# Are Large-Scale Agricultural-Sector Economic Models Suitable for Forecasting?

Robert N. Wisner, University Professor, Department of Economics,

Iowa State University

Marty McVey, Chief Economist, AGRI-Industries, Des Moines, Iowa

C. Phillip Baumel, Professor, Department of Economics and

Charles F. Curtiss Distinguished Professor of Agriculture

Iowa State University

**Abstract:**

In recent years, baseline projections from large agricultural economic models have been used as long-run forecasts. These “forecasts” have frequently been used to make major investment decisions. The models were initially constructed to analyze impacts of alternative U.S. and global agricultural policies, and were never intended for forecasting. An examination of the forecasting performance of such models over the last 14 years shows a strong upward bias in corn and wheat export projections. Several sources of forecasting error are identified in this paper. Substantial funding would be required to convert the existing models into forecasting models.

## Introduction

Large multi-equation models of U.S. and global agriculture have been used for many years as tools for analyzing the impact of alternative agricultural and trade policies.  Two widely known and respected models are the USDA and the FAPRI (Food and Agricultural Policy Institute) models.  FAPRI is a research institute housed jointly at Iowa State University and the University of Missouri, Columbia. The FAPRI model contains over 3,000 equations detailing relationships among prices, production, quantity demanded, and a host of other variables. Models such as these typically evolve over a period of years, require a high degree of teamwork, and provide great opportunity for creativity in applying economic theory and econometric analysis to real-world data. These models were created specifically for policy analysis, and were never designed to be used for forecasting.  There are major challenges in specifying equations that will accurately reflect rapid structural and technological changes occurring within the dynamics of global agriculture

Detailed ten-year baseline projections from both the USDA and FAPRI models are published annually.  Baseline projections are used as a benchmark from which to compare impacts of alternative domestic and international policies. Authors of the USDA and FAPRI models strongly caution against using the projections as forecasts, as indicated by the following quote from the USDA World Agricultural Outlook Board Baseline Projection Report:

> *A Note to Users of USDA Baseline Projections*
>
> *The scenario presented in this report is not a USDA forecast about the future. Instead, it is a conditional, long-run scenario about what would be expected to happen under the 1996 Farm Act and specific assumptions about external conditions."*

Despite these cautions, various commodity and agribusiness groups have frequently used the baseline projections as forecasts. One definition of a baseline projection is that it is a set of outcomes expected to result from one of many possible scenarios. The selected scenario is described by assumptions about exogenous variables such as population and income growth, exchange rates, technological change, weather, fixed agricultural policies and historical trends in production and consumption. Baseline projections are designed to calibrate the large-scale agricultural models rather than to make forecasts.

What are the risks of using baseline projections for purposes for which they were not designed? That question came to the forefront when the U.S. Army Corps of Engineers used the USDA projections as forecasts in their controversial evaluation of the costs and benefits of extending the locks and dams on the Upper Mississippi River from 600 to 1,200 feet. Agricultural commodities are, by far, the dominant products transported on the Upper Mississippi River. Therefore, the potential benefits of lock expansions depend heavily on the future volumes of U.S. grain and soybean exports. Consultants for the Corps of Engineers extrapolated one set of USDA 10-year baseline projections 40 years ahead. These extrapolated projections were used to project the volume of grain expected to move on the Mississippi River up to 50 years into the future.

Three major reviews of the Corps' projections found that the methodology used to forecast exports 50 years into the future was seriously flawed. These conclusions were based, in part, on the following:

- Corps projections failed to acknowledge the long-term down-trend in U.S. corn and wheat exports that had been in place since 1979-80, and

- in the six years since the forecasts were made, Corps projections were **4.34** billion bushels or **19** percent above cumulative actual U.S. exports of corn, wheat, and soybeans.

This article examines the forecasting track record of the USDA and FAPRI baseline projections, offers reasons why the models have had major short-comings in tracking reality, and proposes needed changes if the models are to be used for forecasting.

Figures 1 through 3 compare the last 13 annual ten-year base line projections from the FAPRI model with actual exports of corn, wheat, and soybeans. While U.S. corn exports have trended modestly downward since the 1979-80 marketing year, and U.S. wheat exports have trended sharply downward, the model has almost always projected increasing exports of both products. Performance was better but less than stellar for soybeans.

Figure 4 compares four USDA 10-year projections of gross Chinese corn imports with actual imports. Figures 5 through 7 show actual U.S. corn, wheat, and soybean exports and the last four years of USDA model 10-year projections. The track record from USDA's model is very similar to that of its FAPRI counterpart, except that there is less history over which the USDA model consistently failed to reflect reality.

By the criterion shown in table 1 for corn and wheat, a naïve model consisting of linear trend projections of exports from 1980 through the year prior to the forecast, excluding the high and low, would have out-performed the FAPRI corn and wheat projections as forecasts. The trend line projection utilizes the same set of information as the corresponding FAPRI baseline projections. For example, the 1990 trend line projection for corn exports is based on actual corn export data from 1980 through 1989, excluding the high and the low export years.

Average squared deviations from actual exports were used to estimate the “goodness of fit” of the FAPRI corm, wheat, and soybean projections for the years 1990-1999. The average squared deviations from actual exports were 31 percent higher for the FAPRI projections than from a naïve linear model for corn exports, and 387 percent higher for wheat exports. However, the deviations were only 19 percent as high as the naïve linear model for soybeans. Standard deviations were not calculated because the degrees of freedom with the 3000+ equation FAPRI model were unknown. The criterion for forecast accuracy used here is that the lower the sum of squared deviations, the “better” the projections fit the actual export data. By this standard, the naïve model performed better for corn and wheat, but the FAPRI model performed better than the naïve model for soybeans. Looking at individual years, the linear trend for grain exports over the period provided a better forecast of U.S. corn exports than the FAPRI projections for 1990, 1992, 1996, 1997,and 1998. For U.S. wheat exports, the linear trend projections provide a better forecast than the FAPRI baseline for eight out of the ten years. Perhaps even more troubling is that errors from the FAPRI and USDA models were not randomly distributed with a mean of zero, but have mainly been errors of overestimating corn and wheat exports. Table 2 shows the magnitude of which the FAPRI projections overestimated or underestimated actual corn, wheat, and soybean exports. Using all the projections for 1987-2000, the FAPRI model overestimated total corn and wheat exports by about 10 billion bushels.

For various reasons, both the USDA and FAPRI models have shown an upward bias in export projections. These models have quite consistently generated projections of increasing grain exports, despite a long history in which actual exports trended downward. It is not the intent of the authors to imply that models for long-range forecasting should be replaced by linear trend analysis, but to use the trend analysis as a gauge to illustrate deficiencies of using current policy analysis models for forecasting.

The USDA and FAPRI model projections, if used as forecasts, would have signaled agribusinesses to invest heavily to increase capacities of U.S. grain exporting facilities. But, in reality, the export-oriented part of the U.S. marketing system has struggled with excess capacity for two decades and has idled some facilities. Investments based on output from the models would have been costly to the industry.

*The reader should be cautioned that errors being discussed here are those that are present if the output is used as forecasts. We do not imply that the models are in error for the purposes for which they were created, namely to compare the economic impacts from alternative domestic and international policies.*

**Sources of model forecast errors**

We hypothesize several sources of the forecasting errors including the following:

***Technology***

A striking example of technological developments is the steady long-term gain in U.S. and foreign feed conversion efficiency as new developments in nutrition, veterinary medicine, genetics, animal husbandry, and other sciences are applied to livestock production. These technological developments are not adequately recognized in the FAPRI and USDA models, and may well contribute to the upward bias in U.S. export projections. Figure 8 shows world production of pork and poultry (excluding China) since 1964 and feeding of feed grains in these same countries. Combined pork and poultry production (the largest users of grain) increased by 318 percent over this period while total grain feeding increased by only 85 percent.

Failure to incorporate this dramatic increase in feed conversion efficiency would substantially overstate future growth in grain export demand. China was excluded from figure 8 since its grain and livestock production data are considered by some to be of questionable accuracy. However, when the Chinese data are included, the results are similar, with total world feed grain feeding increasing by 109 percent while combined pork and poultry production rose by 455 percent. Feed conversion efficiency in the U.S. shows a similar pattern, thus affecting long-range price trends and contributing to the long-term downward trend in real grain prices.

***Supply functions***

The models have consistently underestimated grain yields in some countries. Over the past several years, real and nominal grain prices have trended downward while actual land area in grain production has remained relatively constant in many countries and increased rapidly in others such as Argentina, Brazil, and Bolivia. Because of supply-function limitations, the models may project declining planted areas in countries that have actually increased plantings. In Brazil, for example, actual area planted to soybeans increased rapidly despite the lowest world soybean prices in nearly 30 years (in U.S. dollars). In contrast, recent FAPRI projections, shown in figure 9, have shown steady to only slightly increased area devoted to soybeans in Brazil.

Inadequate specification of variable costs may help explain this outcome. Economic theory suggests that, in perfectly competitive markets, a product will be produced as long as its price exceeds its marginal variable cost of production, and hence its average variable cost of production. For grains, as well as many other farm products, a large part of the short-run production cost consists of fixed costs including land, family labor, storage facilities, and fixed machinery costs. Existing models have been structured with supply functions in which lower prices reduce foreign supplies, with an implicit assumption that most of the production cost is variable. Variable costs also become very important in projecting future Chinese grain production and trade if agricultural subsidies in that country are reduced as it enters WTO.

Grain and soybean production costs—especially those for land, labor, and some other inputs—are lower in many developing countries than in the U.S. (McVey, Baumel, and Wisner). In several key developing countries, land has continued to be brought into production even in the face of declining world grain prices.

Currency exchange rates are another influence on foreign production that may not be adequately dealt with in the models. The U.S. dollar appreciated by 42 percent relative to competitors from April 1995 to September 2000 (Shane). As a result, while U.S. agricultural prices declined, local currency output prices in a number of countries have increased. This may help account for projections that show increased U.S. grain exports even as foreign grain supplies continue to increase and actual U.S. corn and wheat exports decline.

***Demand functions***

Demand function specification in baseline models may cause grain export projections to be overly optimistic. For example, some demand equations are specified as linear, or linear in logarithms. This means that rate of growth in the demand for food increases at a constant or increasing rate as income increases (Varian). In this scenario, consumers will not reach a food consumption saturation level without intervention from the modeler. With linear demand equations, the impacts of steady income growth are exacerbated by the fact income elasticities gravitate to 1.0 as incomes rise. Thus, the income elasticity of a linear demand equation for wheat with an initial value of 0.2 will steadily increase as income rises, accelerating the growth of wheat demand (Varian). However, logic suggests that the income elasticity of demand for grains and other farm products in individual countries can be expected to decline as consumer incomes rise. This is supported by observations about Japanese food consumption patterns from Keiji Ohga of the University of Tokyo, who states, "Japanese dietary patterns are in so called "overabundance" that there are increasingly growing concerns over excessive intake of fat or unbalanced diets… The change of eating habits associated with the change of lifestyle such as "skipped meals" is also a problem" (Ohga). Over short intervals (2 to 5 years), the upward bias from this source is less worrisome than for longer-term projections. Over several years, however, steady income growth combined with linear or constant elasticity demand equations will substantially overstate food demands. As population grows, impacts of these income elasticity assumptions are magnified.

The populations of Europe, Japan, and the United States are aging, and that will reduce future food demand for that segment of the global population. China has a strict population control program designed to cause its population to reach a peak by 2030, and to decline thereafter. This policy will also bring increased aging of the Chinese population, eventually reducing its per capita and total food demand.

Over the last several decades, consumers in the U.S. and foreign countries have shifted a higher percentage of their diets to poultry meat and away from other meats. This demand shift increase the aggregate feed conversion efficiency at national and global levels, since production of poultry meat requires fewer pounds of feed per pound of product than grain-fed beef or pork. Other changes in compositions of consumer diets that affect feed demand include the relative share of cereals consumed directly as human food versus the volume of animal-based protein foods consumed. In animal-based protein foods, the consumption shares of grain and grass-fed beef and mutton, pork, chicken, turkey meat, geese, ducks, fish, and other seafood, greatly affect the amount of grain used in individual countries, and hence their net grain export/import position. Each of these products has a different feed requirement per pound of human protein food produced, with changes over time affecting grain import demand or exportable supply. While these developments may not be a major concern when evaluating impacts of alternative U.S. agricultural policies, they are quite important for long-range export forecasts. Failure to adequately incorporate these long-run trends would contribute to over-estimation of U.S. and world grain exports.

***Environmental constraints***

Environmental constraints on long-term trends in livestock and poultry production are most noticeable in East Asia and Western Europe. Consider Taiwan's livestock situation in 1997. Taiwan is a small island nation with extremely dense livestock, poultry, and human population densities. It also has a mountainous interior unsuitable for residential use or livestock production, further increasing the human and animal population densities on the useable land. Taiwan's human population density per square mile is about 40 times as high as in Iowa, and in early 1997 it had a swine population density 1.62 times as large as that in Iowa without adjustment for its mountainous interior. Its poultry production density was nearly 15 times as large as in Iowa. In 1997, Taiwan experienced a foot and mouth disease epidemic that caused it to reduce its aggregate swine inventory by about one-third in less than a year. The disease problem was due partly to environmental problems stemming from a limited land base and extremely dense human, livestock, and poultry populations per unit of land.

During much of the 1990s, South Korea was the second largest export market for U.S. corn. It also experienced foot and mouth disease in 2000, although its problems were less severe than in Taiwan. Korea, Japan, and Taiwan face severe limitations from dense human and animal populations, a limited land base, and major challenges in disposing of animal wastes (Ohga). In 2001, a foot and mouth disease epidemic struck Western Europe, where human, livestock and poultry population densities also are high. Density of livestock production and lack of land for disposal of animal waste create major challenges in managing animal health and controlling livestock diseases in all of these nations.

U.S. Army Corps of Engineers projections, based on the USDA baseline projections, show large increases in U.S. grain and soybean exports to these densely populated nations. If grain export projections from these large-scale models were to materialize, livestock and poultry production densities would greatly increase, multiplying the environmental and disease-control challenges several fold. Environmental challenges such as these have caused a number of major grain importing countries to shift from importing more feed grains to importing a higher percentage of their human protein needs as meat. The changing economics of importing grain for livestock and poultry production versus importing meat can have a significant effect over time on U.S. and global grain trade. Designers of large-scale models in recent years have made some effort to recognize the environmentally led shifts from grain imports to meat product imports in their models, but the shifts may not yet be fully incorporated.

***Foreign government policies***

U.S. policy makers historically have placed high priority on economic efficiency and minimization of food costs to American consumers. A number of foreign governments, however, have objective functions giving substantial weight to non-economic goals. These goals include food security, maintenance of economically viable rural communities, and minimization of the risk of becoming heavily dependent on a foreign supplier that might be tempted to reduce or shut off grain exports to achieve its political objectives. Countries where these considerations are important include Japan, China, some Middle East nations, and the European Union.

Some major agricultural models do not incorporate potential long-term structural changes in former centrally planned nations that may have large impacts on global agricultural trade over a period of several decades. University faculty who have worked in these nations believe that with a stable legal structure and assurance that investors would capture potential investment profits, their future grain production and export potential could be substantial. Despite limitations in the political stability and infrastructures, some East European and former Soviet Republics have become modest grain exporters.

**Constant agricultural policy assumption**

Baseline projections are benchmarks against which impacts of policy changes can be compared. Therefore***, by necessity***, baseline projections do not incorporate future government policy changes. The importance of this omission can be understood clearly by considering the 1995 USDA and FAPRI baseline projections, which did not incorporate major farm policy changes resulting from the 1996 “Freedom to Farm” legislation implemented the next year. The 1996 policy changes produced major impacts on U.S. grain production, world grain and oilseed prices, and U.S. stocks and export levels.

Random shocks from abrupt changes in currency exchange rates and unanticipated decreases in foreign economic activity always will be potential developments causing U.S. exports to deviate from projections. Changes stemming from these sources probably can never be fully anticipated in long-term projections. However, increased funding for improvements in general economic forecasting models might reduce the magnitude of these sources of agricultural forecast errors.

**Historical perspective and lessons for long range projections**

Previous work in long-term projections may provide a useful perspective for the development of long-term forecasting models. Malthus is usually credited as being the first economist to develop a long-range food supply and demand model (Roll). Studying the trend in world population in the 18th century, Malthus concluded that, over time, food demand, driven by an expanding world population, would increase more rapidly than the food supply. This expanding population would lead to widespread starvation and very high food prices. His reasoning was that food production would reach an upper limit because of the finite quantity of land available for agricultural uses. In essence, his supply model was acreage times current yield. Malthus painted a bleak picture of the future for consumers and the world in general, but a very optimistic one for landowners and farmers. Two centuries later, his dismal projections stand in stark contrast to decades of rapidly increasing yields, declining real agricultural and food prices, and U.S. consumers spending a record low percentage of their incomes on food. Malthus' work was faulty because of his failure to recognize the role of technological change on the supply side. Some of his conclusions (rising grain prices and land values) have been implied in projections from USDA and FAPRI models, a conclusion counter to long-run historical trends.

Lester Brown, in his 1995 book, Who Will Feed China?, also painted a bleak modern-day picture for the world's consumers, but an optimistic one for landowners and agricultural producers. His book, published in a year when China experienced serious crop problems and was a large importer of corn and wheat, portrayed a scenario in which China would consume most of the world's exportable supply of grains and oilseeds beginning in the late 1990s or early 21st century. Little food would be left to meet the needs of other importing countries. The Brown analysis predicted a rapidly growing export demand for U.S. grains, and high prices for crops worldwide. Brown's demand model incorporated population plus income growth. His supply model was acreage times yield, with declining total acreage as industrial and other urban uses absorbed additional cropland. The Brown model may have been a reason for the nearly vertical USDA China import projections shown in figure 4. Brown's projection that China would become a huge permanent importer of grain has not materialized.

These works are a reminder that production forecasts, based on technology and economic relationships that existed over the past decades, will undoubtedly be subject to errors. These errors will generally be largest for developing countries where grain and animal production technologies are changing rapidly, and will tend to understate foreign production as well as gains in feed conversion efficiency.

**Needed changes to reducing forecast errors**

If large-scale models are modified to produce both policy analysis and acceptable long-term forecasts, substantially increased financial support for their development and maintenance will be required. Additional research is needed to develop grain supply functions that incorporate more realistic variable costs for foreign grain producing countries as well as environmental constraints for selected Asian and European livestock producing countries. Foreign supply models also require more detailed yield and technology-change forecasts, and production costs for competing crops. An example supporting this need comes from China, where the area in corn production has trended upward for two decades as rising wheat and rice yields allowed shifts of land from these crops into corn despite a slightly declining total agricultural land base. Spatial economic models reflecting transportation cost differentials from various grain exporting nations to final destinations also might provide more accurate estimates of export volumes originating from various countries including the U.S.

Technology advisory groups may be needed to provide the researchers with information to build technology into their models. Membership of these groups should consist of persons with no vested financial interests in the outcome of the forecasts. These groups logically should include:

- livestock production and feed conversion technology,
- crop production technology, with appropriate adjustments for slow acceptance of genetically modified crops in some countries,
- grain handling and transportation technology, and
- environmental quality technology.

USDA and FAPRI enlist the assistance of industry experts to address issues related to growth rates in crop yields and technology. However, many of these experts are representatives of farm and trade organizations. Given that the goals of many trade organizations are to increase the output sales of their members, they often have a financial or political stake in the results of the model and tend to prefer optimistic export forecasts. Regardless of the actual forecasting method selected, an independent panel—or a set of panels—of multidisciplinary experts with little or no financial or political stake in the outcomes should be formed to provide in-depth information on several areas, the most important of which is technological change.

An annual review of the previous forecasting track record and in-depth comparisons of previous forecasts with long-run trends is needed to alert researchers of the quality of their model outputs. Evaluations of forecasting accuracy should provide insights into areas where the model's performance is inadequate, and should help identify sources of forecast errors.

Consideration might also be given to the use of forecasting techniques such as arima models, exponential smoothing for trend analysis, and procedures that utilize information from past forecast errors to improve future forecasts

**Conclusions**

Baseline projections from the two major U.S. large-scale agricultural policy analysis models, when considered to be forecasts, have produced historically large non-randomly distributed errors over the past 15 years. For wheat and corn exports, the models have not performed any better than a naïve linear trend analyses. Had output of these models been used for capital investment decisions in the grain export sector, the resulting investments would have produced large financial losses. Forecast errors stem from a number of sources requiring substantial increases in funding to revise the models if they are to be used for forecasting. Sources of forecasting error include rapid structural changes in global agriculture, inadequate projections of technological change, limitations in supply functions, restrictive assumptions about income elasticity of demand, and failure to adequately utilize information from past forecasting errors. Substantial funding will be required to convert these policy oriented models into reliable forecasting models.

**Acknowledgements**

Financial support for this work came from the Institute for Agricultural Trade and Policy, Minneapolis, Minnesota.

## Endnotes

[1] Food and Agricultural Policy Research Institute. "*Rainbow Book, A Summary of the November, 1999, FAPRI Baseline*," Center for Agriculture and Rural Development, Iowa State University, Ames, November 1999, Iowa, 50011; USDA, WAOB, *USDA Agricultural Baseline Projections to 2009*, Washington, D.C., February 2000.

[2] http://usda.mannlib.cornell.edu/data-sets/baseline/2001/note.txt.

[3] http://www.econ.iastate.edu/faculty/baumel/EvaluationoftheU.S.pdf.

[4] USDA, ERS, PS & D View: http://www.ers.usda.gov/data/psd/feature.htm.

[5] Personal communication with Lynn Lutgen, University of Nebraska, Lincoln and Phillip Hufferd, Iowa State University. USDA PS & D view, op.cit.

[6] Malthus is credited as the stimulus of the description of economics as the "dismal science."

[7] USDA PS & D View, *op. cit.*

## References


Brown, Lester Russell, *Who Will Feed China?*, W.W. Norton & Co., 1995 (NY).

McVey, Marty J., C. Phillip Baumel, and Robert N. Wisner, "U.S. Upgrade Unlikely to Reduce Competition From Brazil," *Feedstuffs*, Vol. 72(4), September 25, 2000.

Ohga, Keiji, "Pacific Food Outlook 2001-2002", paper presented at the Pacific Economic Cooperation Council, Tokyo, Japan, July 7, 2001.

Roll, Eric, *A History of Economic Thought*, 4th edition, Prentice Hall, Inc. Englewood Cliff, NJ, February 1961.

Shane, Mathew D. "Exchange Rate Indexes and U.S. Ag Trade," *Agricultural Outlook*, January-February 2001, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

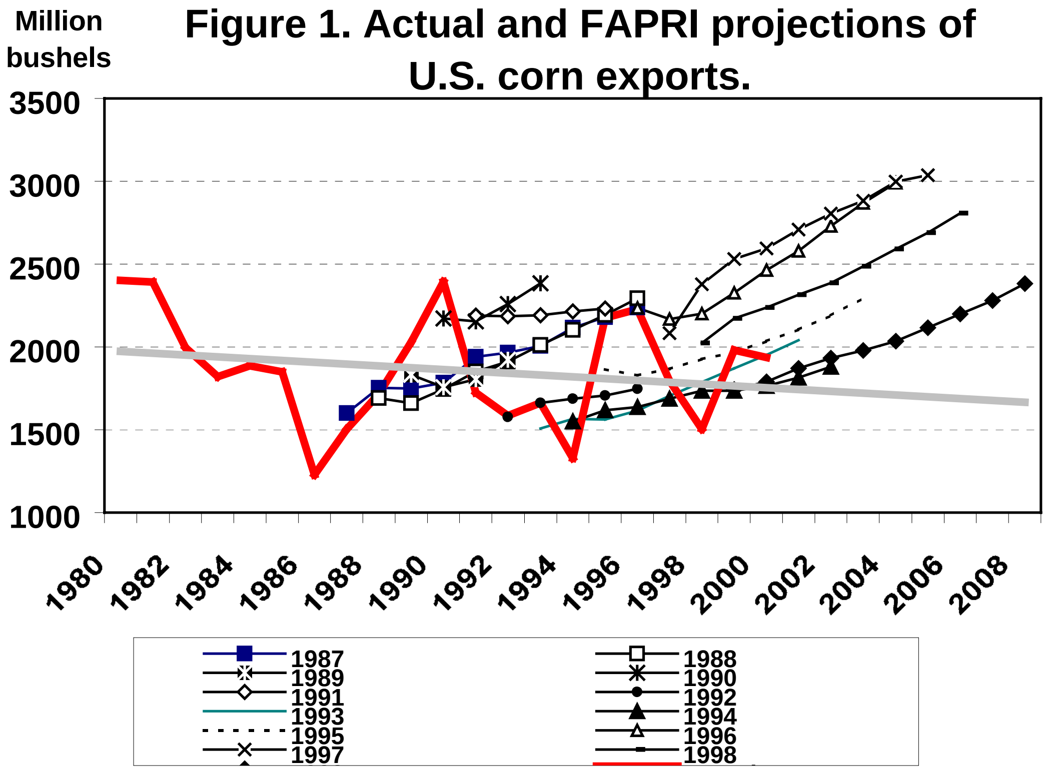
Varian, Hal R., *Microeconomic Analysis,* Third edition, W.W. Norton & Company, New York, 1992.

Table 1. Comparison of "goodness of fit" as measured by sum of squares deviations from actual exports, for the linear trend and FAPRI baseline projections for U.S. grain and soybean exports, 1990-1999.

| | Corn | | Wheat | | Soybeans | |
|---|---|---|---|---|---|---|
| Year | Linear | FAPRI | Linear | FAPRI | Linear | FAPRI |
| 1990 | 605,289 | 1,210,511 | 76,167 | 304,828 | 36,291 | 18,859 |
| 1991 | 496,724 | 1,643,194 | 56,883 | 182,571 | 89,886 | 45,983 |
| 1992 | 461,247 | 349,830 | 59,118 | 196,955 | 236,579 | 49,329 |
| 1993 | 1,073,400 | 932,029 | 60,275 | 585,671 | 727,959 | 63,792 |
| 1994 | 1,167,676 | 865,307 | 47,254 | 335,690 | 458,592 | 96,112 |
| 1995 | 1,663,473 | 450,211 | 49,744 | 276,971 | 522,069 | 95,280 |
| 1996 | 588,210 | 1,022,464 | 47,206 | 155,869 | 286,222 | 33,132 |
| 1997 | 151,683 | 1,582,718 | 25,504 | 66,738 | 125,582 | 13,551 |
| 1998 | 151,693 | 396,443 | 9,655 | 9,145 | 78,851 | 45,090 |
| 1999 | 130,774 | 77,600 | 2,413 | 36 | 43,532 | 22,564 |
| Total | 649,017 | 853,031 | 43,422 | 211,477 | 260,556 | 48,369 |

Table 2. FAPRI export forecast errors for corn, wheat, and soybeans in millions of bushels over and under actual exports, 1987-2000.

| | Corn | Wheat | Soybeans |
|---|---|---|---|
| Mil. Bushels Overestimated | 18,174 | 12,160 | 3,465 |
| Mil. Bushels Underestimated | 8,324 | 365 | 3,830 |
| Net Overestimated, Mil. Bu. | 9,850 | 10,202 | -365 |
| Number of Observations | 79 | 79 | 79 |


Million
bushels
Figure 1. Actual and FAPRI projections of
U.S. corn exports.
3500
3000
2500
2000
1500
1000
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998

## Figure 2. Actual and FAPRI projections of U.S. wheat exports.

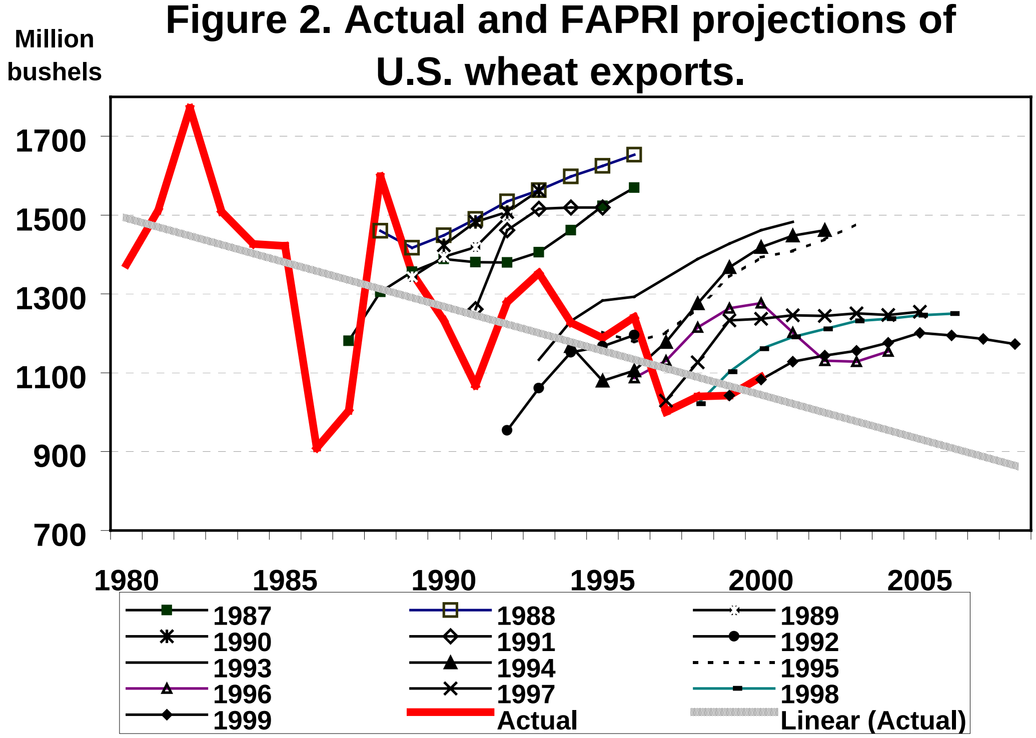


**Figure 3. Actual and FAPRI projections of U.S. soybean exports.**

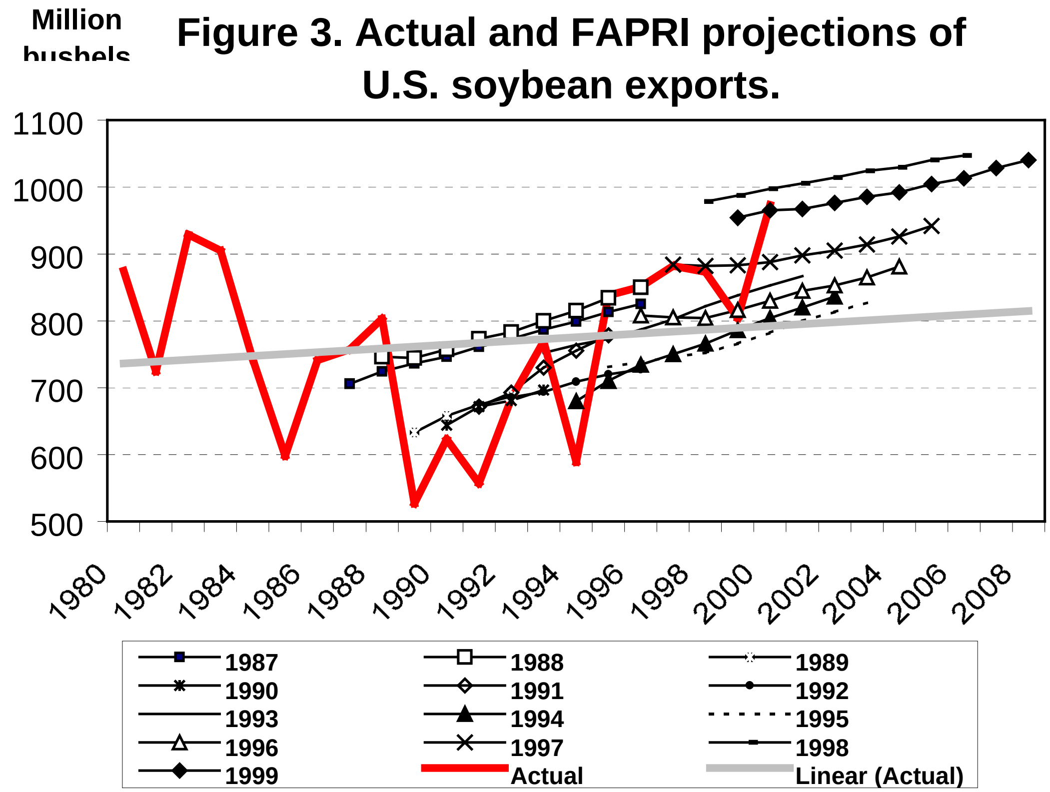
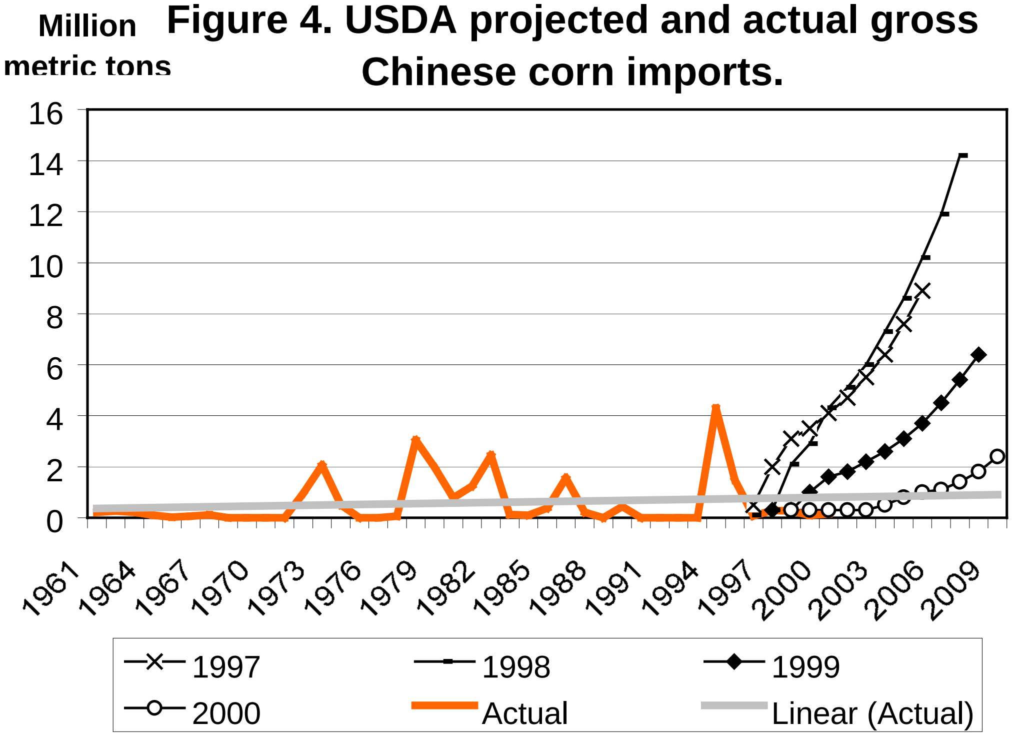
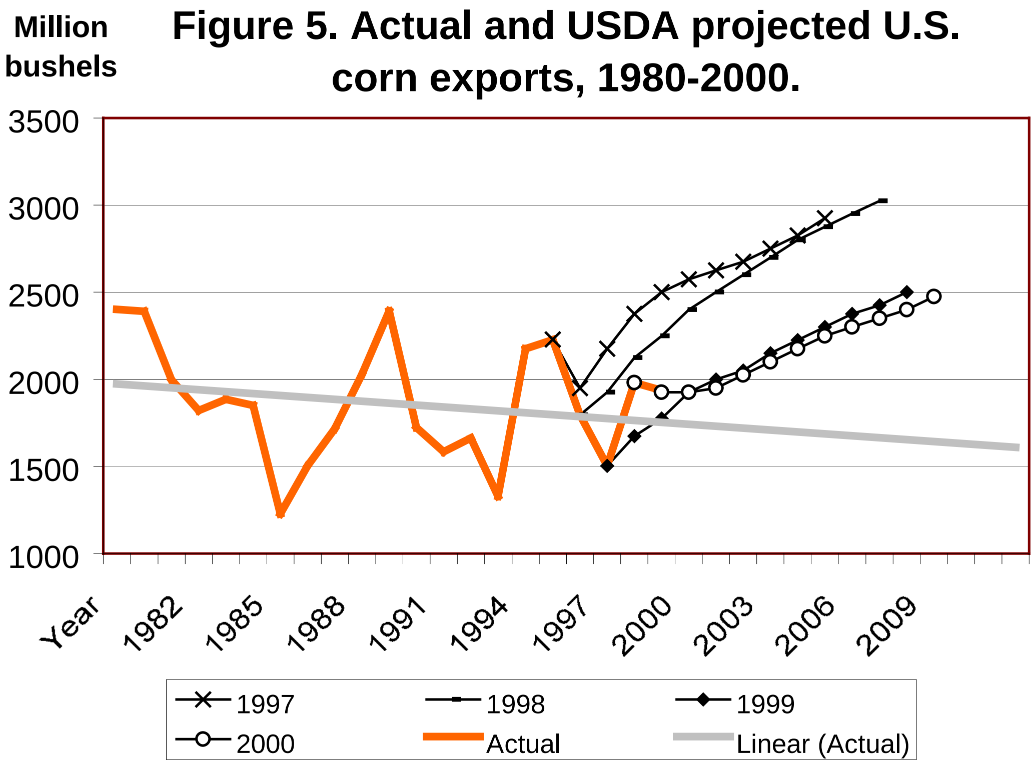
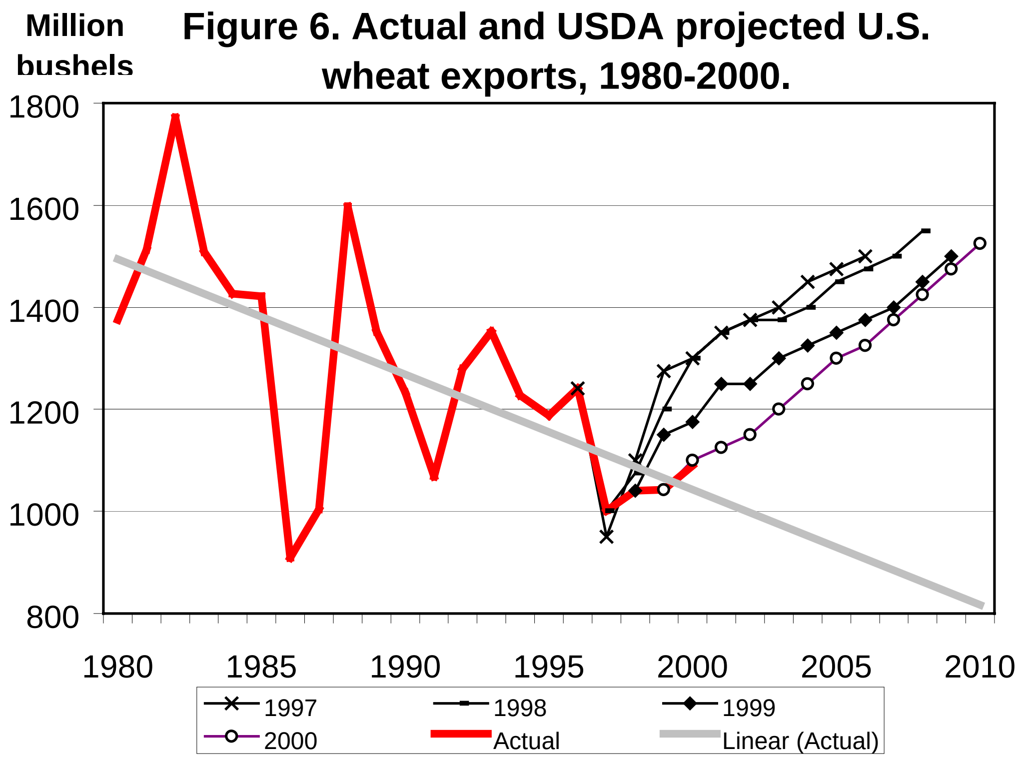


**Figure 4. USDA projected and actual gross Chinese corn imports.**




Million bushels
Figure 5. Actual and USDA projected U.S. corn exports, 1980-2000.
3500
3000
2500
2000
1500
1000
Year
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
1997
1998
1999
2000
Actual
Linear (Actual)



Million bushels
Figure 6. Actual and USDA projected U.S. wheat exports, 1980-2000.
1800
1600
1400
1200
1000
800
1980
1985
1990
1995
2000
2005
2010
1997
1998
1999
2000
Actual
Linear (Actual)

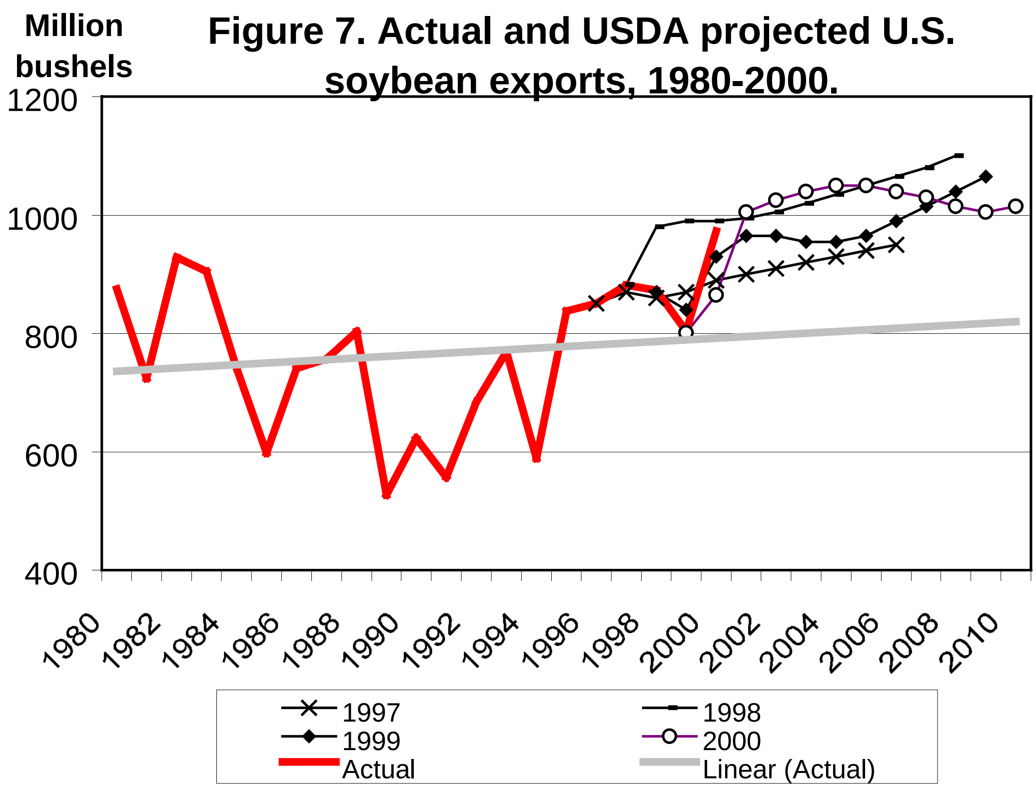
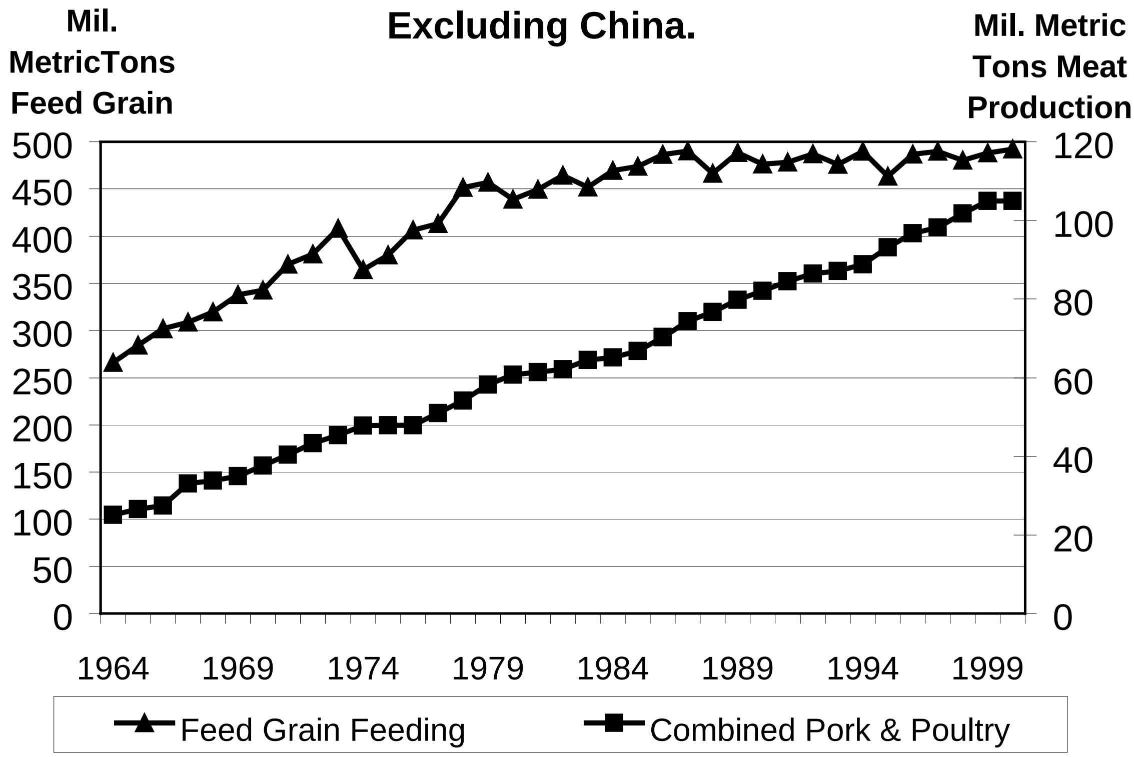
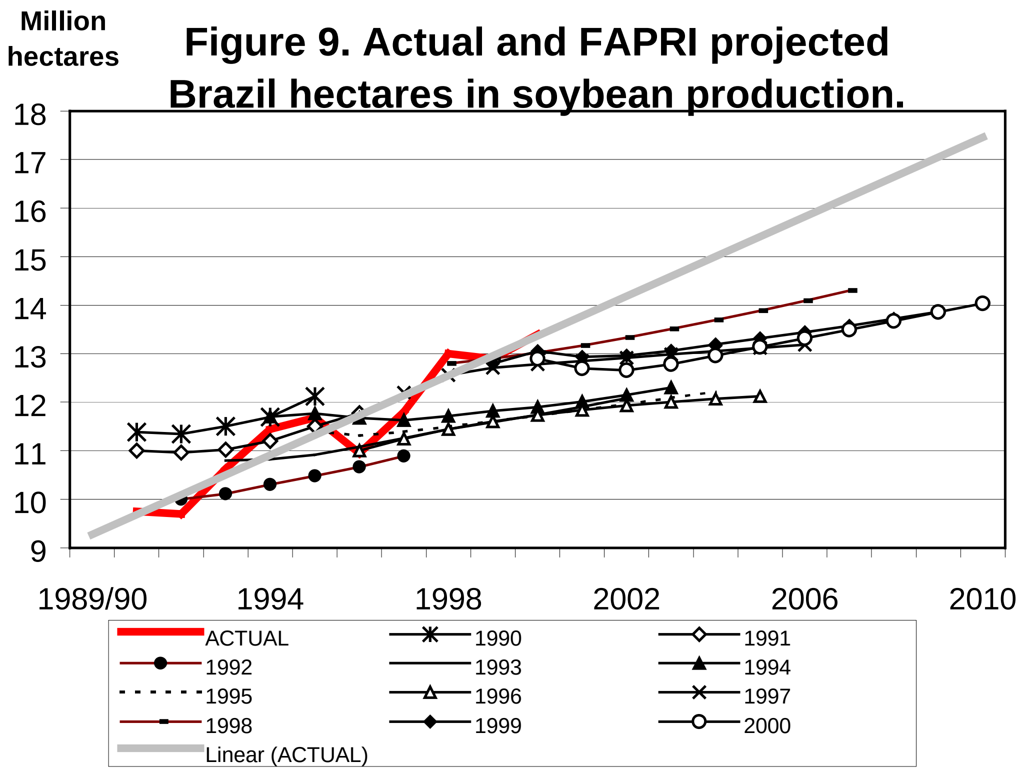

Million bushels
Figure 7. Actual and USDA projected U.S. soybean exports, 1980-2000.
1200
1000
800
600
400
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
1997
1998
1999
2000
Actual
Linear (Actual)

**Figure 8. World Combined Pork and Poultry Consumption & Feed Grain Feeding, 1964-2000, Excluding China.**




**Source: USDA, ERS PS&D Data Base**


Million hectares
Figure 9. Actual and FAPRI projected Brazil hectares in soybean production.
18
17
16
15
14
13
12
11
10
9
1989/90
1994
1998
2002
2006
2010
ACTUAL
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Linear (ACTUAL)