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ABSTRACT

MEASURING AGGREGATE ELASTICITIES WITH A
MULTI-COMMODITY WORLD TRADE MODEL

By

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The effects of reducing grain prices in order to increase exports of U.S. agricultural products and reduce burdensome government stocks are measured in this study. The Michigan State University Agriculture Model, an annual, eleven-region simultaneous equation model is used to measure the price elasticity of export demand for U.S. wheat, feedgrain and soybeans. The prices of the three commodities are changed proportionally and simultaneously to capture an aggregate effect. Farm-level supply elasticities are calculated using change in harvested area to a supply variable and gross revenue per hectare as expected price. Export supply and import demand elasticities are calculated for regions other than the U.S. Farm level supply elasticities are low for most regions. Alternative specifications of revenue are explored. Price elasticity of export demand for U.S. exports is found to be very inelastic.

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CHAPTER I. INTRODUCTION

In order to reduce the burdensome level of grain stocks held by the government, the Food Security Act of 1985 reduced the loan rate, and hence the price, of major crop commodities. The reduced price was expected to increase U.S. exports of grains and soybeans and thus remove excess supplies of these crops from the U.S. market. The expectation that exports would increase was based on the belief that the net effect of a decrease in price would lead to a greater than proportional increase in demand for these crops, or that the price elasticity of export demand (PEXD) was greater than one. In that case, gross revenue from commodity sales would rise with a decrease in price.

The question of whether PEXD is less than, equal to, or greater than one can be investigated empirically by measuring the change in U.S. exports in response to a change in price with a mathematical model of agricultural trade. Frequently, the effects of price shocks are simulated on a commodity-by-commodity basis. However, the change legislated by the Food Security Act is a simultaneous reduction in the prices of all program crops. Since a simultaneous price change reduces the degree of substitution between commodities, the PEXD for a change in prices for all three commodity groups would reasonably be smaller (closer to zero) than for single-price changes. The smaller the PEXD, the less effective the new price policy in reducing excess stocks.

A model of agricultural trade may consist of a single demand equation for exports or of hundreds of equations that interact to determine exports and imports from internal supply and consumption equations. One such large model is the Michigan State University Agriculture Model (Ag Model). It is an annual, multi-region, multicommodity, long-range forecasting model. Its scope includes three commodities important to U.S. agriculture: wheat, feedgrains[1] and soybean products. The Ag Model does not include other crops that may substitute for these three on the farm, such as cotton, or in the world market, such as rice and other oilseeds, nor are effects on livestock considered. While some simplifications are necessary to model the complex world grain and soybean market, the structure of the Ag Model does allow analysis of several crops at once, as opposed to the single-commodity approach.

1.1 OBJECTIVES OF THE STUDY

This study uses the Michigan State University Agriculture Model (Ag Model) to measure the effects of reducing the loan rates of program commodities on world prices, trade and U.S. ending stocks and exports in particular. Attention is paid to the aggregate effect of a proportional price change on all three commodities as a group. The study calculates the short and long run supply elasticities of wheat, feedgrain and soybeans and measures PEXD using the Ag Model. Components of the PEXD are also considered, specifically the supply response of competing exporters at the farm level and the effect of imperfect price transmission between international and domestic markets.

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[1]Feedgrains include corn, sorghum, oats, barley and millet.

1.2 ORGANIZATION OF THE THESIS

In the following chapters, the measurement of PEXD and other elasticities is explained, executed and analysed. Definitions of the economic concepts used and a review of the literature regarding aggregate elasticities appear in Chapter 2. Chapter 3 deals with farm-level supply response and the choice of variables. Chapter 4 contains a more in-depth study of two of the Ag Model's eleven regions. Finally, in Chapter 5, the Ag Model is solved to calculate export supply, export demand, import demand and harvested area elasticities. A summary of the results of the three preceding Chapters and conclusions are presented in Chapter 6.

CHAPTER II. THEORY AND LITERATURE REVIEW

The economic measures used in this study to evaluate the responses of producers to price are defined in Chapter Two. Previous theoretical and empirical investigations are reviewed. In addition, the policy context that makes the question of producer price response relevant is described.

2.1 PRICE ELASTICITY OF EXPORT DEMAND (PEXD)

PEXD is the change in a country's exports of a commodity resulting from a one percent change in the price of that commodity. When PEXD is measured by a single equation, all other variables are held constant. When this value is determined by a system of equations that allows all variables to adjust, it is closer to an impact multiplier than a true elasticity because other endogenous variables are allowed to adjust to change in price (Gardiner and Dixit, 1987). An impact multiplier is the coefficient on a predetermined variable in a reduced form equation in a multi-equation system (Kmenta, 1986). When the relationship is measured over time, it is called an n-period impact multiplier. However, the elasticities reported in this study are expressed as percent changes, which are unitless, rather than simply as coefficients. Therefore, elasticity will be used in this discussion to describe both the single-equation measure reported for some studies and the multi-equation measure resulting from the Ag Model and from other studies.

In the short run, PEXD typically accounts for adjustments in net demand for exports, which include changes in excess supply in competing countries, but does not account for changes in output. Agricultural output cannot adjust immediately to price changes because crops are produced only once a year. In the long run, one year and over, PEXD also incorporates changes in production, in government policies, and in macroeconomic factors, such as exchange rates. However, prices of other goods and the supply of and demand for them, tastes and preferences, income, technology and population are all assumed constant when determining PEXD (Gardiner and Dixit, 1987).

Knowledge of PEXD is of critical importance to policy makers in that it determines whether revenue will increase or decrease as a result of a price change. If the absolute value of PEXD is greater than one, it is elastic, meaning that a drop in price will lead to a greater-than-proportional increase in the quantity exported and revenue is increased by decreasing price. Conversely, when the absolute value of PEXD is less than one, it is inelastic and the quantity exported will respond less than proportionally to the price change. Revenue is maximized in this case by increasing price. In the case of unitary elasticity, the absolute value of PEXD is equal to one, price and quantity change proportionally and revenue is unaffected by price changes (Gardiner and Dixit, 1987). In general, the lower the price, the greater the quantity demanded, thus a negative sign is expected for demand elasticities. In contrast, the higher the price, the more is supplied, yielding a positive sign on supply elasticities. Because PEXD is a net demand elasticity, a negative sign is expected.

2.11 Factors Affecting PEXD

Several factors influence elasticity (Gardiner and Dixit, 1987). One is the availability of substitutes, a second is the share of the total budget that the product holds and a third is the extent to which the product is considered a luxury versus a necessity. In general, the elasticity will tend to be higher the greater the number of substitutes, the smaller the budget share it claims, and the less necessary it is. Demand for food as an aggregate is generally considered to be inelastic because it is a basic necessity and because there are no substitutes. For an individual commodity, such as wheat, however, demand will tend to be more elastic, because other substitutes exist. The greater the substitutability, the greater the elasticity is likely to be.

In the case of a country that is small relative to the world market, the quantity of exports from that particular country will not be sufficient to perceptibly affect world price. Since many alternative suppliers exist, the country theoretically faces a perfectly elastic demand curve. In the case of the U.S., it is a large country relative to share of world exports. The quantities exported by the U.S. (38 percent of net world trade (excluding intra-regional trade) in wheat, 73 percent of feedgrain trade, and 87 percent of soybean trade in 1984) have a significant impact on world price. Because U.S. share is large and the quantity available from competitors is relatively small, one would expect PEXD to be less elastic for the U.S. than for a country that held a smaller market share.

Government interventions in the markets for agricultural commodities also affect elasticities. For example, price supports, set-aside programs and export subsidies restrict the responses of market participants by insulating them from market variations. An elasticity measured from such a constrained market is likely to be considerably smaller (more inelastic) than a value that would be observed in a completely free market (Peterson, 1981).

2.12 Methods of PEXD Estimation

Gardiner and Dixit (1987) surveyed forty five studies that estimate PEXD for U.S. wheat, feedgrains, soybeans and other crops. The estimated short run elasticities range from -.14 to -3.3 for wheat, -.30 to -1.51 for feedgrains, and -.14 to -2.00 for soybean products. Differing sample periods and assumptions about the existence of free trade or government interventions may in part explain the large range of empirical values observed. From these studies, no clear consensus emerges as to the actual values of these elasticities, nor even whether they are elastic or inelastic.

Common techniques for measuring PEXD include a) direct estimation of one single equation for the excess demand of the rest of the world; b) calculation of PEXD by summing net supply and demand for all countries; c) simulation of the entire international market for a commodity or group of commodities; and d) synthetic methods which simulate the market using elasticities obtained from other models. The greater the complexity of the modelling effort, the more likely that the model accounts for the many variables that determine PEXD. These include supply and demand shifters for all countries, governmental actions and international agreements, and financial factors such as exchange rates and foreign exchange reserves. (Gardiner and Dixit, 1987)

Tweeten (1967) characterizes PEXD as:

$$PEXD_{US} = \sum_{i=1}^{n} \left[E_{di} * E_{pi} * \frac{Qdi}{Oef} - E_{si} * E_{pi} * \frac{Qsi}{Cef} \right] \qquad E_{pi} = \frac{\partial Pi}{\partial Pworld}$$

where:

E_{si} and E_{di} = domestic price elasticities of supply and demand in country i

Q_{si} and Q_{di} = quantities supplied and demanded in country i

O_{ef} = U.S. farm exports

E_{pi} = Price transmission elasticity for country i

This is a calculation method of determining PEXD, the percent change in U.S. exports resulting from a percentage change in the commodity's own price. In Tweeten's, and many other studies (Johnson, 1977, Gardiner & Dixit, 1987), E_{pi} is assumed to be one. That is, world prices transmit perfectly to internal prices in each country.

2.13 Price Transmission

Price transmission is the degree to which world price fluctuations are passed across a country's border to it's internal market. Complete transmission would occur if price changes passed immediately between markets. However, many countries are observed to insulate their internal markets from the price variability of the world market (Bredahl, Meyers, and Collins 1979). In these cases, price transmission is low. The Common Market has an explicit variable levy that precisely taxes away the difference between the world price and the supported internal price. In other regions, the insulation is less obvious and less absolute.

Many studies have shown evidence of insulation to some degree. Bredahl and Green (1983) tested statistically for "causal" relationships between harvested crop areas and world prices and found no significant relationship for large exporters of coarse grains other than the U.S. Causality was only significant between exports and world price of coarse grains for France and the U.S.

Bolling (1986) calculated price transmission elasticities in western hemisphere countries and reported values ranging from .07 (wheat in Mexico) to 1.0 for crops of interest. Low price transmission elasticities represent significant insulation from the world market and partially account for inelastic supply responses to world price.

2.2 AGGREGATE RESPONSE

A variation of the normal elasticity calculation is an impact multiplier that is measured by estimating changes in quantities that result from changing prices, but holding relative prices between the commodities being measured constant. If wheat, feedgrain and soybean prices are changed proportionally, substitution effects between crops are eliminated. The resulting elasticity reflects only an aggregate response on both the demand and the supply side to changes in price. This aggregate elasticity would logically be expected to be less elastic than a single commodity elasticity. On the demand side, aggregate elasticity is reduced because the consumer has fewer alternatives than when an individual commodity price is changed while other prices are held constant. By the same token, supply is less elastic because substitution between outputs is eliminated.

Not only is aggregate elasticity less elastic than a single commodity elasticity, but the characteristics of agricultural supply and demand increase the likelihood that this elasticity would be low. In general, aggregate agricultural supply tends to be very inelastic because specialized inputs such as farmland and farm machinery often have no alternative use that would yield an income comparable to agriculture. If the individual farmer decides to reduce his or her hectarage, the land in question is usually rented or sold to another farmer who keeps the land in production. In other words, farm input supply is highly inelastic. Hectarage remains relatively constant in the face of price fluctuations. Although cropland area trends upward as new areas are cleared and as increasingly marginal land is brought into production when prices are favorable.

Cochrane (1958) has suggested that agricultural supply may be characterized by irreversibility. In other words, producers respond more strongly to increases in price than they do to decreases. For a given year, he maintains that agricultural supply in the aggregate is almost completely inelastic. When farm prices are high, farmers adopt new technologies in order to reduce their production costs. Once adopted, new technology increases output per unit of land or labor. Although the supply curve is steep, the quantity supplied expands because the curve is shifting to the right. In times of low prices for agriculture, new investments are not made and the quantity supplied changes very little, since the supply curve is inelastic. This differential response to price changes causes an irreversibility in agricultural product supply. While farmers will respond to increased prices with increased production, a drop in price has little effect on the quantity supplied.

Cochrane described the cycle of continually increasing agricultural productivity as a treadmill (1958). Farming is an atomistic industry where the individual normally is not able to alter price. Early adopters of new technology benefit by reducing their costs, which they can control, but the technological changes do not affect price initially because the adopters are few in number. The price of the crop falls as more and more farmers' costs are reduced and the average farmer's profit margin is squeezed. Average and lagging farmers are then forced to adopt the technology in order to compete. As a significant number of farmers adopt the technology, cost, hence price, falls for a given quantity, or production expands at a given price. In other words, the supply curve shifts to the right. Farm incomes decline as crop prices come to reflect the lower costs of production and excess profits to early adopters are eliminated. As newer still technologies are invented, farmers innovate to capture the cost savings and the cycle repeats itself. Cochrane's focus is not simply on measurement of elasticities, but on how the production possibilities frontier changes.

There are few empirical estimates of aggregate elasticities in the literature. Tweeten (1967) attempted to estimate the elasticity of demand for all U.S. farm output. He obtained a farm-level elasticity of -0.55 in the intermediate term (3-4 years) and -1.1 in the long run. Tweeten listed sources of possible error in his estimates but the net effect of these potential errors is impossible to discern. However, his elasticities were weighted sums of elasticities estimated for categories of consumption for food or for individual food commodities and cotton and tobacco. Further, he based his estimation on free trade and attempted to correct for institutional barriers to it rather than measure an elasticity based on the current set of political institutions.

Cochrane (1958) estimated the elasticity of domestic demand for food at retail in the twentieth century. The short run elasticity given was approximately -0.16 for the period 1950-55, the most recent time period estimated. He suggested (1965) that the farm-level elasticity may be slightly more than half the retail figure. Other studies of domestic aggregate demand published in the early 1960's (Brandow, 1961, Burk, 1961, Waugh, 1964) gave low farm level elasticities of less than -0.2. Buiding on his recent study of domestic food demand, Huang (1985) has calculated an aggregate demand elasticity for food in the U.S. His estimate of -.13 at retail may be considered an upper bound on the farmgate elasticity since demand for food products at the farm level is less elastic than retail demand. This study is based on 1953-83 data and suggests that domestic price elasticity of demand for farm products is very low.

2.3 POLICY RELEVANCE OF PRICE ELASTICITY OF EXPORT DEMAND

Because PEXD is a succinct measure of the effects of price changes on revenue, it is an important variable to policymakers. The crucial question - whether it is elastic or inelastic - shapes the choice of pricing policies. A current issue of concern in the U.S. is the high levels of grain stocks that have accumulated as a result of high domestic support prices. If the PEXD is elastic for wheat and feedgrains, these stocks can be decreased by lowering the prices of these grains. The reverse will occur, stocks will pile up when prices are lowered, if in fact the PEXD's are inelastic.

These excess stocks exist because farm prices have been supported by the government above world market equilibrium levels in order to protect domestic farm incomes. Profitable returns stimulate production by attracting more resources into agriculture and by encouraging innovation which raises the productivity of resources already invested in agriculture. In addition, at high prices, the quantity demanded is below the equilibrium quantity and even farther below the amount supplied, hence stocks accumulate. While some level of stocks is desirable to stabilize the market in short crop years, consistent overproduction has led to levels of stocks that greatly exceed the desired quantity and are costly to maintain.

Because domestic demand for grains is extremely inelastic (Cochrane, 1958; Tweeten, 1967), attention turns to the export market. The more elastic demand is, the less price must fall in order to bring supply and demand into balance. The low elasticities of domestic supply and demand indicate that there must be a sharp decline in prices in order to reach equilibrium. Cochrane (1965) estimated that in the early 1960's agricultural prices would need to fall by as much as 40 percent to achieve balance. Such a drop, he maintained, would reduce net farm income in the aggregate by as much as 60 to 70 percent.

If, on the other hand, the demand for exports is elastic, gross returns would rise because the expanded quantity demanded would more than offset the decrease in price. Lowering the price of grains, therefore, is based on the expectation that PEXD exceeds one. Many economists support this notion at least for individual commodities

(Gardiner and Dixit, 1987). For example, Schuh (1984) has argued that demand for exports should be highly elastic because importers are buying quantities of grain that are small relative to their domestic production. Tweeten's (1967) estimate of aggregate demand for farm output averaged inelastic domestic demand with a very elastic export demand of -6.42. More recent estimates of individual commodity prices range up to -10.2 for coarse grain in the long run (Johnson, 1977).

The actual value of PEXD for U.S. agricultural commodities is unknown because it is difficult to observe in isolation, because the value changes over time with new developments in technological innovation and governmental policies and because the actual situation with its many market imperfections differs considerably from the theoretical case. The latter reason in particular may be an argument that highly elastic estimates of PEXD are biased upward. Many of the studies cited assume free trade or make simplifying assumptions that reduce the insulating effects of government policies.

The elasticities of supply at the farm level in other regions of the world affect PEXD as do demand responses. The same factors that make farm supply inelastic in the U.S. would be expected to apply in these countries as well. If PEXD is in fact inelastic, lower agricultural prices do not alleviate the problem of excess stocks. More importantly, the drop in price is not offset by increased quantity and farmers could suffer significant loss of income. Thus the impact of decisions based on this simple calculation are of considerable importance to agriculture.

CHAPTER III. MEASURING SUPPLY RESPONSES

This chapter is focussed on the measurement of elasticities implied by the Ag Model structure, particularly supply responses. First, the Ag Model itself is briefly described.[1] Then, supply response is described and measured. Special attention is paid to the aggregate response of hectarage to revenue changes and to how closely these two variables approximate the theoretical relationship measured by a supply elasticity.

3.1 THE AG MODEL

The Ag Model was constructed to simulate international trade of wheat, feedgrains and soybean products - beans, meal and oil - by dividing the world into eleven regions. The U.S., Argentina, Brazil, Australia, Canada, and China are each modelled separately. The remainder of the world is divided into five economic regions. The Developed Markets include Western Europe, Japan and South Africa; the Soviet Bloc is composed of Eastern Europe and the USSR; the Oil-Exporting Low Income Countries are Organization of Petroleum Exporting Countries, excluding Gabon and Qatar, plus Oman; the Newly Industrialized Countries are a small group of rapid-growth nations -

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[1]Shagam (1986) describes the structure and statistical validity of the Ag Model in detail.

Hong Kong, Singapore, Taiwan, Malaysia and South Korea; and the Low Income Countries include the rest of the world (See Appendix 1).

Within each region, the equations are arranged to solve sequentially for domestic supply and demand. The net import and export equations interact with those of other regions of the model and with price to determine price and quantities simultaneously. Yield is determined exogenously as a function of trend and harvested area is based on lagged harvested area and lagged revenues per hectare. From these estimates, production is calculated as an identity (harvested area times yield). Consumption is estimated for exporters from price and income and for importers, consumption is calculated as a residual. Net imports are estimated from income and price or policy variables. Ending stocks are a function of domestic production and consumption, net imports where applicable and policy variables for importers and exporters other than the U.S. and Canada (where it is calculated as a residual). Net exports for Canada are a function of residual demand from the rest of the world and are calculated as a residual the U.S. and for other exporters. Except for price, each equation contains only predetermined variables.

The Ag Model is structured on the concept of the U.S. as a residual supplier of grain and soybeans to the world. In practice, the U.S. domestic price, supported for domestic farm policy reasons, sets a floor for the world price because of the large volume of grain stocks and world exports controlled by the U.S. (MacGregor and Kulshreshtha, 1980). Other exporting countries are able to price slightly below the U.S. and export most or all of their excess stocks. When this supply is exhausted, importers turn to the U.S. to satisfy the remainder of their needs (McCalla, 1966; Bredahl and Green, 1983).

The Ag Model formulation approximates this market structure by assuming that competing exporters other than Canada are "surplus exporters." These "surplus exporters" do not hold large stocks, but instead export all surplus production at or slightly below the world price. They do not necessarily subsidize exports substantially below world price. Canada is considered to be a "contingent surplus exporter" that competes in an oligopolistic way with the U.S. for the residual pool of import demand. The remaining unsatisfied import demand is filled by the U.S. (McCalla, 1966).

If the residual supplier structure is correct, the supply response of competing exporters must be extremely inelastic with respect to world price (Bredahl and Green, 1983). Inelastic price response would be characteristic of countries that only hold enough ending stocks to satisfy domestic needs. These countries would export any excess supply at whatever price is necessary in order to dispose of the stocks and the U.S. would hold all excess stocks for the world.

On the other hand, if exporting countries are price elastic, they would hold stocks for speculative reasons when prices are low and sell them when world market prices are higher. Which countries are holding the residual stocks would be indeterminate because the stocks could be spread amongst all the exporters evenly or one or more countries could hold all excess stocks.

The case where competing exporters are inelastic to price is the simpler case to model because it ignores the specific distribution of stocks amongst countries and assumes that the U.S. holds all excess stocks. This structure, with modifications for Canada to hold some stocks, is chosen because it approximates the world market system more closely than a purely competitive model (McCalla, 1966; Bredahl and Green, 1983).

Support for the assumption of inelastic surplus exporters can be found in Australia, for example, where domestic consumption is small relative to exports. Excess stocks resulting from changes in price cannot be absorbed in the domestic market. Therefore, Australia relies on the international market to adjust stocks (Goodloe, 1984). Limited storage capacity further encourages the Australian Wheat Board to dispose of as much grain as possible each year (Spriggs, 1978).

The U.S. Gulf price is considered to be the world price in the Ag Model. Not only does the U.S. occupy a large share of the world market, the U.S. market is relatively open. U.S. prices are therfore used as the basis for pricing decisions in other countries. (MacGregor and Kulshreshtha; 1980, McCalla, 1966; Spriggs, 1978). According to Gilmour and Fawcett (1986),

> "Wheat prices in the United States establish the competitive standard for most wheat entering world trade. Their visible and competitive pricing process provides a convenient branchmark (sic) from which other exporters can establish their export prices."

Prices for each region are handled by converting the world price, as defined by the U.S. price, to a border price. Border price is obtained by converting world price to local currency through the exchange rate and deflating by the local consumer price index. Production and net trade, therefore, are estimated with respect to this converted world price.

The Developed Makets and the Soviet Bloc are exceptions to the method of determining price described above. In the case of the Developed Markets, where consumers and producers are well insulated from world prices, internal European Economic Community (EEC) producer prices are used to estimate supply and demand. For the Soviet Bloc, policy variables are used in place of price variables because the economy of this region is not based on a market with prices that carry information about relative cost or utility.

The transmission of world price to internal economies is not addressed directly in the Ag Model because domestic prices are not used, except in the Developed Markets. There, price transmission is assumed to be zero. The effects of government policies that separate the domestic market from the world market, such as tariffs and subsidies, are implicitly incorporated by observing quantities produced, consumed and traded.

Economic, rather than geographical, aggregation of regions makes monitoring of international transportation costs impractical. Because the focus of the model is on net effects rather than on the specific pattern of trade flows, transportation costs are assumed to be constant.

3.2 MEASURING SUPPLY ELASTICITIES

PEXD is the net effect of the demand responses of importers and the supply responses of competing exporters to a price change. Before measuring PEXD, individual supply elasticities for each country are calculated at the farm level from the harvested area equations. These harvested area elasticities affect export supply at the national level. It is the interaction of the farm- and national- level supply responses of each region with the internal consumption and import demand equations that determines PEXD.

Use of the term "supply elasticity" to describe the harvested area response at the farm level may be misleading. Production is calculated in each country or region as an identity, the product of harvested area and yield. With yields determined exogenously, it is harvested area that responds to price and other variables in the model, but it does not equate with supply. The farm-level acreage response is carried through to the national and international levels and thus understates the supply response throughout the system because factors other than acreage that affect farm-level supply are not captured. The "supply elasticity" in this case measures percent change in a single input with respect to percent change in price rather than percent change in output with respect to percent change in price. Since other inputs are excluded, the elasticities in this study are expected to be lower than ones which measure outputs.

Price elasticity of supply can be calculated by adding the elasticities of each component of production (Chiang, 1974):

$$E_S = \frac{dPRO}{dP} * \overline{P}/\overline{PRO} = \frac{dHA}{dP} * \overline{P}/\overline{HA} + \frac{dY}{dP} * \overline{P}/\overline{Y} = E_{HA} + E_Y$$

where:

E = elasticity
S = supply
Y = yield
PRO = production
HA = harvested area
P = price

Harvested area is estimated in the Ag Model using a partial adjustment framework after Nerlove (1958). The generic form includes lagged harvested area, lagged revenues for own and substitute crops and other variables as follows:

$$HA_{ij} = f(HA_{ij}(-1), REV_{ij}(-1), REV_{kj}(-1), Z)$$

where:

HA_{ij} = harvested area for commodity i in region j,

$HA_{ij}(-1)$ = harvested area, lagged one period,

$REV_{ij}(-1)$ = gross revenue per ha, commodity i, lagged one period,

$REV_{kj}(-1)$ = gross revenue per ha, commodity k, lagged one period,

Z = other relevant variables including time trend, policy proxy. See also Shagam (1987) and Mitchell (1983).

Use of the lagged harvested area structure assumes that a) farmers only partially adjust to a change in expected price in any given year due to uncertainty, high costs of change or other factors; and b) farmers use the previous year's price as an estimate of the current year's price. Revenue is measured on a per hectare basis - price per ton times a four year moving average of yield in metric tons per hectare. Yields are averaged in order to even out the impact of drought years on revenue.

Crop yield is a variable that is difficult to model accurately. The major determinant of yield is weather, which is a stochastic factor, unaffected by economic variables. Advances in technology (including improved plant varieties and new methods of disease and insect control) and the use of fertilizer are two dominant considerations in addition to weather. Weather causes large changes in yield from year to year, while the effects of technological improvements on yield tend to be gradual and unidirectional. In view of the difficulty in predicting weather, yield is simply estimated as a function of a time trend (Mitchell, 1983). The trend variable represents factors that change gradually over time and is intended to incorporate changes in technology.

If price is not included in the yield equation, then E_y is implicitly assumed to be zero. If $E_y = 0$, then $E_S = E_{HA}$, or $dHA/dP * \overline{P}/\overline{HA}$. In the case of the Ag Model, the elasticity calculation is complicated by including yield with the price variable to generate revenue as described above. A further complication is that yield is not simply the value for the current year, but a moving average of the previous four years.[2] Therefore, the elasticity that is calculated is:

$$\frac{dHA}{d(P*Yavg.)} * (\overline{P*Yavg.})/\overline{HA} \quad \text{as opposed to} \quad \frac{dHA}{dP} * \overline{P}/\overline{HA}.$$

The difference between results from these two formulations may not be significant. However, the inclusion of yield may make the revenue variable less volatile than price alone. The smaller the variability in a regression variable, the greater the standard error in its coefficient, all other things equal. Therefore, revenue elasticities may be statistically less precise than price elasticities.

Short run and long run revenue elasticities are calculated from the estimated equations for each region, except the Soviet Bloc, where price variables are not used.

$$E_{\text{Short Run}} = \beta * \overline{P}/\overline{HA} \qquad E_{\text{Long Run}} = \frac{\beta}{(1-\lambda)} * \overline{P}/\overline{HA}$$

The short run in this case is the first year harvested area response, while the long run is greater than one year.

For importing countries, import demand is estimated with a single equation. Price elasticities of demand are calculated for those

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[2]For soybeans, the four-year moving average was replaced by a time trend in order to conserve degrees of freedom.

equations that contain price variables. These elasticities appear in Appendix 2. However, many equations include policy variables, rather than price variables, which account for government actions to insulate domestic producers from price fluctuations. Hence, net import demand elasticities for all regions are calculated by observing the change in model results when price is changed. These elasticities are found in Tables 5 and 9 in Chapter 5. For a detailed discussion of importer behavior within the Ag Model, see Wilde, et al. (1986).

Table 1 presents the harvested area supply elasticities calculated from Ag Model results. All regions of the model show inelastic supply for all commodities in the short run. In most cases, long run supply is also inelastic. The notable exception is Brazil, where both long run elasticities that are calculated exceeded one.

While these results suggest that farmers' responses are inelastic to price changes, they should be interpreted with some caution because they are measured from harvested area, an input, rather than from total supply, the output. Nerlove (1956) has suggested that "the elasticity of acreage is probably only a lower limit to the supply elasticity." If these elasticities are viewed merely as minimums, then the minimums are quite low and do not provide much information about the true value of the elasticity. Greater restrictions on the harvested area equations may imporve the precision of the elasticities. However, the use of harvested area rather than supply, and revenue rather than price, raises uncertainty in imposing standard restrictions. More robust estimations may be obtained with a less restricted model than with an incorrectly restricted model (Beattie and Taylor, 1985).

TABLE 1: Revenue Elasticities of Supply at Farm Level

	Short Run	Long Run	Cross Revenue	Sample Period
Argentina				
Wheat	.327	.474	-.407 (S)	'65-'84
Feedgrain	.291	.461	-.372 (W)	'64-'83
Soybeans	.341	11.470	-.165 (W)	'65-'84
Brazil				
Wheat	.670	3.050	-.605 (F)	'64-'84
Feedgrain	.573	-	-.312 (W)	'68-'83
			-.161 (S)	
Soybeans	.184	1.743	-.053 (F)	'68-'83
Australia				
Wheat	.095	.488	-.360 (F)	'64-'84
Feedgrain	.354	-	-.667 (W)	'64-'84
Wheat (new)	.097	1.744	-.097 (F)	'64-'84
Feedgrain (new)	.650	-	-.650 (W)	'64-'84
Canada				
Wheat	.098	.207	-.467 (F)	'64-'84
Feedgrain	.361	1.400	-.260 (W)	'64-'84
Developed Markets				
Wheat	.436	1.949	-.285 (F)	'64-'83
Feedgrain	.196	.354	-.214 (W)	'64-'83
Soybeans	.098	.436	-1.053 (F)	'65-'83
Low Income Countries				
Wheat	.055	8.670	-.111 (F)	'64-'84
Feedgrain	.103	.200	-.073 (W)	'64-'83
Soybeans	.121	.309	-.530 (F)	'65-'83
Newly Industrialized Countries				
Wheat	.831	7.931	-.936 (F)	'64-'83
Feedgrain	.394	.607	-.122 (W)	'64-'83
Soybeans	.164	.258	-	'65-'83
U.S.				
Wheat	.195	.390	-.208 (F)	'64-'84
Feedgrain	.376	.430	-.249 (W)	'64-'84
Soybeans	.367	1.453	-.343 (F)	'65-'84
Oil-Exporting Low Income Countries				
Wheat	.169	.173	-.343 (F)	'64-'83
Feedgrain	.238	-	-.104 (S)	'68-'83
Soybeans	.200	.311	-.197 (F)	'64-'82
China				
Wheat	.072	.106	-	'64-'84
Feedgrain	.111	.493	-.074 (W)	'64-'84
Soybeans	-	-	-.167 (F)	'65-'84

While the cross elasticities are all inelastic with one exception (soybeans in the Developed Markets), many of them are larger than the short run and even the long run own-revenue elasticities in the same equation. These relatively strong cross elasticities indicate that substitution between crops is an important factor in predicting farm level response to price. In some cases, it is possible that these elasticities overstate the effect of a competing revenue. This may be the case where some overriding factor is overlooked in the specification. Multicollinearity may also blur the distinct effects of the price variables. An example of large cross-elasticities that will be discussed in detail in subsequent sections is that of Australia.

The cross-elasticities for both crops exceeded the own-elasticities in the short run and also in the long run for feedgrain. Because wheat is the dominant crop in Australia, its revenue could reasonably have a strong influence on feedgrain hectarage. However, it is unrealistic that the reverse should be true at the same time - that feedgrain revenue would be more important in wheat harvested area than wheat revenue. One factor at work in this situation may be land clearing that brings more cropland into production despite a downward trend in both grain prices. A second factor is the degree to which the revenue variables move in the same direction. The competing revenue variables in both equations pick up the negative sign associated with downtrending revenue but it is difficult to separate the effects of the two variables when they are collinear. New equations are estimated that constrained the cross-elasticities to equal the own-revenue elasticities. While such a restriction may not be completely correct, a ratio of revenues reduces multicollinearity problems by halving the number of revenue variables in the equation. These results appear under Australia and are labeled "new."

3.3 AGGREGATE RESPONSE

3.31 Measuring Aggregate Supply Responses

Supply response includes the effect of substitution between crops and that of overall contraction or expansion of area. Relative price changes induce substitution between crops rather than a shift in total harvested area. On the other hand, when all prices change simultaneously, substitution amongst crops will be minimal and the dominant effect will be an overall change in total harvested area. The net effect on all three crops is an aggregate response.

In order to measure the behavior of aggregate area, it must either be modelled directly, which focuses on the aggregate response, or with each crop modelled separately, which focuses on the individual response. The estimated areas are then summed over the three crops to arrive at a total harvested area, or cropland base. The formulation of the Ag Model follows the latter method because the intent is to capture the dynamics of each commodity.[3]

Cropland base of the major exporters is estimated directly to compare the accuracy of this method to that of the summation method. For each country, an average revenue, weighted annually by the proportion of each crop's area, is calculated as follows:

$$REV = \sum_{i=1}^{n} \left[\frac{HA(j)}{CLB} * \text{4-yr avg. yield}(i) * Pw * \frac{XR(j)}{CPI(j)} \right]$$

---

[3]Land that is double-cropped is counted as twice the area.

where:

REV = average weighted revenue,

HA(i) = harvested area for crop i,

CLB = cropland base, sum of the harvested areas,

yield(i) = metric tons per hectare of crop i,

Pw = world price,

XR(j) = exchange rate for country/region j,

CPI(j) = consumer price index, country/region j.

Cropland base is regressed using ordinary least squares in a Nerlovian adjustment framework on lagged values of the weighted average revenue:

CLB = f(CLB(-1), REV(-1)).

A weighted average of revenues is used because of high correlation between prices. Multiple prices would increase the likelihood of multicollinearity in the independent variables and decrease the reliability of the coefficients. Because harvested area shares of the individual crops would need to be determined from the total area, the use of individual revenues in the cropland base equation would create simultaneity problems if those same variables are used in addition to cropland base in the individual harvested area equations.

Each cropland base equation is then inserted in a model of the appropriate region that solved recursively for harvested area, production and the other variables as described in Section 3.1, but with revenue exogenous. The estimated values are then functions of estimated lagged values rather than actual values. The fit of this direct estimation method is compared to that of summed harvested areas, both based on estimated lagged values. T-statistics are examined for the contribution of weighted average revenue to the fit of the estimated equation.

In all cases where cropland base is regressed on lagged revenue and lagged cropland base no strong positive linear relationship appeared. For most countries, t-statistics for the revenue variables are non-significant. In the case of Australia, revenue is significant, but negatively signed (see Appendix 3 for statistical results). Figures 1 - 6 compare the fit of the forecast cropland base and the sum of estimated harvested areas to the actual area. In most cases, summed harvested area estimations are superior to the direct cropland base estimate. Only in the U.S. did direct estimation follow the actual cropland base more closely than summed harvested areas. However, in the U.S., as in the other regions, the summed harvested areas captured more turning points correctly, implying that they contain more information than the direct estimate. Therefore, the summation method of determining cropland base is retained.

3.32 Sources of Low Correlation

Several factors contribute to the poor fit of the cropland base equations. First, while the revenues for own and competing crops capture the tradeoffs in the cropping mix, they do not reflect the important decision variables in determining aggregate response. Changing total harvested area is essentially an investment decision. The profitability of a non-farming investment alternative may be relevant, but the relative returns for various crops are not. Second, with a single revenue variable, only one coefficient can be attached to

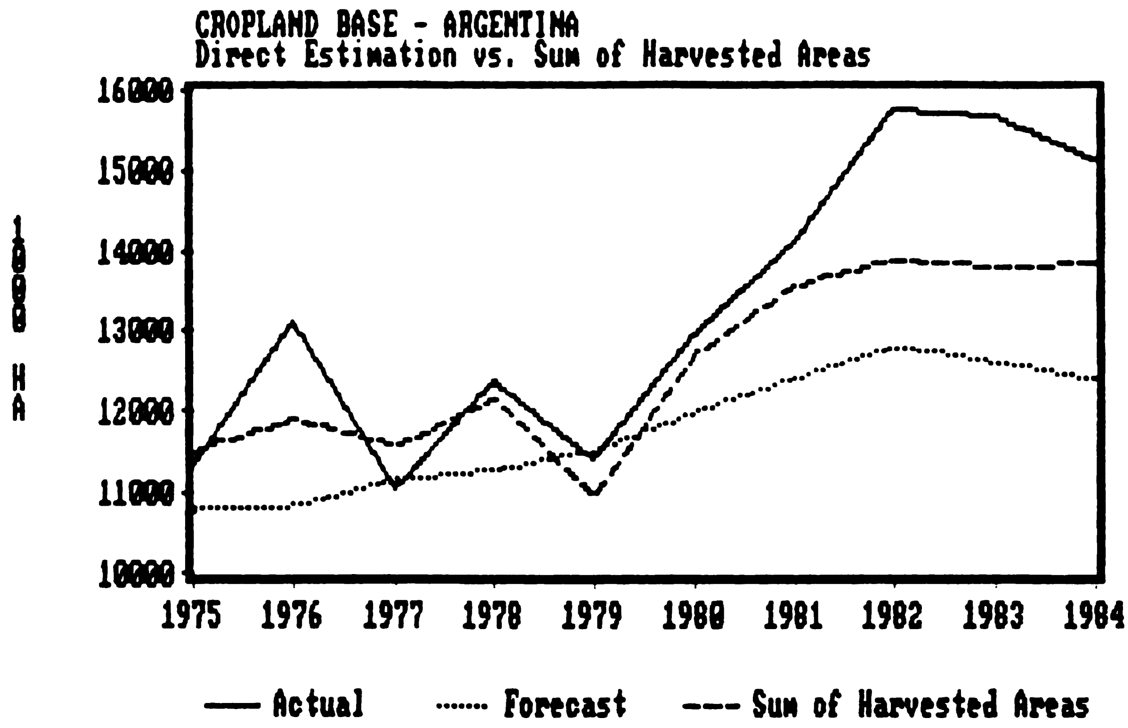

Figure 1: Cropland Base Estimations - Argentina

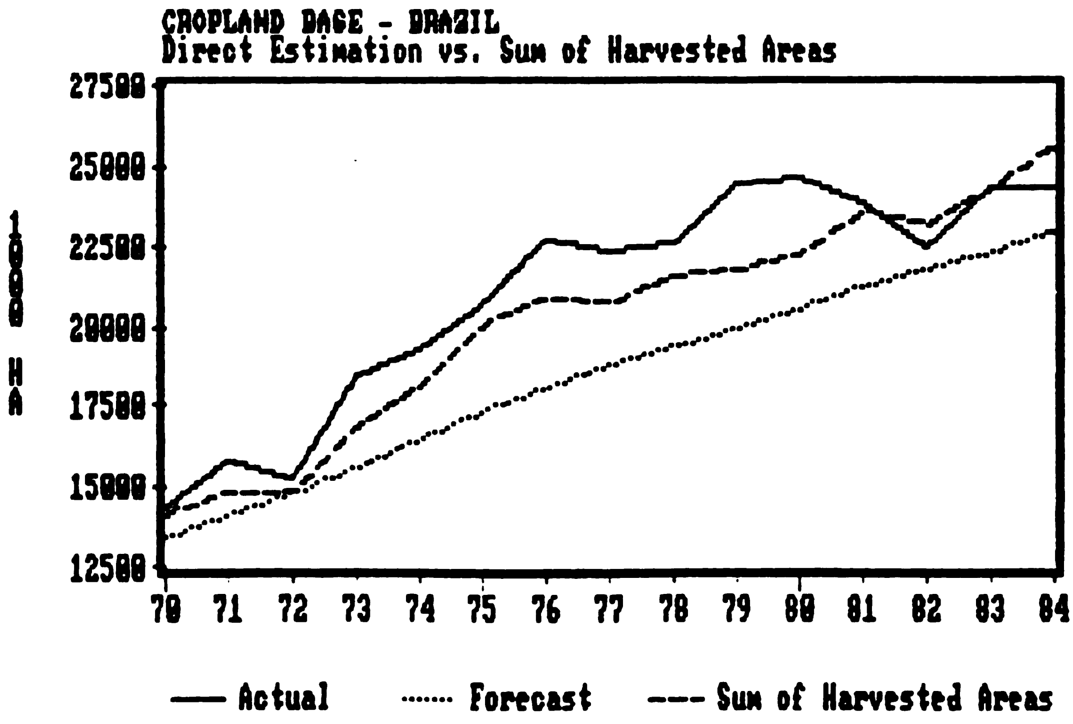

Figure 2: Cropland Base Estimations - Brazil

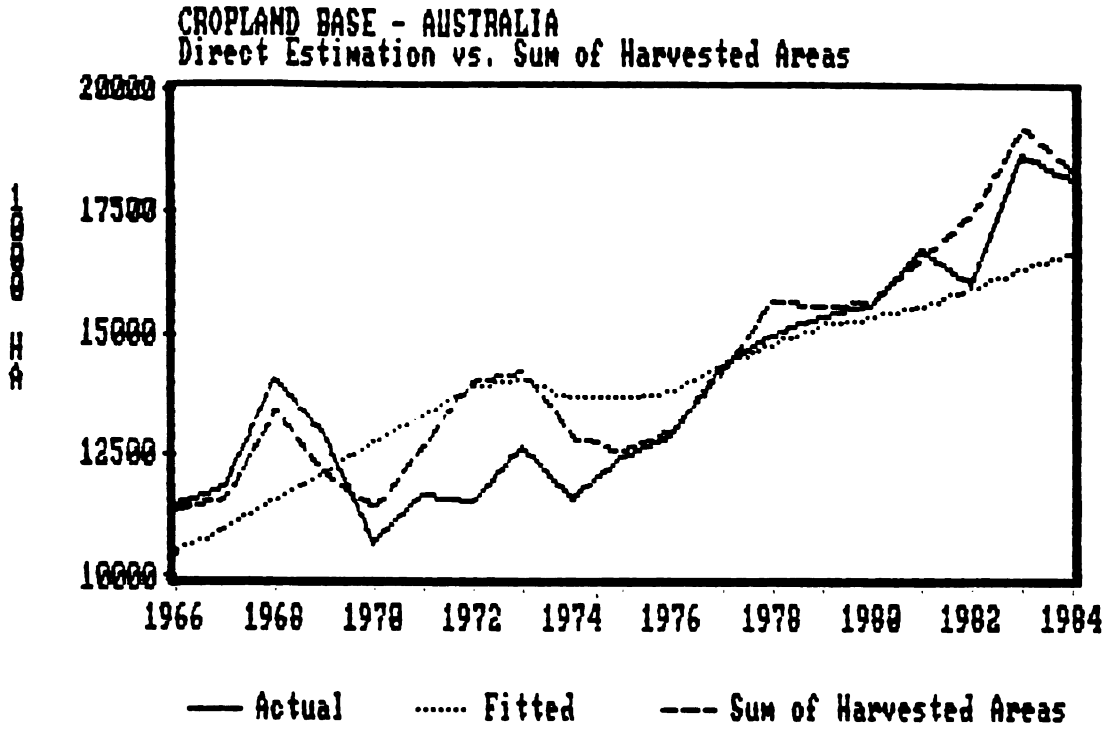

Figure 3: Cropland Base Estimations - Australia

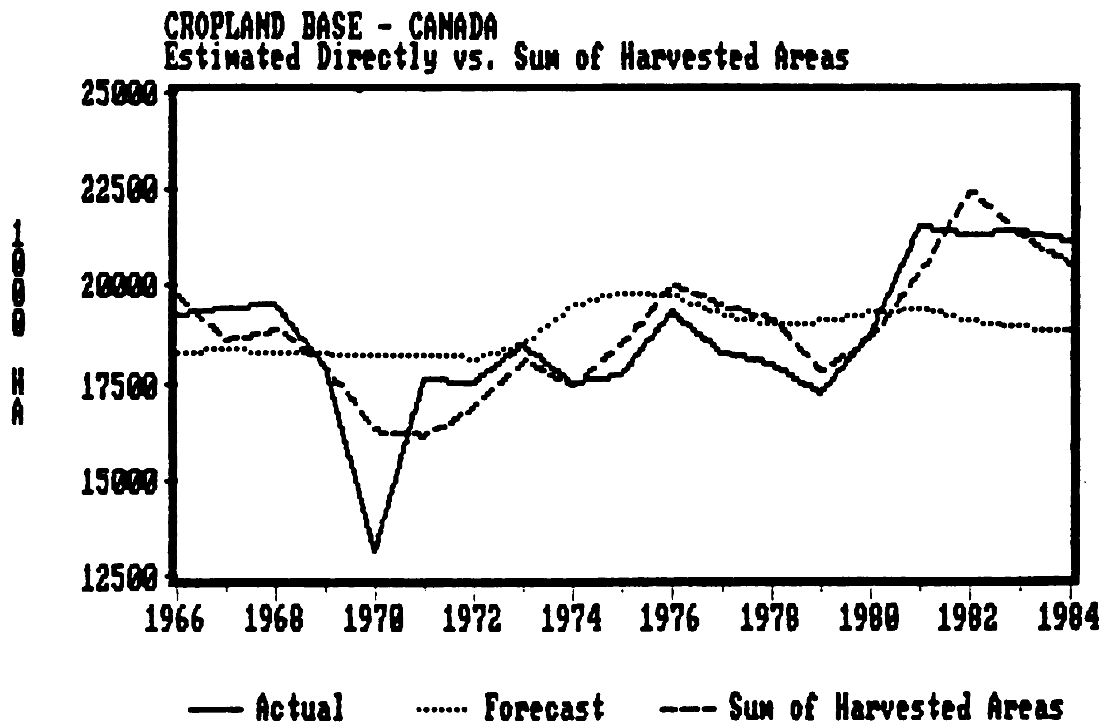

Figure 4: Cropland Base Estimations - Canada

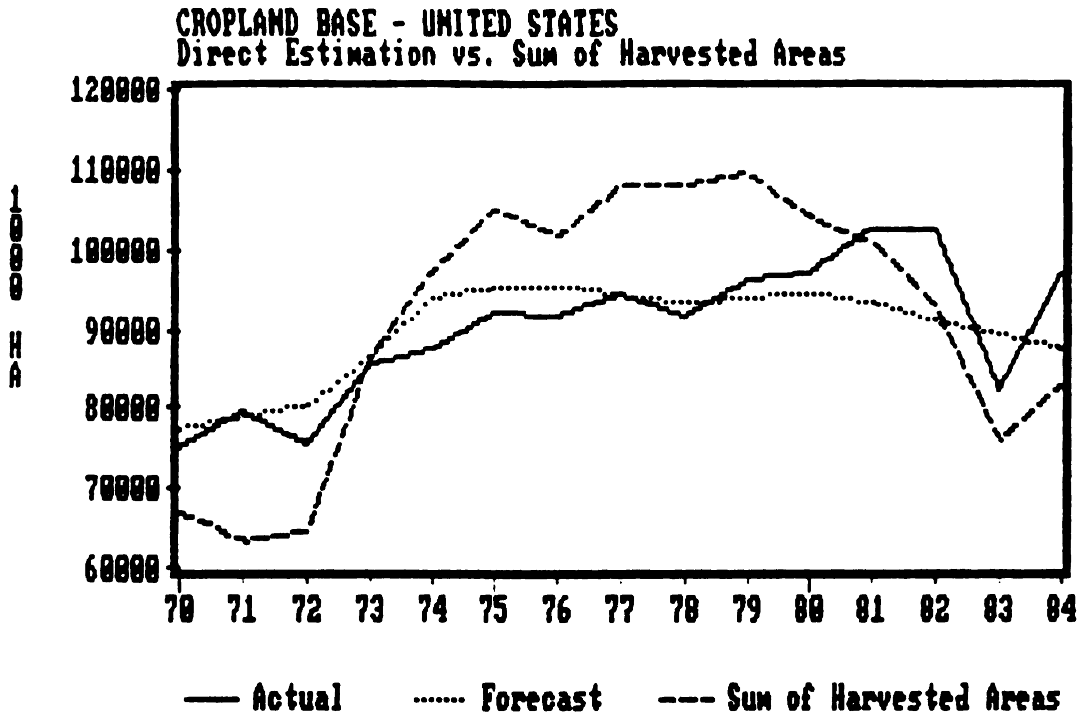

Figure 5: Cropland Base Estimations - United States

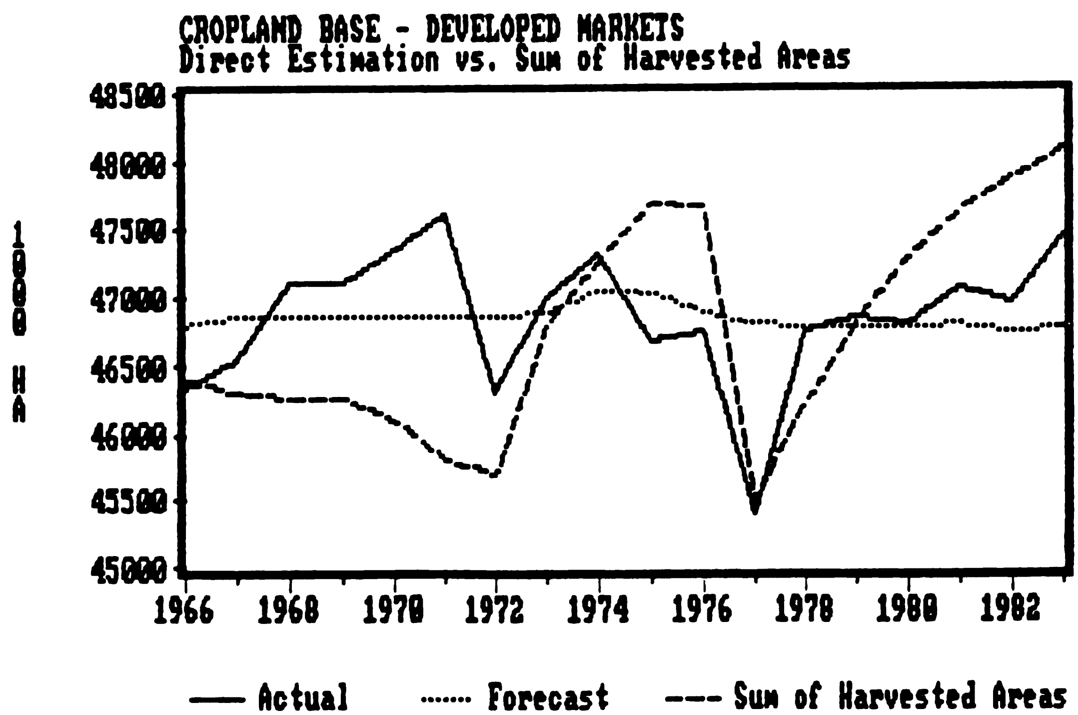

Figure 6: Cropland Base Estimations - Developed Markets

the revenues of the three crops of interest. Some information and flexibility is lost by restricting the weight on each crop to its proportion of total area.

The individual harvested area equations may perform better than a single cropland base equation because they contain more information, such as policy variables that influence supply of the particular crop. When they are summed, the fit is closer to the actual values than that of direct estimation (Figures 1 - 6). In comparison, the cropland base equations, identical for each country, contain only revenue and the lagged dependent variable. It might be possible to estimate cropland base equations that track quite closely to the actual values, but they have less ability to capture the dynamics of individual commodities and substitution effects, which are usually considered more interesting. Both specifications show cropland base to be unresponsive to world price. This finding supports the view that elasticities are low in the aggregate.

Both the direct estimation and the summing approaches likely share some of the same weaknesses in attempting to measure supply responsiveness. As suggested above, the relative prices of the crops of interest would not be expected to elicit a strong aggregate response. However, a key variable may be revenue from enterprises that are not included in the model, whether they are products that are locally important such as sunflowers in Argentina or livestock in Australia or non-farm activities that compete for land. Poor returns to livestock production may cause a shift from pasture to small grains even in the face of declining revenues for grains. Including these other country-relevant variables may improve the predictive power of these equations.

Another important consideration is that gross revenue may not be as relevant to the investment decision as net revenue. Changes in the price of farm output may have no relation to changes in farm income, especially in countries where government intervention in the economy is considerable.

In a supply elasticity, the relationship that is theoretically measured is farmers' intent to produce relative to expected price. Droughts and other supply-reducing events appear as outliers in the cropland base data. This is an imperfection in modelling farmers' intentions that is accomodated by the Ag Model. Intent is better captured in area planted, but cropland base is the sum of area harvested. The complexity of estimation and the possibilities for error increase if both planted area and harvested area are included in the specification or if supply must be estimated from planted area instead of calculated from harvested area.

The relationship of the cropland base to revenue based on border price reflects the aggregate responsiveness of harvested area to world prices. While this is specifically the intent of the modelling effort, this relationship may not be strong if the border price is substantially different from the internal price that farmers actually face. The less world price is transmitted to the domestic market, the less a market participant will respond to changes in the world price, resulting in a low price elasticity value.

3.33 Relationship of Cropland Base to Gross Revenue

Cropland base and weighted average gross revenue are plotted over the historical period to note obvious patterns or discrepancies. A pattern of strong association would suggest that the two are related and high adjusted R^2's would be expected (Appendix 3). Little or no association over time would support the idea that other variables or specifications are needed to improve accuracy. These plots appear in Figures 7 - 12. From these figures, cropland base shows little relationship to gross revenue in most cases.

It is evident from Figure 7 that the large rise in world prices does not translate into increased hectarage in Argentina. Some interventions such as a tax or tariff may have prevented the market signal from ever reaching the farmers. Price stabilization policies could be expected to smooth aggregate response by insulating farmers from world market instability.

In Figure 8, Brazilian cropland base has trended upward considerably, during a period of roughly constant revenue, before the sharp increase in revenue of 1973. During the late 1970's and early 1980's, cropland base leveled off, as did revenue, on average, but an association between the two is not clearly evident.

In Australia (Figure 9) some overriding trend such as declining production costs or substitution away from other competing enterprises and into wheat and feedgrain may have swamped the effects of revenue. Again, farmers may be highly insulated from world prices. Whether there is little aggregate response to price or whether low price transmission disguises a stronger response is not clear from this figure alone. However, it does suggest that aggregate revenue elasticities would be low.

No distinct association between cropland base and revenue emerges from Figures 10 - 12 of Canada, the U.S. and the Developed Markets.

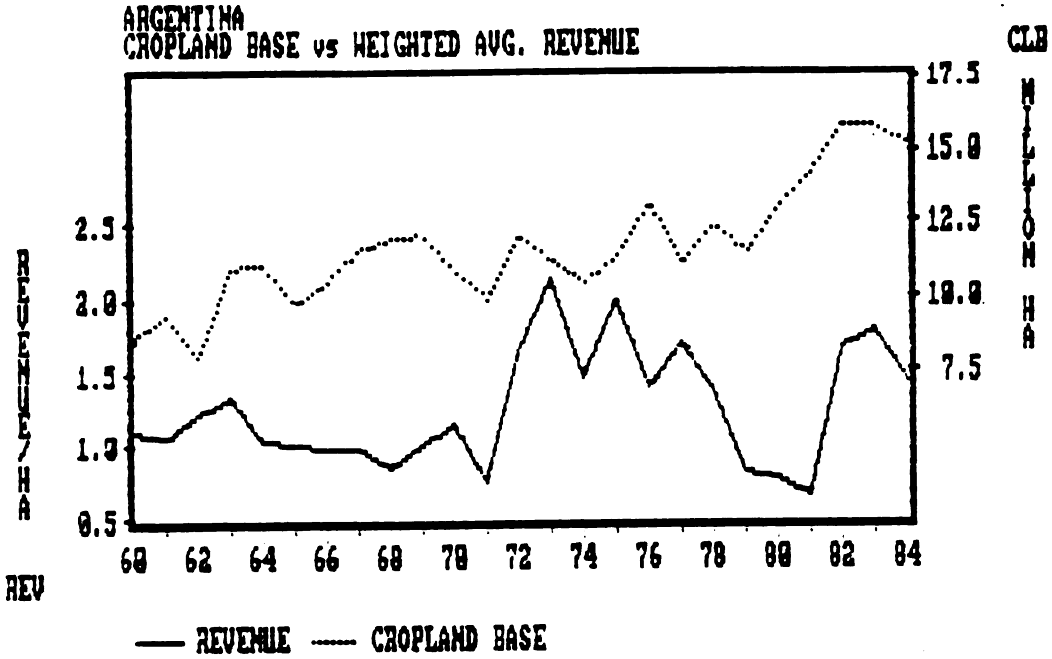

Figure 7: Cropland Base vs. Gross Revenue - Argentina

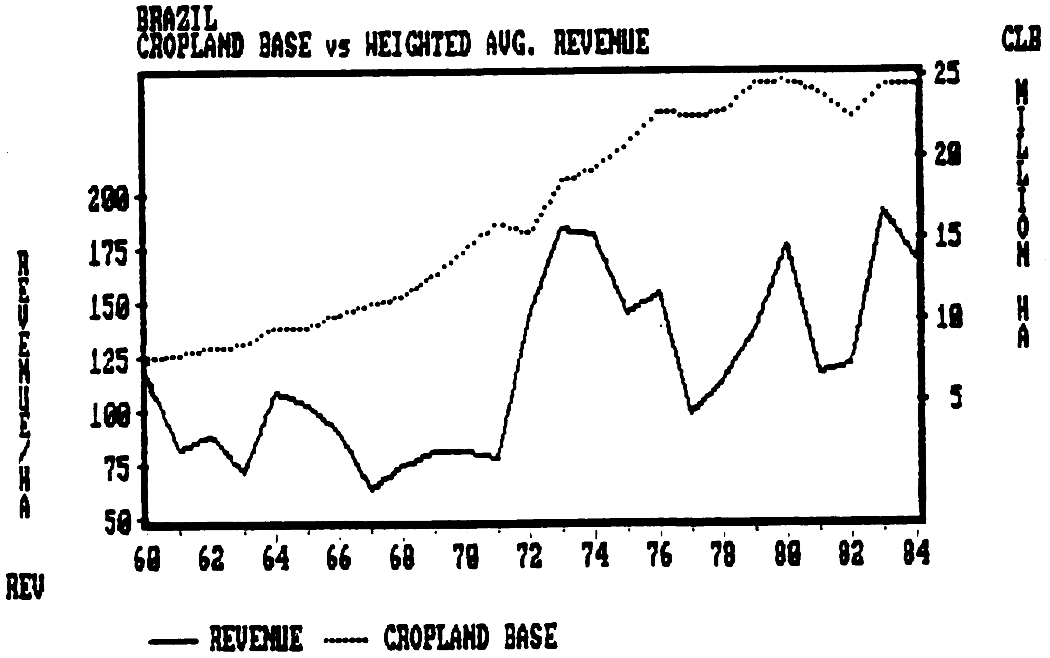

Figure 8: Cropland Base vs. Gross Revenue - Brazil

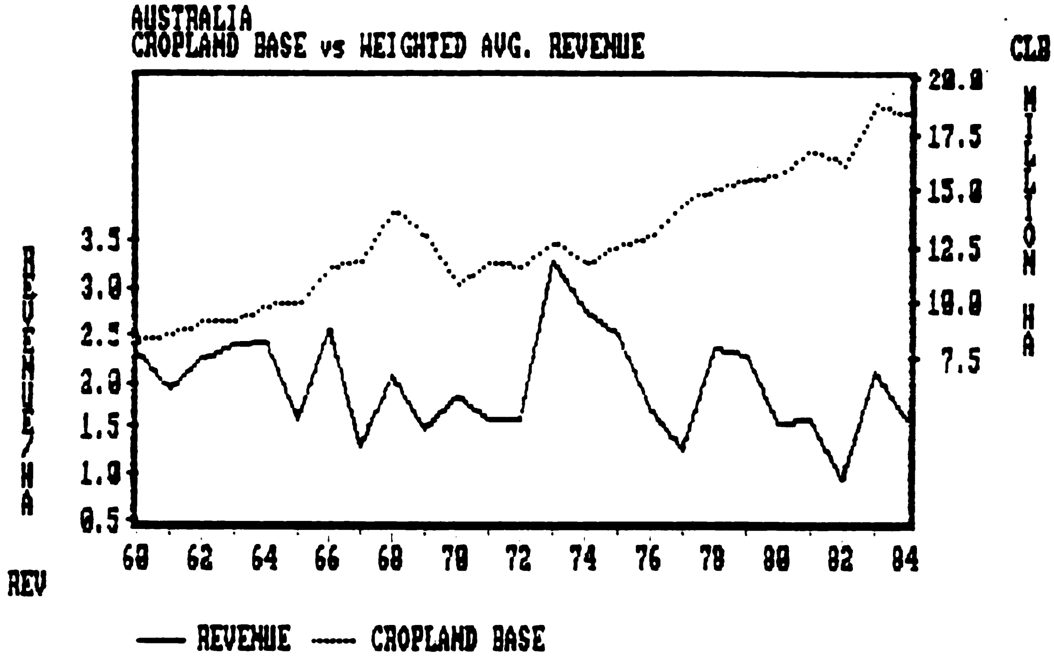

Figure 9: Cropland Base vs. Gross Revenue - Australia

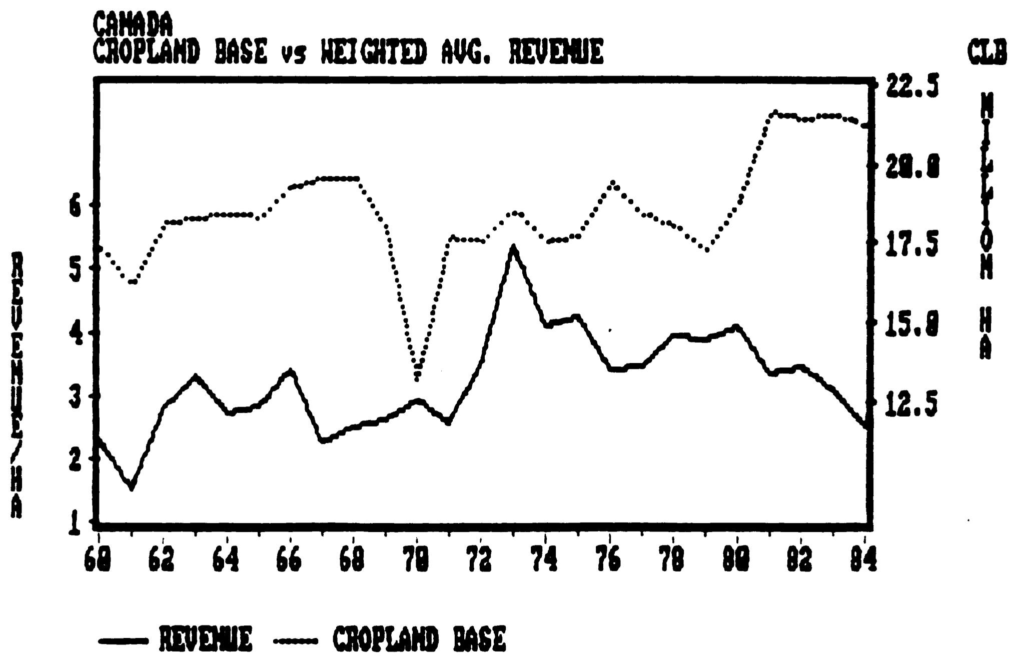

Figure 10: Cropland Base vs. Gross Revenue - Canada

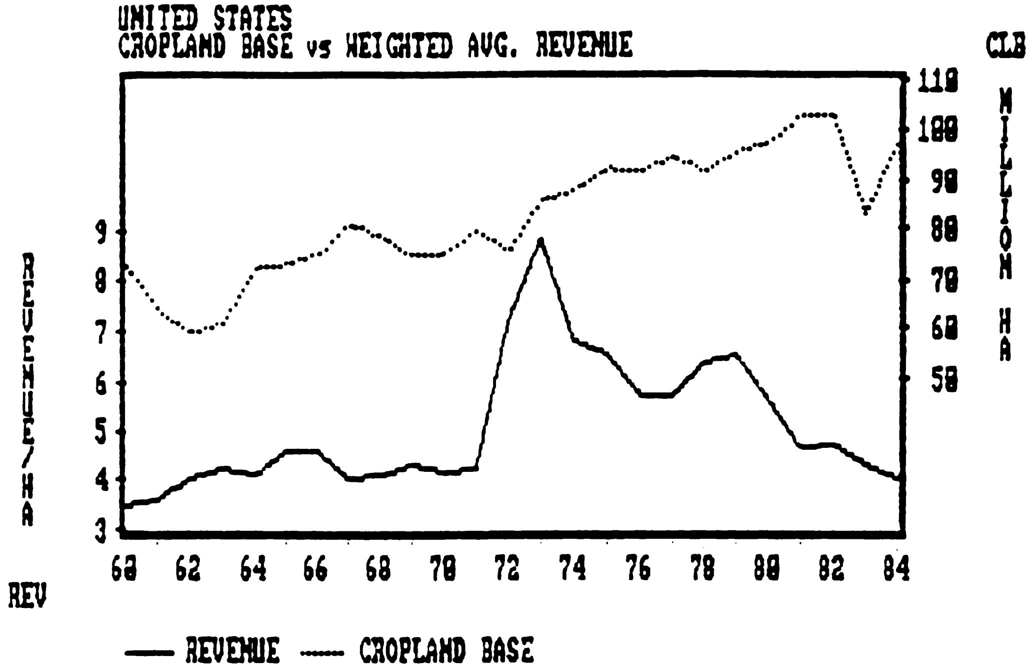

Figure 11: Cropland Base vs. Gross Revenue - United States

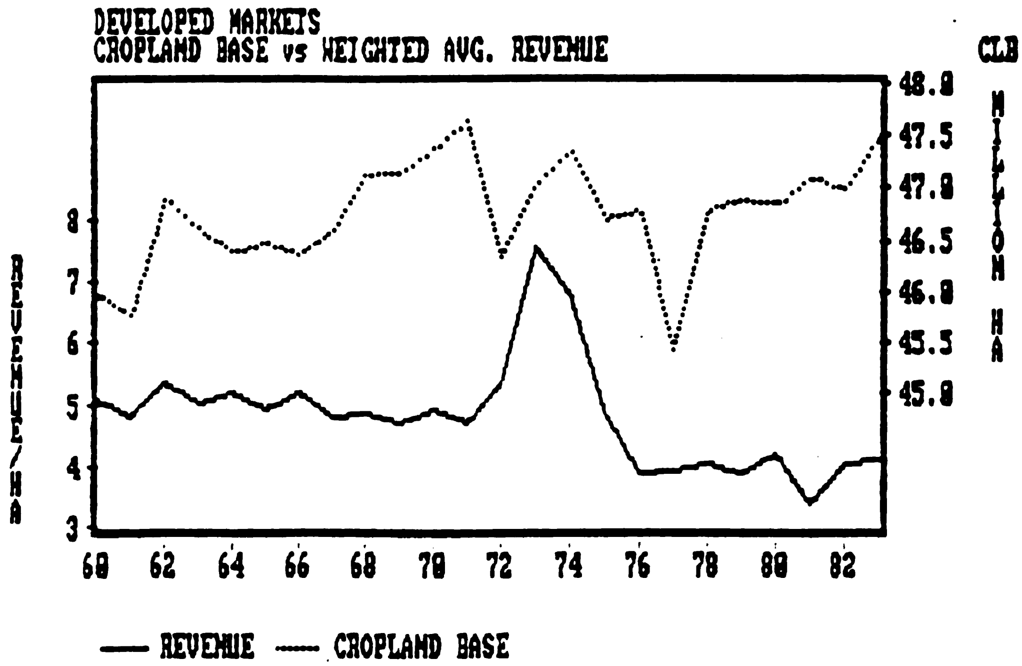

Figure 12: Cropland Base vs. Gross Revenue - Developed Markets

Cropland base and revenue are both relatively flat (except the revenue peak in 1973) for Canada and the Developed Markets, although for the Developed Markets revenue dropped to a lower plateau after 1975. In the U.S., cropland base trends upward in a fairly uniform manner despite volatility of revenue. Sharp drops in cropland base are due to factors other than price response, such as the government-induced reductions in hectarage in the U.S. in 1983 when the Payment-In-Kind program paid farmers with stored grain to idle a percentage of their cropland.

3.34 Relationship of Internal Prices to Border Prices

A low responsiveness of cropland base to gross revenue based on border prices raises the possibility that price transmission is low in some countries. In order to determine whether border price is a reasonable proxy for producer price, the two are compared graphically wherever internal price data is obtained.

Argentina has had markedly different policies toward agriculture depending on which political group is in power. During Peronist regimes, agriculture was heavily taxed and in the intervening periods agriculture was more market-oriented. Peronist administrations controlled Argentina in 1948-55 and again in 1973-75, which was a period of high world food prices. Taxation of agriculture was extremely high during this period and prevented agriculture from receiving the benefits of high world prices. Export taxes and differential exchange rates separated agriculture from the world market. In recent years, exceedingly high inflation and frequent changes in government have created instability in the economy that may have reduced the response of farmers to any change (Wainio, 1983).

Wholesale market prices[4] for Argentina (Bolsa de Cereales, 1984) are used to calculate an internal revenue in the same way that weighted average revenue is constructed from border prices previously (Section 3.31). These revenues are plotted together in Figure 13. While internal prices followed the general pattern of world prices in years of stable prices, they failed to reflect the extremes, such as in the mid-seventies. In the case of Argentina, border prices do not closely represent the prices that farmers receive.

The Brazilian government has supported commodity prices to ensure a minimum income to farmers and an adequate supply for the domestic market. Domestic price ceilings, an overvalued currency and export quotas for soybean products in most years have all served to separate the domestic market from the world market (Williams and Thompson, 1984).

Farm prices in Brazil are used to calculate an internal revenue which is plotted against border-price revenue in Figure 14. Internal revenue is lower than border revenue in all years but one, and followed the general movements of border revenue. However, internal revenue does not rise as sharply as border revenue in years of large price increases. As in Argentina, border price does not reflect the price farmers face, but because both revenues follow the same general pattern, border price may be an acceptable, though not ideal, proxy for internal price in Brazil.

In Australia, wheat prices received by farmers reflect a weighted average of returns from wheat sold domestically and wheat that is exported. This "pooled" price is paid to all farmers regardless of where their grain is actually sold. Producer price is determined by the

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[4]Data from sources outside the Ag Model are presented in Appendix 4.

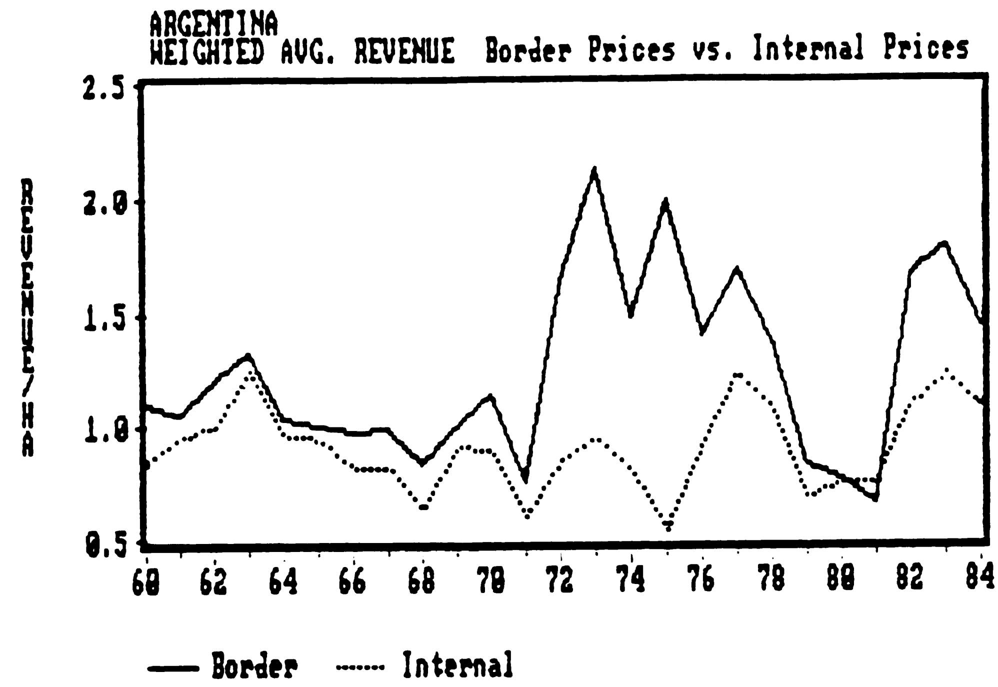

Figure 13: Weighted Avg. Revenue - Argentina
Border Prices vs. Internal Prices

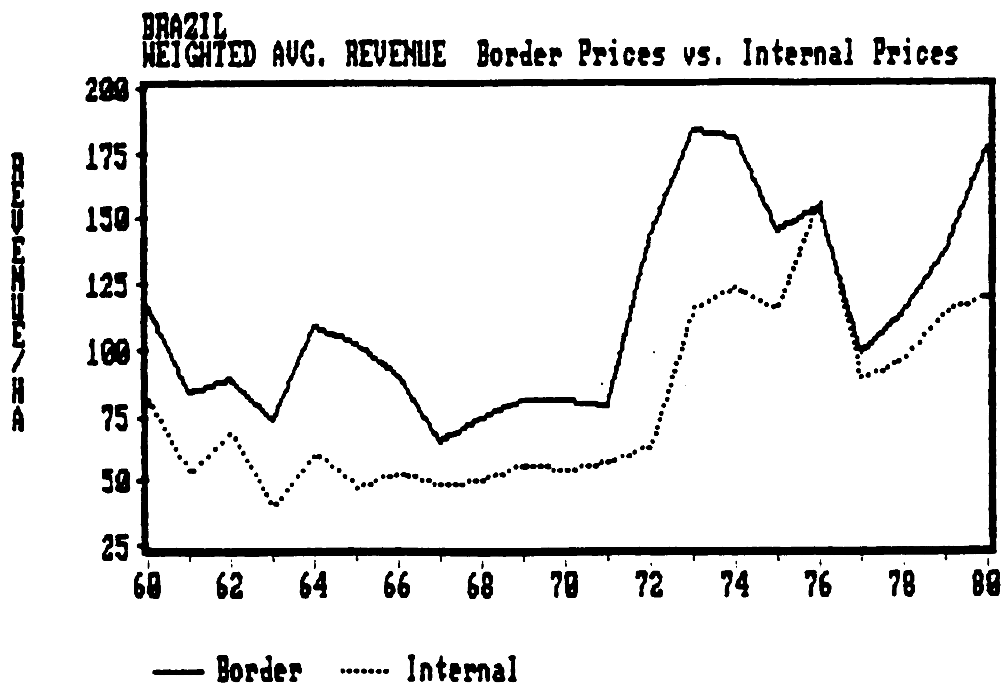

Figure 14: Weighted Avg. Revenue - Brazil
Border Prices vs. Internal Prices

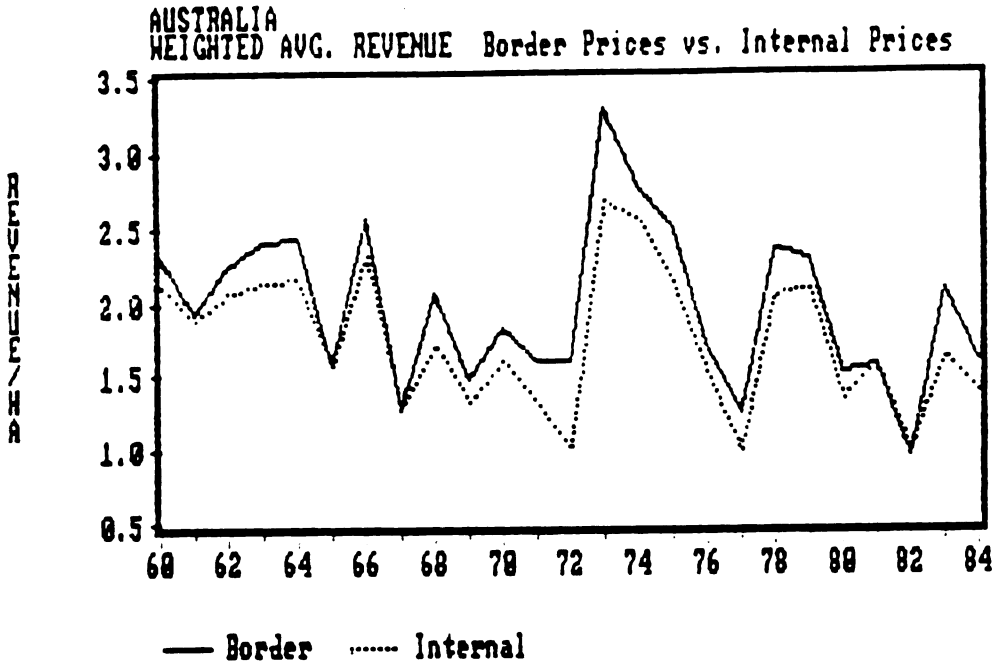

Figure 15: Weighted Avg. Revenue - Australia
Border Prices vs. Internal Prices

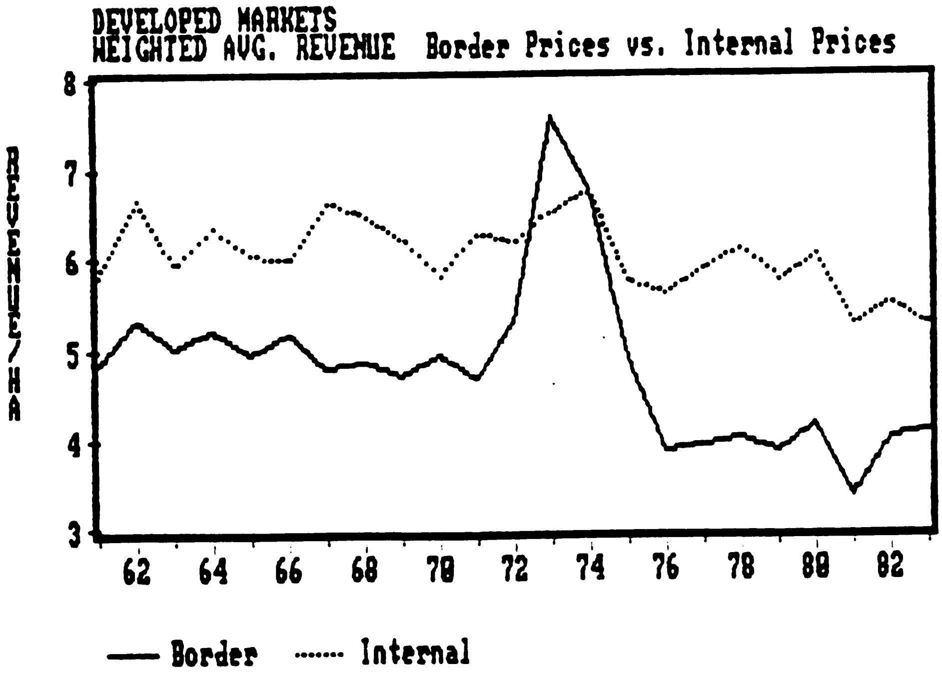

Figure 16: Weighted Avg. Revenue - Developed Markets
Border Prices vs. Internal Prices

Australian Wheat Board which controls all wheat marketing in Australia. The Board bases the price of wheat for export on world prices (Spriggs, 1978) while various schemes have been used for pricing domestically consumed wheat. Currently, domestic wheat is priced at approximately twenty percent above the export price. With a population of only about 14 million, Australia's domestic consumption of grain is quite small in proportion to the harvest. Thus, pool price is dominated by the export price.

The price of feedgrain in Australia is approximated by the domestic price of barley, the main feedgrain produced in Australia, as opposed to corn price, which represents world market feedgrain price in the Ag Model. Barley and oats are primarily grown in the States of Western Australia, South Australia, and New South Wales, much of the same area as wheat, where the climate is suited to winter crops (Spriggs,1978). Barley marketing is controlled by four marketing boards. Unlike wheat however, it is legal to sell barley privately and most barley for domestic feed consumption is handled through private channels. The boards handle all barley for export and for domestic malting purposes. In order to represent the price received by farmers for feedgrains, the gross value of barley is divided by total barley production. A revenue variable is constructed using these average returns for wheat and barley.

In Figure 15 internal and border weighted average revenues are plotted for Australia. Internal price closely follows world price in this case. The only year where the two deviate substantially is 1973, a year of exceptionally high world grain prices. This difference is partly explained by the wide disparity between domestic and export price in that year and the effect of averaging. Of the four regions studied here, Australia is the only one that appears to have an open market that bases prices on world prices. Near perfect price transmission is suggested by the closeness of the two plots in Figure 15.

The European Economic Community (EEC), which is the majority of the Developed Markets region, has clear policies of farm price insulation (Jabara and Brigida, 1980). The main mechanism of price insulation is the variable levy. Imports from outside the EEC that are cheaper than the supported price of domestic agricultural products are subject to a levy. The value of the levy adjusts in order to raise the price of the imported commodity to a fixed threshhold price, which is greater than or equal to the price of the domestic product. Producers and consumers are completely insulated from the world price in this way.

Figure 16 shows revenue calculated with producer prices used in the Ag Model for feedgrain and wheat as well as border price revenues for the Developed Markets. Although the overall trend in producer revenue follows the trend of revenue generated by world price, it does not respond to large swings in world price and producer revenues demonstrate very little variation. This revenue stability suggests that producers in the Developed Markets are effectively insulated from the world market. Therefore, border price would not capture the prices that producers in this region face.

In most of the regions examined in this chapter, cropland base shows little association with weighted average gross revenue, both from plots of the two variables over time and from statistical regression. The lack of a strong correlation between the two could occur because cropland base poorly represents farmers' intentions to produce or because lagged revenue per hectare does not approximate expected price. Alternatively, the lack of a strong association may be either because world price is unrelated to the price farmers face (low price transmission) or because farmers simply do not respond to expected price. The association between border revenue and internal revenue studied in this section identifies regions where price transmission is an important factor, specifically Argentina and the Developed Markets and possibly Brazil. The use of internal prices, which circumvents low price transmission, and other factors that affect the relationship between price and supply are examined in the following chapter.

CHAPTER IV. COUNTRY-LEVEL INVESTIGATION

The relationship between farm-level supply and price is examined in further detail in this chapter to determine why Ag Model elasticity estimates are low. Low elasticity values may result from specification error in either the supply or the price variable, from low price transmission, or from low actual elasticities. To examine these possibilities, new country-specific variables are introduced in two of the Ag Model's eleven regions. The new variables include a) an alternative specification of revenue, b) internal prices, which eliminate price transmission difficulties, and c) prices of substitute products (for suppliers).

The two countries studied are Australia and Argentina. Australia is chosen because of the apparent negative relationship between cropland base and weighted average gross revenue. It may be possible to explain this unusual result by including other variables in the specification. Argentina is identified in the previous chapter as a region where border price poorly approximates internal price. Re-estimation with internal prices may result in a higher elasticity. If so, then price transmission is the cause of low elasticity. If internal prices do not raise the elasticity or improve the fit of the harvested area equation, then the likelihood that the elasticity is in fact low is increased.

To explore the importance of each of the considerations discussed above, the new variables are introduced in the harvested area equations.

Specifically, 1) internal real wholesale or producer prices were substituted for border prices to observe the responsiveness of supply, when imperfect price transmission is eliminated as an obstacle; 2) an index of prices paid by farmers is introduced, to deflate gross revenue to account for variations in real costs of production; 3) enterprises identified as likely competitors for crop area are included to examine their effects on hectarage decisions.

4.1 AUSTRALIA

4.11 Internal Prices

Internal prices are the first variables tested in the harvested area equations. Because the internal price for Australia followed the world price closely, internal prices would not be expected to improve the equations appreciably. The old equations contain wheat and feedgrain revenues calculated from border prices. In the wheat equation neither revenue is significant, but both revenues are significant in the feedgrain equation. The original wheat equation also contains lagged harvested area, a time trend and wheat ending stocks, a proxy for government policy. The initial feedgrain equation contains only the two revenues and a time trend, but not lagged harvested area. The coefficient of adjustment for harvested area in this case is one and the partial adjustment specification is dropped.

When both internal revenues are introduced into the wheat and feedgrain harvested area equations, t-statistics are lower than for border price revenues. Other measures of fit also worsen. Specifically, in both cases adjusted R2 and F-statistics decline and standard errors of the regressions (SER's) rise.

Because grower returns for wheat reflect a weighted average price for a particular year's crop, farmers in Australia do not receive the full price until the entire crop has been disposed of. However, at delivery farmers do receive an initial payment. This initial payment had represented 70-80 percent of the anticipated final price in the past. Beginning with the steep rise in world prices in the 1970's, initial payments did not keep up as a percentage of the final price. Since 1979 initial payments have equalled the guaranteed minimum price. If market prices fall below this level, the farmer receives a subsidy. Operating costs for the Board are deducted from wheat returns before growers are paid and transportation differentials are also charged depending on farmer location.

Because farmers receive wheat price information over a period of years, an alternative lag structure is tested in order to measure the effect of the delay in receiving price information on supply response. The lags are intended to differentiate between the effects of the initial payments and the final price.

A two-year lag for wheat revenue only is tested in both the wheat and feedgrain harvested area equations to capture the lag in determining the pooled wheat price. Feedgrain prices are not complicated by delays in price information, therefore only a single period lag is used for feedgrain revenue. A two-year lag for wheat revenue does not produce a significant coefficient for either border price or for internal price. This result suggests that farmers do not rely on final payments from a wheat crop two years earlier in order to form price expectations.

While initial wheat payments may be important in forming expectations of the final price, initial payments have been set equal to the guaranteed minimum price since 1979. A complete series for initial payments is not available, but the guaranteed minimum price is tested in the wheat harvested area equation and shows no statistical significance.

4.12 Gross Revenue vs. Net Revenue

The question of net revenue as compared to gross revenue is addressed by deflating both border and internal revenue variables by an index of prices paid by producers. This net revenue index variable is then substituted into the harvested area equations in place of gross revenue. First, border-price revenues. Net revenues shows no significance in the harvested area equation for wheat. In the feedgrain equation, net wheat revenue is significant, as is gross wheat revenue and net feedgrain revenue is slightly more significant than gross revenue ($t=2.49$ vs. 2.34). However, the overall fit of the net revenue equation is slightly worse with lower adjusted R^2 and F-statistic and higher SER. Therefore, the net revenue specification is rejected. Second, net revenues based on internal prices are tried and again, yield poorer results than gross border revenues.

4.13 Competing Enterprises

Experts have suggested that the relative unprofitability of raising livestock in Australia, particularly on marginal, droughty land has contributed to growth of the cropland base, especially wheat area. The average price of greasy (raw) wool is introduced into the wheat equation to test the significance of a competing enterprise. Although sheep and wheat are produced in overlapping areas of the country, primarily in the "wheat-sheep belt," the land that is shifting from livestock to small grains is only marginally suitable for sheep ranching because of seasonal drought. Therefore, a measure of profitability per hectare of such land may be more appropriate. However, such a variable is not available. The price variable is not expected to show statistical significance because it does not capture the tradeoff between sheep pasture and wheat production. In fact, real wool price shows no significance in determining wheat or feedgrain harvested area. This result does not rule out the importance of sheep enterprises in decision-making for wheat, but merely suggests that some other variable is needed to capture that effect.

4.14 Summary

In each step of the analysis, the initial Ag Model equation is used as a basis for comparison over the sample period, 1960 to 1984. Internal and net revenue variables are substituted for gross revenues in the initial specification while competing prices and policy variables are added to the initial explanatory variables. Statistical significance, as measured by t-statistics, is the primary criterion for the contribution of a variable to the equation. Contribution to adjusted R2, Durbin-Watson, standard error and F-statistics are also considered.

None of the variables tested showed a clear improvement over the initial equations for wheat or feedgrain harvested area. However, the initial equations have the problem that in each case the cross-revenue elasticities are considerably larger than the own-revenue elasticities. This is not an unrealistic result a priori, but in Australia, where wheat harvested area is twice as large as feedgrain harvested area, it is unlikely that the feedgrain cross-revenue would have such a large effect on wheat harvested area. Further, large cross-elasticities have the undesirable property of causing cropland base to respond in a counter-intuitive (opposite) direction to simultaneous wheat and feedgrain price changes. As mentioned earlier, the strong downward trend in revenue for Australia may be responsible for the large relative magnitude of the cross elasticities (see Table 1).

As no new insights are gained from the new variables in this chapter, the cross elasticities are constrained to equal the own elasticities by replacing the two revenue variables with a single ratio of own to cross revenues (lagged). This specification allows harvested area to respond to changes in relative prices, but does not address aggregate response to proportional price changes. In this regard, this specification is completely inadequate. However, it mitigates illogical behavior of the equations in the absence of more detailed information that would better explain Austrailian planting decisions.

Australia is not a country where low price transmission inhibits farmer response to world price. Therefore, the use of border prices is appropriate. The inclusion of country-specific data does not improve the fit of these equations for Australia. In order to improve the Ag Model's representation of Australia, a considerably more detailed regional model would be necessary. Inclusion of the livestock sector and possibly weather-related variables would likely enhance the Ag Model's performance.

4.2 ARGENTINA

4.21 Internal Prices

In Argentina, a procedure similar to that for Australia is followed. Real internal wholesale prices, which differ from producer prices by a stable marketing margin, are substituted for real border prices in the calculation of revenue for wheat, feedgrains and soybeans. These internal revenue variables are compared to border-price revenues in the harvested area equations.

In the case of wheat, the initial equation contains lagged harvested area, a time trend, and lagged wheat and soybean border price revenues. When these are replaced with internal revenues, soybean revenue remained significant, but wheat revenue does not (t=.91) and fit does not change significantly.

For feedgrain harvested area, neither internal price, wheat or feedgrain, is significant and own revenue has an unexpected sign. The original equation for feedgrain contains lagged harvested area, lagged feedgrain and wheat revenues and a dummy variable for 1971 and 1979, years of drought.

Soybean harvested area is the only equation that shows some slight improvement with internal prices. The original soybean harvested area equation consisted of lagged harvested area, lagged soybean and wheat revenues and a splined time trend beginning in 1976, when soybean production accelerated in Argentina. Wheat revenue, which is not significant in the original, is still not significant (critical alpha =.18 vs .25) but the variance of the coefficient is somewhat reduced. One important difference is that the sign on wheat is positive for internal prices and negative for world prices. At first glance, the positive sign appears incorrect, but is plausible in view of the fact that soybeans are frequently double-cropped with wheat in Argentina (Wainio, 1983).

No suitable index of production costs is available for Argentina. Hence, the response to net revenues rather than gross revenues is not tested.

4.22 Competing Enterprises

Important enterprises that compete with Ag Model crops in Argentina include beef, sunflowerseed and flaxseed production. Wheat is most important amongst the crops, but they are all subordinate to cattle ranching in central Argentina's Pampa region (Wainio, 1983). Revenues for each of these commodities are introduced in the harvested area equation for each Ag Model crop.

Revenues for sunflowerseed and flaxseed are calculated in the same way as wheat and feedgrain revenues, using internal sunflowerseed and flaxseed prices. For beef, the wholesale steer price is deflated and used. However, beef price data is only available from 1970 onward. When beef price is used, sample size is reduced to 1971 to 1984. Internal soybean price data is available only from 1966. When it is necessary to change the sample period of the estimation due to data limitations, an equivalent original equation is estimated using the shorter sample period in order to compare similar equations.[1]

Enterprises deemed important by Wainio in his study of farmers' responses to grain prices under various political regimes are tested first. In the case of wheat, beef is the only relevant commodity

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[1]The initial sample period for soybean equations is 1964 to 1984

considered by Wainio. However, beef price is not statistically significant for wheat, nor for the other crops of interest. Subsequently, feedgrain, sunflowerseed and flaxseed revenues are tested. Only sunflowerseed is significant and signed as expected (negatively). Replacing soybeans in the original equation, it improves fit slightly with higher adjusted R^2 and F-statistic and lower SER. The best equation, therefore, is a function of lagged harvested area, lagged wheat and sunflowerseed revenues, and time.

In the feedgrain case, wheat and sunflowerseed revenues and beef prices are all deemed relevant by Wainio. Beef and sunflowerseed are not significant, but wheat is. Flaxseed is also tested and proved significant, but feedgrain is never significant, even in the equivalent original specification. The best equation includes wheat and flaxseed revenues only (in addition to lagged harvested area and a dummy). Adjusted R^2 rose but SER and F do not change considerably.

Wheat, feedgrain, sunflowerseed, flaxseed and beef are all tested in the soybean equation but none prove better than the original specification of wheat and own revenue (with the change of sign for wheat revenue), lagged harvested area, and a splined time trend. While fit is slightly improved by the inclusion of one more competing revenue, flaxseed, the coefficient is not significant.

4.23 Summary

The inclusion of internal variables improves the fit of each of the harvested area equations for Argentina, but only slightly. In this case, aggregated, international variables can be improved upon by measuring separately the response of farmers to price and the relationship of internal prices to world prices.

In order to include these new equations in the model, it would be necessary to forecast all of the price variables in order to simulate into the future. In addition, some relationship between the internal price and the world price must be calculated in order to relate these revenue responses ultimately to changes in world prices. Because the internal price series would be difficult for Ag Model researchers to maintain in the future, the new equations are not incorporated into the model.

4.3 MULTICOLLINEARITY

One complicating factor that arises with many similar competing enterprises appearing in the equation is the degree of multicollinearity present. While there are no definitive tests for multicollinearity, the coordinated movement of the prices of substitutes strongly suggests some problem with collinear data. Figure 17 shows the movement of real domestic prices for the three oilseeds and two grain groups used in the Argentine case. Specifically, oilseed prices are highly correlated with each other and wheat and feedgrain prices are highly correlated, but oilseeds and grains are less so. According to Pindyke and Rubinfeld (1981),

> "A rule of thumb states that multicollinearity is likely to be a problem if the simple correlation between two variables is larger than the correlation of either or both variables with the dependent variable."

This rule serves as a first test for simple correlation but does not measure multiple correlation. Due to time and resource limitations, multiple correlation tests are not performed as part of this study. For

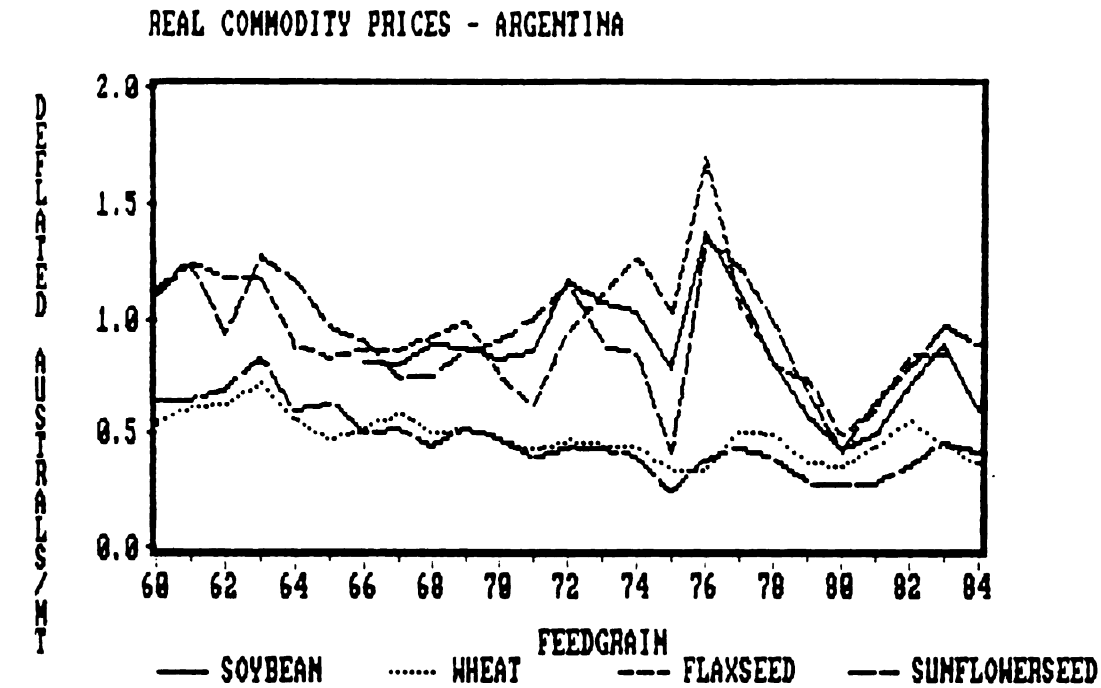

Figure 17: Real Commodity Prices - Argentina

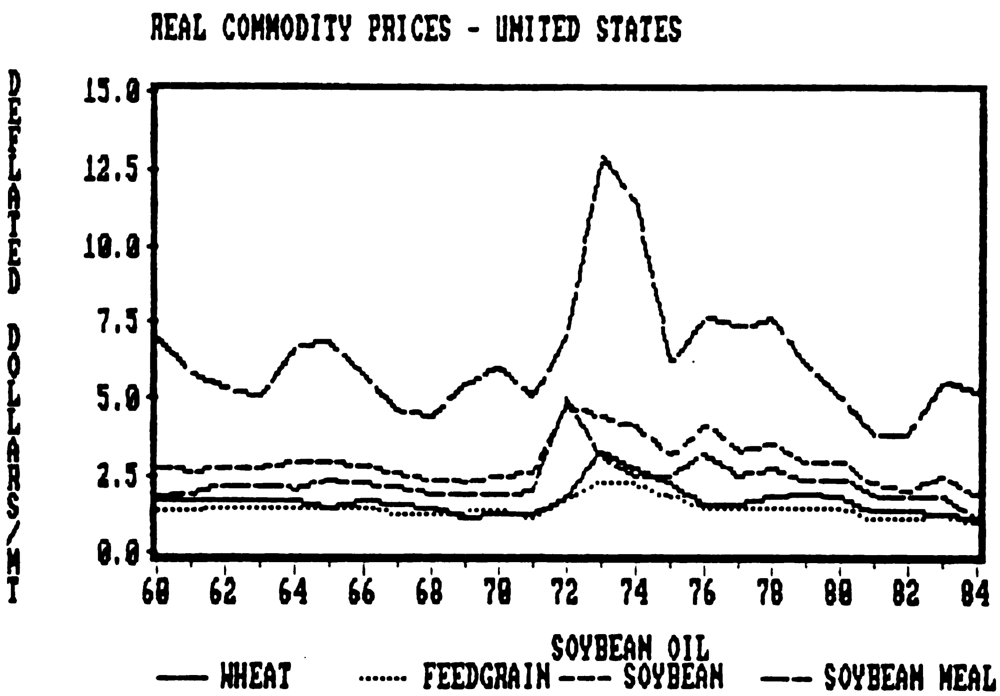

Figure 18: Real Commodity Prices - United States

a discussion of methods for detecting multiple correlation, see Judge _et al_. (1985).

Argentina provides an example of potential problems with multicollinearity because several price variables are involved. The best specification for each harvested area equation contains one grain price and one oilseed price. Correlation between revenue variables is thus minimized because very close substitutes are not included in the same equation (eg. two oilseeds). Correlations between the revenues are not as large as the R^2 of the equations. Correlations in the wheat equation are the highest. With an R^2 of .56 in the wheat equation, the correlation between wheat revenue and sunflower revenue is .41. Correlation between wheat harvested area and sunflowerseed revenue is .33, and between harvested area and wheat price, .37. Multicollinearity is most likely a problem in this case, according to the rule of thumb. Whether a strong relation exists or not is obscured by the presence of multicollinearity.

The problem of multicollinearity is present in any equation that contains the price of substitutes or complements in addition to own price because some degree of collinearity exists between any two price variables used in the Ag Model. In the Ag Model, prices in most regions other than the U.S. are generated by converting the U.S. price to a border price. Figure 18 demonstrates the relationship between U.S. wheat, feedgrain and soybean product prices. Simple correlations between pairs of real prices range from .41 between wheat and soybean meal prices to .93 between wheat and feedgrain prices.

Multicollinearity obscures the relationships between independent and dependent variables. Where multicollinearity is serious, there is little that can be done to measure the relationships between variables more accurately without introducing _a priori_ information. Restrictions based on prior information increase economic efficiency when they are valid, but introduce bias if they are overly restrictive (Abbott, 1987). Multicollinearity no doubt exists among other Ag Model variables, but is most obvious among the price variables.

CHAPTER 5: ELASTICITIES FROM MODEL SIMULATION

In this chapter, price elasticities of export and import demand are measured and reported from simulation runs of the Ag Model. Hectarage response is also calculated from these runs. The runs consist of solving the model for a best estimate of future prices and quantities, then solving again with specific variable changes. The difference between the two runs measures the effects of the altered variables. The first step is estimation of the effect of loan rates on world prices.

5.1 EFFECT OF THE U.S. LOAN RATE ON PRICES

The loan rate is essentially the price at which the U.S. government stands ready to buy certain agricultural commodities. A non-recourse loan is an arrangement where the U.S. government will lend money to farmers using their grain as collateral. The loan rate itself is the price at which the commodity is valued for loan purposes. If the market price of the commodity is unprofitable for the farmer, he or she may repay the loan in full with the commodity and the Commodity Credit Corporation (USDA) has no recourse but to accept this payment. These stocks accepted by the government enter the market when commodity prices reach a release price set by the government, generally 10 to 35 percent above the loan rate (Knutson, et al., 1986).

During recent years, the loan rate has supported U.S. wheat and feedgrain prices above equilibrium levels. When this is the case, one would expect that lowering the loan rates on wheat and corn would cause an immediate drop in the prices of wheat and feedgrain. Because U.S. prices are used as world prices in the model, world prices would also adjust immediately to changes in the loan rate in a simulation run. While there is a loan rate for soybeans, market prices have been high enough that it has not effectively supported prices in most years. For this reason, the loan rate for soybeans is not included in the specification of the U.S. component and cannot be directly tested. However, soybean price is expected to respond to changes in wheat and feedgrain prices due to substitution effects.

To determine initial baseline results, the Ag Model is solved for the period 1975 to 1996. This preliminary run, call it number A1, uses historical data through 1983, and 1984 where available, and uses the model's standard projections for exogenous variables beyond 1984. Appendix 5 contains the loan rates used for each crop.

In a second run, A2, wheat and feedgrain loan rates are reduced by twenty percent below baseline levels, beginning in 1986, to test the degree of adjustment. The model is again solved over the ten year forecast period and the simultaneous adjustment of wheat, feedgrain and soybean prices is estimated. The results are presented in Table 2.

TABLE 2: Percent Change in Price in Response to a 20 Percent Change in Wheat and Feedgrain Loan Rates

	1986	1990	1996
Wheat	-20.1	-20.0	-20.7
Feedgrain	-20.2	-16.8	-18.6
Soy Meal	-16.9	-23.5	-20.1

The reduction of the loan rates has an immediate effect on all three estimated commodity prices. On the basis of a twenty percent decrease in both the wheat and feedgrain (corn, sorghum, oats and barley) loan rates, wheat price drops 20.1 percent from the baseline in the first year (1986) and 20.7 percent by 1996. Feedgrain price responds to these same changes by declining 20.2 percent in 1986 and by only 18.6 percent by 1996. Dropping the wheat and corn loan rates by twenty percent causes soybean meal price to fall only 16.9 percent in 1986 but 23.5 percent in 1990 and 20.1 percent by 1992.

Soybean meal price is used rather than soybean price because it is the main component of soybeans that interacts with feedgrain and wheat as livestock feed and because soybean price is simply a function of meal and oil prices in the model. Soy oil price is exogenous and therefore does not respond to changes within the model. As a result, soybean price is biased upward and does not fully reflect the response of the soybean market to changes in grain loan rates.

The results indicate that a change in loan rates leads to a comparable change in U.S. market prices at times when the market price is close to and supported by the loan rate. In the following simulations, world prices (which are U.S. prices) are changed in addition to loan rates to assure precision in calculating elasticities. However, the results correspond to the effects of changes in the U.S. loan rate alone under current market conditions for wheat and feedgrains, assuming immediate price transmission from the U.S. to the world market.

This simulation is conducted to determine the effect on world prices of changes in the U.S. loan rate. Subsequent runs measure the effect of those price changes on U.S. exports and export revenues.

5.2 AGGREGATE PRICE ELASTICITIES

Aggregate[1] elasticities measure the effects of a simultaneous change in the prices of all Ag Model commodities on the supply and demand of exports and on the harvested area response for each commodity. The price changes parallel equal percentage changes in the loan rates. Aggregate export supply elasticities measure the percent change in net exports between two model runs as a result of a fixed percent change in all prices. Aggregate import demand, export demand and harvested area elasticities are calculated in the same manner.

A baseline for comparison, number B1, is generated by fixing revenues and ending stocks for the forecast period of 1986 to 1996 at the 1986 estimated values. These 1986 values are taken from the initial run (no. A1) which determined equilibrium levels for the forecast period. The results of this baseline (B1) serve as a basis for comparison with runs where revenues are lowered by a fixed percentage (numbers B2 and B3). Figure 19 illustrates the baseline and scenario revenue levels.

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1 Aggregate refers to elasticities calculated for a group of similar products, such as wheat, feedgrain and soybeans. Use of this terminology follows Cochrane (1958) and Tweeten (1967).

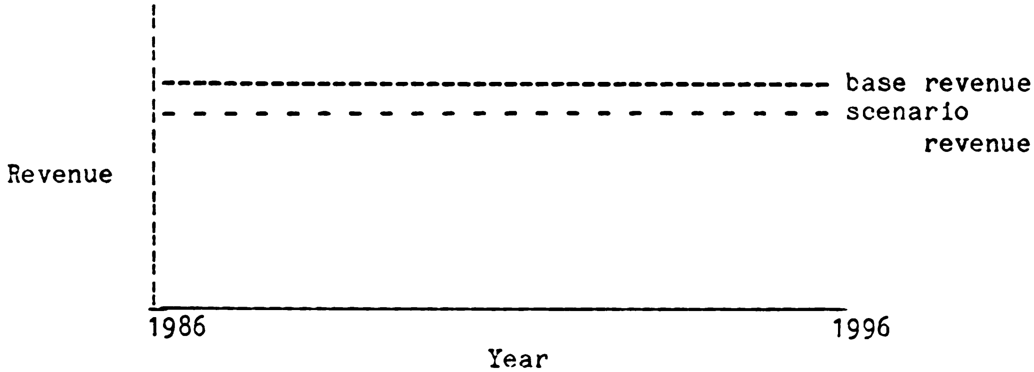

Figure 19: Base and Scenario Revenues for One Commodity, 1986 - 1996

Two ordinarily endogenous variables are exogenized in the PEXD simulations (B2 and B3), the first is revenue. Revenues are held constant rather than prices because the focus is supply response rather than demand response. While it is price that consumers face, revenue per unit (per hectare in this case) is a more relevant measure for producers. Crop revenues trend upward over time if prices are held constant because changes in technology cause yields per hectare to rise. This upward trend in yield is maintained in the PEXD scenarios, but is counterbalanced by a proportional downtrend in real prices, thus holding revenue constant. While real agricultural prices tend to decline over time, the incremental decline in trend price is calculated for forecasting purposes to just offset, on average, the increase in revenues due to yield increases. As a result, wheat prices are reduced by 1.7 percent per year, which is approximately the worldwide average increase in wheat yields per hectare. Feedgrain and soybean prices are adjusted downward by 1.6 percent and 0.9 percent per year respectively.

Soybean meal and oil prices are decreased by the same increment as soybean price (0.9 percent per year).

Another variable that is exogenized is ending stocks. Ending stocks are held constant to represent constant government policies because ending stock variables are used as proxies for policy in many countries. Ordinarily, changes in ending stocks would have a strong effect on prices. Because the forces that determine prices are ignored in this scenario, the effects of changes in ending stocks are also ignored. Constant ending stocks also eliminate effects due to changes in speculative and storage demand in importing countries (surplus exporters are not assumed to hold speculative stocks).

Two exogenous variables are held constant to eliminate the effects of differential rates of change in these variables between regions. First, inflation is removed from these scenarios by holding the deflator constant in all countries. Similarly, exchange rates are held constant to ensure that relative prices between countries do not change. While the equations in the model are estimated with very few restrictions imposed on them, this assumption in the PEXD simulation runs is a strong one. By holding exchange rates constant, it is assumed that exchange rates act as real price effects and, as such, are not relevant to the measurement of PEXD. For an alternative opinion on exchange rate effects, see Chambers and Just (1979).

The first simulation run, number B2, tests the effect of reducing all prices and revenues simultaneously by twenty percent. The only changes made from the initial baseline run (B1), are to lower wheat, feedgrain, soybean, soy meal and soy oil prices, which automatically adjusts revenues downward by twenty percent also, and to reduce loan rates by the same percentage.

The model has been structured to reflect the assumption that the U.S. is the residual supplier to the world market. Competing exporters are assumed to face infinite demand elasticity for their exports because their share of the world market is small and the quantities they export would not affect world price appreciably. If the demand they face is infinitely elastic, then quantities sold at different prices trace out the supply curve as shown in Figure 20.

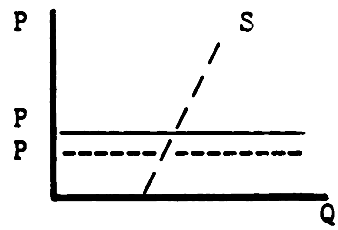

Figure 20: Supply of Exports by Countries Facing Infinitely Elastic Demand

The U.S. is assumed to be able to supply all demand that remains after the competitors have exported. Constant ending stocks in this scenario ensure that U.S. supply is infinitely elastic. When supply is infinitely elastic, changes in price trace out the demand curve for U.S. exports as in Figure 21.

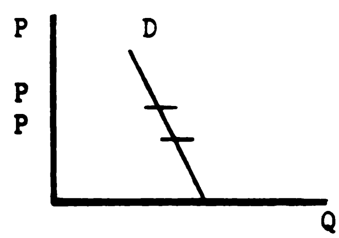

Figure 21: Demand for U.S. Exports

Thus supply elasticities for competing exporters and PEXD for the U.S. can be calculated from changes in exports as a result of changes in price.

For importing regions, elasticity of demand for imports can be calculated. If a country imports, demand exceeds domestic supply. When price drops, quantity demanded increases and quantity supplied domestically decreases. The elasticity calculated from the model is a net elasticity of demand for imports, which is total demand minus domestic supply and incorporates adjustments in both supply and demand, shown in Figure 22.

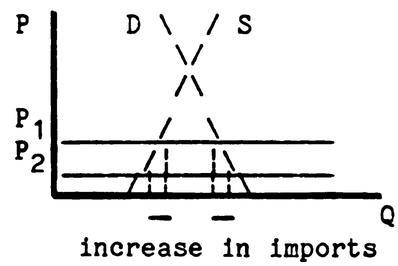

Figure 22: Change in Net Import Demand

5.21 Results

Elasticities are calculated from the differences between the constant-price run and the simultaneous-price-drop run rather than at a single price-quantity combination, therefore they are arc elasticities. U.S. PEXD is calculated for each commodity by dividing percent change from the baseline (constant prices for the entire period) in U.S. net exports by twenty (for percent change) and multiplying the result by one hundred. Export supply elasticities for competing exporters are calculated in a similar way. Elasticities of supply at the farm level are approximated by measuring percent change in harvested area for a percentage change in revenue.

Short run export and import elasticities are calculated for the same year the changes occurred (1986) when demand responds, but production does not; and for the following year (1987) when production also adjusts to changes in price. Long run elasticities are calculated for 1996, ten years after the change in prices began. Elasticities are presented for soy meal and oil equivalent exports and imports and for the three soybean products individually. Except for the U.S., exports and imports are calculated on an equivalent basis. Meal and oil equivalents include a percentage of the whole beans as well as the actual meal or oil. The percentages are the amounts of meal and oil extracted when beans are crushed. For meal, 79.5 percent is used for all regions, while 17.5 percent is used for oil equivalent. The remaining three percent is waste.

Table 3 presents PEXD for the U.S. and supply elasticities for other net exporters. It also shows percent changes in world trade, calculated in elasticity form. As a result of a twenty percent drop in price and revenue, world trade increased for all commodities except wheat. The unexpected behavior of wheat may be due to income effects. When prices are lowered in unison, animal protein becomes more affordable and consumption of wheat, an inferior good, declines as more meat is consumed. Secondly, more feedgrains are fed to animals than wheat when soybean meal price is low because the extra nutrition of wheat can be compensated for with more soybean meal. More specifically, wheat is substituted for feedgrain when soybean meal prices are high

TABLE 3: Price Elasticities for Exporters - Aggregate Run*

	Same Year 1986	Next Year 1987	Tenth Year 1996	Expected Sign
Export Demand - United States				
Wheat	+0.09	+0.30	+0.39	-
Feedgrain	-0.07	-0.16	-0.15	-
Soybeans	-0.05	-0.10	-0.95	-
Soy Meal	-0.15	-0.23	+0.56	-
Soy Oil	-0.08	-0.40	+0.17	-
Meal Equiv.	-0.09	-0.13	-0.52	-
Oil Equiv.	-0.07	-0.19	-0.59	-
Export Supply - Argentina				
Wheat	-0.10	-0.31	-0.48	+
Feedgrain	+0.02	+0.11	+0.11	+
Soybeans	0.00	+0.15	+2.63	+
Soy Meal	0.00	-0.11	-3.83	+
Soy Oil	0.00	-0.13	-3.98	+
Meal Equiv.	0.00	+0.06	-0.34	+
Oil Equiv.	0.00	+0.06	+0.35	+
Export Supply - Australia				
Wheat	0.00	0.00	0.00	+
Feedgrain	+0.23	+0.19	+0.12	+
Export Supply - Brazil				
Soybeans	0.0	+0.33	+1.08	+
Soy Meal	0.0	+0.08	+0.68	+
Soy Oil	0.0	+0.13	+1.25	+
Meal Equiv.	0.0	+0.11	+0.71	+
Oil Equiv.	0.0	+0.19	+1.22	+
Export Supply - China				
Feedgrain	+0.36	+0.45	+0.93	+
Soybeans	0.0	-0.72	-0.41	+
Soy Meal	0.0	-0.06	+0.01	+
Meal Equiv.	0.0	-0.33	-0.16	+
Export Supply - Developed Markets				
Wheat	+0.34	+0.23	+0.08	+
Soy Oil	+0.00	0.00	-0.02	+
World Trade				
Wheat	+0.07	+0.17	+0.19	-
Feedgrain	-0.03	-0.07	-0.04	-
Soybeans	-0.05	-0.06	-0.04	-
Soy Meal	-0.05	-0.05	-0.04	-
Soy Oil	-0.03	-0.15	-0.22	-
Meal Equiv.	-0.05	-0.05	-0.04	-
Oil Equiv.	-0.05	-0.11	-0.10	-

*Aggregate Run = simultaneous 20% drop in all crop revenues because of its higher nutrient content. In this case, as soybean meal becomes more affordable, more of it plus feedgrain is fed to livestock and less wheat is demanded.

PEXD's for all commodities in the U.S. are less than one, even in the long run. Similar to world trade, U.S. wheat exports decreased in response to lower prices, but at twice the rate. This implies that the U.S. loses market share in wheat.

Supply elasticities are quite low in general. This low response to price change is consistent with low elasticities calculated from the harvested area equations. U.S and Canadian net exports are based on the pool of demand remaining after the other countries export, rather than on price. Canada is the exception to the residual supplier structure of the model. It is not considered a surplus exporter, but a contingent surplus exporter, which means it shares the residual pool of world demand with the U.S. Since Canada does not face perfectly elastic demand for its exports, as the other exporters are assumed to, movements in equilibrium quantities do not trace out the supply curve. Therefore, export supply elasticities for Canada are not meaningful and are not calculated.

Changes in hectarage in response to changes in revenue are presented in Table 4. Elasticities are calculated for the short run, the year following the change, and the long run, ten years later. Planting decisions in all regions are assumed to be based on revenues from the year before, hence no response is possible in the first year of the price change, 1986.

In most cases elasticities are low and some are negative, opposite the direction that is expected. Aggregate elasticities for wheat and

TABLE 4: Revenue Elasticities of Supply at Farm Level
- Aggregate Run*

	Next Year 1987	Tenth Year 1996	Expected Sign
United States			
Wheat	-0.04	-0.08	+
Feedgrain	+0.13	+0.16	+
Soybeans	-0.06	-0.27	+
Cropland Base	+0.03	-0.02	+
Argentina			
Wheat	-0.12	-0.26	+
Feedgrain	+0.03	+0.09	+
Soybeans	+0.06	+0.33	+
Cropland Base	-0.02	+0.05	+
Brazil			
Wheat	+0.07	+0.11	+
Feedgrain	+0.13	+0.27	+
Soybeans	+0.09	+0.53	+
Cropland Base	+0.11	+0.37	+
Australia			
Wheat	0.00	0.00	+
Feedgrain	0.00	0.00	+
Cropland Base	0.00	0.00	+
Canada			
Wheat	-0.25	-0.52	+
Feedgrain	+0.14	+0.44	+
Cropland Base	-0.11	-0.14	+
Soviet Bloc			
Wheat	0.00	0.00	+
Feedgrain	0.00	0.00	+
Soybeans	0.00	0.00	+
Cropland Base	0.00	0.00	+
Developed Markets			
Wheat	0.00	0.00	+
Feedgrain	0.00	0.00	+
Soybeans	+0.03	+0.12	+
Cropland Base	0.00	0.00	+
Newly Industrialized Countries			
Wheat	-0.51	0.00	+
Feedgrain	+0.61	+3.72	+
Soybeans	+0.28	+1.67	+
Cropland Base	+0.47	+3.06	+

TABLE 4 (cont'd)

	Next Year 1987	Tenth Year 1996	Expected Sign
Oil-Exporting Low Income Countries			
Wheat	-0.11	-0.11	+
Feedgrain	+0.10	+0.09	+
Soybeans	-0.01	-0.02	+
Cropland Base	+0.02	+0.01	+
Low Income Countries			
Wheat	-0.04	-0.35	+
Feedgrain	+0.03	+0.06	+
Soybeans	-0.04	-0.06	+
Cropland Base	0.00	-0.08	+
China			
Wheat	+0.15	+0.21	+
Feedgrain	+0.14	+0.41	+
Soybeans	-0.43	-0.53	+
Cropland Base	+0.09	+0.21	+

*Aggregate Run = simulation of simultaneous 20% drop in revenues for wheat, feedgrain, soybeans and soybean products for feedgrain in Australia and the Developed Markets are zero because these harvested area equations have been restricted to yield zero elasticities when prices change simultaneously. In each case there is insufficient information to specify a more informative equation. In the Soviet Bloc, harvested areas do not respond because they are functions of ending stocks rather than revenue. In these centrally planned economies, farmers are assumed not to respond to price incentives, but to government policy, represented by ending stocks.

Cropland base in the U.S. holds essentially constant over the ten year forecast period. In fact, in most countries, cropland base responds very little to a simultaneous price change in the three crops. The exceptions are the NIC's, where cropland base is highly elastic, and Brazil and China, where moderately inelastic responses of .37 and .21 respectively, are observed for the long run. Production of Ag Model crops in the NIC's has trended downward over time as these countries rapidly industrialize. Reduced revenue in this scenario may speed the removal of cropland from production.

Table 5 presents demand elasticities for importing regions. All regions showed inelastic demand for every commodity, even in the long run, with the exception of feedgrain imports in Brazil. These are very elastic for the entire period. While the Developed Markets export some soy oil, the region is a net importer of oil equivalent. Thus the oil equivalent elasticity appears under import demand. Very few unexpected signs appear among the demand elasticities and most of these are very close to zero. The two exceptions are wheat demand in the LDC's and China. The unexpected signs for wheat suggest that the prices of other

TABLE 5: Price Elasticities of Demand for Importers - Aggregate Run*

	Same Year 1986	Next Year 1987	Tenth Year 1996	Expected Sign
Brazil				
Wheat	-0.05	-0.07	-0.06	-
Feedgrain	-3.19	-7.45	-1.78	-
Soviet Bloc				
Wheat	0.00	0.00	0.00	-
Feedgrain	-0.03	-0.02	-0.01	-
Soybeans	0.00	-0.03	-0.02	-
Soy Meal	0.00	+0.01	+0.01	-
Soy Oil	-0.27	-0.17	-0.33	-
Meal Equiv.	0.00	0.00	0.00	-
Oil Equiv.	-0.06	-0.05	-0.04	-
Developed Markets				
Feedgrain	+0.02	+0.02	+0.02	-
Soybeans	-0.06	-0.06	-0.05	-
Soy Meal	-0.06	-0.06	-0.05	-
Meal Equiv.	-0.06	-0.06	-0.05	-
Oil Equiv.	-0.08	-0.08	-0.06	-
Newly Industrialized Countries				
Wheat	+0.06	+0.04	+0.01	-
Feedgrain	-0.04	-0.04	-0.02	-
Soybeans	-0.11	-0.10	-0.03	-
Soy Meal	-0.30	-0.31	-0.21	-
Soy Oil	-0.50	-0.68	-0.23	-
Meal Equiv.	-0.16	-0.16	-0.11	-
Oil Equiv.	-0.11	-0.12	-0.09	-
Oil-Exporting Low Income Countries				
Wheat	-0.02	-0.01	-0.01	-
Feedgrain	+0.01	-0.29	-0.27	-
Soybeans	-0.16	-0.20	-0.12	-
Soy Meal	-0.18	-0.17	-0.11	-
Soy Oil	-0.16	-0.15	-0.12	-
Meal Equiv.	-0.18	-0.17	-0.11	-
Oil Equiv.	-0.15	-0.15	-0.12	-
Low Income Countries				
Wheat	0.00	+0.43	+0.64	-
Feedgrain	0.00	-0.03	+0.09	-
Soybeans	0.00	-0.01	0.00	-
Soy Meal	0.00	-0.01	0.00	-
Soy Oil	0.00	-0.21	-0.14	-
Meal Equiv.	0.00	0.00	0.00	-
Oil Equiv.	0.00	-0.19	-0.13	-

TABLE 5: (cont'd)

	Same Year 1986	Next Year 1987	Tenth Year 1996	Expected Sign
China				
Wheat	+0.42	+0.26	+0.12	-
Soy Oil	0.00	-0.14	-0.51	-
Oil Equiv.	0.00	+0.04	-0.60	-

*Aggregate Run = simulation of simultaneous 20% drop in revenues for wheat, feedgrain, soybeans and soybean products

agricultural commodities and non-agricultural products may be important in determining demand for Ag Model commodities.

Market shares for the major commodities are presented in Table 6 for each exporter. U.S. market share in wheat tends downward in the baseline, but accelerates with the simultaneous price declines of the scenario to lose an additional two percent of the market. The U.S. gains market share in feedgrain and soybeans over the baseline estimations during the entire forecast period. While U.S. soy meal and oil lose some market share, this loss is compensated for by the gain of over ten percent of the soybean market. This shift in soybean product markets corresponds to a loss of nearly twelve percent of the soybean market for Argentina, with a gain of ten percent in the meal and oil markets for Argentina. U.S. feedgrain gains and wheat losses of market share are distributed fairly evenly amongst the competing exporters with no shifts of more than one or two percent. Brazil, however, loses market share in all three soybean products.

TABLE 6: Market Shares (%) - Aggregate Run*

	Baseline		Aggregate Run	
	1986	1996	1986	1996
U.S.				
Wheat	50.4	49.9	50.2	47.9
Feedgrain	73.7	74.1	74.3	75.7
Soybeans	71.2	68.9	71.5	81.3
Soy Meal	35.8	31.4	36.5	27.7
Soy Oil	38.3	41.7	38.7	38.5
Argentina				
Wheat	6.8	6.6	7.0	7.6
Feedgrain	12.4	12.4	12.3	12.0
Soybeans	15.7	22.4	15.6	10.5
Soy Meal	10.6	13.9	10.5	24.4
Soy Oil	7.8	13.8	7.7	23.8
Australia				
Wheat	12.5	8.5	12.7	8.9
Feedgrain	5.0	5.6	4.7	5.4
Canada				
Wheat	25.5	24.5	25.5	24.5
Feedgrain	5.4	5.7	5.4	5.2
Brazil				
Soybeans	9.0	4.0	8.9	3.1
Soy Meal	47.5	46.8	47.0	40.1
Soy Oil	19.3	23.8	19.2	17.1
Developed Markets				
Wheat	4.9	10.4	4.6	10.6
Soy Oil	18.2	13.2	18.0	13.2
China				
Feedgrains	3.6	2.2	3.3	1.8
Soybeans	4.1	4.8	4.0	3.1
Soy Meal	6.1	7.8	6.1	7.8
Soy Oil	16.4	7.5	16.3	7.9

*Aggregate Run = simulation of simultaneous 20% drop in revenues for wheat, feedgrain, soybeans and soybean products

5.22 Discussion

In this study, elasticities are measured from decreases in product prices. However, the linear relationships in the structure of the Ag Model cause it to respond equally in magnitude to price increases or to price decreases. If Cochrane is correct in stating that supply responses to price increases are greater than responses to price decreases, then the Ag Model results would tend to overestimate the actual supply response to a drop in price. However, it is necessary to keep in mind that the elasticities are based on harvested area rather than supply and as such represent probable lower bounds to farm level supply elasticities.

In some cases, shifts occur between the amounts of soybeans and soybean products traded. In Argentina, soybeans has a large negative PEXD, but meal and oil have unexpected positive elasticities. These contradictory results are due to the behavior of the percentage meal equation that determines the share of meal equivalent exports actually exported as meal. To reflect the limited capacity of the crushing industry in Argentina, soybean production appears in the equation with a negative sign. In years of high production, the country's crushing capacity would be exceeded and soybeans would be exported whole rather than as meal and oil. In this scenario where production declines in response to lower price, the percentage of meal equivalent exported as meal jumps and causes a reversal of sign in the elasticity for meal (and oil). This change in supply by Argentina may be sufficient to change the composition of the residual pool of demand for U.S. soybean products and increase demand for U.S. soybean meal and oil.

5.3 SINGLE COMMODITY PRICE ELASTICITIES

It is common to measure elasticities for individual commodities in isolation, where own price is changed while other prices are held constant. This situation is simulated for wheat with wheat price, revenue and loan rate each reduced by twenty percent from the baseline (B1) levels in each year between 1986 and 1996. The prices and loan rates of feedgrain and soybeans are fixed, but all other endogenous variables in the model are allowed to adjust.

The purpose of a single-commodity run (number B3) is to provide a basis of comparison between the results generated by the Ag Model and those of other studies that have used the single-commodity approach. Further, it enables comparison of Ag Model results between the aggregate and the individual commodity situations. The same types of elasticities as in the aggregate case are calculated. Percent changes are measured from the baseline constant-price run (B1) for U.S. PEXD, competing exporter supply, harvested area and import demand. Changes in market shares are also calculated. As in the aggregate run (B2), exchange rates are constant and inflation is zero in each country.

5.31 Results

The exporter elasticities are presented in Table 7. The volume of world trade in wheat rises by one percent in the first year as a result of a twenty percent reduction in wheat price (elasticity of -0.05) and increases by five percent over the baseline at the end of the period (-.25 elasticity). Feedgrain trade declines very slightly and soybeans and soy products show essentially no change during the entire period.

TABLE 7: Price Elasticities for Exporters - Single Commodity Run

	Same Year 1986	Next Year 1987	Tenth Year 1996	Expected Sign
Export Demand - United States				
Wheat	-0.10	-0.37	-0.51	-
Feedgrain	+0.16	+0.36	+0.27	+
Soybeans	0.00	+0.07	+0.50	+
Soy Meal	0.00	-0.02	-0.95	+
Soy Oil	0.00	-0.07	-0.68	+
Meal Equiv.	0.00	+0.05	+0.08	+
Oil Equiv.	0.00	+0.03	+0.12	+
Export Supply - Argentina				
Wheat	+0.08	+0.47	+0.46	+
Feedgrain	0.00	-0.34	-0.40	-
Soybeans	0.00	-0.10	-1.42	-
Soy Meal	0.00	+0.07	+2.13	-
Soy Oil	0.00	+0.09	+2.21	-
Meal Equiv.	0.00	-0.04	-0.17	-
Oil Equiv.	0.00	-0.04	-0.17	-
Export Supply - Australia				
Wheat	0.00	+0.08	+0.60	+
Feedgrain	+0.01	-0.82	-0.69	-
Export Supply - Brazil				
Soybeans	0.0	0.00	0.00	-
Soy Meal	0.0	0.00	0.00	-
Soy Oil	0.0	0.00	0.00	-
Meal Equiv.	0.0	0.00	0.00	-
Oil Equiv.	0.0	0.00	0.00	-
Export Supply - China				
Feedgrain	-1.29	-1.37	-1.91	-
Soybeans	-0.04	-0.73	-0.51	-
Soy Meal	0.00	-0.06	-0.01	-
Meal Equiv.	-0.01	-0.34	-0.21	-
Export Supply - Developed Markets				
Wheat	+0.34	+0.23	+0.10	+
Soy Oil	0.00	0.00	0.00	-
World Trade				
Wheat	-0.05	-0.18	-0.25	-
Feedgrain	+0.07	+0.10	+0.04	+
Soybeans	0.00	0.00	0.00	+
Soy Meal	0.00	0.00	-0.01	+
Soy Oil	0.00	-0.04	+0.01	+
Meal Equiv.	0.00	0.00	0.00	+
Oil Equiv.	0.00	0.00	-0.01	+

The PEXD for U.S. wheat is -.10 in the same year, -.37 one year later and -.55 in the long run, ten years later. Other U.S. exports decline as they become more expensive relative to wheat. However, for all commodities the U.S. PEXD is inelastic over the entire period. Wheat and feedgrain respond slightly more strongly than in the aggregate run but soybean products are less responsive. The signs are as expected. While soy meal and oil move in the opposited direction from expectations, the shift is not significant because meal and oil equivalents are signed as expected.

Supply elasticities are largely inelastic except for feedgrain in China, which is elastic even in the short run. Soybean products, in general, show very little response to a change in wheat price, being a more distant substitute for wheat than feedgrain is.

Harvested area responses appear in Table 8. All harvested areas either respond in the expected direction or negligibly in the opposite direction. Wheat in both the NIC's and Brazil shows elasticities greater than one. The elasticity of feedgrain harvested area in the NIC's also exceeds one in the long run. Wheat harvested area declines steadily in the NIC's in the baseline and reaches a minimum before 1996. Thus the elastic response to lower wheat revenue is eliminated by that year in the scenario run.

Change in cropland base in this single-commodity run is dominated primarily by the relative areas of wheat and the other crops. Only in the NIC's, where the response is determined by an elastic feedgrain harvested area, is cropland base response moderate in the long run, though still inelastic. Short run elasticities for cropland base are not greatly different from zero in value.

TABLE 8: Revenue Elasticities of Supply at Farm Level - Single Commodity Run

	Next Year 1987	Tenth Year 1996	Expected Sign
United States			
Wheat	+0.11	+0.17	+
Feedgrain	-0.14	-0.14	-
Soybeans	-0.01	-0.04	-
Cropland Base	-0.04	-0.02	-
Argentina			
Wheat	+0.23	+0.26	+
Feedgrain	-0.27	-0.33	-
Soybeans	-0.03	-0.16	-
Cropland Base	-0.03	-0.08	-
Brazil			
Wheat	+0.58	+2.45	+
Feedgrain	-0.32	-0.18	-
Soybeans	0.00	0.00	-
Cropland Base	-0.10	+0.10	-
Australia			
Wheat	+0.06	+0.42	+
Feedgrain	-0.65	-0.60	-
Cropland Base	-0.19	+0.02	+
Canada			
Wheat	+0.03	+0.08	+
Feedgrain	-0.13	-0.48	-
Cropland Base	-0.03	-0.14	+
Soviet Bloc			
Wheat	-0.03	-0.03	+
Feedgrain	+0.04	+0.03	-
Soybeans	0.00	0.00	-
Cropland Base	+0.01	+0.01	-
Developed Markets			
Wheat	0.00	0.00	+
Feedgrain	0.00	0.00	-
Soybeans	0.00	0.00	-
Cropland Base	0.00	0.00	-
Newly Industrialized Countries			
Wheat	+1.75	0.00	+
Feedgrain	-0.20	-1.05	-
Soybeans	0.00	+0.01	-
Cropland Base	-0.06	-0.71	-

TABLE 8 (cont'd.)

	Next Year 1987	Tenth Year 1996	
Oil-Exporting Low Income Countries			
Wheat	+0.06	+0.06	+
Feedgrain	+0.01	0.00	-
Soybeans	0.00	0.00	-
Cropland Base	+0.02	+0.02	-
Low Income Countries			
Wheat	+0.04	+0.30	+
Feedgrain	-0.06	-0.09	-
Soybeans	0.00	0.00	-
Cropland Base	-0.03	+0.04	-
China			
Wheat	+0.15	+0.21	+
Feedgrain	-0.21	-0.53	-
Soybeans	-0.43	-0.53	-
Cropland Base	-0.06	-0.17	-

Table 9 contains demand elasticities for the importers under this scenario. Price elasticities of demand for importers are extremely inelastic. Only Brazil, LDC's and China respond even moderately. Brazilian feedgrain net imports, one of the worst equations in the model in terms of magnitude of error (Shagam, 1987), shows very elastic responses in both the aggregate and the single commodity runs. However, Brazilian imports are quite inelastic to price and depend largely on variations in domestic production. The Brazilian government is willing to import corn, even when the world price exceeds the domestic price, in order to ensure stable domestic prices (ERS, 1986). A further complication results from the fact that the mean level of imports for Brazil is slightly negative, Brazil is technically a net exporter of feedgrains over this sample period. Therefore, the interpretation of the import elasticities measured for Brazil is questionable.

Table 10 presents market shares for each exporting region. The U.S. and Canada gain slight increases over the baseline forecast in their shares of the wheat market at the expense of other exporters. The U.S. gain in the wheat market is offset by loss of market share in feedgrain over the period. This loss is distributed approximately evenly across the competing exporters. In the soybean market, the U.S. loses several percentage points, but gained as much in the soy meal and oil markets. As in the aggregate case, this shift mirrors the behavior in Argentina's market shares. China gains slightly in soybean product markets and Brazil is completely unaffected by the wheat price drop.

TABLE 9: Price Elasticities of Demand for Importers - Single Commodity Run

	Same Year 1986	Next Year 1987	Tenth Year 1996	Expected Sign
Brazil				
Wheat	-0.05	-0.26	-0.62	-
Feedgrain	-0.09	+4.22	-0.34	+
Soviet Bloc				
Wheat	0.00	+0.03	+0.03	-
Feedgrain	+0.18	+0.16	+0.09	+
Soybeans	0.00	0.00	0.00	+
Soy Meal	0.00	0.00	0.00	+
Soy Oil	-0.02	-0.02	-0.01	
Meal Equiv.	0.00	0.00	0.00	+
Oil Equiv.	0.00	0.00	0.00	
Developed Markets				
Feedgrain	0.00	0.00	0.00	+
Soybeans	0.00	0.00	0.00	+
Soy Meal	0.00	0.00	0.00	+
Meal Equiv.	0.00	0.00	0.00	+
Oil Equiv.	0.00	0.00	0.00	
Newly Industrialized Countries				
Wheat	-0.14	-0.15	0.00	-
Feedgrain	0.00	0.00	0.00	+
Soybeans	0.00	0.00	0.00	+
Soy Meal	0.00	0.00	+0.04	+
Soy Oil	0.00	0.00	+0.03	
Meal Equiv.	0.00	0.00	0.00	+
Oil Equiv.	0.00	0.00	0.00	
Oil-Exporting Low Income Countries				
Wheat	-0.02	-0.04	-0.03	-
Feedgrain	+0.13	+0.17	+0.14	+
Soybeans	+0.03	+0.04	0.00	+
Soy Meal	0.00	-0.01	0.00	+
Soy Oil	0.00	0.00	0.00	
Meal Equiv.	0.00	0.00	0.00	+
Oil Equiv.	0.00	0.00	0.00	
Low Income Countries				
Wheat	0.00	-0.35	-0.52	-
Feedgrain	0.00	+0.12	-0.04	+
Soybeans	0.00	+0.02	+0.01	+
Soy Meal	0.00	+0.02	+0.01	+
Soy Oil	0.00	0.00	0.00	
Meal Equiv.	0.00	+0.02	+0.01	+
Oil Equiv.	0.00	0.00	0.00	

TABLE 9: (cont'd)

	Same Year 1986	Next Year 1987	Tenth Year 1996	Expected Sign
China				
Wheat	-0.20	-0.35	-0.39	-
Soy Oil	0.00	-0.13	-0.40	
Oil Equiv.	+0.01	+0.05	-0.27	

TABLE 10: Market Shares (%) - Single Commodity Run

	Baseline 1986	Baseline 1996	Wheat Run 1986	Wheat Run 1996
U.S.				
Wheat	50.4	49.9	50.9	52.4
Feedgrain	73.7	74.1	72.4	70.7
Soybeans	71.2	68.9	71.2	62.0
Soy Meal	35.8	31.4	35.8	37.3
Soy Oil	38.3	41.7	38.3	47.3
Argentina				
Wheat	6.8	6.6	6.6	5.7
Feedgrain	12.4	12.4	12.6	13.5
Soybeans	15.7	22.4	15.7	28.8
Soy Meal	10.6	13.9	10.6	8.0
Soy Oil	7.8	13.8	7.8	7.7
Australia				
Wheat	12.5	8.5	12.4	7.2
Feedgrain	5.0	5.6	5.0	6.4
Canada				
Wheat	25.5	24.5	25.6	25.0
Feedgrain	5.4	5.7	5.4	6.4
Brazil				
Soybeans	9.0	4.0	9.0	4.0
Soy Meal	47.5	46.8	47.5	46.8
Soy Oil	19.3	23.8	19.3	23.8
Developed Markets				
Wheat	4.9	10.4	4.5	9.7
Soy Oil	18.2	13.2	18.2	13.1
China				
Feedgrains	3.6	2.2	4.6	3.0
Soybeans	4.1	4.8	4.1	5.2
Soy Meal	6.1	7.8	6.1	7.9
Soy Oil	16.4	7.5	16.4	8.1

5.32 Discussion

The single-commodity run of the Ag Model can be compared to other studies of PEXD for wheat. In the short run, the PEXD of -.10 is smaller than any estimate reported in Gardiner and Dixit's (1987) review of the empirical literature (see Table 11). However, the Ag Model's long run estimate of -.51 falls within the range of estimates in Gardiner and Dixit's study, -.23 to -6.72, albeit at the lower end. Table 11 contains the wheat PEXD's reported in Gardiner and Dixit.

The farm level revenue elasticities of this study that appear in Table 8 are similar to supply elasticities reported by the IIASA model (Seeley, 1985). Similar magnitudes appear for Ag Model changes in harvested area due to revenue changes and for adjustments in production due to changes in the world price for the IIASA model study. The two measures are not identical, as previously stressed, but are analagous. Table 12 compares IIASA model results to Ag Model results from Table 8. For example, Seeley reports elasticities of 0.19 in the second year and 0.29 in the tenth year[2] for Argentine wheat, while the Ag Model gives 0.23 in 1987 and .26 in 1996.

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[2]The IIASA study's forecast period was 1985 to 1994, close to the present study's 1986 to 1996 period. By IIASA methods of calculating years, Ag Model values for 1996 are actually the eleventh year.

TABLE 11: Price Elasticities of Export Demand for U.S. Wheat

Study	Period	Method	Elasticity Short run	Elasticity Long run
Konandreas and Schmitz (1978)	1955-72	Estimation (OLS)	-3.13	--
Taylor and Talpaz (1979)	1960-74	Estimation (SUR)	-.15	--
Baumes and Meyers (1980)	1951-76	Estimation (OLS)	-.35	--
Gallagher, Lancaster, Bredahl and Ryan (1981)	1960-74	Estimation (OLS)	-.41	--
Chambers and Just (1981)	1969(I) 1977(II)	Estimation (3SLS)	-.17	-0.23
Gadson, Price, and Salathe (1982)	1963-78	Estimation (OLS)	-.21	--
Morton, Devadoss, and Heady (1984)	1962-79	Estimation (3SLS)	-.14	--
Conway (1985)	1969(I)- 1977(II)	Estimation (SC)	-.26	-.43
Johnson (1977)	1970 base	Calculation	--	-6.72
Miller and Washburn (1978)	1976 base	Calculation	--	-5.00
Bredahl, Meyers, and Collins (1979)	1972/73- 1975/76	Calculation	--	-1.67
Burt, Koo, and Dudley (1980)	--	Calculation	-2.50	--
Webb and Blakely (1982)	--	Calculation	-1.05	--
Paarlberg (1983)	1960-75	Calculation	--	-1.82
Dunmore and Longmire (1984)	1980/81- 1982/83	Calculation	--	-.84
Honma and Heady (1984)	1964-78	Calculation	-.44	--
Liu and Roningen (1985)	1984 base	Calculation	--	-2.30
Gardiner (1986)	1967-80	Calculation	--	-.81

TABLE 11: Price Elasticities of Export Demand for U.S. Wheat--Continued

Study	Period	Method	Elasticity Short run	Elasticity Long run
Kost, Schwartz, and Burris (1979)	1960-75	Simulation	-0.35	-0.35
Holland and Sharples (1984)	1979/80-1981/82	Simulation	-.70	--
Green and Price (1984)	1986	Simulation	-.54	--
Seeley (1985)	1985 base	Simulation	-.81	-1.49
Ray and Parvin (1978)	--	Synthetic	-.50	-1.50
Holland and Sharples (1981)	--	Synthetic	-.50	--

Source: Gardiner and Dixit, 1987. -- = Not available.

TABLE 12: Comparison of Price Elasticities of Supply - IIASA Model and Ag Model

Country	Commodity Supplied	Elasticity with respect to world price of wheat			
		IIASA		Ag Model	
		Year 2	Year 10	Year 2	Year 10
Argentina	Wheat	+0.19	+0.29	+0.23	+0.26
Australia	Wheat	+0.35	+0.31	+0.06	+0.42
Canada	Wheat	+0.50	+0.43	+0.03	+0.08
	Feedgrain	-0.28	-0.40	-0.13	-0.48

Source: Seeley (1985)

In comparison to the aggregate run, U.S. PEXD's are predictably larger in the single commodity run because of substitution effects between wheat and feedgrain. There is little interaction between wheat price and soybean supply in this run, where wheat prices are changed independently.

CHAPTER VI. SUMMARY AND CONCLUSIONS

In this chapter the results presented in the preceding chapters are briefly summarized and conclusions are drawn from the findings of the study. The objectives of the study are to determine the short and long run price elasticities of supply implied by the Michigan State University Agriculture Model for wheat, feedgrain and soybeans and to examine the effects of alternative specifications of price.

6.1 SUMMARY OF RESULTS

Chapters 3 and 4 address the second objective, that of comparing alternative specifications of price to determine whether the results are consistent or whether choice of specification alters the results. Specifically, do the low elasticities generated by the Ag Model result from the chosen specification of price? The relationship of cropland base,[1] as an aggregate supply variable, and a weighted average of gross revenue based on border prices, as the expected price variable, is examined in Chapter 3. In no country studied is the relationship between cropland base and revenue strong. Among the possible alternative specifications of the price variable are revenue calculated on internal prices rather than on border prices in order to avoid problems of imperfect price transmission and deflated gross revenue to account for deviations in input costs from the general inflation rate.

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[1] Sum of wheat, feedgrain and soybean harvested areas.

Estimation may also be improved by inclusion of cross revenues relevant to the particular country.

Some of the alternative specifications mentioned above are tested in Chapter 4. Internal prices, prices of substitutes and production costs are introduced in the harvested area equations for Australia, a country where internal prices are based on world prices. While the t-statistic is the primary criterion for judging performance, other measures of fit, such as adjusted R-squared and F-statistics are also used. As might be expected in an open economy, internal prices do not contain more information than world prices. Imperfect price transmission is therefore ruled out as a cause for low price response in this country. In order to account for variation from general inflation in production costs, revenue is deflated by an index of prices paid by producers. The results show no improvement, however. A third trial is the introduction of competing prices. Wool is an enterprise that competes for land in much of the wheat and feedgrain area of Australia, but wool price is not significant in either the wheat or the feedgrain harvested area equation.

Similarly for Argentina, internal and competing prices are tested in the harvested area equations. Internal prices for wheat and feedgrains do not show a stronger relationship to harvested areas than do border prices in Argentina where there is considerable government intervention in agriculture. In the case of soybeans where market intervention is less strong, internal prices improve the fit somewhat. However, the internal variables do not present any evidence that harvested areas are in fact price elastic. Prices of competing enterprises, specifically sunflowers, flax and beef are introduced with mixed results. Sunflowerseed revenue is statistically significant in the wheat equation and flaxseed revenue in the feedgrain equation. For soybeans however, none of these competing revenues are significant.

The price elasticity of export demand (PEXD) for the U.S. and import demand and export supply elasticities for regions other than the U.S. are measured in Chapter 5 for each commodity. Aggregate elasticities are calculated for a simultaneous and proportional price drop for wheat, feedgrain and soy products. Aggregate elasticities are low for both supply and demand. When PEXD is calculated for a single commodity price decline, elasticities are still quite low, but generally more elastic than in the aggregate run.

6.2 CONCLUSIONS

Four types of elasticities are measured in the Ag Model simulations. The two supply elasticities are the elasticity of harvested area (supply) with respect to revenue (price), measured for each region, and price elasticity of export supply for regions that compete with the U.S. On the demand side, price elasticity for imports is calculated for importing regions and PEXD is measured for U.S. exports to the rest of the world. Most of these elasticities calculated from the Ag Model, both of supply and demand, are quite inelastic.

In part, the low elasticities result from the Ag Model's specification. First, at the farm level, supply is approximated imperfectly by harvested area, an input to supply rather than the output itself. Further, the yield component of supply is exogenized for simplicity and it is the actual harvested area, rather than the planted area that is measured. Planted area would more accurately represent farmers' production intentions.

Second, though the pattern of change in revenue per hectare is similar to that in price, it is not identical. The partial adjustment framework is intended to account for time lags in hectarage adjustment, but by no means does it represent expected price perfectly. These simplifications in specification of the supply and price variables cause the model to measure the supply elasticity imperfectly and may have reduced the estimated value.

Third, many regions are insulated from the world economy by government policies, as illustrated in Chapter 3. The estimated elasticities for these insulated regions are likely lower than they would be with no government interventions, but the responsiveness of farmers in insulated regions to the actual prices they face is masked by the use of world price as a basis. Insulation from the world market dampens the response that is measured by an elasticity based on world price.

Finally, the specification of some well-insulated regions does not include world prices at all, but policy variables, because the production and import decisions in these regions are policy-driven. For example, the Soviet Bloc showed no supply response to price because price variables are not included in the harvested area equations. Rather, these equations are based on lagged ending stocks, which are intended to represent government policy. Ending stocks, in turn, are based on the price of the crop as well as domestic supply. Because ending stocks and prices are fixed at particular levels in this study, the indirect link between price and harvested areas is broken and harvested areas show no response to price in these scenarios. If price were not fixed, it would have an indirect effect on harvested areas in the Soviet Bloc.

The aggregate elasticities presented in this study are lower than those frequently seen primarily because there are few estimations in the literature measured for several commodities at once, rather than the usual ceteris paribus analysis. A more general reason for low elasticities in comparison to other studies is that these elasticities measure net effects under imperfect market conditions. Government intervention prevents the world price from having a direct impact on farmers' decisions in many parts of the world. Exchange controls, tariffs and subsidies and other barriers often lie between the two prices. Government programs to control production also restrict farmers' responses. Many studies in the literature assume neoclassical free trade conditions (Gardiner and Dixit, 1987). For example, Tweeten (1967) excluded certain types of exports specifically to adjust for barriers to free trade. In contrast, the present study measures supply and demand elasticities with these barriers intact.

The evidence presented in Chapters 3 and 4 supports the low elasticity measurements in Chapter 5. Harvested area does not respond strongly to changes in revenue. Harvested area in the aggregate, or cropland base, responds even less. To the extent that hectarage responds to changes in revenue, it is through substitution between crops rather than an adjustment in total area. Attempts in this study to more accurately formulate the price variable do not demonstrate an elastic relationship. If supply is unresponsive at the farm level (hectarage), it is not surprising to find it inelastic at the national level in countries that do not hold large stocks.

The PEXD's generated by the Ag Model are clearly inelastic. This result may be seen to imply that the decision to reduce grain prices on the world market in order to expand U.S. exports has two important consequences. The policy fails to dispose of grain stock surpluses because exports do not increase substantially. More importantly, farm revenues would suffer substantially if the loss were not made up with deficiency payments and other forms of farm income subsidization. Larger subsidies to offset lower market prices cause government expenses to increase substantially and may exceed the cost of storing the surplus grain that accumulated with high prices.

APPENDICES

APPENDIX 1

TABLE 13: Ag Model Regional Groupings

Region	Acronym	Countries
United States	US	United States
Canada	CA	Canada
Australia	AU	Australia
Argentina	AR	Argentina
Brazil	BR	Brazil
Developed Markets	DM	United Kingdom, Belgium, Denmark, Netherlands, Finland, Luxembourg, Portugal, Ireland, Greece, Iceland, Austria, France, West Germany, Italy, Switzerland, Sweden, Norway, Malta, Spain, Japan, South Africa
Soviet Bloc	SB	Albania, Bulgaria, East Germany, Hungary, Poland, Romania, Yugoslavia, Czechoslovakia, USSR
China	CH	China
Oil-Exporting LDC's	OP	Algeria, Ecuador, Indonesia, Iran, Iraq, Libya, Oman, Saudi Arabia, Venezuela, Nigeria, United Arab Emirates, Kuwait
Newly Industrialized Countries	NC	Hong Kong, Singapore, Malaysia, Taiwan, South Korea
LDC's	LD	all others

APPENDIX 2

TABLE 14: Price Elasticities of Import Demand

	Own Price	Cross Price	Sample Period
Brazil			
Wheat	-0.07	-	'61-'83
Feedgrain	+4.40	-	'61-'84
Developed Markets			
Wheat	+0.19***	-	'61-'84
Feedgrain	-	+0.05****	'61-'83
Meal Equivalent	-0.14*	-	'64-'83
Oil Equivalent	-0.16*	-	'64-'83
Low Income Countries			
Wheat	-0.56	+0.97(F)	'61-'84
Oil Equivalent	-0.50**	-	'65-'83
Newly Industrialized Countries			
Wheat	-0.31	+0.35(F)	'69-'83
Feedgrain	-0.18	-	'61-'83
Meal Equivalent	-0.71*	-	'65-'83
Oil Equivalent	-0.34**	-	'65-'83
Oil-Exporting Low Income Countries			
Wheat	-0.13	-	'62-'83
Feedgrain	-0.99	+1.33(W)	'61-'83
	-2.33 (lagged feedgrain price)		
Meal Equivalent	-1.88*	-	'64-'81
Oil Equivalent	-0.81*****	-	'64-'81
Soviet Bloc			
Feedgrain	-1.25	+1.36(W)	'61-'82
Oil Equivalent	-0.98**	-	'64-'83
China			
Wheat	-0.37	+0.86(F)	'61-'83
Feedgrain	-7.56	+7.39(W)	'61-'84

* Soybean Price
** Soy Oil Price
*** EEC Producers' Wheat Price minus World Wheat Price
**** Weighted Average of Cassava and Soy Meal Prices
***** Crush Margin = (Soy Meal Price *.795 + Soy Oil Price *.175 - Soybean Price)

APPENDIX 3

Cropland Base Estimation, Statistical Results

Cropland base is estimated for Argentina, Brazil, Australia, Canada, the U.S. and the Developed Markets. Cropland base (the sum of wheat, feedgrain and soybean harvested areas in a region) is regressed in a partial adjustment framework on cropland base lagged one year and lagged gross revenue. The form of the equations is:

$$CLB = f(CLB(-1),\ REV(-1)).$$

where:

CLB(-1) = cropland base, lagged one year

$$REV = \sum_{i=1}^{n} \left[\frac{HA(j)}{CLB} * \text{4-yr avg. yield}(i) * Pw * \frac{XR(j)}{CPI(j)} \right]$$

REV = average weighted revenue,

HA(i) = harvested area for crop i,

CLB = cropland base, sum of the harvested areas,

yield(i) = metric tons per hectare of crop i,

Pw = world price,

XR(j) = exchange rate for country/region j,

CPI(j) = consumer price index, country/region j.

The statistical results of the regressions are presented in the remainder of this appendix.

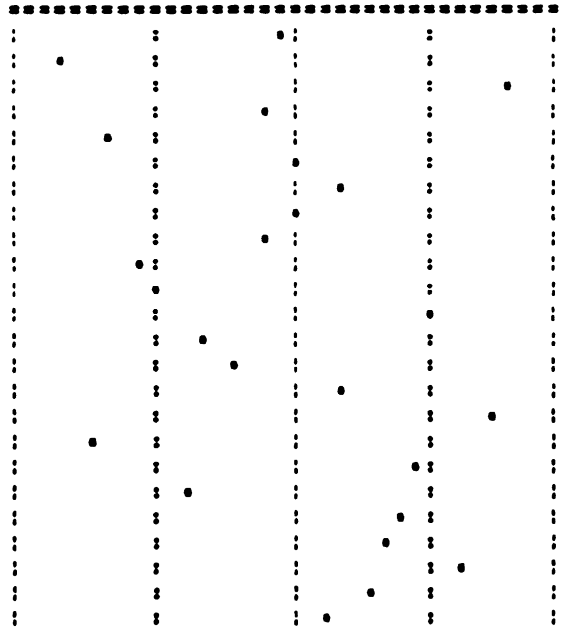
APPENDIX 3 (cont'd)

SMPL 1961 - 1984
24 Observations
LS // Dependent Variable is CLBAR   Cropland Base, Argentina

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	3084.5911	1691.8386	1.8232183	0.083
CLBAR(-1)	0.8097941	0.1430335	5.6615694	0.000
REV(-1)	-504.29227	676.03539	-0.7459554	0.464

R-squared	0.606177	Mean of dependent var	11756.63
Adjusted R-squared	0.568670	S.D. of dependent var	1955.566
S.E. of regression	1284.332	Sum of squared resid	34639698
Durbin-Watson stat	2.466518	F-statistic	16.16172
Log likelihood	-204.2440		

Residual Plot



obs	RESIDUAL	ACTUAL	FITTED
1961	-159.376	9322.00	9481.38
1962	-2222.49	7882.00	10104.5
1963	2068.07	10926.0	8857.93
1964	-229.237	11039.0	11268.2
1965	-1800.92	9703.00	11503.9
1966	16.5197	10456.0	10439.5
1967	453.335	11515.0	11061.7
1968	-7.82116	11902.0	11909.8
1969	-275.655	12022.0	12297.7
1970	-1465.81	10845.0	12310.8
1971	-1393.65	9901.00	11294.6
1972	1296.96	12016.0	10719.0
1973	-816.907	11167.0	11983.9
1974	-609.060	10442.0	11051.1
1975	512.828	11312.0	10799.2
1976	1870.54	13111.0	11240.5
1977	-1940.20	11058.0	12998.2
1978	1207.81	12394.0	11186.2
1979	-1005.07	11424.0	12429.1
1980	1049.39	12967.0	11917.6
1981	939.434	14137.0	13197.6
1982	1582.03	15778.0	14196.0
1983	683.020	15699.0	15016.0
1984	246.251	15141.0	14894.7

where: CLBAR(-1) = Cropland base, Argentina, lagged one year

REV(-1) = Weighted average revenue per hectare, lagged one year

APPENDIX 3 (cont'd)

SMPL 1961 - 1984
24 Observations
LS // Dependent Variable is CLBBR Cropland base, Brazil

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	961.98325	729.41355	1.3188448	0.201
CLBBR(-1)	0.9654743	0.0469419	20.567452	0.000
REV(-1)	2.5004898	7.5912935	0.3293892	0.745

R-squared	0.972924	Mean of dependent var	16831.75
Adjusted R-squared	0.970346	S.D. of dependent var	6244.760
S.E. of regression	1075.371	Sum of squared resid	24284876
Durbin-Watson stat	2.263989	F-statistic	377.3044
Log likelihood	-199.9823		

```
           Residual Plot                obs RESIDUAL   ACTUAL    FITTED
:          :  *   :      :         :  1961 -531.473   7981.00   8512.47
:          :   *  :      :         :  1962 -497.029   8282.00   8779.03
:          : *    :      :         :  1963 -812.433   8370.00   9182.43
:          :      : *    :         :  1964  295.595   9520.00   9224.41
:          :*     :      :         :  1965 -879.622   9548.00   10427.6
:          :     *:      :         :  1966 -128.126   10309.0   10437.1
:          :    * :      :         :  1967 -283.830   10856.0   11139.8
:          :     *:      :         :  1968 -190.954   11414.0   11605.0
:          :      :  *   :         :  1969  475.490   12644.0   12168.5
:          :      :     *:         :  1970  924.156   14297.0   13372.8
:          :      :    * :         :  1971  851.204   15818.0   14966.8
:         *:      :      :         :  1972 -1212.54   15218.0   16430.5
:          :      :      :       * :  1973  2395.63   18410.0   16014.4
:          :      *      :         :  1974  49.3905   19245.0   19195.6
:          :      :   *  :         :  1975  675.290   20672.0   19996.7
:          :      :      : *       :  1976  1440.55   22723.0   21282.4
:          :*     :      :         :  1977 -976.128   22310.0   23286.1
:          :     *:      :         :  1978 -134.015   22614.0   22748.0
:          :      :      : *       :  1979  1371.74   24452.0   23080.3
:          :    * :      :         :  1980 -298.307   24616.0   24914.3
:        * :      :      :         :  1981 -1369.99   23800.0   25170.0
:      *   :      :      :         :  1982 -1822.13   22410.0   24232.1
:          :      :      : *       :  1983  1381.63   24286.0   22904.4
:          :  *   :      :         :  1984 -624.099   24267.0   24891.1
```

where: CLBBR(-1) = Cropland base, Brazil, lagged one year

REV(-1) = Weighted average revenue per hectare, lagged one year

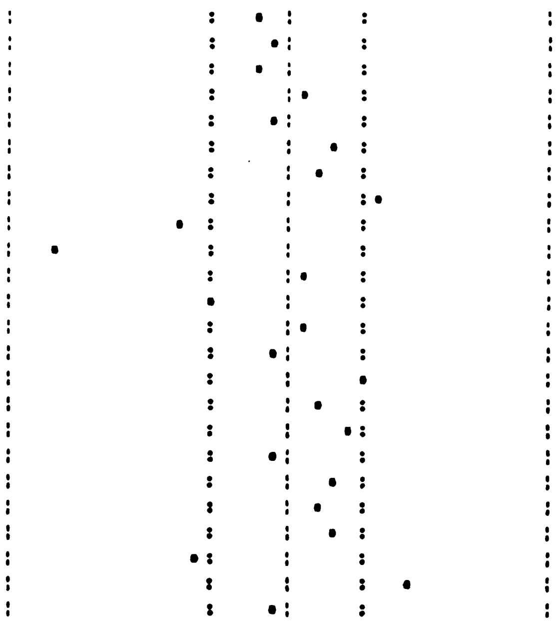
APPENDIX 3 (cont'd)

SMPL 1961 - 1984
24 Observations
LS // Dependent Variable is CLBAU Cropland base, Australia

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	3348.6059	1402.7519	2.3871691	0.026
CLBAU(-1)	0.9081472	0.0777019	11.687573	0.000
REV(-1)	-903.65241	391.86737	-2.3060160	0.031

R-squared	0.887947	Mean of dependent var	12903.58
Adjusted R-squared	0.877275	S.D. of dependent var	2857.197
S.E. of regression	1000.936	Sum of squared resid	21039330
Durbin-Watson stat	2.038945	F-statistic	83.20561
Log likelihood	-198.2607		

Residual Plot



obs	RESIDUAL	ACTUAL	FITTED
1961	-324.088	8442.00	8766.09
1962	-192.616	9094.00	9286.62
1963	-473.643	9118.00	9591.64
1964	284.762	9750.00	9465.24
1965	-184.060	9823.00	10007.1
1966	619.391	11472.0	10852.6
1967	335.158	11796.0	11460.8
1968	1151.27	14056.0	12904.7
1969	-1390.31	12866.0	14256.3
1970	-2966.71	10719.0	13685.7
1971	216.751	11654.0	11437.2
1972	-971.689	11522.0	12493.7
1973	283.946	12650.0	12366.1
1974	-250.958	11615.0	11866.0
1975	1038.00	12444.0	11406.0
1976	490.745	12879.0	12388.3
1977	807.746	14323.0	13515.3
1978	-284.423	14944.0	15228.4
1979	559.306	15350.0	14790.7
1980	342.096	15569.0	15226.9
1981	615.642	16718.0	16102.4
1982	-1096.66	16014.0	17110.7
1983	1653.74	18689.0	17035.3
1984	-263.395	18179.0	18442.4

where: CLBAU(-1) = Cropland base, Australia, lagged one year

REV(-1) = Weighted average revenue, lagged one year

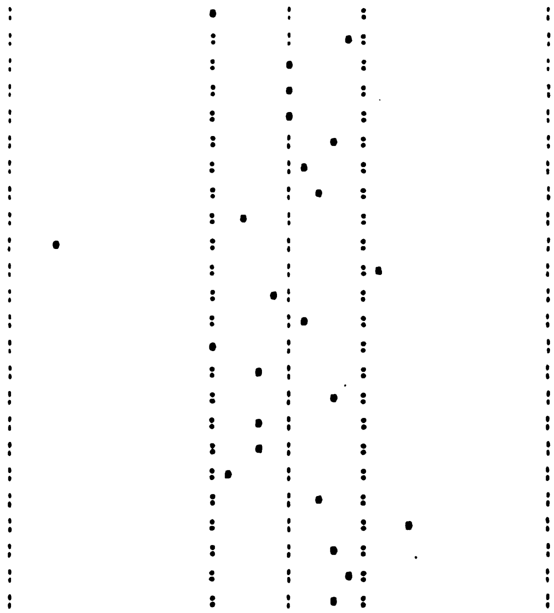
APPENDIX 3 (cont'd)

SMPL 1961 - 1984
24 Observations
LS // Dependent Variable is CLBCA Cropland base, Canada

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	7543.9846	3597.4436	2.0970404	0.048
CLBCA(-1)	0.5414351	0.1905878	2.8408699	0.010
REV(-1)	321.60681	413.24810	0.7782415	0.445

R-squared	0.309641	Mean of dependent var	18538.83
Adjusted R-squared	0.243892	S.D. of dependent var	1837.840
S.E. of regression	1598.083	Sum of squared resid	53631283
Durbin-Watson stat	2.004140	F-statistic	4.709472
Log likelihood	-209.4896		

Residual Plot



obs	RESIDUAL	ACTUAL	FITTED
1961	-1576.32	16102.0	17678.3
1962	1324.24	18072.0	16747.8
1963	21.6789	18252.0	18230.3
1964	-142.570	18358.0	18500.6
1965	-81.8826	18280.0	18361.9
1966	930.474	19284.0	18353.5
1967	415.061	19497.0	19081.9
1968	706.762	19533.0	18826.2
1969	-982.245	17950.0	18932.2
1970	-4968.93	13133.0	18101.9
1971	2072.55	17679.0	15606.5
1972	-395.218	17545.0	17940.2
1973	321.127	18493.0	18171.9
1974	-1750.19	17539.0	19289.2
1975	-625.024	17739.0	18364.0
1976	852.112	19366.0	18513.9
1977	-773.136	18351.0	19124.1
1978	-538.592	18060.0	18598.6
1979	-1353.46	17242.0	18595.5
1980	647.416	18784.0	18136.6
1981	2561.43	21592.0	19030.6
1982	1083.92	21405.0	20321.1
1983	1248.68	21496.0	20247.3
1984	1002.12	21180.0	20177.9

where: CLBCA(-1) = Cropland base, Canada, lagged one year

REV(-1) = Weighted average revenue per hectare, lagged one year

APPENDIX 3 (cont'd)

SMPL 1965 - 1984
20 Observations
LS // Dependent Variable is CLBUS Cropland base, United States

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	18556.976	12217.038	1.5189423	0.147
CLBUS(-1)	0.6833248	0.1479206	4.6195374	0.000
REV(-1)	1815.0897	1132.6011	1.6025852	0.127

R-squared	0.652119	Mean of dependent var	86594.55
Adjusted R-squared	0.611191	S.D. of dependent var	9931.862
S.E. of regression	6192.965	Sum of squared resid	6.52D+08
Durbin-Watson stat	2.561705	F-statistic	15.93362
Log likelihood	-201.3770		

Residual Plot

obs	RESIDUAL	ACTUAL	FITTED
1965	-2303.61	72915.0	75218.6
1966	-2148.15	74506.0	76654.1
1967	2853.80	80634.0	77780.2
1968	-2654.83	78316.0	80970.8
1969	-5073.80	74462.0	79535.8
1970	-2305.99	74907.0	77213.0
1971	2188.40	79508.0	77319.6
1972	-5049.95	75583.0	80632.9
1973	2359.03	85683.0	83324.0
1974	-5609.86	87599.0	93208.9
1975	1413.79	92154.0	90740.2
1976	-1634.59	91661.0	93295.6
1977	2818.65	94345.0	91526.4
1978	-1919.22	91411.0	93330.2
1979	3657.65	96227.0	92569.4
1980	1239.55	97259.0	96019.5
1981	7393.96	102570.	95176.0
1982	5424.77	102590.	97165.2
1983	-14694.4	82638.0	97332.4
1984	14044.8	96923.0	82878.2

where: CLBUS(-1) = Cropland base, United States, lagged one year

REV(-1) = Weighted average revenue per hectare, lagged one year

APPENDIX 3 (cont'd)

```
SMPL    1961  -  1983
23 Observations
LS // Dependent Variable is CLBDM   Cropland base, Developed Markets
```

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	33958.156	9963.4101	3.4082864	0.003
CLBDM(-1)	0.2703127	0.2146573	1.2592756	0.222
REV(-1)	37.161764	123.15756	0.3017416	0.766

R-squared	0.082855	Mean of dependent var	46760.43
Adjusted R-squared	-0.008859	S.D. of dependent var	524.6445
S.E. of regression	526.9633	Sum of squared resid	5553807.
Durbin-Watson stat	2.025626	F-statistic	0.903404
Log likelihood	-175.1723		

```
           Residual Plot                  obs RESIDUAL   ACTUAL    FITTED
:        .  :     :     :          : 1961 -825.079   45739.0   46564.1
:           :     :   . :          : 1962  370.227   46872.0   46501.8
:           :  .  :     :          : 1963 -256.951   46570.0   46827.0
:           : .   :     :          : 1964 -378.709   46354.0   46732.7
:           :  .  :     :          : 1965 -243.393   46439.0   46682.4
:           : .   :     :          : 1966 -365.406   46329.0   46694.4
:           :    .:     :          : 1967 -117.937   46556.0   46673.9
:           :     :   . :          : 1968  383.719   47105.0   46721.3
:           :     :  .  :          : 1969  246.632   47119.0   46872.4
:           :     :    .:          : 1970  487.291   47358.0   46870.7
:           :     :     : .        : 1971  685.751   47629.0   46943.2
:         . :     :     :          : 1972 -706.348   46301.0   47007.3
:           :     :   . :          : 1973  323.643   46996.0   46672.4
:           :     :   . :          : 1974  388.052   47331.0   46942.9
:           : .   :     :          : 1975 -329.839   46675.0   47004.8
:           :     .     :          : 1976  19.1625   46776.0   46756.8
:  .        :     :     :          : 1977 -1347.50   45399.0   46746.5
:           :     :   . :          : 1978  386.065   46763.0   46376.9
:           :     :.    :          : 1979  109.908   46859.0   46749.1
:           :     .     :          : 1980  40.6274   46810.0   46769.4
:           :     :  .  :          : 1981  310.375   47078.0   46767.6
:           :     : .   :          : 1982  155.041   46964.0   46809.0
:           :     :     :.         : 1983  664.665   47468.0   46803.3
```

where: CLBDM(-1) = Cropland base, Developed Markets, lagged one year

REV(-1) = Weighted average revenue per hectare, lagged one year

APPENDIX 4

Raw Data from Sources Other than the Ag Model

Table 15: Argentine Price Data

obs	WHEATP	FEEDGP	SOYP	SUNFLP	FLAXP	BEEFP
1960	0.003000	0.003542	NA	0.006100	0.006270	NA
1961	0.003936	0.004169	NA	0.007990	0.008040	NA
1962	0.005142	0.005727	NA	0.007710	0.009720	NA
1963	0.007190	0.008495	NA	0.012820	0.011910	NA
1964	0.007819	0.008179	NA	0.016450	0.012520	NA
1965	0.007540	0.010020	NA	0.015380	0.013400	NA
1966	0.010660	0.010400	0.016860	0.018520	0.017810	NA
1967	0.015840	0.013970	0.021690	0.019980	0.023430	NA
1968	0.015520	0.013820	0.028120	0.023500	0.028720	NA
1969	0.017410	0.017260	0.029510	0.028900	0.033080	NA
1970	0.017780	0.018130	0.031810	0.034420	0.028370	0.000102
1971	0.021570	0.019740	0.044180	0.051770	0.031880	0.000188
1972	0.038100	0.035560	0.096460	0.093750	0.076720	0.000301
1973	0.058790	0.055270	0.141900	0.116240	0.145450	0.000439
1974	0.070850	0.064260	0.167810	0.136310	0.207350	0.000431
1975	0.151080	0.106830	0.362580	0.185330	0.465160	0.000904
1976	0.849000	0.957500	3.474080	3.371830	4.275160	0.006205
1977	3.497250	2.940410	7.793000	8.412911	7.221660	0.016854
1978	9.274830	7.226000	15.39633	18.49983	14.94633	0.037111
1979	17.93841	13.73108	28.82633	32.95408	36.05116	0.120919
1980	33.99183	26.62258	41.98833	40.74175	48.02508	0.185893
1981	87.57050	56.27233	99.61950	130.6613	122.4258	0.334800
1982	296.7571	185.8124	383.3923	419.4101	449.1897	1.539900
1983	1040.300	1089.200	2112.900	2321.600	1995.000	6.690000
1984	6225.000	6968.000	10402.00	15115.00	NA	43.25000

Source: Bolsa de Cereales, 1984

WHEATP = Nominal wheat price, Australes/500 kg.

FEEDGP = Nominal feedgrain price, Australes/500 kg.

SOYP = Nominal soybean price, Australes/500 kg.

SUNFLP = Nominal sunflowerseed price, Australes/500 kg.

FLAXP = Nominal flaxseed price, Australes/500 kg.

BEEFP = Nominal beef price, Australes/100 kg.

APPENDIX 4 (cont'd)

Table 16: Brazilian Price Data

obs	WHEATP	FEEDP	SOYP
1960	16.00000	6.000000	NA
1961	22.00000	8.000000	NA
1962	40.00000	15.00000	NA
1963	64.00000	17.00000	NA
1964	139.0000	40.00000	NA
1965	191.0000	52.00000	NA
1966	254.0000	71.00000	122.0000
1967	302.0000	93.00000	155.0000
1968	365.0000	106.0000	208.0000
1969	437.0000	136.0000	251.0000
1970	478.0000	155.0000	329.0000
1971	539.0000	184.0000	383.0000
1972	584.0000	253.0000	484.0000
1973	736.0000	363.0000	1110.000
1974	1160.000	540.0000	1100.000
1975	2130.000	750.0000	1130.000
1976	2090.000	1410.000	2320.000
1977	3170.000	1380.000	2620.000
1978	3969.000	1966.000	3312.000
1979	5161.000	2968.000	5044.000
1980	10810.00	5780.000	8751.000
1981	NA	NA	NA
1982	NA	NA	NA
1983	NA	NA	NA
1984	NA	NA	NA

Source: FAO tapes

WHEATP = Nominal wheat price, Cruzeiros/MT

FEEDP = Nominal feedgrain price, Cruzeiros/MT

SOYP = Nominal soybean price, Cruzeiros/MT

APPENDIX 4 (cont'd)

Table 17: Australian Price Data

obs	WHEATP	BARLEY	PINDEX	WOOLP	GMINPW
1960	50.08000	40.30000	23.40000	95.64000	55.74000
1961	53.06000	46.70000	23.60000	99.45000	57.87000
1962	51.22000	47.60000	23.90000	108.3100	58.17000
1963	50.45000	48.30000	23.90000	128.0400	52.98000
1964	49.57000	49.70000	24.60000	105.4500	53.57000
1965	51.81000	50.50000	26.00000	110.4100	55.74000
1966	52.07000	52.80000	27.00000	104.4500	56.95000
1967	54.09000	50.50000	27.90000	92.04000	60.26000
1968	45.46000	42.80000	28.40000	98.48000	52.28000
1969	43.85000	38.90000	28.60000	82.78000	53.61000
1970	48.30000	47.10000	29.80000	64.68000	54.20000
1971	42.40000	40.50000	31.40000	75.25000	55.78000
1972	43.51000	52.60000	33.80000	183.7700	57.61000
1973	97.41000	79.50000	39.00000	181.1600	58.79000
1974	96.84000	102.1000	50.80000	126.9900	73.49000
1975	86.50000	98.70000	59.30000	143.2500	76.55000
1976	69.25000	103.5000	66.00000	182.7300	76.29000
1977	77.57000	86.00000	73.00000	187.1400	80.94000
1978	107.3500	82.00000	78.00000	205.2400	91.96000
1979	132.7200	121.0000	87.00000	243.5700	114.7100
1980	124.6800	142.0000	100.0000	255.9700	131.9200
1981	122.1900	134.0000	111.0000	264.6900	141.5500
1982	144.4700	167.0000	123.0000	269.8500	141.3200
1983	121.8100	151.0000	133.0000	293.8400	150.0000
1984	133.3900	141.0000	141.0000	318.6400	145.6400

Sources: BAE

Quarterly Rev. of the Rural Econ. a)

Trends in the Aust. Rural Sector b)

Hist. Trends in Aus. Ag. Prodn, Expts, Fm Inc. & Indexes of Prices Rec'd & Pd by Fmrs c)

Commodity Stat. Bulletin d)

The Wool Outlook e)

Wheat Sit. and Outlook f)

Coarse Gr. Sit. & Outlook g)

WHEATP = Nominal wheat price, AU$/MT d), f)

BARLEY = Nominal barley price, AU$/MT c), d), g)

PINDEX = Index of Prices Paid by Farmers, 1980 = 100 a), b), c)

WOOLP = Nominal price of greasy wool, AU$/MT d), e)

GMINPW = Guaranteed minimum wheat price, AU$/MT d), f)

APPENDIX 5

TABLE 16: Nominal Loan Rates*

Year	Wheat	Corn	Sorghum	Barley	Oats	Soybeans
1975	1.37	1.10	1.05	0.90	0.54	2.25
1976	2.25	1.50	1.43	1.22	0.72	2.50
1977	2.25	2.00	1.90	1.63	1.03	3.50
1978	2.35	2.00	1.90	1.63	1.03	4.50
1979	2.50	2.10	2.00	1.71	1.08	4.50
1980	3.00	2.25	2.14	1.83	1.16	5.02
1981	3.20	2.40	2.28	1.95	1.24	5.02
1982	3.55	2.55	2.42	2.08	1.31	5.02
1983	3.65	2.65	2.42	2.16	1.36	5.02
1984	3.30	2.55	2.42	2.08	1.31	5.02
1985	3.30	2.55	2.42	2.08	1.31	5.02
1986	2.40	1.92	1.82	1.56	0.99	4.77
.	.	.	.	.	.	.
.	.	.	.	.	.	.
1996	2.40	1.92	1.82	1.56	0.99	4.77

* Dollars per bushel

APPENDIX 6

Argentine Harvested Area Estimation, Statistical Results

SMPL 1964 - 1984
21 Observations
LS // Dependent Variable is WHAAR

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-1680.8308	2069.6244	-0.8121429	0.429
WHAAR(-1)	0.4093181	0.1714918	2.3868082	0.030
WRREAL(-1)	3891.9137	1326.3794	2.9342386	0.010
NRREAL(-1)	-3482.7557	871.74228	-3.9951666	0.001
TIME	61.901073	25.439874	2.4332304	0.027

R-squared	0.652335	Mean of dependent var	5241.714
Adjusted R-squared	0.565419	S.D. of dependent var	987.3547
S.E. of regression	650.8918	Sum of squared resid	6778561.
Durbin-Watson stat	2.314513	F-statistic	7.505324
Log likelihood	-162.9876		

uses domestic prices and prices of substitutes

SMPL 1964 - 1984
21 Observations
LS // Dependent Variable is WHAAR

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-3774.4461	2373.1437	-1.5904836	0.131
WHAAR(-1)	0.3794200	0.1669022	2.2733076	0.037
WRAR(-1)	1771.0655	662.23182	2.6743890	0.017
SRAR(-1)	-1167.0536	330.16420	-3.5347672	0.003
TIME	100.62243	32.482998	3.0976953	0.007

R-squared	0.578651	Mean of dependent var	5241.714
Adjusted R-squared	0.473314	S.D. of dependent var	987.3547
S.E. of regression	716.5542	Sum of squared resid	8215199.
Durbin-Watson stat	2.304511	F-statistic	5.493324
Log likelihood	-165.0059		

original equation using border prices

where: WHAAR(-1) = Wheat harvested area, lagged one year

WRREAL(-1) = WY*WP, lagged   WRAR(-1) = WY*Pw, lagged

NRREAL(-1) = NY*NP, lagged   SRAR(-1) = SY*Ps, lagged

TIME = Time trend, 1964 = 64

WY, NY, SY = 4-year moving average yields, wheat, sunflowerseed, soybeans

WP, NP = Real domestic prices, wheat, sunflowerseed

Pw, Ps = Real border prices, wheat, soybeans

APPENDIX 6 (cont'd)

SMPL 1964 - 1984
21 Observations
LS // Dependent Variable is FHAAR Feedgrain harvested area, Argentina

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	5404.2448	1052.9481	5.1324893	0.000
FHAAR(-1)	0.4697474	0.1386605	3.3877523	0.004
LRREAL(-1)	-905.64834	403.79940	-2.2428174	0.039
WRREAL(-1)	-2153.1459	668.43913	-3.2211548	0.005
DV7179	-1449.6922	307.02927	-4.7216743	0.000

R-squared	0.735075	Mean of dependent var	5972.429
Adjusted R-squared	0.668844	S.D. of dependent var	667.3186
S.E. of regression	384.0161	Sum of squared resid	2359494.
Durbin-Watson stat	1.510176	F-statistic	11.09863
Log likelihood	-151.9068		

uses doemstic prices and prices of substitutes

SMPL 1964 - 1984
21 Observations
LS // Dependent Variable is FHAAR

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	4145.8615	981.77240	4.2228336	0.001
FHAAR(-1)	0.4288164	0.1751541	2.4482240	0.026
FRAR(-1)	868.86783	534.12976	1.6263236	0.123
WRAR(-1)	-1643.3118	603.44460	-2.7232190	0.015
DV7179	-1595.1059	333.02915	-4.7896885	0.000

R-squared	0.690692	Mean of dependent var	5972.429
Adjusted R-squared	0.613366	S.D. of dependent var	667.3186
S.E. of regression	414.9383	Sum of squared resid	2754780.
Durbin-Watson stat	1.516843	F-statistic	8.932114
Log likelihood	-153.5331		

original equation using border prices

where: FHAAR(-1) = Feedgrain harveested area, lagged one year

LRREAL(-1) = LY*LP, lagged FRAR(-1) = FY*Pf, lagged

WRREAL(-1) = WY*WP, lagged WRAR(-1) = WY*Pw, lagged

DV7179 = Dummy variable to account for adverse weather

= 1, 1971, 1979; otherwise, = 0

LY, FY, WY = 4-year moving average yields, flax, feedgrain, wheat

LP, WP = Real domestic prices, flaxseed, wheat

Pf, Pw = Real border prices, feedgrain, wheat

APPENDIX 6 (cont'd)

SMPL 1967 - 1984
18 Observations
LS // Dependent Variable is SHAAR Soybean harvested area, Argentina

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-587.95523	259.67799	-2.2641704	0.041
SHAAR(-1)	0.9350342	0.0876551	10.667194	0.000
SRREAL(-1)	234.51682	90.949000	2.5785530	0.023
WRREAL(-1)	528.98212	372.95689	1.4183465	0.180
SPL76	3.6976303	1.9323527	1.9135380	0.078

R-squared	0.983362	Mean of dependent var	1060.278
Adjusted R-squared	0.978243	S.D. of dependent var	1074.041
S.E. of regression	158.4232	Sum of squared resid	326272.8
Durbin-Watson stat	2.391077	F-statistic	192.0907
Log likelihood	-113.7869		

uses domestic prices and prices of substitutes

SMPL 1967 - 1984
18 Observations
LS // Dependent Variable is SHAAR

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	-119.86270	130.54064	-0.9182022	0.375
SHAAR(-1)	0.9584958	0.0818427	11.711437	0.000
SRAR(-1)	201.12661	75.460483	2.6653236	0.019
WRAR(-1)	-203.10784	156.32800	-1.2992416	0.216
SPL76	3.4224289	1.8694793	1.8306857	0.090

R-squared	0.982233	Mean of dependent var	1060.278
Adjusted R-squared	0.976766	S.D. of dependent var	1074.041
S.E. of regression	163.7128	Sum of squared resid	348424.2
Durbin-Watson stat	2.289665	F-statistic	179.6717
Log likelihood	-114.3781		

original equation using border prices

where: SHAAR(-1) = Soybean harvested area, lagged one year

SRREAL(-1) = SY*SP, lagged SRAR(-1) = SY*Ps, lagged

WRREAL(-1) = WY*WP, lagged WRAR(-1) = WY*Pw, lagged

SPL76 = Splined time trend, 1967-75 = 0, 1976 = 76

SY, WY = 4-year moving average yields, soybeans, wheat

SP, WP = Real domestic prices, soybeans, wheat

Ps, Pw = Real border prices, soybeans, wheat

APPENDIX 7

Usefulness of the Ag Model for Policy Analysis

Econometric models are built for various purposes - forecasting, scenario analysis and as tools for understanding. Very few models as large as the Ag Model are built. Because the large models are built for different reasons with different structures, estimation techniques and types of data, there is little basis for comparison between existing models. Econometric models are frequently judged on how closely the results of ex post forecasts compare to actual values. In the case of this study, elasticities are calculated ex ante and can only be compared to other estimates and the general consensus of what the true values may be. As a basis for assessing the validity of the model, the structure of the model itself has been examined to search for obvious sources of error.

The structure of the Ag Model tends to concentrate error in certain equations. The error accumulates, first because the equations within each region are solved recursively. Error in the estimate of harvested area is transferred to the production equation which depends upon harvested area. In a similar manner, ending stocks are estimated as a function of the estimated production value. Each equation builds upon the solution values of previous equations and is subject to the error of those previous estimates. Secondly, the fact that the U.S. is considered a residual supplier means that U.S. export and ending stock equations are functions of the net trade of all other regions. Error in each of the net export and import equations is accumulated in the residual U.S. equations. As a result, the price equations, dependent on ending stocks, receive the accumulated error of all the equations in the model. The error in the price equations is then transmitted to the harvested area, import and consumption equations in the subsequent year.

One advantage of using a structure with a residual equation (determined as the sum or difference of the other variables) is that it provides closure to the system - the quantities produced, traded, consumed or stored are internally consistent. However, the residual variable also contains the largest amount of potential error. While multiple errors may cancel out, the amount of error that remains cannot be measured statistically. It is apparent that scenarios in which the variables of interest are residual variables would be subject to the largest error, but in the case of the Ag Model the simultaneous nature of residual quantities and price transmits the accumulated error throughout the model. Therefore, the accumulated error is distributed through all estimated quantities and prices in an unmeasurable way. Testing the model's robustness with respect to error in price estimates would indicate the severity of the impact of price error on other estimated quantities. Unfortunately, because this study exogenized price, robustness could not be tested by measuring elasticities.

A more straightforward method of dealing with the unavoidable error in the Ag Model would be to estimate the residual variables - net exports, consumption or ending stocks - and report a statistical discrepancy without attributing the entire error to any one equation. However, the purpose of constructing multi-equation regions within the Ag Model is to incorporate more of the variables that affect domestic supply and demand in each region. A net export equation that is estimated directly accounts for price, domestic supply and consumption, but fails to capture all of the shifters of domestic supply and demand which influence exports indirectly. A major difficulty in measuring PEXD is that direct estimations do not account for the many relevant forces affecting net exports or imports while complex models contain accumulated errors and other problems (Gardiner and Dixit, 1987).

A model is necessarily a simplification of reality. The Ag Model simplifies global agricultural commodity trade by considering only three crop groups, by aggregating the world into eleven regions and by using a common world price to link these regions in trade. The economy is further simplified by disregarding differences in transportation costs and specific local conditions, such as internal prices or relevant competing crops. From the experimentation in Chapter 4 with more specific, local variables it appears that the inclusion of more detailed specifications within the present model structure would not improve its predictive ability appreciably. In order to significantly improve the model's forecasting capability, detailed modelling of each region with much more specific data would be necessary.

On the other hand, in comparison to other models used to estimate PEXD, the Ag Model is very complex. Estimation of PEXD frequently uses a model with only a few equations that measure net excess supply or demand for the rest of the world or for only a few regions. When combined with a U.S. excess supply equation, these equations yield an estimate of PEXD. The additional equations in each region and the large number of regions in the Ag Model enable it to account for many more of the factors that determine PEXD than a simple model is capable of. If the additional error from the extra equations does not overwhelm the estimate, the size and complexity of the Ag Model is an asset in obtaining estimate of PEXD and other relevant economic measures.

As future research, it may be possible to devise some method of accounting for accumulated error in the residual equations and adjusting the variables or the interpretation accordingly. With corrections for error, the reliability of the Ag Model may be improved sufficiently to produce credible forecasts.

While indeterminate levels of error may leave the Ag Model's forecasting capabilities in question, a major purpose for constructiong the Ag Model is to gain a greater understanding of the world economy. The validity of the Ag Model for this purpose remains intact.

Despite our inability to measure its error, the Ag Model remains a useful tool for policy analysis. Some mechanical limitations of the model do exist, however, and probably deserve further attention. The fact that the soy oil price equation is exogenous removes some of the Ag Model's power in determining the other prices since soybean price is directly calculated from soy meal and oil prices. An exogenous soy oil price is no limitation for the PEXD runs in this study because all prices are exogenized. However, it is impossible to accurately determine the effect of changing the loan rates because soybean price is based on soy meal price, which responded to lower grain prices, and on soy oil price, which did not.

A potential problem exists with the percent meal (pmeal) equations. Imports and exports are estimated on an equivalent basis, then the pmeal equations determine the breakdown between beans and oil and meal. In some cases, particularly where the equation contains a time trend, the estimated value may exceed one or be less than zero. The rosult is that exporters begin to import and importers may export soy products that they cannot produce. In other cases, a small error in the pmeal equation may lead to large shifts in the trade of the three products as seen in this study for Argentina. The problems with this equation do not seem significant enough to invalidate the entire model, but may warrant additional scrutiny of unusual shifts in the mix of soy products.

BIBLIOGRAPHY

BIBLIOGRAPHY

Abbott, Philip C. "Estimating U.S. Agricultural Export Demand Elasticities: Econometric and Economic Issues." paper presented at IATRC Symposium on Elasticities in International Agricultural Trade. Dearborn, Michigan. July 30-August 1, 1987.

_________. "Modeling International Grain Trade with Government Controlled Markets." Amer. J. Agr. Econ. 61 (1979):22-31.

Armstrong, J. Scott. Long-Range Forecasting From Crystal Ball to Computer. John Wiley & Sons. New York. 1985.

Arnade, Carlos, and Cecil Davison. "Export Demand for U.S. Corn, Wheat, and Soybeans." FAER Draft. USDA Econ. Res. Serv. 1986.

Austin, Lynn A. "Beef versus Wool Production in Australia." FAER No.130. USDA, Econ. Res. Serv. 1977.

Beattie, Bruce R. and Robert C. Taylor. The Economics of Production. John Wiley and Sons, New York. 1985.

Binkley, J. K., and L. D. McKinzie. "A Monte Carlo Analysis of the Estimation of Export Demand." Can. J. Econ. 29 (1981):187-202.

Bolling, H. Christine. "Price and Exchange Rate Transmission Revisited: The Latin America Case." paper presented at IATRC Symposium on Elasticities in International Agricultural Trade. Dearborn, Michigan. July30-August1, 1987.

Bolsa de Cereales, Bolsa de Cereals, Numero Estadistico. Buenos Aires. 1984.

Bredahl, Maury E., William H. Meyers, and Keith J. Collins. "The Elasticity of Foreign Demand for U.S. Agricultural Products: The Importance of the Price Transmission Elasticity." Amer. J. Agr. Econ. 69 (1979):58-63.

Bredahl, Maury E., and Leonardo Green. "Residual Supplier Model of Coarse Grains Trade." Amer. J. Agr. Econ. 65 (1983):785-90.

Brandow, G.E. "Interrelationships Among Demands for Farm Products and Implications for Control of Market Supply." Pennsylvania Agricultural Experiment Station. Bulletin No. 680. University Park. August, 1961.

Bureau of Agricultural Economics, BAE Trends in the Australian rural sector. Canberra, Australia. Various issues.

________. Commodity Statistical Bulletin. Canberra, Australia. 1986.

________. Historical Trends in Australian Agricultural Production, Exports, Farm Incomes and Indexes of Prices Received and Paid by Farmers, 1952-53 to 1978-79. Canberra, Australia. 1980.

________. Quarterly Review of the Rural Economy. Canberra, Australia. Various issues.

________. Coarse Grains Situation and Outlook. Canberra, Australia. Various issues.

________. "Wheat Marketing in Australia: An Economic Evaluation." Occasional Paper No.86. Canberra, Australia. 1983.

________. Wheat Situation and Outlook. Canberra, Australia. Various issues.

________. The Wool Outlook. No. 31. Canberra, Australia. Dec. 1971.

Burk, Marguerite. "Ramifications of the Relationship Between Income and Food." Journal of Farm Economics. February, 1962.

Chaing, Alpha C. Fundamental Methods of Mathematical Economics. 2nd ed. McGraw-Hill Book Co., New York. 1974.

Chambers, Robert G. and R. E. Just. "A Critique of Exchange Rate Treatment in Agricultural Trade Models." Amer. J. Agr. Econ. 61 (1979):249-257.

Cochrane, Willard W. The City Man's Guide to the Farm Problem. University of Minnesota Press, Minneapolis. 1965.

________. Farm Prices - Myth and Reality. Univ. of Minnesota Press, Minneapolis. 1958.

Daly, R. F. "Demand for Farm Products at Retail and the Farm Level." Journal of the American Statistical Association. September, 1958.

Economic Research Service. "The Agricultural Situation in the Far East and Oceania." FAER No.121. USDA, Econ. Res. Serv. 1976.

________. "Agricultural Trade Responsiveness in Western Hemisphere Countries." ERS Staff Report No. AGES860326. USDA, Econ. Res. Serv. April, 1986.

________. "Latin America, Outlook and Situation Report." USDA, Econ. Res. Serv. Various issues.

Food and Agriculture Organization, United Nations. "Farm Price Data Base." Unpublished data available on USDA TDAM computer system and computer tapes from FAO.

Friend, Reed E., E. Wayne Denney, Mary E. Long, and Thomas A. Twomey. "Australia: Growth Potential of the Grain and Livestock Sectors." FAER No.80. USDA, Econ. Res. Serv. 1972.

Gardiner, Walter H., and Praveen M. Dixit. "Price Elasticity of Export Demand: Concepts and Estimates." FAER No. 228. USDA, Econ. Res. Serv. February, 1987.

Gilmour, Brad and Peter Fawcett. "The Relationship Between American and Canadian Wheat Prices." Agriculture Canada. Working Paper. September, 1986.

Goodloe, Carol A. "North America and Oceania: Outlook and Situation." RS-84-1. USDA, Econ. Res. Serv. March, 1984. pp. 26-28.

Huang, Kuo. "U.S. Demand for Food: A Complete System of Price and Income Effects." ERS Technical Bulletin No. 1714. Econ. Res. Serv. December, 1985.

International Wheat Council. <u>World Wheat Statistics</u>. London, England. Various issues.

Jabara, Cathy L. and Alan S. Brigida. "Variable Levies: Barriers to Grain Imports in France, the Netherlands, Federal Republic of Germany, and United Kingdom." FAER No. 156. USDA, Econ. Res. Serv. March, 1980.

Johnson, Paul R. "The Elasticity of Foreign Demand for U.S. Agricultural Products." <u>Amer. J. Agr. Econ.</u> 59 (1977):735-36.

Judge, George G., W.E. Griffiths, R. Carter Hill Helmut Lutkepohl and Tsoung-Chao Lee. <u>The Theory and Practice of Econometrics</u>. 2nd edition. John Wiley and Sons. New York. 1985.

Kmenta, Jan. <u>Elements of Econometrics</u>. 2nd Edit. Macmillan Publishing Co. New York. 1986.

Knutson, Ronald D., James W. Richardson, Danny A. Klinefelter, Mechel S. Paggi and Edward G. Smith. <u>Policy Tools for U.S. Agriculture</u>. Agricultural and Food Policy Center, Texas A&M University. No. B-1548. August, 1986.

MacGregor, R.J. and Kulshreshtha, S.N. "Pricing in the International Coarse Grainse Market." Can. J. Agr. Econ. 28 (1980):110-118.

Martin, Lee R., ed. <u>A Survey of Agricultural Economics Literature</u>. Vol. 1. Univ. of Minn. Press. Minneapolis, MN. 1977.

McCalla, Alex F. "A Duopoly Model of World Wheat Pricing." J. Farm Econ. 48 (1966):711-27.

Meilke, Karl D. "A Comparison of the Simulation Results from Five International Trade Models." paper presented at International Trade Consortium, Vancouver, B.C. Dec. 1985.

Meilke, Karl D. and A.C. Zwart. "Effects of Alternative Specifications on the Policy Implications of a Model: An Illustration." Can. J. of Ag. Econ. 27 (1979):15-22.

Mitchell, Donald O. "Global Rice Model: Conceptualization and Design." Washington, DC. 1983.

Myers, Robert. Personal communication. 1986.

Nerlove, Marc. "Distributed Lags and Estimation of Long Run Supply and Demand Elasticities: Theoretical Considerations." Journal of Farm Economics. 40 (1958):301-311.

Peterson, Willis L. "The Market as an Experiment: Problems of Data Generation." Staff Paper P81-17. Univ. of Minn., Dept. of Agr. and Applied Econ. 1981.

Pindyke, Robert S. and Daniel L. Rubinfeld. Econometric Models and Economic Forecasts. 2nd edition. McGraw-Hill Book Co. New York. 1981.

Roe, Terry, Mathew Shane, and De Huu Vo. "Price Responsiveness of World Grain Markets." ERS Technical Bull. No. 1720. USDA, Econ. Res. Serv. June, 1986.

Schuh, G. Edward. "The Exchange Rate and U.S. Agriculture." Amer. J. Agr. Econ. 56 (1974):1-13.

Schuh, G. Edward. in U.S. Senate Committee on Agriculture, Nutrition and Forestry. "Farm Policy Perspectives: Setting the Stage for 1985 Agricultural Legislation." Committee Print 98-174. Washington, DC. April, 1984. pp. 47-61.

Seeley, Ralph. "Price Elasticities from the IIASA World Agriculture Model." ERS Staff Report No. AGES850418. USDA Econ. Res. Serv. May, 1985.

Shagam, Shayle D. Specification and Structure of an International Trade Model with Linkage Capability. M.S. Thesis. Michigan State Univ. 1986.

Spriggs, John. "An Econometric Analysis of Export Supply of Grains in Australia." FAER No.150. USDA, Econ. Res. Serv. 1978.

Tweeten, Luther. "The Demand for United States Farm Output." Food Research Institute Studies. 7 (1967):343-69.

Wainio, John T. "Argentina: Farmers' Response to Grain Prices." ERS Staff Report AGES830726. USDA, Econ. Res. Serv. 1983.

Waugh, Fred V. "Demand and Price Analysis." USDA Technical Bulletin No. 1316. Washington, DC. 1964.

Wilde, Linda Chase, Laurence D. Cornell, Vernon Sorenson, and J. Roy Black. "World Grain Trade: An Evaluation of Factors Affecting Net Import Demand for Wheat and Coarse Grains by Selected Countries." Ag. Econ. Report No. 487. Michigan State Univ. July, 1986.

Williams, Gary W. and Robert Thompson. "The Brazilian Soybean Industry: Economic Structure and Policy Interventions." FAER No. 200. USDA Econ. Res. Serv. October, 1984.