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TRENDS AND PROJECTIONS FOR U.S. AGRICULTURE USING "AGMOD"

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"AGMOD" is an econometric model of U.S. and world agriculture designed to focus on the most salient variables for major crops and livestock. Developed for micro-computer use with MicroTSP software, the model includes 290 variables and 218 equations. The equations include 55 behavioral relationships and 163 transformations. Because the upper limit for variables in MicroTSP (Version 5.0) is 300, careful selection was required in deciding which relationships to include.

The model is annual and the current application is to project year by year to the year 2000. The behavioral relationships were estimated by ordinary least squares from annual data beginning in 1960. The commodity coverage includes cattle, hogs, broilers, turkeys, eggs, milk, corn, other feed grain, wheat, soybeans, soybean meal, and soybean oil. The entire model--data base, work file and edit file--is on one floppy disk.

The basic structure of the model is presented in Figure 1. It is primarily recursive, but involves a simultaneous equation solution focusing on the real U.S. farm price of grain and soybeans. The solution is obtained through the Gauss-Seidel method.

The supply equations feature gross margins over variable costs on crops and gross margins over feed costs on livestock. Gross margin type variables provide indicators of profits from enterprises over time. Many farmers are familiar with partial budget analysis. For this reason, expected gross margins may well represent a major consideration in farmers' decision making process in the aggregate.

The demand equations for livestock are standard with market or farm prices as dependent variables. Since consumption is closely related to amounts available and the latter largely predetermined, this formulation seems appropriate. Also, this approach helps to resolve some statistical problems encountered when consumption is dependent. The demand for crops is a function of the livestock sector and the international sector.

The international sector is basically the "rest of the world" except that forecasts of area harvested are delineated between the major exporting nations and other nations. Also, the availability of soybeans and soybean products from Argentina and Brazil is estimated in part from a "supporting" model.

The "core" AGMOD also provides input into several "satellite" models. One such model generates forecasts of retail food prices. Another has been developed to forecast macro agricultural variables such as cash receipts, government payments, net cash income to farmers, total acreage harvested, value of exports, etc. AGMOD also provides inputs into a model which forecasts the major elements in Michigan agriculture including commodity projections and farm income.

The speed of solution of the model aided greatly in model development and diagnostic checking. AGMOD normally solves in two to three minutes on an IBM-AT or Zenith 248-82. This rapid feedback enhances the modeler's understanding of the system and ability to improve its estimation. The graphics options also assist in establishing reasonable projections.

The model has been used primarily for generating long-term projections and presenting a review of past trends. Alternative scenarios of the future can easily be explored. "What if" questions can be conveniently addressed and quick feedback is provided from alternative assumptions. "Live" demonstrations in extension programs have been tried and show promise as an educational tool.

Another application has been to provide input into budgets for representative farms. This facilitates the development of long-term financial plans including cash flow,

balance sheets and capital budgets. Also AGMOD can be used for policy analysis. Major farm policy parameters are included in the model.

Future applications of AGMOD will involve stochastic processes. For example, rather than projecting crop yields linearly from past trends, probability distributions around past trends will be generated to provide a more realistic look at production prospects. This will contribute to more definitive risk analysis for farmers.

A more detailed description of AGMOD will appear in the proceedings of the 1988 AAEA Pre-Conference Symposium on "Large Scale Models and Economic Policy Analysis." These proceedings, which include the results from seven such models, should be available from the co-chairpersons early in 1989. The co-chairpersons were C. Robert Taylor, Department of Agricultural and Rural Sociology at Auburn University, and Katherine Reichelderfer, Associate Director, Resources and Technology Division, Economic Research Division, USDA.

Assumptions for the 1990's

Key to any set of projections into the long-range future is the set of assumptions underlying the analysis. For the base run of AGMOD in projecting to the year 2000, the following conditions were established:

1. Real consumer incomes per capita will increase by one percent per year in the U.S. and abroad.
2. Inflation in the Consumer Price Index will average three to four percent per year.
3. Real interest rates will average about six percent as represented by farm mortgages in the Farm Credit Service.
4. Crop yields will increase in line with past trends.
5. Biotechnology will not noticeably enhance trends to increased productivity already assumed in the projections on crops and livestock.

6. The Food Security Act of 1985 will be continued into the 1990's. Loan rates and target prices will increase by two percent per year after 1990.
7. The Conservation Reserve will reach 45 million acres by the early 1990's, but will not be expanded to 65 million acres.

The assumption concerning economic growth, particularly in the less developed nations, is probably the most crucial in charting the likely course of U.S. agriculture in the 1990's. The impact of the world recession in the 1980's is reflected in the per capita consumption of coarse grain outside the U.S. as shown in Figure 2. Since two-thirds of the coarse grain utilized abroad is through livestock, the decline represents an attenuation in the upward trend to consuming more animal protein. The assumed one percent per year growth in real consumer incomes is more rapid than in the 1980's, but less than in the 1970's--and more in line with long-term performance of world economies. As a result, coarse grain consumption outside of the U.S. is projected to increase modestly to levels near the late 1970's peaking by the year 2000.

Per capita wheat consumption continued to increase in the 1980's in foreign countries, a trend projected to continue to the year 2000. To some extent, wheat has replaced coarse grain consumed directly by the human population.

Projections of total consumption, of course, depend on population growth. Population projections were not listed in the assumptions because the pattern between now and the year 2000 is fairly well established. Specifically, U.S. population (civilian) is forecast to increase from 241 million in 1987 to 272 million in 2000, a 12.5 percent rise. Outside of the U.S., population, at 4805 million in 1987, is forecast to expand to 5915 million by 2000, a 23.1 percent increase.

Because of the large population in the developing world and the rate at which it is expanding, an increase in per capita consumption can have major implications to total demand. This is indicated in Figures 3 and 4 which display trends and projections in total utilization of coarse grains and wheat abroad. The possible acceleration in the total

utilization could put some pressure on production in these nations to keep pace. If this develops, U.S. grain exports would expand to fill this gap.

The question is not whether these nations have the physical capacity to expand production in line with consumption. Based on past relationships, it is doubtful that they will--at least during the remainder of this century. In Argentina and Brazil, for example, the land which could conveniently be brought into production exceeds the projected level of utilization.

In the first run of AGMOD under the stated assumptions, certain results were contrary to the modeler's judgment about a realistic scenario of future developments. For one, the area in grain expanded only modestly in nations outside of the U.S. and major exporting countries. This area remained well below the peak of the early 1980's. Secondly, holding 45 million acres in the Conservation Reserve seemed to divert exports, particularly of wheat, from the U.S. to other nations. At the same time, carryovers of grain dropped to historically low levels.

These results prompted certain modifications in the model which could be considered additional assumptions, i.e.:

8. Areas harvested for grain in nations outside the U.S. and major exporting nations will at least reach previous peaks by the year 2000.
9. Exports of grain from the U.S. will offset shortfalls if ending stocks outside the U.S. drop below prescribed minimums in the previous year.
10. Land in the Conservation Reserve will be tapped if U.S. ending stocks of feed grain, soybeans and wheat drop below prescribed minimums in the previous year.

The projections presented in this report were based on information available in October 1988 and incorporates 1988 crop production estimates of the USDA as of October 1. The 1988 calendar year on livestock and 1988-89 season on crops represent

the first year of the forecast. To some extent, "add" factors were employed to take into account what is already known about the values for the variables for 1988 or 1988-89.

International Sector

The projected growth in grain consumption throughout the world, directly by humans or indirectly through livestock, is expected to be shared by producers in the U.S., in major exporting nations and in other nations as well. Expansion abroad is shown in Figure 5 in terms of area harvested. Responses to higher grain prices of the late 1980's and early 1990's is expected to encourage a reversal from the declines of the mid 1980's. Area harvested should reach or exceed the peak levels of the 1970's and early 1980's. Some strengthening of the dollar relative to currencies of other nations is assumed, but not to the levels of the early 1980's.

Grain yields abroad should increase in line with past trends with wheat increasing somewhat more rapidly than coarse grain (Figure 6). Even with the expansion in area and higher yields, AGMOD indicates that carryover levels as a percent of utilization will decline into the 1990's (Figure 7). Wheat carryover will rebuild some, but coarse grain stocks will remain relatively low as a percent of utilization outside of the U.S.

In absolute terms, coarse grain stocks will increase in the rest of the world as indicated in Figure 8. Note the predominant role of the U.S. in holding world stocks of coarse grain. In recent years, well over half of this carryover has been in the U.S. The Food Security Act of 1985, in combination with the 1988 drought, has cut these stocks sharply making the rest of the world much more vulnerable to a crop shortfall. U.S. coarse grain carryover is projected to increase irregularly, but remain well below levels of the past decade.

Some lag in production, in combination with growing utilization, have brought down stocks of wheat in the rest of the world, a development likely to continue into the first part of the 1990's (Figure 9). The role of the U.S. in world wheat carryover has been much less prominent than on coarse grain. U.S. wheat stocks have declined sharply since

1985 for the same reasons as for coarse grains. The projections indicate that carryover of wheat will fluctuate around this lower level during the next decade.

The area harvested for soybeans in South America has expanded spectacularly since the mid 1960's (Figure 10). This area is forecast to continue to grow at a somewhat slower pace. However, Argentina and Brazil will continue to capture a larger share of the soybean (and soybean product) export market. Amounts available for export should exceed one billion bushels in soybean equivalent by the early 1990's.

Domestic Crop Sector

The total area in the U.S. devoted to corn and soybeans, including area set aside under the Feed Grain Program increased through the late 70's and then leveled off (Figure 11). Some decline is noted in the mid 1980's which can be traced to a decline in returns to those crops. This area may be reduced further with increased enrollments in the Conservation Reserve. If the CR were not in the picture, AGMOD would project more expansion in this total area than indicated for the 1990's in Figure 11.

An alternative in projecting total area in corn and soybeans would be to hold the area constant at the level of the early 1990's, assuming the 45 million acres would remain in the CR for most of this period. Of course, corn and soybean acres would expand slowly and reach earlier peaks by the year 2000. One caveat was that some land in CR would be released if the U.S. carryover of feed grain dropped below 15 percent of utilization or if soybean carryover dropped below 10 percent of utilization. This did develop to a moderate degree in the mid 1990's.

The essence of the projections on corn area is that CR will replace the set-aside program. AGMOD is geared to implement a set-aside requirement if feed grain carryover reaches 30 percent of annual utilization. The amount of set-aside starts at 10 percent and is scaled upward as carryover levels increase. For the projection period beginning with 1990, no set-aside was triggered.

The impact of CR was similar for wheat although the boost from expanding exports was more pronounced (Figure 12). The implication is that the projected growth in area harvested for wheat may put on pressure for release of some of the land in the CR in the mid 1990's. U.S. wheat stocks are projected to drop below 25 percent of annual utilization which is considered to be low.

Suggesting the land base may be challenged to meet expanding demand for grain and soybeans seems inconsistent with the recent experience with large surplus stocks and land retirement. Again, this scenario is predicated on steady but moderate economic growth in the U.S. and abroad. The drought has stepped up the timing on this possibility. As indicated in Figure 13, yields were severely impacted. Carryover levels in terms of a ratio to annual utilization are projected in Figure 14. While soybean stocks are in line with historical levels, keeping feed grain and wheat carryovers under 25 percent of use for a decade would be unprecedented in the post-World War II period.

The level of carryover is a major factor in establishing crop prices. As shown in Figure 15, the nominal price of corn would move up to the $3 per bushel level for much of the next decade. In real terms, however, the level is about the same as in the 1980's. Underlying the nominal price is the assumed increase in the general price level of three to four percent per year. This comparison could also be applied to soybeans and wheat whose nominal prices are plotted with corn in Figure 16 or to nominal soybean meal prices in Figure 17. The conclusion would be that the long-term trend to lower real commodity prices may level off during the decade of the 1990's.

While real commodity prices have declined over the long-term, some consistency can be observed in indicators of profits such as gross margins over variable costs. Using representative costs such as published regularly by the USDA, real gross margins over variable costs (1967 dollars) on corn have fluctuated around $50 per acre (Figure 18). Returns to nonparticipants in the Feed Grain Program did drop sharply in the 1980's, but

in recent years, less than 20 percent of the corn base was outside the program. Obviously, the profit incentive to participate has been quite strong.

With the phasing out of the Feed Grain Program in the 1990's, no distinguishing of participants and nonparticipants is indicated in Figure 18. The possibility exists for some years of strong returns followed by a retrenchment. The pattern remains, however, for real gross margins to vary around the $50 per acre level.

Similar patterns can be observed on real gross margins over variable costs on wheat (Figure 19). In this case, the equilibrium appears to be around $20-$25 per acre (1967 dollars). As with corn, the incentive to participate in the farm program has been strong in recent years. The projections point to a phasing out of the Wheat Program by 1990 so that no distinction is made between returns to participants versus nonparticipants in the 1990's.

Since soybeans have not had special programs involving direct government payments, the pressures from the declining market prices from corn has brought real gross margins down sharply in the 1980's. As shown with corn in Figure 20, real gross margins on soybeans (1967 dollars) have also averaged over time close to corn's $50 per acre. The discrepancy noted in the mid 1980's could not be expected to last. The higher prices realized in the past year are in line with the increased returns projected for the 1990's.

Domestic Livestock Sector

The central question in the long-term outlook for the livestock sector is what will happen to the shifting demands among the meats. While the profession of agricultural economics is divided on whether there has been a structural change in demand, many responsible for regular forecasts have been challenged to accurately predict cattle and hog prices in recent years. In AGMOD, the conclusion was reached that there was a pronounced shift in meat demand in the late 1970's. On all major meats, demand, as measured at the farm or wholesale level, has declined in the long-run. That is, in price

dependent equations which take into account own and cross supplies per capita and real disposable income per capita, the addition of a trend factor revealed a downward shift over the 1960 to 1987 period. On cattle and hogs, however, the trend became much more pronounced after the late 1970's.

Concerns about health and diet and changing lifestyles have apparently been the main reason for the shift. The presumption is that the shift will continue, but the task is to determine to what extent. The assumption in the projections is that the down trend in demand for red meat relative to white meat will continue, slowing in the 1990's, but not ending. As can be seen in Figure 21, per capita consumption of poultry meat will likely exceed beef by the end of the next decade.

Demand trends on milk and eggs are also downward in spite of a recovery in milk consumption per capita in the 1980's (Figure 22). Part of the projected decline in milk production per capita as shown in Figure 22 is due to a reduction forecast in returns to milk producers and their response.

Rising feed costs and general inflation are expected to be translated into higher nominal livestock prices (Figure 23). The rise late in the decade on steers and hogs can be partly attributed to the leveling off in the down trend in demand. If this doesn't happen, the rise will be much less obvious. Also, there are cyclical patterns on both cattle and hogs from the supply side that can create false impressions about longer-term trends. Nominal milk and egg prices are projected to strengthen in the 1990's also due to rising feed prices and general inflation (Figure 24).

Perhaps more meaningful than projections of nominal prices are forecasts of real gross margins on livestock. In Figure 25, trends and projections of the real gross margin over the cost of feed and feeder in a representative calf feeding program are charted. The risky nature of cattle feeding is evident. Margins are forecast to continue to fluctuate around the level of the past--between $2.50 and $5.00 per hundredweight in 1967 dollars. The actual fluctuations will probably be greater than this due to the fact

that models such as AGMOD do not adequately simulate the real world in terms of "shocks" to the system such as international events, extreme weather, etc.

One trademark of the cattle feeding business is that improved profits tend to be bid into the price of feeder cattle. This keeps margins fluctuating around a so-called equilibrium level. While somewhat less evident, real feeder cattle prices also adjust over time to an equilibrium (Figure 25). However, the process is somewhat slow. Real prices on feeders are expected to increase into the early 1990's, fall off and then rise again cyclically in the last part of the decade ahead.

Trends and projections for real gross margins over feed costs are presented in Figures 26 and 27 for dairy, hogs (farrow to finish), broilers and eggs. The contrast in year to year variability between dairy and hogs is evident in Figure 26. As with cattle feeding, the projected returns on hogs probably understates the future variability. The level of gross margins, however, is in line with the past.

On dairy, on the other hand, the projected level of returns over feed costs is much lower than in the past. The reason is the rising costs of feed, lower real support prices on milk and the structure of dairy farming which tends to hold resources in production. Downsizing the dairy operation is a slow process without government incentives.

Improved technology, economies of scale and more efficient feed conversion have allowed poultry producers to expand and survive at lower real gross margins over feed costs (Figure 27). This trend is projected to continue into the next decade on broilers with some leveling off on eggs.

Trends and projections for the size of U.S. livestock industries are shown in Figures 28 to 31. While per capita consumption of beef is projected to decline, the total number of beef cows may actually increase in the decade to come. This is partly due to increasing population, but also due to the higher percent of the total beef supply which will have to come from beef herds as compared to cull animals and steers from the dairy

herd. As charted in Figure 28, a cyclical expansion in beef cows into the mid 1990's is to be followed by a modest liquidation. Dairy cow numbers will continue to drift downward.

Total beef supplies will vary with the beef herd in a somewhat lagged relationship (Figure 29). Little trend is seen in either beef or pork supplies in the next decade. On the other hand, a continued strong expansion is plotted for poultry meat in the 1990's (Figure 30). Like beef and pork, milk and egg production will vary some in the balance of the century with no strong trends evident (Figure 31).

General Outlook and Summary

Adding up the various sectors discussed in this presentation, the outlook for the next decade would be considered quite optimistic. The aggregate effect can be observed in Figure 32 which translates the commodity projections into forecasts of cash receipts from marketings of crops and livestock and from government payments. Increased returns from marketings will more than offset the decline in government payments.

Increased income would also be reflected in higher farmland prices as indicated in Figure 33. Although farmland prices could reach their earlier peak in nominal terms before the end of the century, real land prices are not likely to even approach the high of 1981.

In the judgment of the modeler, the conclusions of the base run of AGMOD do seem more optimistic than expected. Clearly, if the real economic growth per capita in the U.S. and abroad falls short of one percent per year, the scenario could be quite different and demands would be much less buoyant. Technological breakthroughs that would transcend linear upward trends in production rates would also cloud the picture.

In any case, AGMOD provides a framework for testing alternative assumptions and identifying which are the most crucial. Efforts will continue to monitor and improve its performance.

Figure 1

AGMOD

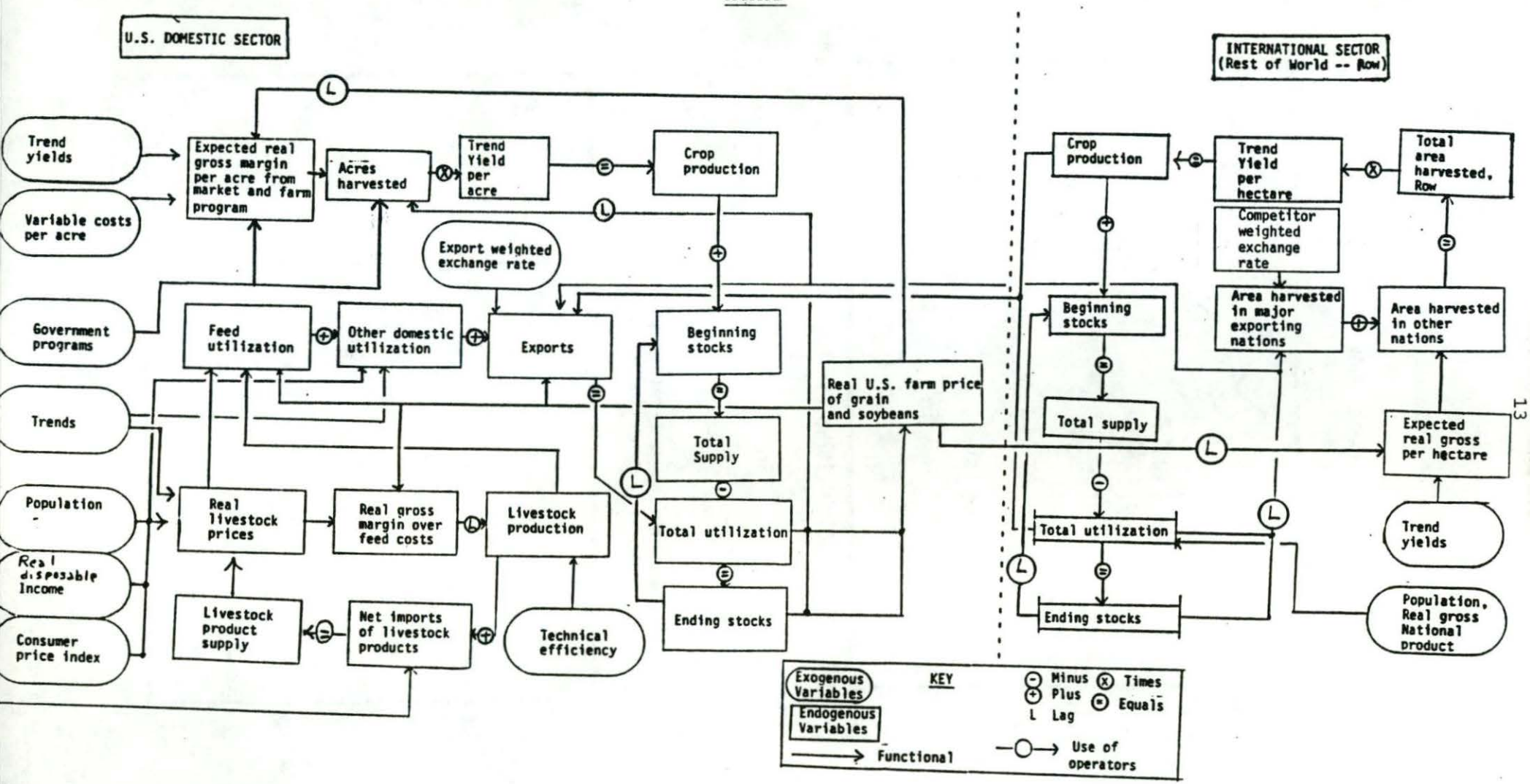


Figure 2

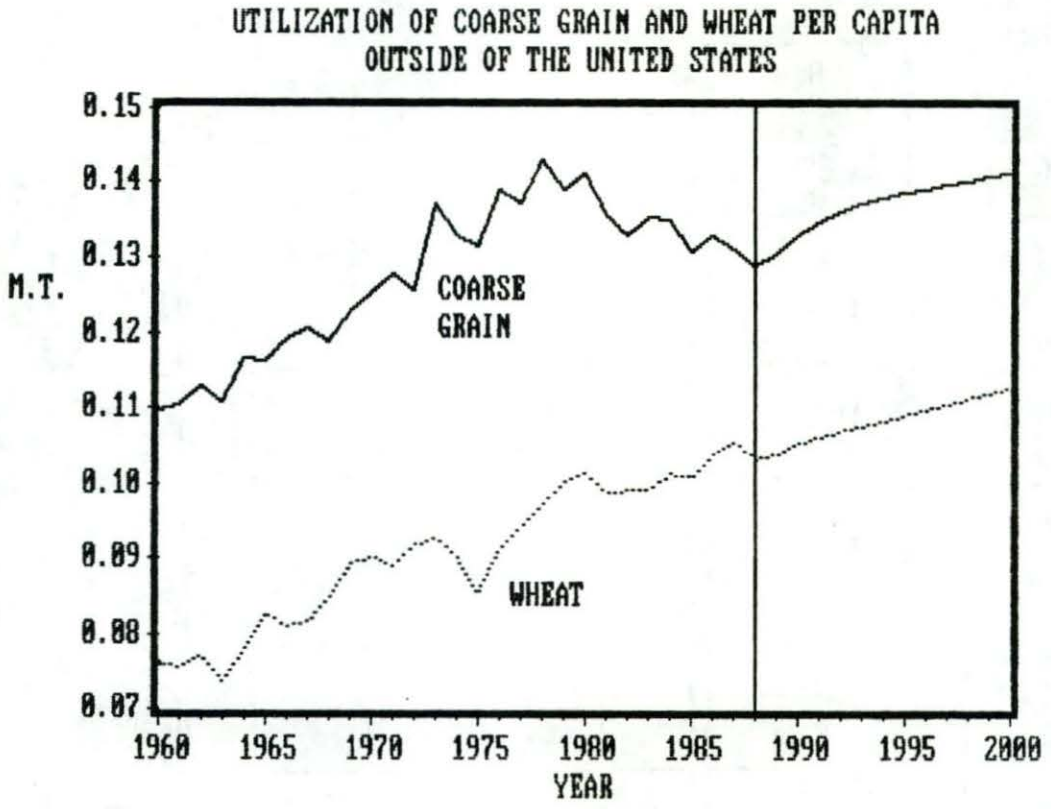


Figure 3

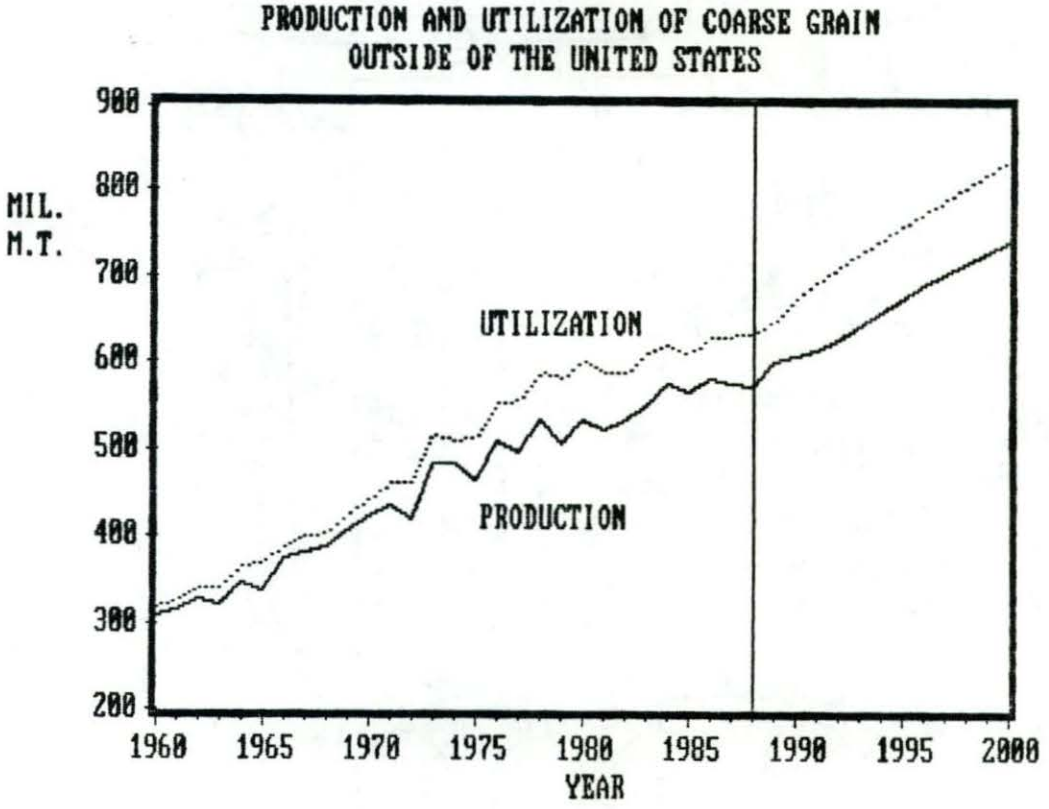


Figure 4

PRODUCTION AND UTILIZATION OF WHEAT
OUTSIDE OF THE UNITED STATES

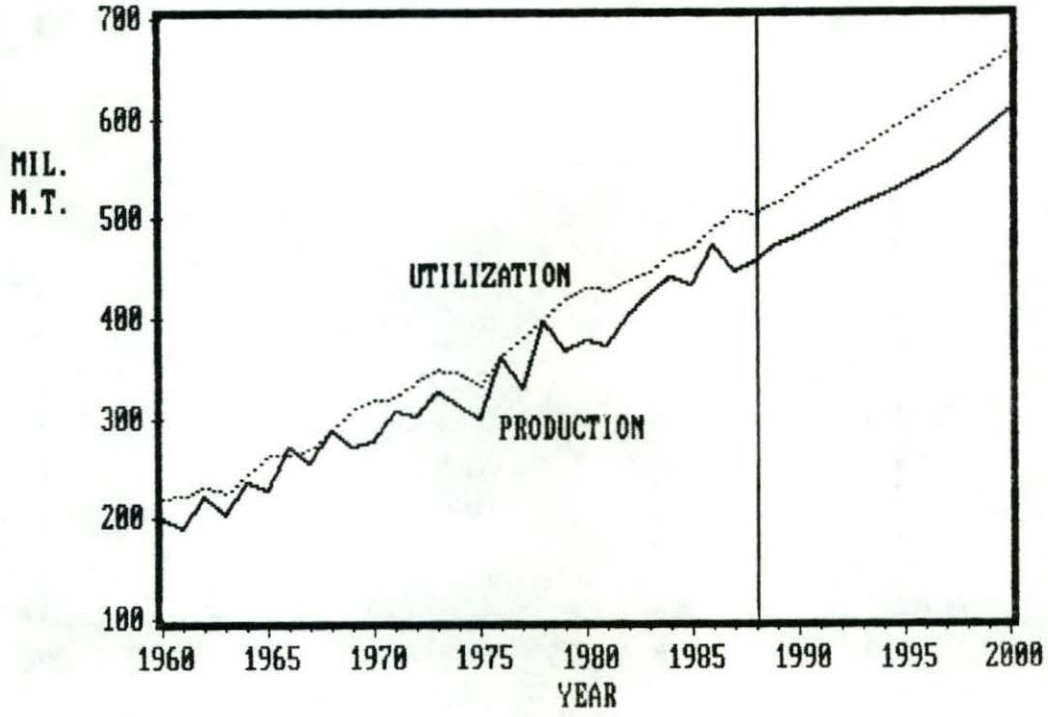
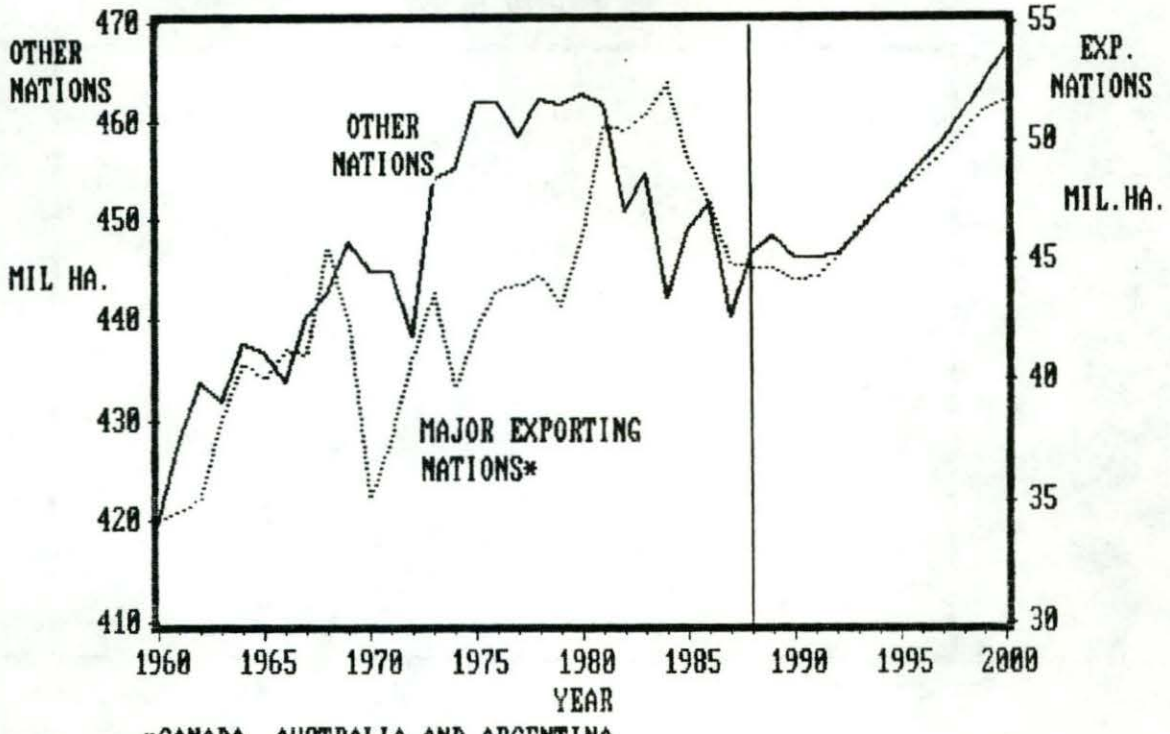


Figure 5

AREA HARVESTED FOR COARSE GRAIN AND WHEAT
IN MAJOR EXPORTING NATIONS AND OTHER NATIONS OUTSIDE OF THE U.S.



*CANADA, AUSTRALIA AND ARGENTINA

Figure 6

YIELDS PER HECTARE ON COARSE GRAIN AND WHEAT
OUTSIDE OF THE U.S.

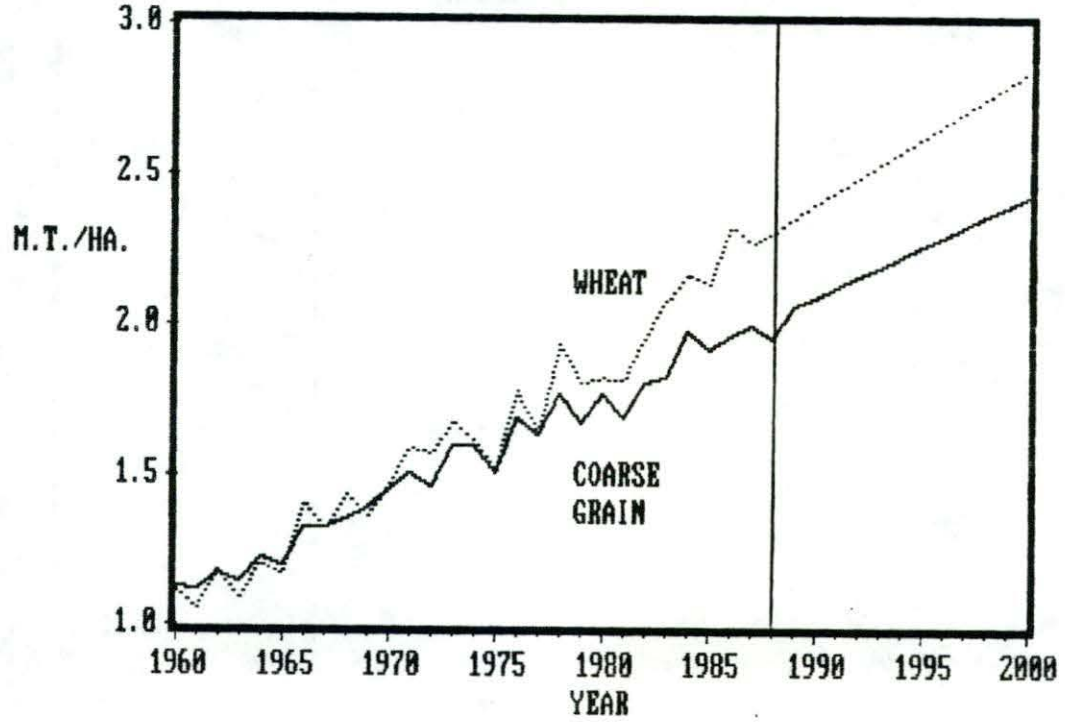


Figure 7

ENDING STOCKS OF WHEAT AND COARSE GRAIN OUTSIDE OF THE U.S.
AS A RATIO TO USE

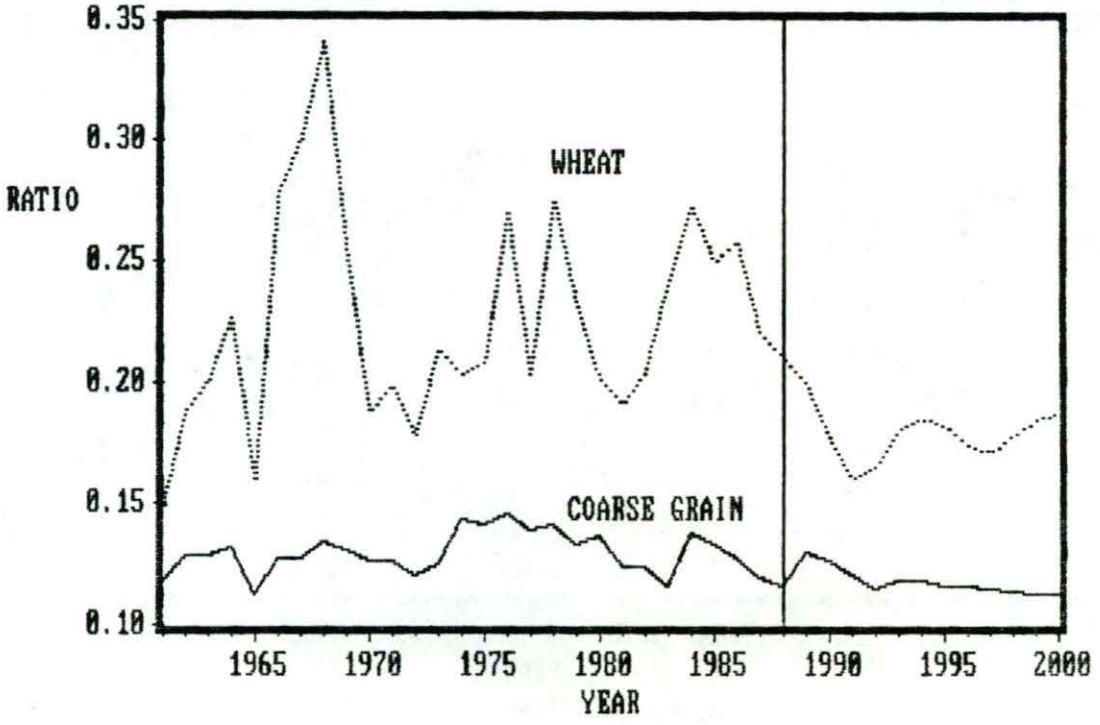


Figure 8

ENDING STOCKS OF COARSE GRAIN IN THE U.S. AND REST OF WORLD

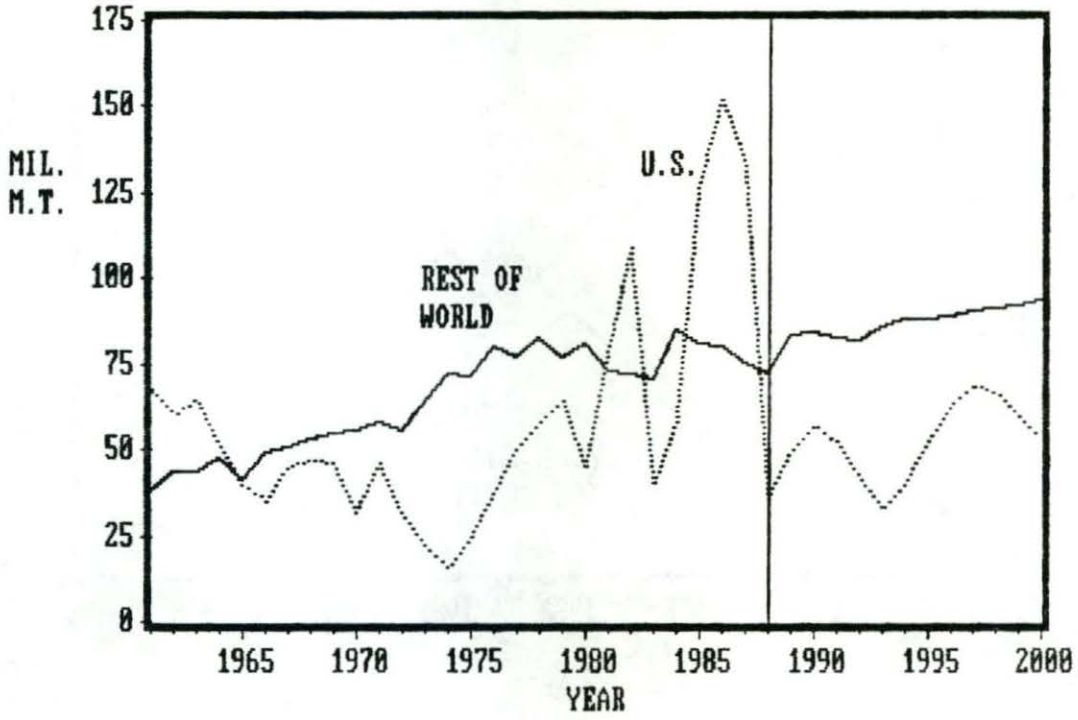


Figure 9

ENDING STOCKS OF WHEAT IN THE U.S. AND REST OF WORLD

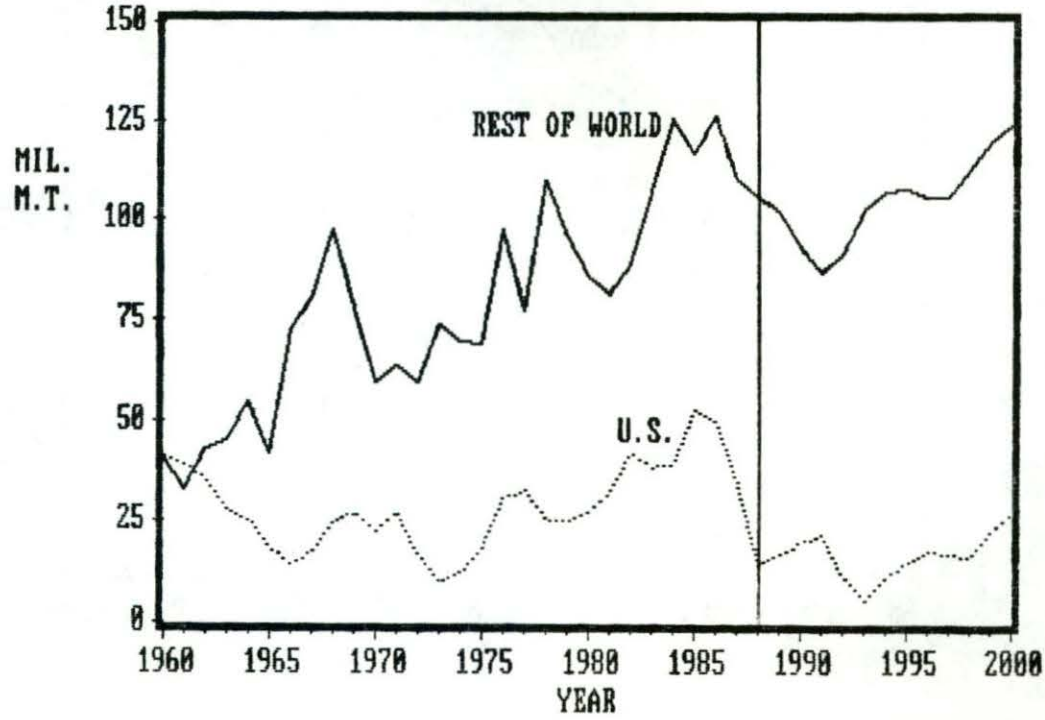


Figure 10

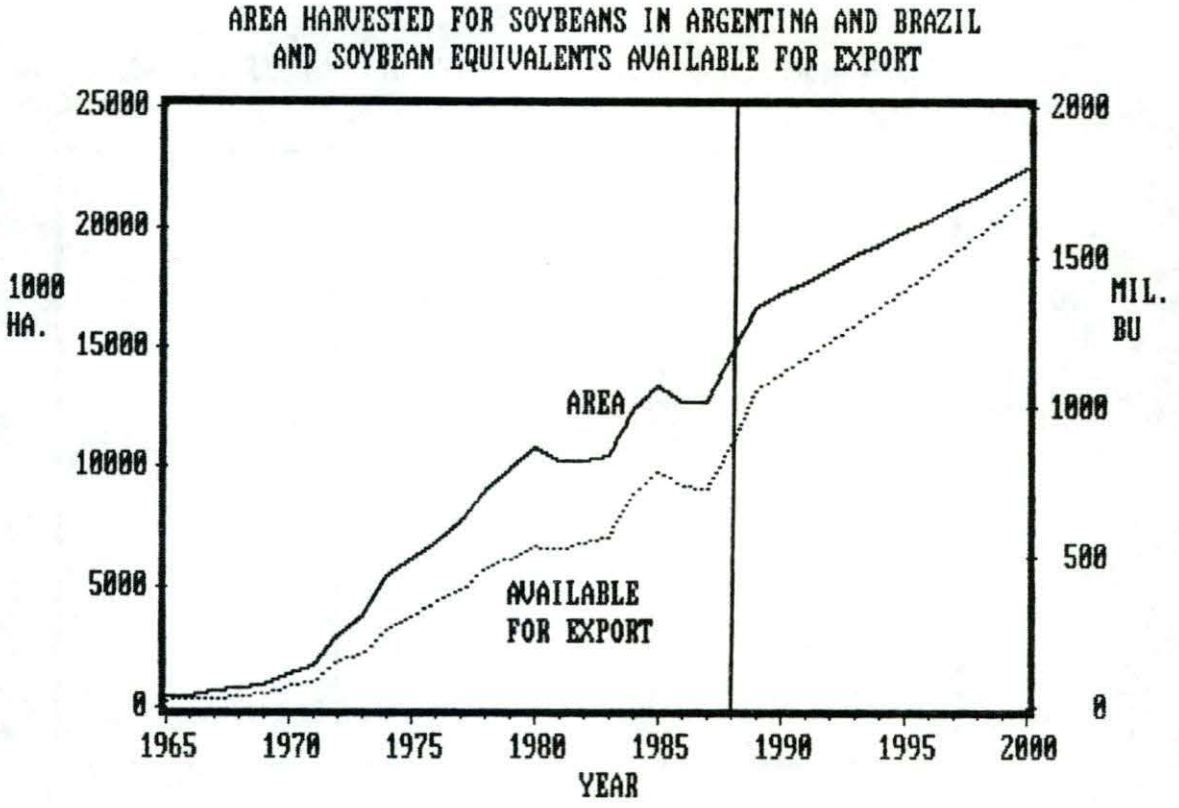


Figure 11

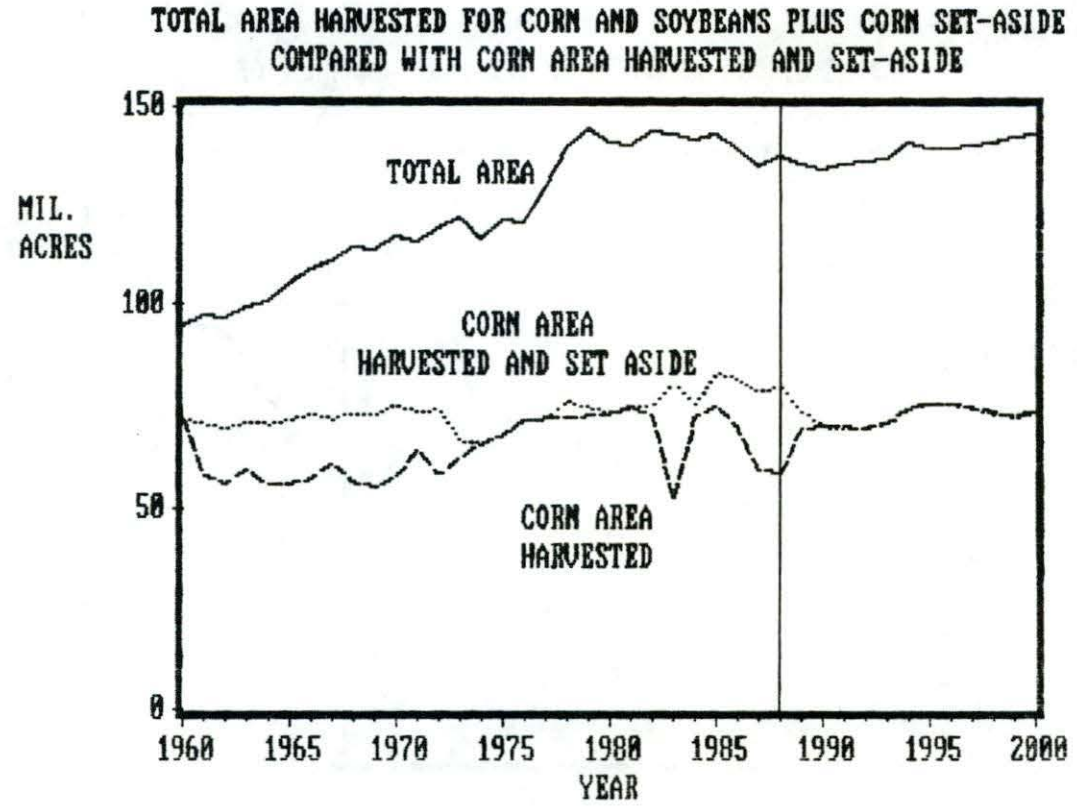


Figure 12

TOTAL AREA HARVESTED FOR WHEAT AND SET ASIDE

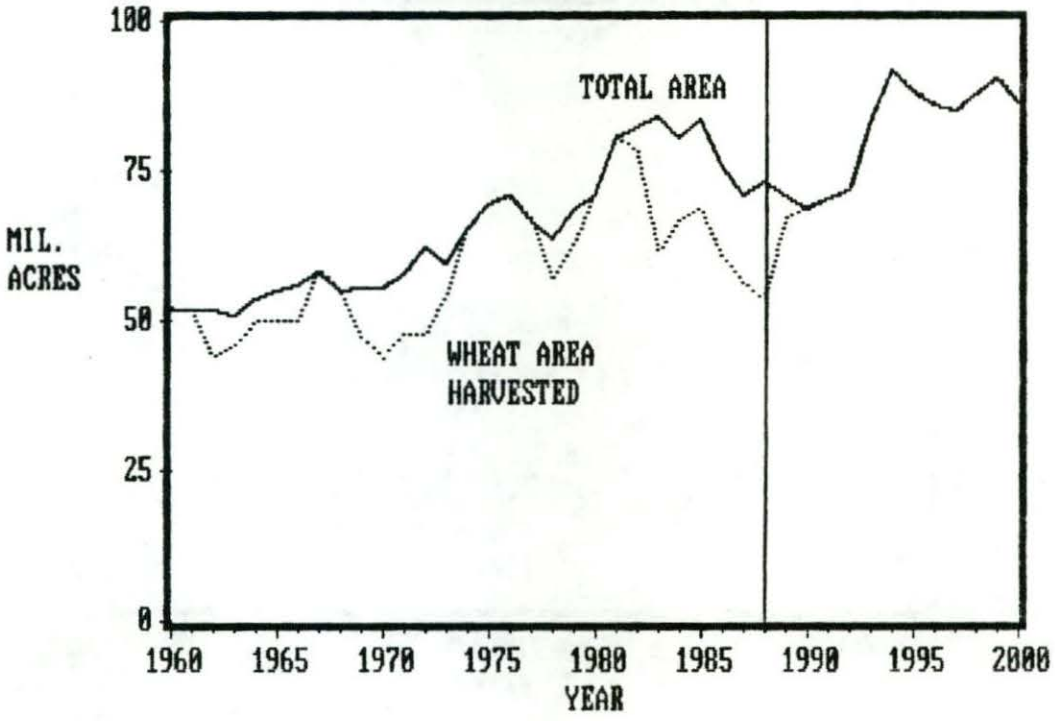


Figure 13

YIELDS PER ACRE ON CORN, WHEAT AND SOYBEANS

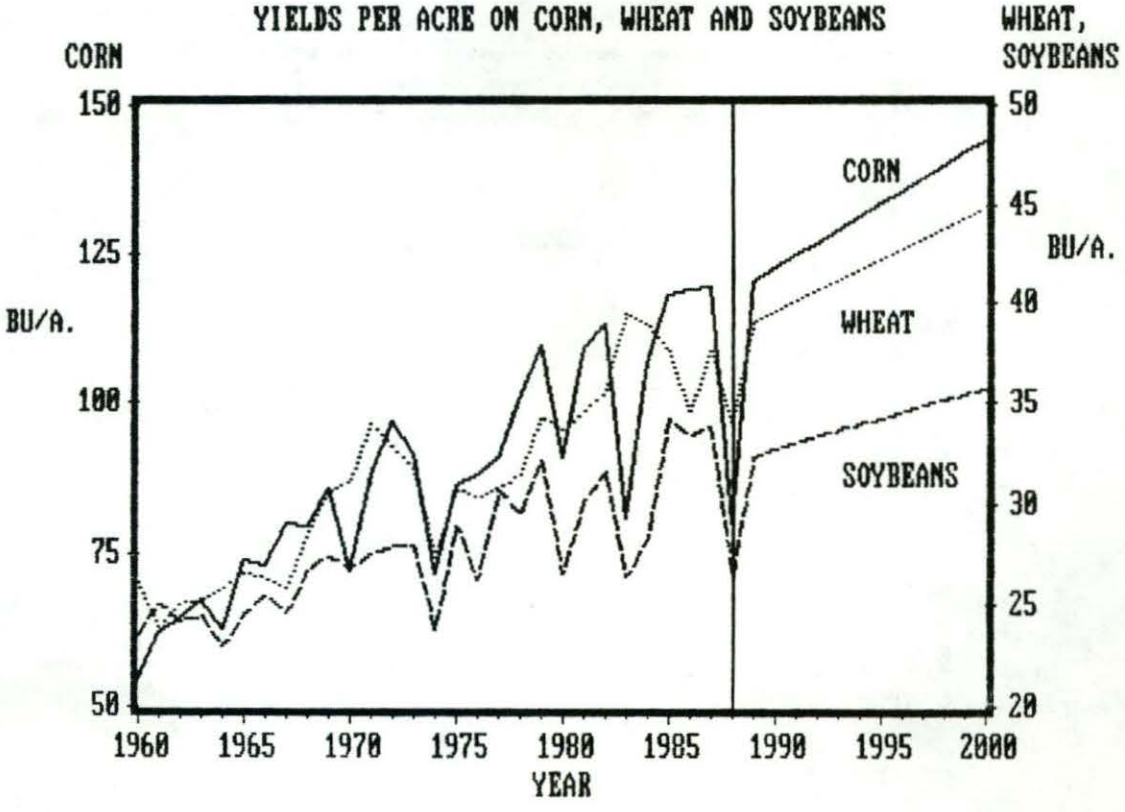


Figure 14

ENDING STOCKS OF FEED GRAIN, WHEAT AND SOYBEANS IN THE U.S.
AS A RATIO TO UTILIZATION

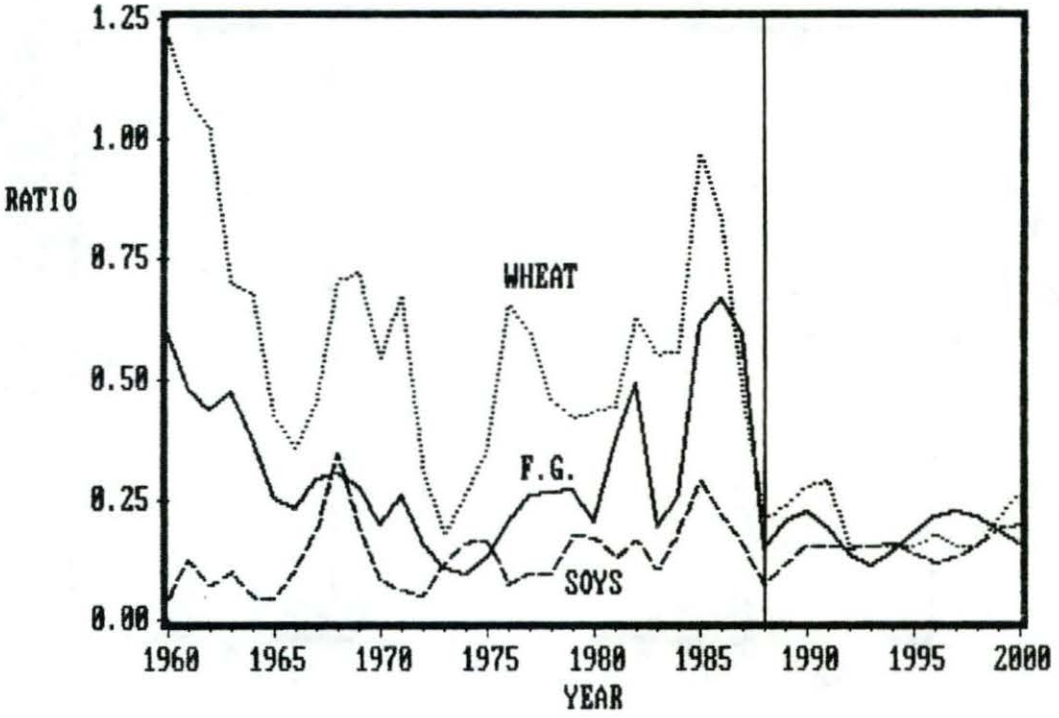
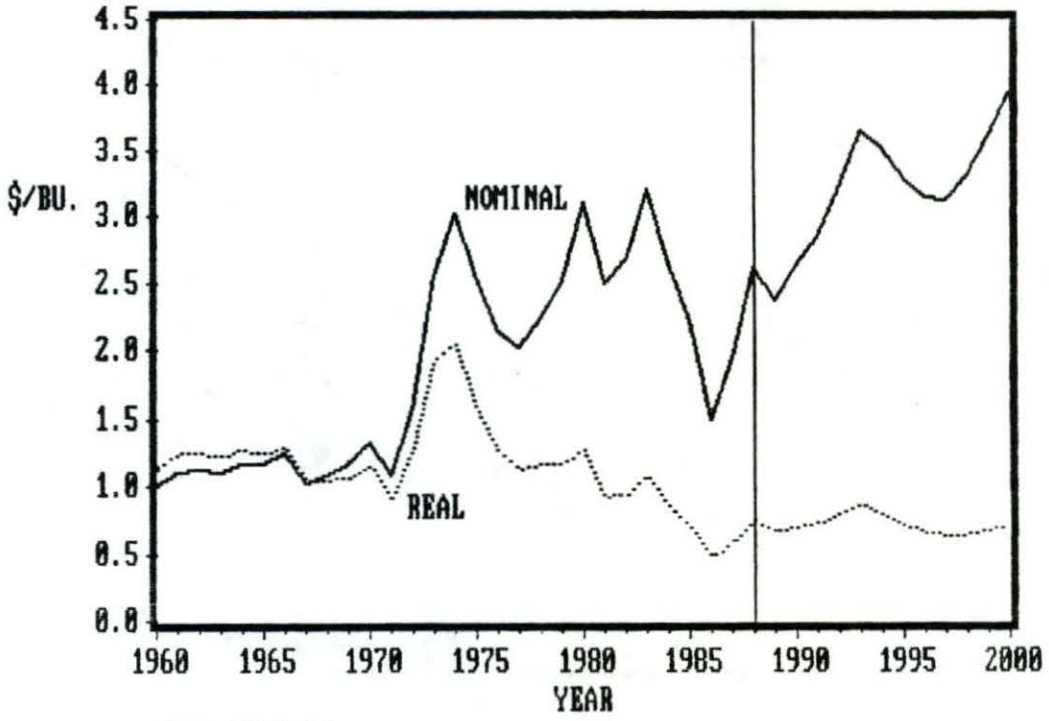


Figure 15

FARM PRICE OF CORN, NOMINAL AND REAL*



*1967 DOLLARS

Figure 16

NOMINAL FARM PRICES OF CORN, WHEAT, AND SOYBEANS

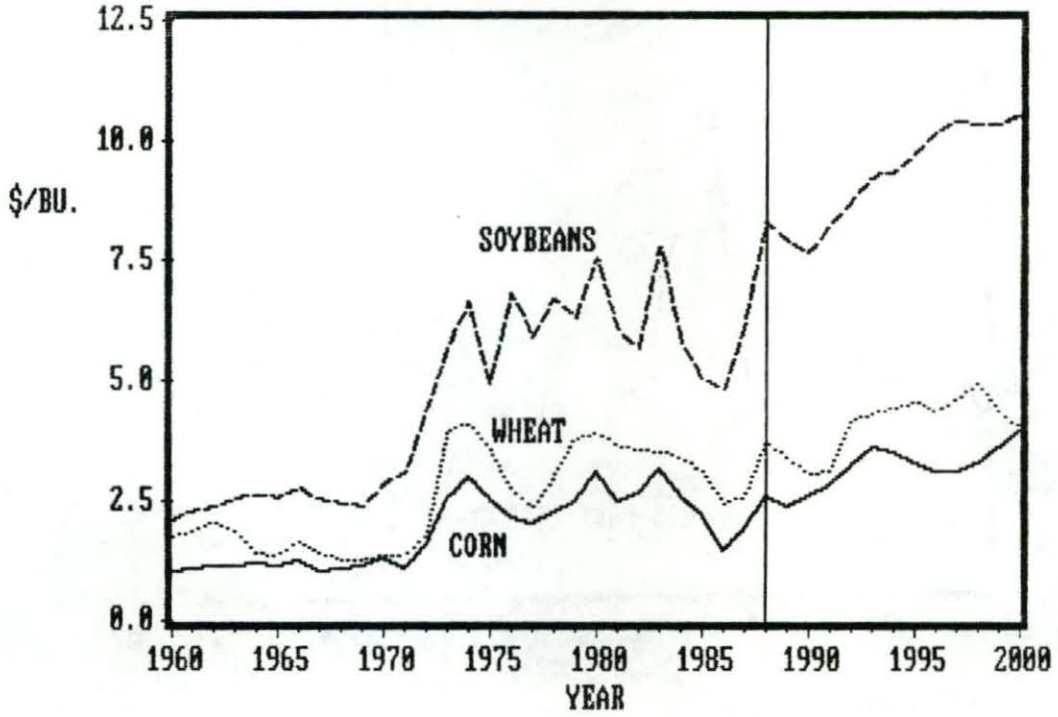


Figure 17

PRICE OF SOYBEAN MEAL AT DECATUR, IL.

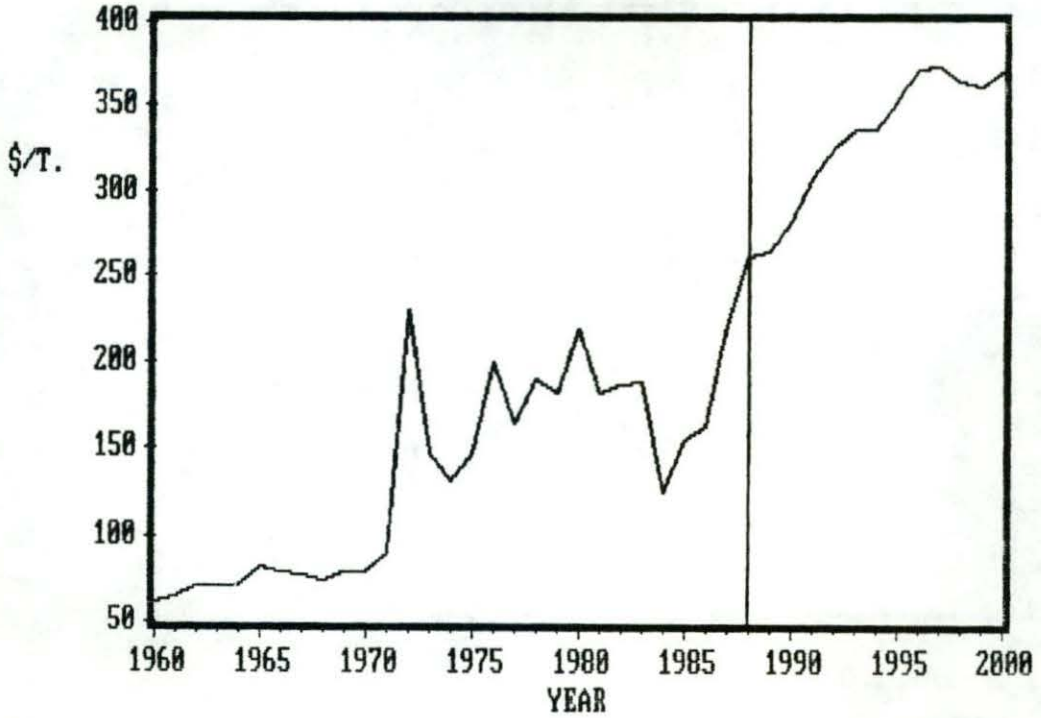
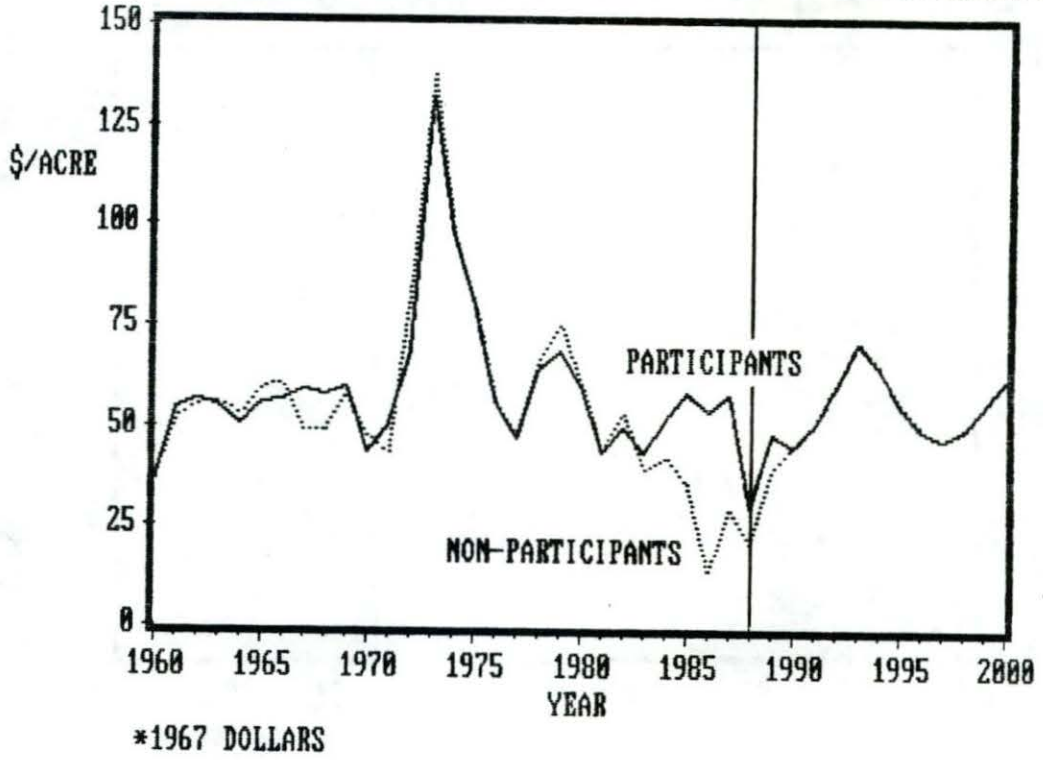


Figure 18

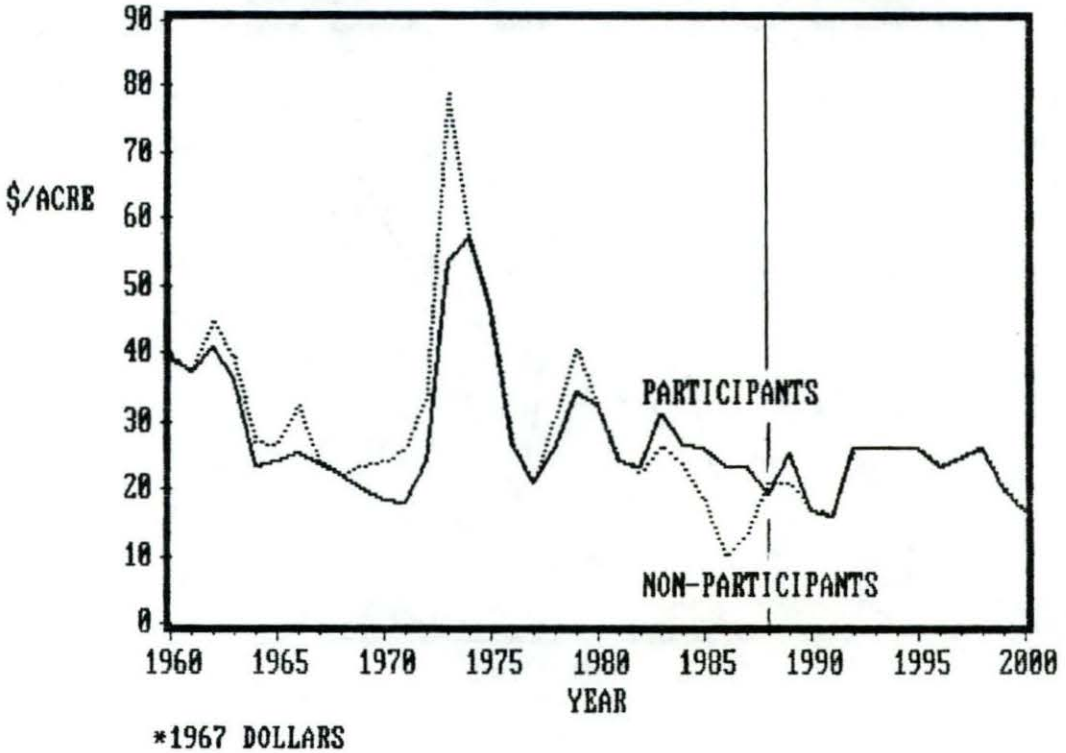
GROSS MARGINS OVER VARIABLE COSTS IN CORN PRODUCTION
FOR PARTICIPANTS AND NON-PARTICIPANTS IN THE FEED GRAIN PROGRAM*



*1967 DOLLARS

Figure 19

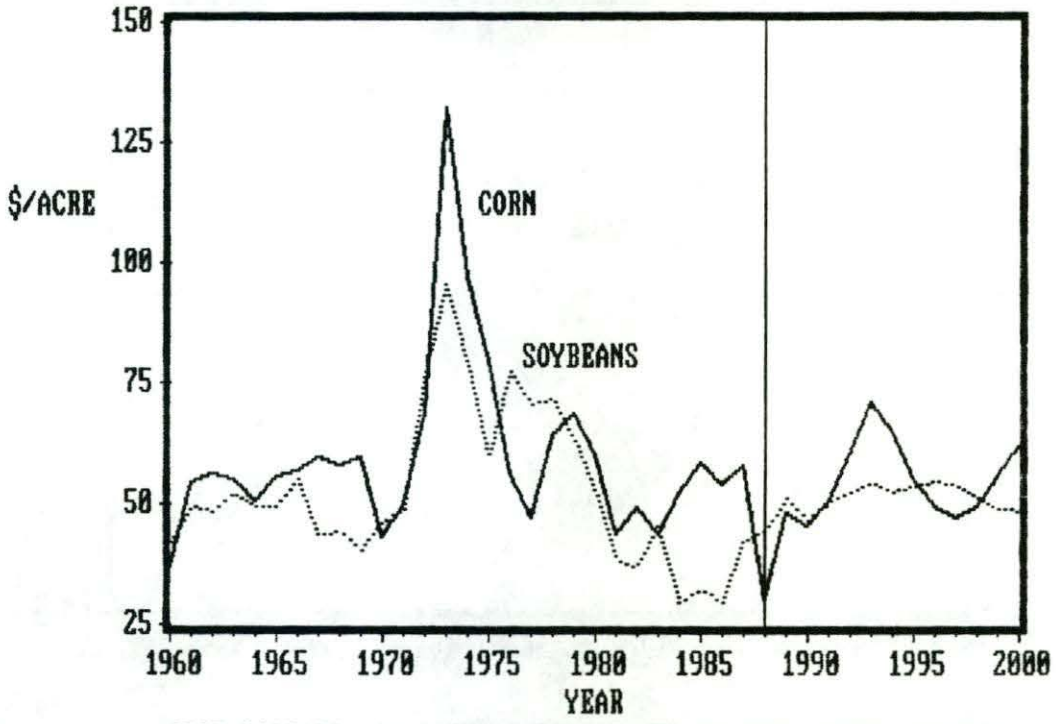
GROSS MARGINS OVER VARIABLE COSTS IN WHEAT PRODUCTION
FOR PARTICIPANTS AND NON-PARTICIPANTS IN THE WHEAT PROGRAM*



*1967 DOLLARS

Figure 20

GROSS MARGINS OVER VARIABLE COSTS FOR CORN AND SOYBEANS*



*1967 DOLLARS. ON CORN, PARTICIPANTS IN FEED GRAIN PROGRAM

Figure 21

CONSUMPTION OF BEEF, PORK, POULTRY MEAT AND FISH
PER CAPITA IN EDIBLE WEIGHT

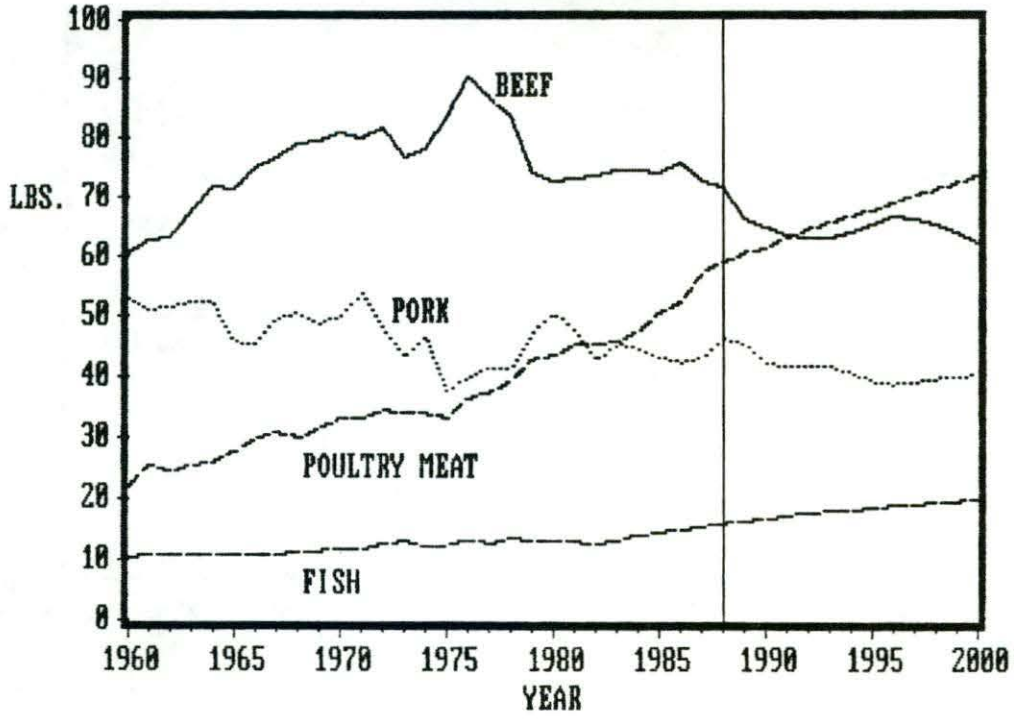


Figure 22

PRODUCTION OF MILK AND EGGS PER CAPITA

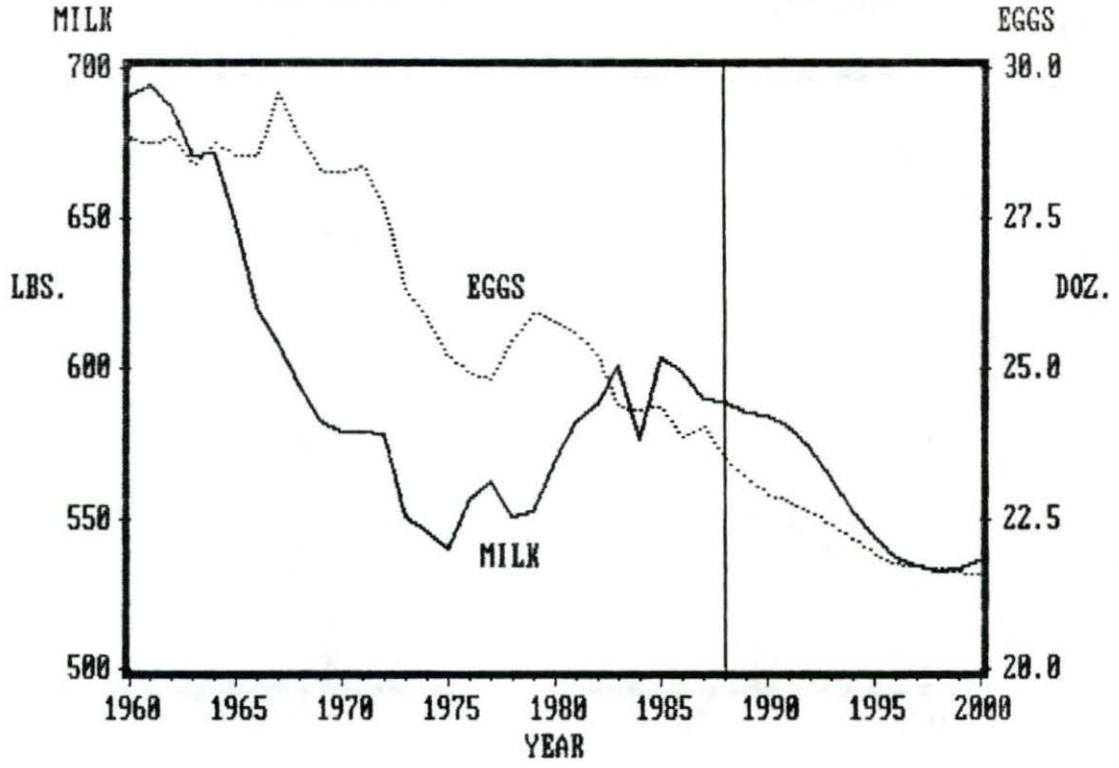


Figure 23

NOMINAL PRICES OF STEERS, BARROWS AND GILTS, AND BROILERS

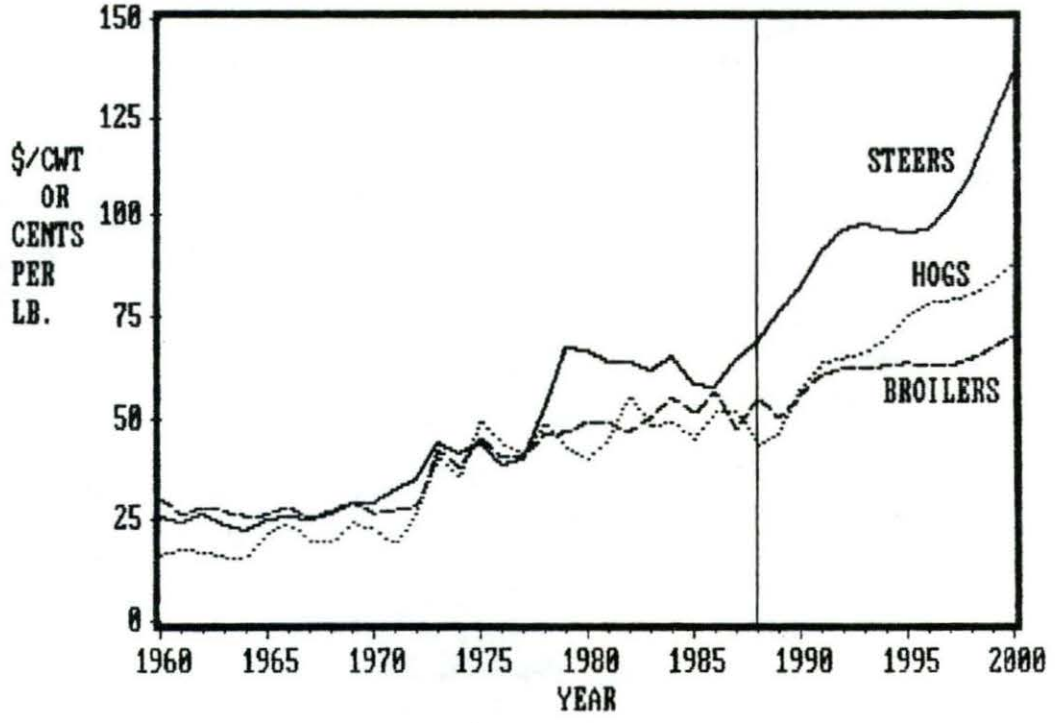


Figure 24

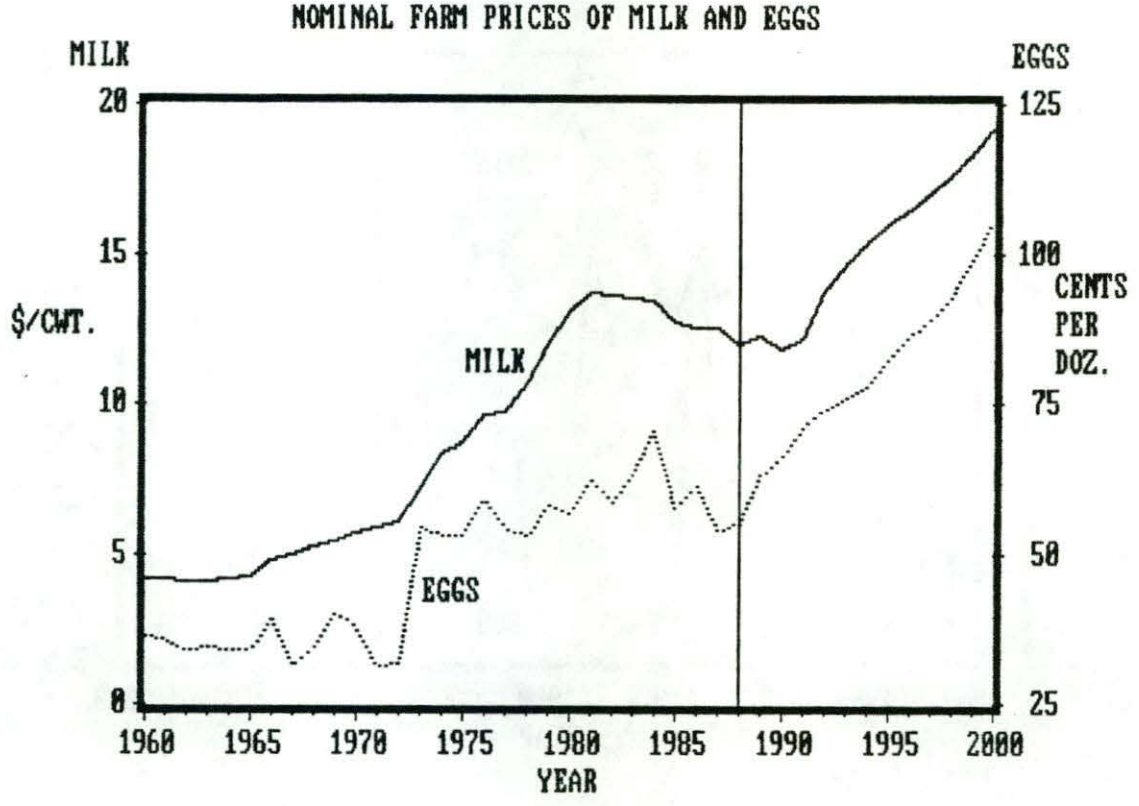


Figure 25

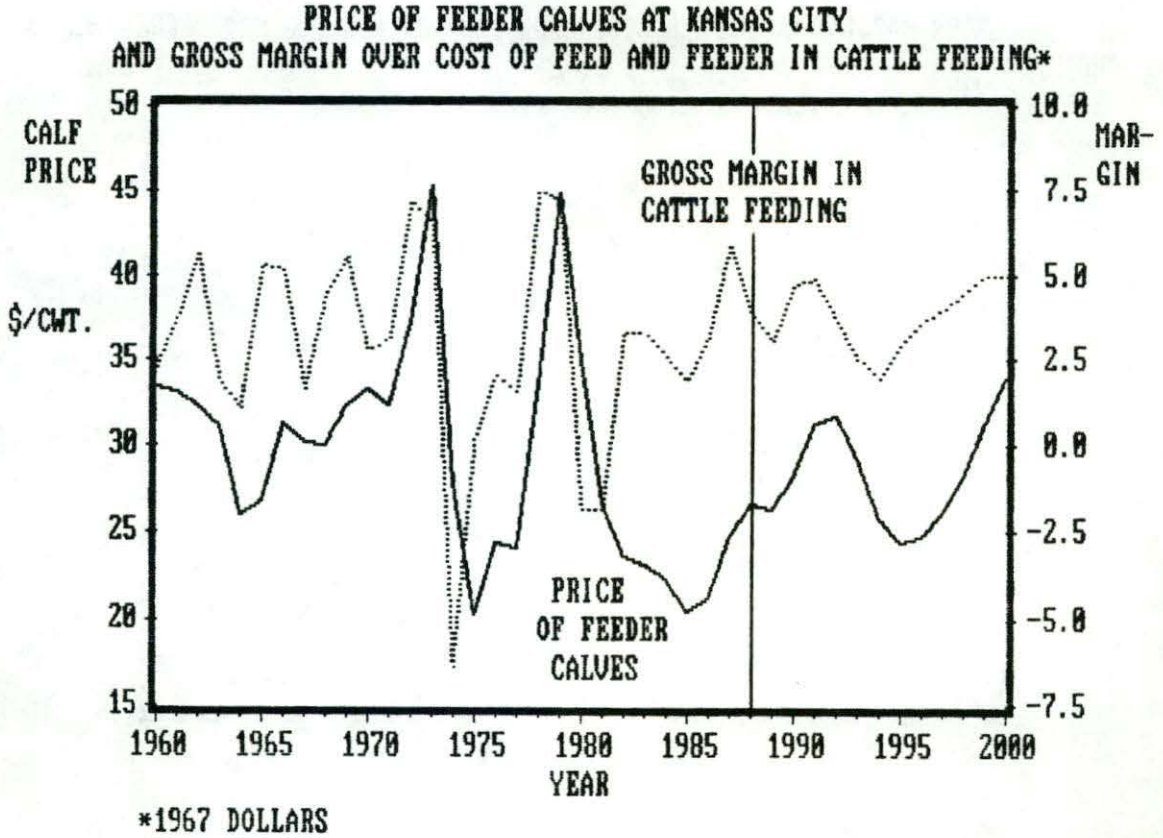


Figure 26

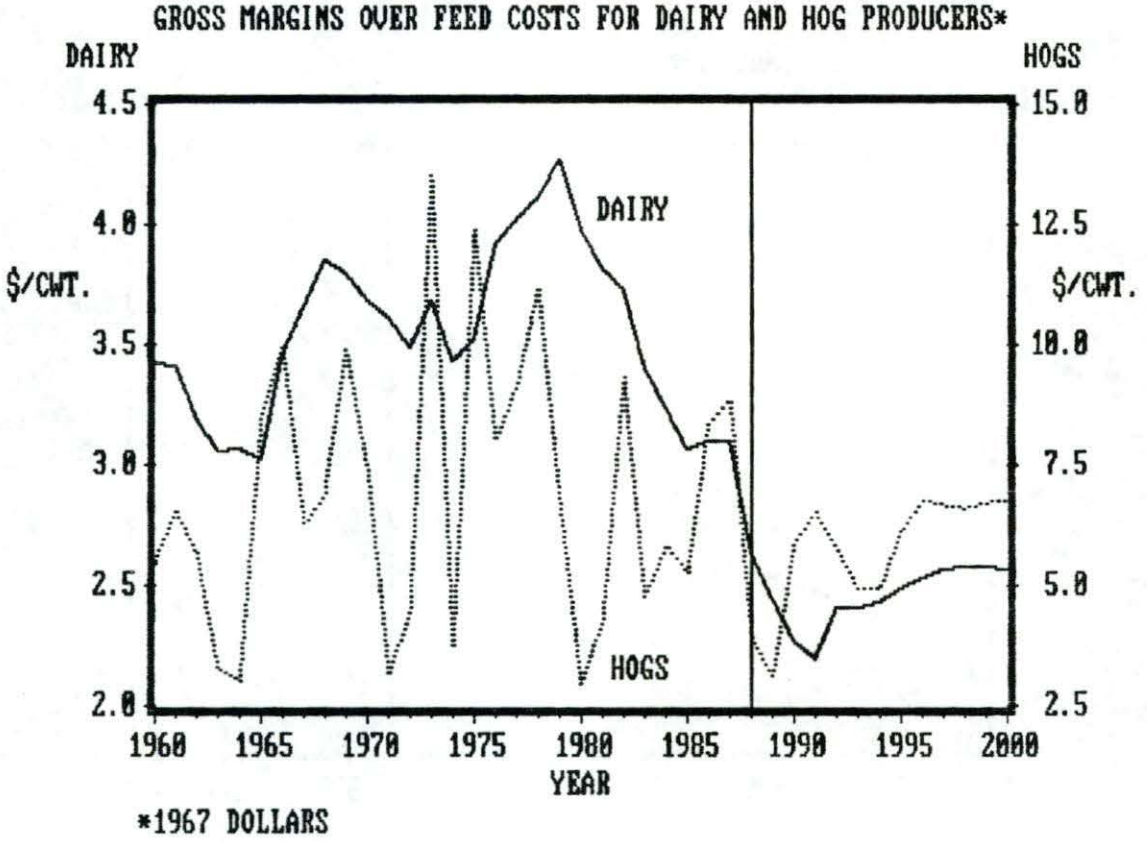


Figure 27

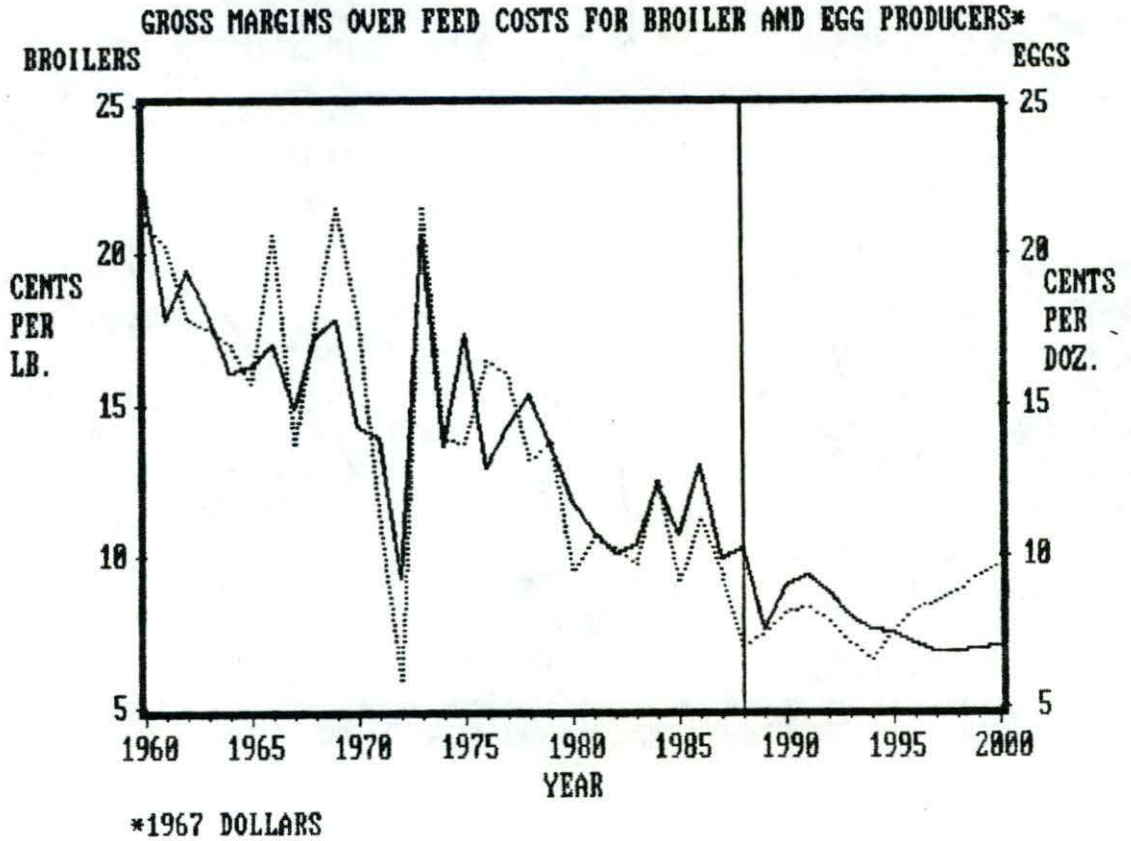


Figure 28

NUMBER OF BEEF COWS AND DAIRY COWS ON FARMS, JAN. 1

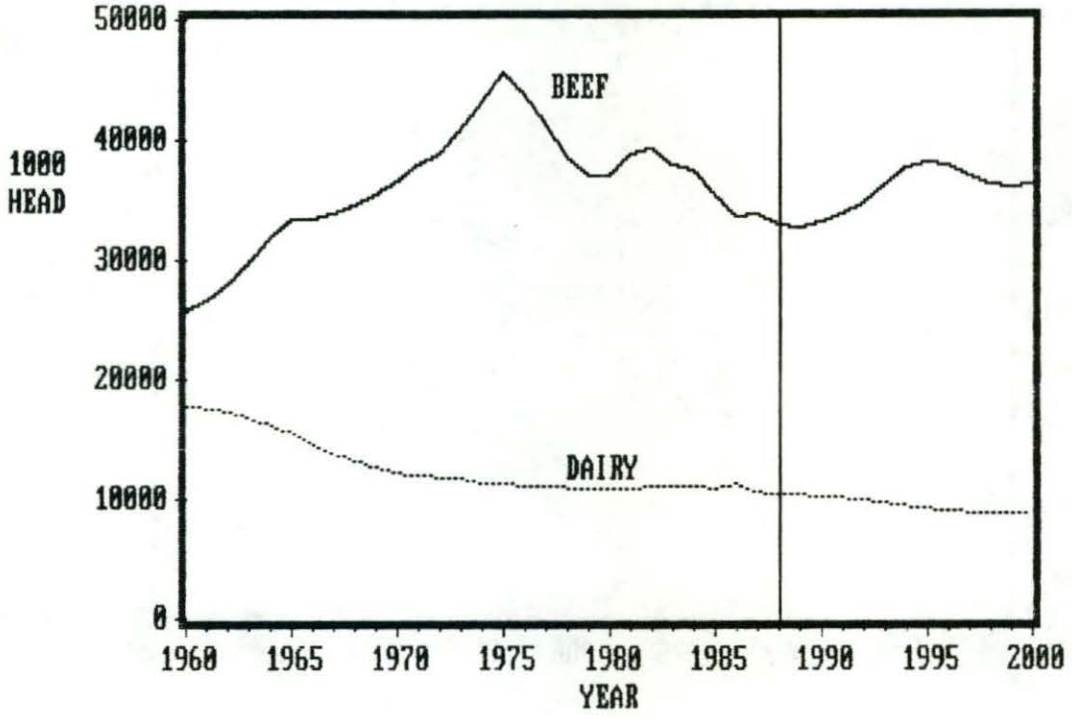
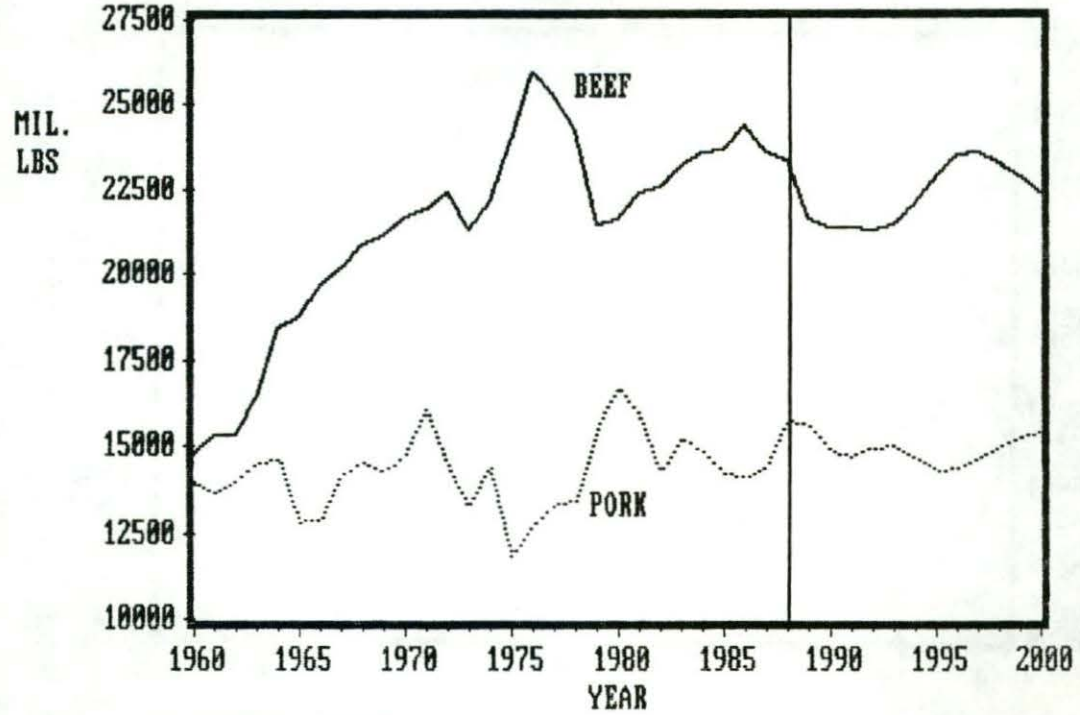


Figure 29

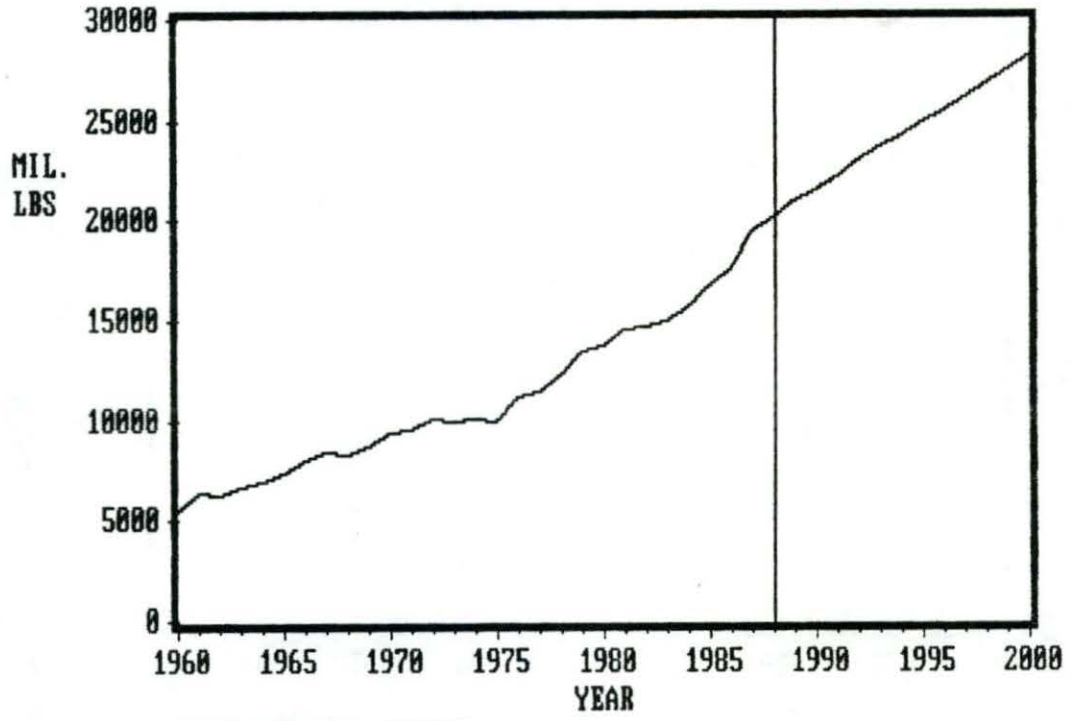
DOMESTIC PRODUCTION OF BEEF AND PORK*



*CARCASS WEIGHT

Figure 30

PRODUCTION OF POULTRY MEAT (BROILERS AND TURKEYS)*



*READY-TO-COOK WEIGHT

Figure 31

PRODUCTION OF MILK AND EGGS

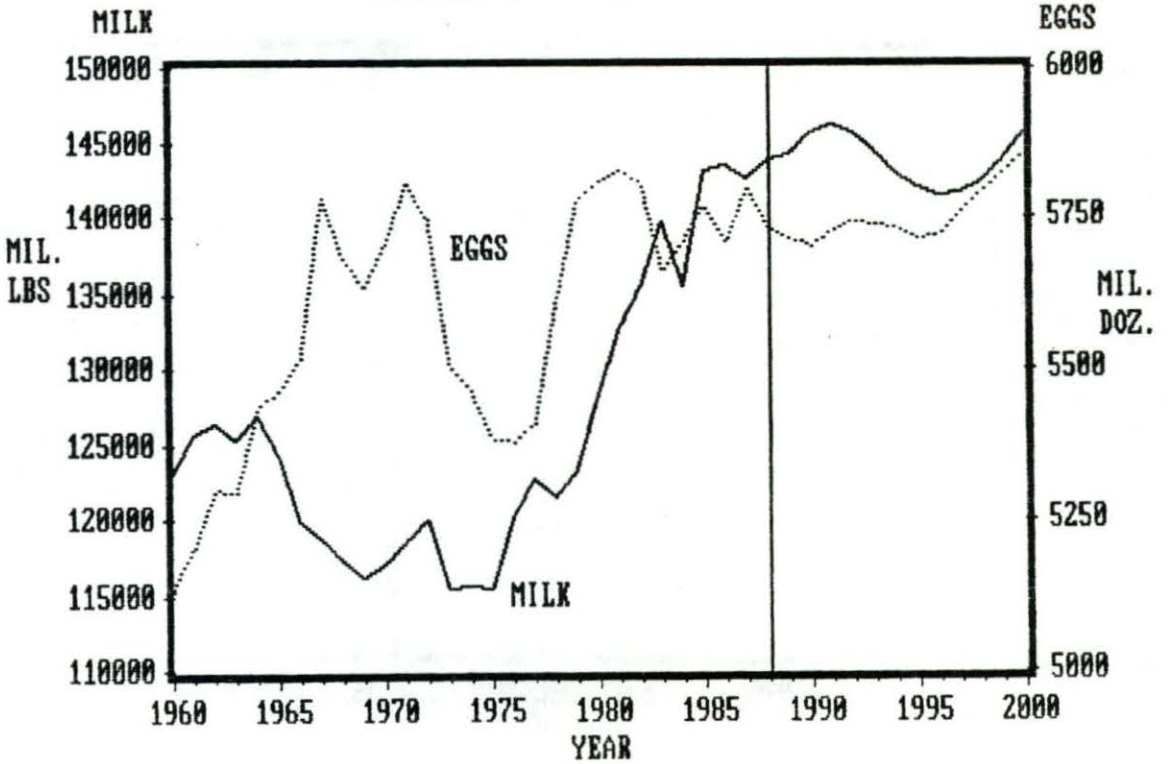
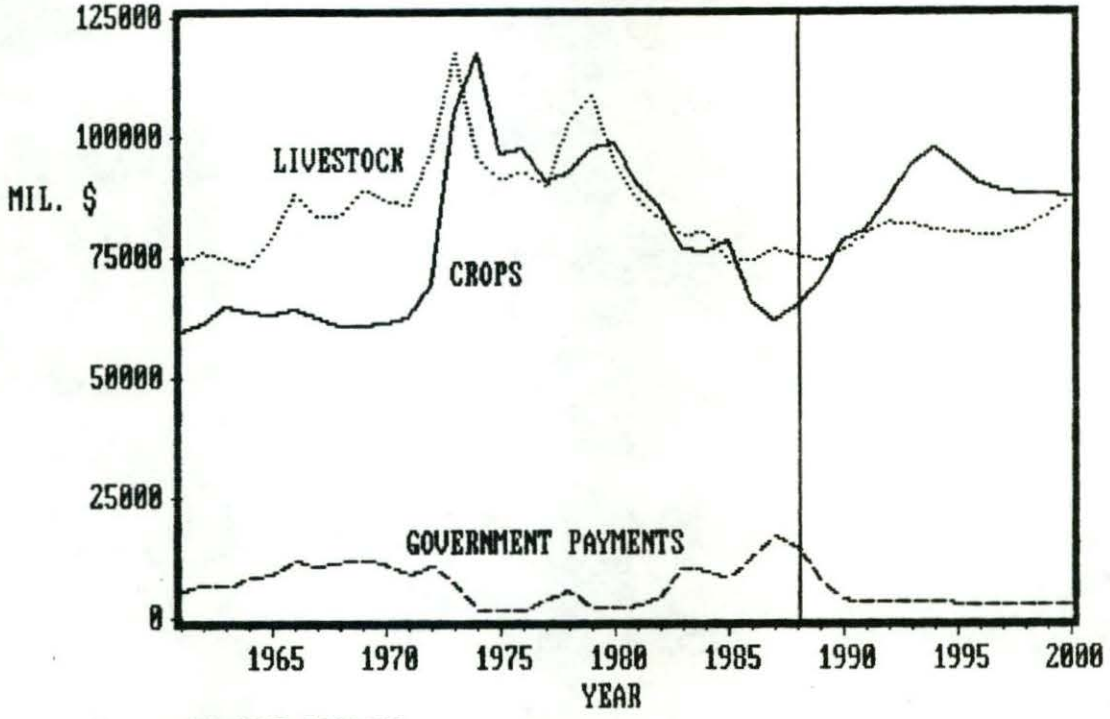


Figure 32

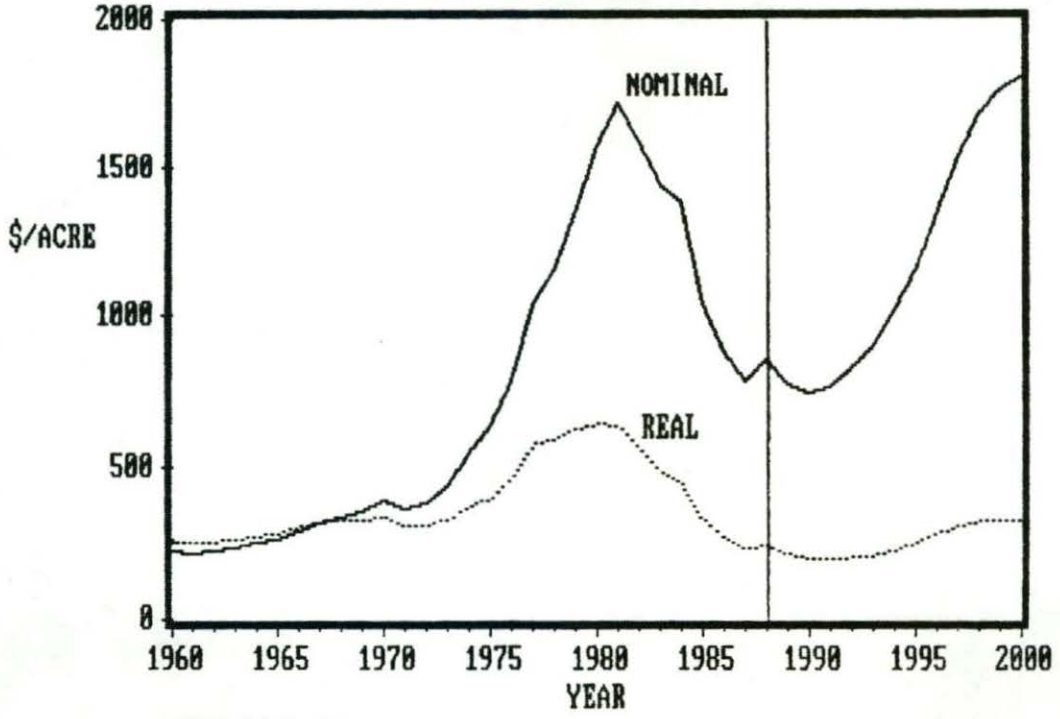
CASH RECEIPTS FROM MARKETINGS OF CROPS AND LIVESTOCK
AND FROM GOVERNMENT PAYMENTS*



*IN 1987 DOLLARS

Figure 33

PRICE OF FARM LAND IN THE CORN BELT
IN NOMINAL AND REAL TERMS*



*1967 DOLLARS