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Assessing Model Assumptions in Trade Liberalization Modeling: An Application to SWOPSIM

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Abstract

This report reviews research on the effectiveness of acreage reduction programs and describes the methodology developed for the Static World Policy Simulation (SWOPSIM) modeling framework to capture the effect of removing these programs. It also analyzes the results of several sensitivity tests of a SWOPSIM model used by the Economic Research Service to study the effects of agricultural trade liberalization. Assumptions concerning how U.S. acreage reduction programs are modeled significantly influence predictions as to how trade liberalization affects commodity prices, production, and trade. However, these assumptions do not significantly influence predictions of how trade liberalization affects producer welfare. In terms of trade liberalization analysis, more crucial are the assumptions regarding agricultural commodity supply elasticities and the degree to which U.S. agricultural policies are decoupled from production.

Keywords: Acreage reduction programs, slippage, deficiency payments, economic model, trade liberalization, supply elasticity, SWOPSIM

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ASSESSING MODEL ASSUMPTIONS IN TRADE LIBERALIZATION MODELING: AN APPLICATION TO SWOPSIM

Introduction

Pressure for reform of domestic agricultural policies has been building for some time. The Uruguay Round of multilateral trade negotiations under the auspices of the General Agreement of Tariffs and Trade (GATT) is a historic opportunity to reform agricultural policies and liberalize trade. Economists and policymakers concerned with the effect of trade liberalization must deal with the effects of removing the myriad policy instruments that currently distort global agricultural production and trade.

The Static World Policy Simulation (SWOPSIM) modeling framework has been used to construct a model (ST86) designed to estimate the effects of agricultural trade liberalization by the industrial market economies. The construction of the model required the adoption of a modeling structure and the choice of model parameters for use in evaluating agricultural policy reform. Although the objective of the model is complicated, its structure is relatively simple: it is a price wedge model based on reduced-form supply and demand equations. Producer and consumer subsidy equivalents (PSE's and CSE's, respectively) are used as price wedges that capture the effects of government policies on production and consumption of agricultural commodities.

As with any economic policy modeling exercise, it is important that the sensitivity of model results to economic and policy parameters be examined. We analyzed the results of sensitivity tests on three key sets of parameters used in ST86. The first set consists of the supply shift terms used to model the removal of acreage reduction programs. Because these programs involve quantitative restrictions that restrict output, their effects are not captured in the PSE framework. Instead, the effect of removing quantitative restrictions is modeled as an explicit shift in a commodity's supply schedule. The second is the PSE. The PSE is a measure of the value of transfers from government and consumers to farm producers. The SWOPSIM formulation assumes that the entire PSE is coupled to (or directly affects) farm production decisions. However, recent research indicates that U.S. agricultural policies may, in fact, be decoupled. The third set of parameters examined is the supply elasticities for agricultural commodities. The size of the elasticities represent the degree to which resources used in agriculture have alternative uses. If agricultural resources are immobile, then removal of output-expanding subsidies will have less effect on production than previously published results indicate.

The Model

The model ST86 is a static, partial equilibrium model of world agricultural trade that has been used by the U.S. Department of Agriculture's Economic

Research Service (USDA,ERS) to analyze the economic effects of agricultural trade liberalization by the industrial market economies (Roningen and Dixit, 1989).[1] The model was constructed in the SWOPSIM framework (Roningen 1986) using the ST86 database (Sullivan, Wainio, and Roningen, 1989).
Models created by the SWOPSIM procedure are in spreadsheets and are modified and solved as spreadsheets. They are characterized by an economic structure that includes constant elasticity supply and demand equations and summary policy measures. For each region i and each commodity j in the model, demand and supply functions are modeled as follows:

$$D_{ij}=D_{ij}(CP_{ij},CP_{im},X_{il}) \quad (1)$$

$$X_{ij}=X_{ij}(PP_{ij},PP_{im},CP_{im}) \quad (2)$$

where CP_{ij} and PP_{ij} are domestic incentive prices facing consumers and producers, respectively, of commodity j in country i. CP_{ik} and PP_{ik} are consumer and producer prices of commodities closely related to commodity j in either consumption or production, respectively. CP_{ik} in the demand function accounts for substitution possibilities in consumption. CP_{ik} in the supply function accounts for the use of commodity k as an intermediate input in the production of commodity j. PP_{ik} in the supply function represents substitution possibilities for the producer. X_{ih} in the demand function accounts for the derived demand for the product as an intermediate input for the production of X_{ih}. X_{ih} is typically a livestock quantity which enters into demand functions for feed. Trade is the difference between domestic supply and demand:

$$T_{ij}=X_{ij}-D_{ij} \quad (3)$$

Domestic incentive prices depend on the level of consumer and producer support (measured in terms of consumer and producer price wedges CSW_{ij} and PSW_{ij}) and on world prices denominated in local currency:

$$CP_{ij}=CSW_{ij}+F(E_i*WP_j) \quad (4)$$

$$PP_{ij}=PSW_{ij}+G(E_i*WP_j) \quad (5)$$

where E_i is the exchange rate of i with respect to the U.S. dollar, and WP_j is the world reference price of j measured in U.S. dollars. Functional relationships F( ) and G( ) allow a specification of world to domestic prices

[1]The industrial market economies as defined here include the United States, Canada, the European Community (EC-12), Other Western Europe, Japan, Australia, and New Zealand.

to be less than or equal to 1. If equal to 1, then 100 percent of a world price change is transmitted domestically. A value less than 1 indicates that the government intervenes to cushion domestic producers or consumers from experiencing the full change.

World markets clear when net trade of a commodity across all regions sums to zero:

$$\sum_{i=1}^{n} T_{ij}=\sum_{i=1}^{n} X_{ij}-\sum_{i=1}^{n} D_{ij}=0 \tag{6}$$

ST86 covers 22 agricultural commodities and includes 11 countries/regions. Livestock commodities include beef and veal, pork, mutton and lamb, poultry meat, poultry eggs, milk, butter, cheese, and milk powder. The crops include wheat, corn, other coarse grains (barley, rye, oats, sorghum, millet, mixed grains), rice, soybeans, other oilseeds, cotton, sugar, and tobacco. Other commodities included are soybean meal, soybean oil, other oilseed meals, and other oilseed oils. Tropical products are not included. The countries/regions modeled are the United States, Canada, the European Community (EC-12), Other Western Europe, Japan, Australia, New Zealand, developing exporters (Brazil, Argentina, Indonesia, Thailand, Malaysia, Philippines), newly industrialized Asia (South Korea, Taiwan, other east Asia), centrally planned economies (Eastern Europe, Soviet Union, China), developing importers, and the rest of the world.

The economic effects of trade liberalization are estimated by removing PSE's, CSE's, and quantitative restrictions for the industrial market economies in the base model and then simulating the model to obtain a new equilibrium solution. The difference between the base and new solutions reflects the effect of removing support in the base year (1986) given a 5-year period of adjustment.

Producer and Consumer Subsidy Equivalents

The summary policy measures used in the model are PSE's and CSE's calculated by ERS researchers and analysts (USDA,1988). The PSE is a measure of the amount of income that a producer would have to be compensated to be as well off after the removal of government support under current programs and at current prices. Likewise, the CSE is a measure of the amount of income that a consumer would have to be compensated to be as well off after the removal of government support. In the model, PSE's and CSE's are used as price wedges that separate world commodity prices from domestic producer and consumer prices. Agricultural policy reform is modeled by removing these wedges (and the quantitative restrictions they do not capture) and then observing the effects on production, consumption, trade, prices, and other important economic variables.

There are a variety of technical issues involved in calculating PSE's and CSE's. Because they are aggregate measures of support, the effects of many types of distortionary policies must be combined. Table 1 provides examples of policies that are typically included in PSE estimates. Calculation of PSE's is based primarily on government budget figures or the difference between domestic and world reference prices.[2]

Table 1--Examples of policies included in PSE estimates

Market price support:
- Domestic price supports linked with border measure (quotas, permits, tariffs, variable levies, and export restitutions)
- Tariffs and export taxes
- Two-price systems and home consumption schemes
- Price premiums (often used for fluid milk)
- Domestic price supports linked with production quotas
- CCC inventory and commodity loan activities
- Marketing board price stabilization policies
- State trading operations

Direct income support:
- Direct payments -- deficiency, disaster, direct storage, headage and acreage diversion, PIK entitlements, stabilization payments, and other direct government payments
- Producer coresponsibility levies (negative support)

Programs affecting variable costs of production:
- Fertilizer subsidies
- Fuel tax exemptions
- Concessional domestic credit for production loans
- Irrigation subsidies
- Crop insurance

Programs affecting marketing of commodities:
- Transportation subsidies
- Marketing and promotion programs
- Inspection services

Programs affecting long-term agricultural production:
- Research and extension services
- Conservation and environmental programs
- Structural programs

Controlled exchange rates:
- Fixed rates
- Differential rates
- Crawling-peg rates

Source: U.S.D.A., Government Intervention in Agriculture: Measurement, Evaluation, and Implications for Trade Negotiations, Econ. Res. Serv., FAER-229, Apr. 1987.

[2]For information on how PSE's and CSE's were calculated for 1982-86, see (USDA,1988).

An important aspect of PSE's and CSE's is that they are based on an income compensation principle. Unlike the effective rate of protection (ERP), the PSE is not meant to be a measure of trade distortion.[3] The individual components are not weighted by their effects on either production or consumption. This specification implies that individual components of the PSE or CSE are perfect substitutes. Hertel (1989) has shown that reducing agricultural support through PSE reduction depends crucially on the specific policy instruments in place or on those instruments chosen for reform. Specifically, he shows that effects on output, factor employment, land rental, and exports differ according to whether support is reduced in the form of an output subsidy, input subsidy, or export subsidy. Only where there is no input substitutability in the production of a good will equal cost reductions in output and input subsidies have the same effects. Because inputs are not explicitly modeled in ST86, the no-substitutability assumption is embedded in its structure.

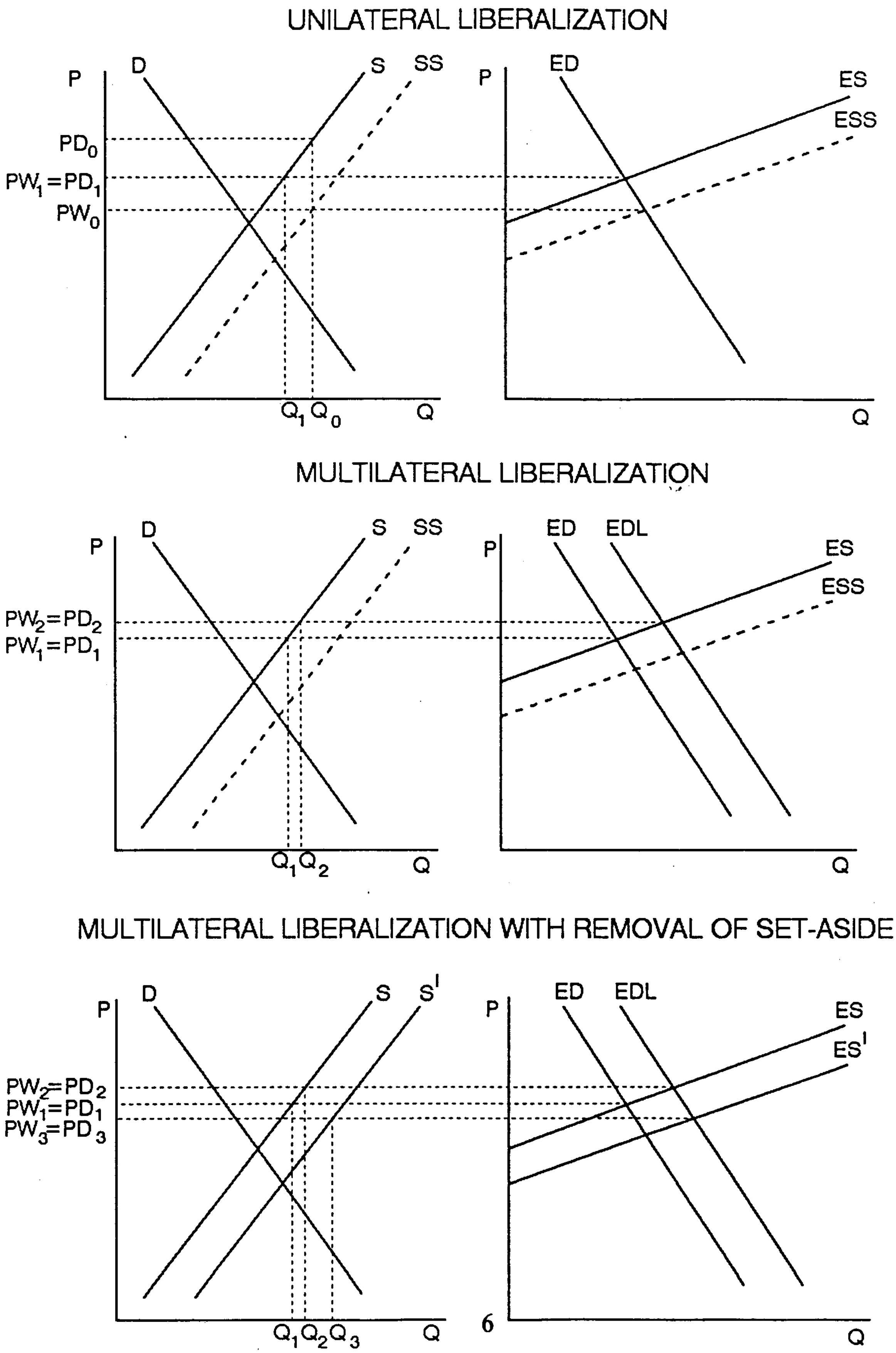
An important point to remember about PSE's is that they do not capture the effect of programs that involve quantitative restrictions which ultimately restrict output, such as U.S and Japanese acreage reduction programs. If PSE's and CSE's are used in a modeling framework as summary policy measures, then the effect of removing quantitative restrictions must be modeled separately. In ST86, the effect of removing quantitative restrictions is modeled as an explicit shift in a commodity's supply curve.

The Mechanics of SWOPSIM

In a typical trade liberalization scenario, government programs affecting agricultural production and consumption are removed. The scenario may involve one country removing its policies (unilateral liberalization) or a number of countries removing their policies (multilateral liberalization). The top panel of figure 1 illustrates the unilateral case. The undistorted domestic supply and demand curves are shown as S and D in the left graph. The excess supply (ES) curve in the right graph represents the amount available to be exported along a schedule of world price levels, after domestic demand has been satisfied. The excess demand (ED) represents rest-of-world demand for the product. Its intersection with ES determines the world price and the level of trade. In the figure, it is assumed that domestic production is subsidized at a constant unit level. SS in the left graph represents the subsidy-laden supply curve. It is vertically separated from S by the amount of the unit subsidy. At each world price level, domestic production is greater than without the subsidy because producers receive the subsidy in

[3] The ERP incorporates the influence of government intervention on output and intermediate input prices. It measures the percentage change in value-added of a sector with and without trade distortions. It is essentially a weighted average of producers' nominal rate of protection for output, and consumers' nominal rate of protection for intermediates, adjusted by the set of undistorted input-output coefficients. See Schwartz and Parker (1989) for a discussion of various measures of protection and their use.

Figure 1--Trade liberalization and SWOPSIM



addition to the world price for each unit of production. The amount available for export is greater with the subsidy. In the right graph, the curve ESS is the excess supply curve incorporating the subsidy. Its intersection with ED determines the initial world price level PW_0. The domestic producer incentive price is PD_0 (PW_0 plus the subsidy), and Q_0 is produced. If the subsidy is removed, production decreases and the amount available for export decreases. SS no longer exists, and ES is the new excess supply curve. The world price increases to PW_1, and the domestic producer incentive price decreases to PD_1, which is equal to PW_1 (assuming away transport, processing, and other differentials). Production falls to Q_1.

The middle panels show a multilateral liberalization scenario. Countries constituting the rest-of-world aggregate region also remove policies that distort agricultural production and trade. Along a schedule of world prices, there is less foreign production, and demand has remained the same. Therefore, there is greater demand for imports. In the figure, the excess demand curve shifts rightward to EDL. The new higher equilibrium world price is PW_2. At this higher world price, domestic producers increase production to Q_2.

The bottom panel shows the removal of an acreage reduction program. Land withheld from production is reintroduced to produce additional output along the schedule of world prices. S shifts rightward to S', and ES correspondingly shifts out to ES'. With increased excess supply, the world price drops from PW_2 to PW_3 to restore equilibrium to the world market. The amount by which the world price decreases depends on how much domestic supply is increased when diverted land returns to production. In the figure, domestic production is shown to increase from Q_2 to Q_3 at a world price of PW_3.

U.S. Policies for Grain and Cotton

U.S. policies for grain and cotton have been characterized by two essential features: participation in the programs is voluntary, and program benefits are linked to program obligations. As a result, the level of program participation depends on a weighing of expected program benefits and obligations.

The primary benefit to participants is the deficiency payment. It is a direct payment to the producer equal to the difference between the target price and the higher of either the loan rate or the average market price of the first 5 months of the marketing year. Price supports are maintained through nonrecourse loans by the Commodity Credit Corporation (CCC) to participating producers at the loan rate. The crop serves as collateral. If the market price falls below the loan rate, the producer may pay off the loan by forfeiting the crop to the CCC. The nonrecourse loan program supports production by providing market stability through an effective price floor.[4]

Participating producers receive deficiency payments based on their base acreage and program yield. Under the Food and Agriculture Act of 1981, program acreage was determined by the multiplying a program allocation factor by the number of acres planted for harvest on individual farms. This factor ranged between 80 and 100 percent, depending on harvest projections. The program yield was estimated by USDA based on historical yields adjusted for abnormal factors. The act included a proven-yield provision which allowed farmers to substitute actual yields if they were higher than their program yields. Therefore, under the 1981 act, deficiency payments were tied to actual yields and acreage and, thus, encouraged farmers to expand plantings and increase yields. Thus, deficiency payments were highly coupled to, and directly affected, the level of production.

The Food Security Act of 1985 changed the linkage between deficiency payments and production (Miller and House). The acreage base was set at the average number of acres planted (diversion and set-aside are considered planted) over the preceding 5 years, not to exceed the average of the last 2 years. At most, only 20 percent of an acreage change could show up in the calculation of deficiency payments in the following year. Also, the 50-92 provision permitted no loss of base acreage in the calculation of deficiency payments if at least 50 percent (or in some cases 0 percent) were planted in the permitted crop. The program payment yield was set at the average farm payment yields during 1981-85, excluding the highest and lowest yields. Thus, the 1985 act removed the direct linkage between increased production and deficiency payments that characterized the 1981 act.

Nevertheless, deficiency payments still may indirectly influence the level of production. Miller and House divide deficiency payments into two components. The first is a production adjustment component that compensates the producer for income forgone plus conservation costs on idled acres. This portion of the deficiency payment affects the producer's decision to participate in the program and, hence, will have an effect on production. The second component is an income component. It increases economic rents earned by fixed resources. Although it may attract excess resources into the sector that may enhance production, Miller and House speculate that its effect in the long run is small and probably unmeasurable.

In 1986 (the base year for ST86), deficiency payments constituted a major portion of the PSE for program commodities: 61 percent for wheat, 62 percent for corn, 43 percent for other coarse grains, and 51 percent for rice. Deficiency payments (like other components of the PSE) are modeled as price wedges that raise domestic producer incentive prices above world levels. The total value of deficiency payments for a crop is spreadout over total

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[4]The Food Security Act of 1985 provided additional program benefits to rice and cotton producers through a marketing loan program, and to wheat and coarse grain producers through the Findlay loan. Essentially, these measures allowed participating producers to receive additional deficiency payments if market prices were below loan rate levels. See Glaser (1986) for additional details.

production ex post to calculate the wedge. This is consistent with the SWOPSIM modeling structure only if deficiency payments are fully coupled. Although deficiency payments may have been fully coupled under provisions of the Food and Agriculture Act of 1981, Miller and House argue that they definitely were not under the Food Security Act of 1985. Other policies included in the U.S. PSE's for grains and cotton, such as government expenditures on agricultural research and extension programs, subsidized grain inspection services, grain storage subsidies, and interest subsidies may also be partially decoupled. The possibility that deficiency payments and other U.S. programs for grains and cotton may be decoupled has not been accounted for in previously published model results.

Effectiveness of Acreage Reduction Programs

The effectiveness of acreage reduction programs in reducing supply has been encapsulated in the term "slippage." Slippage describes the situation where the effectiveness of these programs is less than the number of idled acres would suggest, because of a variety of actions taken by farmers which offset the effect of acreage restrictions on the quantity of the commodity supplied.

Slippage can arise from a number of sources. One type of slippage, referred to as acreage slippage, occurs when harvested acres change by less than the change in acres diverted under the programs (Ericksen and Collins, 1985). Acreage slippage arises in the United States in part because not all farmers participate in the programs. Farmers operating outside the commodity programs are able to sow as much land as they wish to program crops. As program participants cut back on acreage sown to comply with acreage restrictions and, thus, retain eligibility for program payments, nonparticipants often expand acreage in anticipation of higher prices.

For participating farmers as well, the program provisions may have a number of incentives that diminish the effectiveness of the acreage restrictions over time and, thus, contribute to acreage slippage. For example, the relative price stability of U.S. program provisions may have encouraged risk-averse farmers to bring additional land into production above what would have been used in the absence of the programs. In addition, some discretion in area eligibility under the programs may have allowed farmers to declare fallow and other nonproductive land as program acreage, so when land needs to be withdrawn under an acreage restriction provision, farmers are able to comply with little effective reduction in acreage planted. Noncompliance on the part of participating farmers also can lead to acreage slippage.

Another type of slippage associated with commodity programs is yield slippage. Yield slippage occurs when acreage reduction programs lead to an increase in average yields, thereby reducing the effectiveness of the programs. Yield slippage can arise from three sources. The first source is an accounting problem. Because farmers rationally choose to withdraw their least productive land from production first, average reported yields can be expected to rise. Secondly, farmers may substitute other inputs (such as fertilizer, chemicals, water, labor, or capital) for land, thereby increasing yields on the land remaining in production. And finally, withdrawing land from production one year may boost yields on that same land in the following year because of the retention of higher levels of soil moisture and nutrients.

Approaches to Quantifying Slippage

Various approaches have been used to quantify the effect of slippage on the effectiveness of acreage reduction programs (table 2). The following section draws on literature identified by Norton (1985), supplemented with a number of more recent sources.

Table 2--Acreage slippage coefficients for the United States

Study	Period	Wheat	Corn	Barley	Oats	Sorghum	Rice	Cotton	Total Cropland Acreage
Houck and Ryan (1972)	1949-69	--	0.500	--	--	--	--	--	--
Sharples and Walker (1974)	1961-72	--	0.379 1/	--	--	--	--	--	--
Ericksen and Richardson (1975)	1937-73	--	--	--	--	--	--	--	0.400
Garst and Miller (1975)	1961-70	0.390 2/	--	--	--	--	--	--	--
	1971-74	0.590 3/	--	--	--	--	--	--	--
Tweeten (1979)	1959-75	--	--	--	--	--	--	--	0.350 4/
	1959-75	--	--	--	--	--	--	--	0.260 5/
	1959-75	--	--	--	--	--	--	--	0.430 6/
	1959-75	--	--	--	--	--	--	--	0.360 7/
Bancroft (1981)	1959-79	0.210	0.360	0.610	--	0.520	--	--	--
Gadson, Price and Salathe (1982)	1959-79	0.328	0.399	0.646	--	0.646	--	--	--
Evans (1984)	1962-83	0.350	--	--	--	--	--	--	--
Norton (1985)	1948-82 8/	-0.080	0.343	--	--	--	--	0.215	--
	1948-82 9/	0.339	0.258	--	--	--	--	0.267	--
Dvoskin (1988)	1956-85	0.250	0.390	--	0.380	0.420	0.240	0.370	0.340

-- = Not available
1/ Corn and soybeans combined.
2/ For paid diversion programs.
3/ For set-aside programs.
4/ Short-run estimate for short-term acreage diversion programs.
5/ Long-run estimate for short-term acreage diversion programs.
6/ Short-run estimate for long-term land retirement programs.
7/ Long-run estimate for long-term land retirement programs.
8/ Calculated from coefficients estimated using seemingly unrelated regression (SUR).
9/ Calculated from coefficients estimated using ordinary least squares (OLS).

Acreage Slippage

One of the seminal pieces of work on acreage response to farm program variables was that of Houck and Ryan (1972). They estimated acreage supply equations for corn using weighted corn prices and acreage diversion payments for corn as the main explanatory variables. The diversion variable weights diversion payment rates by eligible diversion acreage. Yield changes were assumed to be independent of acreage changes, a strong assumption.

Houck and Ryan also estimated an equation for corn acres diverted, with weighted acreage diversion payments for corn as the only explanatory variable. The coefficient estimated for acreage diversion payments in this equation is roughly double the absolute value of the coefficient estimated for the acreage diversion variable in the area-planted equations. This indicates that for a given increase in the acreage diversion variable, corn acres planted decreased by only half the amount by which corn acres diverted increased. The results obtained by Houck and Ryan imply an acreage slippage coefficient of 0.50 for corn. The time period covered in this study, 1949-69, includes only paid diversion programs.

Sharples and Walker (1974) estimated the effect of acreage diverted from crop production by wheat and feed grain programs on the planted acreage of row crops (corn and soybeans) in the North Central region of the United States. Planted acreage of row crops was estimated as a function of the acreage diverted under the wheat, feed grain, and cotton programs, a time trend, and a dummy variable representing changes in program rules for diverting cropland for 1971-72. They found that for each acre increase in diversion or set-aside over 1961-72, total acres planted in row crops declined by only 0.621 acres. This implies that for every acre diverted from production under these programs, 0.379 (1 - 0.621) acre is effectively retained in production of row crops due to actions taken by both participating and nonparticipating farmers (the model cannot determine which).

Ericksen (1976) defined acreage slippage in the following terms:

$$AS_1 = 1 - \frac{\overline{AH_1} - AH_1}{AD_1} \tag{7}$$

where:

AS_1 = acreage slippage for crop 1,
$\overline{AH_1}$ = acreage of crop 1 that farmers would harvest under program provisions without acreage diversion requirements,
AH_1 = actual acreage of crop 1 harvested under the same program provisions with acreage diversion requirements, and
AD_1 = acreage of crop 1 diverted.

The acreage slippage coefficient defined by Ericksen can range between 0 and 1. A coefficient of 0 means that the land diversion requirement is 100 percent effective in reducing acreage harvested, that is acreage harvested falls by the full amount of acreage idled under the program. A coefficient of 1, on the other hand, indicates that the land diversion requirement has had no effect on acreage harvested.

Since the value of $\overline{AH_1}$ is not known, the acreage slippage coefficient (AS_1) cannot be calculated directly. However, as Houck and Ryan, and Sharples and Walker had already demonstrated, econometric estimates can be used to measure the acreage slippage concept defined above.

Ericksen reported the results of some unpublished research undertaken with Richardson in which they analyze factors affecting total cropland use (cropland harvested plus failure plus fallow). In the model they formulated, a lagged parity ratio was used to capture farmers' expectations of net returns for the current year. A second variable, land idled in the acreage reserve programs (annual and long term) was used to estimate the effect of diverted acreage on total cropland use independent of net returns expectations. The model, based on data for 1937-73, was able to explain a large proportion of variation in total crop acreage. The acreage slippage coefficient implied by their results is 0.40 (1 - 0.6), where 0.6 is the estimated coefficient for the acreage reserve variable).

Garst and Miller (1975) estimated the effect of the acreage diversion and set-aside programs on U.S. wheat acreage over 1961-74. They attempted to isolate the effects of policy and price variables using ordinary least squares (OLS). Total acreage planted to all wheat, spring wheat, and winter wheat were estimated separately as a function of acreage allotments, additional paid diversion acres for wheat, wheat acres set-aside, lagged real producer prices for wheat, and dummy variables representing changes in policy instruments at discrete times.

The coefficients on the wheat set-aside variable in the all wheat and spring wheat equations were not significant and were found to be highly correlated with the price variable. To eliminate problems of multicollinearity between the price variable and the set-aside variable, the price term was dropped. With this formulation, Garst and Miller estimated coefficients for both the diversion and set-aside programs. Their estimates imply an acreage slippage coefficient for all wheat of 0.39 for diversion programs and 0.59 for set-aside programs. The implied acreage slippage coefficients for winter wheat are 0.70 for diversion and 0.72 for set-aside, and for spring wheat 0.25 for diversion and 0.38 for set-aside. The analysis showed that diversion programs were more effective than set-aside programs in reducing wheat area. Garst and Miller expected that slippage would be smaller under the diversion programs because the acreage requirements were more restrictive than those of the set-aside programs.

Tweeten (1979) estimated an acreage response equation for total cropland harvested as part of an analysis of the social cost of government production controls. Cropland harvested was specified as a function of lagged cropland harvested, acres diverted by short-term acreage-diversion programs, acres in long-term land retirement programs, the ratio of crop prices to prices paid by farmers, and a time trend. He estimated the equation using annual data for 1959-75 and OLS.

His results indicate that each acre increase in short-term diversion programs decreased cropland harvested by 0.65 acre in the short run and by 0.74 acre in the long run. Each acre increase in long-term land retirement programs is estimated to decrease cropland harvested by 0.57 acre in the short run and by 0.64 acre in the long run. The implied acreage slippage coefficients for short-term diversion programs are 0.35 in the short run and 0.26 in the long run. For long-term land retirement programs, the implied slippage coefficients are 0.43 for the short run and 0.36 for the long run. Based on these results, Tweeten suggests that approximately 2 of 3 diverted acres would return to crop production if government diversion programs were eliminated.

Recognizing that participating and nonparticipating farmers may respond differently to changes in farm policies and market conditions, Bancroft (1981) estimated separate acreage response equations for each group of producers for the model he developed in his Ph.D. dissertation. The response of participating farmers was captured in two equations, one that estimated total program participation (acres planted and idled by participants) and a second that explained additional land diverted beyond minimum diversion or set-aside requirements. A third equation explained the response of nonparticipants. In this equation, acres planted by nonparticipants to a particular crop were estimated as a function of acres diverted or set-aside in the program for that crop, acres planted in the program for that crop, the average of market and program real expected net returns per acre for competing crops, real expected market net returns per acre for that crop, a time trend, and selected dummy variables.

Bancroft estimated equations for wheat, corn, barley, and sorghum using OLS and annual data for 1959-79. His results indicate that the net effect of a 1-acre increase in wheat diversion or set-aside was to decrease plantings of wheat by 0.79 of an acre. This implies an acreage slippage coefficient of 0.21 (1 - 0.79) for wheat, somewhat lower than those of Garst and Miller (table 2). Bancroft's estimates of acreage slippage for corn (0.36), sorghum (0.52), and barley (0.61) suggest that the wheat program was the most effective in terms of withdrawing land from production.

The approach used by Bancroft was subsequently incorporated into the Food and Agricultural Policy Simulator (FAPSIM) model of USDA (Gadson, Price, and Salathe, 1982). Although Bancroft's equations were revised slightly and reestimated for the FAPSIM model, the implied acreage slippage coefficients from Gadson, Price, and Salathe are very close to those reported by Bancroft (table 2).

Evans (1984) calculated the effectiveness of diversion, set-aside, and acreage reduction programs for wheat using year-to-year changes in wheat area harvested and in acres diverted under wheat programs. Using data for 1962-83, he calculated the ratio of total changes in harvested acres to total changes in diverted acres. The result (-0.65) indicates that acreage programs for wheat were 65 percent effective on average in reducing harvested acreage. Put another way, this implies that a 1-million-acre increase in diversion resulted in only a 650,000-acre reduction in area harvested. Evan's calculations imply an acreage slippage coefficient of 0.35 for wheat.

In her work on slippage, Norton (1985) used a profit function approach to estimate the effect of set-aside, acreage reduction, and diversion programs on acreage harvested and production using annual data for 1948-82. The study covered wheat, corn, and cotton. The model developed by Norton contained six product supply equations that were estimated using the restrictions usually imposed on an aggregate profit function model (Norton, pp. 33-37). The model was estimated with production and acreage harvested as dependent variables in two separate estimations. Norton used Zellner's seemingly unrelated regression (SUR) method because it provides more efficient estimates than OLS and allows behavioral restrictions to be imposed on the equations. For comparison, the model was also estimated without any restrictions using OLS.

Unfortunately, the results were not entirely consistent between the two approaches, suggesting specification problems. The acreage slippage coefficient reported for wheat from the SUR model is negative (-0.08), indicating that acreage harvested decreased by an amount greater than acreage diverted. This is not consistent with published data, nor does it agree with results from other studies. In contrast, the estimates of acreage slippage obtained from the OLS model are positive for all three crops (table 2).

An important limitation of the estimates produced by Norton is the way in which prices were incorporated into the model. Norton used the average futures price for a commodity as a proxy for expected prices faced by farmers in the year in question. However, program participants and nonparticipants face different prices. When acreage reduction programs are announced, along with loan rates and target prices, each farmer has to make an assessment of whether they would be better off in or out of the programs in the coming year. The decision to participate depends on expected profits in and out of the program and this is difficult to model ex post because of a lack of farm level data. Bancroft accounted for this problem by endogenizing the participation rate. Houck and Ryan handled it by defining an "incentive price" which took account of the prices facing farmers both within and outside of the program.

Norton notes the limitations placed on her analysis by the choice of the price variable. In particular, the expected price variable captures only part of the slippage effects discussed above. For example, if output prices are expected to rise because of an acreage reduction program, then profit-maximizing farmers will increase the use of nonland inputs on the land remaining in production, thereby boosting yields. Similarly, nonparticipants could increase the amount of land sown to program crops. Neither of these effects is captured by her estimated acreage and production slippage coefficients but are instead captured in the expected price variable. Therefore, slippage will be underestimated because of the specification used for the price variable.

More recently, Dvoskin (1988) analyzed the effectiveness of set-aside, acreage reduction, and diversion programs using an approach similar to the one employed by Ericksen and Richardson (1975). Using annual data for 1956-85, he estimated acreage slippage for a wide range of commodities including wheat, corn, barley, oats, sorghum, rice, and cotton. The method used by Dvoskin estimated changes in acreage harvested as a function of changes in program acres idled. The estimated coefficients were significant for all crops except barley.

The acreage slippage coefficients implied by Dvoskin's results are very similar to those of the other studies. The coefficients for wheat (0.25), corn (0.39), and total cropland (0.34) are within the range of estimates reported in table 2. Although the acreage slippage coefficient for sorghum (0.42) is significantly less than that obtained from Gadson, Price, and Salathe, it is only slightly lower than the one estimated by Bancroft. The coefficient for cotton (0.37) is somewhat higher than either of those estimated by Norton. The Dvoskin study was the only one of the studies reviewed that provided estimates of acreage slippage for oats (0.38) and rice (0.24).

Yield Slippage

In contrast to the considerable amount of work done on acreage slippage, relatively little research has been undertaken on yield slippage. As noted earlier, the potential for yield slippage arises from program participants withdrawing their least productive land from production first, the substitution of other inputs for land, and investment in additional capacity as a result of higher returns and less price risk under the farm programs.

On the first issue, Weisgerber (1969) estimated the relative productivity of U.S. cropland diverted under both annual and long-term retirement programs during 1966 by comparing the average productivity of diverted cropland to the average productivity of cropland in production. His results showed that the productivity of diverted cropland was indeed lower than that of cropland remaining in production and that it varied between crops. Weisgerber estimated the relative productivity of diverted cropland at 90 percent for wheat, 85 percent for grain sorghum, 83 percent for barley, 82 percent for corn, and 80 percent for cotton. His calculations are based on the assumption that land idled under annual programs would return to production of the crops from which it was diverted and that land in long-term retirement programs would be used to grow program crops in the proportion specified for annual programs.

Ericksen (1976) defined acreage slippage in terms of the difference between what farmers would harvest under commodity programs with and without acreage diversion provisions. The effect of acreage restriction programs on yields (yield slippage) can be defined in similar terms:

$$YS_1 = \frac{YD_1 - \overline{YD_1}}{AD_1} \qquad (8)$$

where:

YS_1 - yield slippage for crop 1,
YD_1 - actual yield for crop 1 under program provisions with acreage diversion requirements,
$\overline{YD_1}$ - yield for crop 1 under program provisions without acreage diversion requirements, and
AD_1 - acreage of crop 1 diverted.

The effect of acreage reduction programs on yields was estimated indirectly by Lin and Davenport (1982) and Ash and Lin (1987). Lin and Davenport examined factors affecting corn yields in the major producing regions of the United States over the period 1955-80. The yield of corn harvested for grain was estimated as a function of acreage planted to corn, nitrogen application, precipitation, temperature, dummy variables for corn blight and frost conditions, and time as a proxy for technology. The results indicated that as acreage planted increased, yields declined.

Ash and Lin also examined yield response in the United States. They applied the specification developed by Lin and Davenport to a wider range of crops and regions. The commodity coverage included wheat, corn, barley, oats, sorghum, and rice. Wheat was further disaggregated into spring and winter plantings. The yield response equations were estimated using OLS and data generally for 1956-84. The authors found that as planted acreage expands, average yields fall.

Ash and Lin calculated elasticities of yield and production with respect to acreage changes using the estimated coefficients on the acreage planted variable and the following identity.

$$E_{qa}=1+E_{ya} \tag{9}$$

where:

E_{qa} - elasticity of production with respect to a change in planted acreage, and
E_{ya} - elasticity of yield with respect to a change in planted acreage.

The elasticity of yield calculated for wheat in the Northern Plains is -0.41. The authors conclude that a 10-percent reduction in acreage planted to wheat in the Northern Plains would raise average wheat yields by 4.1 percent. Assuming 100-percent compliance, they estimate that this would reduce wheat production by only 5.9 percent. Similar estimates were made for the other commodities in the study.

Ash and Lin estimate the yield effect of farmers' withdrawing less productive cropland to comply with program requirements in 1986. Compared with no acreage reduction programs, they estimated that in 1986 national average yields per acre were higher by 2.5 bushels for wheat, 5.7 bushels for corn, 0.7 bushel for barley, 0.1 bushel for oats, and 580 pounds for rice. They reported that the programs had no measurable effect on sorghum yields.

More recently, Love and Foster (1991) examined the effect of acreage reduction programs on yields for corn, wheat, and soybeans. (Although soybeans are not a program-crop, they compete with corn for land. Love and Foster argue that diversions of land from corn potentially affect soybean yields in addition to corn yields.) Using data covering 1964-86, they estimated an eight-equation simultaneous system that included per-acre production functions, per-acre fertilizer demand equations, and equations explaining proportions of planted acreage relative to total acreage (that is, the sum of planted and diverted acreage). The specification of production allowed for nonconstant yield slippage. The authors argue that slippage is likely to vary inversely with the level of land diverted. The expectation is that slippage is greatest at low levels of land diversion. Their results support this hypothesis, implying yield slippage elasticities of 29 to 37 percent for wheat, 48 to 58 percent for corn, and 30 to 38 percent for soybeans.

Using the results from Ash and Lin and equation 9, we can calculate yield slippage, that is how much national average yields per acre increased on average for each million acres diverted under the programs in 1986. For wheat, this implies an average yield effect or slippage coefficient of 0.123 bushel per acre. The implied yield slippage coefficients for the other commodities included in this study are listed in table 3.

The formulation used in the studies by Lin and Davenport and Ash and Lin does not directly quantify the relationship between acreage idled under acreage reduction programs and yields. Instead, the authors estimate the effect of acreage reductions by using the calculated elasticities of yield.

Table 3--Yield slippage coefficients for the United States 1/

Study	Period	Wheat	Corn	Barley	Oats	Sorghum	Rice	Cotton
Gadson, Price, and Salathe (1982)	1951-79	0.131	0.473	0.344	--	1.332	540 2/	5.4 2/
Ash & Lin (1987)	1986	0.123	0.419	0.389	0.250	--	456	--

-- = Not available.
1/ Increase in national average yield per million acres diverted from production under program provisions. Units are bushels per acre for wheat, corn, barley, oats, and sorghum; pounds per acre for rice and cotton.
2/ Obtained from unpublished research undertaken by Mike Price.

The yield equations that were incorporated into the FAPSIM model (Gadson, Price, and Salathe, 1982) explicitly quantify the relationship between diverted acreage and yields. In this formulation, yields are estimated as a function of acreage set-aside and diverted, the ratio of crop prices to the price of fertilizer, weather, a time trend to reflect changes in technology, and selected dummy variables. Yield equations were estimated for wheat, corn, barley, sorghum, rice, and cotton using OLS and data generally from 1950-79.

The results from this specification indicate that yields per acre harvested rise as the acreage diverted by program participants increases. For example, the coefficient on the diversion variable for wheat implies that for every million acres diverted from production under program provisions, the national average wheat yield increased by 0.131 bushel. Yield slippage coefficients estimated for the other crops in the FAPSIM model can be found in table 3. For most commodities, these estimated slippage coefficients are very close to those that were calculated from the results of Ash and Lin.

Production Slippage

Another type of slippage discussed in the economics literature is production slippage. Production slippage refers to the situation where production of a crop changes by less than the amount implied by the acreage reduction programs. The coefficient of production slippage is a more comprehensive measure of the slippage effect in that it attempts to capture the combined effect of acreage reduction programs on both acreage harvested and yields.

Ericksen (1976) defined production slippage in the following terms:

$$PS_1 = 1 - \frac{\overline{AH_1} * \overline{YH_1} - AH_1 * YH_1}{AD_1 * \overline{YH_1}} \qquad \textbf{(10)}$$

where:

- PS_1 - production slippage for crop 1,
- AH_1 - acreage of crop 1 that farmers would harvest under program provisions without acreage diversion requirements,
- YH_1 - yield for crop 1 given AH_1 acres harvested,
- $\overline{AH_1}$ - actual acreage of crop 1 harvested under the same program provisions with acreage diversion requirements,
- $\overline{YH_1}$ - actual yield for crop 1 with $\overline{AH_1}$ acres harvested, and
- AD_1 - acreage of crop 1 diverted.

Two different approaches have been used to estimate the magnitude of production slippage for U.S. crops. Norton (1985) estimated the effects of acreage reduction programs on the area harvested and production of wheat, corn, and cotton (see Acreage Slippage section above). She used the estimated coefficients from a system of product supply equations to calculate production slippage coefficients directly. The production slippage coefficients were calculated as follows:

$$SC_p = 1 - \frac{EDC*10}{AYD} \qquad (11)$$

where:

SC_p - slippage coefficient for production,
EDC - estimated coefficient on the acreage diversion variable in the product supply equation with production as the dependant variable, and
AYD - average yield per acre for 1956-82.

The coefficient on the acreage diversion variable (EDC) is an estimate of the production effect of the acreage reduction programs per acre increase in diversion. In terms of Ericksen's formula, this coefficient represents an estimate of $[(\overline{AH_1} \times \overline{YH_1}) - (AH_1 \times YH_1)] / AD_1$.

The slippage coefficients from both the SUR and OLS equations are presented in table 4. The estimate of production slippage for wheat from the SUR equation (0.343) indicates that for every million acres idled under the program provisions for wheat, production of wheat declined by the equivalent of 657,000 harvested acres. This result implies that production slippage is about 34 percent for wheat, that is, acreage reduction programs for wheat were about 66 percent effective in reducing production. Results from the other equations estimated with SUR suggest that production slippage is over 30 percent for corn and is just slightly less than 50 percent for cotton. For wheat and corn, the OLS estimates reported by Norton are considerably different. They imply that production slippage for wheat is almost 70 percent, while for corn it is close to zero.

Table 4--Production slippage coefficients for the United States

Study	Period	Wheat	Corn	Barley	Oats	Sorghum	Rice	Cotton
Norton (1985)	1948-82 1/	0.343	0.312	--	--	--	--	0.496
	1948-82 2/	0.692	0.067	--	--	--	--	0.606
Herlihy, Haley, and Johnston (1992)	1986 3/	0.434	0.563	0.394	0.380	0.582	0.429	0.423

-- = Not available.
1/ Calculated from coefficients estimated using seemingly unrelated regression (SUR).
2/ Calculated from coefficients estimated using ordinary least squares (OLS).
3/ Calculations shown in table 5.

We calculated production slippage coefficients from the ST86 model using the formula developed by Ericksen. Acreage and yield slippage coefficients from selected studies and 1986 data were used to obtain estimates of area harvested and yield in the absence of acreage reduction programs (AH_{1*} and YH_{1*}). The calculation of these variables is described in the next section of this report. Production slippage coefficients are not used directly in the ST86 model (acreage and yield slippage coefficients are used instead), but rather are calculated to compare with other studies.

Our results indicate that production slippage for wheat, barley, rice, and cotton is between 35 and 45 percent, while for corn and sorghum, it is closer to 55 percent (table 4). The slippage coefficient for wheat is within the range of estimates reported by Norton, while the coefficient calculated for corn is higher than its SUR and OLS counterparts. The coefficient calculated for cotton (0.423) is very close to the one estimated for cotton by Norton using SUR. For barley, oats, sorghum, and rice, no production slippage coefficients were available for comparison.

Calculating of the Effect of Removing Acreage Reduction Programs

The following section illustrates how acreage and yield slippage coefficients are used in the Static World Policy Simulation (SWOPSIM) modeling framework to calculate the effect of removing acreage reduction programs. Detailed information on the SWOPSIM framework is provided in Roningen (1986) and Roningen and Dixit (1989).

The methodology used in SWOPSIM to capture the effect of removing acreage reduction programs is similar to the approach developed by Magiera (1985) for the OECD Ministerial Trade Mandate (MTM) model. First, a quantitative estimate is made of the effect of removing acreage restrictions on the production of program commodities, given certain assumptions about slippage. Then to simulate agricultural policy reform, the observed supply curves for these commodities are exogenously shifted to reflect this effect, at the same time that PSE's and CSE's are removed (Haley, 1989).

If acreage restrictions were 100-percent effective in reducing production (that is, no slippage), then estimating the effect on supply of removing these restrictions would be straightforward. Take wheat, for example. In 1986, 60.723 million acres of wheat were harvested for grain in the United States at a national average yield of 34.446 bushels per acre. This resulted in 2.092 billion bushels (56.926 million metric tons) of wheat being produced. To be eligible for CCC loans and deficiency payments, wheat producers were required to idle 25 percent of their established crop acreage base. Of this amount, 22.5 percent was to be enrolled in the acreage reduction program (ARP), while 2.5 percent was to be placed in the paid land diversion program (PLD). In addition, winter wheat producers were given the option of placing an additional 5 or 10 percent of their land in the paid land diversion program. As a result of these annual programs, 20.4 million acres were removed from production.[5]

Assuming that all 20.4 million acres would return to wheat production if the ARP and PLD programs were removed and that 86 percent of this acreage would actually be harvested (based on historical harvested-to-planted ratios), then the production effect is simply the number of acres diverted times the harvested to planted ratio times the observed national yield (20.4 million acres * 0.86 * 34.446 bushels per acre = 604 million bushels). Thus, removing U.S. acreage reduction programs in a case where we assume no slippage (and all else is held constant) would cause the U.S. supply curve for wheat to shift to the right by approximately 604 million bushels (16.4 million metric tons) or 29 percent of 1986 wheat production. This estimate provides an upper bound on how much the U.S. supply of wheat might increase as a result of removing the ARP and PLD programs in place in 1986.

The studies surveyed in this report indicate that there is considerable evidence of slippage under U.S. commodity programs. The approach used in SWOPSIM to calculate the effect of removing acreage reduction programs accounts for the effects of both acreage and yield slippage. The procedure is divided into four steps. First, acreage slippage coefficients are used to estimate the number of diverted acres that would actually return to production of program commodities. Second, the change in national average yields due to the elimination of these programs is estimated using yield slippage coefficients for each program commodity. Third, the results from steps 1 and 2 are used to estimate the average yield, area harvested, and production that can be expected in the absence of acreage reduction programs. Finally, the estimated production effect and exogenous shift terms for the domestic supply curves are calculated.

Table 5 presents the data and selected acreage and yield slippage coefficients used to calculate the effect of removing U.S. acreage reduction programs. A detailed description of the procedure used to calculate the supply shift terms is provided below for the case of wheat. Details on the calculation of the production slippage coefficient for wheat are also provided below.

Sensitivity Analysis

We analyzed the results of respecifying the model and running several alternative trade liberalization scenarios. First, we examined the implications of assumptions as to how U.S. acreage reduction programs are modeled in the context of two alternative supply elasticity specifications. Then, we examined the effect of assumptions about the degree to which U.S. agricultural policies are decoupled from production.

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[5]This total does not include land enrolled in the long-term conservation reserve program.

Slippage and Model Supply Elasticities

Three scenarios are run to analyze the sensitivity of trade liberalization results to differing assumptions about the effectiveness of U.S. acreage reduction programs. The first scenario assumes no slippage. That is, all land diverted under acreage reduction programs is brought back into production of the commodity from which it was diverted, and no adjustment is made to the average yield. The second scenario assumes some acreage slippage in that not all diverted land is brought back into production. The third scenario assumes that average yields are affected as diverted land is brought back into production (yield slippage). The amount of land brought back into production is the same as in the second scenario.

Table 6 shows the supply shift factors used to capture the effect of removing U.S. acreage reduction programs for the slippage specifications discussed above. Accounting for both area and yield slippage reduces the shift factor by 53 percent for corn but only 38 percent for wheat. The other commodities fall between these extremes. The estimated yield effect of the programs is strongest for wheat and rice. It comprises two-thirds of the shift reduction for wheat and more than half of the reduction for rice. Yield slippage matters the least for cotton; it constitutes less than one-quarter of the supply shift reduction.

Table 7 lists the estimated production effect for grains and cotton of eliminating acreage reduction programs in the United States.[6] The different slippage assumptions imply a wide range of possible production effects. For corn, the difference between the no slippage case and the area and yield slippage case is quite large (12.1 million metric tons). For wheat, the difference is roughly half that of corn (6.2 million metric tons), while for other coarse grains, rice, and cotton, the difference is considerably smaller (2.2, 1.1, and .2 million metric tons, respectively).

Slippage assumptions are examined in the context of two elasticity specifications. The first retains the agricultural commodity supply elasticities used in ST86 at their default values.[7] The second specification uses supply elasticities set at half the default value for all commodities in all regions of the model. The elasticities are lowered to analyze the implications of assuming that resources are more fixed in agriculture than is currently assumed in ST86. For a multilateral trade liberalization scenario, this specification implies smaller world price increases. Greater U.S. excess supply and a lower foreign supply response to subsidy removal implies greater downward pressure (or less upward pressure) on world prices to keep world markets in equilibrium.

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[6]These estimates incorporate adjustments in world markets resulting from changes in commodity prices due to an increase in U.S. supply of grains and cotton. As a result, the production increases are slightly less than those estimated with fixed prices.

[7]See Gardiner, Roningen, and Liu (1989) for documentation of the elasticities used in ST86.

Table 5--U.S. supply shift and production slippage calculations for 1986

Commodity	Acreage Diverted 1/	Acreage slippage coefficient	Acreage returning to production	Yield slippage coefficient	Change in average yield	Observed area harvested	Observed average yield	Observed production	No-program area harvested	No-program average yield	No-program production	Estimated production impact	Supply shift factor	Production slippage coefficient
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Million acres		Million acres		Bushels per acre	Million acres	Bushels per acre	Thousand metric tons	Million acres	Bushels per acre	Thousand metric tons	Thousand metric tons		
Wheat	20.4	.25	15.300	.131	2.004	60.723	34.446	56,926	76.023	32.442	67,122	10,196	.179	.434
Corn	13.6	.39	8.296	.475	3.924	69.159	119.228	209,556	77.455	115.364	226,973	17,417	.083	.563
Other coarse grains 2/	4.5	--	4.500	--	--	32.726	--	42,730	35.496	--	45,739	3,009	.070	.497
Barley 3/	1.8	.34	1.188	.344	.409	12.007	50.847	13,293	13.195	50.438	14,490	1,198	.090	.394
Sorghum	2.3	.42	1.334	1.332	1.777	13.859	67.691	23,830	15.193	65.914	25,438	1,608	.067	.582
Oats	0.4	.38	.248	0	0	6.860	56.320	5,608	7.108	56.320	5,811	203	.036	.380
Rice 4/	1.3	.24	.966	540.0	521.618	2.360	5648.0	6,049	3.326	5,126.4	7,738	1,689	.279	.429
Cotton 4/	3.3	.37	2.079	5.4	11.227	8.357	547.0	2,073	10.436	535.8	2,536	463	.223	.423

-- = Not applicable.

1/ Includes acreage enrolled in the acreage reduction program (ARP) and paid land diversion programs (PLD). Land enrolled in the conservation reserve program is not included.

2/ The other coarse grains supply shift and production slippage coefficient are the weighted average of barley, oats, and sorghum.

3/ The estimated acreage slippage coefficient for barley was not significant in the Dvoskin study. The average slippage coefficient from Dvoskin is used for barley.

4/ Yield is reported in pounds for acre.

Notes and Sources:

Col. 1 : USDA, CCC Report.
Col. 2 : USDA, Dvoskin AER 580.
Col. 3 = [(Col. 1)*[1-(Col. 2)]].
Col. 4 : USDA, FAPSIM MODEL.
Col. 5 = (Col. 3)*(Col. 4).
Col. 6 : USDA, Crop Production, 1988.
Col. 7 : USDA, Crop Production, 1988.
Col. 8 : [(Col. 6)*(Col. 7)]*conversion factor.
Col. 9 = (Col. 3)+(Col. 6).
Col. 10= (Col. 7)-(Col. 5).
Col. 11= [(Col. 9)*(Col. 10)]*conversion factor.
Col. 12= (Col. 11)-(Col. 8).
Col. 13= (Col. 12)/(Col. 8).
Col. 14= 1 - [(Col. 12)/[(Col. 1)*(Col.10)]].

Table 6--Supply shift factors for the United States

Commodity	No slippage	Area slippage	Area and yield slippage
Wheat	.287	.250	.177
Corn	.175	.120	.083
Other coarse grains	.129	.089	.070
Rice	.529	.406	.276
Cotton	.363	.249	.223

Source: Calculated by the authors.

Table 7--US supply changes due to set-aside removal

Commodity	No slippage	Area slippage	Area and yield slippage
		1,000 Metric tons	
Wheat	15,802	13,538	9,591
Corn	23,252	16,057	11,169
Other coarse grains	4,769	3,285	2,607
Rice	2,213	1,701	1,158
Cotton	635	440	395

Source: Results from SWOPSIM ST86 multilateral trade liberalization scenarios.

The world price effects of agricultural trade liberalization under different slippage and elasticity assumptions are presented in table 8. For each commodity, the changes can be grouped around the elasticity assumptions. The world price changes corresponding to the default elasticity case are considerably larger than those corresponding to the low elasticity case. The low elasticity scenarios show the possibility of world price reductions for corn, other coarse grains, and cotton. Predicted price declines for these commodities are due primarily to the effect of diverted land coming back into production in the United States. The downward pressure put on world prices as a result of the increase in U.S. crop area outweighs the supply response in the United States and elsewhere to the elimination of domestic producer subsidies.

Table 8--World price effects of agricultural trade liberalization by the industrial market economies, 1986

Commodity	Default elasticities			Low elasticities		
	No slippage	Area slippage	Area and yield slippage	No slippage	Area slippage	Area and yield slippage
	Percentage change from base					
Wheat	27.0	29.7	33.2	9.6	13.8	19.2
Corn	14.8	20.9	25.6	-9.5	-1.7	4.6
Other coarse grains	18.0	20.5	22.6	-3.2	1.0	4.8
Rice	22.7	23.7	24.7	18.5	20.3	22.2
Cotton	5.3	8.4	9.3	-6.3	-1.6	-0.1

Source: Results from SWOPSIM ST86 multilateral trade liberalization scenarios.

Within each elasticity grouping, the slippage specifications show a range of world price outcomes. The most significant differences are for wheat and corn. The range of outcomes for the world price of wheat is 6 percentage points for the default elasticity case, and nearly 10 percentage points for the low-elasticity case. In 1986, area diverted under the programs for wheat was equal to about one-third of area harvested (20.4 million acres diverted versus 60.7 million acres harvested). The range of outcomes for corn is even larger: 11 percentage points for the default elasticity case and 14 percentage points for the low-elasticity case. The percentage of corn area diverted in 1986 was smaller (13.6 million acres diverted versus 69.2 million acres harvested), but the United States is a bigger player in global export markets. (U.S. exports accounted for 69 percent of world corn trade in 1986, compared with only 31 percent of world wheat trade.) Assumptions about how much of the acreage diverted in the United States will return to production have important implications for predicting world price changes following agricultural trade liberalization.

Predicted changes in U.S. supply and net trade are presented in table 9. In all but one case, the model predicts reductions in production and net trade for other coarse grains following multilateral liberalization. For cotton, the results depend on the elasticity used: supply and net trade reduction for the default elasticity case and expansion for the low-elasticity case.

The results for wheat, corn, and rice follow a similar pattern. For the low-elasticity case, there is expansion in both production and net trade. Here, the effect of reintroducing land idled under U.S acreage reduction programs and the world price effect dominate the effect of removing domestic producer subsidies. For the default elasticity case, there is uniform production and net trade expansion only for the no-slippage case. There are uniform declines in both production and net trade only when both acreage and yield slippage are accounted for. In this case, the effect of removing domestic producer subsidies dominates the effect of reintroducing acreage diverted in the United States and the world price effect.

These results illustrate the importance of assumptions regarding the effectiveness of U.S. acreage reduction programs and agricultural commodity supply elasticities. Large amounts of cropland were removed from production in 1986 under U.S. acreage reduction programs. Because the United States is a major producer and exporter of grains and cotton, assumptions made in modeling acreage reduction programs for these commodities significantly influence trade liberalization outcomes. Also, if agricultural resources are relatively immobile, even over a 5- year period, then the effect of multilateral liberalization on world agricultural production and trade will be substantially different from a situation where resources are free to move to other sectors of the economy.

Decoupling

The methodology used in ST86 assumes that the entire PSE is coupled to production. However, recent research suggests that provisions of the Food Security Act of 1985 have decoupled U.S. deficiency payments from actual production levels. In addition, other components of PSE's for U.S. grains and cotton -- such as agricultural research and extension programs, subsidized grain inspection services, grain storage subsidies, and interest subsidies -- may also be decoupled in the 5-year time frame used by the model. Therefore, an alternative scenario was run in which U.S. agricultural policies included in the PSE's for grains and cotton were assumed to be partially decoupled. In the alternative scenario reported below, the price wedges for U.S. grains and cotton were cut by 50 percent.

Table 10 shows predicted world price effects of agricultural trade liberalization from scenarios in which U.S. policies are assumed to be either fully coupled or partially decoupled. Assuming U.S. policies are partially decoupled results in smaller predicted increases (or larger predicted decreases) in world prices for grains and cotton following multilateral liberalization. The reason is that lower levels of support are removed for the United States, U.S. producers supply more, so world prices rise by less (or fall by more) compared with the fully coupled case. Corn is a good example. The base ST86 run (which assumed policies are fully coupled, accounted for both area and yield slippage, and used the default elasticities) predicted world prices would rise nearly 26 percent, while the decoupled scenario with similar slippage and elasticity assumptions predicted they would rise only by half that amount. The differences for the no-slippage case are even larger. The use of the reduced price wedges changes the direction of world price change only in two cases: cotton (no slippage, default elasticities) and corn (full slippage, low elasticities).

Table 9--U.S. supply and net trade effects of agricultural trade liberalization, 1986

Commodity	Default elasticities: No slippage	Default elasticities: Area slippage	Default elasticities: Area and yield slippage	Low elasticities: No slippage	Low elasticities: Area slippage	Low elasticities: Area and yield slippage
			1,000 Metric tons 1/			
			Supply			
Wheat	2,509 (4.4%)	723 (1.3%)	-2,352 (-4.1%)	8,902 (15.7%)	6,962 (12.2%)	3,518 (6.2%)
Corn	2,256 (1.1%)	-3,166 (-1.5%)	-6,915 (-3.3%)	15,230 (7.3%)	8,080 (3.9%)	3,070 (1.5%)
Other coarse grains	-5,529 (-12.8%)	-6,586 (-15.2%)	-7,036 (-16.2%)	284 (0.7%)	-1,061 (-2.5%)	-1,678 (-3.9%)
Rice	347 (8.1%)	-11 (-.3%)	-393 (-9.2%)	1,184 (27.7%)	760 (17.8%)	308 (7.2%)
Cotton	-76 (-3.6%)	-212 (-10.0%)	-244 (-11.5%)	323 (15.3%)	145 (6.9%)	102 (4.8%)
			Net trade			
Wheat	3,287 (12.3%)	1,505 (5.6%)	-1,472 (-5.5%)	9,475 (35.4%)	7,575 (28.3%)	4,316 (16.1%)
Corn	5,903 (15.1%)	2,107 (5.4%)	-510 (-1.3%)	15,352 (39.3%)	10,737 (27.5%)	7,565 (19.4%)
Other coarse grains	-8,034 (-107.7%)	-9,1[illegible] (-122[illegible])	-9,642 (-129.[illegible])	-2,448 (-32.8%)	-3,710 (-49.8%)	-4,279 (-57.4%)
Rice	397 (15.1%)	41 (1.6%)	-339 (-12.8%)	1,226 (46.5%)	805 (30.5%)	357 (13.6%)
Cotton	-69 (-4.7%)	-201 (-13.8%)	-231 (-15.9%)	314 (21.5%)	143 (9.8%)	102 (7.0%)

1/ Percentage change from base is reported immediately below the supply and net trade quantities.
Source: Results from SWOPSIM ST86 multilateral trade liberalization scenarios.

Table 10--World price effects of agricultural trade liberalization under differing decoupling assumptions, 1986

Commodity	Fully coupled		50 percent decoupled	
	No slippage	Area and yield slippage	No slippage	Area and yield slippage
	Percentage change from base			
	Default elasticities			
Wheat	27.0	33.2	18.5	25.0
Corn	14.8	25.6	2.9	13.9
Other coarse grains	18.0	22.6	10.7	15.5
Rice	22.7	24.7	20.3	22.6
Cotton	5.3	9.3	-1.0	3.2
	Low elasticities			
Wheat	9.6	19.2	3.9	13.7
Corn	-9.5	4.6	-16.0	-1.3
Other coarse grains	-3.2	4.8	-8.1	.2
Rice	18.5	22.2	16.5	20.4
Cotton	-6.3	-.1	-10.8	-4.4

Source: Results from SWOPSIM ST86 multilateral trade liberalization scenarios.

The supply effects resulting from different decoupling assumptions are shown in table 11. There are larger U.S. supply effects assuming that U.S. policies are more decoupled. A smaller negative U.S. subsidy effect is less of an offset to the production enhancing effects of reintroducing set-aside land and of removing foreign producer subsidies. Take wheat, for example. Using the default elasticities and assuming no slippage, the model predicts that U.S. wheat production will increase by nearly 17 percent when policies are assumed to be partially decoupled, compared with only a 4-percent increase when no decoupling is assumed. If acreage and yield slippage are both accounted for, the increase in wheat production is reduced to 7.3 percent for the partially decoupled case. However, when policies are assumed to be fully coupled, U.S production of wheat is predicted to decline by over 4 percent. The pattern is similar for the low-elasticity specifications, although no production declines are predicted.

Welfare Implications

Producer welfare will change if the trade negotiations are successful in eliminating subsidies affecting production and trade. Producer surplus is the economic measure used in the SWOPSIM modeling framework to account for changes in producer welfare (Haley and Dixit, 1988). Changes in producer surplus account for the changes in returns to fixed factors such as land and perhaps some forms of farm labor.

Table 11--U.S. supply effects of agricultural trade liberalization under differing decoupling assumptions, 1986

Commodity	Fully coupled		50 percent decoupled	
	No slippage	Area and yield slippage	No slippage	Area and yield slippage
	1,000 Metric tons 1/			
	Default elasticities			
Wheat	2,509 (4.4%)	-2,352 (-4.1%)	9,577 (16.8%)	4,178 (7.3%)
Corn	2,256 (1.1%)	-6,915 (-3.3%)	12,869 (6.1%)	2,689 (1.3%)
Other coarse grains	-5,529 (-12.8%)	-7,036 (-16.2%)	-1,017 (-2.4%)	-2,725 (-6.3%)
Rice	347 (8.1%)	-393 (-9.2%)	1,109 (25.9%)	262 (6.1%)
Cotton	-76 (-3.6%)	-244 (-11.5%)	215 (10.1%)	26 (1.3%)
	Low elasticities			
Wheat	8,902 (15.7%)	3,518 (6.2%)	12,721 (22.4%)	7,015 (12.3%)
Corn	15,230 (7.3%)	3,070 (1.5%)	21,061 (10.1%)	7,561 (3.6%)
Other coarse grains	284 (.7%)	-1,678 (-3.9%)	2,351 (5.4%)	193 (5%)
Rice	1,184 (27.7%)	308 (7.2%)	1,621 (37.9%)	690 (16.1%)
Cotton	323 (15.3%)	102 (4.8%)	512 (24.2%)	268 (12.7%)

1/ Percentage change from base is reported immediately below the supply quantities.
Source: Results from SWOPSIM ST86 multilateral trade liberalization scenarios.

Table 12 shows the changes in producer surplus corresponding to each of the modeling assumptions. For the fully coupled case, model results imply that there are substantial producer losses resulting from multilateral trade liberalization. In spite of relatively large gains in production, the producer losses from the low-elasticity case exceed those of the default case. Although the same unit subsidies are removed in both elasticity runs, lower world price

Table 12--Change in producer surplus in the United States from agricultural trade liberalization, 1986

Commodity	Default elasticities: Coupled	Default elasticities: 50 percent decoupled	Low elasticities: Coupled	Low elasticities: 50 percent decoupled
	Million dollars			
No slippage:				
Wheat	-4,479	-2,029	-5,169	-2,497
Corn	-8,312	-4,807	-11,125	-6,922
Other coarse grains	-1,785	-943	-2,177	-1,256
Rice	-998	-356	-835	-303
Cotton	-1,692	-907	-1,897	-497
Acreage and yield slippage:				
Wheat	-4,036	-1,739	-4,755	-2,174
Corn	-6,708	-3,412	-9,288	-5,207
Other coarse grains	-1,593	-812	-1,958	-1,081
Rice	-168	-379	-879	-364
Cotton	-538	-1,295	-1,784	-935

Source: Results from SWOPSIM ST86 multilateral trade liberalization scenarios.

changes in low-elasticity case limit producer gains. Also, because fixed costs form a higher percentage of total costs in the low-elasticity case, any negative effect on producers will more strongly affect resources fixed in the agricultural sector. Within each elasticity classification, our assumptions regarding area and yield slippage have little effect on producer surplus. The decoupled specifications show producer losses about 50 percent lower than the corresponding fully coupled specification. Although world prices do not increase as much in the coupled scenario, removing smaller initial price wedges leads to a smaller decrease in U.S. producer prices and, thus, producer welfare.

Conclusions

Deficiency payments and acreage restrictions are important components of U.S. agricultural programs for wheat, corn, other coarse grains, rice, and cotton. It is important that economists and policymakers concerned with the effect of agricultural trade liberalization understand the net effect of removing policies that distort production and trade. There are varying degrees of consensus regarding the effects of set-asides and deficiency payments on U.S. commodity production.

This report has presented results of sensitivity tests ERS's Trade Liberalization (TLIB) model. The effects of agricultural trade liberalization by the industrialized market economies were examined using different assumptions about slippage, model supply elasticities, and decoupling.The slippage assumptions deal with the method of projecting the effect on production of reintroducing land that had been set aside as a requirement for program participation. Either all land withheld from production is put back into production of program commodities or only a portion of it. Then, either average yields change as a result of the additional planted acreage or average yields are unaffected. These differing set-aside assumptions are shown to have significant effects on possible trade liberalization outcomes. Depending on the commodity, world price changes can vary by as much as 10 percentage points as a result of worldwide policy reform. The effect on U.S. net trade of wheat, corn, and rice is very sensitive to the average yield effect. In spite of these outcomes, the projected effects of trade liberalization on producer welfare are fairly close regardless of the set-aside assumption employed.

More significant challenges to ST86 results come from varying model supply elasticities that reflect the degree to which agricultural resources are believed to be immobile, that is, not transferable for use to other sectors of the economy. Also, the degree to which deficiency payments are assumed to be decoupled from production imply trade liberalization outcomes less severe than those implied in the base model solution. If additional research is to be performed, then higher returns are likely to be derived from examining the elasticity and decoupling issues rather than the set-aside issue.

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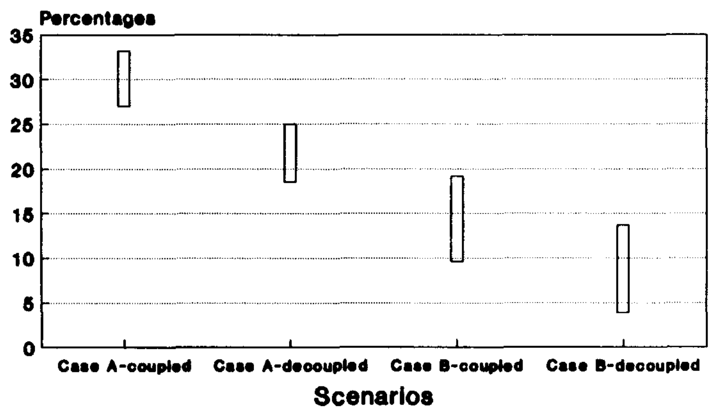
Appendix

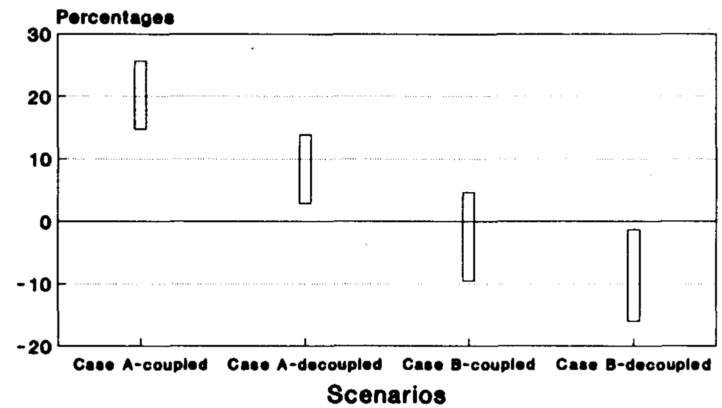
The results from tables 10 and 11 are depicted in the figures in this appendix. Figures 2-6 show world price changes for the grains products and cotton. The bars in each figure represent for a commodity the range of outcomes corresponding to the elasticity and decoupling scenarios. The top of a bar shows the outcome assuming both acreage and yield slippage, and the bottom of a bar shows the outcome assuming no slippage. Figures 7-11 show U.S. crop production changes corresponding to the same set of scenarios. In these figures, however, the top of the bar shows the no slippage case, while the bottom of the bar shows the acreage and yield slippage case.

Figure 2 **World Wheat Price Changes**
Results from Differing Scenarios



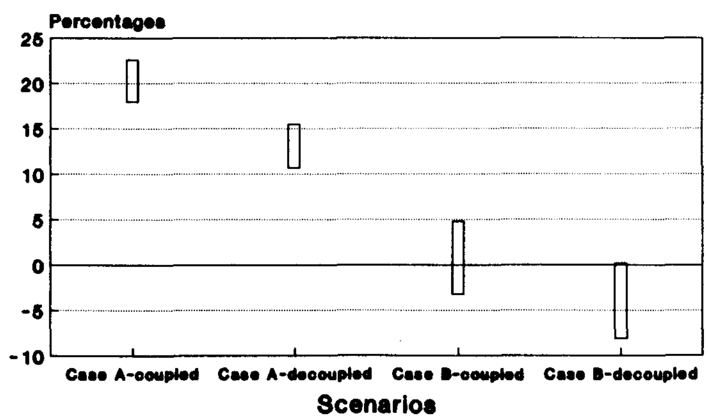
A = Default elast. B = Low elast.
Top of bar = full slippage.
Bottom of bar = no slippage.

Figure 3 **World Corn Price Changes**
Results from Differing Scenarios



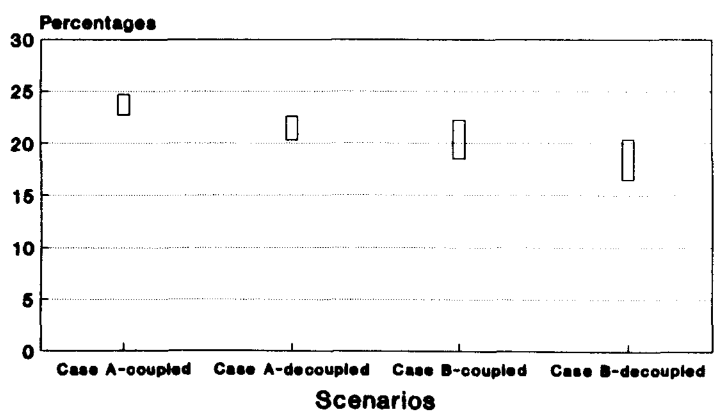
A = Default elast. B = Low elast.
Top of bar = full slippage.
Bottom of bar = no slippage.

Figure 4 **Other Coarse Grain Price Changes**
Results from Differing Scenarios



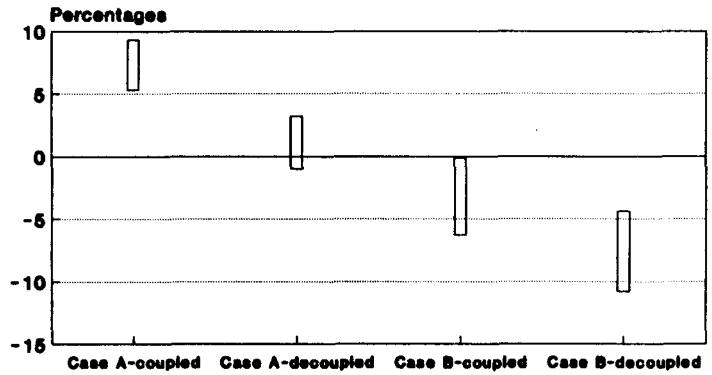
A = Default elast. B = Low elast.
Top of bar = full slippage.
Bottom of bar = no slippage.

Figure 5 **World Rice Price Changes**
Results from Differing Scenarios



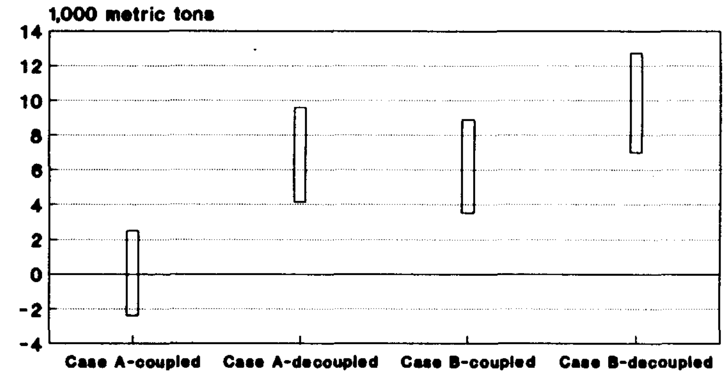
A = Default elast. B = Low elast.
Top of bar = full slippage.
Bottom of bar = no slippage.

Figure 6 World Cotton Price Changes
Results from Differing Scenarios



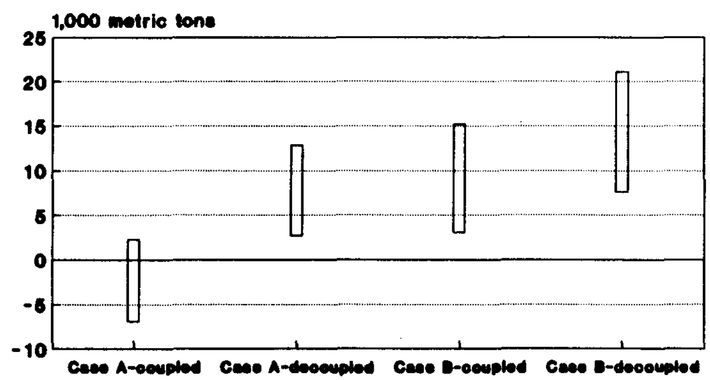
A - Default elast. B - Low elast.
Top of bar - full slippage.
Bottom of bar - no slippage.

Figure 7 Changes in Wheat Production
Results from Differing Scenarios



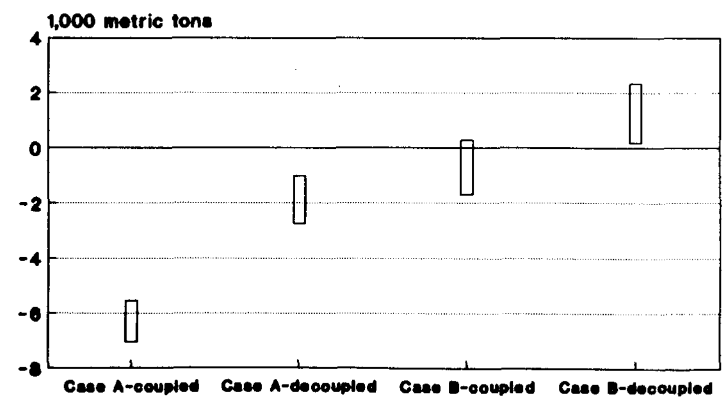
A - Default elast. B - Low elast.
Top of bar - No slippage.
Bottom of bar - full slippage.

Figure 8 Changes in Corn Production
Results from Differing Scenarios



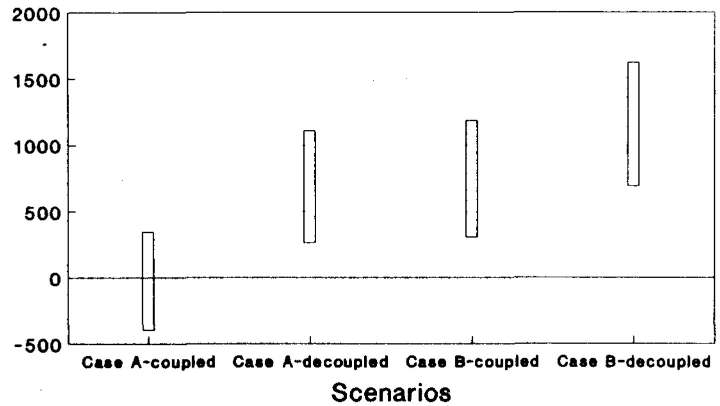
A - Default elast. B - Low elast.
Top of bar - No slippage.
Bottom of bar - full slippage.

Figure 9 Changes in Oth.Coarse Gr.Production
Results from Differing Scenarios



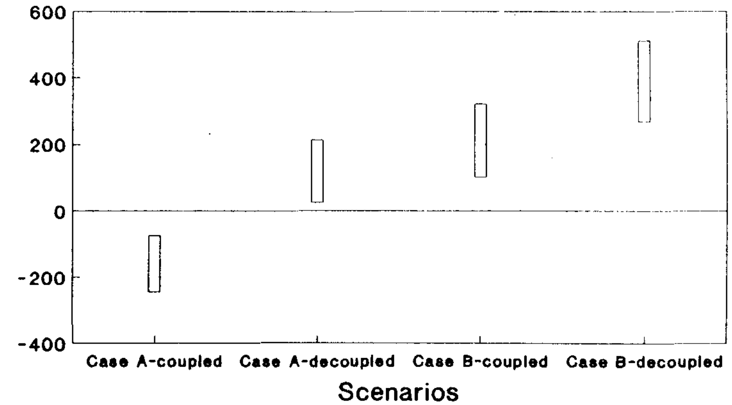
A - Default elast. B - Low elast.
Top of bar - No slippage.
Bottom of [illegible] - full slippage.

Figure 10 **Changes in Rice Production**
Results from Differing Scenarios



A = Default elast. B = Low elast.
Top of bar = No slippage.
Bottom of bar = full slippage.

Figure 11 **Changes in Cotton Production**
Results from Differing Scenarios



A = Default elast. B = Low elast.
Top of bar = No slippage.
Bottom of bar = full slippage.