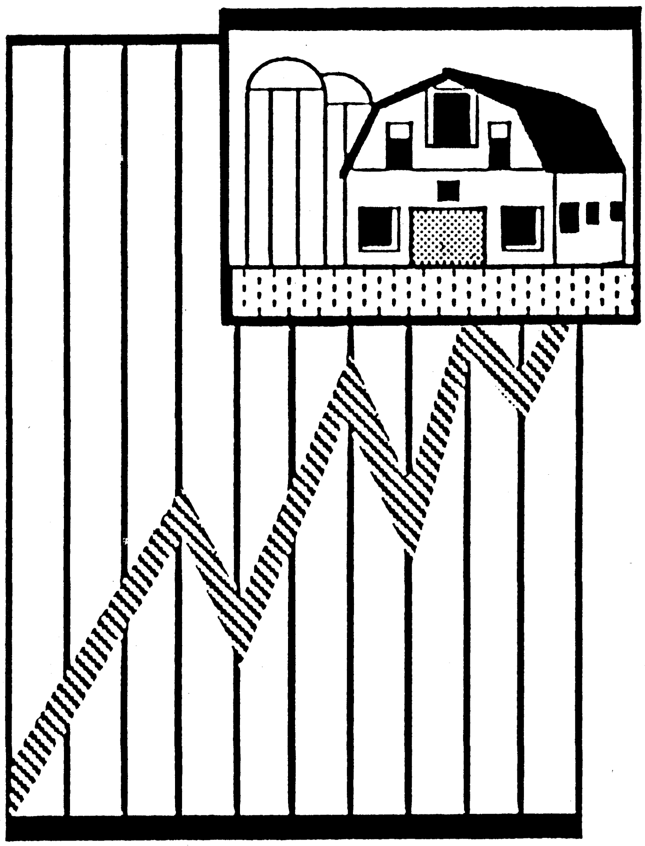
The Potential Role of Fuel Ethanol to Expand Corn Use and Farm Income in a "Second Best" Market

Norman Rask, Luther Tweeten, and Mario J. Miranda



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by

NORMAN RASK, LUTHER TWEETEN,
and MARIO J. MIRANDA

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Norman Rask is Professor, Luther Tweeten is Professor, and Mario J. Miranda is Assistant Professor in the Department of Agricultural Economics and Rural Sociology, The Ohio State University, Columbus. *Comments of Carl R. Zulauf and Donald W. Larson are much appreciated.*

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Introduction

In a world of well-functioning markets without externalities or government interventions, U.S. ethanol production from grains cannot compete with petroleum based fuels at 1989 prices. Sugarcane based ethanol (Brazil) is lower cost but still not competitive in the U.S. automotive fuel market at current oil prices. To ensure domestic production and use of corn based ethanol in this unfavorable economic setting, an elaborate set of production and use incentives and import disincentives has been created. These incentives have fostered the development of a small but significant fuel ethanol industry in the U.S.

The original and main objective of the fuel ethanol program was to increase energy independence. A secondary objective was to raise farmer income. Corn producer organizations strongly support continuation and expansion of the ethanol program. Because of the modest size of the program, (800 million gallons per year) benefits for the farm sector from the current ethanol program are small. The phaseout of lead (octane additive) and concerns over meeting Clean Air Act emission requirements are creating a growing potential premium market for ethanol which could increase demand, raise price, and thus lower needed subsidy levels.

Future tax, supply, and price changes for imported petroleum may also reduce the subsidy support level necessary to make ethanol competitive in the automotive fuel market. A related opportunity is that Brazil with a comparative advantage in ethanol production from sugarcane and a comparative disadvantage in corn production presents an alternative growth market for corn through potential bilateral trade agreements in corn and ethanol.

In the U.S. agricultural sector, the government, through the political process, has chosen to intervene to support farm income through various instruments influencing supply and demand. Given that neither free markets nor mandatory supply control appear to be politically acceptable for major farm commodities, the government is likely to continue to rely on voluntary acreage diversion programs to maintain farm income. The government also is likely to continue to stimulate demand for farm output through domestic food subsidies such as food stamps, export subsidies and commercial subsidies such as tax exemptions for ethanol.

These instruments to control supply and expand demand are not equally cost-effective in use of government outlays to raise farm income. Also, one instrument may be cost effective within a range of farm income support but not be cost-effective at the margin. The need to diminish budget deficits creates a premium on raising farm income at minimum Treasury cost.

At issue is what set of policies are most cost effective in enhancing farm income and under what circumstances will Treasury costs from intervention to maintain farm income be less by converting grains into fuel ethanol (or by trading grains for Brazilian ethanol) than by paying farmers not to produce or by some other means to maintain farm income. This is the concept explored in this paper and the subject of a proposed research program.

A brief overview of the U.S. ethanol program is presented first including a description of the ethanol incentive policies, cost of production from grains, and a summary of early studies on the estimated farm income gains from corn ethanol production. This is followed by a discussion of the potential premium market for ethanol as an octane enhancer. Next, a comparative production cost analyses is presented for corn, sugarcane and ethanol in Brazil and the U.S. -- including total costs of accessing each country's markets. This is followed by a description of U.S. farm income support programs. In the final section, a research agenda is outlined to investigate the feasibility of a joint agriculture - ethanol minimum Treasury cost program to maintain farm income.

U.S. Ethanol Program

The U.S. ethanol program was initiated in 1978 with passage of the national Energy Tax Act (PL-618) which granted a four cent per gallon federal excise tax exemption until October 1, 1985 for gasoline containing 10 percent ethanol made from biomass. The federal excise tax exemption was later raised to six cents per gallon and extended to 1993. Other benefits to the ethanol program have included grants for feasibility studies, investment and other income tax credits, grants of grain from Government stocks, participation by alcohol production in the crude oil entitlements program, direct loans, and loan guarantees (1, pg 1).

The six cent tax exemption on a 10 percent blend translates to a 60 cent subsidy per gallon of ethanol. Companion tax exemptions in a number of states raised the effective subsidy level on ethanol to about 80 cents per gallon or more during much of the 1980's. In 1985 for example, the federal subsidies totalled about $500 million and state subsidies $302.5 million (2, pg 70). These subsidies were granted to ethanol sales of 793,000 gallons, a subsidy level of more than $1.00 per gallon. In recent years, the overall level of state tax exemption has been reduced gradually as some states have eliminated or reduced support for ethanol programs.

Domestic ethanol production and use grew rapidly during the early 1980's but growth has slowed since 1985 as gasoline prices declined and political support, both state and federal, was less apparent. Also, the nearness of the 1993 cutoff for federal subsidy support along with low ethanol prices has discouraged new production initiatives.

To exclude less expensive imported ethanol from the federal tax subsidy, a compensating 60 cents per gallon tariff is levied against imported ethanol. Imports were a small but significant ethanol supply source during the early 1980's, reaching about 100 million gallons in 1985 or about 12 percent of total supply. Subsequent U.S. price declines coupled with growing domestic needs within the Brazilian economy where over 90 percent of all new cars have pure ethanol engines have reduced imports to negligible levels in recent years.

Cost of Production

High and uncertain costs of production which necessitated the government subsidy program have continued to limit growth of the ethanol industry.

Determining an accurate cost profile for the corn ethanol industry is a difficult task. The industry has three principal components: the corn feed stock which accounts for over one-half of the production costs, processing the corn into ethanol including the drying of the feed by-products, and the credit to the production process from selling by-product feeds. From an agricultural industry perspective, the by-product feeds dampen the market for protein feeds such as soybean oil meal.

The price of corn is determined in the international feed market and is subject to substantial price fluctuations depending on weather and other supply and demand conditions throughout the world. Processing costs are more stable but vary by plant size, processing energy source and cost, and alternative and complementary uses such a corn sweetener production. By-product credits are in part related to corn price through the feed market but, by increasing the total feed supply, by-product sales limit considerably the anticipated corn price increase from expanded corn use. This occurs principally through the impact on soybean demand and price and thus on the farm level decision to release soybean acreage to corn production. Estimates have shown that this substitution of corn for soybean acreage can exceed 80 percent in some situations (3, pg 9).

When each of these factors is taken into account, a wide range of production costs are possible. Cost estimates for major ethanol production facilities in recent years range from $1.20 to $1.60 per gallon depending on price of corn. The Economic Research Service of the U.S.D.A. estimates that over the past six years an average cost of production in the U.S. was about $1.36 per gallon (4, 1, pg 7). With current corn prices near $3.00 per bushel, ethanol production costs have risen to about $1.45 per gallon (5, pg 4).

Impact on Agriculture, Government Program Costs and Consumers

Only a few studies have attempted to evaluate the overall economic impact of the ethanol program. No studies have incorporated the possibility of bilateral trade in corn and ethanol. The results of these studies confirm that ethanol programs raise farm income, especially corn farmers' income, but they come to somewhat different conclusions concerning the impact on overall Government costs.

ERS studied the total costs and benefits of a projected 10-year domestic ethanol program using corn as the ethanol feedstock and assuming production levels of 595 million gallons in 1985 and rising steadily to 1,058 million gallons by 1995. The results of their analysis were summarized as follows:

> While additional ethanol production would benefit farmers and offers an opportunity to reduce some Government program costs, these gains must be paid for by large subsidies to ethanol producers and higher consumer food prices. This analysis suggests that ethanol production is a very costly proposition in the United States. Ethanol production has little effect on total Government costs. Its major benefit is higher net farm income. But increases in consumer food expenditures caused by additional ethanol production far exceed the increases in farm income. Consumers would be better off if they burned straight gasoline in their automobiles and paid a direct cash subsidy to farmers in the amount that net farm income would be increased by ethanol production. (6, pg 38).

A second study by the National Advisory Panel on Cost-Effectiveness of Fuel Ethanol Production estimated the impact of a six-year ethanol program that increased from 850 million gallons in 1987/88 to 1,700 million gallons by 1992/93. The analysis did not include consumer impacts but did measure projected changes in farm income and Government program costs. Summary statements from the analysis are as follows:

> The major impact of increased ethanol production will be felt in the corn sub-sector. --- ethanol production is projected to increase farm net cash receipts from corn by a total of more than $1.2 billion over the next 6 years --- relative to the baseline.
>
> Savings on federal agricultural program outlays provide an important offset for costs incurred in encouraging ethanol production. Net federal outlays, including both reductions in farm program costs and additional ethanol excise tax exemption costs, are reduced by roughly $1 billion over 6 years. (7, pg 3-28/29)

Note that both studies report positive results for enhancing farm income through increased ethanol production but arrive at contradictory conclusions concerning the impact of the ethanol program on total costs.

The Premium Octane Market

To date, ethanol has made only limited inroads in the gasoline octane market. Reasons accounting for this failure include cost, supply uncertainty, refinery resistance, and incompatibility with refinery and pipeline systems. The market price of ethanol has been adversely affected because its value as an octane source would be $0.20-$0.30 per gallon greater than its value as a gasoline substitute. Primary use of ethanol as an octane source, of course, would improve substantially the economic analyses reported above.

Several changes in the past few years hold out some promise for a greater role for ethanol in meeting future octane pool requirements, and thus improving the economic justification for an ethanol industry. These include the phaseout of lead as the principal octane additive, a gradual increase in the octane pool requirement as average octane needs rise, problems in meeting the Clean Air Act emission requirements, and the development of ETBE as an ethanol based octane additive that can be incorporated within refinery and pipeline systems. ETBE is an especially encouraging development because it can compete directly with methanol based MTBE which has captured most of the octane market void created by the elimination of lead (1, 8, 9, 10). Finally, recent research indicates that the efficiency in converting biomass into ethanol can be raised from the current 47 percent to a potential 95 percent (11, pg B1).

These developments are important for several reasons. First, they draw the major refineries into the ethanol market, creating a more dependable demand structure. Secondly, this move is reinforced by regulations mandating the use of oxygenate fuels in specific geographical settings. Finally, the market will pay a higher value for these premium ethanol uses, reducing the required subsidy level. For example, Rask and Ahmed estimate that overall ethanol subsidies could be reduced from $0.80 to about $0.45 to $0.60 per gallon if ethanol were priced at its octane enhancing value (8, pg 7). The possibility of primary use of ethanol as an octane source has not been incorporated in the economic analyses reported earlier, but will be included in the research proposed below.

Bilateral Trade in Corn and Ethanol

Corn and ethanol markets in Brazil and the U.S. present a striking comparison in terms of costs of production and market value, especially when the premium U.S. octane market is considered. Basically, Brazil has a low cost, low value ethanol market while the U.S. has a high cost, high value ethanol market. In contrast, corn markets are just the opposite (Table 1).

Brazil uses most of it's ethanol as a pure fuel, where its value per gallon is only about 75 percent that of gasoline. In the U.S. octane market, however, ethanol as noted above will have a value 20-30 percent greater than gasoline. Thus, by simply moving ethanol from Brazil to the U.S. (at a cost of about $0.15 per gallon) its market value can be increased by two-thirds.

Table 1. Estimated Costs of Producing and Marketing Corn, Wheat, Soybeans, and Ethanol - Brazil and United States - 1986.

Cost	Corn	Wheat	Soybeans	Ethanol
	-----------($.MT)-----------			($/Liter)
Brazil				
Farm (Distillery)	$148	$303	$198	$.206
Santos (FOB)	186	344	242	.211
New Orleans (CIF)	202	360	258	.248
Tokyo (CIF)	220	378	276	--
U.S.A.				
Farm (Distillery)	$119	$159	$243	$.346
New Orleans (FOB)	144	190	268	.359
Santos (CIF)	160	206	284	.396
Tokyo (CIF)	170	216	294	--

Source: 12

Ethanol costs of production from corn (U.S.) are about 70 percent greater than from sugar cane (Brazil). This means that Brazilian ethanol can be shipped to the U.S. and compete effectively in the U.S. octane market when petroleum prices reach $26 per barrel (Figure 1). U.S. ethanol will be competitive (without subsidy) only when petroleum prices are above $40 per barrel. Market prices are unlikely to reach that level in the foreseeable future but a tax on petroleum imports or gasoline at the pump would increase the likelihood of reaching that level.

The U.S. has a cost advantage in the production of corn and can access Brazilian ports at less cost than Brazil can move corn from interior production regions to the ports (Table 1). Thus, the U.S. is a lower cost corn supplier than is domestic Brazilian production for most corn deficit areas in Brazil. Brazil is normally self-sufficient in the production of corn but has been an occasional importer of U.S. corn. With an expanding livestock industry, Brazilian corn needs are expected to grow substantially in the future.

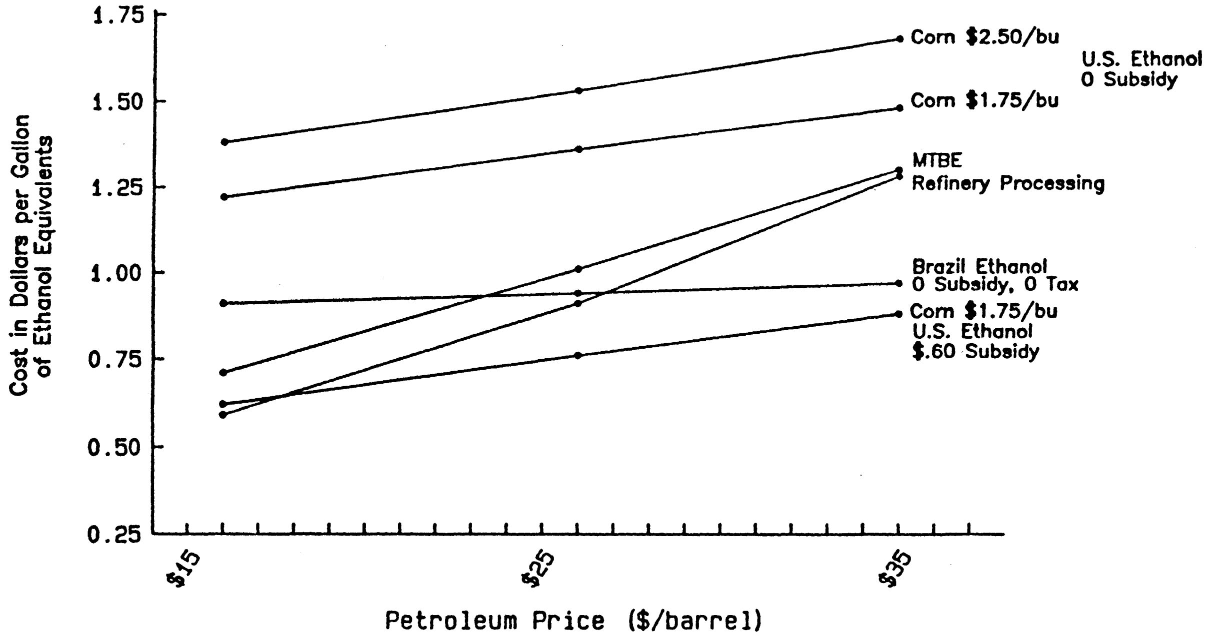

Figure 1. Costs of Alternative Octane Sources to U.S. Refineries at Current Capacities - 1987.
Source: 12

As noted earlier, Brazil supplied up to 100 million gallons of ethanol annually to the U.S. in the early 1980's when oil prices were higher, while paying an import duty equivalent to the U.S. federal subsidy. A supplementary issue in the proposed research is whether a bilateral agreement to trade specified quantities of corn and ethanol would enhance U.S. farm income without increasing Treasury costs.

Farm Income Support Programs

Since 1933 the federal government has committed itself to maintain farm income, especially grain producers' income. The principal means used to maintain income has been acreage diversion but other means have been employed including stock accumulation, direct payments, and demand expansion. Ethanol production is one form of demand expansion. At a federal subsidy of approximately one-half billion per year in the mid-1980s, it was dwarfed by other farm income support programs costing the Treasury over $20 billion in some years.

As noted earlier, the various types of commodity programs are not equally cost-effective in making limited government funds go far to enhance farm income. Direct payments to producers raise farm income approximately $1 for each Treasury dollar spent. Stock *accumulation* raises farm income but stock *depletion* depresses income, hence on average stock policy outlays while reducing variability do little to raise average farm income over time. Acreage reduction programs have a dual impact on farm income: (1) diversion payments plus (2) farm receipts enhanced by lesser output pressing an inelastic demand. Slippage in diversion programs is very large from diverting inferior land, application of more inputs on nondiverted acres, and other sources. Consequently, acreage reduction payments that in theory should raise farm income $4 per Treasury dollar in fact raise farm income only $1.50 to $2.00 (14, pg. 493).

Demand expansion through ethanol production has several advantages in addition to raising farm income. First, it avoids the obvious subsidy of direct payments and the objections of producers who feel less than comfortable about receiving acreage diversion payments "to not produce". Ethanol also has the advantage of octane and environmental enhancement noted earlier. However, while previous studies have confirmed that using corn for ethanol production does raise farm income, especially corn farmers' income, they come to somewhat different conclusions concerning the impact of overall government and consumer costs. At issue is under what circumstances ethanol can be cost-effective compared to other income enhancement measures and, if it is not, do the nonpecuniary advantages of ethanol production compensate.

The attractiveness of ethanol production is in part a function of the degree of excess production capacity defined as farm production in excess of what the market will absorb at politically acceptable prices. Excess capacity averaged approximately 5 percent of normal (weather adjusted) production in the 1960s and 1980s (15, pg. 12). Excess capacity currently is lower, making ethanol production as a "commodity program" less feasible. Obviously, the degree of expected future excess capacity is a factor to consider in determining the feasibility of ethanol production.

A Research Agenda

A major objective of this analysis is to determine under what circumstances of production capacity, farm income support, petroleum prices, and technical constraints ethanol production becomes a cost-effective instrument for government to maintain net farm income above that of a free market. Specifically, the model outlined in the Appendix is designed to determine the optimal mix of acreage diversion, direct deficiency payment, export subsidy, and ethanol subsidy programs that minimize government cost of holding net farm income from feed grain and soybeans at a prescribed level. Alternatively, the problem could be stated as enhancing income of corn and soybean producers with an optimal combination of public programs subject to a Treasury budget constraint. Food aid programs for domestic consumers (food stamps) and for foreign consumers (PL 480) are not assumed to be influenced by the ethanol program.

Figure 2 illustrates some possible policy options for raising income of feed producers given domestic supply of feed S, domestic demand for livestock feed D_F (here assumed to be perfectly inelastic), and demand for ethanol D_E added horizontally to D_F. In the absence of market intervention, total demand $D_F aD_E$ intersects S at market price p and quantity q of which q_F is for feed use and q-q_F is for ethanol production. Gross revenue is pq and net revenue is area 7+8+9 if the area beneath S is total variable cost.

Suppose this net farm revenue is deemed by the political process to be too low. One option is for the government to use a paid diversion program to raise the market price to p_1 by paying producers rent 2+3+7 equal to the difference between the cost of production and the market price to reduce what would have been production at q_1 to the lower quantity q_F. Gross revenue then is $p_1 q_F$ plus 2+3+7. Compared to the free market outcome, net revenue is increased by area 1 from the domestic market plus 2+3 from diversion payments plus production cost savings of area 6+11. Net income would be even higher to the extent that government pays more than the minimum (area 2+3+7) required to induce producers to cut production to q_F.

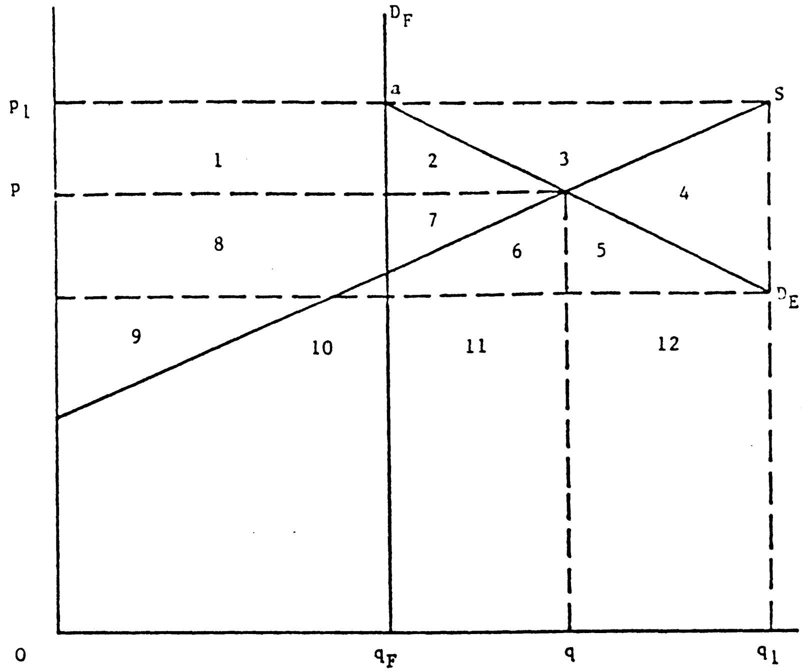

Figure 2. Supply and Demand Curves for Feed Grain Illustrating Alternative Policy Scenarios to Raise Farm Income.

Under the above scenario of government intervention, the ethanol market was foregone to obtain higher prices. An alternative scenario is to subsidize utilization q_1-q_F in the ethanol market to bring total utilization to q_1 at price p_1 so that no production need be diverted. If the government discriminates to pay the minimal cost of utilization of ethanol, the subsidy would be area 3+4 in Figure 1. Gross farm revenue would be p_1q_1 if the government paid producers p_1 for grain used to produce ethanol and delivered it to ethanol producers at the minimal discriminating demand price along D_E. Net revenue in excess of the free market scenario would be only 1+2+3 because production costs would be higher than in the scenario of paid diversion. In reality, the government probably would not discriminate price among ethanol users so the subsidy might need to be area 2+3+4+5+6+7 or even higher. Some of this additional government outlay might go to feed grain producers and some to ethanol producers.

The situation becomes more complex when recognition is made of alternatives such as direct payments or of market channels such as exports. Alternative assumptions regarding the generosity of government payments also can give different results. An additional complication is that ethanol production provides a byproduct of high-protein corn gluten feed which displaces some soybean meal utilization -- this too needs to be accounted for. A mathematical model accommodating these interactions and alternatives is called for. One approach is the Lagrangian formulation detailed in the Appendix (An alternative is a linear programming formulation.)

Appendix

The Model and Data Sources

The following feed grain-soybean model assumes that net farm income is maintained at some level K at minimum government program cost by an optimal combination of voluntary acreage diversion, export subsidy, ethanol subsidy, and direct payments to farmers. The model assumes that the government does not discriminate subsidies within a given market but pays a subsidy per unit on all ethanol or export utilization on grain equal to the subsidy required on the marginal unit. Feed grain can be expressed in corn-equivalent units.

Equations

(1) Minimize $C = C_G + C_E + C_X + D$
(Government cost)

(2) Subject to $NFI = P_F Q_F + P_B Q_B + D - W_F - W_B \geq K$
(Net farm income restraint)

(3) $Q_F = Q_{FS} = Q_{FD}$
(Feed market clearing condition)

(4) $Q_{FS} = f_S(P_F)$
(Supply function for feed grain, corn equivalent)

(5) $Q_{FD} = Q_{FL} + Q_{FE} + Q_{FX} + Q_{FG}$
(Sum of grain demands)

(6) $Q_{FL} = f_L(P_F)$
(Feed grain demand function for livestock feed)

(7) $Q_{FE} = f_E(P_E)$
(Ethanol demand function for feed grain)

(8) $P_E = P_F - T_E$
(Ethanol subsidy T_E per unit)

(9) $Q_{FX} = f_X(P_X)$
(Export demand function for feed grain)

(10) $P_X = P_F - T_X$
(Export subsidy T_X per unit of grain)

(11) $Q_{FG} = f_G(T_G)$
(Grain production diverted by government programs)

(12) $T_G = f_n(P_F)$
(Government diversion cost per unit as function of grain market price)

(13) $Q_B = Q_{BS} = Q_{BD}$
(Soybean market clearing condition)

(14) $Q_{BS} = f_b(P_B)$
(Soybean supply function)

(15) $Q_{BD} = Q_{BFE} - aQ_{FE}$
(Quantity of soybeans demanded adjusted for protein substitute equivalent from ethanol aQ_{FE})

(16) $Q_{BFE} = f_h(P_B)$
(Soybean and high-protein demand function)

(17) $C_G = T_G Q_{FG}$
(Treasury cost of feed grain paid diversion)

(18) $C_E = T_E Q_E$
(Treasury cost of feed grain ethanol program)

(19) $C_X = T_X Q_X$
(Treasury cost of feed grain export program)

(20) $D = (T_a - P_F)(Q_{FL} + Q_{FE} + Q_{FX})$
(Treasury cost of direct payment program)

(21) $W_F = f_{WF}(Q_{FL} + Q_{FE} + Q_{FX})$
(Feed grain production expense function)

(22) $W_B = f_{WB}(Q_B)$
(Soybean production expense function)

Lagrangian Expression

$$C^* = C_G + C_E + C_X + D + \lambda(P_F Q_F + P_B Q_B + D - W_F - W_B - K)$$

Instrumental variables T_E, T_X, T_G, and T_a

Definition of Variables

C = Government cost of grain programs

C_G = Government cost of paid diversion

C_E = Government cost of ethanol subsidy

C_X = Government cost of export subsidy

D = Government cost of direct (deficiency) payments

NFI = Net farm income from feed grain and soybeans

P_F = Market price of feed grain

Q_F = Quantity produced and marketed of feed grain

P_B = Market price of soybeans

Q_B = Quantity produced and marketed of soybeans

W_F = Total production cost of feed grain

W_B = Total production cost of soybeans

Q_{FS} = Quantity supplied of feed grain

Q_{FD} = Quantity demanded of feed grain

Q_{FL} = Quantity demanded of feed grain for livestock feed

Q_{FE} = Quantity demanded of feed grain for ethanol

Q_{FX} = Quantity demanded of feed grain for export

Q_{FG} = Quantity of feed grain diverted under paid diversion

P_E = Price of grain for ethanol production

T_E = Ethanol subsidy per unit of grain

P_X = Price of grain for export

T_X = Export subsidy per unit of grain

T_G = Government cost per unit of grain diverted by paid acreage diversion

T_a = Target price for grain

Q_{BS} = Quantity supplied of soybeans

Q_{BD} = Quantity demanded of soybeans

Q_{BFE} = Quantity of soybean and high-protein demand

Critical Behavioral Functions and Parameter Estimates

Critical behavioral functions in the model include:

(a) the supply function for feed grain (equation 4)

(b) the demand function for feed grain for domestic feed (equation 6)

(c) the demand function for feed grain for ethanol (equation 7)

(d) the export demand function for feed grain (equation 9)

(e) government grain acreage diversion cost (equation 12)

(f) the supply function for soybeans (equation 14)

(g) the soybean-high protein demand (equation 16)

(h) the feed grain production expense (equation 21)

(i) the soybean production expense (equation 22)

To the extent possible, the study will rely on previously estimated parameters for these functions.

Supply Functions for Feed Grain and Soybeans

Supply response parameters from numerous sources have been summarized for a number of farm commodities by Henneberry (17, pg. 177). Estimates for corn vary considerably by source but elasticities average approximately .25 in the short run and 1.00 in the long run. Short-run soybean supply elasticity estimates average higher, approximately .50. Econometric models (see 18) provide additional estimates of supply responses.

Feed and Export Demand Functions for Feed Grain and Soybeans

Domestic and export elasticities of demand for feed grain and soybeans are available from various sources (see 14, 19, 20). Numerous existing econometric models designed to predict economic outcomes for the U.S. and/or world agricultural economies under alternative policy scenarios also provide supply and demand parameter estimates. These are described briefly below.

These models include the system of linked submodels developed by the Food and Agriculture Program at the International Institute for Applied Systems Analysis (IIASA) in Laxemburg, Austria (21). This base linked system (BLS) model is a dynamic equilibrium framework for projecting world trade and prices of nine agricultural commodities.

The Grain-Livestock-Sugar (GLS) model is a dynamic, partially equilibrium model that simulates 30 countries and 7 commodities including wheat, feed grains, and rice (22). GLS was commissioned by the World Bank and developed by the Australian National University and the University of Adelaide.

AGSIM is an annual, dynamic econometric model of regional crop and livestock production in the United States. Export and import demand equations are used to link the U.S. with the rest of the world. Taylor (23) outlines the present version of AGSIM; a previous version is outlined by Collins and Taylor (24).

The Ministerial Trade Mandate (MTM) model was commissioned by the Secretariat of the Organization for Economic Cooperation and Development (25). The model system is constructed around individual country models which capture domestic supply and demand responses. The Static World Policy Simulation (SWOPSIM) model was developed by the International Economics Division of the Economic Research Service of the U.S. Department of Agriculture (26). SWOPSIM consists of an array of spreadsheets which define country and commodity parameters in relationships including supply, demand, and net trade equations for individual countries and country groupings.

The Food and Agricultural Policy Research Institute (27) model is a dynamic, econometric formulation consisting of a series of integrated submodels including grains and soybeans. AGMOD is a relatively small-scale, annual, econometric model adapted for use on microcomputers (28). The model developed at Michigan State University includes grains and soybeans. POLYSIM is a simulation model using direct and cross elasticities to determine policy-induced changes in prices and other variables from base line projections (29, 30).

The above models in many cases rely on judgment or consensus estimates of supply and demand parameters from previous studies but provide a rich source of parameter estimates for the proposed analysis.

Farm Expense Functions

Annual farm operating expenses as related to farm production have been estimated by White, Tweeten, and Pinstrup-Andersen (16). The equations are outdated but can be made current using data from the U.S. Department of Agriculture (31, 32).

Diversion Cost Functions

Government costs of paid acreage diversion programs depend on the production marketed, prices received by farmers, and costs of production. In general, Treasury costs rise per unit of grain removed as production is diverted on more productive land. Various estimates have been made of the diversion payments required per unit of production both on an average and marginal cost basis (16, pg. 131). In addition, Zepp and Sharples (33) have estimated national and regional costs of land retirement based on discriminatory payments to remove the most production per dollar of program outlay as well as based on uniform payments per acre. Value of production removed per program dollar generally ranges from a minimum of 1.0 to 2.0. However, previous estimates are outdated and need revision based on recent data.

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