both is present. It also assumes a supply curve with at most two segments of constant elasticity, joined at a "kink," in general.[1]

The main thrust of the logic of the program is to add new demand for alcohol feedstock to the system, and then to see how farmers will react to

1. The importance of such supply-demand configurations has been pointed out by Hertzmark (private communication), who also suggested the form of earlier versions of the present model. Hertzmark derived these kinked supply curves on the assumption that early responses to the alcohol program would use more of initially elastic supplies of labor. When labor constraints, however, begin to appear, the supply curve will become more inelastic. However, at even higher prices, more land will become available and, together with the use of more machinery, the supply curve will become more elastic again.

possible higher prices. In general, overproduction or underproduction will tend to result. However, if the discrepancy between projected supply and demand is too great, a new price guess will be determined by the market taking into account what past years' experience has been. The final demand--less stocks--rigorously equals supply as a function of the given demand schedule.

Each annual iteration begins by estimating each crop's demand shift resulting from the addition of government demand for alcohol fuels feedstock to 'normal' market demand. Ex ante demand prices (or preseason 'apparent willingness to pay') are estimated for the entire market (private and government) based on the previous year's end of season prices and demand and the current year's estimated new demand. This price estimate may be constrained by the floor/ceiling prices.

Next, the model calculates the farmers' supply response for each crop. That is, the farmers will produce at a level determined by each crop's supply elasticities, last year's prices and the farmers own anticipated current year's prices--which are themselves weighted averages of last year's prices and this year's implied ex ante prices. The model adjusts for kinked supply curves and the possibility of a priori export estimates being excessive. In the latter case, fulfilling domestic demand is given priority.

If the estimated supply response is perceived as unrealistic, then a different procedure from that described above is used. The model defines a supply response as unrealistic when the difference between supply and demand is one-fifth greater--in absolute terms--than either supply or demand. In such an event, farmers reestimate the current year's crop price by reviewing and averaging previous years' prices and then produce accordingly. This method tends to discourage the cobweb model from "exploding" and is designed to be a truer representation of market responses than the assumption of overly erratic crop market disequilibrium resulting from mechanical and unrealistically short-sighted production decisions.

The differences between the ex ante demand and the ex post supply are calculated. Where possible, excess supply is placed in stock. To the extent to which this is not possible, then the market is assumed to clear the rest of the quality supplied, and the ex post demand is then defined as

equal to the net quantity finally supplied. In this way, the market is forced back into an equilibrium which results in either higher or lower market clearing prices than the ex ante values. The ex post crop prices are then determined by the intersection of the supply and demand schedules at this new equilibrium point.

If the supply of feestock for alcohol fuels that results is less than the amount that the government had set as a quota at the beginning of the year, the actual feedstock crop is divided up between the government and the private markets. The split of supply is determined somewhat arbitrarily by the ratio between the original government quota and the ex ante private market demand for the crop.

The model calculates the future land and yield estimates (i.e. future supply potential) for each crop based on the current season's ex post price equations.

Finally, the model loops to begin the procedure anew until the supply/demand prices responses are calculated for each year.

Model Calculations

Calculations were made with sample data in order to test out the BILYSON model. These data combine real data points with estimates where data are lacking, and are designed to display the features of a "realistic" case. The few calculations carried out do not attempt to adequately model any actual national situations--because of lack of data--but do attempt to give some indication of the kind of policy problems that could be attacked through use of the model.

First, we consider a case analogous to that for an alcohol fuels program in the United States, based on carbohydrates from corn. This case is based loosely on that carried out by Hertzmark and collaborators (Hertzmark and coauthors, 1980) with the POLYSIM model. It assumes the original domestic demand for 4 billion bushels of corn, plus an export demand of two and one half billion bushels, at a price of $2.75 a bushel. It assumes a demand for soybeans at a domestic level of eight hundred million bushels, with additional equivalent export demand of one billion bushels, at a price of $7 a bushel. It also assumes a modest response of supply to changes in prices up to certain price levels and then at a much

greater supply response (see the appendix for details, especially table A-2). It does not consider many things, including the complicated mixture of processes and markets for soybean meal, distillers dried grains, and so on, nor does it consider explicitly lands set aside in the soil bank. Therefore, we do not expect the results to be similar to those of the SERI group. For alcohol programs rising from a small base to three million gallons a year, it predicts rises in the price of corn to the vicinity of $4.36 and a fall in the price of soybeans to $5.78. (These prices will shift from year to year, depending on the exact year chosen, because of poor estimation of this year's market if supply elasticities are high.) This compares to prices of $2.74 for corn and $7.14 for soybeans under the POLYSIM simulation. Since the POLYSIM calculation takes full advantage of idle lands in the soil bank, one expects it to produce lower corn prices than the present model.

Another "realistic" case study has been carried out using in part data from Celis, et al (Celis and coauthors, 1982). Their data are compressed here into six categories: sugar, rice, corn, other grains, fruit and fiber, and pasture. The general idea of the calculations is shown in tables 1 and 2, where the prices, quantities produced, and land used in producing them are shown for the six crop categories, both for the original year and after a number of years of the simulation.

The "realism" of this model is restricted mostly to demand elasticities, price, and amounts of production. There are almost no data in the literature that can be used for supply elasticities. However, the general magnitude of most of the elasticities is based on suggestions by Hertzmark (1982), rising from experience with the POLYSIM calculations for the U.S. case. In addition, the choice of the "moderate" elasticity of 1.80 is inspired by a long-run price elasticity for Egyptian cotton, taken from Zaki (1976). The "larger" elasticity of 3.60 is arbitrarily chosen as twice that of the moderate elasticity. Table 1 shows the similation for the case considered by Celis of four large distilleries (36 million liters each) injected into the economy of the "Dry Pacific" (northeast) section of Costa Rica. This area has at present a relatively small amount of land in sugarcane, about 6,000 hectares out of the total land area considered here of almost 800,000 hectares. The middle column of table 1 shows that for four distilleries the scenario could be met, but only with the ridiculous

Table 1. BILYSON Simulation of Prices, Production, and Land Use for Four 36 Million Liter Distilleries Added to Region ("Realistic" Data for Dry-Pacific Region of Costa Rica)

	Initially*	At end of simulation	
		Unrestricted sugarcane price, moderate elasticity	Sugarcane price lid, higher elasticity
Prices ($/t)			
Sugar	15.00	200.0	50.00
Rice	229.8	255.4	237.4
Corn	96.51	114.8	101.5
Other grain	213.0	236.6	219.1
Fruit & fiber	75.83	81.7	76.66
Pasture	898.3	1019.0	929.3
Production (10^3t)			
Sugar	408.9	2870.7	491.1
Rice	30.9	30.0	30.5
Corn	31.5	30.9	31.3
Other grain	7.22	7.03	7.15
Fruit & fiber	7.34	7.19	7.29
Pasture	249.2	243.2	247.2
Land (10^3ha)			
Sugar	5.91	41.5	7.10
Rice	29.0	28.3	28.8
Corn	14.0	13.7	13.9
Other grain	9.14	8.89	9.06
Fruit & fiber	0.57	0.56	0.57
Pasture	733.5	715.3	727.0
	792.1	808.3	786.4
Cane "Quota" for Alcohol	-0-	2216 x 10^3t	2216 x 10^3t
Percent Quota Met	--	100 percent	21 percent*

* See Appendix Table A-3.

Source: Present study.

result that the price of sugarcane is over $200 per ton--corresponding to a price of $10 a pound for sugar! It is, of course, possible that this result is only an artifact of the model. On the other hand, the result is intuitively reasonable, in the sense that the sugar industry is being asked under this program to expand from a very small initial base up to a production of 4 or 5 times the original supply. Therefore, it may not be wholly unexpected to encounter rather high prices during the process.

Assuming, for the moment, that the model result is realistic, one can examine how to avoid the difficulty. One obvious way out is to have the government set a fixed price ceiling on sugarcane. But if we set the ceiling somewhat arbitrarily at $50 a ton of sugar--corresponding roughly to a price of $2.00 a pound (the last column of table 1), the goals of the program cannot be met. That is, the goals cannot be met if no other intervention takes place in the marketplace. The moral here would be that the price of other commodities, and perhaps of other factors such as land, would have to be controlled in order to produce alcohol at any kind of reasonable price in this type of scenario; or, alternately, that entirely new lands would have to be colonized. It should be stressed that this calculation does assume a rather rapid responsiveness to sugar prices as far as getting more land into production of sugarcane, but still the quota program fails. The problem is that the prices of other crops are driven up, too, making them more attractive to farmers to grow also. Again, under central planning, some constraints could be put on production in such a way as to assure that the norms for the distilleries would be met, but in a free economy, even a rather high guarantee price for sugar cannot do the job alone.

Somewhat different results are shown in table 2 for a rather more modest program of only one distillery of capacity of 36 million liters a year, and assuming again two different supply elasticities. In the second case, cane can be produced at a somewhat lower price than the government lid. But it is seen that even in such cases it is somewhat difficult to derive, from the small base of sugar production with which one starts out, a reasonable price for the amount of sugarcane needed to feed the distilleries.

Naturally, these results depend on the exact parameters chosen as far as supply elasticities are concerned, and on the other land, yield, and

Table 2. BILYSON Simulation of Prices, Production, and Land Use for One 36 Million Liter Distillery Added to Region ("Realistic" data for Dry-Pacific Region of Costa Rica)

	Initially*	At end of simulation	
		Unrestricted sugarcane price, moderate elasticity	Sugarcane price lid, higher elasticity
Prices ($/t)			
Sugar	15.00	62.2	41.12
Rice	229.8	242.7	240.8
Corn	96.51	105.0	104.0
Other grain	213.0	224.0	222.2
Fruit & fiber	75.83	72.0	76.6
Pasture	898.3	953.7	945.4
Production (10^3t)			
Sugar	408.9	1083.1	681.7
Rice	30.9	31.4	30.6
Corn	31.5	32.1	31.3
Other grain	7.22	7.36	7.18
Fruit & fiber	7.34	7.45	7.32
Pasture	249.2	254.0	247.8
Land (10^3ha)			
Sugar	5.91	15.6	9.85
Rice	29.0	29.6	28.9
Corn	14.0	14.3	13.9
Other grain	9.14	9.31	9.08
Fruit & fiber	0.57	0.58	0.57
Pasture	733.5	747.1	728.9
	792.1	816.5	791.2
Cane "Quota" for Alcohol	-0-	554 x 10^3t	554 x 10^3t
Percent Quota Met	--	100 percent	100 percent

* See Appendix Table A-3.

Source: Present study.

price variables assumed. The rather arbitrary nature of the supply elasticities chosen has been stressed above. The exact supply elasticities used are given in the appendix table A-4, but it should be noted that the supply elasticities in table 1 and 2 range, for the region after the supply "kink", from 1.8 to 3.6, usually considered rather large numbers. Limited sensitivity analyses suggest that the results are not very sensitive to the exact values of these supply elasticities chosen.

The results for land in production are also of interest, if only because the program allows new land to be brought into production in line with given supply elasticities, but even though the amount of land for the one case in table 1 for sugarcane climbs from 5910 hectares to 41,500 hectares, the total land in cultivation only rises from 792,000 hectares to 808,000.

It must be pointed out, of course, that the goal of starting with a very small cane base (about 400,000 tons) and taking that up to 1,000,000 or even 2,000,000 tons for an alcohol fuels program is by nature an ambitious undertaking. Countries like Brazil and the Dominican Republic, with much greater sugar industries, could support large alcohol programs with much less proportional change in sugar production. It is evident that in such cases production quotas could be filled at much lower price guarantees.

Conclusion

Alcohol fuels programs in many developing areas have the disadvantage that they may cause undesirable impacts on the national agricultural sector. The key to determining these impacts on the agricultural sector should be reflected in changes in prices of alcohol feedstock crops, other crops, and also all the factors used in agricultural production. The BILYSON program has been designed as a relatively simple model that simulates the changes in supply and demand equilibria under the impact of new quotas for fuel alcohol production introduced into existing agricultural markets. It is possible to test the model with real data on crop prices, production, existing land use, and demand elasticity. Data on supply elasticities are much more difficult to come by, and have been selected on a fairly arbitrary basis here to calculate some "realistic" cases. Despite data difficulties, these "realistic" bases do seem to

follow some intuitive notions of how markets will behave under a stimulus of the fuel alcohol quota kind. The model may perhaps prove useful in policy planning for alcohol fuels programs if sufficient data are available. One advantage of this type of simple model is that it is fast to run, and it is therefore possible to carry out a number of sensitivity analyses, to test the behavior of the results as parameters are varied, such as supply elasticities that are poorly known. Such calculations may be able to give some guidance to policymakers on the practicality of proposed feedstock quotas and on possibilities and problems of market interventions such as establishing fixed prices for certain commodities.

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APPENDIX

Some of the details of the BILYSON program are explained in this appendix.

Table A-1 gives a complete list of all the input variables. These variables are also listed with explanations on the program printout. The output variables, including prices, demands, lands, yields, etc., are explained by notations on the actual program.

The following is a detailed description of the program flow:

Table A-1. BILYSON Model: Input Variables

ILIM	The number of crops considered
IYRS	The number of years of simulation
P3(I,1)	The original price of Crop I
D4(I,1)	The original domestic demand for Crop I
S3(I,1)	The original domestic supply of Crop I
L3(I,1)	The original land devoted to Crop I
Y3(I,1)	The original yield (t/ha) of Crop I
STK(I,1)	The original stock of Crop I
MAXSTK(I)	The maximum stock allowed (if any) of Crop I
PGVT(I)	The ceiling price (if any) of Crop I
FLPC(I)	The floor price (if any) of Crop I
PNWEL(I)	The (price) position of any kink in the supply curve for Crop I
EL1(I,J)	The elasticity of land for Crop I with respect to price of Crop J, to the <u>left</u> of the supply curve kink
EL2(I,J)	(ditto, but to the <u>right</u> of the kink)
EY1(I,J)	The elasticity of yield to Crop I with respect to price of Crop J, to the <u>left</u> of the supply curve kink
EY2(I,J)	(ditto, but to the <u>right</u> of the kink)
ED(I)	The price elasticity of demand of Crop I

Table A-1 (cont'd)

DTR(I)	The fractional yearly increase in demand for Crop I as a result of long-term trends
LTR(I)	(ditto for land under Crop I)
YTR(I)	(ditto for yield per hectare of Crop I)
SI(I,T)	The scheduled imports of Crop I in period T-1 (exports if negative). Note existing baseline reports are SI(I,1).
KNOW(I)	The fractional probability that farmers know what imports (exports) will be of Crop I in future periods
DALK(I,T)	Scheduled additional demand for Crop I in period T-1 to meet needs of alcohol distilleries
ETA	A weighting factor less than or equal to one (0.33 used in tests) giving relative influence of new ex ante price on farmers. 1-ETA ("ETA1") gives relative influence of last year's price.
BLWMAX	An optional limit to the number of times the program will try to improve the results of an exploding cobweb (5 used in tests)
XRED	A factor to reduce exports if they overwhelm production (0.2 will be used if no input made here)

1. Input Stage--the input variables displayed in table A-1 are provided to the program.

2. The long-range trends, due to exogenous factors, for demands, and yield, are factored in to produce a base line for the year to come.

3. The projected demand for a particular crop for use in alcohol production is input.

4. An ex ante price is estimated on the basis of last year's price and demand, projected demand for this year, and the price elasticity of demand.

5. A price perceived by farmers is calculated on the basis of an arbitrary weighing between the ex ante price and last year's price.

6. The response of the farmers in yield and land allocated to the various crops is determined, on the basis between the expected price and

last year's price, taking into account, in general, a possible kink in the supply curve.

7. The total supply is calculated, including stocks, imports (exports), and new production, and adjustments are made in exports plans if necessary.

8. If the projected supply curve represents a wild swing compared to projected demand, the expected price is replaced by a weighted average price over the previous year's. The "wild swing" is defined as happening if a multiple of the difference between projected supply and demand (taken in the program as 5) that exceeds either the value of the supply or demand itself. The program will then recalculate, trying to match supply and demand better, until it is instructed to stop by an iteration limit, or until the new averaging makes things better rather than worse.

9. The total agricultural land is computed.

10. Demand is set equal to supply plus imports (minus exports) except for stocks, when stocks are allowed.

11. The actual export price is determined from the intersection of the supply and demand curves.

12. Plans are made for the new year, as far as yield and land are concerned, on the basis of the ratio of the ex post price to the farmers' initially expected price. The kink in the supply curve is taken into account.

13. If the amounts supplied do not fill the alcohol fuels quota, the supply is split between the quota and the private sector.

14. A new year begins--until the year limit for the similation is reached--and the program begins again at step no. 2 above.

Table A-2 gives the detailed actual inputs to one test case, that for U.S. corn and soybeans.

The test case for the developing areas, based on Costa Rican data, is displayed in the text tables 1 and 2. However, the initial inputs to tables 1 and 2 are given in table A-3. The elasticities used are given in table A-4 below.

Table A-2. U.S. Case: Input Data (cf. Table A-1)

1. Crops and Time Limit: ILIM = 2, IYRS = 8
2. Initial price, domestic demand, domestic supply, land, and yield for Crop I (corn)
   P3(1,1) = $2.75/bu., D4(1,1) = 4.0 billion bu. = S3(1,1), L3(1,) = 0.065 billion acres, Y3(1,1) = 100 bu./acre
3. Initial Stocks and Allowed Stocks (STK(I,1) = 0
   MAXSTK(1) = 0.0
4. Ceiling price PVGVT(1) = $999999.99/bu. ("infinite")
   floor price $2/bu., the kink in the supply curve comes at $4/bu.
5. The two direct elasticities are EL1(1,1) = 0.15 and EL2(1,1) = 0.84. The cross elasticities are EL1(1,2) = -0.09, EL2(1,2) = -0.27. (The yield elasticities are taken as zero), the price elasticity is -0.42.
6. The long-range trends are taken as 0.005, 0.015, and -0.008.
7. Exports every year are taken as 2.5 billion bu. The farmers are assumed to know perfectly what they are (KNOW(1) = 1.).
8. The initial variables for Crop II (soybeans) are P3(2,1) = $7/bu., D4(2,1) = 0.8 billion bu. = S3(2,1), L3(2,1) = 0.06 billion acres, Y3(2,1) = 30 bu./acro.
9. Initial Stocks and maximum stocks are set = 0.
10. Ceiling price is "infinite." Also, floor price FLPC(2) = $5/bu., the supply curve kink comes at PNWEL(2) = $7.40.
11. The two direct elasticities are -0.15 and -0.45, with the cross elasticities of 0.25 and 0.75. Again, all elasticity is subsumed under land rather than yield.
12. The long-range trends are taken to be DTR(2) = -0.01, LTR(2) = -0.015, YTR(2) = 0.02.
13. Exports are taken each year to be 1 billion bushels, and farmers know what they are.
14. The farmers give the <u>ex ante</u> price a weight of 0.33, compared to 0.67 for last year's export price.

    The "blow" routine is allowed 5 chances to reaverage expected prices every year (BLWMAX = 5).

Table A-3. Parameters for Costa Rican Model

	1. Areas[f] (10^3ha)	2. Volume[g] 10^3t [or animals]	3. Recovery[h] factor	4 = 2. x 3. Net volume 10^3t	5. Price $/t[o]	6. = 4/1 Yield net t/ha	7. Demand elasticity
1. Sugar cane	5.91	413.00	0.99	408.87	15.00[l]	69.2	-0.29[i]
2. Rice	29.05	50.97	0.6063	30.90	229.8	1.06	-0.38
3. Corn	14.00	33.16	0.95	31.50	96.51	2.25	-0.17
4. Other grains[m]	9.14	7.56	0.955	7.220	213.0[a]	0.790	0.35[j]
5. Fruit and fiber[n]	0.57	8.67	0.847[a]	7.343	75.83[b]	12.9	-0.29[j]
6. Pasture	733.51	790.46M[c] 14.28L	0.225[d] 5.	249.25	898.3[e]	0.340	-0.27[k]

Notes:
[a]Weighted by volume.
[b]Weighted by volume, cotton price from Celis 1980 table 4.13.
[c]781.84 meat (M), 5.66 milk (L) with 17.23 "D.P." split proportionately, in animals.
[d]In tons/animal, at 45 percent of 500 kg annual (lean) usable meat, 5t milk year as 2/3 of U.S.
[e]At 1196.86 $/tM, 154 70 $/t L, and proportional to volume (Celis, 1980, table 4.13).
[f]Celis, 1982, table 14.
[g]Celis, 1982, table 15.
[h]Celis, 1980, table 4.10.
[i]Celis, 1980 table 4.13, weighted between refined sugar and "panela" by volume.
[j]Celis, 1980, table 4.13, weighted by volume in Celis, 1982, table 15, exc. cotton, no data.
[k]Celis, 1980, table 4.13, weighted by 177.85M and 71.4L used in column 4 calculation.
[l]Villasuso, pers, comm.
[m]Sorghum and beans.
[n]Plantan, oranges, cotton.
[o]Celis, 1982, table 16.

Table A-4. Costa Rican Data: Land Elasticities Adopted with Respect to Price
EL1(I,J) (Upper Entry) and EL2(I,J) (Lower Entry)

I \ J	1	2	3	4	5	6
1	0.15	-0.01	-0.01	-0.01	-0.01	-0.02
	1.80[a]	-0.02	-0.02	-0.02	-0.015	-0.04
2	-0.01	0.10	-0.01	-0.01	-0.01	-0.01
	-0.01	0.10	-0.01	-0.01	-0.01	-0.01
3	-0.01	-0.01	0.10	-0.01	-0.01	-0.01
	-0.01	-0.01	0.10	-0.01	-0.01	-0.01
4	-0.01	-0.01	-0.01	0.10	-0.01	-0.01
	-0.01	-0.01	-0.01	0.10	-0.01	-0.01
5	-0.01	-0.01	-0.01	-0.01	0.15	-0.02
	-0.01	-0.01	-0.01	-0.01	0.20	-0.02
6	-0.01	-0.01	-0.01	-0.01	-0.01	0.10
	-0.01	-0.01	-0.01	-0.01	-0.01	0.20

[a] 1.80 for EL2(1,1) is listed as "moderate" in the text. The value 3.60 is used as "larger".

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