AN ANALYSIS OF EXCESS CAPACITY IN UNITED STATES CROP PRODUCTION

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TABLE OF CONTENTS

Chapter Page

Chapter Page

CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

PROBLEM STATEMENT

Excess capacity has plagued U.S. agriculture for several decades. Sometimes viewed as inefficiency or under-utilized resources in agriculture, excess capacity is defined in this paper as the ability to produce in excess of the quantity demanded. Several factors have been identified as the cause of this perpetual epidemic in agriculture, including immobile resources in agriculture, increases in supply-inducing technologies, and government farm programs (Knutsen et al.). As a result, agriculture is plagued by depressed prices for farm outputs and low rates of returns to the factors of production.

Domestic agriculture is one of few industries that closely fit the model of a perfectly competitive industry. Under these conditions, equilibrium or market-clearing price is determined where the supply curve and demand curve intersect or where buyers are willing to purchase a good for a price at which producers are willing to sell. Both buyers and sellers remain content as long as supply and demand remain fairly stable over time and few exogenous or unforeseen events occur. However, observation of agricultural markets over the last few decades reveals that this type of output and price stability occurs infrequently. Weather and government policies cause the supply curve to fluctuate, while international trade policies and political actions in other countries cause shifts and changes in the demand curve. In addition, the inelastic nature of supply and demand creates price instability for agricultural commodities. Changes in supply and demand frequently create large variations in food availability from food shortages to food surpluses.

A main role for government in agriculture has been to support price in order to stabilize agricultural markets and to maintain excess capacity for the lean years. A key feature of interest to policy makers is designing policies that will maintain some excess capacity in order to lessen the socially undesirable problems in agriculture. Since government involvement in agriculture in the 1930s, farm policies have generally taken three distinct forms. These include land retirement, commodity stocks, and price supports. Each policy bears a government cost and is ultimately paid by society's tax dollars.

Primarily, excess capacity is managed through land-retirement and stock policy. For the most part, price supports are used to stabilize farm income and prices. Both annual and long-term land retirement policies have been used to divert crop production, although a more recent focus of such policies is to preserve natural resources and reduce agricultural externalities. Government stocks provide a readily accessible reserve for the lean times. In addition, since the 1950s, the government has sold under-priced commodities on the world market for humanitarian relief to developing countries. Domestic food programs have also been used to manage excess capacity.

The focus of American farm policy is to maintain excess capacity at acceptable levels. The price at which excess capacity is maintained determines whether or not an outcome is acceptable. Measurement of excess capacity provides a basis for determining an acceptable level. In this study, the magnitude of excess capacity is determined, and a short term forecast of excess capacity is constructed. Previous methods for measuring excess capacity are based on various assumptions regarding supply and demand for agricultural products.

Acceptability is also defined relative to the market conditions occurring from one year to the next. This implies that excess capacity changes over time, but it does not guarantee that an acceptable level is always, or ever, attained. For the most part, the question of defining an acceptable level of excess capacity is subjective and depends on the assumptions made by policy analysts and applied academic researchers.

Who should pay the costs and who should be awarded the benefits of maintaining excess capacity? In some industries, such as utility companies and hospitals, the costs of maintaining excess capacity are passed on to its customers.

In agriculture, the cost of maintaining excess capacity is often a direct government cost and its magnitude depends on the policy tool employed. But the costs are passed on to consumers and producers. The benefits are not easily visible, and, depending on current market conditions, may accrue to producers or consumers.

In the early 1980s, surplus production and stocks from the employment of additional resources in agriculture from the 1970s and weak demand created high levels of excess capacity. Farm prices and incomes dropped from those attained in the 1970s and consumer prices stabilized. As a result, consumers benefitted via depressed prices. On the other hand, after a mild drought in 1988, excess capacity declined. Crop production dropped in this period, leading to the drawdown of stocks and the reduction in diverted acres. Producers benefitted from the higher prices, but the benefits of still having some amount of excess capacity to draw from were received by consumers, because without it prices would have been higher. Over time the benefactors and the beneficiaries of holding excess capacity may be offsetting, but this can only be hypothesized. Of primary importance is that excess capacity is needed in agriculture to alleviate the perpetual problems in a very competitive industry. The role of government policies to maintain excess capacity is also crucial to stabilize market conditions, reduce production risks, and to slow the adjustment of resources in agriculture.

Objectives and Organization of the Dissertation

The objectives of this dissertation are to determine the magnitude of excess capacity for U.S. crop production over the period 1950-1990, and to predict excess capacity requirements for the period 1992 to 1996. The following section of this chapter reviews relevant literature relating to capacity and excess capacity measurement in agriculture and industry. The next chapter describes the conceptual framework of excess capacity in U.S. crop production. Chapter 3 develops a consistent method of measuring excess capacity in U.S. food and feed grains and cotton. Theoretical equations of aggregate demand and aggregate potential supply are developed. Using equations of aggregate potential supply and aggregate demand for seven commodities, excess capacity is estimated over the period 1950 to 1990 in chapter 4. Data requirements and estimation results are also provided. The remaining section of this dissertation provides a short term forecast of excess capacity under alternative assumptions about future conditions. Finally, a brief summary and the conclusions of this research are presented.

Review of Excess Capacity Studies

The importance of excess capacity in U.S. crop production is demonstrated by previous studies. In this chapter, several definitions and measurements of excess capacity are identified and reviewed to provide a foundation for the development of this research. Methods of defining and measuring capacity and excess capacity from both agricultural and nonagricultural literature are reviewed and key distinctions are made between capacity measurements in the two sectors. Excess capacity has been a term used by previous researchers to define, in a broad sense, supply in excess of demand at an acceptable price (Quance and Tweeten, Dvoskin).

Defining Excess Capacity

The term *excess capacity* is not of recent origin and several researchers have avoided explicit use of the term in favor of *excess production* or *surplus capacity* (Brandow). These terms are used synonymously in the literature. *Production capacity* or *reserve capacity*, on the other hand, refers to potential production if unused or underutilized resources are fully employed in production. Still other researchers have implied excess capacity, although not explicitly stated (Heady and Mayer).

From a historical perspective, *production capacity* has generally been studied in periods of tight supplies and strong demand, while *excess capacity* has been studied in times of commodity surpluses and weak demand. For example, in the early 1970s, the production capacity of U.S. agriculture was extensively studied when questions arose about the ability of the agricultural sector to meet future domestic and foreign demand for food and feed products (Brandow; Heady and Mayer;

Cotner et.al.). In contrast, concerns in the early 1980s were reversed from that of inadequate supplies to excessive supplies of agricultural products, as demand for U.S. agricultural products declined, commodity surpluses increased and consumer prices for food stabilized (Dvoskin).

Two distinctly different interpretations of excess capacity prevail in the literature. One view that has gained acceptance over the past three decades was put forth by Tyner and Tweeten in a pioneering 1964 AJAE article titled "Excess Capacity in U.S. Agriculture." In this article, they view excess capacity as the cumulative value of government diversions for all major farm commodities. In other words, this implies an overcommitment of resources to agriculture and an oversized agricultural plant due solely to government involvement in agricultural markets.

In a contrasting view, Brandow (1972) interprets excess capacity in agriculture as a necessary reserve capacity for lean years. Brandow defines the magnitude of excess supply of agricultural outputs as the difference between actual supply and demand, less a change in inventories and exports for a given period of time.

The view held by Tyner and Tweeten implies that excess capacity is an indication of the level of government involvement in agriculture, while Brandow's interpretation takes a more historical perspective, implying that excess capacity is production beyond the current necessary market-clearing level.

Both interpretations from the agricultural economics literature have merit. Within a conceptual framework, excess capacity has been defined as the difference between aggregate demand and potential supply at an acceptable price level (Quance and Tweeten). In figure 1, this definition is illustrated using Tyner and Tweeten's representations of excess capacity.

Actual aggregate supply and demand are respectively, S_o and D_o, intersecting at market-clearing price p^e and quantity q^e. At this point, there exists no surplus production. However, assuming that the resources are readily available to produce q^*, maximum supply reserves of $q^* - q^e$ are available as potential production. Such a case exists when land representing output, $q^* - q^e$, is idled through government programs, fallowed or failed, and prices are extraordinarily high.

Tweeten uses the terms: *prevailing* prices, *socially acceptable* prices, and *politically acceptable* prices to represent government supported prices, and measures excess capacity at a supported price level p^s illustrated in figure 1 (Tyner and Tweeten; Quance and Tweeten; Tweeten). At a supported price (p^s), production (q_o^s) is greater than what would occur in the absence of government involvement. If consumer prices are held at p^s and producer prices are held at p^s, the difference between q_o^s and q^e is government-held stocks or excess supply.

If idled production resources induced by government

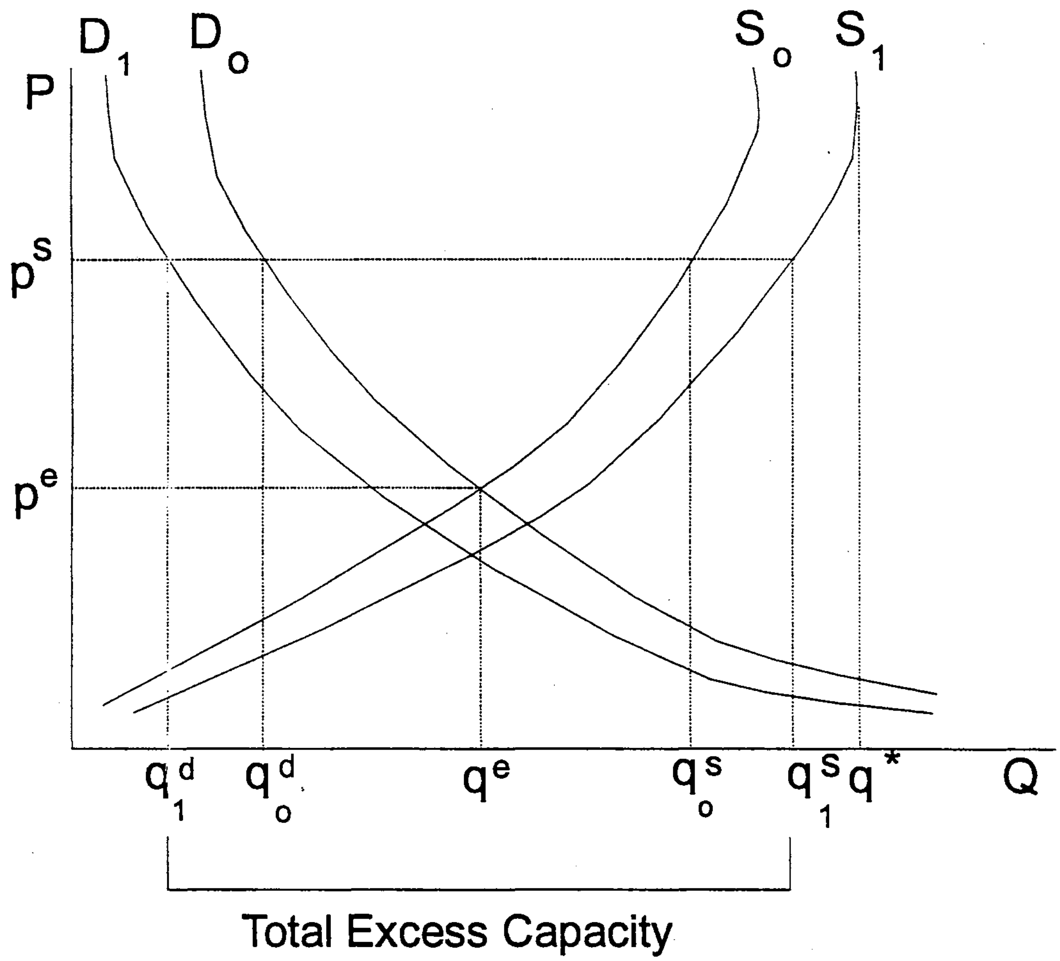

Figure 1. Tweeten's Representation of Excess Capacity in U.S. Agriculture Using Aggregate Supply and Demand Curves and Supported Prices

diversion programs are brought into production, output could expand to S_1. At p^s, the potential output, $q_1{}^s$, is greater than actual output $q_o{}^s$. Line D_o represents aggregate domestic and foreign demand, where foreign demand is the sum of commercial and noncommercial exports. By eliminating noncommercial exports, commercial demand is denoted as D_1. Commercial demand would absorb output $q_1{}^d$ at price p^s. $q_o{}^d$ less $q_1{}^d$ is demand expansion, and the difference between $q_o{}^s$ and $q_1{}^s$ is defined as production diversions.

Thus, in Tweeten's study, excess capacity consists of three components: demand expansion, excess supply and production diversions. Illustrated in figure 1, the difference between commercial output demanded, $q_1{}^d$, and potential output, $q_1{}^s$, is total excess capacity.

Capacity and Excess Capacity Measurement

Various methods for measuring excess capacity in agriculture have been adopted by past researchers. One reason for the difference in methods is that excess capacity is simply a phenomenon that economists attempt to measure, but for which little solid data is available (Brandow). There are far fewer studies that actually attempt to measure excess capacity than there are that define excess capacity. The focus of this section is on agricultural measures of capacity and excess capacity employed over the past four decades. Nonagricultural measures will also be reviewed in this chapter.

Agricultural Measures

Previous studies have been indecisive on how excess capacity should be measured and inconsistent across studies. In an early study by Tyner and Tweeten (1964), excess capacity was measured as the sum of all diverted acres by Government programs. This procedure estimated a value of aggregate annual excess capacity over the period 1955 to 1962 in terms of production diverted from commercial markets by government storage activities (CCC stocks), land withdrawal programs, and subsidized exports (e.g. P.L.480). Results varied significantly, depending on the value attached to subsidized exports. Excess production as a percentage of production plus land diversions varied from 14.5 to 46.3 percent for wheat, 6 to 21.5 percent for feed grains, and 11.8 to 56.0 percent for cotton. Farm price changes necessary to eliminate excess capacity were estimated to range from 23 to 25 percent lower. However, the estimate of the price elasticity of aggregate demand adopted was estimated with government subsidized programs in place.

A decade later, Quance and Tweeten (1972) estimated excess capacity over the period 1962 to 1969, using the same measure as Tyner and Tweeten. Total excess capacity, expressed as a percentage of potential farm output, ranged from 4.54 to 8.19 percent over the period. Projections of agricultural adjustments necessary to return to a free market by 1980 were made based on recursive aggregate demand and supply equations, and various output demand and supply elasticities, under three policy alternatives. Free market conditions imply no excess capacity in this study.

Along these lines, several early studies obtained estimates of excess capacity indirectly from studies that focused principally on the implications of free markets in agriculture (Shepherd et.al.; Yeh et al.; Heady and Mayer). Excess capacity was measured as an indication of government involvement in agricultural markets.

Brandow (1974) predicted agriculture's capacity outcomes under various scenarios. Excess capacity for all major U.S. crops was determined based on certain assumptions regarding supply and demand growth and historical (pre-1972) price relationships. Excess capacity output was calculated as the difference between production and the sum of domestic and export demand. Thus, excess capacity consisted of only commodity stocks. Production was the product of projected harvested acres and crop yields. Each of these aggregates were projected for 1985 across all commodities. Results from this study indicated 9 million tons of excess capacity for feed grains, 344 million bushels for wheat, and 20 million tons for all grains.

Heady and Mayer (1967) defined excess capacity as the amount of cropland not needed to meet the demand requirements for agricultural products, measured as idled cropland acreage. Under the assumption of constant population and income growth, and increasing productivity and export demand growth, excess capacity was projected to continue in 1980. Productivity gains in crop yields offset total demand growth, resulting in less acreage needed in production. Consequently, idled cropland acreage was estimated for wheat, cotton, feed grains, and soybeans by region and on a national level using a multi-regional linear programming model. Four alternative farm policy models which incorporate various degrees of a free market were analyzed. Projected national annual excess capacity in 1980 ranged from 0.0 to 78.4 million acres. The highest level corresponds to a free market policy with all acreage restrictions removed, except for cotton quotas, and exports set at projected trend levels. Excess capacity was eliminated under a free market policy with all acreage restrictions removed and exports set at their maximum projected 1980 levels. That is, production less projected domestic demand equals exports. Specific results of seven policy options are presented by production regions in Appendix A.

Several studies in the 1970s focused on the production capacity of U.S. agriculture when questions arose about the ability of the agricultural sector to meet future domestic and especially foreign demand for food and feed products (Cotner, et al.; Frey and Otte; ERS). Nearly all of the studies imply use of the definition of excess capacity discussed by Brandow. That is, excess capacity in agriculture is the "necessary" reserved capacity for lean years.

In an ERS study (1973), the capacity of American agriculture was projected to expand to 345 million harvested acres by 1980 and 350 million acres by 1985 or an increase of 9 percent from 1973 harvested cropland levels. Capacity calculations were based on the 1967 Conservation Needs Inventory. Most of the increase, conditioned on favorable prices, unrestricted land use, adequate input supplies and normal growing conditions, would come from returning government-diverted acres and former cropland now in pasture to crop production. In addition, production could be expanded by growth in crop yields, assumed to persist at historical rates in the 1960s, and by growth in irrigated acreage. By 1985, corn production capacity was projected to expand to 9.1 billion bushels, soybeans 2.3 billion bushels, feed grains 315 million tons, wheat 2.3 billion bushels, and cotton 16.4 million bales. Actual land use and cropland use changes for selected years are outlined in Appendix A (Table 37 and Table 38).

Projected production capacity less actual production can be a crude measure of excess capacity. That is, based on the above assumptions regarding future conditions, projected 1980 and 1985 production of corn, soybeans, wheat, feed grains and cotton, less production levels actually experienced in these years, should be a crude measure of excess capacity existing in these crops. Results are presented in table 1. Conditioned on the above assumptions, excess capacity declines between 1980 and 1985 from 1.5 to 0.2 billion bushels for corn, 65 to 13 million tons for feed grains, 0.3 to 0.2 billion bushels for soybeans, 4.0 to 3.0 million bales for

TABLE 1

EXCESS CAPACTIY CALCULATIONS BASED ON CAPACITY ESTIMATES FROM ERS STUDY.[a]

Crop	Units	Proj. Year	Est. Production Capacity	Actual Production	Excess Capacity
Corn		1980	8.10	6.64	1.5
	(bil. bu.)	1985	9.10	8.86	0.2
Soybeans		1980	2.10	1.80	0.3
	(bil. bu.)	1985	2.30	2.10	0.2
Feed Grains[b]		1980	283	218	65
	(mil. tons)	1985	315	302	13
Wheat[c]		1980	2.2	2.4	(0.2)
	(bil. bu.)	1985	2.3	2.4	(0.1)
Cotton		1980	15.0	11.1	4.0
	(mil. bales)	1985	16.4	13.4	3.0
Total[d]		1980	831.2	692.3	137.9
	(bil. lbs.)	1985	913.9	882.7	33.4

[a]Excess capacity is determined by subtracting actual production from projected production capacity.

[b]Feed grains includes corn, barley, sorghum, and oats.

[c]Numbers in parenthesis indicates actual production greater than projected capacity levels.

[d]Total includes corn, soybeans, barley, oats, sorghum, wheat and oats, converted to pound equivalent. Numbers may not add due to rounding.

cotton, and increases from -0.2 to -0.1 billion bushels for wheat. It is important to note that these are based on capacity production estimates projected into the future, and not actual potential production in the current year.

The most recent study and the most relevant to this analysis was conducted by Dvoskin (1986). Dvoskin constructed an annual aggregate measure of excess capacity for eleven major U.S. crops. Adopting the interpretation of excess capacity put forth by Quance and Tweeten, Dvoskin assumed excess capacity represents the difference between what farmers could have produced (at the given or prevailing price levels) and the value of production that can be cleared by the commercial market (domestic and foreign demand). The procedure implies that all government-induced diverted acres, an element of potential supply production, will be in production or will be available for production if no payments are available for producers and if prices remain constant. Dvoskin also recognized that the amount of potential production that might be available from diverted or set-aside acres is considerably lower than land currently in production because set-aside acres usually have lower yields and because considerable slippage exists in the set-aside program.[1]

In calculating excess capacity, Dvoskin (1986) summed national aggregates for actual production and imports, less domestic use and exports, to represent excess supply. Taking

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[1] Slippage is the difference between the estimated production adjustment from set-aside and the actual reduction in production.

the sum of excess supply, noncommercial exports, and set-aside production, Dvoskin approximated the amount of excess capacity for eleven U.S. commodities over the period 1940 to 1986.[2] Excess capacity as a percentage of actual production plus possible production from set-aside ranged from -3.17 in 1950 to 12.48 in 1985 for all crops. Negative excess capacity was experienced in years in which stocks were drawn down, because demand exceeded supply. A wide range of excess capacity estimates occurred for individual commodities. Results of Dvoskin's study are presented and discussed in further detail in chapter 4 and compared with estimates derived in this research.

Previous measures of excess capacity vary considerably in the literature, lending to no general consensus. However, Dvoskin's measure has the greatest appeal because of its disaggregation of excess capacity for individual commodities, over a lengthy period of analysis. Important distinctions between the method employed in this study and the methods employed in previous studies are identified and highlighted as the measurement method employed in this research is described later in this report.

Nonagricultural Capacity Measures

Capacity in the nonagricultural literature is frequently defined as the maximum output that can be produced with

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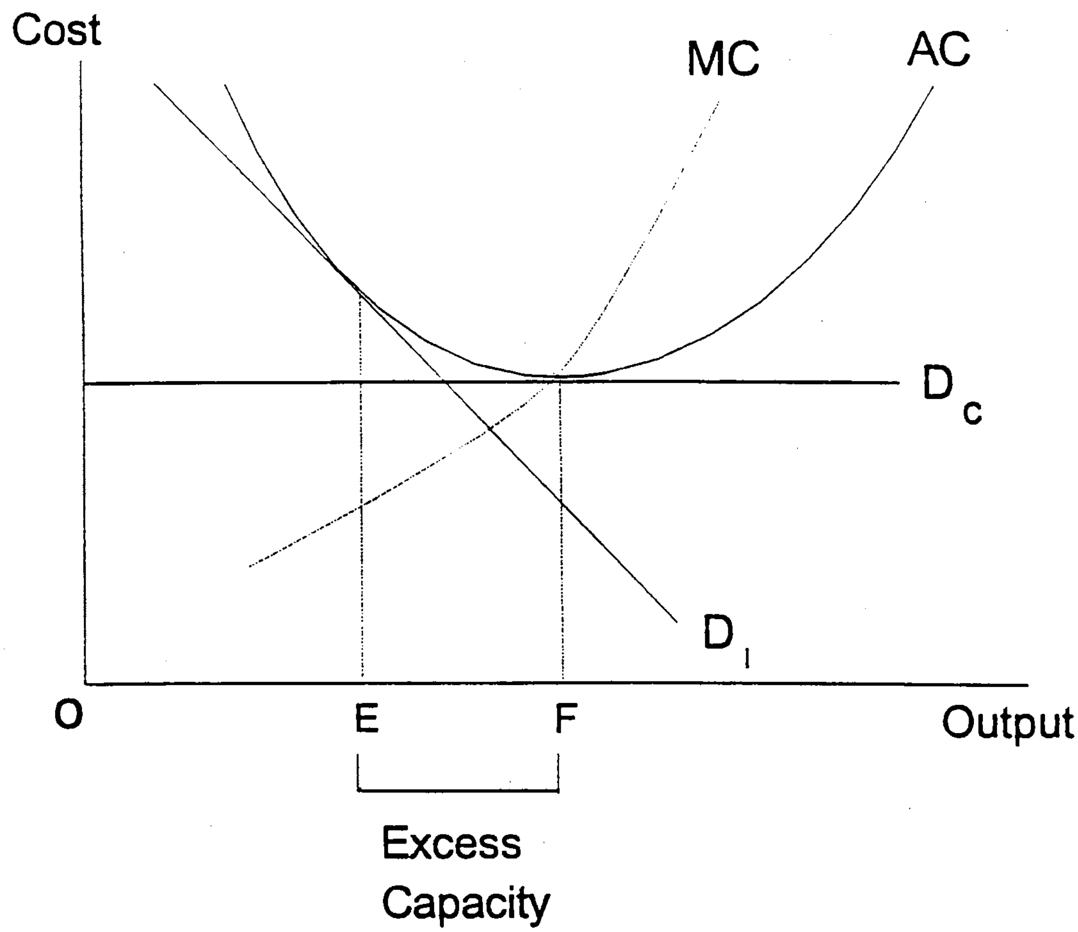
[2] Noncommercial or *subsidized* exports represent commodity exports moved under agricultural export programs.

existing plant and equipment over a specified period of time (Spielmann). However, the interpretation and measurement of capacity, similar to excess capacity in the agricultural literature, is not clear cut. Capacity utilization measures help explain how much real output is produced from a given amount of resources and are often used to investigate costs, prices, profits, and investment behavior (Hertzberg et al.). Nonagricultural measures of capacity are discussed in this section, and then employed to measure capacity in agriculture.

Excess Capacity from Imperfect Competition. Capacity measurement in the nonagricultural literature is an important variable used in the theory of the firm. Excess capacity arises from inefficiencies in imperfectly competitive markets (Chamberlin). Following Klein's reconstruction of these concepts, this is illustrated graphically in Figure 2. For an individual competitive firm, full capacity output is defined as the long-run output level occurring at the minimum on the average cost curve, or OF in Figure 2. The traditional competitive equilibrium conditions occur at this output level, equating marginal cost, marginal revenue, price and average revenue. Social welfare is also maximized at this point. It is important to note that in the short run, a firm may not produce where average cost is at a minimum, since the marginal cost curve may intersect the marginal revenue curve at other levels of output.

Under a regime of imperfect competition, demand (D_I) is downward-sloping, producing a tangency with the average cost



Source: Klein, L.R. "Some Theoretical Issues in the Measurement of Capacity." Econometrica, Vol.28 (2), 1960.

Figure 2. Excess Capacity from Imperfect Competitive Markets

curve where output (E) is less than the competitive output level (F). If we assume that the average cost curve is invariant between the two regimes, full capacity output is not achieved at OE. Thus, a social welfare loss occurs under imperfectly competitive markets. To measure excess capacity in this framework, cost functions must be estimated. Klein proposes a probit total cost function to represent decreasing and increasing marginal costs, but a cubic cost function would also suffice.

In general, for a total cost function represented by TC(v,w,Q), where v and w are input costs and Q is output, average cost can then be determined as:

$$AC(v,w,Q) = TC(v,w,Q)/Q. \tag{1}$$

Taking the derivative of the average cost function with respect to Q, and setting equal to zero, gives the minimum point on the average cost curve where long-run competitive conditions are met. To solve for the output level of an imperfectly competitive industry, marginal revenue is equated with marginal cost. Marginal revenue is derived from the demand function and, assuming the same cost structure as the competitive firm, marginal cost is determined as:

$$MC(v,w,Q) = \partial TC(v,w,Q)/\partial Q. \tag{2}$$

At the output level where these conditions hold, long-run average cost is tangent with the demand curve (D_I). If institutional barriers or entry and exit of firms is restricted, for example the long-run average cost curve lies above the demand curve, the firm would enjoy positive profits in the long run. The distance between the competitive output level (F) and the imperfectly competitive output level (E) is a measure of excess capacity.

Engineering Measures of Excess Capacity. As an alternative to these economic measures of capacity, an engineering definition for capacity is the maximum sustainable level of output that can be produced or the physical capability of existing plant and equipment when the firm is operating at its usual or normal intensity (Klein and Summers; Hertzberg et.al.).[3] Smithies defines full-capacity output as the output that the "existing stock of equipment is intended to produce under normal working conditions with respect to hours of work, number of shifts, and so forth (Smithies)."

Technical relationships can be illustrated using a production function with output (y) and two factor inputs (n and k). At full capacity the following relation holds,

$$y=f(n_f,k), \tag{3}$$

where y is capacity output, n_f is a fully employed labor force, and k is the stock of capital.

The production function can be viewed as a point or flow measurement. As a flow measurement of capacity, Klein defines capacity output y as the production flow associated with the input of a fully employed workforce, capital, and other

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[3] The literature provides various interpretations of *normal operating conditions*. Some argue that 24 hours a day, 7 days a week are *normal operating conditions* (Hertzberg, et.al.). However, it is generally recognized that this varies by industry.

factors of production.[4] Full capacity may also be interpreted as the level of output at which the marginal product of additional inputs is zero. From equation 3, this occurs where $\partial y/\partial n_f = 0$ and $\partial y/\partial k = 0$. Engineering approaches have also taken peak output production over previous years to indicate potential production (Spielmann and Weeks). Costs of operation are ignored in a purely engineering approach to capacity measurement.

Capacity and Capacity Utilization Measures. Three approaches to measuring capacity or capacity utilization in the nonagricultural literature are sample survey inquiry, overall capacity index, and trend-through-peaks. All three measures are widely applied in the industrial sector. Appendix A provides a list of the commonly applied measures of manufacturers' capacity utilization, along with their approaches.

Beginning with engineering estimates of capacity for individual firms or industries, an aggregate industry or economy capacity index is constructed by combining the individual units. This approach requires a weighting system to aggregate up to the industry or national level. The Federal Reserve Board's *Index of Capacity Utilization* averages utilization rates using 1967 value-added weights to obtain an aggregate capacity rate or index for total manufacturing. The

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[4] In an agricultural context, the engineering measure of capacity may be defined as production associated with fully utilized labor, land, capital, and management skills or information resources.

overall capacity index approach often requires data, such as capital stock estimates, obtained from the survey approach and governmental agencies. In addition, the measure is adjusted by time-series analysis to correct for directional biases (De Leeuw).

In the sample survey approach, capacity utilization rates are obtained directly by soliciting a sample of companies. A capacity utilization rate is the ratio of actual output of the firm to capacity output at a given point in time (Spielmann and Weeks). Firm managers may be asked about capacity operations, such as actual and preferred operating rates. Answers are weighted in a similar fashion as the overall capacity index approach to produce an average aggregate measure.

The final measure of capacity is obtained by plotting trend lines through peaks of production series in the trend-through-peaks approach. The lines connecting the peaks in output represents full capacity utilization. The distance between the full-capacity trend line and the points representing actual production imply unused (or excess) capacity.

Indexes of capacity utilization or capacity utilization rates are constructed by each of the three methods, or a combination of these methods, and are widely published in the business literature (see Appendix A). The Bureau of Economic Analysis (BEA) and McGraw-Hill annual series are based entirely on survey data. The Wharton School series is based on indirect, deductive calculations in the trend-through-peaks method. The monthly McGraw-Hill series, the Federal Reserve Board series, and the Conference Board Series are based on combinations of survey data and calculations.

In addition, each method provides unique information, along with the common end result of measuring capacity utilization. For example, preferred operating rates can be derived from the survey method but not the trend-through-peaks method.

Comparison of Agriculture and Non-Agriculture Capacity Measures and Excess Capacity

Excess capacity is generally measured in the agricultural literature, while capacity or capacity utilization is often measured in the non-agricultural literature. A generally agreed-upon definition of excess capacity in the agricultural literature is supply in excess of demand at an acceptable price, or the ability to produce in excess of the quantity demanded. Likewise, a common definition of capacity in the non-agricultural literature is the maximum output that can be produced with existing plant and equipment over a specified period of time.[5] Capacity utilization refers to the relationships between actual production and physical production capacity, and excess capacity refers to the

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[5] The trend-through-peaks method employed by the Wharton School is an exception.

difference between actual production and the optimal or efficient rate of production (Dvoskin). A general consensus has not been reached for measuring the two terms. Excess capacity is often not measured directly in the non-agricultural literature, but can be implied. For instance, full or preferred capacity less actual operating capacity is a measure of excess capacity.[6]

In addition, in the agricultural sector, most of the studies mentioned previously were primarily concerned with measuring excess capacity in relation to market-clearing conditions. Unlike capacity measurement in the business literature, commodity demand is often included in the analysis of capacity in the agricultural literature.

<u>Characteristics of the Farm Sector for Capacity Measurement</u>. Applying capacity measures discussed from the nonagricultural literature to the measurement of capacity in the farm sector poses several problems. Some characteristics of the farming sector are not common throughout the economy and should be considered in capacity measurement in agriculture.

First, output substitution possibilities, given the same set of fixed factors, are far greater for the crop producer than for the manager in a manufacturing industry. Thus, the degree of disaggregation of total farm output into individual

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[6] Alternatively, one minus the capacity utilization rate can also be interpreted as a measure of excess capacity, in terms of a percentage of total capacity.

commodity production for capacity measurement is difficult in agriculture. For the manufacturing industry, output flexibility is limited. That is, output diversity is fixed given the same set of input factors.

Second, output quality and rates in agriculture can be profoundly affected by weather variations from one production period to the next. Thus, physical measurement of capacity in a given year may be quite misleading (Dvoskin). On the other hand, output from a manufacturing firm is generally known with greater certainty and occurs continuously over a period of a year.

Third, several fixed factors are employed in agriculture. Unlike industrial firms with capital as the primary fixed input, agriculture encompasses several fixed factors, such as machinery, equipment, land, breeding herds, perennial crops, and management. However, Dvoskin argues that agricultural enterprises have considerable flexibility in increasing production in the short run. For instance, adoption of more intensive cropping practices, higher-yielding plant varieties, use of fertilizers, water and other inputs, allow output to increase rapidly.

Nonetheless, these technologies and inputs are limited in the short run, so output expansion may occur quickly, relative to the industrial sector, but only up to a point before fixed factors are exhausted. Capital is the principal factor determining capacity measurement in other industries. What factors should be included in capacity measurement in agriculture? Obviously, different magnitudes of capacity and capacity utilization will result from different measures.

This list is not exhaustive of the characteristics unique to agriculture. These unique characteristics require careful consideration before applying capacity measurements used in the industrial sector to the agricultural sector.

Applying Nonagricultural Sector Measures in the Agricultural Sector

Applying nonagricultural sector measures of capacity measurement in the agricultural sector has been attempted in one study (Spielmann and Weeks). The trend-through-peaks method employed by the Wharton School may prove useful in agriculture. The method used by the Wharton School requires an industry-by-industry analysis which is based on monthly output data aggregated to quarters (Klein and Summers). It is applied to industries which have a continuous annual output with regular cyclical changes. This provides a degree of consistency in capacity utilization rates necessary to create an aggregate index for the industrial sector.

The most serious drawbacks hindering potential application of this method to the agricultural sector are the discontinuous production process, the volatility in output, and the infeasibility of obtaining industry-by-industry or farm enterprise-by-farm enterprise data. However, some degree of consistency exists among agricultural enterprises, and the potential drawbacks can be lessened by modifying the underlying assumptions in order to make this method compatible with the unique characteristics of agriculture.

Plotting annual production data and connecting peaks with straight line segments, the trend-through-peaks method can be employed for specific farming enterprises. In this analysis, only cropping activities are considered. Illustrated graphically for corn, wheat, sorghum, barley, oats, cotton and soybeans, a capacity measure is created by connecting the peak production periods over the period 1950 to 1990 (Figures 3 thru 9). Figure 10 conveys the measure of excess capacity for the cumulative total of the seven crops. Excess capacity is measured as the distance between the full capacity trend line and the level of actual production. Following the Wharton School, the capacity trend line is non-decreasing over time. Obviously, for peak years where actual production is greater than in subsequent years, excess capacity is zero.

Excess capacity represents production shortfalls and may be caused by weather, government policy regulating program set-aside requirements, and price or cost disincentives for planting or harvesting. Thus, the cause of excess capacity and the limiting factors are not clear, using the trend-through-peaks method. Also, output prices, inventory levels or stocks, and numerous other exogenous events are ignored in this measure. Thus, caution must be exercised in interpreting the results from the modified trend-trough-peaks method.

Second, application of the survey method, employed by McGraw-Hill and BEA, for construction of aggregate capacity

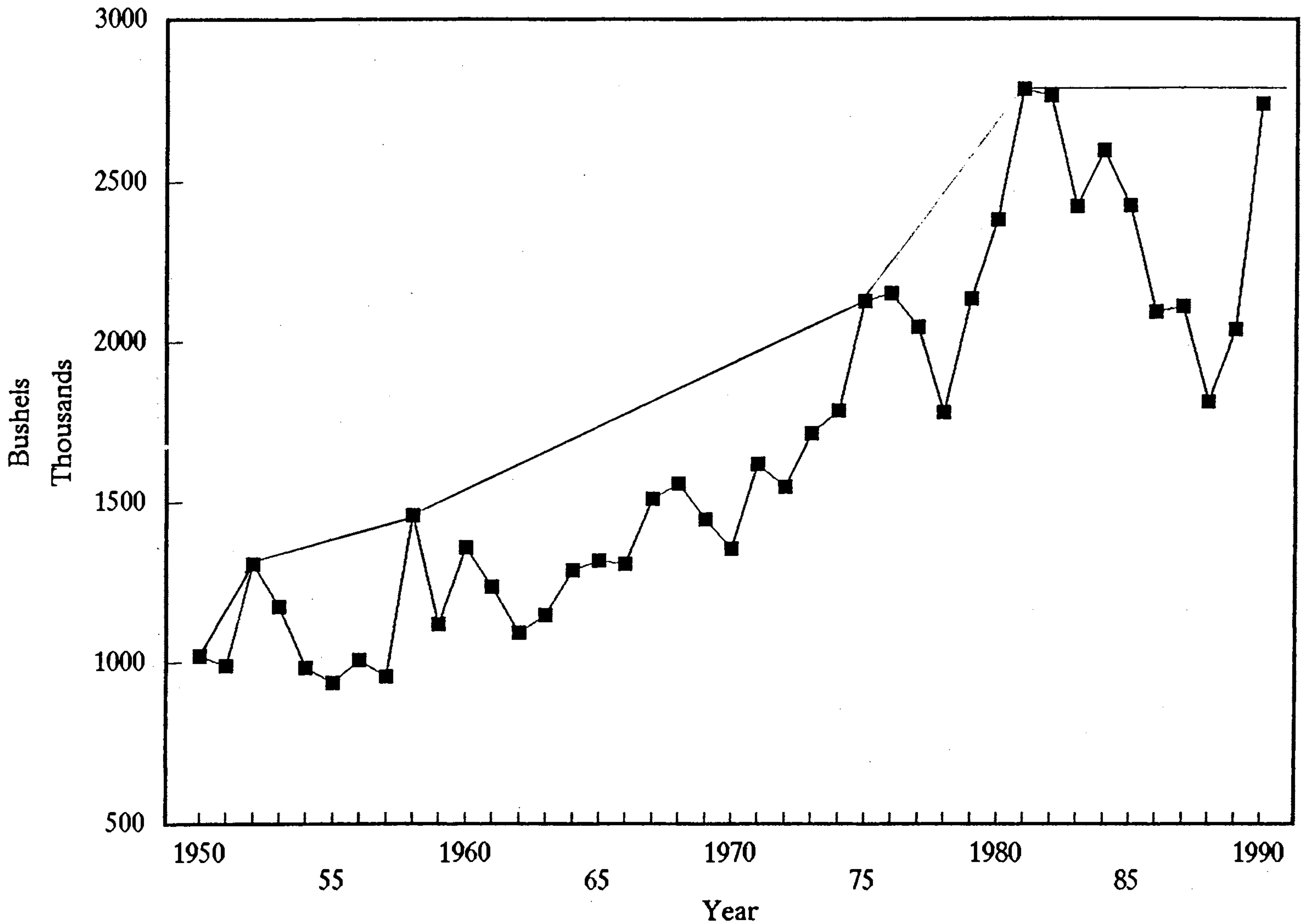

Figure 3. Capacity Measure Using a Modified Trend-Through Peaks Method for Wheat Production, 1950-1990

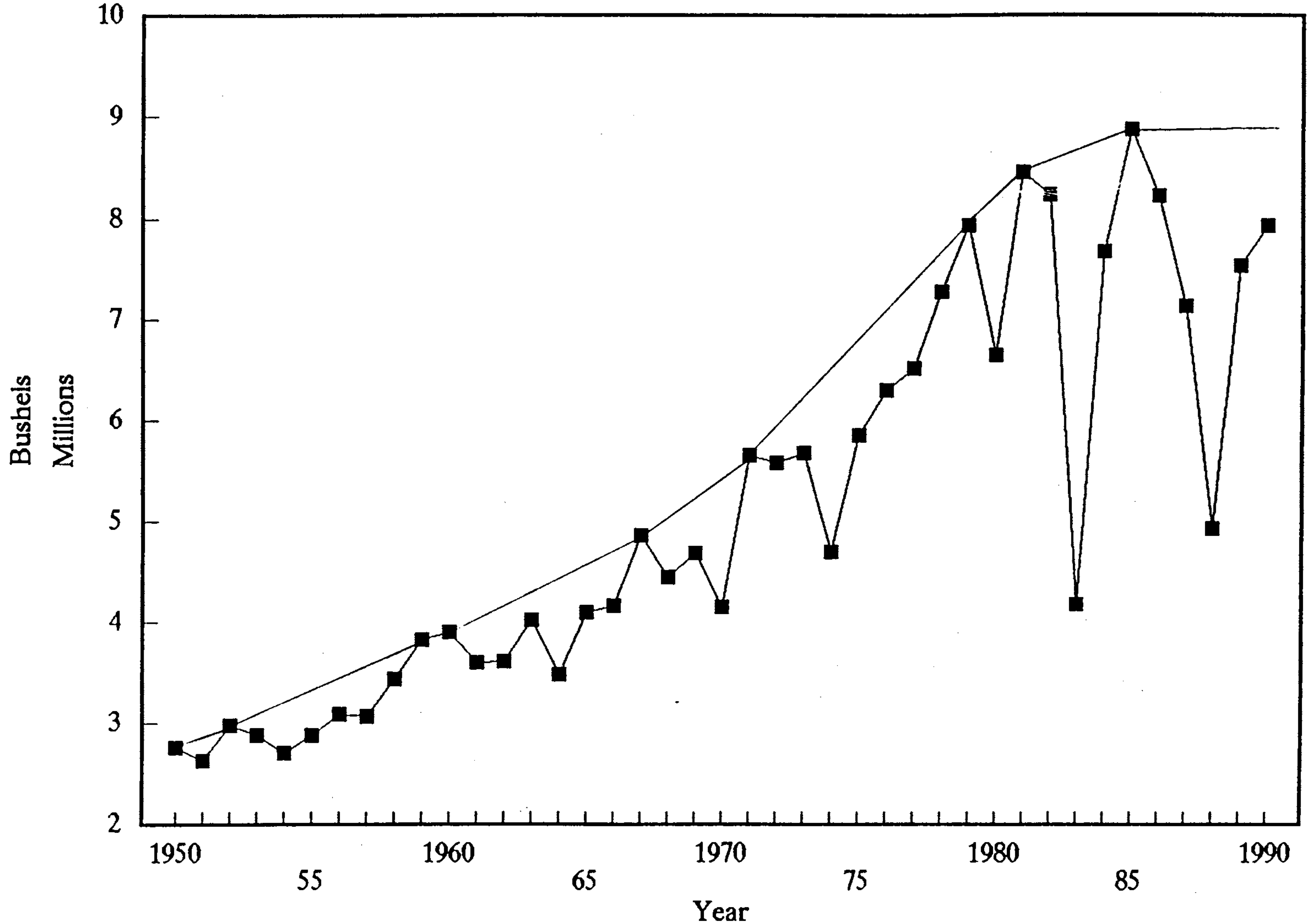

Figure 4. Capacity Measure Using a Modified Trend-Through Peaks Method for Corn Production, 1950-1990

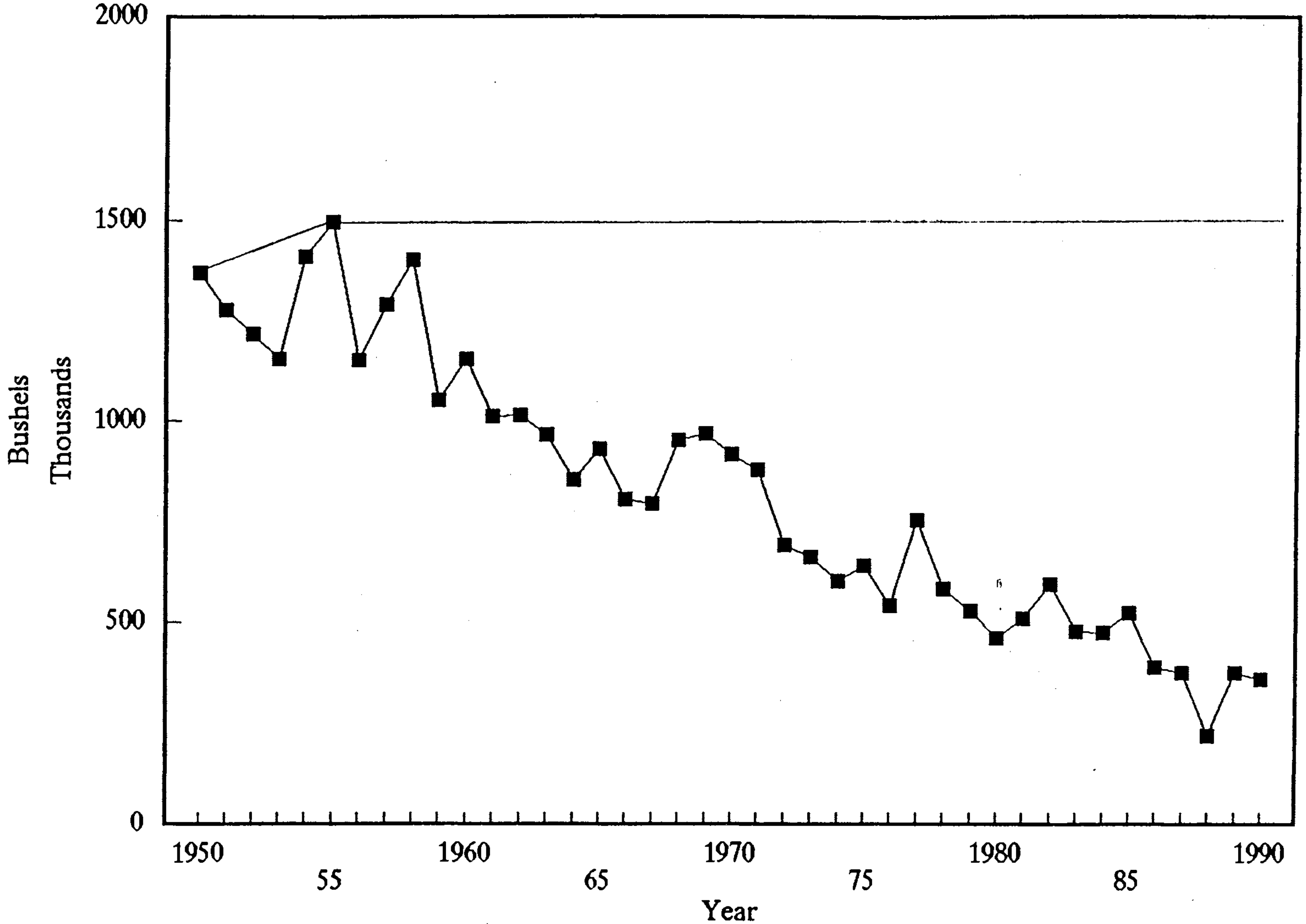

Figure 5. Capacity Measure Using a Modified Trend-Through Peaks Method for Oat Production, 1950-1990

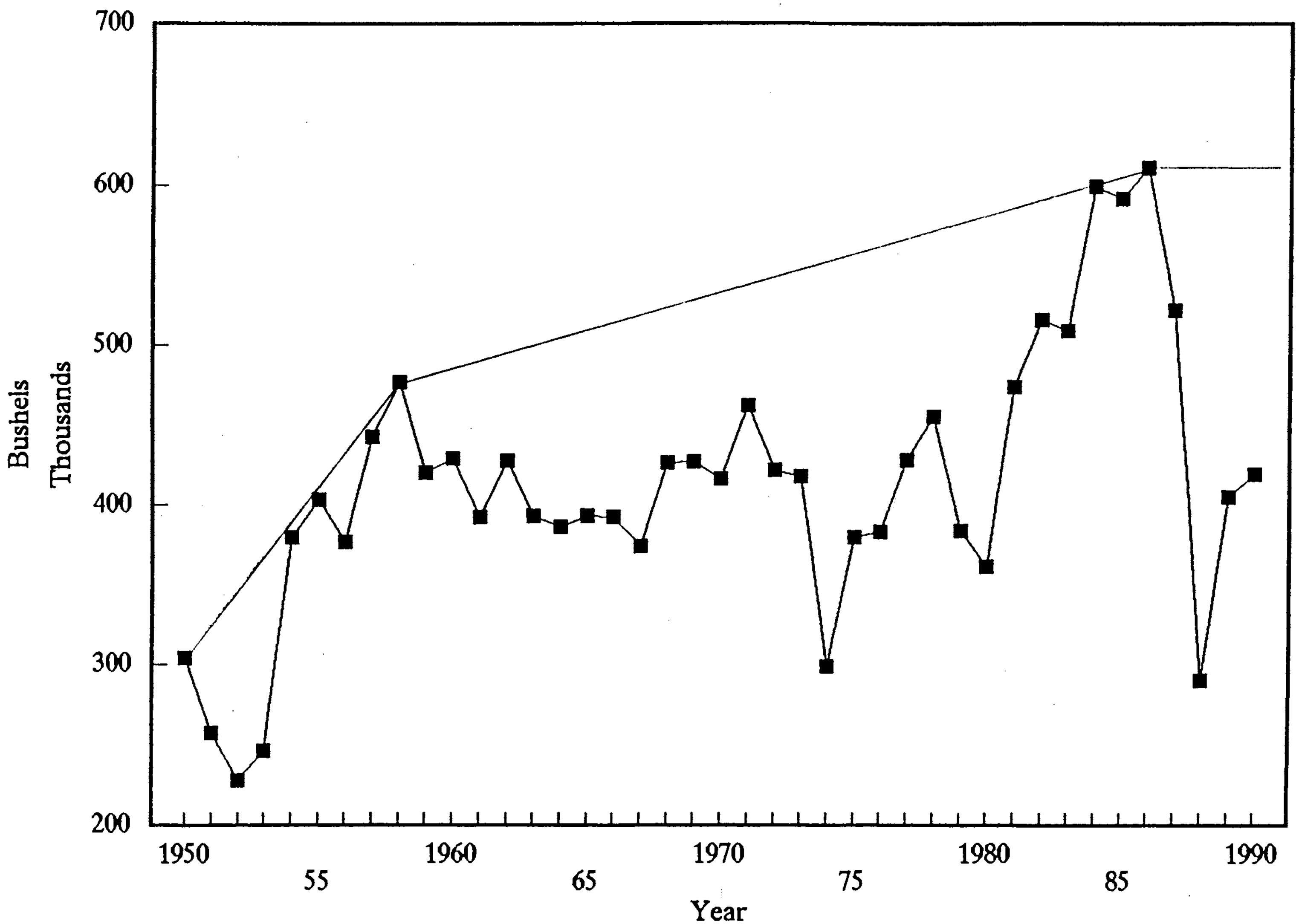

Figure 6. Capacity Measure Using a Modified Trend-Through Peaks Method for Barley Production, 1950-1990

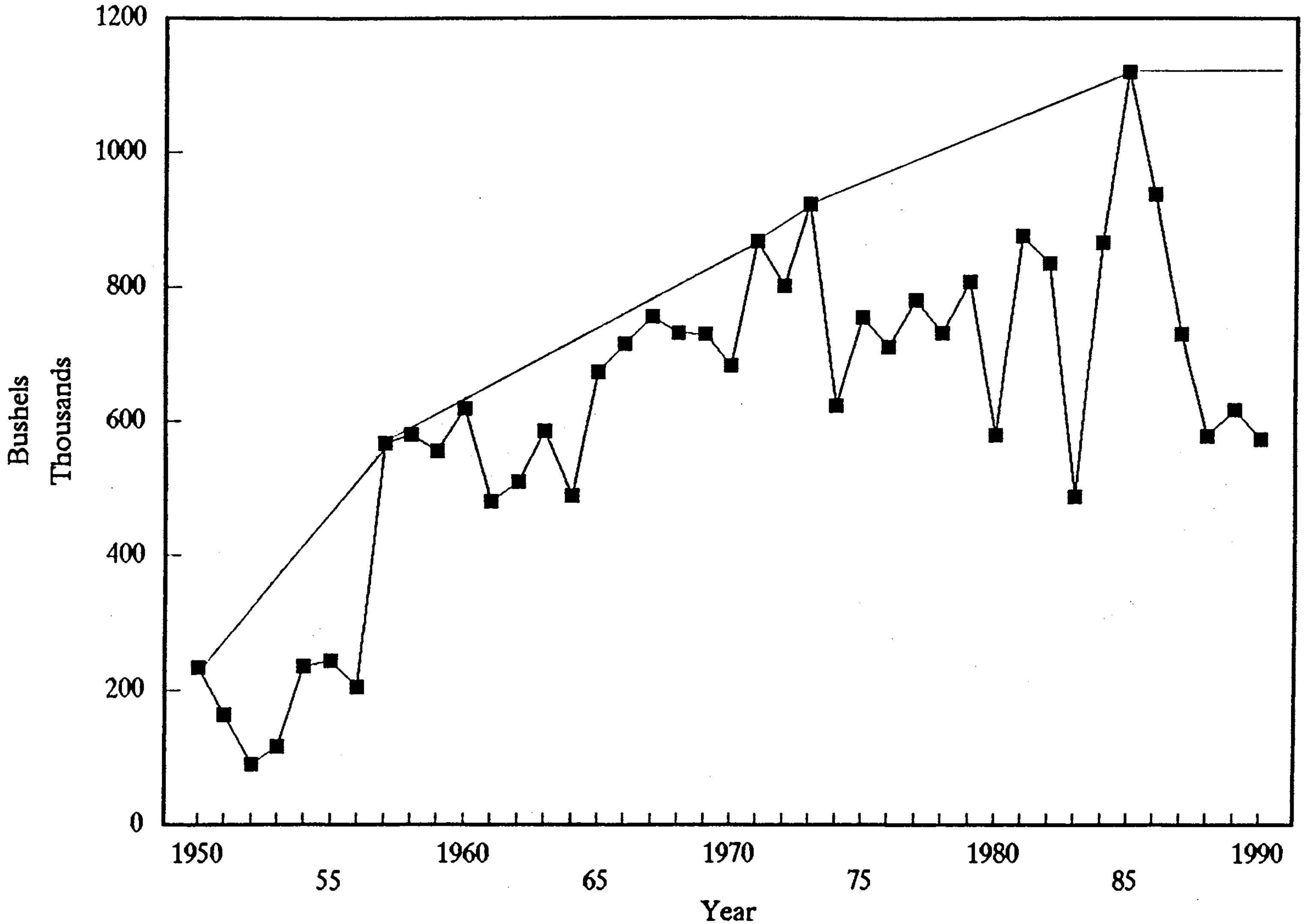

Figure 7. Capacity Measure Using a Modified Trend-Through Peaks Method for Sorghum Production, 1950-1990

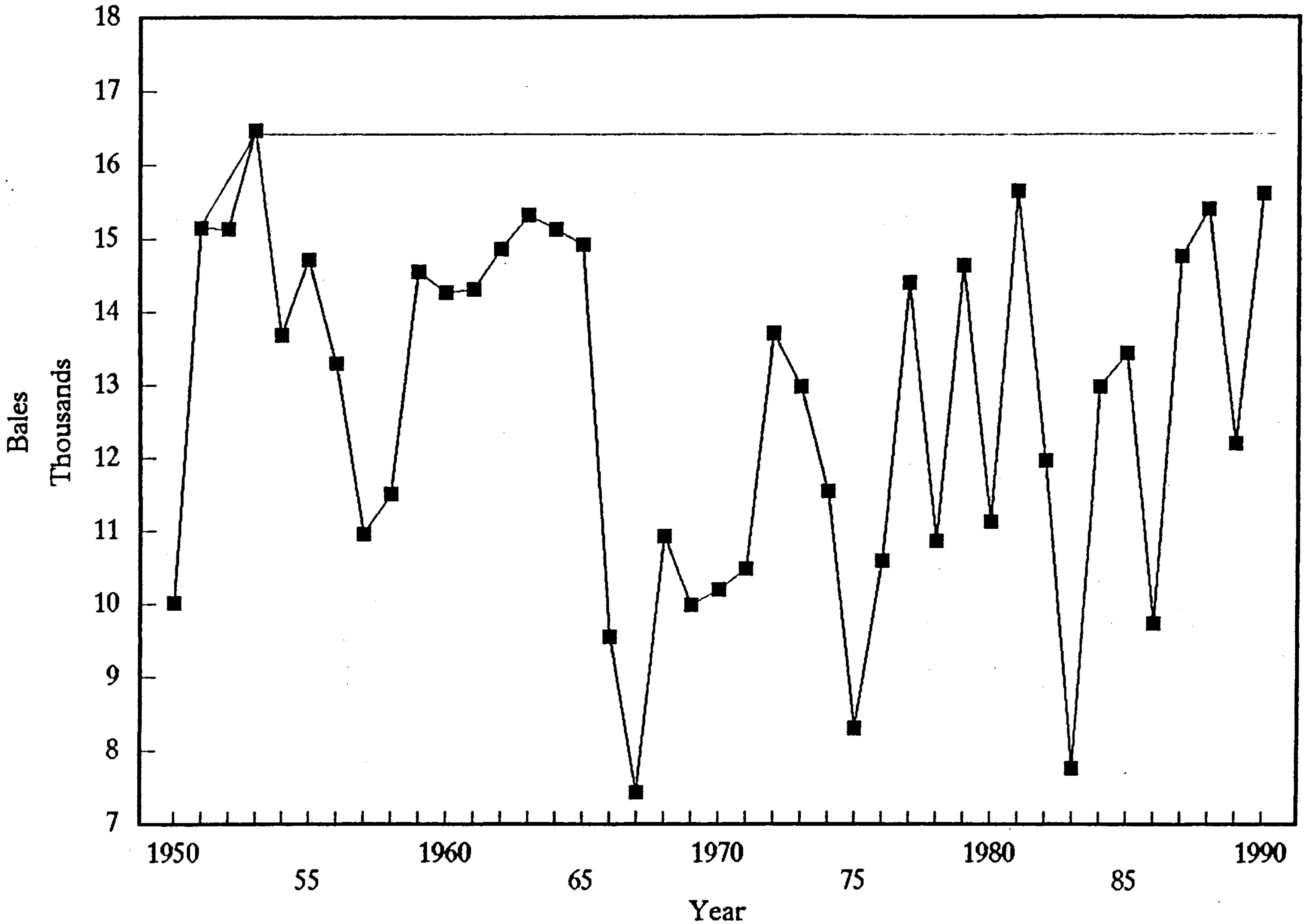

Figure 8. Capacity Measure Using a Modified Trend-Through Peaks Method for Cotton Production, 1950-1990

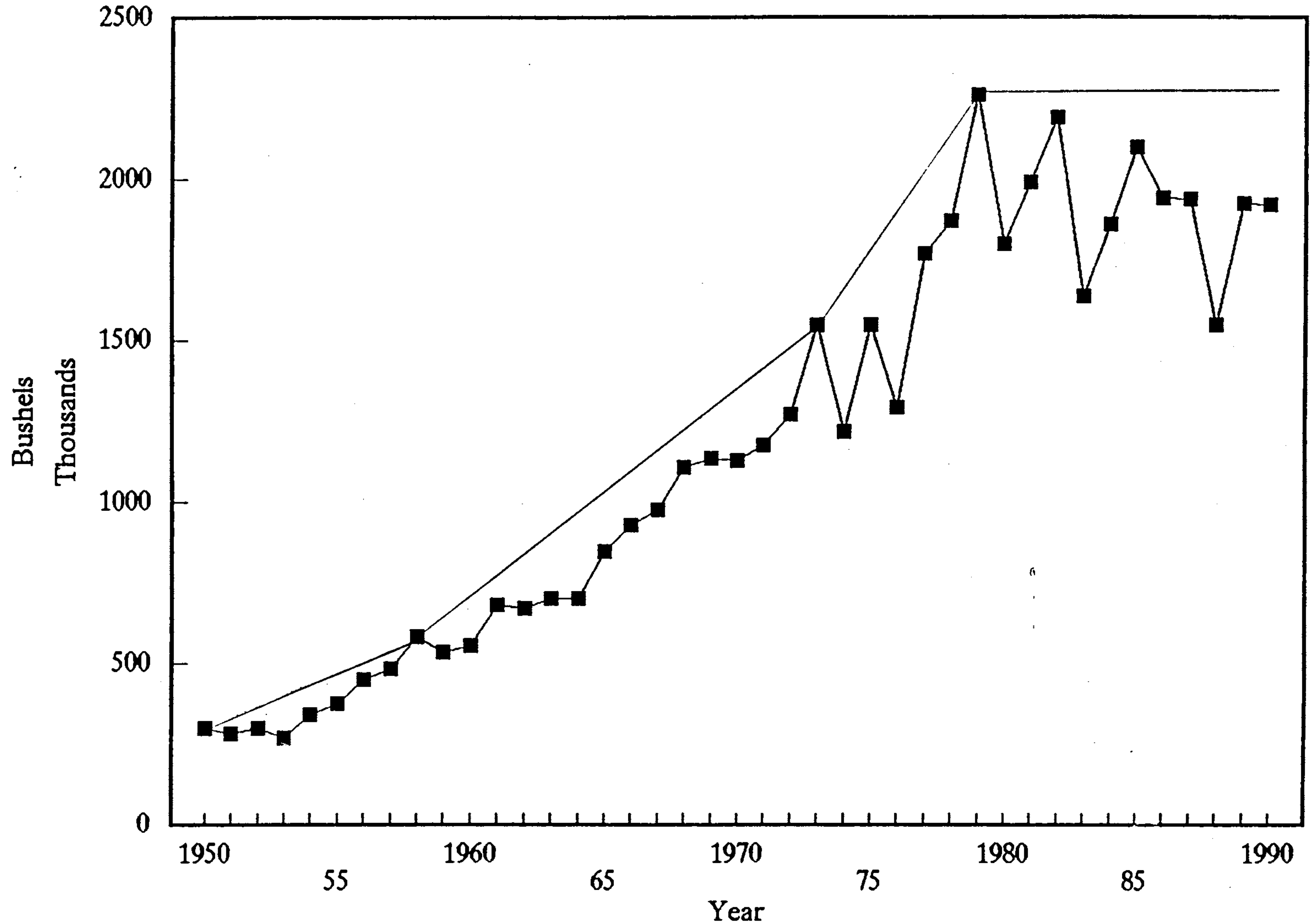

Figure 9. Capacity Measure Using a Modified Trend-Through Peaks Method for Soybean Production, 1950-1990

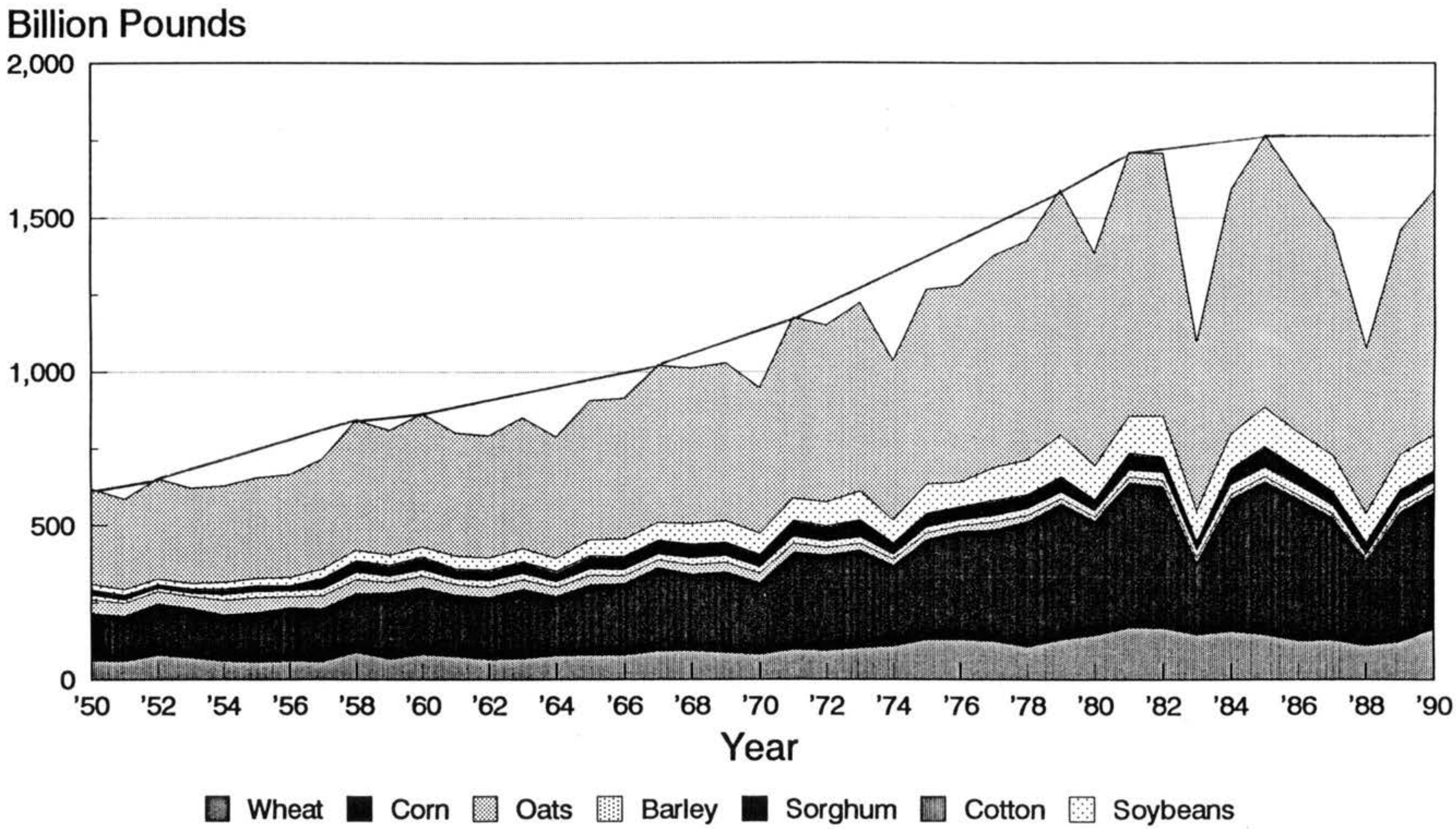

Figure 10. Capacity Measure Using a Modified Trend-Through Peaks Method for Production of Seven U.S. Crops, 1950-1990

indices has merit in agriculture. Considering the unique characteristics of agriculture, implementation could prove useful. Producers from various regions and specific farming enterprises would be randomly sampled. It is important that capacity and capacity utilization rates are explicitly defined on the questionnaire and understood by producers. Questions pertaining to actual capacity use and preferred capacity use would be requested. An optimal use of fixed resources on the farm is assumed to be identifiable by the producer. Causes of deviations from the optimal or preferred capacity level must be recognized: for example, newly acquired acreage, acreage reduction requirements and transfer of capital. A closer analysis of the relationships between the behavior of farms and exogenous factors influencing capacity could provide an important policy tool and a decision aid at the micro and macro levels.

To create an aggregate capacity index, capacity utilization rates from specific farming enterprises must be grouped and weights assigned. Spielmann and Weeks suggest weighting the farming enterprises by the value of total output. However, higher value crops such as soybeans and corn would receive a disproportionate representation. An alternative might be to weight by acres and the output value. Financial feasibility and education of producers would be the most limiting factors in applying the survey method in the agricultural sector.

Third, Spielmann and Weeks envision an alternative method for measuring capacity in the agricultural sector. They propose the estimation of a production possibilities frontier, assuming it can be identified, for various farming sectors, such as crops and livestock. Fixing the currently available equipment complement, land, and employed technology, a point off the frontier, where the output is maximum for both sectors, can be identified. That is, an interior point representing the sum of current crop and livestock production from the same set of fixed factors and technology can be identified. This interior production point divided by the maximum output point on the frontier would produce an aggregate capacity utilization rate. This approach is flexible in that responses from a survey or secondary data may be used. However, the approach is overly simplified and requires estimation of the production possibilities frontier.

Of the three approaches to capacity measurement in agriculture discussed, each provides a degree of conceptual accuracy, feasibility and compatibility with corresponding measures employed in the non-agricultural sector. However, important hurdles remain (eg. time, resources, and information dissemination) before these methods can be successfully implemented.

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CHAPTER II

THEORETICAL DEVELOPMENT

Conceptual Framework of Excess Capacity

A discussion of the conceptual framework of excess capacity is presented in this chapter. A unique measure of excess capacity adopted in this research is explained. Comparisons are made with the measurement methods reviewed in the preceding chapter. The conceptual representation of U.S. agricultural excess capacity will depict the important contribution that theoretical economic constructs make to the measurement of excess capacity.

Excess capacity is defined in this study as the difference between aggregate demand and potential supply at an acceptable price level or simply the ability to produce in excess of the quantity demanded. The interpretation of excess capacity adopted in this analysis places more weight on the historical interpretation of excess capacity used by Brandow, in that excess capacity is needed due to the inherent unstable nature of the farming sector.

These constructs are illustrated graphically in figure 11. Actual aggregate supply and demand are respectively, S_o and D_o, intersecting at market clearing price p_o and quantity q_o. If all government-induced idled production resources were

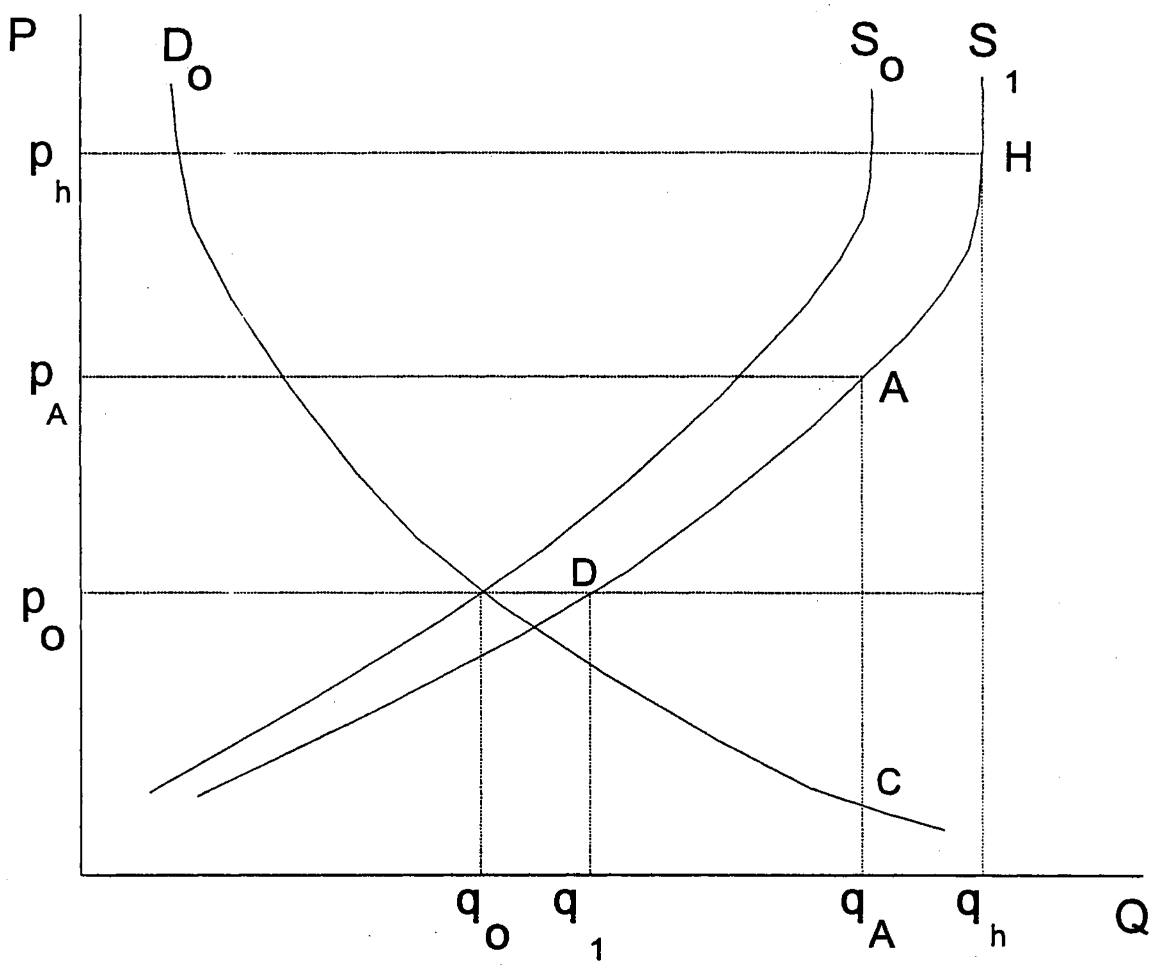

Figure 11. Representation of Excess Capacity in U.S. Agriculture Using Aggregate Supply and Demand Curves

employed, production could potentially expand to S_1. The difference between q_o and q_1 is termed excess production capacity.

Output could be expanded until resources are completely utilized, if prices are high enough (eg. p_h). In figure 11, production could expand to q_h where the potential supply (S_1) curve becomes vertical. At this output level all readily available resources are conceptually exhausted. The difference between q_h and q_1 is termed excess reserve capacity.

Ignoring the price where excess capacity is measured, Tyner and Tweeten's interpretation of excess capacity (q_1 less q_0) can be viewed as government-induced production diversions, which result from potentially expanded production, S_1, if brought into crop production. Likewise, following Brandow's interpretation of excess capacity, q_h less q_1 can be viewed as idled production resources not directly induced by government diversion programs, but available if needed. However, government stock policy lowers price, forcing the idling of some resources. Without the stocks policy, prices would be higher and production would come closer to q_h. Thus, if government production diversion and stock programs are eliminated, and all additional resources are employed in production, total excess capacity would be q_h less q_o in figure 11.

Considering the price at which excess capacity is measured, the notion of an acceptable price can be included in the analysis. Since government price support and storage programs were introduced in the 1930s, prices are said to be supported above free-market price (p_o) in figure 11 (Hallberg et al.). An acceptable price may be the market price where a representative buyer is willing to pay exactly what a representative seller is asking for quantity q_o.[1] Market-clearing conditions occur at price p_o in figure 11. If market-clearing price (p_o) is an acceptable price, excess supply or stocks would not exist. However, few would disagree that a buffer is generally needed to offset dramatic events, such as food shortages. On the other hand, it is possible, but unlikely, that an acceptable price would lie at a high price of p_h. Between these two extremes lies a socially acceptable price where excess capacity is maintained. For example, excess capacity can be measured at point A, corresponding with an acceptable price p_A and quantity q_A.

It is possible that production diversions could be expanded to q_A, at an acceptable price p_A. But holding all of excess capacity in production diversion programs may not be desirable to producers and policy makers. Thus, a balance will eventually be reached where both stock accumulation and production diversion programs maintain some excess capacity at an acceptable price. That is, excess capacity is the ability to produce in excess of the quantity demanded at an acceptable price (eg. p_A).

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[1] Representative buyers and sellers are used to denote the aggregate nature of supply and demand.

The basic difference between Tweeten's measure, illustrated in the previous chapter, and the measure laid out in figure 11 lies in the price at which excess capacity is measured. Thus, in this study total excess capacity consists of excess production capacity (q_1 - q_o) and excess supply (q_A - q_1), at an acceptable price, p_A. In order to employ an operational measure of excess capacity, these constructs must be measured quantitatively. That is, potential supply and demand must be measured at an acceptable price.

Measures of excess capacity discussed in the previous chapter vary considerably, leading to no general consensus. However, Dvoskin's measure has the greatest appeal because of its disaggregation of excess capacity for individual commodities, over a lengthy period of analysis.

The measurement method employed in this research bears resemblance to Dvoskin's measure discussed previously, but is different in that excess capacity for individual commodities is estimated using econometric models. Models of potential supply and demand are estimated for seven major U.S. commodities: wheat, corn, oats, barley, sorghum, cotton, and soybeans. Only storable commodities with government involvement are considered in this analysis. These commodities were chosen because excess capacity has traditionally been maintained for these commodities via production diversion programs and commodity stocks. Perishable commodities are excluded from the analysis.

Excess capacity results of Dvoskin's study are compared with estimates derived in this research and are discussed in further detail in chapter 4. Important distinctions between the method employed in this study and the method employed in previous studies are identified and highlighted as the measurement method employed in this research is described.

Overview of the Measure of Excess Capacity in this Study

Excess capacity is the ability to produce in excess of the quantity demanded at an acceptable price. That is, potential supply less aggregate demand is total excess capacity:

$$Q^{EC} = Q^{PS} - Q^{TD}, \tag{4}$$

where Q^{EC} is excess capacity, Q^{PS} is potential production or supply and Q^{TD} is total aggregate demand. If an acceptable price (p_A) is the market-clearing price, then $Q^{EC} = 0$ (see figure 11). If p_A is a government supported price, then $Q^{EC} > 0$, and equation 4 can represent the distance between q_A and q_o. Land available and harvested yield represent potential supply (Q^{PS}):

$$Q^{PS} = LA * Y. \tag{5}$$

Cropland available for producing a commodity is measured as the sum of land idled in government diversion programs, fallowed area, failed area, and land currently in crop production. This represents the size or capacity of the agricultural plant.

In modification of the definition employed by Dvoskin, potential production includes production on set-aside acres, and production from temporary nonplanted acres not set aside in the government programs. It is not unreasonable to assume that some cropland acres are routinely idled without a financial incentive by the government. For example, idled or fallowed cropland and acreage converted into pasture or forage on a temporary basis may return to crop production, and thus is accounted for as a component of potential supply in this research.

From Equation 4 and Equation 5, total excess capacity can be represented as:

$$Q^{EC} = (LA * Y) - Q^{TD}. \qquad (6)$$

Total aggregate demand (Q^{TD}) is calculated as the sum of domestic demand and export demand. Thus, the operational definition of excess capacity is simply the difference between aggregate demand and potential supply. Each component of excess capacity in equation 6 is estimated using econometric methods.

Several aggregate econometric models representing potential supply and demand are estimated for individual commodities. Thus, the measurement method employed in this research is different from previous studies in that excess capacity for individual commodities is estimated using econometric models. A consistent commodity modelling framework to measure each component of excess capacity is presented in the next chapter.

CHAPTER III

COMMODITY MODELLING DEVELOPMENT

In order to measure excess capacity in U.S. agriculture, theoretical models of aggregate potential supply and demand are developed. The focus of this chapter is on specification aggregate models to estimate annual excess capacity in the production of seven basic commodities for the period 1950 to 1990, and to be used later to forecast annual excess capacity in the short term (1992-96). In order to forecast the magnitude of excess capacity in crop production, it is necessary to design a theoretical model that adequately represents the functioning of the crops sector and then translate the theoretical model into an empirical model that can measure these effects quantitatively. Seven aggregate econometric models representing potential supply and demand for seven commodities are specified in this chapter.

A Brief Review of Econometric Modelling Developments

Due to biological and climatic factors, the nature and functioning of agricultural commodity markets can be highly complex. Closely related domestic markets, the length of the production process, uncertain weather events, international market diversity, political involvement, and the diverse marketing chains for various products produce highly complex commodity markets. Actual prices and quantities realized in agricultural commodity markets are the product of dynamic interactions between factors of supply and demand which are influenced by exogenous factors.

Constructing models to incorporate these interactions has evolved from enhancements in the techniques used to develop them. Since the emergence of modelling as an important research tool in agricultural economics, there have been several technical developments. Early modelling activities, focusing primarily on policy analysis, were limited by available data, computational feasibility and a solid theoretical framework (S.R. Johnson). The information age, ushered in by computer technologies, has brought about advancements in modelling methods. Structural changes and technological developments in agricultural production also stimulated refinements in modelling activities.

Commonly applied modelling methods include mathematical programming, statistical analysis, system dynamics, systems analysis, and regression analysis (S.R. Johnson, Hallem). Although not of recent origin, these modelling tools have expanded the scope of research in the past four decades, adding to the capability for problem solving. These modelling developments have greatly expanded modelling activities in research and policy applications in agricultural economics. Adopting tools from statistical and regression analysis, an econometric approach is applied in this analysis.

The econometric approach is flexible in terms of allowing decision rules and other constraints not estimated from previous data to be incorporated in the analysis, and it is widely used (Hallem). Unlike the previous applied modelling methods, all of the quantified relationships within an econometric model will have a direct causal interpretation, and describe how the market is assumed to have worked in the past. The relationships between supplies and prices, and demand and prices, for example, are quantified on the basis of historical data. Also, the independent variables influence the dependent variable, but the reverse is not true.

Commodity modelling attempts to characterize real-world markets by accounting for exogenous and endogenous factors in explaining supply and demand. As these models become better predictors of real-world events, their size and degree of complexity increases exponentially. At the other end of the spectrum, simple models, parsimonious in specification, are less accurate in representing real world conditions but have some conceptual appeal. This analysis adopts a modelling approach between these two extremes. The model size reflects an adequate description of the important interactions observed in real-world markets. Limitations in the extent to which the models account for all relevant factors, their relative importance, and the complexity of the relationships between them are recognized.

Econometric commodity models were first applied in policy analysis by Meinken in the middle 1950s to investigate feed grains and wheat. By the 1970s, advances in computer technology and economic theory brought about significant developments in econometric modelling. Mainly developed for policy analysis and forecasting, several comprehensive commodity models became operational (Houck, Ryan and Subotnik, Teigen, Meyers and Hacklander). With the application of these models, supply and demand components were estimated. Interactions from macroeconomic factors and livestock and foreign trade were explicitly considered. The next step was to include directly the influence of government program provisions on the supply side of the market.

Rational expectations theory in the late 1970s provided a basis for incorporating price expectations in supply response estimates (Gallagher). The basic idea of the rational expectations hypothesis (REH) is that forecasts of a variable are not a function of its past levels, but rather the predicted values of all the factors that determine the level of the endogenous variables in question. Using the example applied by Muth, a supply response is represented by the equation,

$$S_t = gP^e{}_t + U_t, \qquad (7)$$

where S is the production of units in one period as long as the production lag; $P^e{}_t$ is the expected market price in period t, based upon information available in period t-1; U_t is the random error term, unknown when production decisions are made, but known when the product is sold, and t is the time period.

Muth illustrates that if the errors are serially uncorrelated and have mean zero then rationality implies that

$$EP_t = P^e_t. \qquad (8)$$

So, if producers have perfect foresight, the realized price equals the expected equilibrium price.

Other commonly applied theories of expectations include naive expectations, represented by $P^e = P_{t-1}$, and adaptive expectations represented by $P^e_t - P^e_{t-1} = g(P_{t-1} - P^e_{t-1})$. According to naive expectations, expectations of next period's value for a variable called P are simply the currently observed value. Adaptive expectations states that the revision in our anticipation of P_t is proportional to the error we made in our forecast of P_{t-1}. Each theory of expectation is not without drawbacks, and real-world price expectations are probably formed by a combination of these expectations. These developments have been tested and applied in previous econometric models (Moore and Meyers; Westhoff et al.). In addition to these innovations on the supply side of commodity markets, a disaggregation scheme for the demand side has been used to design and estimate the supply and demand equations in this study.

Very few comprehensive operational crop models exist in the literature which incorporate recent econometric developments. One such model is the Food and Agricultural Policy Research Institute (FAPRI) U.S. crops model. This model is a simultaneous system of nearly 1,000 behavioral equations and identities that determine the production, stocks, exports, imports, consumption, and cross-commodity interactions of all major U.S. commodities.

Several technical innovations and behavioral relationships incorporated in the FAPRI crops model are used in this analysis. This analysis is different from the FAPRI crops model due to the focus on potential supply or the ability to produce in excess of the quantity demanded. Emphasis is placed on the supply side, in particular, the estimation of potential supply. Also, key behavioral relationships are developed via use of historical time-series data beginning in 1950. The FAPRI crops model is fit for a shorter time period, with the objective of predicting prices and supply and demand via a simultaneous link with livestock, trade and macroeconomic models, under certain policy assumptions.

Modelling Framework

The construction of aggregate commodity supply and demand models in this analysis involves five stages:

1) Specification
2) Data Methods
3) Estimation
4) Validation
5) Application

Model specification includes selection of the variables to be considered in the model and the functional form of the model. Hallem explains that model specification will represent a simplification and interpretation of reality guided by the model-builders' prior beliefs as to how the market works (Hallem). The second stage of model building requires that the variables be defined in terms of observable, available data.

After relevant data is collected for the models, the supply and demand models are estimated to obtain the unknown parameters. The estimated models are then validated to satisfy the model-builder of its adequacy in achieving the desired objectives (e.g. predicting excess capacity) (Hallem, Brorsen, Mapp). Model validation can be summed up as a cursory check of the signs of the estimated coefficients against prior expectations, economic theory, results of previous studies, and the appraisal of the goodness of fit criteria and hypothesis tests of individual parameter estimates. In addition, static and dynamic simulations of previous trends are compared with actual estimates of excess capacity in this analysis in order to validate the commodity models developed.

Finally, the validated models are applied to uncertain future conditions to predict the magnitude of excess capacity in the short run. That is, the econometric models developed in this chapter are used to forecast excess capacity in crop production and as a vehicle for attempting to trace the likely effects of alternative possible courses of action. These five stages are applied in the development of aggregate supply and demand models employed in this analysis.

Theoretical Model Specifications and Discussion

The first step in developing econometric models of aggregate supply and demand for predicting excess capacity is to formulate each disaggregated model in light of economic theory and a priori information. Economic theory provides a foundation for the specification of the aggregate models. The size of the final model specification and level of aggregation are determined primarily by the data available, as presented in the subsequent chapter.

It is important to recognize that in the process of building aggregate models to represent an industry or sector of the economy, all factors influencing individuals' decisions and all of the decisions themselves can not be fully accounted for. In this analysis, economic theory, hypothesis tests and a priori information are used to identify the important variables that influence individual behavior. Econometric models are then constructed to emulate key behavioral and technical relationships which cause decision responses or changes in decision responses. The degree of success accomplished in this process will influence the ability of the model to explain historical changes that have occurred and predict changes caused by future conditions.

The best mathematical form of the model and the model variables were determined based on economic theory, formal hypothesis tests and a priori information (e.g. technical relationships). The focus of this section is on developing theoretical specifications for demand and potential supply equations for seven commodities in order to estimate excess capacity. Idiosyncracies in the model specifications for particular commodities are discussed in chapter 4, and actual estimated equations are presented.

Potential Supply

Potential supply is composed of two separate components: harvested crop yield and land available for production. These two components are estimated and specified independent of each other, and are expressed as:

$$Q^{PS}{}_i = LA_i * Y_i, \tag{9}$$

where $Q^{PS}{}_i$ is potential supply of commodity i, LA_i is land available for production of commodity i, and Y_i is harvested yield of commodity i.

Harvested Yield

While general production theory suggests that crop yields are dependent on input and output prices and existing technology, it is very difficult to estimate yield equations, because most of the annual variation in observed yields is due to weather conditions. Included in the yield equations are variables representing planted area and idled area under government programs. Increases in planted area and decreases in idled area generally reduce national average yields, since more marginal land is being utilized. Likewise, reductions in planted area and increases in idled area generally increase national average yields, since marginal land is removed from production before productive land.

Economic theory would indicate that if output price increases, yields should increase because marginal value product of inputs increases. Likewise, if input price rises, yields should fall. Higher yielding plant varieties and more efficient cropping practices result from improvements in production technology. Harvested crop yield per acre is expressed as:

Y = f(Program area idled, Total area planted, Weather, Input prices, Output prices, Technology).

Planted Area

Price impacts may enter the yield equation via the planted area variable, which is estimated and specified independently. The planted acreage equation includes variables representing expected net returns for nonparticipants planting the crop in question and planting alternative crops. A nonparticipant refers to a producer electing not to participate in government commodity programs, while a participant refers to a producer enrolled in USDA's commodity programs and eligible for program benefits. Program participants are eligible to receive deficiency payments, as well as other program benefits, in return for not planting or setting aside some of their cropland. Higher expected net returns for nonparticipants should increase the total area planted, while higher expected net returns for participants may increase or reduce total area planted, depending on the set-aside requirements and program provisions for competing crops. Expected net returns for competing commodities may influence planted area for a specific crop. Government idled area includes required and voluntary annual set aside acreage, as well as long-term idled acreage (ie. CRP). As government idled area increases, area planted should fall, holding other things constant. To an extent, substitution among crops, physical land characteristics, government program requirements, and resource constraints restrict annual changes in planted area. As a result, planted area in previous years may influence planted area in the current year. Total planted area may be expressed as:

PLT = f(Expected participant and nonparticipant net returns for the crop, Expected participant and nonparticipant net returns for alternative crops, Government idled area, Planted area in previous years).

The estimated total planted area variable is used as an explanatory variable in the commodity yields model.

<u>Cropland Available</u>

While estimated crop yield represents one component of potential supply, estimated land available for crop production represents the second component. Available cropland will depend on various physical and economic factors affecting alternative land uses. Over the past four decades, exogenous events (e.g. world-wide food shortages) and federal agricultural policy have resulted in the expansion and contraction of the total agricultural cropland available (Mills).

As stated earlier, annual cropland available for production of a specific commodity is defined in this analysis as the sum of harvested area, fallowed area, failed area and government idled area for the commodity in question. However, the measure of excess capacity employed assumes that cropland available includes only harvested and government idled area, because fallowed and failed cropland are routinely idled by physical constraints and weather, respectively. Factors explaining harvested and government idled area are employed in the general specification. That is, variation in cropland available for a given year is primarily explained by factors influencing harvested and government idled area.

Expected net returns from crop production and crop prices received determine the land available for crop production. Producers' decisions are generally based on expected prices and net returns, but may be based on previous years' returns and prices.[1] The expected sign of such a variable to represent these expectations is positive. Higher net returns and prices of closely related commodities will negatively influence land available for production. Returns from alternative cropland uses, such as forage, grazing, and hunting, should also influence cropland available.

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[1] Rational and naive expectations of price and returns are considered.

In addition, total area planted, last year's land available, and government program provisions influence cropland available for production of a specific crop in the current year. Government payments for annual or long-term acreage diversions should have a positive effect on land available. Changes in the area planted determine the area harvested and, indirectly, cropland available.

LA = f(Expected and lagged net returns and prices for crop production, Competing crop returns and prices, Alternative land use returns, Area planted, Cropland available last year, Government diversion payments).

Thus, total potential supply is determined by the identity in equation 9.

Domestic Demand

From consumer theory, the traditional quantity-dependent demand function is expressed as:

$$x^* = x(\mathbf{p},m), \tag{10}$$

where x^* is the consumer's utility-maximizing demand bundle, x is an operator, $\mathbf{p} = (p_1,...,p_k)$ is the vector of prices of goods 1,...,k, and m is the consumer's income endowment. The consumer's demand bundle expresses how much of each good the consumer desires at a given level of prices and income (Varian).

With these theoretical considerations in mind, the demand equations developed are specified to represent these theory variables to the extent possible. In applied demand analysis, numerous exogenous factors, such as interest rates, government redistributions, consumer tastes and preferences, and consumer expectations, may also influence the consumer's demand bundle (Pyles).

Total aggregate demand in this study is aggregated from domestic demand and export demand for wheat, corn, sorghum, barley, oats, soybeans, and cotton. For feed grains, domestic demand is aggregated from feed demand and non-feed demand which consists of food, seed, industrial, and other domestic uses. Different specifications are used for the various demand equations.

Feed Demand

Feed demand provides an important link between the crop and the livestock sector. Because of the biological requirements of livestock, total feed demand is determined by animal numbers. As livestock numbers increase, feed demand is also expected to increase. Livestock producers substitute among different feed rations based on relative prices. The own-commodity price is expected to have a negative coefficient, while competing commodity price is expected to be positive. Both livestock and feed prices affect feeding rates. Livestock prices are expected to positively influence feed demand. Changes in the nature of the livestock industry are also likely to affect livestock feeding rates. Feed demand is expressed as:

Q^{FE} = f(Livestock numbers, Real price of commodity, Real price of substitute commodities, Real livestock price, Technology).

Non-Feed Domestic Demand

At least a portion of each commodity is used for food and industrial purposes, except for cotton and soybean meal. For wheat and soybean oil, food and industrial uses constitute the majority of domestic consumption, while for feed grains these uses constitute a small share of domestic consumption. Seed use is also included in this specification. Because aggregate demand data are not categorized into separate food, seed, and industrial uses, a composite domestic demand or non-feed domestic demand equation representing these uses is estimated.

Non-feed domestic demand equations, Q^{NFE}, are estimated in per capita terms because food and industrial uses generally dominate seed and other uses. The own-commodity price, cross-commodity price(s), and income per capita determine non-feed domestic demand. The price of the commodity is expected to be negatively related to the quantity of non-feed domestic demand, and the price of substitute commodities is expected to be positively related. Also, price of complement commodities is expected to be negatively related to non-feed domestic demand. The sign of the coefficient for income per capita is expected to be positive. Since seed demand is included in non-feed domestic demand, next year's area planted is expected to have a positive influence on the quantity of non-feed demand.

Consumers' tastes and preferences for various food products may influence domestic demand. Improved technologies in planting could also affect domestic demand. In general, non-feed domestic demand for corn, sorghum, barley and oats is presented as:

$$Q^{NFE}/\text{Capita} = f(\text{Price of commodity, Income per capita, Prices of substitute commodities, Expected planted area per capita, Consumers' tastes and preferences, Technology}).$$

Thus, total non-feed domestic demand, Q^{TNFE}, is calculated as:

$$Q^{TNFE} = Q^{NFE}/\text{Capita} * \text{Population},$$

For cotton, soybean oil, non-crush soybeans, and wheat, domestic demand is not disaggregated, but is presented in per capita terms, except for non-crush soybeans.[2] Domestic cotton is used primarily by cotton mills for the production of textiles. Soybean oil is used in food and industrial products, while food use dominates in the domestic demand for wheat. Non-crush soybeans are used primarily for seeding next year. General specification of domestic demand equations for these four commodities is similar to the specification of the non-feed domestic demand for feed grains above. Idiosyncracies will be detailed in the next chapter of this research.

Crush Demand

For soybeans, a crushing demand is specified to account

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[2] Non-crush soybeans are not estimated in per capita terms.

for the use of soybean oil and meal. Since soybeans produce joint products of soybean oil and meal, the value of soybeans is determined via the value of the joint products. The difference between the value of soybeans and soybean products, or the crushing margin, explains the amount of soybeans that are crushed for any given year.

Because of the time lag involved in increasing the crushing capacity of the industry, a lagged dependent variable may also explain crushing demand. The amount of soybean crush will also depend on current soybean production. All of the coefficients are expected to have a positive sign. Crushing demand is determined by:

Q^{CR} = f(Quantity of soybeans crushed last year, Crushing margin, Soybean production).

<u>Ending Stocks</u>

Ending stocks are not a component of demand, but provide a balance between aggregate demand and supply. For market-clearing conditions to hold, supply must equal demand for a given period of time. However, the seven commodities analyzed in this study can be stored from one period to the next in order to meet demand in future periods and remove excess production in the current period. Thus, for markets to clear in a given period, the quantity produced must equal the quantity demanded plus carryover stocks.

In this study, total ending stocks are estimated. Total ending stocks are the sum of government-held stocks and free stocks at the end of the period. The level of total ending stocks is determined by a variety of factors, including government stock policy and market signals. The opportunity cost of holding stocks today is represented by the current market price and the storage charge. The expected sign of the coefficient on real price of the commodity is negative. The speculative motive for holding stocks indicates that when prices are expected to increase, stocks will rise. And in the next period if expectations are correct, stocks are drained to capture the higher prices.

Future production may reflect expected price. Producers and speculators will increase stock-holdings when a small crop is anticipated next year and reduce stock-holdings when a large crop is anticipated. Current production may also affect ending stocks. When producers are unable to market a large crop, involuntary stock-holding may occur. The coefficient on current production is expected to have a positive sign.

The stocks equation also includes a lagged dependent variable, to reflect a partial adjustment process. Large stocks generally require several years to reduce, and storage capacity is generally slow to adjust. The expected sign on the lagged dependent variable is positive. Thus, ending stocks are represented by:

Q^{STK} = f(Real commodity price, Current production, Expected production, Previous year's total stocks).

Export Demand

A reduced-form specification for U.S. commodity exports is applied in this analysis. U.S. exports of major commodities are determined by current and lagged commodity prices. Current and lagged own-commodity prices are expected to influence commodity exports negatively. Prices of related commodities should also influence exports. An increase in commodity production in the rest of the world is expected to result in lower U.S. commodity exports.

Previous economics literature is inconclusive on whether or not exchange rates explain U.S. exports (Chambers and Just). In general, studies using non-market or fixed exchange rate data before 1973 conclude that exchange rates have little effect on U.S. exports, while studies using flexible exchange rate data after 1973 suggest that the opposite occurs (Hennebery et al.; Chambers and Just; Bessler and Babula; Schuh). In this paper, it is hypothesized that the exchange rate (in foreign currency per U.S. dollar) will have a negative effect on U.S. exports, since foreign demand should decline in response to an increase in the value of the dollar. Since U.S. feed grains are imported primarily for domestic livestock feed in importing countries, cattle production in the rest of the world may affect U.S. commodity exports. Increases in world income and population will also influence U.S. exports in the same direction.

Commodity exports are represented by:

Q^{EX} = f(Current and lagged prices of the commodity, Current and lagged prices of related commodities, Production of the commodity in the rest of the world, Cattle production in the rest of the world, Exchange rates, World population and income).

Imports are negligible for most commodities, but net exports are estimated for soybeans and oats due in part to data limitations.

Total aggregate demand for corn, sorghum, oats and barley is presented by:

$$Q^{TD} = Q^{FE} + Q^{TNFE} + Q^{EX} \quad (11)$$

Total aggregate demand for soybean meal excludes other domestic demand:

$$Q^{TD} = Q^{FE} + Q^{EX} \quad (12)$$

Total demand for wheat, soybean oil, and cotton is determined by:

$$Q^{TD} = Q^{TAGD} + Q^{EX}, \quad (13)$$

where Q^{TAGD} is total aggregate demand.

And total demand for non-crushed soybeans is represented as:

$$Q^{TD} = Q^{AGD} + Q^{EX} + Q^{CR}, \quad (14)$$

where Q^{AGD} is aggregate demand.

<u>Summary</u>

This chapter has specified the theoretically important structural relationships and identities that will be used to construct a measure of excess capacity in U.S. crop production. Total aggregated demand for various commodities, less potential supply, is a measure of excess capacity. The important structural relationships specified in this chapter ranged from harvested yield and land available on the supply side to the final domestic and foreign consumer on the demand side. The next chapter moves away from the theoretically specified equations developed in this chapter to the estimation of the empirical equations.

Economic theory, a priori information, and visual data examination were used to identify the variables to be included in the final equations, and the functional form of the relationship between them. The next section explains the data requirements and methods used in this research to estimate quantitatively the theoretical equations developed in this section.

CHAPTER IV

EMPIRICAL RESULTS

Data Requirements and Estimation Methods

The second stage of model building requires that the variables be defined in terms of observable, available data. The availability of data often restricts the direct estimation of the theoretical model. As a result, the estimated equations may not contain all of the information identified in the theoretical equations.

Data Requirements

In general, several different data series are available as relevant observations on each theory variable in the specified model. By placing restrictions on the set of available data, the size of the possible data series was reduced. That is, consistency, relevance to theory, and conforming to a priori expectations of the relationships determine the data series ultimately selected for the theory variables discussed in the previous chapter.

In cases where the theory variable may be inherently unmeasurable, a "proxy", depicting a relevant data series, must be used. For example, in the crop yield equations a trend variable or productivity index is used to represent increases in crop yields over the past 40 years. On the demand side, proxies were used to represent changes in technology and consumers' tastes and preferences.

Additional difficulties were posed by the discontinuities introduced by changes of definitions, base years, and data collection methods. Certain data series were used even if the definition was modified slightly. However, if the discontinuity created sizeable or abrupt changes in the data series, another data series with greater reliability was used, if available. In other cases, if the data series was not reliable or continuous, and another relevant data series was not available, the equation was re-specified. Such a problem was encountered in specifying the yield equations. Although economic theory would indicate that input and output prices should be included, negative signs on the output price coefficients led to respecification of the yield equations.

Price indices were frequently reported with varying base years, so backward extrapolation of the series from the most recent base year was done based on percentage changes between two consecutive reported years. That is, extrapolation of a price index with base year j in reported year t-1 was performed as:

$$P_{j,t-1} = (P_{i,t-1} - P_{it})/P_{it} * P_{jt} + P_{jt}, \quad (15)$$

where $P_{j,t-1}$ is price index with base year j in reported year t-1, $P_{i,t-1}$ is price index with base year i in reported year t-1, P_{it} is price index with base year i in reported year t, and P_{jt} is a price index with base year j in reported year t. The extrapolated price index is assumed to have a consistent base year j for t=1950, 1951,...,1990. Several price indices were extrapolated using this procedure: the Implicit GDP Price Deflator, the Consumer Price Index (CPI) all items, and the Index of Prices Paid by Farmers, to name a few.

This extrapolation process was also used to obtain a consistent data series for variable and total production expenses. In a provision of the Agriculture and Consumer Protection Act of 1973, USDA was required to make annual estimates of production costs for various crops. Prior to conducting the first Farm Costs and Returns Survey (FCRS) in 1973, and publishing of the first annual estimates in 1974, national production cost estimates were not available. Thus, to obtain a consistent data series, the Index of Prices Paid by Farmers was used to extrapolate back to 1950. Previous research has illustrated that this aggregate price index closely approximates actual production expense estimates before 1974 (Persaud and Mapp; White et al.).

Another discontinuity created by the reported data was caused by changes in the way the data was collected. For instance, the costs of production for the commodities analyzed are obtained by annual estimates in the FCRS. Prior to 1988, soybeans, sorghum and wheat national cost-of-production estimates were based on the Farm Enterprise Data System (FEDS), a computerized budget generator. However, beginning in 1988, cost-of-production estimates for these crops are based on farm-level cost models, which calculate production costs for each farm in the FCRS and then aggregate the costs to produce national estimates (USDA).

In a few instances a data series was "discontinued" for various reasons. In the 1980s USDA discontinued several spot price data series due to budgetary cuts. As a result, industry sources and business journals were searched to replace the missing data.

Because the availability of data restricts the direct estimation of the theoretical equations, the estimated equations will not contain all of the important information identified in the theoretical equations. Variables used in the final model specifications are discussed later in this chapter. Tables are used to present the variables specified in the final equations, the estimation results, and the variable definitions and data sources. Also, detailed derivations of the data series used for each variable are presented in Appendix B.

Estimation Methods

After relevant data was collected for the variables in the theoretical specifications, the equations were reformulated in a linear form and estimated to obtain the unknown parameter values for the corresponding variables. Because the purpose of the research is to forecast excess capacity in U.S. crop production for policy analysis, the estimation method chosen must produce reliable parameter estimates and sufficient model fits. In applied modelling of aggregate agricultural markets, adherence to the adequacy of performance measures, such as R-squares and signs of coefficients, takes precedence over rigid theoretical considerations (e.g. hypothesis testing) (Pindyck and Rubinfeld).

In light of the simultaneous structure observed in most agricultural markets, recent researchers have argued for the use of a simultaneous estimation method (e.g. 2SLS) (Hallem (1990), Willett and French (1991)). As a result, recent applied modelling efforts have made less use of single equation estimation techniques, such as generalized least squares (GLS), in favor of two-stage least squares (2SLS), three-stage least squares (3SLS), full information maximum likelihood (FIML), and limited information maximum likelihood (LIML) (Hallem (1990)).

In this study, two-stage least squares (2SLS) and generalized least squares (GLS) are applied for the supply-side and demand-side equations. 2SLS is a simultaneous estimation method, maintaining that the error terms across equations are correlated, and that endogenous variables appear on the right-hand side of a specific equation. GLS, on time series data, is a single equation estimation method, assuming the error terms are uncorrelated across equations but correlated across time. Since the variance is assumed to be unknown, an estimated GLS, referred to as EGLS by Judge et al., is applied.

In preliminary analysis, some equations indicated serious autocorrelation. If economic theory and market information could justify the use of a lag dependent variable on the right-hand side of the equation, then autocorrelation was "corrected" and did not pose a serious problem. Although several alternative methods have been applied by previous researchers, each has its limitations (Greene, p609; Johnston, p319; Brorsen). The method chosen for this study was applied because of its technical simplicity and because of software limitations in applying other techniques. The resulting parameter estimates, using 2SLS and EGLS, are consistent, unbiased, and asymptotically efficient (Greene, p609).

The use of ratios or products of variables (eg. deflated prices and composite net returns) result in non-linear relationships. In this case, GLS estimation procedures, with non-linear variables, will result in inconsistent parameter estimates. However, 2SLS estimation will result in consistent estimates under these conditions (Greene; Amemiya).

Thus, the final supply and demand equations are estimated by 2SLS. Because some equations are not simultaneous, and for a comparison with 2SLS results, EGLS is also applied and results presented in Appendix B. In most cases, the parameter estimates are not significantly different from those obtained using two-stage least squares (2SLS), lending some credibility to the structural specification of the equations.

Empirical Specifications and Results

Variables used in the final model specifications are discussed in this section, along with two-stage least squares estimation results for each equation. Attention is focused primarily on variables included in the equations and signs of the estimated coefficients, and to a lesser degree on performance criteria and hypothesis tests.

The aggregate supply and demand equations for corn, wheat, sorghum, barley, oats, soybeans, and cotton are estimated empirically using annual data from 1950 to 1990. Although several of the data series used existed prior to 1950, several inconsistencies (in the data), which could not be explained prior to 1950, have resulted in estimation of the time period chosen for this analysis.

The empirical equations are provided in tables throughout this section. T-values are reported in parentheses below the estimated coefficients. Also, both adjusted R-square and Durbin-Watson statistics are reported for each equation.

Potential Supply Equations

Potential supply equations, consisting of planted area, harvested yield, and cropland available, include variables representing input and output prices. A composite net return variable is often used as a proxy variable for input and output prices in the supply equations. Composite net returns may incorporate nonparticipant and participant net returns. In some cases, participant net returns may impact potential supply differently than nonparticipant net returns. Nonparticipant net returns (NPNRET) or market net returns for a given commodity in a specific year are calculated as:

NPNRET = Market returns - Production Expenses,

where Market returns is average farm price times production, and Production expenses are total or variable production expenses per acre times acres planted.[1] Total production expenses include fixed and variable expenses reported by USDA after 1973. As explained in the previous section, extrapolation of the cost series was performed to obtain estimates prior to 1974.

Participant net returns (PNRET) for a given commodity in a specific year are calculated as:

PNRET = Market returns + Government benefits - Production expenses - Conserving use expenses,

where Market returns and Production expenses are defined above, Government benefits include deficiency payments after 1974 and support payments before 1974, and Conserving use expenses are applied to government idled area and generally based on a percentage of variable production expenses.[2] Net return variables for participants and nonparticipants (or

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[1] In most cases, only variable expenses were used, while in a few cases total expenses were applied. This is explained further in the next section.

[2] Calculation of conserving use expenses vary by commodity, based on ERS Background reports for 1990 Farm Legislation (ERS, UDSA). Deficiency payments replaced "support" payments in 1974.

market returns) are deflated and calculated on a per bushel basis (see Table 2 and Table 3). These net return variables are applied in various potential supply equations. Detailed derivations of the calculated variables used in the supply equations, and throughout this chapter, are provided in Appendix B.

Planted Area

The primary reason for estimating a planted area equation is so that input and output prices (or net returns) can be incorporated in the yield equation, and so that planted area can be estimated instead of exogenously determined when used in forecasting excess capacity.[3] Also, planted area is a policy variable, important in determining expected crop production (White et al.)

The estimated total area planted equations are provided in table 4 for each commodity, and specified variables defined in table 5. Signs of the estimated coefficients are consistent with expectations.

For wheat, corn, oats, sorghum, soybeans, and cotton, only variable expenses are used to calculate expected net returns.[4] For barley, the ratio of average barley price

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[3] In preliminary testing, real input and output prices, if included directly in the yield equation, were not significant and provided intuitively incorrect signs on the estimated coefficients for most of the equations.

[4] In preliminary analysis, use of total expenses results in incorrect signs on the coefficients and were not significant at 5 percent level.

TABLE 2

NOMINAL NET RETURNS (DOLLARS PER BUSHEL)

YEAR	BARLEY MARKET	BARLEY PARTIC.	WHEAT MARKET	WHEAT PARTIC.	SOYBEANS MARKET	COTTON MARKET	COTTON PARTIC.
1950	0.57	0.57	0.45	0.45	0.97	10.89	10.89
1951	0.59	0.56	0.16	0.16	0.99	4.80	4.80
1952	0.72	0.71	0.60	0.60	0.97	2.61	2.61
1953	0.56	0.55	0.43	0.43	0.80	4.96	4.96
1954	0.48	0.48	0.60	0.60	0.75	9.13	9.13
1955	0.30	0.29	0.51	0.51	0.58	12.11	12.11
1956	0.38	0.37	0.52	0.52	0.66	10.29	9.86
1957	0.28	0.27	0.64	0.64	0.61	7.14	5.70
1958	0.34	0.34	0.78	0.78	0.58	14.30	12.07
1959	0.19	0.19	0.45	0.45	0.50	12.13	12.13
1960	0.23	0.22	0.68	0.68	0.65	9.73	9.73
1961	0.30	0.29	0.65	0.65	0.90	11.88	11.88
1962	0.33	0.21	0.84	0.80	0.88	11.55	11.55
1963	0.29	0.20	0.60	0.64	1.05	14.05	14.05
1964	0.42	0.26	0.19	0.49	1.03	12.47	13.01
1965	0.55	0.39	0.14	0.47	1.04	10.99	11.95
1966	0.52	0.37	0.42	0.89	1.23	-0.38	7.80
1967	0.49	0.48	0.07	0.55	0.89	0.50	14.21
1968	0.43	0.41	0.03	0.51	0.93	1.88	12.54
1969	0.38	0.22	0.07	0.57	0.80	-4.51	12.17
1970	0.43	0.29	0.13	0.67	1.22	-5.11	13.14
1971	0.45	0.42	0.18	0.68	1.36	-0.49	14.85
1972	0.61	0.54	0.45	0.84	2.61	0.94	12.51
1973	1.41	1.43	2.47	2.66	3.67	16.01	27.41
1974	1.89	1.73	2.15	2.15	3.94	2.78	2.85
1975	1.56	1.42	1.67	1.67	2.50	8.89	8.94
1976	1.45	1.36	0.79	0.79	4.26	22.41	22.43
1977	0.99	1.13	0.47	0.96	3.46	12.53	12.53
1978	1.01	1.07	0.98	1.29	3.95	7.71	7.57
1979	1.23	1.14	1.69	1.66	3.53	16.92	16.92
1980	1.49	1.37	1.42	1.42	3.72	9.71	9.71
1981	1.23	1.22	0.84	0.99	2.37	-1.64	4.59
1982	0.98	1.02	0.69	0.83	2.22	-4.40	4.03
1983	1.23	1.21	0.53	0.57	3.39	-0.74	3.63
1984	1.10	1.12	0.51	0.74	1.56	0.43	9.95
1985	0.69	0.90	0.70	1.24	2.14	1.86	13.81
1986	0.47	0.91	0.10	1.64	2.02	-11.21	13.89
1987	0.75	1.11	0.43	1.84	3.04	16.45	28.48
1988	1.04	0.71	1.15	1.64	3.61	1.58	16.51
1989	1.09	0.82	0.88	1.01	2.26	6.61	17.81
1990	1.01	0.78	0.34	1.14	2.54	10.44	14.81

TABLE 2 (CONTINUED)

NOMINAL NET RETURNS (DOLLARS PER BUSHEL)

YEAR	CORN MARKET	CORN PARTIC.	SORGHUM MARKET	SORGHUM PARTIC.	OATS MARKET	OATS PARTIC.
1950	0.50	0.50	0.24	0.24	0.47	0.47
1951	0.48	0.48	0.20	0.20	0.48	0.48
1952	0.48	0.48	0.13	0.13	0.42	0.42
1953	0.44	0.44	-0.07	-0.07	0.35	0.35
1954	0.62	0.62	0.18	0.18	0.37	0.37
1955	0.33	0.33	-0.23	-0.23	0.28	0.28
1956	0.29	0.29	-0.09	-0.09	0.29	0.29
1957	0.22	0.22	0.27	0.27	0.26	0.26
1958	0.30	0.30	0.42	0.42	0.29	0.29
1959	0.20	0.20	0.29	0.29	0.28	0.28
1960	0.17	0.17	0.32	0.32	0.29	0.29
1961	0.37	0.37	0.54	0.74	0.28	0.28
1962	0.39	0.39	0.54	0.72	0.29	0.29
1963	0.41	0.48	0.49	0.64	0.28	0.28
1964	0.38	0.45	0.50	0.79	0.28	0.28
1965	0.49	0.57	0.55	0.82	0.31	0.31
1966	0.53	0.64	0.60	0.84	0.30	0.30
1967	0.37	0.46	0.52	0.66	0.33	0.33
1968	0.40	0.51	0.49	0.68	0.28	0.28
1969	0.49	0.62	0.60	0.84	0.25	0.25
1970	0.52	0.66	0.61	0.88	0.24	0.24
1971	0.38	0.54	0.52	0.67	0.23	0.23
1972	0.89	1.10	0.88	1.16	0.26	0.26
1973	1.72	1.88	1.57	1.74	0.66	0.66
1974	1.79	1.79	1.89	1.89	0.94	0.94
1975	1.44	1.44	1.50	1.50	0.86	0.86
1976	1.11	1.11	1.23	1.23	0.93	0.93
1977	0.98	0.98	1.08	1.26	0.54	0.54
1978	1.27	1.28	1.18	1.41	0.42	0.42
1979	1.45	1.45	1.50	1.56	0.47	0.47
1980	1.61	1.61	1.55	1.55	0.55	0.55
1981	1.13	1.13	1.16	1.43	0.69	0.69
1982	1.22	1.26	1.27	1.33	0.38	0.38
1983	1.36	1.36	1.30	0.91	-0.22	-0.21
1984	1.24	1.45	1.10	1.27	0.48	0.48
1985	0.94	1.22	0.98	1.17	0.16	0.18
1986	0.38	1.13	0.49	1.04	-0.20	-0.13
1987	0.85	1.67	0.84	1.54	-0.35	-0.30
1988	0.86	1.27	1.31	1.65	-0.22	-0.20
1989	1.08	1.52	0.70	1.23	-0.10	-0.10
1990	1.05	1.36	0.85	1.29	-0.30	-0.28

TABLE 3

REAL NET RETURNS (DOLLARS PER BUSHEL)

YEAR	BARLEY MARKET	BARLEY PARTIC.	WHEAT MARKET	WHEAT PARTIC.	SOYBEANS MARKET	COTTON MARKET	COTTON PARTIC.
1950	0.02	0.02	0.02	0.02	0.04	0.46	0.46
1951	0.02	0.02	0.01	0.01	0.04	0.19	0.19
1952	0.03	0.03	0.02	0.02	0.04	0.10	0.10
1953	0.02	0.02	0.02	0.02	0.03	0.19	0.19
1954	0.02	0.02	0.02	0.02	0.03	0.35	0.35
1955	0.01	0.01	0.02	0.02	0.02	0.45	0.45
1956	0.01	0.01	0.02	0.02	0.02	0.37	0.35
1957	0.01	0.01	0.02	0.02	0.02	0.25	0.20
1958	0.01	0.01	0.03	0.03	0.02	0.48	0.41
1959	0.01	0.01	0.01	0.01	0.02	0.40	0.40
1960	0.01	0.01	0.02	0.02	0.02	0.31	0.31
1961	0.01	0.01	0.02	0.02	0.03	0.38	0.38
1962	0.01	0.01	0.03	0.03	0.03	0.36	0.36
1963	0.01	0.01	0.02	0.02	0.03	0.43	0.43
1964	0.01	0.01	0.01	0.01	0.03	0.38	0.40
1965	0.02	0.01	0.00	0.01	0.03	0.33	0.35
1966	0.01	0.01	0.01	0.03	0.04	-0.01	0.22
1967	0.01	0.01	0.00	0.02	0.02	0.01	0.40
1968	0.01	0.01	0.00	0.01	0.02	0.05	0.33
1969	0.01	0.01	0.00	0.01	0.02	-0.11	0.31
1970	0.01	0.01	0.00	0.02	0.03	-0.12	0.31
1971	0.01	0.01	0.00	0.02	0.03	-0.01	0.33
1972	0.01	0.01	0.01	0.02	0.06	0.02	0.27
1973	0.03	0.03	0.05	0.05	0.07	0.32	0.55
1974	0.03	0.03	0.04	0.04	0.07	0.05	0.05
1975	0.03	0.03	0.03	0.03	0.04	0.15	0.15
1976	0.02	0.02	0.01	0.01	0.07	0.36	0.36
1977	0.01	0.02	0.01	0.01	0.05	0.19	0.19
1978	0.01	0.02	0.01	0.02	0.05	0.11	0.10
1979	0.02	0.02	0.02	0.02	0.04	0.22	0.22
1980	0.02	0.02	0.02	0.02	0.04	0.11	0.11
1981	0.01	0.01	0.01	0.01	0.03	-0.02	0.05
1982	0.01	0.01	0.01	0.01	0.02	-0.04	0.04
1983	0.01	0.01	0.01	0.01	0.03	-0.01	0.03
1984	0.01	0.01	0.00	0.01	0.01	0.00	0.09
1985	0.01	0.01	0.01	0.01	0.02	0.02	0.12
1986	0.00	0.01	0.00	0.01	0.02	-0.10	0.12
1987	0.01	0.01	0.00	0.02	0.03	0.14	0.24
1988	0.01	0.01	0.01	0.01	0.03	0.01	0.14
1989	0.01	0.01	0.01	0.01	0.02	0.05	0.14
1990	0.01	0.01	0.00	0.01	0.02	0.08	0.11

TABLE 3 (CONTINUED)

REAL NET RETURNS (DOLLARS PER BUSHEL)

YEAR	CORN MARKET	CORN PARTIC.	SORGHUM MARKET	SORGHUM PARTIC.	OATS MARKET	OATS PARTIC.
1950	0.02	0.02	0.01	0.01	0.02	0.02
1951	0.02	0.02	0.01	0.01	0.02	0.02
1952	0.02	0.02	0.00	0.00	0.02	0.02
1953	0.02	0.02	-0.00	-0.00	0.01	0.01
1954	0.02	0.02	0.01	0.01	0.01	0.01
1955	0.01	0.01	-0.01	-0.01	0.01	0.01
1956	0.01	0.01	-0.00	-0.00	0.01	0.01
1957	0.01	0.01	0.01	0.01	0.01	0.01
1958	0.01	0.01	0.01	0.01	0.01	0.01
1959	0.01	0.01	0.01	0.01	0.01	0.01
1960	0.01	0.01	0.01	0.01	0.01	0.01
1961	0.01	0.01	0.02	0.02	0.01	0.01
1962	0.01	0.01	0.02	0.02	0.01	0.01
1963	0.01	0.01	0.01	0.02	0.01	0.01
1964	0.01	0.01	0.02	0.02	0.01	0.01
1965	0.01	0.02	0.02	0.02	0.01	0.01
1966	0.02	0.02	0.02	0.02	0.01	0.01
1967	0.01	0.01	0.01	0.02	0.01	0.01
1968	0.01	0.01	0.01	0.02	0.01	0.01
1969	0.01	0.02	0.02	0.02	0.01	0.01
1970	0.01	0.02	0.01	0.02	0.01	0.01
1971	0.01	0.01	0.01	0.02	0.01	0.01
1972	0.02	0.02	0.02	0.02	0.01	0.01
1973	0.03	0.04	0.03	0.04	0.01	0.01
1974	0.03	0.03	0.03	0.03	0.02	0.02
1975	0.02	0.02	0.03	0.03	0.01	0.01
1976	0.02	0.02	0.02	0.02	0.01	0.01
1977	0.01	0.01	0.02	0.02	0.01	0.01
1978	0.02	0.02	0.02	0.02	0.01	0.01
1979	0.02	0.02	0.02	0.02	0.01	0.01
1980	0.02	0.02	0.02	0.02	0.01	0.01
1981	0.01	0.01	0.01	0.02	0.01	0.01
1982	0.01	0.01	0.01	0.01	0.00	0.00
1983	0.01	0.01	0.01	0.01	-0.00	-0.00
1984	0.01	0.01	0.01	0.01	0.00	0.00
1985	0.01	0.01	0.01	0.01	0.00	0.00
1986	0.00	0.01	0.00	0.01	-0.00	-0.00
1987	0.01	0.01	0.01	0.01	-0.00	-0.00
1988	0.01	0.01	0.01	0.01	-0.00	-0.00
1989	0.01	0.01	0.01	0.01	-0.00	-0.00
1990	0.01	0.01	0.01	0.01	-0.00	-0.00

TABLE 4

TOTAL AREA PLANTED ESTIMATION RESULTS BY CROP USING TWO-STAGE LEAST SQUARES, 1950-1990

$$WTPLT_t = .6844\ E5 + .3665\ E6\ *WTMKTRT1 - .1029\ E5\ *WTPNRET + .9802\ E6\ *BYPNRET$$

(32.17) (4.39) (-8.05) (10.86)

$$+ .1654\ E5 * DUMS80 - .4355\ E3 * WTACRDVT$$

(8.88) (-4.64)

Adj.R^2= .90 D.W.= 1.91

$$CNPLT_t = .8374\ E5 + .1833\ E6\ *CNNPNRET_t - .2763\ E6\ *WTNPNRET_t - .7364\ E3\ *CNACRDVT_t$$

(87.95) (2.85) (-6.28) (-20.44)

Adj.R^2= .92 D.W.= 1.22

$$SBPLT_t = .2283\ E4 + .8619\ E3\ *SBRTTMA3 + .6227\ E0 * SBPLT_{t-1} + .3054\ E0\ *SBPLT_{t-2}$$

(1.62) (1.67) (4.84) (2.54)

$$+ .6992\ E4\ *DUM78 + .8001\ E4\ *DUM73$$

(2.26) (2.61)

Adj.R^2= .98 D.W.= 2.27

$$SGPLT_t = .9645\ E4 + .9426\ E5\ *SGNPNRET_t - .5152\ E3\ *SGACRDVT_t - .6505\ E5\ *WTNPNRET_t$$

(3.19) (1.48) (-2.92) (-1.35)

$$- .2633\ E4\ *DUMS74 + .5281\ E4\ *DUM55 - .5495\ E0\ SGPLT_{t-1}$$

(-2.69) (2.02) (3.59)

Adj.R^2= .58 D.W.= 1.97

TABLE 4 (Continued)

$$OTPLT_t = .1799\ E4 + .1135\ E6\ {*}OTMKTRT1_t - .1157\ E6\ {*}SGNPNRET_t + .7515\ E4\ {*}DUM83$$

(1.05) (0.99) (-1.70) (3.14)

$$+ .9127\ E0\ {*}OTPLT_{t-1}$$

(14.77)

Adj.R^2= .96 D.W.= 1.99

$$CTPLT_t = .7613\ E4 - .6019\ E3\ {*}CTARPPLD_t - .4758\ E4\ {*}DUM75 - .5302\ E3\ {*}CTMKTRT1_t$$

(9.45) (-6.21) (-4.79) (-0.45)

$$+ .4230\ E0\ {*}CTPLT_{t-1}$$

(6.42)

Adj.R^2= .86 D.W.= 2.16

$$BYPLT_t = .5265\ E4 - .4044\ E3\ {*}BYACRDVT + .3530\ E5\ {*}BYWTPRC6 + .6814\ E0\ {*}BYPLT_{t-1}$$

(3.42) (-3.69) (1.21) (7.05)

$$- .4537\ E5\ {*}SBRETMA1$$

(-2.86)

Adj. R^2= .81 D.W.= 2.19

TABLE 5

VARIABLE DESCRIPTIONS AND SOURCES FOR TOTAL AREA PLANTED EQUATIONS

Variable	Description	Source
BYACRDVT	Barley area diverted	FAPRI S&U
BYPLT	Barley area planted	Ag Stat
BYPNRET	Barley participant net returns	ERS
BYWTPRC6	Barley - Wheat price ratio	Calculated
CNACRDVT	Corn area diverted	FAPRI S&U
CNNPNRET	Corn nonparticipant net returns	ERS
CNPLT	Corn area planted	Ag Stat
CTARPPLD	Cotton area diverted	FAPRI S&U
CTMKTRT1	Cotton net market returns	Calculated
CTPLT	Cotton area planted	Ag Stat
DUM55	Dummy variable for year=1955	Calculated
DUM73	Dummy variable for year=1973	Calculated
DUM75	Dummy variable for year=1975	Calculated
DUM78	Dummy variable for year=1978	Calculated
DUM83	Dummy variable for year=1983	Calculated
DUMS74	Shift variable for year>=1974	Calculated
DUMS80	Shift variable for year>=1980	Calculated
OTMKTRT1	Oat net market returns	Calculated
OTPLT	Oat area planted	Ag Stat
SBPLT	Soybean area planted	Ag Stat
SBRETMA1	Soybean moving-average net returns	ERS
SBRTTMA3	Soybean moving-average net returns	ERS
SGACRDVT	Sorghum area diverted	FAPRI S&U
SGNPNRET	Sorghum nonparticipant net returns	ERS
SGPLT	Sorghum area planted	Ag Stat
WTACRDVT	Wheat area diverted	FAPRI S&U
WTMKTRT1	Wheat net market returns	Calculated
WTPNRET	Wheat participant net returns	ERS
WTPLT	Wheat area planted	Ag Stat
WTNPNRET	Wheat nonparticipant net returns	ERS

received by farmers over the average wheat price received by farmers is deflated and used in the planted area equation. Barley, produced mainly in the Northern Midwest States, often competes with wheat for cropland (Hoffman et al.).

Net returns and prices were deflated to remove the effects of inflation. The Implicit GDP Price Deflator, adjusted for the appropriate crop year, was used.[5] Substitution among crop area planted to alternative crops is reflected in net returns of competing crops. The coefficient is negative for returns of competing crops, as expected.

Weather or policy-related events causing significant variations in plantings for some years were captured in various dummy variables.[6] The use of dummy variables is often undesirable, but it is necessary to obtain reasonable coefficient estimates for the variables of primary interest in the planted area equations for soybeans, sorghum, oats, and cotton. Significant structural changes in the time series, such as expanded output in the mid 1970s, were represented by the use of shift variables in the planted area equations for wheat and sorghum.

Government idled area includes required and voluntary annual set aside acreage (eg. ARP, PLD and 0-92), and long

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[5] Equation 15 was used to make the price index consistent over time.

[6] Most of the variation in plantings is related to rainfall or temperature at the time of planting the commodity. An alternative approach, to reduce the number of proxies used and to increase the variation in planted area explained by the model, would be to include time and location specific weather variables explicitly in the planted area equation.

term idled acreage (eg. Soil Bank and CRP). Variables representing government idled area explain area planted for wheat, corn, sorghum, cotton, and barley. The sign on the coefficient is negative, as expected. The annual adjustment in planted area is explained by lagged dependent variables in most equations. The predicted values for total planted area are used as right-hand side variables in some of the yield and cropland available equations.

Harvested Yields

Tables 6 and Table 7 present a summary of the results of the harvested yield equations, and define the variables used. Yields are positively related to the number of acres idled under government programs in the wheat, corn, and sorghum equations. This indicates that national average yields on harvested area increase as marginal acreage diverted in government programs increases for these commodities. Government idled area includes acreage diverted in the annual set-aside program and in the voluntary paid land diversion (PLD) program. Government idled area was not found to explain average cotton, barley and oats yields. No government income support programs exist for soybeans, but soybean area retired in the Conservation Reserve Program is used as a proxy for soybean acreage idled. Since soybean base acres were not recorded at signup in the CRP, it was assumed that 50 percent of the non-base acres from the major soybean producing areas enrolled for a given crop year are attributable to soybean

TABLE 6

HARVESTED YIELD ESTIMATION RESULTS BY CROP USING TWO-STAGE LEAST SQUARES, 1950-1990

$$WTYLD_t = -.1121\text{ E3} + .3338\text{ E2 } {*}LNYEAR50 + .1253\text{ E0 } {*}WTARPPLD_t - .2070\text{ E-4 } {*}WTPLT_t$$

(-10.90) (12.18) (2.40) (-0.60)

Adj. R^2 = .90 D.W. = 1.66

$$CNYLD_t = -.4915\text{ E1} + .7246\text{ E0 } {*}PRDLINDX_t + .5373\text{ E0 } {*}CNARPPLD_t - .1420\text{ E2 } {*}DUMS80$$

(-0.15) (13.76) (1.89) (-3.11)

$$+ .3604\text{ E-3 } {*}CNPLT_t$$

(0.89)

Adj. R^2 = .91 D.W. = 1.84

$$SBYLD_t = .1861\text{ E2} + .9273\text{ E-1 } {*}PRDLINDX_t - .3796\text{ E1 } {*}SBMDUM_t + .2547\text{ E-4 } {*}SBPLT_t$$

(27.74) (3.74) (-4.59) (0.52)

$$- .1470\text{ E0 } {*}SBACRP_t$$

(-0.36)

Adj. R^2 = .87 D.W. = 1.65

$$SGYLD_t = -.2309\text{ E1} + .9217\text{ E-3 } {*}SGPLT_t + .2393\text{ E1 } {*}SGARPPLD_t + .3655\text{ E0 } {*}PRDLINDX_t$$

(-0.32) (2.80) (7.34) (13.93)

Adj. R^2 = .87 D.W. = 1.40

$$CTYLD_t = .4627\text{ E3} + .1549\text{ E1 } {*}PRDLINDX_t - .8059\text{ E2 } {*}CTMDUM_t - .5964\text{ E-2 } {*}CTPLT_t$$

(7.31) (6.44) (-3.74) (-1.60)

Adj. R^2 = .69 D.W. = 1.23

TABLE 6 (Continued)

$$OTYLD_t = .6238\ E2 + .9330\ E1\ {*DUM85} - .6040\ E\text{-}3\ {*OTPLT_t}$$

(37.89) (2.19) (-9.95)

Adj.R^2= .74 D.W.= 1.79

$$BYYLD_t = -.2246\ E2 + .2025\ E2\ {*LNYEAR40} - .3181\ E\text{-}3\ {*BYPLT} -.1479\ E2\ {*DUM88} - .3615\ E1\ {*DUM61}$$

(-2.80) (11.98) (-1.23) (-4.96) (-1.20)

Adj.R^2= .89 D.W.= 1.19

TABLE 7

VARIABLE DESCRIPTIONS AND SOURCES FOR HARVESTED YIELD EQUATIONS

Variable	Description	Source
BYYLD	Barley harvested yield	Ag Stat
CNARPPLD	Corn area diverted	FAPRI S&U
CNYLD	Corn harvested yield	Ag Stat
CTMDUM	Cotton yield dummy	Calculated
CTYLD	Cotton harvested yield	Ag Stat
DUM61	Dummy variable for year=1961	Calculated
DUM85	Dummy variable for year=1985	Calculated
DUM88	Dummy variable for year=1988	Calculated
DUMS80	Shift variable for year>=1980	Calculated
LNYEAR40	Trend variable	Calculated
LNYEAR50	Trend variable	Calculated
OTYLD	Oat harvest yield	Ag Stat
PRDLINDX	Productivity index	Ag Stat
SBACRP	Soybean CRP area	FAPRI S&U
SBMDUM	Soybean yield dummy	Calculated
SBYLD	Soybean harvested yield	Ag Stat
SGARPPLD	Sorghum area diverted	FAPRI S&U
SGYLD	Sorghum harvested yield	Ag Stat
WTARPPLD	Wheat area diverted	FAPRI S&U
WTYLD	Wheat harvested yield	Ag Stat

area retired (Smith).

Yields are negatively related to area planted, except for corn, sorghum, and soybeans. For most commodities, increasing the area planted, means that more marginal land is brought into production, resulting in lower average yields. This is also likely the case for acres planted to corn, sorghum, and soybeans, but other factors, such as changes in net returns and fallowed area, counter this effect.

In preliminary analysis, target prices were tested in the yields equations, but found to have little relationship with yields, partly due to the relatively recent separation of support price into loan rate and target price for most commodities.[7] Similarly, other variables representing policy provisions such as loan rates, were investigated.

In the yield equations, a productivity index or logarithmic trend was included as a proxy for technological progress and productivity gains. Trend variables are commonly used in applied modelling efforts, despite their weak theoretical underpinnings (Tweeten, FAPRI). In preliminary analysis, three trend variables were tested for explaining yields. These included a linear trend, a logarithmic trend, and a productivity index. A logarithmic trend, specified in the wheat and barley yield equations, indicates that yields have been increasing at a decreasing rate, assuming other factors remain fixed. A productivity index used in the corn,

[7] The target price system was implemented in 1974 for wheat, corn, sorghum, barley, and cotton, and in 1982 for oats.

soybeans, sorghum, and cotton equations implies that increases in yields are in line with productivity gains in agriculture.

To account for weather effects, a proxy is used. A dummy variable, taking on the value of one for year(s) of severe drought and zero otherwise, serves as a weather proxy in the cotton, soybean, oats and barley yield equations.[8]

Cropland Available

Annual cropland available was determined by summing harvested area and government idled area for each commodity. The physical capacity of potential agricultural cropland also includes fallowed and failed area, but these components are not available for crop production. Failed and fallowed area remain moderately constant over time (see Figures 12 thru 18). Full capacity production is assumed to represent the sum of harvested area, fallowed area, failed area, and diverted area. Thus, it is recognized that full capacity is not attainable for any given year, because failed and fallowed area are routinely idled by weather or physical cropland constraints.

In Figure 12 thru 18, government idled area includes cropland diversion programs such as, Acreage Reduction (ARP), Paid Land Diversion (PLD), 0-50/92, and Conservation Reserve (CRP). Fallowed and failed area was estimated by USDA on a regional level (ERS, USDA). To obtain commodity estimates of

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[8] As mentioned in the planted area equations, an alternative to using dummy variables to represent weather effects would be to use location-specific rainfall and temperature for critical periods of the growing season. However, this poses forecasting problems.

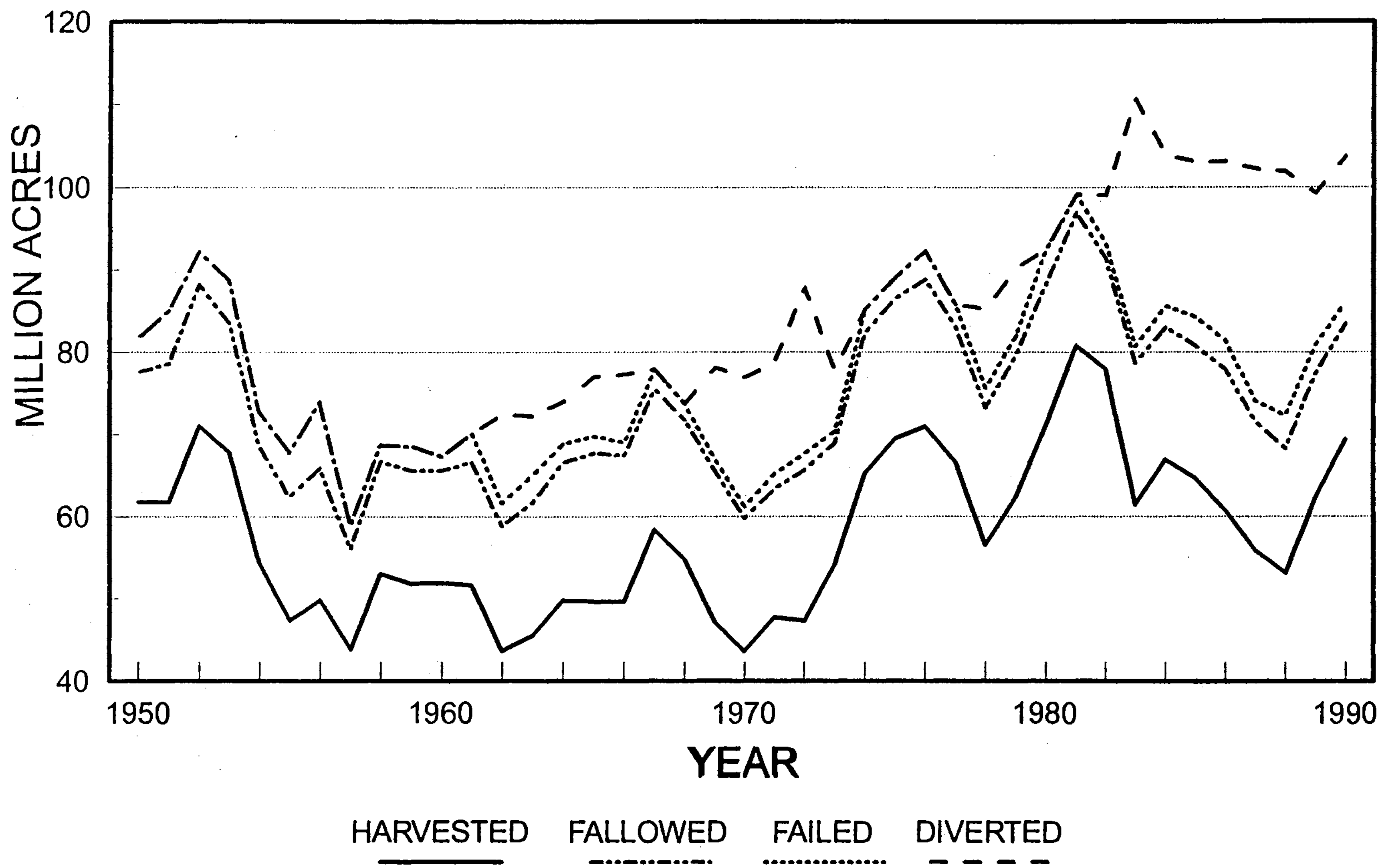

Figure 12. Potential Cropland Available for Wheat

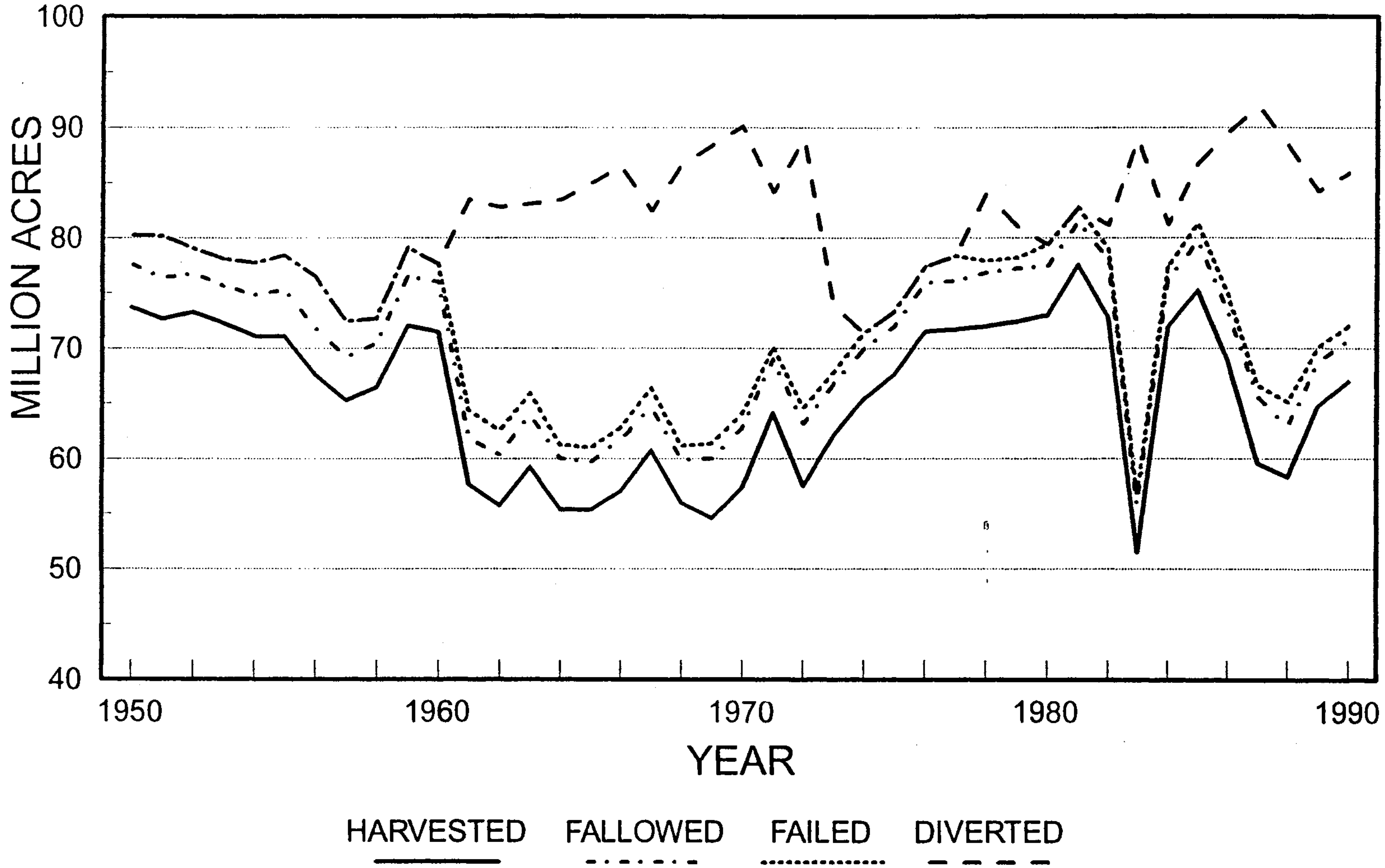

Figure 13. Potential Cropland Available for Corn

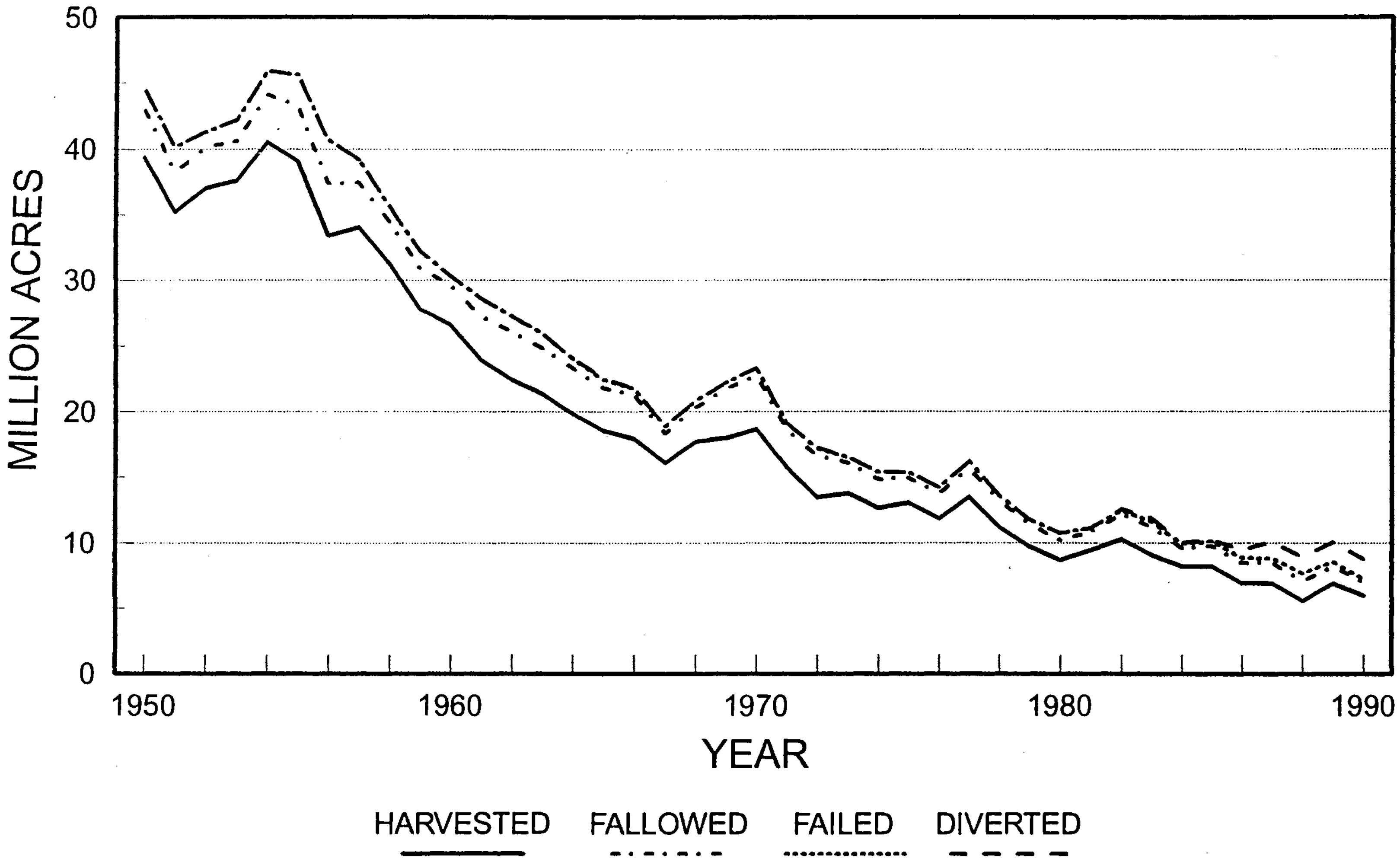

Figure 14. Potential Cropland Available for Oats

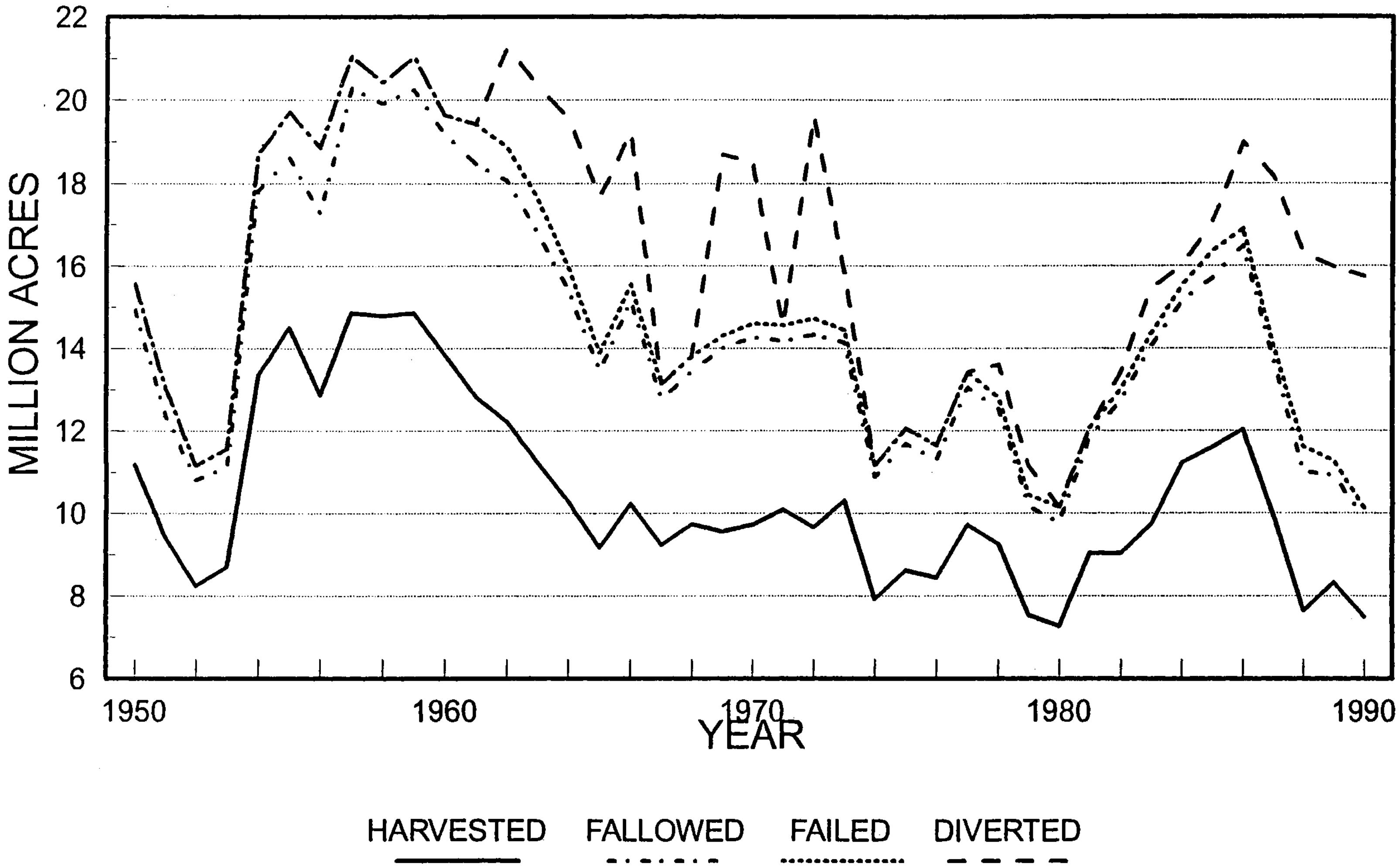

Figure 15. Potential Cropland Available for Barley

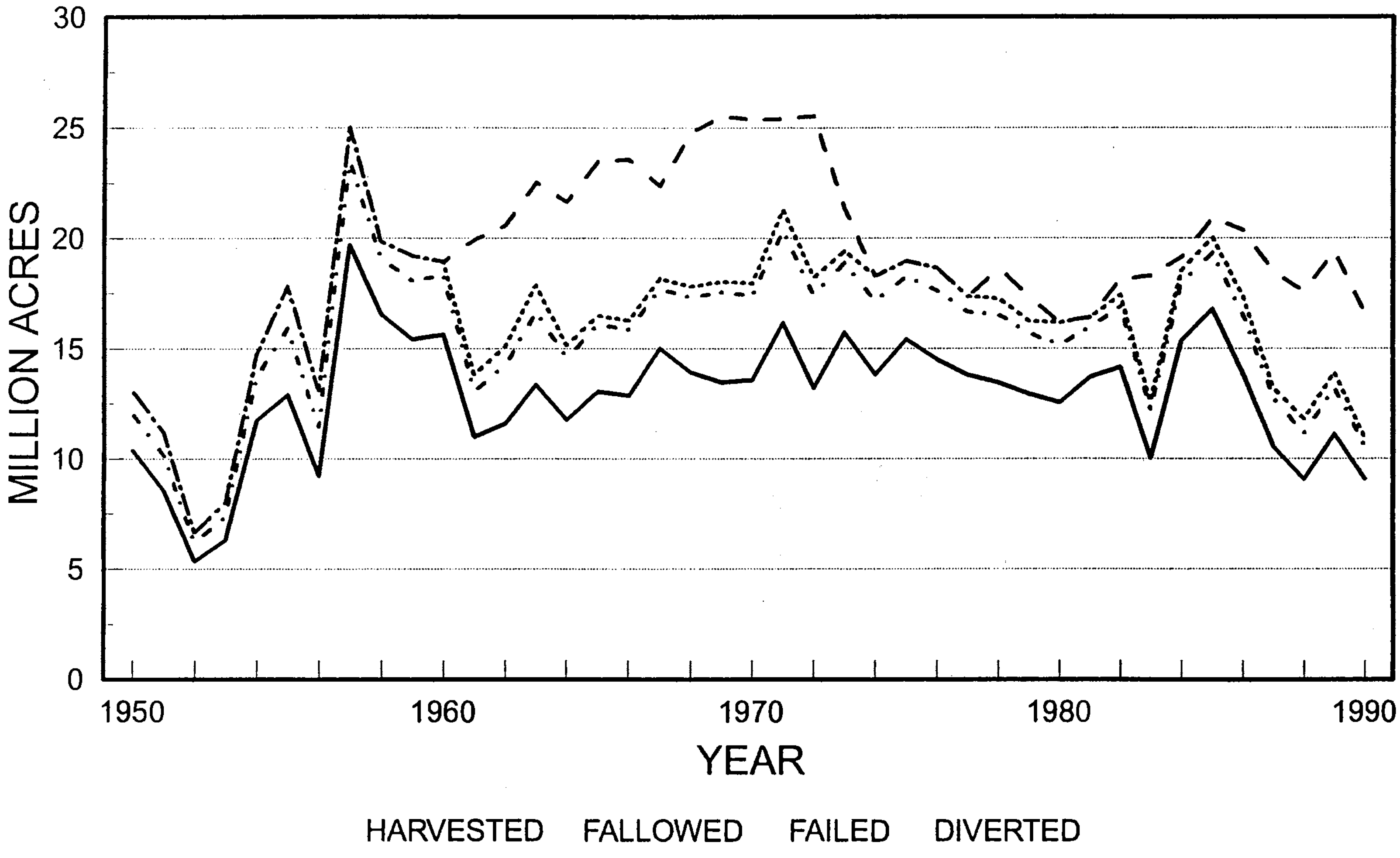

Figure 16. Potential Cropland Available for Sorghum

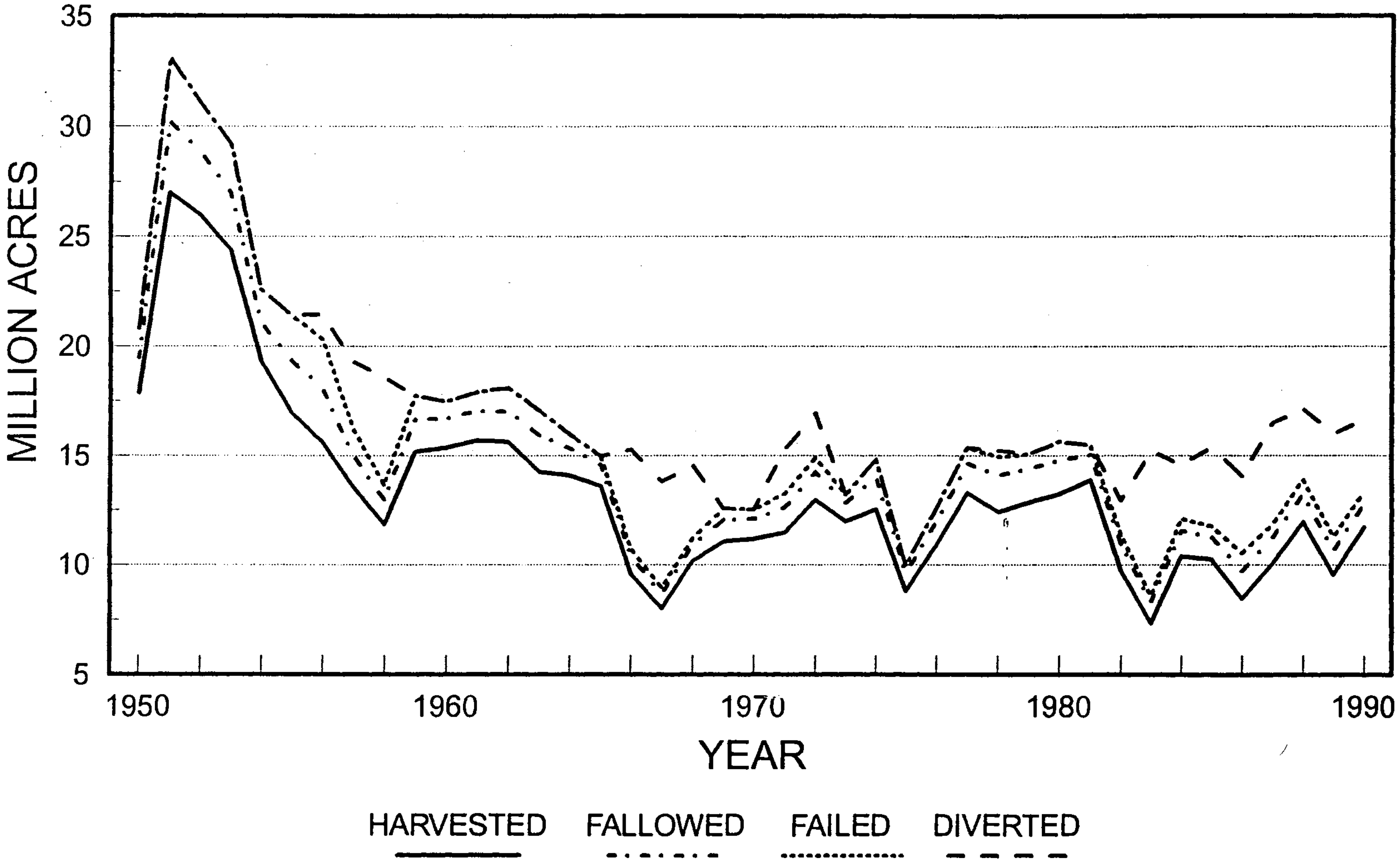

Figure 17. Potential Cropland Available for Cotton

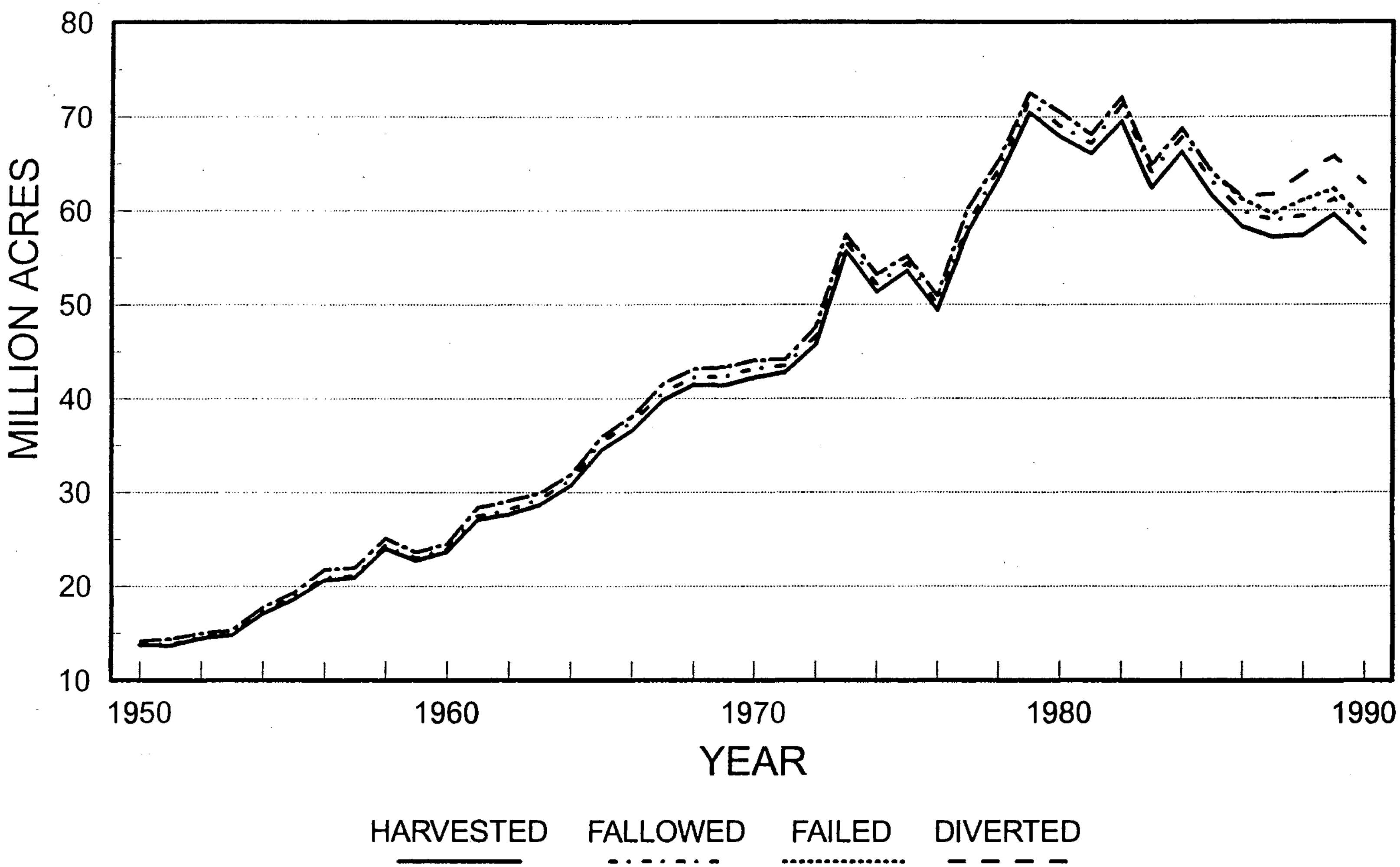

Figure 18. Potential Cropland Available for Soybeans

failed and fallowed area, regional estimates of failed and fallowed area were weighted by planted acres to each crop within a region.[9] The weighting of failed area by planted area may be under-estimated in drought years.

Cropland available, consisting of harvested and diverted area, has trended upwards over the past forty years for wheat, sorghum, and soybeans (see Figures 12 thru 18). Just the opposite has occurred for oats and cotton available cropland area. Land available for corn and barley has shown significant variability over time, possibly due to government policy and economic factors, such as commodity prices. Actual data on harvested, failed, fallowed, and diverted acres are provided in Appendix B (Table 50).

Table 8 illustrates the estimation results for the land available equations. Variable descriptions and sources are provided in table 9.

The specifications for the cropland available equations varied by commodity, in part because of the cross-commodity relationships in production and policy changes for specific crops. Returns from alternative cropland uses, such as forage, grazing and hunting may influence cropland available. However, data series serving as proxies for these uses were not found to explain cropland available for the seven crops

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9 More precise estimates can be obtained for failed area by taking the differences between planted and harvested area. If available, county or state-level estimates would also improve the accuracy of these estimates.

TABLE 8

CROPLAND AVAILABLE ESTIMATION RESULTS BY CROP USING TWO-STAGE LEAST SQUARES, 1950-1990

$WTLA_t$= -.6087 E5 + .3841 E0 $*WTPLT_t$ + .5294 E0 $*WTLA_{t-1}$ + .3057 E4 $*WTVDIVW_t$
(-2.68) (3.64) (4.33) (2.45)

+ .1758 E5 LNYEAR50
(2.72)

Adj.R^2= .89 D.W.= 2.39

$CNLA_t$= .6286 E5 - .1395 E0 $*CNLA1_{t-1}$ + .6294 E5 *CNRTT - .3450 E6 *RROTLPRC - .1743 E6 *WTSGRTT
(5.13) (2.34) (1.18) (-2.83) (-4.24)

Adj.R^2= .74 D.W.= 2.22

$SBLA_t$= .1365 E4 + .7113 E-1 $*SBLA_{t-1}$ - .3232 E5 $*RRWTLPRC_t$ + .9174 E0 *SBPLT
(1.42) (1.74) (-3.05) (21.36)

Adj.R^2= .99 D.W.= 0.60

$SGLA_t$= .7398 E4 + .4339 E0 $*SGLA_{t-1}$ + .3658 E0 $*SGPLT_t$ + .3596 E5 $*SGRTT_t$
(2.09) (2.54) (3.29) (1.44)

- .1008 E6 $*RRWTLPRIC_{t-1}$ - .1437 E4 *DUMS74
(-3.33) (-1.78)

Adj.R^2= .87 D.W.= 2.15

TABLE 8 (Continued)

$$CTLA_t = -.5690\text{ E5} + .5784\text{ E0} * CTLA1_{t-1} - .9392\text{ E5} * CNRTTMA1_t + .3727\text{ E4} * RRCTLSP2_{t-1}$$

(-1.19) (4.70) (-4.27) (2.76)

$$+ .2870\text{ E4} * LNYEAR_t$$

(2.96)

Adj.R^2= .69 D.W.= 2.41

$$OTLA_t = .6537\text{ E3} + .7470\text{ E0} * OTLA_{t-1} + .2475\text{ E7} * OTCOMPT1_t$$

(1.17) (8.89) (2.65)

Adj.R^2= .98 D.W.= 2.05

$$BYLA_t = .8596\text{ E4} + .1929\text{ E0} * BYLA1_{t-1} + .1344\text{ E5} * BYCOMPT1 - .6858\text{ E5} * SBRETMA1$$

(4.21) (1.17) (0.76) (-3.48)

$$+ .2863\text{ E0} * BYPLT_{t-1}$$

(1.93)

Adj.R^2= .61 D.W.= 2.25

TABLE 9

VARIABLE DESCRIPTIONS AND SOURCES FOR CROPLAND AVAILABLE EQUATIONS

Variable	Description	Source
BYCOMPV1	Composite barley returns	Calculated
BYLA	Barley cropland available	Calculated
BYRSPRIC	Barley support price	Calculated
CNLA	Corn cropland available	Calculated
CNRTT	Corn net returns	ERS
CNRTTMA1	Corn moving average net returns	ERS
CTLA	Cotton cropland available	Calculated
DUMS74	Shift variable for year>=1974	Calculated
LGYEAR49	Trend variable	Calculated
LNYEAR	Trend variable	Calculated
LNYEAR50	Trend variable	Calculated
OTCOMPT1	Composite oat returns	Calculated
OTLA	Oat cropland available	Calculated
RRCTLSP2	Cotton spot price	ERS
RROTLPRC	Oat price last year	Ag Stat
RRWTLPRC	Wheat price last year	Calculated
SBLA	Soybean cropland available	Calculated
SBRETMA1	Composite soybean net returns	ERS
SGLA	Sorghum cropland available	Calculated
SGRTT	Composite sorghum net returns	ERS
WTLA	Wheat cropland available	Calculated
WTSGRTT	Net returns for competing crops with corn	ERS
WTVDIVW	Wheat voluntary diversion pymt. rate	Calculated

analyzed.[10]

Expected net returns from the production of alternative crops explain the land available for production of those crops. Producers' decisions are generally based on expected prices and net returns, but may also be based on previous years' returns and prices. Composite net returns for corn and sorghum are defined as the sum of expected participant and nonparticipant net returns for these commodities in the land available for corn and sorghum equations, respectively. Own-composite net returns for corn and soybeans are defined as the average of expected participant and non-participant net returns, respectively, in the current year and the two previous years. This (moving-average) composite return variable is used in the cropland available equation for cotton and barley. The sum of expected participant and nonparticipant net returns for wheat and sorghum represent competing crop returns for corn.

Lagged competing and own prices were used in the cropland available equations for corn, sorghum, cotton and soybeans. For example, last year's oat prices were used to explain cropland available for corn. For the soybeans cropland available equation, composite returns for soybeans are defined as the sum of last year's average farm price for soybeans and the current loan rate. In the oats and barley cropland

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[10] Relevant data series for hay prices, hay production, livestock numbers and livestock prices were tested. Cash rent estimates on a national level were not available before the 1987 Census of Agriculture, and were estimated by states, not by crops.

available equations, a net returns variable was constructed by dividing the sum of last year's average farm price and the current loan rate by variable production expenses.

Government program provisions, such as payments for acreage diversions, may also influence cropland available (Moe, Whittaker, and Oliveira). Government payments from voluntary land diversions of wheat, weighted by the program participation rate, explained land available for the production of wheat. Various trend or shift variables were also employed to capture the overall changes in cropland available. Primarily, these variables represent changes in harvested area over time. These trend variables are incorporated in the land available equations for wheat, sorghum, cotton and soybeans.

The adjustment process in cropland available over time is best explained by a lagged dependent variable. Since area planted influences area harvested, and indirectly cropland available, area planted to wheat, barley, sorghum and soybeans was found to explain cropland available for these crops.

Aggregate Demand Equations

Total aggregate demand for each commodity in this study is aggregated from domestic demand and export demand. Disaggregation was performed if data was available for specific commodity uses. For feed grains (ie. corn, sorghum, barley and oats), domestic demand is aggregated from feed demand and non-feed demand, which consists of food, seed, industrial and other domestic uses.[11] Feed demand is also estimated for soybean meal. Food and industrial uses are relatively small for these grains. Since food and beverage use generally dominates the non-feed demand component, they are expressed in per capita terms.

For cotton the primary domestic use is in textile production. For soybean oil, domestic use consists mainly of industrial and food products. And the principle domestic use for wheat is food consumption. Aggregate domestic demand equations for cotton, soybean oil and wheat are estimated in per capita terms. Table 10 illustrates the major domestic uses of wheat, corn, sorghum, soybeans, barley, oats, cotton, soybean meal, and soybean oil. Each use is estimated empirically in this chapter. Relevant prices are deflated by either the Consumer Price Index or the Implicit GDP Price Deflator, depending on the demand being estimated.

Feed Demand

Feed demand is a major component of domestic use for feed grains and soybean meal (Table 10). Competition among feed ingredients for livestock and poultry depends on relative prices and relative feed values (on pound for pound and bushel for bushel basis).

Own-commodity prices and competing commodity prices are included in the final feed equation specifications (Table 11).

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[11] Typically a "residual" category is also included in the aggregate data.

TABLE 10

AVERAGE DOMESTIC USES OF 7 MAJOR U.S. COMMODITIES, 1950–90

Commodity	1950–55	1956–60	1961–65	1966–70	1971–75	1976–80	1981–85	1986–90
			(Million Bushels)					
WHEAT								
AGGREGATE DOMESTIC USE	633.8	588.0	628.9	717.1	760.0	803.2	1015.4	1125.8
CORN								
FEED	2390.7	2766.0	3139.2	3576.4	3841.0	4077.8	94184.4	4493.2
FOOD,SEED, RESIDUAL	251.3	279.4	337.2	367.0	470.2	606.0	947.6	1296.4
SORGHUM								
FEED AND RESIDUAL	116.0	299.4	450.8	612.8	588.4	442.8	502.0	495.6
FOOD, SEED, INDUSTRIAL	14.5	12.6	12.4	12.0	11.4	11.4	15.2	17.6
BARLEY								
FEED AND RESIDUAL	162.5	233.5	238.0	244.4	225.6	185.4	270.8	225.0
FOOD, ALCOHOL, SEED	112.4	113.2	110.2	124.2	142.0	169.6	171.4	172.8
OATS								
FEED AND RESIDUAL	1186.9	1062.3	827.8	737.2	652.4	493.0	454.8	297.8
FOOD AND SEED	143.6	129.7	110.8	99.8	89.8	77.8	75.8	99.8
SOYBEANS								
CRUSH	245.8	372.8	471.7	647.8	766.0	975.7	1040.7	1148.9
NON–CRUSH	24.1	35.7	49.5	57.7	74.1	86.1	85.2	93.7
SOYBEAN MEAL				(Thousand Short Tons)				
AGGREGATE DOMESTIC USE	5580.5	8285.6	9510.2	12029.2	13422.0	16971.4	18641.0	21261.0
SOYBEAN OIL				(Million Pounds)				
AGGREGATE DOMESTIC USE	2332.2	3115.0	4004.2	5685.0	7002.0	8546.0	9786.8	11242.6
COTTON				(Thousand Bales)				
AGGREGATE DOMESTIC USE	9298.8	8522.8	8930.0	8553.6	7059.2	6147.4	5479.2	7775.4

TABLE 11

FEED DEMAND ESTIMATION RESULTS FOR FEED GRAINS AND SOYBEAN MEAL USING TWO-STAGE LEAST SQUARES, 1950-1990

$$CNFEUSE_t = \underset{(-3.52)}{-.3230\text{ E4}} - \underset{(-2.74)}{.1341\text{ E5}} *RRCNPRIC + \underset{(2.31)}{.1718\text{ E3}} *RRSBMPRC + \underset{(7.67)}{.3616\text{ E-5}} *CTLOFED1 + \underset{(4.50)}{.4738\text{ E3}} *DUMS79$$

$Adj.R^2 = .91$ D.W.= 1.81

$$SBMUSE_t = \underset{(-19.04)}{-.8340\text{ E6}} + \underset{(2.71)}{.5997\text{ E-1}} *GRCONSN1_t + \underset{(3.55)}{.3819\text{ E4}} *RCTLPRIC_t - \underset{(-4.60)}{.9309\text{ E3}} *RRSBMPRC_t + \underset{(18.05)}{.4241\text{ E3}} *YEAR_t$$

$Adj.R_2 = .98$ D.W.= 1.81

$$SGFEUSE_t = \underset{(1.46)}{.9934\text{ E3}} - \underset{(-4.71)}{.5143\text{ E4}} *RRSGPRIC_t + \underset{(11.91)}{.5360\text{ E-1}} *CTLOFED3 - \underset{(-5.51)}{.1282\text{ E3}} *DUMS74$$

$Adj.R^2 = .87$ D.W.= 1.74

$$OTFEUSE_t = \underset{(1.39)}{.6936\text{ E2}} + \underset{(2.92)}{.2073\text{ E-1}} *MILKCOWS_t - \underset{(-4.55)}{.1505\text{ E5}} *RROTPRIC_t - \underset{(-1.77)}{.5155\text{ E2}} *TRND7186_t + \underset{(3.99)}{.6317\text{ E4}} *RRCNPRIC_t + \underset{(4.62)}{.6061\text{ E0}} *OTFEUSE_{t-1}$$

$Adj.R^2 = .97$ D.W.= 2.38

TABLE 11 (Continued)

$$BYFEUSE_t = \underset{(-0.19)}{-.6808\text{ E1}} - \underset{(-3.38)}{.4781\text{ E4}} *RRBYPRIC + \underset{(6.20)}{.5392\text{ E0}} *BYFEUSE1 + \underset{(4.79)}{.2724\text{ E-3}} *BYPROD$$

$$+ \underset{(3.69)}{.4515\text{ E4}} *RRSGPRIC$$

Adj.R^2= .82 D.W.= 1.98

TABLE 12

VARIABLE DESCRIPTIONS AND SOURCES FOR
FEED DEMAND EQUATIONS

Variable	Description	Source
BYFEUSE	Barley feed and residual use	ERS
BYPROD	Barley production	Ag Stat
CNFEUSE	Corn feed use	ERS
CTLOFED1	Cattle consumption proxy	Calculated
CTLOFED3	Cattle consumption proxy	Calculated
DUMS74	Shift variable for year>=1974	Calculated
DUMS79	Shift variable for year>=1979	Calculated
GRCONSN1	Grain-consuming animal units fed	Ag Stat
MILKCOWS	Milk cows on farm	Ag Stat
OTFEUSE	Oat feed and residual use	Ag Stat
RCTLPRIC	Livestock (cattle) price	Ag Stat
RRBYPRIC	Average barley price recieved by farmers	Ag Stat
RRCNPRIC	Average corn price received by farmers	Ag Stat
RROTPRIC	Average oat price received by farmers	Ag Stat
RRSBMPRC	Soybean meal price	Ag Stat
RRSGPRIC	Average sorghum price recieved by farmers	Ag Stat
SBMUSE	Soybean meal domestic use	U.S. Soybean Industry & Ag Stat
SGFEUSE	Sorghum feed use	ERS
TRND7186	Trend variable	Calculated
YEAR	Trend variable	Calculated

Variable descriptions are presented in table 12.

Several data series were used to represent livestock numbers. In the sorghum equation, the sum of cattle on feed in the current period and the next period, is included in a composite variable. As an aggregate measure of livestock grain consumption, grain-consuming animal units (GCAU) are used to explain soybean meal feed demand. For the feed use equation for corn, a composite livestock variable is expressed as the sum of cattle on feed and GCAU. The number of milk cows on the farm is used in the oat feed equation, since oats are commonly fed to dairy cattle. Expected livestock price appears in the soybean meal equation.

Changes in the nature of livestock feeding are likely to affect livestock feeding rates in various ways that can not be explained by feed prices and livestock numbers. Shift and trend variables serve as a proxy for changes in technology and feeding patterns in the livestock industry.

Barley feed demand is unresponsive to livestock numbers and prices, since the use of this commodity for feed has declined relative to other feed grains over the past few decades (see Table 10). Thus, to increase the performance of this equation, previous studies were reviewed to identify possible explanatory variables (FAPRI). The final specification for barley feed demand included barley production and feed demand last year.

Non-feed Domestic Demand

Aggregate demand data did not disaggregate non-feed uses for corn, sorghum, barley and oats. As a result, these remaining uses are estimated in a non-feed domestic demand equation for each commodity. These non-feed uses for feed grains include primarily food and seed use. Non-feed domestic demand equations are presented in table 13, and variable descriptions and sources provided in table 14.

Personal disposable income per capita is used to represent consumer income in the demand equations for barley and corn, while personal consumption expenditures for food is used in the sorghum demand equation. Expected area planted next year is also included in the non-feed domestic demand equations, except for sorghum, since seed use is included in the aggregate data series. Area planted next year to sorghum is a very insignificant component of non-feed sorghum demand. Corn is a close substitute for sorghum and oats non-feed demand. In addition, barley use is a substitute for sorghum use in the non-feed demand for sorghum.

Consumers' tastes and preferences for alternative food and industrial products may also influence non-feed domestic uses for corn, sorghum, barley and oats. A brief review of previous literature reveals that no appropriate proxy variable to represent consumers' changes in tastes and preferences over the past 40 years. Thus, trend variables and shift variables were applied in various equations. In addition, trend and shift variables were used to serve as proxies for technology

TABLE 13

NON-FEED DEMAND ESTIMATION RESULTS FOR FEED GRAINS USING TWO-STAGE LEAST SQUARES, 1950-1990

$$CNFOUSEC_t = \underset{(-2.57)}{-.4766\ E0} + \underset{(6.79)}{.1496\ E{-1}} *DPINCC_t + \underset{(1.93)}{.6106\ E0} *CNPLTFIC_{t+1} - \underset{(-1.20)}{.1998\ E1} *RRCNPRIC_t$$

$$+ \underset{(6.76)}{.2094\ E0} *TRND8184 + \underset{(9.82)}{.5913\ E0} *CNFOUSEC_{t-1}$$

Adj.R^2= .99 D.W.= 1.15

$$OTFOUSEC_t = \underset{(5.52)}{.2542\ E2} + \underset{(0.05)}{.1972\ E0} *RROTPRIC_t - \underset{(-5.50)}{.1274\ E{-1}} *YEAR_t + \underset{(4.55)}{.1671\ E0} *DUMS83$$

$$+ \underset{(3.66)}{.9745\ EO} *OTPLTF1_{t+1} + \underset{(0.94)}{.1943\ E1} *RRCNPRIC_t$$

Adj.R^2= .91 D.W.= 0.73

$$SGFOUSEC_t = \underset{(7.30)}{.5764\ E{-1}} - \underset{(-3.19)}{.3448\ E1} *RRSGPRIC_t + \underset{(1.79)}{.1151\ E1} *RRCNPRIC_t + \underset{(2.43)}{.1191\ E{-2}} *PCEFOODC_t$$

$$+ \underset{(4.29)}{.5773\ E{-1}} *DUM85 + \underset{(1.74)}{.1758\ E1} *RRBYPRIC_t$$

Adj.R^2= .43 D.W.= 1.68

TABLE 13 (Continued)

$BYFOUSEC_t$= -.1801 E0 - .1662 E1 *RPBYPRIC + .2060 E1 *RPSGPRIC + .8115 E0 *$BYFOUSEC_{t-1}$
(-1.95) (-0.59) (1.30) (9.34)

+ .4157 E0 *BYPLTF1C + .5791 E-3 *PDICAPP
(1.14) (2.57)

Adj.R^2= .89 D.W.= 2.22

TABLE 14

VARIABLE DESCRIPTIONS AND SOURCES FOR NON-FEED DOMESTIC DEMAND EQUATIONS

Variable	Description	Source
BYFOUSEC	Barley food, alcohol, and seed use per capita	Ag Stat
BYPLTF1C	Barley planted area next year per capita	Ag Stat
CNFOUSEC	Corn food use per capita	ERS
CNPLTF1C	Corn planted area next year per capita	Ag Stat
DPINCC	Disposable personal income per capita	ERS
DUM85	Dummy variable for year=1985	Calculated
DUMS83	Shift variable for year>=1983	Calculated
OTFOUSEC	Oat food and seed use per capita	Ag Stat
OTPLTF1C	Oat planted area next year per capita	Ag Stat
PCEFOODC	Personal consumption expenditures for food per capita	Bureau of the Census
PDICAPP	Person disposable income per capita	Ag Stat
RPBYPRIC	Average barley price received by farmers	Ag Stat
RPSGPRIC	Average sorghum price received by farmers	Ag Stat
RRBYPRIC	Average barley price received by farmers	Ag Stat
RRCNPRI	Average corn price received by farmers	Ag Stat
RROTPRIC	Average oat price received by farmers	Ag Stat
RRSGPRIC	Average sorghum price received by farmers	Ag Stat
SGFOUSEC	Sorghum food use per capita	ERS
TRND8184	Trend variable	Calculated
YEAR	Trend variable	Calculated

change in crop planting. Dummy variables were used in sorghum non-feed domestic demand to explain sporadic repercussions from the supply side caused by political exengencies and production shortfalls in the 1980s. A lagged dependent variable was applied in the barley and corn non-feed equations. This is due in part to the slow adjustment in non-feed domestic use (Brown).

Aggregate Domestic Demand

Aggregate domestic demand equations are estimated for soybean oil, wheat, cotton and non-crush soybeans. For wheat, domestic uses include primarily food, but also include feed and seed. For soybean oil, industrial and food use dominates, while for cotton, textile mill use dominates. Seed use dominates for non-crushed soybeans. Aggregate demand equations for these commodities are presented in table 15. Variable definitions are provided in table 16. Equations are expressed in per capita terms, except for non-crush soybean demand. Next year's planted area explains seed demand for cotton and non-crush soybeans.

The feeding component of aggregate wheat demand indicates considerable variability over time. Whenever wheat prices have been low relative to corn, sharp increases in the amount of wheat fed to livestock have occurred. Thus, the ratio of wheat-to-corn prices is used in the aggregate domestic wheat demand equation and contains a negative sign on the coefficient, as expected. Since cotton is used primarily in

TABLE 15

AGGREGATE DOMESTIC DEMAND ESTIMATION RESULTS FOR SOYBEAN OIL, COTTON, WHEAT, AND NON-CRUSH SOYBEANS USING TWO-STAGE LEAST SQUARES, 1950-1990

$$CTUSEPC_t = \underset{(1.65)}{.3532\ E{-2}} + \underset{(11.94)}{.9651\ E0} *CTUSEPC_{t-1} - \underset{(-2.06)}{.2916\ E{-2}} *TXTPINDR + \underset{(2.00)}{.8298\ E2} *CTPLTF1C_t$$

Adj.R^2= .93 D.W.= 2.07

$$WTUSEPC_t = \underset{(0.06)}{.5064\ E{-1}} - \underset{(-5.19)}{.2820\ E2} *RWTCNPRC_t + \underset{(4.21)}{.7379\ E0} *DUM18390 + \underset{(3.26)}{.5526\ E0} *DUMS85$$

$$+ \underset{(4.77}{.5148\ E1} *GRNCONSF$$

Adj.R^2= .69 D.W.= 1.66

$$SBDUSE_t = \underset{(2.78)}{.1707\ E5} - \underset{(-2.50)}{.1482\ E6} *RRSBPRIC_t + \underset{(18.94)}{.1276\ E1} *SBPLTF1_{t+1}$$

Adj.R^2= .91 D.W.= 1.64

$$SBOUSEPC_t = \underset{(-2.45)}{-.3704\ E2} - \underset{(-2.61)}{.7430\ E1} *RPSBOPRC_t + \underset{(3.05)}{.2048\ E0} *PDICAPP_t + \underset{(3.72)}{.5143\ E0} *SBOUSEPC_{t-1}$$

$$+ \underset{(1.89)}{.2031\ E0} *SBOUSEPC_{t-2}$$

Adj.R^2= .98 D.W.= 2.53

TABLE 16

VARIABLE DESCRIPTIONS AND SOURCES FOR AGGREGATE DOMESTIC DEMAND EQUATIONS

Variable	Description	Source
CTPLTF1C	Cotton planted area next year per capita	Ag Stat
CTUSEPC	Cotton domestic use per capita	Ag Stat
DPINCC	Disposable personal income per capita	Bureau of the Census
DUMS85	Dummy variable for year>=1985	Calculated
GRNCONSF	Grain-consuming animal units fed per capita	Ag Stat
PDICAPP	Personal disposable income per capita	Ag Stat
RPSBOPRC	Soybean oil price	Ag Stat
RRSBPRIC	Average soybean price received by farmers	Ag Stat
RWTCNPRC	Wheat - Corn price ratio	Calculated
SBDUSE	Soybean domestic (non-crush) use	Ag Stat & U.S. Soybean Industry
SBOUSEPC	Soybean oil domestic use per capita	Ag Stat & U.S. Soybean Industry
SBPLTF1C	Soybean planted area next year per capita	Ag Stat
TXTPINDR	Textile price index	Stat. Abstract of the U.S.
WTUSEPC	Wheat domestic use per capita	Ag Stat

textile production, a textile price index is specified in the aggregate domestic demand equation for cotton. All prices are deflated by the Consumer Price Index for food items.

Expected grain-consuming animal units (GCAU) are used in the aggregate wheat demand equation to represent the feeding component of domestic use. Consumer income has a positive affect on aggregate domestic demand for soybean oil. Several data series on consumer income were tested in the wheat and cotton equations, and were found to be unresponsive to aggregate domestic demand for these commodities. Shift variables and trend variables serve as proxies for improvement in technology in consumption and changes in consumers' tastes and preferences for various food products.

Crushing Demand

For soybeans, a crushing demand is specified to account for the use of soybean oil and meal. A large proportion of domestically produced soybeans are crushed to produce oil and meal (see Table 10). Table 17 illustrates the estimation results for soybean crushing demand. Variables are defined in table 18. The value of soybeans is determined via the value of its joint products. The difference between the value of soybeans and soybean products is termed the crushing margin or processing margin. The crushing margin in year t is

TABLE 17

SOYBEAN CRUSH DEMAND ESTIMATION RESULTS USING TWO-STAGE LEAST SQUARES, 1950-1990

$$SBCRUSH_t = \underset{(1.36)}{.2605\ E5} + \underset{(8.36)}{.5195\ E0} * SBCRUSH1_t + \underset{(2.61)}{.5599\ E7} * SBPRAMGR_t + \underset{(7.92)}{.2492\ E0} * SBPROD_t$$

Adj.R^2 = .99 D.W. = 1.85

TABLE 18

VARIABLE DESCRIPTIONS AND SOURCES FOR SOYBEAN CRUSH EQUATION

Variable	Description	Source
SBCRUSH	Soybean Crush	
SBPRAMG	Soybean processing margin	Calculated
SBPROD	Soybean production	Ag Stat

calculated by the following formulation:

$$\text{Crushing Margin}_t = [\text{SBMPRICE}_t * (\text{SBMPROD}_t / \text{SBCRUSH}_t)] + [\text{SBOPRICE}_t * (\text{SBOPROD}_t / \text{SBCRUSH}_t)] - \text{SBPRICE}_t, \quad (16)$$

where SBMPRICE is average soybean meal price (44% protein) reported at Decatur, SBMPROD is soybean meal production, SBCRUSH is soybean crush, SBOPRICE is average market price for soybean oil, SBOPROD is soybean oil production, SBPRICE is the average soybean price received by farmers, and t is years: 1950,...,1990. The crushing margin is deflated by the Implicit GDP Price Deflator. The crushing margin explains the amount of soybeans that are crushed for any given year. As the margin increases a greater number of soybeans are crushed, as expected.

Because a time lag is involved in adjusting industry capacity, a lagged dependent variable is included in the specification. The amount of soybean crush will also depend on current soybean production (USDA).

<u>Export Demand</u>

Commodity exports are estimated for each commodity analyzed. Export demand for each commodity is determined by reduced form equations in table 19. Variable definitions are provided in table 20. Average prices received by farmers were used to represent world prices, since U.S. commodity prices have traditionally been determined at or near world prices.

Foreign commodity production is calculated as world

TABLE 19

EXPORT DEMAND ESTIMATION RESULTS BY CROP USING TWO-STAGE LEAST SQUARES, 1950-1990

$$OTEXPRTT_t = .2882\ E2 - .2038\ E2\ {*}DUMS83 - .3256\ E4\ {*}RROTPRIC_t + .7490\ E3\ {*}RRWTPRIC_t$$
(2.06) (-1.83) (-2.95) (2.30)

$$+ .7957\ E0\ {*}OTEXPRTT_{t-1}$$
(6.19)

Adj.R^2= .73 D.W.= 2.10

$$CTEXPORT_t = .2926\ E4 - .1173\ E4\ {*}CTLPRCLN_{t-1} - .4497\ E{-1}\ {*}CTROWPRO_t + .3147\ E4\ {*}DUM79$$
(1.41) (-0.55) (-0.28) (1.69)

$$+ .6041\ E0\ {*}CTEXPORT_{t-1}$$
(2.57)

Adj.R^2= .08 D.W.= 2.53

$$SGEXPORT_t = -.8705\ E2 - .7008\ E4\ {*}RRSGPRIC_t + .6013\ E{-2}\ {*}SGIMCTL_t + .8406\ E4\ {*}RRBYPRIC_t$$
(-1.65) (-2.11) (3.68) (2.37)

$$+ .1732\ E0\ {*}SGEXPRT1_{t-1}$$
(0.94)

Adj.R^2= .80 D.W.= 1.74

$$CNEXPORT_t = .7497\ E3 - .8559\ E3\ {*}RPCNPRIC_t - .5894\ E4\ {*}RPEXRIGM_t + .5610\ E0\ {*}CNEXPORT_{t-1}$$
(2.41) (-0.23) (-2.89) (4.17)

$$+ .1131\ E3\ {*}RPSBMPRC_t$$
(2.18)

Adj.R^2= .93 D.W.= 2.06

TABLE 19 (Continued)

$$WTEXPORT_t = \underset{(0.66)}{.5494\ E3} - \underset{(-3.40)}{.1618\ E{-3}} *WTROWPRO_t - \underset{(-1.98)}{.7497\ E4} *RRWTLPRC_t + \underset{(2.52)}{.6347\ E{-3}} *WRLDPOP_t$$

$$- \underset{(-2.16)}{.3984\ E3} *DUM5072_t + \underset{(2.51)}{.4281\ E0} *WTEXPORT_{t-1}$$

Adj.R^2= .83 D.W.= 2.13

$$SBOEXPRT_t = \underset{(0.69)}{.2776\ E3} + \underset{(1.12)}{.1015\ E3} *RRSBMLPR_{t-1} + \underset{(4.38)}{.7193\ E0} *SBOEXPRT_{t-1} - \underset{(-0.89)}{.1541\ E4} *RRSBOSBP_t$$

R^2= .65 D.W.= 1.83

$$SBEXPORT_t = \underset{(4.41)}{.7748\ E6} - \underset{(-1.77)}{.3122\ E7} *RRSBPRIC_t - \underset{(-4.29)}{.3863\ E7} *RREXRTGM_t - \underset{(-2.80)}{.5784\ E1} *SBROWPRO_t$$

$$+ \underset{(0.88)}{.2247\ E6} *RRSBOPRC_t + \underset{(1.21)}{.3601\ E6} *RRSBMPRC_t + \underset{(3.14)}{.4432\ E0} *SBEXPORT_{t-1}$$

Adj.R^2= .93 D.W.= 1.98

$$SBMEXPRT_t = \underset{(-3.35)}{-.1228\ E5} - \underset{(-3.48)}{.3055\ E4} *RRSBMSBP_t + \underset{(5.61)}{.4631\ E0} *SBMIMCTL_t$$

Adj.R^2= .84 D.W.= 0.98

$$BYEXPORT_t = \underset{(6.72)}{.1017\ E2} - \underset{(-3.87)}{.3855\ E4} *RRBYLPRC_{t-1} + \underset{(2.09)}{.5643\ E2} *DUM86 + \underset{(3.24)}{.1607\ E4} *RRWTLPRC_{t-1}$$

Adj.R^2= .33 D.W.= 1.91

TABLE 20

VARIABLE DESCRIPTIONS AND SOURCES FOR EXPORT EQUATIONS

Variable	Description	Source
BYEXPORT	Barley exports	Ag Stat
CNEXPORT	Corn exports	Ag Stat
CTEXPORT	Cotton exports	Ag Stat
CTLPRCLN	Cotton price proxy	Calculated
CTROWPRO	Cotton production in rest-of-the-world	Calculated
DUM5072	Trend variable for year<=1972	Calculated
DUM79	Dummy variable for year=1979	Calculated
DUM86	Dummy variable for year=1986	Calculated
DUMS83	Shift variable for year>=1983	Calculated
OTEXPRTT	Net oat exports	Ag Stat
RPCNPRIC	Average corn price recieved by farmers	Ag Stat
RPEXRTGM	Exchange rate proxy	IFS
RPSBMPRC	Soybean meal price	Ag Stat
RRBYLPRC	Average barley price recieved by farmers last year	Ag Stat
RRBYPRIC	Average barley price recieved by farmers	Ag Stat
RROTPRIC	Average oat price recieved by farmers	Ag Stat
RRSBMLPR	Soybean meal price last year	Ag Stat
RRSBMPRC	Sobyean meal price	Ag Stat
RRSBMSBP	Soybean meal-Soybean price ratio	Calculated
RRSBOPRC	Soybean oil price	Ag Stat
RRSBOSBP	Soybean oil-Soybean price ratio	Calculated
RRSBSPRC	Soybean spot price	Ag Stat & U.S. Fats & Oils Statistics
RRSGPRIC	Average sorghum price recieved by farmers	Ag Stat
RRWTLPRC	Average wheat recieved by farmers last year	Ag Stat
RRWTPRIC	Average wheat price recieved by farmers	Ag Stat
SBEXPORT	Soybean exports	Ag Stat
SBMEXPRT	Soybean meal exports	Ag Stat & U.S. Soybean Industry
SBMIMCTL	Cattle production in rest-of-the-world proxy	Calculated
SBOEXPRT	Soybean oil exports	Ag Stat
SBROWPRO	Soybean production in rest-of-the-world	Calculated
SGEXPORT	Sorghum exports	Ag Stat
SGIMCTL	Cattle production in rest-of-the-world proxy	Calculated
WRLDPOP	World population	Stat. Abstract of the U.S.
WTEXPORT	Wheat exports	Ag Stat
WTROWPRO	Wheat production in rest-of-the-world	Calculated

production less U.S. production (in bushels; bales for cotton). Greater crop production in the rest of the world will reduce U.S. commodity exports.

For the exports of sorghum and soybean meal, a variable representing cattle production in the rest of the world was used. Cattle and calves inventory in the five major importing countries of U.S. feed grain exports served as a proxy for cattle production in the rest of the world, and was reported in the Food Agriculture Organization's (FAO) annual Production Yearbook. As expected, cattle production in countries importing U.S. feed grains has increased with U.S. exports of sorghum and soybean meal.

A broad measure of the value of the Dollar relative to other major currencies was found to have a significant influence on U.S. exports of corn and soybeans. The exchange rate, expressed in foreign currency per U.S. dollar, has a negative effect on U.S. exports of these commodities. World population was shown to have a significant influence on U.S. wheat exports. In preliminary analysis, several variables representing world income were tested in the export equations, but was determined to explain little, if any, of the variation in U.S. commodity exports.

Exports of soybeans are closely linked with soybean meal and oil exports. If the price of soybean oil rises relative to the price of soybeans, soybean oil exports fall. Most importing countries have crushing capabilities (USDA), so relatively higher world soybean oil prices may lower soybean oil exports and increase soybean exports. Likewise, if the price of soybean meal rises, relative to the price of soybeans, soybean meal exports fall, holding other factors constant.

A replacement variable for cotton price was employed to obtain a reasonable sign on the coefficient in the cotton exports equation. Since the cotton loan rate traditionally reflects world prices, the highest of the loan rate and the average cotton price last year serves as a proxy for cotton price. The coefficient is negative as expected. Overall, prices of substitute commodities have a positive influence on exports of the commodity in question.

Sporadic changes in U.S. exports for selected years were represented by the use of dummy variables and shift variables in some specifications. These changes may be the result of expanded world production and U.S. and international trade policies. In the early 1970s, flexible exchange rates and expanded domestic production caused a permanent shift in U.S. wheat exports. Adjustments in U.S. exports are generally slow, since production must expand to meet the additional demand requirements, or capacity must be increased to accommodate excessive grain stocks and a weak export demand.

Net exports for oats and non-crushed soybeans were estimated, because imports of these commodities were substantial during part of the analysis period. These reduced-form export equations were the most difficult to specify due to the unlimited number of factors, ranging from trade barriers in international markets to food shortages in developing countries, affecting U.S. exports in various ways.

Ending Stocks

Separate stock equations were estimated for each commodity including soybean oil and meal (Table 21). Table 22 presents definitions for the specified variables. The quantity produced, less the quantity demanded in the current period is carryover stocks for the next year. Thus, stocks are not treated as a component of demand in this analysis, but as a residual of production over demand. Carryover or total ending stocks are the sum of on-farm and off-farm stocks at the end of the cropping year, or equivalently, the sum of private and government-held stocks at the end of the cropping year.

If the commodity price rises in the current period over the previous period, stocks will fall. The price variable in year t is expressed as:

$$PriceChange_t = (Farmprice_t - Farmprice_{t-1}) / PriceIndex_{t+1}, \quad (17)$$

where the Price Index in year t+1 is represented by the Implicit GDP Price Deflator (1981=100).

Current and future production explain ending stocks for all commodities, except soybean meal. Only current production is used in the ending stocks equation for soybean meal.

The stocks equation also includes a lagged dependent variable to reflect a partial adjustment process. That is,

TABLE 21

ENDING STOCKS ESTIMATION RESULTS BY CROP USING TWO-STAGE LEAST SQUARES, 1950-1990

$$WTTOTSTK_t = \underset{(0.96)}{.1151\ E3} + \underset{(6.80)}{.1040\ E1} * WTTOTSTK_{t-1} - \underset{(-2.16)}{.3153\ E0} * WTTOTSTK_{t-2} - \underset{(-1.84)}{.7914\ E5} * WTPRCCHG_t$$

$$+ \underset{(2.72)}{.3308\ E{-3}} * WTPROD_t - \underset{(-1.80)}{.2221\ E{-3}} * WTPRODF1_{t+1}$$

Adj.R^2= .80 D.W.= 1.91

$$CNTOTSTK_t = \underset{(-1.27)}{-.2599\ E3} + \underset{(10.22)}{.6785\ E0} * CNTOTSTK_{t-1} - \underset{(-4.43)}{.5186\ E5} * CNPRCCHG_t + \underset{(7.59)}{.4268\ E{-3}} * CNPROD_t$$

$$- \underset{(-4.52)}{.2602\ E{-3}} * CNPRODF1_{t+1} - \underset{(-2.74)}{.7064\ E3} * DUM8890$$

Adj.R^2= .85 D.W.= 1.89

$$SBTOTSTK_t = \underset{(-1.12)}{-.2329\ E5} + \underset{(3.73)}{.3936\ E0} * SBTOTSTK_{t-1} - \underset{(-2.67)}{.1957\ E7} * SBPRCCHG_t + \underset{(4.32)}{.2023\ E0} * SBPROD_t$$

$$- \underset{(-2.01)}{.9169\ E{-1}} * SBPRODF1_{t+1}$$

Adj.R^2= .81 D.W.= 1.58

$$SBMSTOCK_t = \underset{(0.92)}{.1980\ E2} + \underset{(3.42)}{.3687\ E0} * SBMSTOCK_{t-1} - \underset{(-4.95)}{.1097\ E3} * SBMPRCHG_t + \underset{(1.61)}{.3009\ E{-2}} * SBMELPRO_t$$

$$+ \underset{(3.78)}{.3155\ E3} * DUM72 + \underset{(4.67)}{.2757\ E3} * DUM82 + \underset{(2.04)}{.2349\ E0} * SBMSTOCK_{t-2}$$

Adj.R^2= .77 D.W.= 2.20

TABLE 21 (Continued)

$$SBOSTOCK_t = -.5944\ E2 + .4361\ E0 * SBOSTOCK_{t-1} - .6743\ E3 * SBOPRCHG_t + .2070\ E0 * SBOILPRO_t$$
$$(-0.86) \quad (4.67) \quad (-1.99) \quad (5.78)$$

$$- .1357\ E0 * SBOPROF1_{t+1} - .4145\ E3 * DUM8384 + .4084\ E3 * DUM8687$$
$$(-3.71) \quad (-3.22) \quad (3.00)$$

Adj.R^2= .89 D.W.= 2.25

$$SGTOTSTK_t = .2947\ E1 + .1338\ E1 * SGTOTSTK_{t-1} - .7589\ E4 * SGPRCCHG_t + .2571\ E{-3} * SGPROD_t$$
$$(0.07) \quad (9.95) \quad (-2.87) \quad (2.97)$$

$$- .1599\ E{-3} * SGPRODF1_{t+1} - .5366\ E0 * SGTOTSTK_{t-2}$$
$$(-1.73) \quad (-4.00)$$

Adj.R^2= .87 D.W.= 1.70

$$CTTOTSTK_t = -.5523\ E4 + .8113\ E0 * CTTOTSTK_{t-1} - .1422\ E4 * CTPRCCHG_t + .8148\ E0 * CTPROD_t$$
$$(-2.75) \quad (9.66) \quad (-0.75) \quad (6.22)$$

$$- .2785\ E0 * CTPRODF1_{t+1}$$
$$(-2.22)$$

Adj.R^2= .80 D.W.= 1.87

$$OTTOTSTK_t = -.2096\ E1 + .8499\ E0 * OTTOTSTK_{t-1} - .1142\ E5 * OTPRCCHG_t + .1290\ E{-3} * OTPROD_t$$
$$(-0.09) \quad (8.41) \quad (-3.36) \quad (1.62)$$

$$-.7575\ E{-4} * OTPRODF1_{t+1}$$
$$(-1.11)$$

Adj.R^2= .84 D.W.= 1.67

TABLE 21 (Continued)

$$BYTOTSTK_t = \underset{(-0.99)}{-.3164\ E2} - \underset{(-3.36)}{.3679\ E4} * BYPRCHG1_t + \underset{(5.54)}{.4958\ E0} * BYTOTSTK_{t-1} + \underset{(6.15)}{.4980\ E\text{-}3} * BYPROD_t$$

$$- \underset{(-2.46)}{.2002\ E\text{-}3} * BYPRODF1_{t+1}$$

Adj.R^2= .79 D.W.= 2.19

TABLE 22

VARIABLE DESCRIPTIONS AND SOURCES FOR ENDING STOCKS EQUATIONS

Variable	Description	Source
BYPRCHG1	Barley price change	Calculated
BYPROD	Barley production	Ag Stat
BYPRODF1	Barley production next year	Ag Stat
BYTOTSK1	Total ending barley stocks last year	Ag Stat & U.S. Feed Grains: Background for 1990 Farm Legislation
BYTOTSTK	Total ending barley stocks	Ag Stat & U.S. Feed Grains: Background for 1990 Farm Legislation
CNPRCCHG	Corn price change	Calculated
CNPROD	Corn production	Ag Stat
CNPRODF1	Corn production next year	Ag Stat
CNTOTSK1	Total ending corn stocks last year	ERS
CNTOTSTK	Total ending corn stocks	ERS
CTPRCCHG	Cotton price change	Calculated
CTPROD	Cotton production	Ag Stat
CTPRODF1	Cotton production next year	Ag Stat
CTTOTSK1	Total ending cotton stocks last year	Ag Stat & Fibers: Background for 1990 Farm Legislation
CTTOTSTK	Total ending cotton stocks	Ag Stat & Fibers: Background for 1990 Farm Legislation
DUM72	Dummy variable for year=1972	Calculated
DUM82	Dummy variable for year=1982	Calculated
DUM8384	Shift variable for year=1983,1984	Calculated
DUM8687	Shift variable for year=1986,1987	Calculated
DUM8890	Shift variable for year>=1988	Calculated
OTPRCCHG	Oat price change	Calculated
OTPROD	Oat production	Ag Stat
OTPRODF1	Oat production next year	Ag Stat
OTTOTSK1	Total ending oat stocks last year	ERS
OTTOTSTK	Total ending oat stocks	ERS
SBMELPRO	Soybean meal production	Ag Stat
SBMSPCHG	Soybean spot price change	Calculated
SBMSTOCK	Total ending soybean meal stocks	U.S. Soybean Industry
SBMSTOK1	Total ending soybean meal stocks last year	U.S. Soybean Industry
SBOILPRO	Soybean oil production	Ag Stat
SBOPRCHG	Soybean oil price change	Calculated
SBOPROF1	Soybean oil production next year	Ag Stat
SBOSTOCK	Total ending soybean oil stocks	U.S. Soybean Industry

TABLE 22 (Continued)

Variable	Description	Source
SBOSTOK1	Total ending soybean oil stocks last year	U.S. Soybean Industry
SBPRCCHG	Soybean price change	Calculated
SBPROD	Soybean production	Ag Stat
SBPRODF1	Soybean production next year	Ag Stat
SBTOTSTK	Total ending soybean stocks	Ag Stat & U.S. Soybean Industry
SGPRCCHG	Sorghum price change	Calculated
SGPROD	Sorghum production	Ag Stat
SGPRODF1	Sorghum production next year	Ag Stat
STTOTSK1	Total ending soybean stocks last year	Ag Stat & U.S. Soybean Industry
SGTOTSTK	Total ending soybean stocks	ERS
SGTOTSK1	Total ending soybean stocks last year	ERS
WTPRCCHG	Wheat price change	Calculated
WTPROD	Wheat production	Ag Stat
WTPRODF1	Wheat production next year	Ag Stat
WTTOTSK1	Total ending wheat stocks last year	ERS
WTTOTSTK	Total ending wheat stocks	ERS

storage capacity is generally slow to adjust and large stocks generally require several years to reduce. Dummy variables were used to account for periods of extraordinary tight stocks and enormous oversupply of stocks. Tight or over abundance of commodity stocks are often a result of government stocks policy, world production and stock levels, and weather events reverberating from the production side. For example, the PIK program in 1983 resulted in phenomenal commodity stocks through most of the 1980s. However, stocks were drawn below safety-net levels in the late 1980s due to a severe drought in 1988.[12]

Excess Capacity

The operational definition of excess capacity for each commodity is the difference between potential supply (less imports) and total aggregate demand (plus net stock changes). Net stocks refer to ending stocks and beginning stocks for a given market year. Total aggregate demand is determined by summing the relevant demand components. These demand components are predicted values of the left-hand side endogenous variables from Tables 11,13,15,17, and 21. Empirically, total aggregate demand for corn, sorghum, oats and barley is represented by:

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[12] Safety-net levels refers to stocks available to cover domestic demand until the new crop is harvested.

$$Q_{it}^{TD} = \hat{Q}_{it}^{FE} + \hat{Q}_{it}^{TNFE} + \hat{Q}_{it}^{EX}, \tag{18}$$

where i=1,...,4 is commodity, t=1950,...,1990 is year, $\hat{Q}^{TD}$ is total aggregate demand, $\hat{Q}^{FE}$ is feed demand, $\hat{Q}^{TNFE}$ is non-feed demand, and $\hat{Q}^{EX}$ is export demand.

For soybean meal, the only domestic use is livestock and poultry feed. Thus, total demand for soybean meal is represented by:

$$Q_{it}^{TD} = \hat{Q}_{it}^{FE} + \hat{Q}_{it}^{EX}, \tag{19}$$

where i is soybean meal and t=1950,...,1990 is year.

For wheat, soybean oil, and cotton, total aggregate demand is represented by:

$$Q_{it}^{TD} = \hat{Q}_{it}^{TAGD} + \hat{Q}_{it}^{EX}, \tag{20}$$

where i=1,...3 is commodity, t=1950,...,1990, is year, and $\hat{Q}^{TAGD}$ is total aggregate domestic demand.

Total demand for non-crushed soybeans includes a crush demand, and is represented by:

$$Q_{it}^{TD} = \hat{Q}_{it}^{AGD} + \hat{Q}_{it}^{EX} + \hat{Q}_{it}^{CR}, \tag{21}$$

where i is non-crush soybeans, t=1950,...,1990 is year, $\hat{Q}^{AGD}$ is aggregate domestic demand, and $\hat{Q}^{CR}$ is crush demand. Total aggregate demand for each commodity is presented in Table 23.

TABLE 23

TOTAL AGGREGATE DEMAND FOR WHEAT, CORN, OATS, BARLEY, SORGHUM, COTTON, AND SOYBEANS, 1950-1990

YEAR	WHEAT	CORN	OATS	BARLEY	SORGHUM	SOYBEANS	COTTON
			(Million Bushels)				(Million Bales)
1950	676.45	89.26	145.44	16.56	14.52	0.17	0.74
1951	672.61	255.09	117.51	116.21	10.56	0.24	10.00
1952	645.36	245.13	144.73	109.34	5.56	0.23	9.62
1953	618.96	249.32	147.35	107.64	8.75	0.25	9.51
1954	598.13	244.81	150.36	116.68	11.02	0.28	8.53
1955	591.31	257.28	141.89	114.49	12.67	0.36	8.85
1956	575.63	265.97	137.45	117.12	9.17	0.44	9.12
1957	579.74	266.65	131.51	116.16	11.15	0.51	8.29
1958	596.92	269.01	128.34	113.65	10.94	0.56	8.17
1959	590.79	295.36	123.13	111.31	13.10	0.57	8.80
1960	597.11	298.31	122.91	110.07	13.19	0.61	9.19
1961	600.90	293.23	120.43	112.84	11.89	0.66	8.42
1962	580.30	309.05	117.99	110.42	11.37	0.68	8.82
1963	588.50	320.99	114.39	110.41	12.11	0.71	8.37
1964	643.60	339.24	112.18	108.64	11.92	0.71	8.56
1965	731.20	354.13	109.81	110.80	14.10	0.85	8.70
1966	673.10	368.43	106.20	115.79	14.44	0.89	8.90
1967	633.30	383.82	104.51	116.53	13.25	0.93	9.27
1968	735.40	384.51	102.95	123.91	13.67	1.01	8.91
1969	771.60	384.44	102.17	126.03	11.76	1.17	8.27
1970	772.00	407.94	99.06	129.90	12.49	1.28	8.14
1971	849.00	433.90	92.79	137.58	13.02	1.30	8.48
1972	799.00	446.87	93.68	139.34	12.35	1.41	8.05
1973	754.00	481.80	97.85	148.38	12.83	1.48	7.21
1974	672.00	495.41	97.41	146.97	11.06	1.38	6.44
1975	726.00	515.47	90.08	151.89	11.95	1.40	5.54
1976	754.00	546.78	85.58	155.44	13.55	1.45	6.91
1977	859.00	567.76	80.08	160.85	12.88	1.62	6.59
1978	837.00	603.81	76.12	166.21	12.55	1.83	6.49
1979	783.00	622.63	73.60	174.81	11.90	2.00	6.37
1980	783.00	651.78	73.95	176.95	11.42	1.92	6.31
1981	847.00	718.72	67.55	175.86	14.02	1.88	5.56
1982	908.00	809.70	70.76	175.90	11.36	2.07	5.01
1983	1114.00	926.79	101.69	170.87	12.35	1.18	5.52
1984	1156.00	1060.19	97.42	170.96	13.53	1.81	5.65
1985	1052.00	1158.98	94.37	171.92	28.00	1.84	5.44
1986	1197.00	1224.67	91.99	168.53	15.46	1.91	6.42
1987	1086.00	1266.32	87.38	166.16	14.98	2.00	7.33
1988	975.00	1294.68	85.63	176.19	15.99	1.82	7.42
1989	992.00	1338.35	80.05	177.10	15.49	1.77	7.74
1990	1379.00	1389.20	75.18	177.05	14.53	1.85	8.82

Potential supply is calculated as:

$$Q_{it}^{PS} = \hat{Q}_{it}^{LA} + \hat{Y}_{it}, \qquad (22)$$

where i=1,...,7 is commodity, t=1950,...,1990 is year, Q^{PS} is the quantity of potential supply in bushels, $\hat{Q}^{LA}$ is the estimated quantity of cropland available in acres, and $\hat{Y}$ is the estimated harvested yield in bushels per acre.

From equation 6 in Chapter 2, excess capacity for commodity i in period t is calculated by the identity:

$$Q_{it}^{EC} = Q_{it}^{PS} - Q_{it}^{TD}, \qquad (23)$$

where i=1,...,7 is commodity, t=1950,...,1990 is year, Q^{EC} is the quantity of excess capacity, Q^{TD} is the estimated quantity of total aggregate demand, and Q^{PS} is the estimated quantity of potential supply. Total aggregate demand, Q^{TD} , is aggregated from individual demand components and Q^{PS} is the product of estimated commodity yields and cropland available (from equation 22). Excess capacity results for seven commodities evaluated are presented in the next section.

Excess Capacity Results and Discussion

An objective of this study is to estimate the magnitude of excess capacity from 1950 to 1990. Excess capacity in wheat, corn, sorghum, oats, barley, cotton and soybeans is presented in table 24, in terms of production units and as a percent of potential supply. Potential supply excludes cropland failed and fallowed for a given year. The estimates

TABLE 24

EXCESS CAPACITY ESTIMATES FOR WHEAT, CORN, SOYBEANS, COTTON, OATS, BARLEY, AND SORGHUM, 1950-1990

YEAR	OATS		BARLEY		SORGHUM	
	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL. BU.	PERCENT
1950	--	--	--	--	155.1	39.91
1951	843.3	39.76	--	--	374.1	69.67
1952	71.7	5.57	--	--	-16.7	-22.63
1953	41.6	3.48	113.8	31.57	140.1	54.77
1954	-33.9	-2.46	118.8	23.86	87.1	27.00
1955	67.0	4.28	153.0	27.52	170.0	41.20
1956	-142.4	-14.11	114.7	23.35	285.4	58.21
1957	-91.5	-7.64	140.4	24.08	67.2	10.59
1958	161.6	10.34	131.3	21.57	436.9	42.92
1959	-78.2	-8.05	219.7	34.33	397.8	41.73
1960	-11.7	-1.03	190.3	30.73	268.1	30.19
1961	38.9	3.71	60.7	13.40	228.6	32.25
1962	-21.3	-2.15	223.7	34.34	253.6	33.20
1963	-6.2	-0.64	207.6	34.57	111.8	16.04
1964	71.5	7.74	173.8	31.05	375.7	43.41
1965	37.2	3.85	203.7	34.13	333.3	33.13
1966	27.6	3.32	241.0	38.07	390.1	35.27
1967	29.9	3.64	246.4	39.73	129.5	14.63
1968	22.1	2.28	246.3	36.63	346.4	32.15
1969	62.1	6.04	248.5	36.79	621.2	45.98
1970	50.8	5.26	223.8	34.97	428.5	38.54
1971	37.4	4.08	226.1	32.84	370.8	29.93
1972	-139.5	-25.32	150.4	26.28	428.6	34.85
1973	-346.9	-111.11	157.0	27.33	487.4	34.55
1974	-179.4	-42.58	114.3	27.68	167.7	21.21
1975	38.4	5.67	242.0	38.96	154.7	17.02
1976	58.9	9.82	195.5	33.79	369.3	34.19
1977	118.9	13.64	246.8	36.59	253.7	24.52
1978	62.7	9.73	201.7	30.72	321.4	30.53
1979	-79.3	-17.71	193.2	33.52	385.8	32.33
1980	-137.6	-42.85	134.9	27.20	269.3	31.73
1981	-17.6	-3.58	286.6	37.71	161.1	15.53
1982	3.2	0.54	273.7	34.66	548.8	39.65
1983	-86.1	-17.55	201.3	28.34	596.5	55.03
1984	-42.2	-9.79	314.8	34.44	364.4	29.61
1985	59.5	10.25	291.6	33.03	432.9	27.87
1986	-116.3	-43.05	286.7	31.95	654.4	41.09
1987	-79.1	-26.85	343.1	39.68	908.6	55.42
1988	69.4	24.19	80.5	21.73	533.6	48.06
1989	297.9	44.37	426.4	51.34	208.9	25.34
1990	63.0	15.00	366.1	46.64	153.8	21.21

TABLE 24 (Continued)

YEAR	WHEAT		CORN		SOYBEANS		COTTON	
	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL.BALES	PERCENT
1950	--	--	-340.1	-14.03	--	--	--	--
1951	1050.0	51.52	3132.8	54.37	236.8	45.49	--	--
1952	16.4	1.24	775.9	20.65	108.1	26.56	--	--
1953	756.5	39.21	204.0	6.61	56.3	17.30	--	--
1954	327.8	24.99	-155.1	-6.08	112.3	24.76	3.6	20.91
1955	197.3	17.39	2037.2	41.40	54.5	12.73	4.6	23.81
1956	120.5	10.70	121.5	3.78	8.9	1.95	4.0	22.97
1957	-253.6	-36.12	97.9	3.09	-37.1	-8.30	-4.7	-74.12
1958	334.3	18.66	-91.0	-2.72	6.7	1.15	-0.9	-8.08
1959	338.0	23.22	719.6	15.83	-54.3	-11.34	5.5	27.30
1960	22.6	1.64	571.7	12.77	-106.0	-23.61	-2.7	-22.90
1961	-74.9	-6.47	433.4	10.75	-19.4	-2.94	-0.8	-5.91
1962	-39.0	-3.71	270.2	6.97	-13.0	-1.99	1.8	10.86
1963	119.1	9.41	853.3	17.51	-52.3	-8.08	4.7	23.55
1964	-106.6	-9.06	782.4	18.34	24.0	3.30	1.2	7.50
1965	-94.1	-7.70	1431.9	25.87	11.3	1.31	3.3	18.02
1966	-213.1	-19.52	446.8	9.68	9.6	1.02	-0.2	-1.61
1967	260.8	14.75	2015.3	29.31	117.8	10.76	-7.3	-73.62
1968	377.9	19.53	1093.9	19.73	101.6	8.41	-1.3	-12.94
1969	329.6	18.60	1830.1	28.08	-8.8	-0.78	0.5	4.98
1970	76.9	5.38	738.9	15.11	-212.7	-23.27	-0.8	-8.45
1971	174.5	9.73	2340.1	29.30	-184.4	-18.60	-2.9	-38.14
1972	568.0	26.87	417.1	6.95	-216.4	-20.53	3.5	20.30
1973	-548.4	-47.18	-172.9	-3.15	131.4	7.83	0.9	6.65
1974	303.1	14.54	240.9	4.87	-26.5	-2.22	-5.4	-87.29
1975	559.0	20.81	1803.7	23.59	271.3	14.91	2.3	21.47
1976	717.6	25.04	889.9	12.40	-398.5	-44.77	-1.9	-21.50
1977	481.2	19.04	1319.1	16.86	182.2	9.35	7.1	33.04
1978	-52.7	-3.06	1316.2	15.33	39.4	2.06	-1.1	-11.10
1979	-101.5	-4.99	1802.6	18.52	317.6	12.32	2.8	15.88
1980	347.4	12.73	-1341.3	-25.32	-156.9	-9.56	-3.6	-47.02
1981	532.2	16.04	1803.4	17.59	298.2	13.04	10.4	39.96
1982	675.4	19.63	2422.3	22.73	205.2	8.57	7.1	37.21
1983	1034.9	29.96	-1778.4	-74.23	-386.4	-30.93	-1.5	-24.20
1984	1487.4	36.44	1345.4	14.92	334.5	15.24	6.4	33.02
1985	261.1	9.72	2946.1	24.92	342.1	14.01	8.5	38.63
1986	952.4	31.30	4388.8	34.79	121.3	5.89	5.9	37.91
1987	450.8	17.62	2638.6	27.01	-107.4	-5.87	3.0	16.89
1988	-296.8	-19.58	-1221.3	-32.94	-323.3	-26.38	6.7	30.40
1989	293.0	12.58	1322.2	14.94	320.1	14.27	2.9	19.46
1990	1302.8	32.24	970.8	10.90	28.0	1.44	1.3	7.64

of excess capacity, if fallowed and failed area are included, are presented in Appendix B. Using the notation from Dvoskin's study, the aggregate annual percentage of excess capacity for the seven major crops (E_{p7}) is calculated by the following equation:

$$E_{P7} = \frac{\hat{Q}^{EC}_{it}}{\hat{Q}^{EC}_{it} + Q^{P}_{it}} * 100, \tag{24}$$

where i=1,...,7 is commodity, t=1950,...,1990 is year, $\hat{Q}^{EC}$ is the quantity of excess capacity in year t from equation 23, and Q^{P} is the actual quantity produced in year t.

Table 24 illustrates excess capacity for individual crops over the period 1950 to 1990. The magnitude of excess capacity varies over time for each commodity. Negative excess capacity levels indicate that stock levels are drawn down, and offset the magnitude of diverted acreage. In some cases, the results are reported beginning in 1951, 1952, 1953, or 1954, because of the lag structure of the models. Actual ending stocks before 1950 were used.

In production units, wheat and corn exhibit the largest levels of excess capacity, on average. In percentage terms, excess capacity peaked, for most crops, in the middle to late 1980s. On average, barley and sorghum indicate the greatest percentage of potential supply in excess capacity, while soybeans and oats indicate the lowest percent of excess capacity.

Excess capacity in wheat production exceeded 30 percent in the early 1950s, but remained below 20 percent through the 1960s. The lowest level was experienced in 1973, but increased to 25 percent by 1976. Excess capacity climbed in the early 1980s. After a peak of 36 percent in 1984, excess capacity has fluctuated considerably through the remainder of the decade. By 1990 excess capacity has again exceeded 30 percent.

Excess capacity in most of the feed grains has varied dramatically since 1950. After peaking in the early 1950s, excess capacity declined considerably. Fifty-four percent of potential supply was in excess capacity for corn in 1951. In the same year, there was 69 percent excess capacity in sorghum and 40 percent in oats. Excess capacity again exceeded 40 percent in 1955 for corn. After an overall upward trend in the 1960s, excess capacity bottomed in 1973 for corn and oats, and in 1972 for barley. Significant variability in excess capacity was experienced in the 1980s. Excess capacity in sorghum declined from 55 percent in 1987 to 21 percent in 1990, while capacity in corn declined from 27 percent to 11 percent in 1990. Excess capacity in barley and oats quickly rebounded in 1989 after a severe drought in 1988.

Excess capacity in cotton has fluctuated widely over the past four decades, possibly due to great fluctuations in exports and crop yields. The lowest levels of excess capacity over the past forty years was in 1957, 1967, 1974 and 1980. On average, excess capacity remained at about 30 percent of total supply thru the 1980s.

Excess capacity in soybeans has not followed the same trend as exhibited in the other crops. Since soybeans are a non-program crop, this result is not unexpected. After peaking at 45 percent in 1951, excess capacity fell to -23 percent in 1960. The highest level of excess capacity in the 1960s was experienced in 1967 (11 percent), but quickly declined to -23 percent in 1970. As an example of the annual variability of excess capacity in soybeans, excess capacity fell from nearly 15 percent in 1975 to -44 percent the next year, and again in 1982 it fell from 8 percent to -30 percent in 1983. Overall, soybeans exhibit the lowest levels of excess capacity for most years. This is due in part to the absence of government involvement (ie. income supports), although soybeans are indirectly affected by program provisions of the other six crops analyzed.

Several events caused the observed changes in excess capacity for the commodities analyzed in this study. Rapid growth in planted acres and crop yields continued into the 1950s, following World War II, resulting in large surpluses. In the 1950s diversion programs were introduced to reduce surpluses. During the 1950s and 1960s stocks declined, but diverted production increased through the Soil Bank Programs. By the end of the 1960s and early 1970s, stocks were drawn to their lowest level in decades, but diverted production more than offset the decline. Excess capacity actually increased during this time.

However, excess capacity dropped significantly in 1972 and 1973. This reduction was closely related to the sharp rise in domestic and export demands, and by a severe world-wide drought in 1973. Consequently, when exports fell towards the end of the 1970s, excess capacity increased sharply. Both stocks and diverted production have risen since the early 1980s (until 1988). The Russian grain embargo in 1980 and the payment-in-kind (PIK) program in 1983 resulted in large excess capacity levels in the early-to-middle 1980s. In 1988 a severe drought led to a draw down in stocks to extremely low levels, especially for corn, soybeans and wheat. However, diverted acreage remained high through various programs such as the annual Acreage Reduction Program (ARP) and the Conservation Reserve Program (CRP).

For a comparison, Dvoskin's estimates of excess capacity from 1950 to 1986 are presented in table 25. Dvoskin's study in 1986 investigated excess capacity prior to 1987. The overall pattern of excess capacity over time is comparable between the two studies. Both studies use annual measures of excess capacity, but total carryover stocks are reported as a component of excess capacity in Dvoskin's study, while changes in stocks for a given year are subtracted from potential supply in this study. This implies that Dvoskin's measure of excess capacity is not an annual measure, but a cumulative measure from year to year. Also, this might explain the greater variability of excess capacity over time exhibited in this study.

TABLE 25

DVOSKIN'S EXCESS CAPACITY ESTIMATES FOR WHEAT, CORN, SOYBEANS, COTTON, OATS, BARLEY, AND SORGHUM, 1950-1990

YEAR	WHEAT		CORN		SOYBEANS		COTTON	
	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL.BALES	PERCENT
1950	-11.1	-1.09	-97.8	-3.18	2.2	0.73	-4.6	-45.58
1951	-126.7	-12.82	-247.1	-8.45	0.5	0.17	0.5	3.17
1952	365.3	27.96	286.8	8.71	8.3	2.79	2.9	18.9
1953	342.3	29.19	157.9	4.92	-16.3	-6.06	4.3	25.82
1954	116.1	11.8	125.2	4.09	20	5.86	1.5	11.3
1955	45.6	4.87	134.5	4.18	-3.4	-0.91	3.5	24.09
1956	28.6	2.66	794.1	22.25	24.9	5.55	-2.4	-17.18
1957	281.8	24.99	590.5	16.68	36.6	7.52	-0.5	-4.31
1958	617.2	39.54	668.7	17.01	67.8	11.58	3.2	23.07
1959	179.4	15.48	947.4	24.09	15.8	2.88	-0.8	-5.53
1960	326.8	22.84	730.8	18.02	10.3	1.79	0.2	1.59
1961	195.7	15.03	607.6	13.97	94.5	13.5	1.5	10.2
1962	278	21.08	511.1	11.95	15.5	2.26	4.3	27.88
1963	95.5	7.24	931.5	19.6	29.8	4.14	2.3	14.47
1964	254.2	18.01	422	9.88	175.7	20.46	2.9	18.82
1965	120.1	8.17	683.7	13.49	185.7	19.81	3.4	22.54
1966	246.1	16.64	990.1	19.27	146.5	14.88	-1.4	-11.54
1967	289.9	18.77	1181.8	20.84	265	23.75	-2.2	-20.68
1968	473.5	29.72	1112	19.86	249.3	21.86	3.2	23.98
1969	405.2	24.32	1168.3	19.6	95.4	8.44	-0.1	-1.33
1970	255.9	15.51	680.1	13.2	-74.4	-6.6	-1.2	-11.53
1971	553.5	29.15	1162.9	18.35	-29.1	-2.48	0.4	3.08
1972	121.4	6.24	829.2	12.18	41.4	3.26	2.3	15.03
1973	12	0.65	153.9	2.56	226.8	14.65	0	-0.02
1974	131.1	7.34	-60.8	-1.28	21	1.72	2.1	17.78
1975	286.3	13.43	102.3	1.73	63	4.07	-2	-23.08
1976	520.5	24.06	531	8.39	-127.6	-9.9	-0.5	-5.17
1977	177.2	8.64	275.9	4.23	78.3	4.43	2.5	17.47
1978	48.3	2.47	555.9	7.34	52.3	2.8	-1.2	-11.22
1979	268.1	11.65	548.7	6.79	222.8	9.85	-0.7	-5.02
1980	202	8.48	-503.6	-7.59	7.3	0.41	-0.4	-3.59
1981	319.4	11.49	1154.3	14.22	2.8	0.14	4	25.64
1982	627.5	21.73	1112.1	13.22	156.9	7.17	2.6	19.95
1983	818.3	26.15	-973.8	-17.85	-51.7	-3.16	-1	-8.6
1984	774.7	25.59	867.6	11.02	191.2	10.28	3.3	22.34
1985	1196.4	42.02	2795.8	30.43	315.9	15.06	7.9	49.82
1986	781.8	31.14	2619.9	28.85	184.6	9.2	-1.8	-14.99

TABLE 25 (Continued)

YEAR	OATS		BARLEY		SORGHUM	
	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL. BU.	PERCENT
1950	78.7	5.75	14	4.6	-21.6	-9.25
1951	-109	-8.53	-20.2	-7.86	-28.1	-17.25
1952	-28.2	-2.31	-22.1	-9.7	-2.5	-2.77
1953	-22.4	-1.94	19.6	7.93	14.8	12.76
1954	76.1	5.4	59.5	15.69	53	22.5
1955	39.5	2.64	-8	-1.97	10.2	4.2
1956	-97.5	-8.43	36.2	9.57	21	9.96
1957	119.8	9.09	63.2	14.08	271.1	45.17
1958	99.1	6.8	45.6	9.34	151.6	23.87
1959	-1.6	-0.14	-14.5	-3.27	162	25.16
1960	196.2	15.19	22	4.74	241	32.95
1961	86	7.52	1.2	0.28	214.1	29.46
1962	127.8	11.18	105.7	20.84	222.8	30.57
1963	160.8	14.77	76.4	16.06	196.7	25.21
1964	45.6	4.87	73	15.02	124	17.93
1965	123.4	12.29	108.6	21.75	76.7	8.33
1966	7.7	0.89	112.6	23.02	155.8	15.72
1967	63.3	7.4	36.1	9.12	266.2	28.84
1968	167.5	16.62	85.9	19.18	254.4	26.31
1969	148.2	14.98	160.5	29.61	145.4	15.22
1970	23	2.51	8	1.57	50.1	5.72
1971	29.9	3.41	33.5	7.19	183.4	18.49
1972	-133.4	-19.31	102.2	19.01	168.8	16.4
1973	-154	-23.37	-13	-2.9	74	7.41
1974	-84.2	-14.01	-52.2	-17.35	-0.4	-0.07
1975	-18.3	-2.87	39.8	10.42	37.1	4.8
1976	-39.9	-7.38	0.9	0.24	46.3	6.47
1977	149.6	19.87	49	11.41	107.2	13.67
1978	-32.7	-5.62	81.9	17.21	12.7	1.65
1979	-43.6	-8.82	-16	-3.98	26	3.09
1980	-58.8	-12.81	-54.7	-15.14	-34.8	-6.01
1981	-25.5	-5.01	10.7	2.27	191	21.81
1982	71.6	12.03	81.3	15.4	127.3	14.9
1983	-29.9	-6.15	6.9	1.28	36.5	5.92
1984	3.6	0.76	85.4	13.93	79.6	9.03
1985	7.3	1.39	107.4	17.59	319.8	27.84
1986	-50.2	-12.35	90.8	13.74	263.3	25.61

It is also important to note that Dvoskin used an accounting measure of excess capacity (detailed in Chapter 1). In this study, commodity models are developed to forecast excess capacity. Because Dvoskin used an accounting method, he could not produce a forecast of excess capacity.

A simple regression between the estimates of excess capacity derived from this study and those from Dvoskin's study reveal that excess capacity in these two studies follows a similar trend over time (see Table 26). That is, Dvoskin's estimates of excess capacity are regressed against the estimates derived in this study. R-square values range from .32 for barley to .70 for wheat. Because the net changes in stocks for a given year are ignored in Dvoskin's study, the impact of stock changes in the current year are not fully reflected until the following year for some crops. As a result, the excess capacity estimates for barley and sorghum in this study are lagged one year to correspond with excess capacity estimates from Dvoskin's study.

The R-square value for wheat indicates that 70 percent of the variation in excess capacity in this study is explained by Dvoskin's estimates of excess capacity. 39 percent of the variation in the estimates of excess capacity from corn derived in this study, is explained by Dvoskin's estimates. R-square values were highest for wheat, oats, soybeans, and corn. T-values were all significant at the 1 percent level. The coefficients of variation are also reported in table 26. Clearly, greater variability in excess capacity is illustrated

TABLE 26

REGRESSION RESULTS COMPARING EXCESS CAPACITY ESTIMATES OF THIS STUDY WITH EXCESS CAPACITY ESTIMATES IN DVOSKIN'S STUDY[a]

Excess Capacity in Wheat:

R-square = 0.70 T-Value = 8.83 $CV_{Dvoskin}$ = .59 CV_{Smith} = .83

Excess Capacity in Corn:

R-square = 0.39 T-Value = 4.70 $CV_{Dvoskin}$ = .83 CV_{Smith} = 1.06

Excess Capacity in Oats:

R-square = 0.40 T-Value = 4.83 $CV_{Dvoskin}$ = .94 CV_{Smith} = 3.92

Excess Capacity in Barley:

R-square = 0.32 T-Value = 4.09 $CV_{Dvoskin}$ = .29 CV_{Smith} = 1.22

Excess Capacity in Sorghum:

R-square = 0.33 T-Value = 4.19 $CV_{Dvoskin}$ = .42 CV_{Smith} = .83

Excess Capacity in Cotton:

R-square = 0.33 T-Value = 4.14 $CV_{Dvoskin}$ = .82 CV_{Smith} = 1.97

Excess Capacity in Soybeans:

R-square = 0.39 T-Value = 4.70 $CV_{Dvoskin}$ = 2.27 CV_{Smith} = 1.37

[a] Estimated over the period, 1950-1986.

in this study, except for soybeans.

Summary

The magnitude and percent of excess capacity varies across time and commodity. In production units, wheat and corn exhibited the largest levels of excess capacity, which cotton and oats indicated the lowest levels of excess capacity. As a percent of potential supply, barley and sorghum were found to contain the largest percent of excess capacity, while soybeans and oats indicated the lowest percent of excess capacity. Soybeans, cotton, and oats showed the greatest annual variability.

The pattern of excess capacity exhibited over time corresponds to the economic, political, and natural events that occurred over the past 40 years. Overall, the duration of the shortfalls and the decline of excess capacity are relatively short, and such periods are often followed by even more excess capacity, as seen during the 1950s and late 1970s. And, unless an outside event, such as an expansion in export demand or adverse weather occurs, or government policy changes to reduce excess capacity, excess capacity follows a gradual upward trend.

The estimates of excess capacity derived in this study are not directly comparable with previous studies due to the differences in the measures employed, but some similarities in results were illustrated. Observation of the excess capacity estimates obtained in this study and those obtained in

Dvoskin's study, reveals that the two measures move together over time. Simple regression results substantiate this claim. However, the magnitude of variability is greater in this study, because it is an annual measure of changes in excess capacity levels.

Implications

If an objective of government involvement in agriculture is to stabilize agriculture markets, then the fact that the government was involved over the period analyzed (except for soybeans) explains why excess capacity is positive for most years. And also, because the government maintains excess capacity through various policy tools, it would not be impractical to assert that excess capacity could have been much lower for years of drought or strong demand. As mentioned in Chapter 1, the government maintains excess capacity in agricultural markets via stock policies, cropland diversion programs, and price supports. However, the changes observed in excess capacity over time are also caused by several factors outside of the government's control, such as weather and international trade policies. This implies that government policy focuses around a level of excess capacity that would insure against adverse consequences resulting from these outside events.

Thus, a primary purpose of government involvement is to maintain excess capacity at an acceptable level or an acceptable price, in order to protect consumers and producers from adverse consequences. Letting agricultural prices seek their market-clearing level would undoubtedly eliminate excess capacity, but this alternative might not be socially acceptable (as illustrated earlier in this study).

Also, the results show greater variability in excess capacity in recent years (1970s and 1980s) than depicted toward the beginning of the analysis period (1950s and 1960s). There are two possible causes for this phenomenon. First, U.S. agriculture has moved towards greater market orientation, with export demand for the six crops analyzed (excluding cotton) rising from 588 million bushels in 1950 to 3628 in 1990. Secondly, frequently re-occurring natural disasters in recent years have contributed to the instability in the magnitude of excess capacity.

Model Validation

The forth stage of model-building is validation. Model validation involves testing and evaluating the estimated model so that it conforms to economic theory, a priori information, and statistical criteria, but more importantly, that the models perform adequately and to a degree necessary for projecting excess capacity in crop production.

Model validation is necessary before applying the models to future conditions. However, the apparent past success in predicting real-world trends may not be sufficient as a certain indicator of future success in forecasting excess capacity. Nonetheless, the purpose of validation is essential in highlighting deficiencies in the models and providing valuable insights in interpretation of their results.

The models are validated on the basis of historical simulations, and an out-of-sample simulation, as well as an appraisal of the signs of the estimated coefficients and the goodness of fit criterion. From Tables 11, 13, 15, 17, and 21, in this chapter, t-values, adjusted R-square statistics, and Durbin-Watson statistics are reported, along with the estimated coefficients for each equation. Observations of these measures indicate that the estimated equations perform adequately, with a few exceptions.

In some cases, correct specifications of the equations, such as including own-price in a demand equation, takes precedence over the statistical criteria. For example, several non-feed demand equations contained insignificant coefficients on the own-price variables, at the 5 percent level. The cotton and barley export demand equations contained low adjusted R-square values, but intuitively correct signs on the estimated coefficients. In this case, obtaining relevant data series which adhered to theoretical expectations posed a problem. This may result in a loss in accuracy in predicting excess capacity in these commodities.

The specified equations for wheat, corn, oats, barley, sorghum, cotton, and soybeans were simulated using the Newton algorithm for non-linear systems. Two in-sample simulations (1950-1990) were conducted to access the performance of the model. The first in-sample simulation was a static simulation where actual values were used for the lagged endogenous variables in the equations. This simulation shows the period by period performance of the equations. That is, errors in the prediction of the dependent variable that occur in one period are not allowed to affect future periods.

The second in-sample simulation was a dynamic simulation where model-predicted values were used for lagged endogenous variables in the system. This simulation is a more rigorous test of the model than the static simulation since errors in endogenous variables are allowed to effect future periods. A third out-of-sample simulation (1991) allowed the performance of the model outside the period of fit to be evaluated.

Summary Statistics of the Simulation Results

Table 27 shows the goodness of fit measures used to validate the specified equations. Mean absolute error and root mean square percentage error statistics are provided in this table. These measures are defined in Appendix C. In some cases, no dynamics can be implied, because the static and dynamic simulation statistics are identical. This may be caused by the lag structure of the equations.

Reassuringly, most models correspond to reality to an acceptable degree. After simulating the models using annual aggregates over the period 1950-90, the simulated endogenous values were plotted against the actual values. The simulated results are reported for the wheat models in Appendix C. From

TABLE 27

GOODNESS OF FIT MEASURES FROM MODEL SIMULATIONS

Variable	Mean Absolute Error In−Sample (1950−199090) Static	Dynamic	Out−of−Sample (1991)
WTPLT	3190	3190	350
WTYLD	1.45	1.45	3.94
WTLA	4649	5528	3958
WTUSEPC	0.2119	0.2119	0.4920
WTTOTSTK	145.841	323.643	499.735
WTEXPORT	121.404	143.676	369.918
CNPLT	1568	1568	2518
CNYLD	5.2081	5.2081	6.1056
CNLA	2522	2877	7303
CNFEUSE	161.5885	161.5885	145.2010
CNFOUSEC	0.0805	0.1449	0.6353
CNTOTSTK	339.9187	684.4353	626.6979
CNEXPORT	134.5943	156.0432	178.3722
CTPLT	1004	1292	1403
CTYLD	32.7702	33.6346	45.1700
CTLA	1383	2204	1609
CTUSEPC	0.0037	0.0299	0.0004
CTTOTSTK	1501	2507	2311
CTEXPORT	1272	1310	686
SBPLT	2203	4889	1248
SBYLD	1.0960	4.1102	1.6475
SBLA	2308	4940	3541
SBDUSE	5457	5457	9467
SBEXPORT	48949	63016	35388
SBTOTSTK	43483	50049	3403
SBCRUSH	29522	34760	63575
SBMUSE	554.5834	554.5834	279.0000
SBMEXPRT	785.4207	785.4207	611.0000
SBMSTOCK	45.0114	55.0107	8.0000
SBOUSEPC	1.5181	1.6389	0.0041
SBOEXPRT	275.9756	298.7875	418.0000
SBOSTOCK	112.7422	124.2516	452.0000
SGPLT	1409	1467	326
SGYLD	3.7613	3.812	2.982
SGLA	1791	2053	1132
SGFEUSE	46.6511	46.6511	163.6644
SGFOUSEC	0.00822	0.00822	0.00739
SGTOTSTK	73.0627	190.3340	17.2260
SGEXPORT	29.2339	30.0670	75.2665
OTPLT	2405	12557	1185
OTYLD	6237332	6237399	6
OTLA	1872	4394	642
OTFEUSE	50.5448	75.1424	191.0322
OTFOUSEC	0.0375	0.0375	0.2036
OTTOTSTK	52.2698	120.1745	43.3221
OTEXPRTT	12.508	12.633	6.362
BYPLT	841	1285	423
BYYLD	32.8573	32.0031	0.7476
BYLA	1358	1659	76
BYFEUSE	15.5819	18.3952	21.3167
BYFOUSEC	0.0288	0.0867	0.0271
BYTOTSTK	24.3067	29.9742	42.7048
BYEXPORT	22.0862	22.0862	13.7274

TABLE 27 (Continued)

GOODNESS OF FIT MEASURES FROM MODEL SIMULATIONS

Variable	Root Mean Square Percentage Error		
	In-Sample (1950-199090)		Out-of-Sample (1991)
	Static	Dynamic	
WTPLT	6.4673	6.4673	0.0050
WTYLD	6.4081	6.4081	0.1030
WTLA	9.0979	10.4165	0.0304
WTUSEPC	6.4494	6.4494	0.1097
WTTOTSTK	44.8964	60.4844	0.5548
WTEXPORT	24.4448	31.8609	0.2284
CNPLT	2.7003	2.7003	0.0321
CNYLD	9.5709	9.5709	0.0532
CNLA	4.7138	5.1563	0.0813
CNFEUSE	5.7136	5.7136	0.0301
CNFOUSEC	10.3643	13.1862	0.1344
CNTOTSTK	129.2074	147.5701	0.3670
CNEXPORT	26.9823	29.9256	0.1010
CTPLT	11.5943	13.1702	0.0993
CTYLD	10.5450	10.6138	0.0693
CTLA	14.9399	19.7849	0.0945
CTUSEPC	17.8333	76.3609	0.0121
CTTOTSTK	38.3757	53.3969	0.5879
CTEXPORT	47.2978	46.1723	0.0985
SBPLT	13.6628	21.8191	0.0211
SBYLD	5.8471	5.7160	0.0480
SBLA	14.8891	23.4563	0.0550
SBDUSE	11.6685	11.6685	0.0997
SBEXPORT	78.0186	95.9503	0.0535
SBTOTSTK	148.1002	160.4916	0.0104
SBCRUSH	9.3790	9.9197	0.0515
SBMUSE	5.7418	5.7418	0.0122
SBMEXPRT	677.3175	677.3175	0.1117
SBMSTOCK	127.1304	126.6651	0.0281
SBOUSEPC	11.6398	14.3067	0.0001
SBOEXPRT	137.3587	226.0601	0.5359
SBOSTOCK	36.8071	40.7592	0.2531
SGPLT	12.4153	11.2927	0.0297
SGYLD	16.9854	15.9369	0.0505
SGLA	17.6315	17.5869	0.0710
SGFEUSE	19.5007	19.5007	0.4318
SGFOUSEC	17.2352	17.2352	0.1229
SGTOTSTK	605.23	1314.00	0.15
SGEXPORT	44.8232	44.7747	0.0357
OTPLT	18.9368	48.3144	0.1362
OTYLD	13706056	13706248	0
OTLA	13.8499	21.3976	0.0849
OTFEUSE	12.1801	14.5683	0.7766
OTFOUSEC	13.8129	13.8129	0.4127
OTTOTSTK	36.3982	54.8966	0.4011
OTEXPRTT	359.3506	489.9586	0.0994
BYPLT	10.9694	14.6694	0.0475
BYYLD	91.4162	85.3084	0.0135
BYLA	12.5228	14.6971	0.0049
BYFEUSE	10.1414	11.7158	0.0996
BYFOUSEC	13.4039	22.5364	0.0370
BYTOTSTK	42.1049	44.7307	0.3117
BYEXPORT	134.0832	134.0832	0.1615

figures 19 thru 24 in Appendix C, one can see that the model has behaved reasonably well in reproducing historical trends.

An important criteria on which to base the performance of the model is its ability to predict the turning points of the endogenous variables. The static simulation plots in Figures 19 thru 24 show that the model is able to capture a majority of the turning points. In some cases, the dynamic and static simulations are identical, because few lagged variables are specified in these equations. The dynamic simulation plots in figures 21, 23, and 24 show that the models still capture most of the turning points but the variability in crop production and commodity demand requires some time for the models to correct for errors that occurred in previous years. Given the number of lagged endogenous variables in the equations, this result is not unexpected.

This section has presented simulation results to validate the commodity models estimated in this chapter. Analysis of the estimated wheat equations in this chapter shows that each describes the variation of the dependent variable very well. The model simulations also show that the equations do an adequate job of replicating the endogenous variables in both in-sample and out-of-sample simulations. Although not reported in this study, dynamic and static simulation plots for each of the endogenous variables estimated earlier in the chapter, were authenticated.

Now that the empirical models have been developed and validated, they can be used to forecast excess capacity requirements under alternative future conditions. The following section will focus on a few of the possible shocks that could be imposed on crop production and commodity demand to determine their impacts on excess capacity requirements.

Forecast of Excess Capacity

The final stage in model building is the application of the aggregate models to uncertain future conditions. In this section, the empirical results from forecasting excess capacity for the period 1992-96 for seven basic U.S. commodities are analyzed. The econometric models developed earlier are employed to investigate the implications of alternative future conditions on excess capacity in the succeeding section.

In order to predict excess capacity levels, the endogenous left-hand side variables in the empirical equations are determined on the basis of forecasted values for the exogenous variables. Prediction data for the exogenous variables were obtained from FAPRI 1992 U.S. Agricultural Outlook, WEFA 1992 domestic agriculture forecasts and macroeconomic indicators, various USDA projection reports, personal communication, and calculations.

Specific assumptions are made when projecting future conditions. The FAPRI 1992 baseline is contingent on a series of assumptions regarding agricultural policies, the general economy, technological change, and weather. FAPRI Staff #1-92 details these assumptions (FAPRI). In particular, agricultural policies of the major trading countries are assumed to continue through the period 1992 thru 1996 as they were in 1991. U.S. target prices, program yields, and loan rate formulations are fixed at 1992 levels. "Normal" weather is also assumed in the baseline.

Recent (beyond 1992) economic developments and policy changes are not accounted for in the forecasting of excess capacity. Although some actual data was available for 1992 and 1993, most published USDA data was only "preliminary" at the time of this analysis. In preliminary analysis, unofficial 1992 and 1993 production and price estimates were used, resulting in less excess capacity than indicated in the baseline forecast presented below. Thus, only economic conditions and market information available prior to 1992 were used.

Domestic and world population were projected to continue at the average rate of increase illustrated over the previous five year period, 1987-1991. Crop production, farm prices, and idled acreage, were projected in the FAPRI 1992 Agricultural Outlook. Production expenses were extrapolated as a percentage change from FAPRI's projected variable expenses.[13]

On the basis of forecasted values for the exogenous variable and the estimated equation parameters, the endogenous values for planted area, harvested yields, cropland available,

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[13] The absolute difference between variable expenses of FAPRI and variable expenses of USDA (used in this analysis), was generally within one or two dollars per acre.

domestic use(s), export demand, and ending stocks are forecasted. Excess capacity for wheat, corn, oats, barley, sorghum, cotton, and soybeans is forecasted over the period 1992 through 1996. Results are presented in table 28. Estimated excess capacity in 1991 using actual data is also presented.

After an initial increase in 1991, excess capacity in barley, sorghum, and cotton declines thru 1996. For wheat, excess capacity falls in 1991 from 32 percent to 27 percent, and again in 1992 to 20 percent. By 1996, excess capacity has declined to about 18 percent of potential supply. Soybeans, corn and oats do not follow a clear trend over the forecast period. After an initial increase in excess capacity in 1991 for corn, excess capacity fall off to 14 percent in 1992. After peaking at 19 percent in 1994, excess capacity again declines. On average, excess capacity in oats and soybeans remain at -6.8 percent and 1.5 percent, respectively, over the analysis period from 1992 to 1996.

Overall, greater stability in the magnitude of excess capacity is observed for all crops over the period than seen before 1991. This is a result of the inherent assumptions made in the forecast. In particular, "normal" weather and continuation of 1991 agricultural policies through 1996 creates stability in the magnitude of excess capacity.

Consequently, if some of the assumptions in this baseline forecast are relaxed, results may deviate dramatically. Investigation of alternative conditions facing agriculture are

TABLE 28

FORECAST OF EXCESS CAPACITY, 1991 – 1996

YEAR	WTECN	WTECNP	CNECN	CNECNP	SBECN	SBECNP	CTECN	CTECNP	OTECN	OTECNP	BYECN	BYECNP	SGECN	SGECNP
	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL.BALES	PERCENT	MIL. BU.	PERCENT	MIL. BU.	PERCENT	MIL. BU.	PERCENT
1991	735.5	27.07	2278.9	23.36	262.6	1.30	15.9	47.49	−29.7	−13.91	257.9	35.71	237.8	28.88
1992	585.0	19.66	1387.0	14.09	237.5	1.18	12.2	42.39	−33.1	−13.63	217.3	33.11	285.9	28.91
1993	855.5	26.00	1667.6	16.84	144.7	0.70	12.0	40.38	−13.6	−4.59	210.2	32.94	206.4	25.35
1994	681.8	22.50	2019.8	19.40	427.5	2.00	10.7	38.12	−15.0	−5.33	236.9	33.90	189.7	22.83
1995	573.3	19.55	1921.0	18.24	470.1	2.18	9.9	36.22	−16.0	−5.49	220.9	32.73	179.7	21.68
1996	543.7	18.28	1827.2	17.23	366.5	1.68	9.2	34.21	−14.4	−5.07	231.9	32.62	146.3	17.88

the focus of the following section.

Impact of Alternative Scenarios on Excess Capacity

Changes in the magnitude of excess capacity in crop production are subject to several random factors. International and domestic government farm policy changes have direct impacts on the magnitude of excess capacity. Likewise, changes in the general economy can lead to significant changes in excess capacity.

The empirical models constructed previously in this chapter will be used to explore the effects of three alternative scenarios on the magnitude of excess capacity. These three scenarios include: a shortfall in domestic production, a change in government policy toward set-aside area, and a shortfall in world production. These scenarios are thought to be responsible for most of the changes observed in the magnitude of excess capacity over the previous 40 years.

The first two scenarios deal with supply side changes, while the last scenario deals with a demand side change affecting exports. Each scenario is analyzed independently for selected commodities. Although these three scenarios reflect only a subset of the possible scenarios that could be evaluated, they have often been associated with the changes that have occurred in the magnitude of excess capacity over the past four decades. Also, one is limited to shocking only the exogenous variables specified in the previously constructed models. For example, foreign production is specified in the export equations for wheat, cotton, and soybeans, but not in the export equations for other commodities.

Key assumptions made in the baseline, developed in the previous section, are relaxed in the scenarios to be evaluated. These assumptions include normal weather and continuation of current (1991) agricultural policies. With increasing yields and normal weather, domestic (and international) production for most commodities increases under the baseline. Certain program provisions regarding idled acreage are presented in table 29.

<u>Scenario 1</u>

A possible production shortfall resulting from exogenous factors, such as weather events or pests, is not unlikely, given the great variability in production observed over the past decade. A 10 percent reduction in domestic production is assumed in 1993 for this scenario. Cross-commodity impacts are considered by lowering production estimates for each crop by 10 percent in 1993. Production for the remaining years is assumed to continue at baseline levels, and other factors are held constant. Analysis of this scenario will indicate the changes in excess capacity resulting from such an event, but are not intended to reflect actual conditions observed in 1993.

TABLE 29

FAPRI ASSUMPTIONS ON IDLED AREA

Program	92/93	93/94	94/95	95/96	96/97
			(Percent)		
Acreage Reduction Program (ARP) Rate					
Corn	5.0	7.5	7.5	5.0	5.0
Sorghum	5.0	7.5	7.5	5.0	5.0
Barley	5.0	7.5	7.5	5.0	5.0
Oats	0.0	0.0	0.0	0.0	0.0
Wheat	5.0	5.0	5.0	5.0	5.0
Rice	0.0	5.0	5.0	5.0	5.0
Cotton	10.0	5.0	5.0	5.0	5.0
Normal Flexed Area Rate	15.0	15.0	15.0	15.0	15.0
Conservation Reserve Program (CRP)			(Million Acres)		
Corn	4.1	4.4	4.6	4.9	4.8
Sorghum	2.4	2.5	2.6	2.7	2.4
Barley	2.8	2.9	3.0	3.1	3.0
Oats	1.4	1.4	1.5	1.5	1.4
Wheat	10.7	11.0	11.3	11.7	11.1
Rice	0.0	0.0	0.0	0.0	0.0
Cotton	1.4	1.4	1.5	1.5	1.4
Soybeans	4.3	4.5	4.7	5.0	4.7
0/92-50/92 Program	12.1	12.5	13.3	13.6	12.5

Actual and percent changes for excess capacity are presented in table 30 for each of the seven commodities for 1993 to 1996. A shortfall in domestic production causes a large initial decrease in excess capacity, except for soybeans. Excess capacity for soybeans climbs substantially in 1993, but drops off in 1994. As seen previously in Table 24, excess capacity in soybeans generally does not follow the same trend as the other crops analyzed.

For most commodities, stocks are drawn down and potential production declines in 1993. After the initial shock, production once again increases, causing stocks to accumulate. Also, the higher farm prices often accompanying a production shortfall may induce more production in succeeding years. For all commodities, except oats, excess capacity increased above baseline levels in 1994, which may imply that the price incentive was important.

The fact that a 10 percent decline in production is "small", relative to previous production shortfalls, such as 1983 and 1988, may explain why excess capacity is quick to adjust after a decline in production. That is, a 20 or 30 percent shortfall in production may result in less excess capacity in the intermediate future (ie. 1994-96). Also, other factors are held constant when analyzing the impacts of this scenario.

Scenario 2

Under scenario 2, diverted government acreage is

TABLE 30

CHANGES IN EXCESS CAPACITY FROM A 10 PERCENT DECLINE IN DOMESTIC PRODUCTION PROJECTED FOR 1993

Period	1993	1994	1995	1996	Avg.
WTECN					
Baseline	855.47	681.78	573.34	543.69	663.57
Scenario 1	827.96	691.04	578.76	546.85	661.15
Difference	−27.51	9.26	5.42	3.16	−2.42
% Difference	−3.2%	1.4%	0.9%	0.6%	−0.1%
CNECN					
Baseline	1667.57	2019.82	1920.99	1827.15	1858.88
Scenario 1	1152.91	2383.79	1924.98	1828.42	1822.52
Difference	−514.66	363.98	3.99	1.27	−36.36
% Difference	−30.9%	18.0%	0.2%	0.1%	−3.1%
OTECN					
Baseline	−13.62	−14.97	−16.02	−14.44	−14.76
Scenario 1	−17.89	−35.88	−15.70	−14.15	−20.91
Difference	−4.27	−20.91	0.32	0.28	−6.14
% Difference	−31.3%	−139.6%	2.0%	1.9%	−41.8%
BYECN					
Baseline	210.22	236.90	220.88	231.94	224.99
Scenario 1	199.24	255.93	233.29	237.98	231.61
Difference	−10.98	19.03	12.41	6.04	6.62
% Difference	−5.2%	8.0%	5.6%	2.6%	2.8%
SGECN					
Baseline	206.42	189.69	179.67	146.32	180.52
Scenario 1	178.61	204.83	179.78	146.54	177.44
Difference	−27.81	15.15	0.11	0.22	−3.08
% Difference	−13.5%	8.0%	0.1%	0.2%	−1.3%
CTECN					
Baseline	11.97	10.74	9.94	9.21	10.46
Scenario 1	10.60	11.10	10.26	9.43	10.35
Difference	−1.37	0.36	0.32	0.22	−0.12
% Difference	−11.4%	3.4%	3.3%	2.4%	−0.6%
SBECN					
Baseline	14.47	42.75	47.01	36.65	35.22
Scenario 1	42.83	102.72	74.90	49.87	67.58
Difference	28.36	59.97	27.89	13.22	32.36
% Difference	196.0%	140.3%	59.3%	36.1%	107.9%

increased by 10 percent from projected levels throughout the period (1992-96). Although effective set-aside depends on the specific land retirement program involved, a general increase of 10 percent is assumed for all land retirement programs. In some cases, a change in diverted acres in a specific crop will influence excess capacity in another crop. Thus, cross-commodity impacts are accounted for in each individual crop analyzed.

Actual and percent changes in excess capacity for wheat, corn, barley, sorghum, cotton and soybeans are provided in table 31. Although soybeans are excluded from farm income support programs, Conservation Reserve (CRP) area attributable to soybeans is applied to soybean idled area. Diverted acreage directly affects cropland available for production. An increase in diverted area, however, may increase harvested area outside of government programs, but this can only be hypothesized.

Higher diverted area increases harvested yields for most crops, as shown previously in the development of the models. Also, an increase in diverted area will lower planted area, except for soybeans and oats.

Excess capacity, resulting from these interactions, for wheat, corn, barley, and cotton shows little change in the intermediate term (1991-96), while excess capacity in sorghum and soybeans declines from baseline levels. For sorghum, a sustained reduction in diverted acres gradually lowers excess capacity thru the period. For wheat, cropland available

TABLE 31

CHANGES IN EXCESS CAPACITY FROM A 10 PERCENT INCREASE IN DIVERTED AREA, 1991–1996

Period	1991–92	1993–94	1995–96	Avg.
WTECN				
Baseline	660.26	768.62	558.51	662.47
Scenario 2	665.46	779.94	570.59	672.00
Difference	5.20	11.32	12.08	9.53
% Difference	0.8%	1.5%	2.2%	1.5%
CNECN				
Baseline	1832.93	1843.69	1874.07	1850.23
Scenario 2	1831.77	1844.63	1870.23	1848.88
Difference	−1.16	0.94	−3.84	−1.35
% Difference	−0.1%	0.1%	−0.2%	−0.1%
BYECN				
Baseline	237.59	223.56	226.41	229.19
Scenario 2	237.92	220.96	220.31	226.40
Difference	0.33	−2.60	−6.10	−2.79
% Difference	0.1%	−1.2%	−2.7%	−1.2%
SGECN				
Baseline	261.66	198.05	162.99	207.57
Scenario 2	258.93	184.30	142.46	195.23
Difference	−2.73	−13.75	−20.53	−12.34
% Difference	−1.0%	−6.9%	−12.6%	−6.9%
CTECN				
Baseline	14.06	11.35	9.57	11.66
Scenario 2	14.07	11.37	9.59	11.67
Difference	0.01	0.01	0.02	0.01
% Difference	0.1%	0.1%	0.2%	0.1%
SBECN				
Baseline	25.01	28.61	41.83	31.82
Scenario 2	23.18	24.68	37.61	28.49
Difference	−1.83	−3.92	−4.22	−3.32
% Difference	−7.3%	−13.7%	−10.1%	−10.4%

increases, resulting in a slight increase in excess capacity for wheat. As mentioned previously, soybeans do not respond to exogenous events in a way consistent with other crops.

In general, changes in excess capacity from baseline levels are small. This result is not unexpected, since excess capacity is often maintained through government policy affecting stocks and diverted area. A 10 percent increase in diverted area changes the form of excess capacity from stocks to idled cropland. However, a decrease in stocks does not completely offset an increase in diverted acres. Thus, small changes that occurred are due to slippage (in the models).

Scenario 3

The third scenario investigated allows crop production in foreign countries to fall while U.S. production remains unchanged (from baseline levels). Foreign production will impact U.S. commodity exports. A decline in production in the rest of the world should boost U.S. exports, holding other factors constant. The impacts of this scenario are explored for wheat, soybeans and cotton exports, since these commodity export equations, discussed previously, specify foreign production.

Table 32 presents the results in excess capacity from a 10 percent decline in foreign production of wheat, cotton, and soybeans for 1992 and 1993. World production under the baseline assumes "normal" weather for international markets. While world production of most commodities has tended upward

TABLE 32

CHANGES IN EXCESS CAPACITY FROM A 10 PERCENT DECLINE IN PROJECTED 1992 AND 1993 FOREIGN PRODUCTION

Period	1992	1993	1994	1995–96	Avg.
WTECN					
Baseline	585.01	855.47	681.78	558.51	670.19
Scenario 3	251.56	521.25	681.78	558.51	503.28
Difference	−333.45	−334.22	−0.00	−0.00	−166.92
% Difference	−57.0%	−39.1%	−0.0%	−0.0%	−24.0%
CTECN					
Baseline	12.19	11.97	10.74	9.57	11.12
Scenario 3	9.53	8.17	8.45	8.52	8.67
Difference	−2.66	−3.80	−2.29	−1.05	−2.45
% Difference	−21.8%	−31.7%	−21.3%	−11.0%	−21.5%
SBECN					
Baseline	23.75	14.47	42.75	41.83	30.70
Scenario 3	−43.81	−80.82	0.54	28.34	−23.94
Difference	−67.56	−95.29	−42.21	−13.49	−54.64
% Difference	−284.4%	−658.7%	−98.7%	−32.2%	−268.5%

historically, recent years show greater variability and a declining rate of increase for the commodities analyzed.

Changes in excess capacity for cotton, soybeans and wheat are significant in 1992 and 1993. Wheat shows a rapid adjustment in excess capacity to baseline levels after 1993. Considering the lag structure of the wheat model, this result is not unexpected. The adjustment in cotton and soybeans is slower than observed for wheat. On average, excess capacity in wheat falls 24 percent, for cotton 21 percent, and for soybeans 268 percent, over the 5-year period.

Overall, excess capacity falls as a result of the strengthened demand for U.S. exports. Because exports are a significant proportion of total commodity disappearance, domestic production has become more dependent on commodity exports.

Summary

The magnitude of excess capacity depends on a number of possible factors, some of which have been evaluated in this section. Results from the scenarios evaluated in this chapter are indicative of the affect of changes in baseline assumptions on changes in excess capacity.

A shortfall in domestic production results in immediate and sizeable deviations in excess capacity, depending on the commodity evaluated, but quickly adjusts to baseline levels. Thus, weather or other exogenous events affect supply directly and immediately impact excess capacity.

An increase in diverted acres results in small changes in excess capacity levels over the period (1991-96). Acreage diversions are used when stocks become excessive. Thus, as diverted acres increase, stocks are drawn down. These two effects (increased diverted acres and reduced stocks) have a conflicting affect on excess capacity.

Factors affecting domestic or export demand have a direct impact on excess capacity. U.S. exports of wheat, cotton, and soybeans increased from a successive (2-year) decline in foreign crop production. Such a case was observed in the early 1970s when a world-wide drought occurred.

These scenarios demonstrate that the crops subsector of the economy is not insulated from the rest of the economy or natural events. Excess capacity will rise or fall depending on the magnitude, duration, and direction of these exogenous events. In addition, since a rise in diverted area has small changes in excess capacity, a coherent policy of increasing stocks and increasing diverted area is needed to effectively raise the level of excess capacity in the near future.

A Brief Analysis of Estimated Elasticities

Before concluding this chapter, a presentation of estimated elasticities of exogenous variables with respect to excess capacity in the wheat models are provided. An evaluation of elasticities explaining the impact of exogenous factors on the structure of the commodity models will be investigated for wheat. Short-run elasticities of key exogenous variables specified in the wheat models are presented in table 33. Variable definitions are provided in table 34. The elasticities can be interpreted as the average percent change in excess capacity in wheat from a one percent change in the mean level of the exogenous variable.

The results show that elasticities from the demand side are greater than those on the supply side. Price impacts from the exogenous variables specified in the supply equations have very little impact on excess capacity, holding other factors fixed. On the other hand, wheat price has a sizeable impact on excess capacity thru the export equation. A one percent change in the wheat farm price will change excess capacity by .24 percent.

A slight response of excess capacity to changes in foreign production is illustrated in this analysis. Evaluated at the historical means (1950-1990) of the data, a shortfall in foreign wheat production of 10 percent will lower excess capacity by about 2 percent in the short run.

Overall, the impacts on excess capacity of exogenous factors specified in the wheat models are small, holding other factors constant. Evaluation of the point elasticities in a more recent time period (eg. 1980-1990) would likely change these results.

TABLE 33

ELASTICITIES FROM THE WHEAT EQUATIONS[a]

Variable	Excess Capacity in Wheat
WTMKTRT1	.000688
WTPNRET	-.000688
BYPNRET	.001376
WTACRDVT	.035784
WTARPPLD	.062156
WTPLT	.581609
WTVDIVW	.026638
GRNCONSF	-.1717
WTPRCCHG	.003
WTPROD	-.543
WTPRODF1	.370
WTROWPRO	.205
RRWTLPRC	.242
WRLDPOP	-.037

[a] Elasticities are reported at their mean values.

TABLE 34

DEFINITIONS OF VARIABLES IN THE WHEAT EQUATIONS

Variable	Definition
WTMKTRT1	Wheat market net returns
WTPNRET	Wheat participant net returns
BYPNRET	Barley participant net returns
WTACRDVT	Wheat total diverted acres
WTARPPLD	Wheat diverted acres in the ARP and PLD programs
WTPLT	Wheat planted area
WTVDIVW	Wheat voluntary diversion payment rate
GRNCONSF	Grain-consuming animal units
WTPRCCHG	Wheat price change
WTPROD	Wheat production
WTPRODF1	Expected wheat production
WTROWPRO	Wheat production in rest of the world
RRWTLPRC	Wheat price last year
WRLDPOP	World population

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The primary objectives of this research were twofold. The first objective was to determine the magnitude of excess capacity for U.S. crop production over the period 1950 thru 1990. The second objective was to predict excess capacity levels for the period 1992 thru 1996.

Excess capacity is defined as the ability to produce in excess of the quantity demanded, at an acceptable price. Several pieces of literature were reviewed to accelerate the development of a theoretical and empirical model of excess capacity. Measures of excess capacity were compared and contrasted from both agriculture and non-agriculture literature.

The second chapter developed a conceptual model of excess capacity and discussed the constructs employed therein. Also, a unique measure of excess capacity was proposed. Chapter 3 presented theoretical commodity models employed to measure excess capacity. Specification of aggregate potential supply and demand models were discussed.

The fourth chapter presented the empirical commodity models constructed from the theoretical developments in

Chapter 3. The empirical measure of excess capacity in seven storable U.S. commodities -wheat, corn, oats, barley, sorghum, cotton, and soybeans- was evaluated. Data requirements and estimation methods were discussed. The annual magnitude of excess capacity was measured over the period 1950 to 1990. The results are consistent with previous research (Dvoskin). The models are validated using various simulation techniques and statistical measures.

A forecast of excess capacity levels for the period 1992 to 1996 was developed based on projected future conditions. The response of excess capacity requirements to the shocks of exogenous variables was explored in the last section of Chapter 4. The impacts of domestic and international production shortfalls and increases in diverted acreage on short run excess capacity levels were also discussed.

Conclusions

Observations of past excess capacity levels and important economic, political and natural events that occurred over the 1950-1990 time period, reveal that low levels of excess capacity correspond with exogenous factors, such as adverse domestic (and international) weather, and expanded domestic and international demand. Likewise, high levels of excess capacity often correspond with ample production and weak export demand. Government policy is introduced to maintain excess capacity through policy tools, such as stocks, price supports, demand enhancement (eg. PL-480), and land retirement (or diverted area). Government involvement in agriculture becomes more sensitive to adverse conditions occurring in the lean years. As a result, these policy tools are often applied to maintain excess capacity at an acceptable level. This level must be sufficient to protect consumers and producers from outside factors likely to increase commodity prices, and reduce the stability of the food supply and farm incomes.

The government costs of maintaining excess capacity at an acceptable level are a concern to policy makers. Since each policy tool bears a direct cost to the government, a "least-cost mix" of policy tools for maintaining an optimum level of excess capacity should be an important objective of government policy. Since idling diverted acres is often less expensive than holding excess capacity in stocks, a possible solution would be to hold excess capacity in idled land only. However, stocks provide a buffer against potential production shortfalls in a given year. Also, by increasing land retirement through voluntary programs, such as the Acreage Reduction Program, producers would have less incentive to participate in these programs, unless deficiency payments are also increased. That is, producers would elect not to participate and receive government payments, and the government would then have less control of excess capacity. Thus, an *optimal* level of excess capacity can be conceptually achieved by focusing on a balance of stocks, land retirement, and price support policies, and evaluating the tradeoffs for various agents in the economy.

An important extension of this research would be to determine an *optimal* level of excess capacity given a certain set of social and political goals. Once the optimum level of excess capacity is determined, the optimal mix of policy tools needed to achieve this optimum must be explored. For example, is a 5 percent reduction in base (through diverted acres) and a 10 percent carryover of stocks, the least cost alternative to obtaining an optimum level of excess capacity?

Some concerns about the data used or generated for the analysis have been raised. Clearly, the measure of potential production is constructed based on observed data, but is subject to substantial error, due to the aggregate nature of the data. Improved data collection methods will lead to a more accurate representation of potential supply.

While measuring excess capacity for only seven commodities will grossly ignore the broader issue of excess capacity in U.S. agriculture, the scope of this study can be extended to account for excess capacity in other commodities. *Other* commodities refer to those with capabilities for annual storage, and with existing government involvement, such as tobacco, rice, and dairy products.

Although not of primary importance, commodity models with as many equations as are contained in this analysis are inherently complex and require considerable knowledge of each commodity by the model builder. This dissertation represents a substantial investment of learning by the researcher about commodity modelling and sets the stage for additional model refinements and empirical evaluations to be conducted in order to increase the accuracy of the excess capacity measure developed.

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APPENDIXES

APPENDIX A

REVIEW OF PREVIOUS EXCESS CAPACITY STUDIES

TABLE 35

DESCRIPTIONS OF POLICY OPTIONS OF FREE MARKETS, FEED GRAIN PROGRAM, ACREAGE QUOTAS, AND ACREAGE QUOTAS AND UNSUBSIDIZED EXPORTS[a]

Free Market Model 1 (FMM-1): Free market policy with all acreage restrictions removed, except cotton quotas. Exports set at 1965 levels.

Free Market Model 2 (FMM-2): Same as FMM-1, except exports set at projected trend 1980 levels.

Free Market Model 3 (FMM-3): Free market policy with all acreage restrictions removed, and export set at projected trend 1980 levels.

Free Market Model 4 (FMM-4): Free market policy with all restrictions removed, and exports set at their maximum projected 1980 levels. (No stocks, or production less projected domestic demand equals exports).

Feed Grain Program (FGP): Land retirement needs to feed grains, wheat and cotton to balance output with domestic and foreign demand. Exports set at projected trend 1980 levels.

Acreage Quotas (AQ): Mandatory acreage quotas replace voluntary output control programs for wheat, feed grains, and cotton. Soybeans planted on land freed from acreage quotas on other crops. Exports set at projected trend 1980 levels.

Acreage Quotas and Unsubsidized Exports (AQUE): Terminate Government subsidized programs. Exports for 1980 based on commercial export demand.

[a] Source: Heady and Mayer(1967).

TABLE 36

ACREAGES OF UNUSED LAND BY REGIONS OF THE UNITED STATES, ACTUAL 1965 AND PROJECTED 1980 LEVELS UNDER ALTERNATIVE POLICY OPTIONS (IN THOUSAND ACRES)[a]

Region	1965	FMM-1 1980	FMM-2 1980	FMM-3 1980	FMM-4 1980	FGP 1980	AQ 1980	AQUE 1980
Northeast	1,334	1,119	0	0	0	390	286	693
Lake States	5,428	8,318	4,871	4,526	0	4,332	3,498	6,892
Corn Belt	10,820	17,829	4,101	4,101	0	6,949	4,751	13,693
Northern Plains	15,111	29,749	22,080	22,646	0	10,234	8,744	21,637
Appalachian	3,230	4,395	3,564	4,194	0	3,529	2,365	3,070
Southeast	4,257	6,581	4,930	4,930	0	4,632	3,319	5,159
Delta States	1,255	6,222	4,180	5,758	0	4,749	4,240	4,507
Southern Plains	8,146	2,903	2,563	1,360	0	7,062	8,370	9,733
Mountain	5,084	1,332	690	704	0	3,605	1,728	5,202
Pacific	1,285	0	0	0	0	70	689	689
United States	55,968	78,449	46,979	48,220	0	45,552	37,990	71,275

[a] Source: Heady and Mayer (1967).

TABLE 37

Major Land Uses for Selected Years[1]

Land Use	1900	1910	1920	1930	1940	1950	1959	1969	1978	1982	1987
Cropland[2]	319	347	402	413	399	409	392	384	395	404	399
Grassland Pasture and Range[3]	832	814	750	708	723	700	699	692	663	662	656
Forest Land[4]	---	562	567	607	602	606	728	723	703	655	648
Other Land[5]	---	181	185	176	180	189	452	465	503	544	562
Total Land Area[6]	---	1,904	1,904	1,904	1,904	1,904	2,271	2,264	2,264	2,265	2,265

[1] Estimates are based primarily on reports and records of the U.S. Bureau of the Census and Federal and State land management and conservation agencies.
[2] Total cropland exclusive of cropland used only for pasture.
[3] Grassland and other nonforested pasture and range plus cropland used only for pasture. Idle grassland that probably existed in large acreages only before 1920 is also included.
[4] Total forest land exclusive of forest areas in parks, wilderness, wildlife refuges, and other special uses.
[5] Includes special land uses, such as urban areas, highways and roads, farmsteads, parks, and military reservations, and also land having slight surface-use value (desert, rock, marshes, tundra, etc.).
[6] Changes in total land area are due to the addition of Alaska and Hawaii as States in 1959 and to changes in methods and materials used in occasional remeasurements.

TABLE 38

CROPLAND USES FOR SELECTED YEARS (Million Acres)[a]

Land Use	1910	1920	1930	1940	1950	1959	1969	1978	1982	1987
Cropland Harvested	317	351	360	331	336	317	286	330	347	269
Crop Failure	9	12	11	16	12	10	6	7	5	4
Cultivated Summer Fallow	4	5	11	21	29	31	41	32	31	35
Idle Cropland	17	34	31	32	32	34	51	26	21	91
Cropland Pasture	---	---	---	---	69	66	88	76	65	65
Total Cropland[b]	347	402	413	399	409	392	384	395	404	399

[a] Sources: Economic Research Service and predecessor agencies. Estimates are based mainly on reports and records of the Bureau of the Census and Federal and State land management and conservation agencies.
[b] Total cropland exclusive of cropland used only for pasture.

TABLE 39

SUMMARY OF MEASURES OF MANUFACTURER'S CAPACITY UTILIZATION

Bureau of Economic Analysis (BEA):

Approach: Capacity utilization rates obtained quarterly from survey of companies. Maximum practical capacity generally used by respondents to figure utilization rates. Questionnaire asks actual and preferred operating rates. Specifically, questions posed include: "At what percentage of manufacturing capacity did your company operate in (month and year)?" and "At what percentage of (month and year) manufacturing capacity would your company have preferred to operate in order to achieve maximum profits or other objectives?" In 1973 the sample consisted of almost 2,400 companies, accounting for about 75% of gross depreciable assets in 1969. Companies combined into industry asset-size classes, using company reported 1969 gross depreciable asset weights, to obtain (1) best-change and (2) best-level estimates. Weighted averages of the two yield the composite estimates for industry asset-size classes. The latter are combined into industries using 1969 IRS gross depreciable asset weights. Industries combined into groups, using 1969 capacity weights.

Source: *Survey of Current Business*.

Federal Reserve Board - Manufacturing:

Approach: Capacity utilization rates calculated by dividing derived capacity output into actual output. Implicit concept of capacity like McGraw-Hill's. Three indicators of capacity combined on basis of assumptions about their deviations from "true" capacity. X_1, actual output divided by a utilization rate, assumed to have short-term random disturbances. X_2, McGraw-Hill annual yearend index of capacity, assumed to have upward bias over time. X_3, a gross capital stock series, assumed to have downward bias. General level and major movements of derived capacity estimates established by X_1; X_2 and X_3 smooth and extrapolate beyond the X_1 time period. Steps followed for 2 subgroups: 1. divide Dec seasonal adjusted FRB index of IP by McGraw-Hill yearend operating rate to obtain X_1; 2. using historical relation of X_1 to X_2 and X_1 to X_3 (estimated by regression techniques stipulating that relation depends on time and random disturbance), obtain trend- and level-adjusted X_2 and X_3; 3. average adjusted X_2 and X_3 to obtain final capacity estimates; 4. interpolate linearly between yearend estimates to obtain quarterly estimates; 5. divide quarterly IP by quarterly capacity to obtain utilization rate. Resulting rates average using 1967 value-

TABLE 39 (CONTINUED)

added weights to obtain rate for total manufacturing.

Source: *Federal Reserve Bulletin and Statistical Release*, "Capacity Utilization in Manufacturing."

McGraw-Hill Publications Co.-Annual:

Approach: Capacity utilization rates obtained from survey of companies. Maximum practical capacity generally used by respondents to figure utilization rates. Questionnaire asks actual operating rate and, intermittently, preferred rate. Respondents usually large companies. In 1974, respondents accounted for 53% of fixed assets. Companies combined into industries, using current employment weights. Industries combined into groups, using FRB index of IP 1967 weights.

Source: *Annual McGraw-Hill Survey*, McGraw-Hill Publications Company.

The Conference Board:

Approach: Capacity evaluations obtained from survey of companies; summary utilization rate calculated form evaluations. Questionnaire asks whether facilities inadequate, sufficient, or more than adequate to meet current orders; if more that adequate, respondents check p.c. range indicating extent of underutilization. Questionnaires sent to 1,000 largest companies; about 400 respond. In 1973, respondents accounted for 48-49% of 1967 total assets of companies with at least $10 million assets. Steps followed: 1. assign p.c. utilization rate to each survey response category (inadequate:96.5, sufficient: 91.5, more than adequate: 85.0 to 62.5, depending on extent of underutilization); 2. combine assigned rates, using company-reported 1967 total assets as weights.

Source: *Semiannual Survey of Investment Conditions*, The Conference Board.

Wharton School, Univ. of Penn.:

Approach: Capacity utilization rates are based on deductive calculations. Maximum-attained-output concept of capacity. Steps followed for each growing industry: 1. plot quarterly (average of seasonal adjusted monthly values) FRB index of Industrial Production; 2. identify peak values; 3. draw straight lines between peaks, and for quarters beyond peaks extrapolate (if actual values exceed trend, actual values become peaks); 4. read capacity output from lines drawn; 5. divide actual output (see step 1) by capacity output to obtain utilization rate. Special procedure used for declining

TABLE 39 (CONTINUED)

industries. Thirty-six industries combined into groups, using peak period national income originating weights.

Source: *Wharton Quarterly*, Wharton EFA, Inc.

McGraw-Hill Publications Co.-Monthly:

Approach: Capacity utilization rates calculated from increases in production and from survey data on expected increases in capacity. Concept of capacity same as that of annual survey. Steps followed for each industry: 1. prorate year's expected p.c. change in capacity from annual survey over 12 months; 2. calculate monthly p.c. change in FRB index of IP; 3. divide monthly p.c. change in production by monthly p.c. change in capacity, and link resulting net change to previous month's operating rate. Benchmarked each Dec. to average of survey-based and calculated rate. Industries combined into groups, using FRB index of IP 1967 value-added weights.

Source: *Business Week*

APPENDIX B

ESTIMATION RESULTS USING GENERALIZED LEAST SQUARES, DERIVATIONS OF CALCULATED VARIABLES USED IN FINAL MODEL SPECIFICATIONS, AND COMPONENTS OF CROPLAND AVAILABLE BY COMMODITY

TABLE 40

DERIVATIONS OF THE CALCULATED VARIABLES USED IN THE FINAL MODEL SPECIFICATIONS

Variable	Derivation	Units
WTPLT		acres
WTACTDVT		acres
WTMKTRT1	((wheat price*wheat production) - (variable wheat expenses*wheat area planted)) / wheat production	$/bu.
WTPNRET	((wheat price*wheat production)-(total wheat expenses*wheat area planted)+(gov't wheat payments*1000) - (.25*variable wheat expenses)*(wheat CRP area*1000)-(.25*variable wheat expenses) * (wheat (non-CRP) diverted area * 1000)) / wheat production	$/bu.
BYPNRET	((barley price*barley production) + (gov't barley payments*1000) - (total barley expenses*barley area planted) - (variable barley expenses*.2) * (barley diverted area*1000)) / barley production	$/bu.
DUMS80	Shift variable for year>=1980	
DUMS74	Shift variable for year>=1974	
CNPLT		acres
CNNPNRET	((corn price*corn production) - (variable expenses*corn area planted)) / corn production	$/bu.
WTNPNRET	((wheat price*wheat production) - (total wheat expenses*wheat area planted)) / wheat production	$/bu.
CNACRDVT		acres
SBPLT		acres
SBRETMA1	((((soybean price*soybean production) - (total soybean expenses*soybean area planted)) / soybean production)$_t$ + (((soybean price*soybean production) - (total soybean expenses*soybean area planted)) / soybean production)$_{t-1}$ + (((soybean price*soybean production) - (total soybean expenses*soybean area planted)) / soybean production)$_{t-2}$)/3	$/bu.
DUM78	Dummy variable for year=1978	
DUM73	Dummy variable for year=1973	
SGPLT		acres
SGNPNRET	((sorghum price*sorghum production) - (variable sorghum expenses*(sorghum area planted-sorghum area harvested for silage-sorghum area harvested for forage))) / sorghum production	$/bu.
SGACRDVT		acres
DUM55	Dummy variable for year=1955	

TABLE 40 (Continued)

OTPLT		acres
OTMKTRT1	((barley price*barley production) - (variable barley expenses*barley area planted)) / barley production	$/bu.
DUM83	Dummy variable for year=1983	
CTPLT		acres
CTARPPLD		acres
DUM75	Dummy variable for year=1975	
CTMKTRT1	((cotton price*cotton production) - (variable cotton expenses*cotton area planted)) / cotton production	$/bu.
BYPLT		acres
BYACRDVT		acres
BYWTPRC6	(((barley spot price*.6 + barley malt price*.4) / wheat price)$_t$ + ((barley spot price*.6 + barley malt price*.4) / wheat price)$_{t-1}$ + ((barley spot price*.6 + barley malt price*.4) / wheat price)$_{t-2}$)/3	$/bu.
SBRTTMA3	((((soybean price*soybean production) - (total soybean expenses*soybean area planted)) / soybean production)$_t$ + ((((soybean price*soybean production) - (total soybean expenses*soybean area planted)) / soybean production)$_{t-1}$ * .8) + ((((soybean price*soybean production) - (total soybean expenses*soybean area planted)) / soybean production)$_{t-2}$ *.2))/3	$/bu.
WTYLD		bu./acre
LNYEAR50	log(year - 1900)	
WTARPPLD		acres
CNYLD		bu./acre
PRDLINDX		
CNARPPLD		acres
DUMS80	Shift variable for year>=1980	
SBYLD		bu./acre
SBMDUM	=1 in 1976, 1980, 1983, 1988, 0 otherwise	
SBACRP		acres
SGYLD		bu./acre
SGARPPLD		acres
CTYLD		bu./acre
CTMDUM	=1 in 1974-1976, 1978, 1983, and 1986, 0 otherwise	
OTYLD		bu./acre
LNYEAR40	log(year - 1940)	
DUM85	Dummy variable for year=1985	
BYYLD		bu./acre
DUM88	Dummy variable for year=1988	
DUM61	Dummy variable for year=1961	
WTLA		acres
WTVDIVW	wheat voluntary diversion payment rate * wheat program participation rate	
CNLA		acres

TABLE 40 (Continued)

CNRTT	((((corn price*corn production) - (variable corn expenses*corn area planted) + (gov't corn payments*1000) - ((.2*variable corn expenses) * (corn diverted area*1000))) / corn production) + (((corn price*corn production) - (variable corn expenses*corn area planted)) / corn production))	$/bu.
RROTLPRC		$/bu.
WTSGRTT	(.8*total wheat net returns + .2*total sorghum net returns)	$/bu.
SBLA		acres
RRWTLPRC		$/bu.
LGYEAR49	log(year - 1949)	
SGLA		acres
DUMS74	Shift variable for year>=1974	
SGRTT	((((sorghum price*sorghum production) - (variable sorghum expenses*(sorghum area planted-sorghum sorghum area harvested for silage-sorghum area harvested for forage))) / sorghum production) + (((sorghum price*sorghum production) - (variable sorghum expenses*(sorghum area planted-sorghum sorghum area harvested for silage-sorghum area harvested for forage)) - (total sorghum expenses*.2)*(sorghum diverted area*1000)) / sorghum production))	$/bu.
CTLA		acres
CNRTTMA1	$(CNRTT_t + CNRTT_{t-1} + CNRTT_{t-2})/3$	$/bu.
RRCTLSP2		$/bales
LNYEAR	log(year)	
OTLA		acres
OTCOMPT1	(oat $price_{t-1}$ + oat support $price_t$) / total oat $expenses_t$	$/bu.
BYLA		acres
BYRSPRIC		$/bu.
BYCOMPV1	(barley $price_{t-1}$ + barley support $price_t$) / variable barley $expenses_t$	$/bu.
CNFEUSE		bushels
RRCNPRIC		$/bu.
RRSBMPRC		$/ston
CTLOFED1	Cattle on feed + GRCONSN1	head
DUMS79	Shift variable for year>=1979	
SBMUSE		short tons
GRCONSN1		units
RCTLPRIC		$/cwt.
YEAR		
SGFEUSE		bushels
RRSGPRIC		$/bu.

TABLE 40 (Continued)

CTLOFED3	.5*cattle on feed$_t$ + .5*expected cattle on feed$_{t-1}$	head
DUMS74	Shift variable for year>=1974	
OTFEUSE		bushels
MILKCOWS		head
RROTPRIC		$/bu.
TRND7186	=1 in 1971, 2 in 1972,..., 16 in 1986-1990, 0 otherwise	
BYFEUSE		bushels
RRBYPRIC		$/bu.
BYPROD		bushels
CNFOUSEC		bushels/ person
DPINCC		$/person
RRCNPRIC		$/bu.
CNPLTF1C		acres/ person
TRND8184	=1 in 1981, 2 in 1982, 3 in 1983, 4 in 1984-1990, 0 otherwise	
OTFOUSEC		bushels/ person
RROTPRIC		$/bu.
YEAR		
DUMS83	Shift variable for year>=1983	
OTPLTF1C		acres/ person
SGFOUSEC		bushels/ person
RRSGPRIC		$/bu.
PCEFOODC		$/person
DUM85	Dummy variable for year=1985	
RRBYPRIC		$/bu.
PDICAPP		$/bu.
BYFOUSEC		bushels/ person
RPBYPRIC		$/bu.
RPSGPRIC		$/bu.
BYPLTF1C		acres/ person
WTUSEPC		bu./ person
DPINCC		$/person
GRNCONSF		units/ person
RWTCNPRC	Wheat - Corn price ratio	
DUMS85	Dummy variable for year>=1985	
SBDUSE		bushels
RRSBPRIC		$/bu.
SBPLTF1C		acres/ person

TABLE 40 (Continued)

SBOUSEPC		pounds/ person
RPSBOPRC		$/lb.
PDICAPP		$/person
CTUSEPC		bales/ person
CTPLTF1C		acres/ person
TXTPINDR		
SBCRUSH		pounds
SBPRAMGR	(soybean meal price*soybean meal processing yield + soybean oil price*soybean oil processing yield) - soybean price	
SBPROD		bushels
WTTOTSTK		bushels
WTTOTSK1		bushels
WTPRCCHG	wheat $price_t$ - wheat $price_{t-1}$	$/bu.
WTPROD		bushels
WTPRODF1		bushels
CNTOTSTK		bushels
CNTOTSK1		bushels
CNPRCCHG	corn $price_t$ - corn $price_{t-1}$	$/bu.
CNPROD		bushels
CNPRODF1		bushels
DUM8890	Shift variable for year>=1988	
SBTOTSTK		bushels
STTOTSK1		bushels
SBPRCCHG	soybean $price_t$ - soybean $price_{t-1}$	$/bu.
SBPRODF1		bushels
SBMSTOCK		short tons
SBMSTOK1		short tons
SBMSPCHG	soybean meal spot $price_t$ - soybean meal spot $price_{t-1}$	$/ston
SBMELPRO		short tons
DUM72	Dummy variable for year=1972	
DUM82	Dummy variable for year=1982	
SBOSTOCK		pounds
SBOSTOK1		pounds
SBOPRCHG	soybean oil $price_t$ - soybean oil $price_{t-1}$	$/lb.
SBOILPRO		lbs.
SBOPROF1		lbs.
DUM8384	Shift variable for year=1983,1984	
DUM8687	Shift variable for year=1986,1987	
SGTOTSTK		bushels
SGTOTSK1		bushels
SGPRCCHG	sorghum $price_t$ - sorghum $price_{t-1}$	$/bu.
SGPROD		bushels
SGPRODF1		bushels

TABLE 40 (Continued)

CTTOTSTK		bushels
CTTOTSK1		bushels
CTPRCCHG	cotton $price_t$ - cotton $price_{t-1}$	$/bale
CTPROD		bales
CTPRODF1		bales
OTTOTSTK		bushels
OTTOTSK1		bushels
OTPRCCHG	oat $price_t$ - oat $price_{t-1}$	$/bu.
OTPROD		bushels
OTPRODF1		bushels
BYTOTSTK		bushels
BYTOTSK1		bushels
BYPRCHG1	barley $price_t$ - barley $price_{t-1}$	$/bu.
BYPROD		bushels
BYPRODF1		bushels
OTEXPRTT		bushels
DUMS83	Shift variable for year>=1983	
RROTPRIC		$/bu.
RRWTPRIC		$/bu.
CTEXPORT		bushels
CTLPRCLN	max(cotton $price_{t-1}$, cotton loan rate)	$/bale
CTROWPRO		metric tons
DUM79	Dummy variable for year=1979	
SGEXPORT		bushels
RRSGPRIC		$/bu.
SGIMCTL		head
RRBYPRIC		$/bu.
CNEXPORT		bushels
RPCNPRIC		bushels
RPEXRTGM		German Markper U.S. $
DUM5072	Trend variable for year<=1972	
RPSBMPRC		$/ston
WTEXPORT		bushels
WTROWPRO		metric tons
RRWTLPRC		$/bu.
SBOEXPRT		lbs.
RRSBMLPR		$/ston
WRLDPOP		persons
RRSBOSBP		
SBEXPORT		bushels
RRSBSPRC		$/bu.
SBROWPRO		metric tons
RRSBOPRC		$/lb.
RRSBMPRC		$/ston
SBMEXPRT		short tons

TABLE 41

TOTAL AREA PLANTED ESTIMATION RESULTS BY CROP USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$$WTPLT_t = .6830\ E5 + .3696\ E6\ {*}WTMKTRT1 - .1003\ E5\ {*}WTPNRET + .1074\ E7\ {*}BYPNRET$$
(33.32) (4.50) (-8.34) (11.62)

$$+ .1684\ E5 * DUMS80 - .4553\ E3 * WTACRDVT$$
(9.37) (-5.06)

Adj.R^2= .91 D.W.= 1.95

$$CNPLT_t = .8368\ E5 + .1819\ E6\ {*}CNNPNRET_t - .2722\ E6\ {*}WTNPNRET_t - .7346\ E3\ {*}CNACRDVT_t$$
(88.24) (2.83) (-6.23) (-20.43)

Adj.R^2= .92 D.W.= 1.21

$$SBPLT_t = .3327\ E4 + .9775\ E3\ {*}SBRTTMA3 + .7302\ E0 * SBPLT_{t-1} + .2145\ E0\ {*}SBPLT_{t-2}$$
(0.99) (1.67) (4.84) (2.54)

$$+ .7532\ E4\ {*}DUM78 + .9674\ E4\ {*}DUM73$$
(2.26) (2.61)

Adj.R^2= .97 D.W.= 2.27

$$SGPLT_t = .8141\ E4 + .9445\ E5\ {*}SGNPNRET_t - .4865\ E3\ {*}SGACRDVT_t - .6213\ E5\ {*}WTNPNRET_t$$
(2.52) (1.41) (-2.64) (-1.22)

$$- .2407\ E4\ {*}DUMS74 + .5210\ E4\ {*}DUM55 - .6249\ E0\ SGPLT_{t-1}$$
(-2.35) (1.93) (3.83)

Adj.R^2= .55 D.W.= 2.09

TABLE 40 (Continued)

RRSBMSBP		
SBMIMCTL		head
BYEXPORT		bushels
RRBYLPRC		$/bu.
DUM86	Dummy variable for year=1986	

TABLE 41 (Continued)

$$OTPLT_t = .1715\ E4 + .1148\ E6\ {*}OTMKTRT1_t - .1157\ E6\ {*}SGNPNRET_t + .1575\ E4\ {*}DUM83$$
(9.24) (0.99) (-1.70) (.7515)

$$+ .9127\ E0\ {*}OTPLT_{t-1}$$
(14.77)

Adj.R^2= .88 D.W.= 1.38

$$CTPLT_t = .2985\ E4 - .5779\ E3\ {*}CTARPPLD_t - .5006\ E4\ {*}DUM75 + .2563\ E3\ {*}CTMKTRT1_t$$
(1.87) (-2.37) (-2.01) (-0.45)

$$+ .8701\ E0\ {*}CTPLT_{t-1}$$
(7.83)

Adj.R^2= .74 D.W.= 1.33

$$BYPLT_t = .5980\ E4 - .4325\ E3\ {*}BYACRDVT + .2677\ E5\ {*}BYWTPRC6 + .6583\ E0\ {*}BYPLT_{t-1}$$
(3.81) (-3.92) (0.82) (6.31)

$$- .5288\ E5\ {*}SBRETMA1$$
(-3.20)

Adj. R^2= .80 D.W.= 2.10

TABLE 42

HARVESTED YIELD ESTIMATION RESULTS BY CROP USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$$WTYLD_t = -.1134\ E3 + .3384\ E2\ *LNYEAR50 + .1166\ E0\ *WTARPPLD_t - .3363\ E\text{-}4\ *WTPLT_t$$

(-11.13) (13.46) (2.28) (-0.94)

Adj.R^2= .92 D.W.= 1.63

$$CNYLD_t = -.3668\ E1 + .7348\ E0\ *PRDLINDX_t + .7789\ E0\ *CNARPPLD_t - .1451\ E2\ *DUMS80$$

(-0.15) (14.66) (2.38) (-3.27)

$$+ .7441\ E\text{-}3\ *CNPLT_t$$

(1.55)

Adj.R^2= .93 D.W.= 1.80

$$SBYLD_t = .1867\ E2 + .9689\ E\text{-}1\ *PRDLINDX_t - .3767\ E1\ *SBMDUM_t + .2679\ E\text{-}4\ *SBPLT_t$$

(27.51) (3.78) (-4.60) (0.55)

$$- .1393\ E0\ *SBACRP_t$$

(-0.34)

Adj.R^2= .87 D.W.= 1.65

$$SGYLD_t = -.4055\ E1 + .1005\ E\text{-}2\ *SGPLT_t + .2417\ E1\ *SGARPPLD_t + .3691\ E0\ *PRDLINDX_t$$

(-0.55) (2.98) (7.37) (13.91)

Adj.R^2= .87 D.W.= 1.40

TABLE 42 (Continued)

$$CTYLD_t = .5003\ E3 + .1485\ E1\ {*}PRDLINDX_t - .8458\ E{-2}\ {*}CTMDUM_t - .8458\ E2\ {*}CTPLT_t$$
(12.40) (6.73) (-4.44) (-4.18)

Adj.R^2= .79 D.W.= 1.28

$$OTYLD_t = .6238\ E2 + .9330\ E1\ {*}DUM85 - .6040\ E{-3}\ {*}OTPLT_t$$
(37.89) (2.19) (-9.95)

Adj.R^2= .74 D.W.= 1.79

$$BYYLD_t = -.2340\ E2 + .2040\ E2\ {*}LNYEAR40 - .2823\ E{-3}\ {*}BYPLT - .1481\ E2\ {*}DUM88 - .3708\ E1\ {*}DUM61$$
(-2.58) (11.96) (-1.07) (-4.95) (-1.22)

Adj.R^2= .89 D.W.= 1.20

TABLE 43

CROPLAND AVAILABLE ESTIMATION RESULTS BY CROP USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$$WTLA_t = \underset{(-3.61)}{-.9710\ E5} + \underset{(2.74)}{.2753\ E0} * WTPLT_t + \underset{(4.25)}{.5193\ E0} * WTLA_{t-1} + \underset{(2.28)}{.2702\ E4} * WTVDIVW_t$$

$$+ \underset{(3.52)}{.2789\ E5}\ LNYEAR50$$

Adj.R^2= .90 D.W.= 1.63

$$CNLA_t = \underset{(4.40)}{.7052\ E5} - \underset{(1.62)}{.2800\ E0} * CNLA1_{t-1} + \underset{(1.11)}{.7130\ E5} * CNRTT - \underset{(-2.64)}{.3629\ E6} * RROTLPRC - \underset{(-3.75)}{.1764\ E6} * WTSGRTT$$

Adj.R^2= .77 D.W.= 2.01

$$SBLA_t = \underset{(1.69)}{.5280\ E4} + \underset{(1.31)}{.2073\ E0} * SBLA_{t-1} - \underset{(-1.92)}{.7105\ E5} * RRWTLPRC_t + \underset{(4.66)}{.7439\ E0} * SBPLT$$

Adj.R^2= .98 D.W.= 2.03

$$SGLA_t = \underset{(2.89)}{.1420\ E4} + \underset{(0.50)}{.1047\ E0} * SGLA_{t-1} + \underset{(1.61)}{.3306\ E0} * SGPLT_t + \underset{(2.10)}{.6938\ E5} * SGRTT_t$$

$$- \underset{(-3.91)}{.1330\ E6} * RRWTLPRIC_{t-1} - \underset{(-2.04)}{.2281\ E4} * DUMS74$$

Adj.R^2= .70 D.W.= 1.85

TABLE 43 (Continued)

$$CTLA_t = -.2006\ E5 + .2331\ E0\ {*CTLA1_{t-1}} - .1248\ E4\ {*CNRTTMA1_t} + .4804\ E4\ {*RRCTLSP2_{t-1}}$$
$$\qquad (-0.32) \qquad (1.06) \qquad (-4.24) \qquad (3.71)$$

$$+ .2995\ E4\ {*LNYEAR_t}$$
$$(2.59)$$

Adj.R^2= .71 D.W.= 1.85

$$OTLA_t = .1459\ E4 + .5783\ E0\ {*OTLA_{t-1}} + .4284\ E7\ {*OTCOMPT1_t}$$
$$\qquad (1.29) \qquad (4.36) \qquad (2.99)$$

Adj.R^2= .98 D.W.= 1.77

$$BYLA_t = .7101\ E4 + .2981\ E0\ {*BYLA1_{t-1}} + .1421\ E5\ {*BYCOMPT1} - .6119\ E5\ {*SBRETMA1}$$
$$\qquad (2.48) \qquad (1.24) \qquad (0.80) \qquad (-2.36)$$

$$+ .2767\ E0\ {*BYPLT_{t-1}}$$
$$(1.95)$$

Adj.R^2= .65 D.W.= 1.96

TABLE 44

FEED DEMAND ESTIMATION RESULTS FOR FEED GRAINS AND SOYBEAN MEAL USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$$CNFEUSE_t = .4738\ E4 - .1491\ E5\ *RRCNPRIC + .1853\ E3\ *RRSBMPRC + .3539\ E\text{-}5\ *CTLOFED1$$
(4.50) (-3.26) (2.56) (7.66)

$$+ .4732\ E3\ *DUMS79$$
(4.57)

Adj.R^2= .93 D.W.= 1.80

$$SBMUSE_t = -.8352\ E6 + .6135\ E\text{-}1\ *GRCONSN1_t + .4095\ E4\ *RCTLPRIC_t - .9485\ E3\ *RRSBMPRC_t$$
(-19.15) (2.83) (3.94) (-4.75)

$$+ .4246\ E3\ *YEAR_t$$
(18.18)

Adj.R_2= .98 D.W.= 1.83

$$SGFEUSE_t = .1017\ E3 - .5190\ E4\ *R1SGPRIC_t + .5332\ E\text{-}1\ *CTLOFED3 - .1284\ E3\ *DUMS74$$
(1.50) (-4.74) (11.88) (-5.52)

Adj.R^2= .87 D.W.= 1.74

$$OTFEUSE_t = .6936\ E2 + .2073\ E\text{-}1\ *MILKCOWS_t - .1505\ E5\ *RROTPRIC_t - .5155\ E2\ *TRND7186_t$$
(1.39) (2.92) (-4.55) (-1.77)

$$+ .6317\ E4\ *RRCNPRIC_t + .6061\ E0\ *OTFEUSE_{t-1}$$
(3.99) (4.62)

Adj.R^2= .97 D.W.= 2.38

TABLE 44 (Continued)

$BYFEUSE_t$= -.7982 E1 - .4849 E4 *RRBYPRIC + .5301 E0 *BYFEUSE1 + .2778 E-3 *BYPROD
(-0.22) (-3.39) (6.08) (4.88)

+ .4613 E4 *RRSGPRIC
(3.73)

Adj.R^2= .82 D.W.= 1.97

TABLE 45

NON-FEED DEMAND ESTIMATION RESULTS FOR FEED GRAINS USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$$CNFOUSEC_t = \underset{(-2.57)}{-.4766\ E0} + \underset{(6.79)}{.1496\ E\text{-}1} * DPINCC_t + \underset{(1.93)}{.1397\ E1} * CNPLTF1C_{t+1} - \underset{(-1.20)}{.1998\ E1} * RRCNPRIC_t$$

$$+ \underset{(6.76)}{.2094\ E0} * TRND8184 + \underset{(9.82)}{.5913\ E0} * CNFOUSEC_{t-1}$$

Adj.R^2= .99 D.W.= 1.15

$$OTFOUSEC_t = \underset{(5.52)}{.2542\ E2} + \underset{(0.05)}{.1972\ E0} * RROTPRIC_t - \underset{(-5.50)}{.1274\ E\text{-}1} * YEAR_t + \underset{(4.55)}{.1671\ E0} * DUMS83$$

$$+ \underset{(3.66)}{.9745\ EO} * OTPLTF1_{t+1} + \underset{(0.94)}{.1943\ E1} * RRCNPRIC_t$$

Adj.R^2= .91 D.W.= 0.73

$$SGFOUSEC_t = \underset{(7.90)}{.5908\ E\text{-}1} - \underset{(-2.86)}{.3206\ E1} * RRSGPRIC_t + \underset{(1.82)}{.1197\ E1} * RRCNPRIC_t + \underset{(2.24)}{.1109\ E\text{-}2} * PCEFOODC_t$$

$$+ \underset{(4.26)}{.5734\ E\text{-}1} * DUM85 + \underset{(1.37)}{.1446\ E1} * RRBYPRIC_t$$

Adj.R^2= .43 D.W.= 1.68

TABLE 45 (Continued)

$$BYFOUSEC_t = -.1683\ E0 - .6496\ E0\ {*RPBYPRIC} + .1750\ E1\ {*RPSGPRIC} + .8346\ E0\ {*BYFOUSEC_{t-1}}$$
$$(-1.77) \quad (-0.39) \quad (1.08) \quad (10.80)$$

$$+ .3017\ E0\ {*BYPLTF1C} + .5236\ E\text{-}3\ {*PDICAPP}$$
$$(1.14) \quad (2.57)$$

Adj.R^2= .89 D.W.= 2.22

TABLE 46

AGGREGATE DOMESTIC DEMAND ESTIMATION RESULTS FOR SOYBEAN OIL, COTTON, WHEAT, AND NON-CRUSH SOYBEANS USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$$CTUSEPC_t = .9544\ E\text{-}2 + .7829\ E0\ {*}CTUSEPC_{t-1} - .2064\ E\text{-}2\ {*}TXTPINDR_t + .2201\ E2\ {*}CTPLTF1C_t$$

(2.07) (7.78) (-1.45) (0.76)

$Adj.R^2 = .93$ D.W.= 1.92

$$WTUSEPC_t = .5064\ E\text{-}1 - .2820\ E2\ {*}RWTCNPRC_t + .7379\ E0\ {*}DUM18390 + .5526\ E0\ {*}DUMS85$$

(0.06) (-5.19) (4.21) (3.26)

$$+ .5148\ E1\ {*}GRNCONSF$$

(4.77)

$Adj.R^2 = .69$ D.W.= 1.66

$$SBDUSE_t = .1707\ E5 - .1482\ E6\ {*}RRSBPRIC_t + .1276\ E1\ {*}SBPLTF1_{t+1}$$

(2.78) (-2.49) (18.94)

$Adj.R^2 = .91$ D.W.= 1.64

$$SBOUSEPC_t = -.3704\ E2 - .7430\ E1\ {*}RPSBOPRC_t + .2048\ E0\ {*}PDICAPP_t + .5143\ E0\ {*}SBOUSEPC_{t-1}$$

(-2.45) (-2.61) (3.05) (3.72)

$$+ .2031\ E0\ {*}SBOUSEPC_{t-2}$$

(1.89)

$Adj.R^2 = .98$ D.W.= 2.53

TABLE 47

SOYBEAN CRUSH DEMAND ESTIMATION RESULTS USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$$SBCRUSH_t = \underset{(2.26)}{.4052\ E5} + \underset{(7.74)}{.4724\ E0} * SBCRUSH1_t + \underset{(2.91)}{.5963\ E7} * SBPRAMGR_t + \underset{(2.84)}{.2638\ E0} * SBPROD_t$$

$Adj.R^2 = .99$ D.W. = 1.67

TABLE 48

EXPORT DEMAND ESTIMATION RESULTS BY CROP USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$$OTEXPRTT_t = \underset{(2.06)}{.2882\ E2} - \underset{(-1.83)}{.2038\ E2} *DUMS83 - \underset{(-2.50)}{.3256\ E4} *RROTPRIC_t + \underset{(2.30)}{.7940\ E3} *RRWTPRIC_t$$

$$+ \underset{(6.19)}{.7957\ E0} *OTEXPRTT_{t-1}$$

Adj.R^2= .73 D.W.= 2.10

$$CTEXPORT_t = \underset{(2.63)}{.3569\ E4} - \underset{(-1.07)}{.9393\ E3} *CTLPRCLN_{t-1} - \underset{(-0.93)}{.4311\ E-1} *CTROWPRO_t + \underset{(2.12)}{.3527\ E4} *DUM79$$

$$+ \underset{(1.91)}{.4005\ E0} *CTEXPORT_{t-1}$$

Adj.R^2= .09 D.W.= 2.40

$$SGEXPORT_t = \underset{(-1.69)}{-.8897\ E2} - \underset{(-2.46)}{.8398\ E4} *RRSGPRIC_t + \underset{(3.92)}{.6331\ E-2} *SGIMCTL_t + \underset{(2.72)}{.9926\ E4} *RRBYPRIC_t$$

$$+ \underset{(0.61)}{.1103\ E0} *SGEXPRT1_{t-1}$$

Adj.R^2= .80 D.W.= 1.69

TABLE 48 (Continued)

$$CNEXPORT_t = \underset{(2.41)}{.7497\ E3} - \underset{(-0.23)}{.8559\ E3}\ {*}RPCNPRIC_t - \underset{(-2.89)}{.5894\ E4}\ {*}RPEXRTGM_t + \underset{(4.17)}{.5610\ E0}\ {*}CNEXPORT_{t-1}$$

$$+ \underset{(2.18)}{.1131\ E3}\ {*}RPSBMPRC_t$$

Adj.R^2= .93 D.W.= 2.06

$$WTEXPORT_t = \underset{(0.81)}{.5903\ E3} - \underset{(-3.52)}{.1653\ E{-3}}\ {*}WTROWPRO_t - \underset{(-2.45)}{.7759\ E4}\ {*}RRWTLPRC_t + \underset{(2.74)}{.6646\ E{-3}}\ {*}WRLDPOP_t$$

$$- \underset{(-2.60)}{.4388\ E3}\ {*}DUM5072_t + \underset{(2.31)}{.3385\ E0}\ {*}WTEXPORT_{t-1}$$

Adj.R^2= .86 D.W.= 2.00

$$SBOEXPRT_t = \underset{(0.63)}{.2464\ E3} + \underset{(1.26)}{.1177\ E3}\ {*}RRSBMLPR_{t-1} + \underset{(4.45)}{.7182\ E0}\ {*}SBOEXPRT_{t-1} - \underset{(-0.92)}{.1577\ E4}\ {*}RRSBOSBP_t$$

R^2= .65 D.W.= 1.80

$$SBEXPORT_t = \underset{(4.43)}{.7782\ E6} - \underset{(-1.72)}{.3038\ E7}\ {*}RRSBPRIC_t - \underset{(-4.32)}{.3889\ E7}\ {*}RREXRTGM_t - \underset{(-2.78)}{.5761\ E1}\ {*}SBROWPRO_t$$

$$+ \underset{(0.83)}{.2136\ E6}\ {*}RRSBOPRC_t + \underset{(1.18)}{.3517\ E6}\ {*}RRSBMPRC_t + \underset{(3.10)}{.4362\ E0}\ {*}SBEXPORT_{t-1}$$

Adj.R^2= .93 D.W.= 1.97

$$SBMEXPRT_t = \underset{(-3.31)}{-.1216\ E5} - \underset{(-3.50)}{.3086\ E4}\ {*}RRSBMSBP_t + \underset{(5.56)}{.4608\ E0}\ {*}SBMIMCTL_t$$

Adj.R^2= .84 D.W.= 0.99

TABLE 48 (Continued)

$$BYEXPORT_t = \underset{(6.40)}{.9943\text{ E2}} - \underset{(-3.61)}{.3637\text{ E4}} * RRBYLPRC_{t-1} + \underset{(2.12)}{.5720\text{ E2}} * DUM86 + \underset{(3.06)}{.1521\text{ E4}} * RRWTLPRC_{t-1}$$

Adj.R^2= .33 D.W.= 1.89

TABLE 49

ENDING STOCKS ESTIMATION RESULTS BY CROP USING ESTIMATED GENERALIZED LEAST SQUARES, 1950-1990

$WTTOTSTK_t$= .1091 E3 + .1042 E1 $*WTTOTSTK_{t-1}$ - .3142 E0 $*WTTOTSTK_{t-2}$ - .3611 E5 $*WTPRCCHG_t$
(0.94) (6.82) (-2.15) (-1.90)

+ .4455 E-3 $*WTPROD_t$ - .2183 E-3 $*WTPRODF1_{t+1}$
(2.69) (-1.77)

Adj.R^2= .80 D.W.= 1.92

$CNTOTSTK_t$= -.2599 E3 + .6786 E0 $*CNTOTSTK_{t-1}$ - .5196 E5 $*CNPRCCHG_t$ + .4267 E-3 $*CNPROD_t$
(-1.27) (10.22) (-4.45) (7.58)

- .2601 E-3 $*CNPRODF1_{t+1}$ - .7064 E3 *DUM8890
(-4.52) (-2.74)

Adj.R^2= .85 D.W.= 1.89

$SBTOTSTK_t$= -.1554 E5 + .4162 E0 $*SBTOTSTK_{t-1}$ - .2234 E7 $*SBPRCCHG_t$ + .1757 E0 $*SBPROD_t$
(-0.60) (3.52) (-2.67) (3.50)

- .1151 E-1 $*SBPRODF1_{t+1}$
(-1.22)

Adj.R^2= .80 D.W.= 1.60

TABLE 49 (Continued)

$$SBMSTOCK_t = .2133\ E2 + .3278\ E0\ {*}SBMSTOCK_{t-1} - .1197\ E3\ {*}SBMPRCHG_t + .2698\ E{-2}\ {*}SBMELPRO_t$$
(0.98) (2.98) (-5.21) (1.42)

$$+ .3457\ E3\ {*}DUM72 + .2798\ E3\ {*}DUM82 + .2980\ E0\ {*}SBMSTOCK_{t-2}$$
(4.03) (4.69) (2.52)

Adj. R^2 = .77 D.W. = 2.18

$$SBOSTOCK_t = -.2245\ E2 + .4906\ E0\ {*}SBOSTOCK_{t-1} - .2001\ E3\ {*}SBOPRCHG_t + .2052\ E0\ {*}\ SBOILPRO_t$$
(-0.83) (4.92) (-0.96) (5.56)

$$- .1428\ E0\ {*}\ SBOPROF1_{t+1} - .4227\ E3\ {*}DUM8384 + .4011\ E3\ {*}DUM8687$$
(-3.77) (-3.19) (2.86)

Adj. R^2 = .88 D.W. = 2.20

$$SGTOTSTK_t = .3142\ E1 + .1338\ E1\ {*}SGTOTSTK_{t-1} - .7222\ E4\ {*}SGPRCCHG_t + .2583\ E{-3}\ {*}\ SGPROD_t$$
(0.07) (9.39) (-2.61) (2.98)

$$- .1588\ E{-3}\ {*}SGPRODF1_{t+1} - .5430\ E0\ {*}SGTOTSTK_{t-2}$$
(-1.71) (-3.79)

Adj. R^2 = .87 D.W. = 1.68

$$CTTOTSTK_t = -.5329\ E4 + .7915\ E0\ {*}CTTOTSTK_{t-1} - .9202\ E3\ {*}CTPRCCHG_t + .8344\ E0\ {*}CTPROD_t$$
(-2.72) (9.69) (-1.02) (6.04)

$$- .3029\ E0\ {*}CTPRODF1_{t+1}$$
(-2.29)

Adj. R^2 = .81 D.W. = 1.86

TABLE 49 (Continued)

$$OTTOTSTK_t = -.2096\ E1 + .8499\ E0\ *OTTOTSTK_{t-1} - .1118\ E5\ *OTPRCCHG_t + .1315\ E\text{-}3\ *OTPROD_t$$
(-0.10) (8.83) (-3.10) (1.65)

$$-.7763\ E\text{-}4\ *\ OTPRODF1_{t+1}$$
(-1.12)

Adj.R^2= .84 D.W.= 1.66

$$BYTOTSTK_t = -.3396\ E2 - .3550\ E4\ *BYPRCHG1_t + .5084\ E0\ *BYTOTSTK_{t-1} + .4933\ E\text{-}3\ *BYPROD_t$$
(-1.06) (-3.06) (5.75) (6.44)

$$-\ .1703\ E\text{-}3\ *BYPRODF1_{t+1}$$
(-2.30)

Adj.R^2= .77 D.W.= 2.20

TABLE 50

COMPONENTS OF CROPLAND AVAILABLE FOR WHEAT

YEAR	HARVESTED	FAILED	FALLOWED	DIVERTED
		(Million Acres)		
1950	61.778	4.225	15.698	0.000
1951	61.760	6.412	16.804	0.000
1952	71.002	4.006	17.121	0.000
1953	67.808	5.159	15.619	0.000
1954	54.359	4.204	14.218	0.000
1955	47.328	5.387	14.988	0.000
1956	49.772	8.031	16.105	0.000
1957	43.841	2.868	12.189	0.000
1958	52.998	2.007	13.617	0.000
1959	51.747	2.981	13.764	0.000
1960	51.905	1.736	13.631	0.000
1961	51.563	3.536	14.993	0.000
1962	43.678	2.797	15.176	10.700
1963	45.509	3.338	16.102	7.200
1964	49.743	2.285	16.757	5.100
1965	49.645	2.077	18.007	7.200
1966	49.616	1.625	17.747	8.200
1967	58.434	2.364	17.042	0.000
1968	54.811	1.956	16.946	0.000
1969	47.146	1.428	18.373	11.100
1970	43.599	1.407	16.162	15.700
1971	47.747	1.824	15.620	13.500
1972	47.285	2.020	18.331	20.100
1973	54.139	1.417	14.809	7.400
1974	65.272	2.836	17.083	0.000
1975	69.507	2.572	16.969	0.000
1976	70.917	3.441	17.878	0.000
1977	66.630	2.687	16.426	0.000
1978	56.545	2.340	16.685	9.600
1979	62.399	2.356	17.183	8.200
1980	71.073	4.254	17.111	0.000
1981	80.735	2.182	16.132	0.000
1982	77.886	1.899	13.445	5.800
1983	61.417	1.987	17.194	30.000
1984	66.876	2.650	16.038	18.300
1985	64.643	3.469	16.108	18.800
1986	60.772	3.544	17.042	21.700
1987	55.907	2.553	15.607	28.100
1988	53.144	3.991	15.113	29.600
1989	62.282	3.452	15.051	18.400
1990	69.331	2.555	14.034	17.800

TABLE 50 (Continued)

COMPONENTS OF CROPLAND AVAILABLE FOR CORN

YEAR	HARVESTED	FAILED	FALLOWED	DIVERTED
		(Million Acres)		
1950	73.709	2.658	3.888	0.000
1951	72.623	3.828	3.722	0.000
1952	73.238	2.262	3.551	0.000
1953	72.226	2.504	3.365	0.000
1954	71.074	2.883	3.729	0.000
1955	71.027	3.123	4.215	0.000
1956	67.615	4.718	4.193	0.000
1957	65.242	3.213	3.902	0.000
1958	66.439	2.255	3.950	0.000
1959	72.026	2.630	4.425	0.000
1960	71.425	1.636	4.559	0.000
1961	57.657	2.510	4.159	19.100
1962	55.739	2.160	4.565	20.300
1963	59.193	1.918	4.749	17.200
1964	55.394	1.203	4.573	22.200
1965	55.369	1.272	4.293	24.000
1966	57.012	1.061	4.724	23.700
1967	60.679	1.737	3.927	16.100
1968	55.969	1.222	3.929	25.500
1969	54.564	1.387	5.368	27.100
1970	57.351	1.232	5.395	26.100
1971	64.089	1.097	4.867	14.100
1972	57.524	1.433	5.607	24.400
1973	62.111	1.022	4.686	6.000
1974	65.388	1.413	4.506	0.000
1975	67.625	1.316	4.342	0.000
1976	71.468	1.509	4.382	0.000
1977	71.641	2.250	4.416	0.000
1978	71.960	1.075	4.845	6.100
1979	72.403	0.993	4.788	2.900
1980	72.960	2.023	4.386	0.000
1981	77.582	1.215	3.927	0.000
1982	72.748	1.069	5.229	2.100
1983	51.470	0.921	4.297	32.200
1984	71.904	1.187	4.217	3.900
1985	75.216	1.571	4.520	5.400
1986	68.893	1.555	4.522	14.500
1987	59.527	1.044	6.036	25.300
1988	58.259	2.265	4.515	23.300
1989	64.708	1.343	3.952	14.200
1990	66.946	1.296	3.693	13.900

TABLE 50 (Continued)

COMPONENTS OF CROPLAND AVAILABLE FOR OATS

YEAR	HARVESTED	FAILED	FALLOWED	DIVERTED
		(Million Acres)		
1950	39.345	1.510	3.642	0.000
1951	35.197	1.921	3.008	0.000
1952	37.004	1.155	3.101	0.000
1953	37.564	1.573	3.025	0.000
1954	40.506	1.818	3.572	0.000
1955	39.059	2.364	4.154	0.000
1956	33.374	3.284	3.989	0.000
1957	34.034	1.750	3.373	0.000
1958	31.281	1.169	3.198	0.000
1959	27.779	1.353	3.139	0.000
1960	26.574	0.724	3.036	0.000
1961	23.884	1.386	3.318	0.000
1962	22.394	1.221	3.613	0.000
1963	21.314	1.136	3.470	0.000
1964	19.774	0.716	3.472	0.000
1965	18.517	0.619	3.224	0.100
1966	17.891	0.487	3.292	0.000
1967	16.101	0.533	2.213	0.000
1968	17.704	0.541	2.570	0.000
1969	17.986	0.504	3.726	0.000
1970	18.602	0.564	4.073	0.000
1971	15.708	0.538	2.812	0.000
1972	13.410	0.593	3.190	0.000
1973	13.761	0.376	2.342	0.000
1974	12.619	0.541	2.195	0.000
1975	13.040	0.412	1.888	0.000
1976	11.826	0.494	1.874	0.000
1977	13.491	0.520	2.159	0.000
1978	11.122	0.404	2.044	0.000
1979	9.683	0.325	1.719	0.000
1980	8.656	0.557	1.497	0.000
1981	9.401	0.287	1.423	0.000
1982	10.253	0.282	1.895	0.100
1983	9.068	0.381	2.133	0.300
1984	8.167	0.311	1.415	0.100
1985	8.176	0.385	1.503	0.100
1986	6.862	0.411	1.540	0.600
1987	6.882	0.322	1.557	1.300
1988	5.537	0.597	1.517	1.210
1989	6.880	0.362	1.277	1.500
1990	5.943	0.253	1.003	1.530

TABLE 50 (Continued)

COMPONENTS OF CROPLAND AVAILABLE FOR BARLEY

YEAR	HARVESTED	FAILED	FALLOWED	DIVERTED
		(Million Acres)		
1950	11.168	0.629	3.793	0.000
1951	9.422	0.687	2.961	0.000
1952	8.237	0.342	2.568	0.000
1953	8.687	0.456	2.422	0.000
1954	13.354	0.866	4.479	0.000
1955	14.499	1.106	4.099	0.000
1956	12.855	1.555	4.430	0.000
1957	14.858	0.773	5.412	0.000
1958	14.779	0.525	5.114	0.000
1959	14.848	0.789	5.391	0.000
1960	13.839	0.475	5.320	0.000
1961	12.825	0.949	5.634	0.000
1962	12.221	0.821	5.820	2.400
1963	11.224	0.832	5.565	2.700
1964	10.268	0.566	5.115	3.600
1965	9.162	0.441	4.276	3.800
1966	10.238	0.369	4.921	3.700
1967	9.228	0.393	3.509	0.000
1968	9.729	0.361	3.709	0.000
1969	9.554	0.291	4.446	4.400
1970	9.722	0.329	4.532	3.900
1971	10.097	0.376	4.068	0.000
1972	9.650	0.397	4.664	4.900
1973	10.307	0.302	3.819	1.400
1974	7.922	0.276	2.963	0.000
1975	8.617	0.377	3.054	0.000
1976	8.436	0.342	2.858	0.000
1977	9.722	0.375	3.315	0.000
1978	9.243	0.282	3.265	0.800
1979	7.529	0.267	2.646	0.700
1980	7.266	0.380	2.494	0.000
1981	9.036	0.234	2.808	0.000
1982	9.020	0.280	3.721	0.400
1983	9.731	0.294	4.323	1.100
1984	11.221	0.377	3.916	0.500
1985	11.596	0.654	4.112	0.700
1986	12.018	0.415	4.455	2.100
1987	9.952	0.355	3.752	4.100
1988	7.631	0.609	3.355	4.700
1989	8.317	0.349	2.593	4.700
1990	7.493	0.257	2.381	5.600

TABLE 50 (Continued)

COMPONENTS OF CROPLAND AVAILABLE FOR SORGHUM

YEAR	HARVESTED	FAILED	FALLOWED	DIVERTED
		(Million Acres)		
1950	10.346	1.024	1.676	0.000
1951	8.544	1.038	1.564	0.000
1952	5.326	0.473	0.844	0.000
1953	6.295	0.648	1.044	0.000
1954	11.718	0.992	1.992	0.000
1955	12.891	1.907	2.984	0.000
1956	9.209	1.686	2.199	0.000
1957	19.682	1.528	3.779	0.000
1958	16.524	0.781	2.538	0.000
1959	15.386	1.125	2.661	0.000
1960	15.616	0.656	2.644	0.000
1961	10.989	0.757	2.062	6.100
1962	11.571	0.862	2.634	5.500
1963	13.335	1.194	3.297	4.700
1964	11.746	0.570	2.805	6.500
1965	13.037	0.411	3.018	7.000
1966	12.831	0.410	3.007	7.300
1967	14.987	0.478	2.678	4.200
1968	13.903	0.496	3.381	7.000
1969	13.442	0.479	4.082	7.500
1970	13.555	0.568	3.812	7.400
1971	16.134	0.987	4.171	4.100
1972	13.202	0.813	4.192	7.300
1973	15.701	0.522	3.168	2.000
1974	13.807	1.147	3.303	0.000
1975	15.395	0.691	2.850	0.000
1976	14.477	1.046	3.099	0.000
1977	13.798	0.696	2.826	0.000
1978	13.418	0.765	3.059	1.400
1979	12.898	0.576	2.741	1.100
1980	12.513	0.980	2.641	0.000
1981	13.685	0.437	2.251	0.000
1982	14.130	0.535	2.734	0.700
1983	10.011	0.354	2.212	5.700
1984	15.359	0.607	2.575	0.600
1985	16.771	0.693	2.568	0.900
1986	13.857	0.846	2.652	3.000
1987	10.530	0.445	2.197	5.300
1988	9.039	0.672	2.058	5.800
1989	11.109	0.673	2.113	5.500
1990	9.086	0.379	1.452	5.700

TABLE 50 (Continued)

COMPONENTS OF CROPLAND AVAILABLE FOR COTTON

YEAR	HARVESTED	FAILED	FALLOWED	DIVERTED
		(Million Acres)		
1950	17.869	1.357	1.490	0.000
1951	26.992	2.858	3.212	0.000
1952	25.962	2.250	2.834	0.000
1953	24.378	2.232	2.575	0.000
1954	19.280	1.553	1.740	0.000
1955	16.945	2.090	2.358	0.000
1956	15.621	2.248	2.440	1.120
1957	13.564	1.223	1.450	3.016
1958	11.858	0.694	1.090	4.926
1959	15.158	1.088	1.476	0.000
1960	15.360	0.757	1.328	0.000
1961	15.691	0.873	1.316	0.000
1962	15.615	1.089	1.380	0.000
1963	14.237	1.125	1.676	0.000
1964	14.061	0.625	1.246	0.000
1965	13.606	0.397	0.958	0.000
1966	9.557	0.340	0.800	4.560
1967	7.993	0.321	0.623	4.848
1968	10.163	0.321	0.727	3.318
1969	11.049	0.508	0.991	0.000
1970	11.169	0.442	0.905	0.000
1971	11.482	0.624	1.111	2.060
1972	12.974	0.652	1.237	2.052
1973	11.976	0.356	0.843	0.000
1974	12.532	0.818	1.456	0.000
1975	8.796	0.357	0.814	0.000
1976	10.922	0.606	1.068	0.000
1977	13.282	0.724	1.313	0.000
1978	12.407	0.852	1.664	0.290
1979	12.837	0.668	1.531	0.000
1980	13.214	0.859	1.549	0.000
1981	13.856	0.423	1.165	0.000
1982	9.732	0.414	1.211	1.580
1983	7.343	0.283	0.940	6.613
1984	10.385	0.537	1.163	2.478
1985	10.234	0.508	1.029	3.613
1986	8.462	0.814	1.240	3.540
1987	10.035	0.600	1.187	4.640
1988	11.951	0.661	1.255	3.250
1989	9.534	0.647	1.091	4.720
1990	11.712	0.568	1.050	3.250

TABLE 50 (Continued)

COMPONENTS OF CROPLAND AVAILABLE FOR SOYBEANS

YEAR	HARVESTED	FAILED	FALLOWED	DIVERTED
		(Million Acres)		
1950	13.790	0.297	0.112	0.000
1951	13.643	0.556	0.129	0.000
1952	14.437	0.312	0.180	0.000
1953	14.790	0.327	0.150	0.000
1954	17.054	0.484	0.170	0.000
1955	18.591	0.423	0.202	0.000
1956	20.608	0.878	0.244	0.000
1957	20.837	0.844	0.196	0.000
1958	23.977	0.770	0.292	0.000
1959	22.677	0.634	0.245	0.000
1960	23.621	0.517	0.282	0.000
1961	27.034	0.889	0.418	0.000
1962	27.652	0.851	0.511	0.000
1963	28.654	0.657	0.541	0.000
1964	30.742	0.435	0.632	0.000
1965	34.515	0.583	0.825	0.000
1966	36.554	0.609	0.910	0.000
1967	39.855	0.974	0.708	0.000
1968	41.459	0.902	0.738	0.000
1969	41.355	1.004	0.914	0.000
1970	42.213	0.858	0.921	0.000
1971	42.767	0.655	0.651	0.000
1972	45.705	0.993	0.879	0.000
1973	55.667	0.804	0.932	0.000
1974	51.320	1.070	0.794	0.000
1975	53.576	0.776	0.783	0.000
1976	49.372	0.861	0.640	0.000
1977	57.754	1.748	0.744	0.000
1978	63.563	0.883	1.038	0.000
1979	70.426	0.816	1.191	0.000
1980	67.832	1.447	1.122	0.000
1981	66.083	0.922	1.095	0.000
1982	69.533	0.821	1.665	0.000
1983	62.434	0.781	1.700	0.000
1984	66.223	0.931	1.575	0.000
1985	61.556	1.020	1.460	0.000
1986	58.261	1.216	1.648	0.300
1987	57.160	0.681	1.763	2.100
1988	57.364	1.705	1.987	2.900
1989	59.556	1.074	1.623	3.500
1990	56.523	0.991	1.386	4.000

APPENDIX C

DEFINITIONS OF GOODNESS OF FIT CRITERIA USED IN SIMULATIONS, AND SIMULATION PLOTS OF ACTUAL VERSUS SIMULATED VALUES FOR ENDOGENOUS VARIABLES IN THE WHEAT EQUATION

TABLE 51

DEFINITIONS OF GOODNESS OF FIT STATISTICS USED TO VALIDATE COMMODITY MODELS

Mean Absolute Error (MEA):

$$MEA = \frac{1}{T} \sum_{t=1}^{T} |\hat{y}_t - y_t| ,$$

where T = number of time periods simulated,
t = time,

$\hat{y}_t$ = simulated level of the variable at time t, and

y_t = actual level of the variable at time t.

Comment: MEA is a measure of bias for a simultaneous system.

Root Mean Square Percentage Error (RMSPE):

$$RMSPE = \sqrt{\frac{1}{T}\sum_{t=1}^{T} \left(\frac{\hat{y}_t - y_t}{y_t}\right)^2}$$

Elements are defined above.

Comment: RMSPE is a measure of variability.

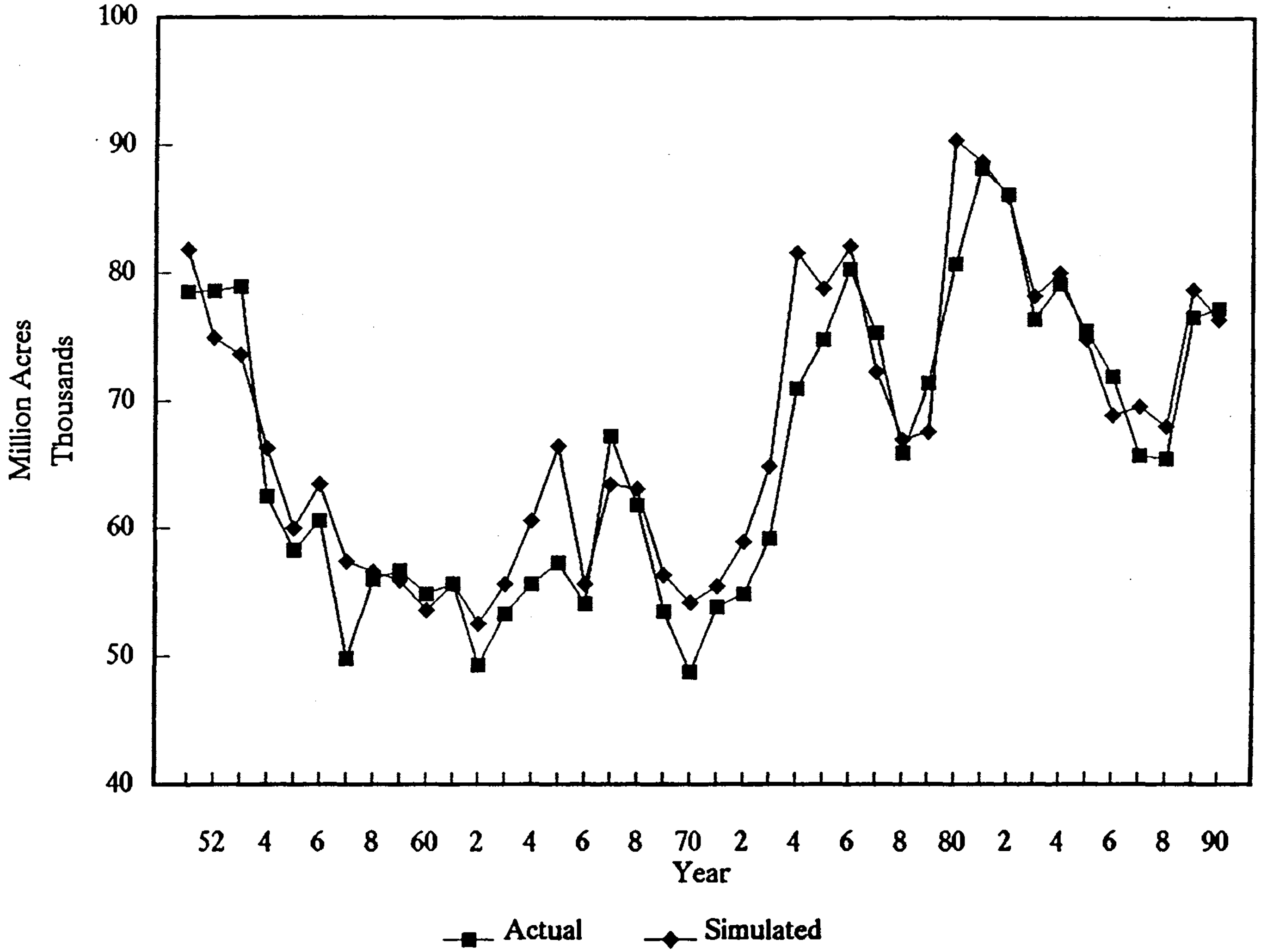

Figure 19. Simulation Results for Wheat Area Planted

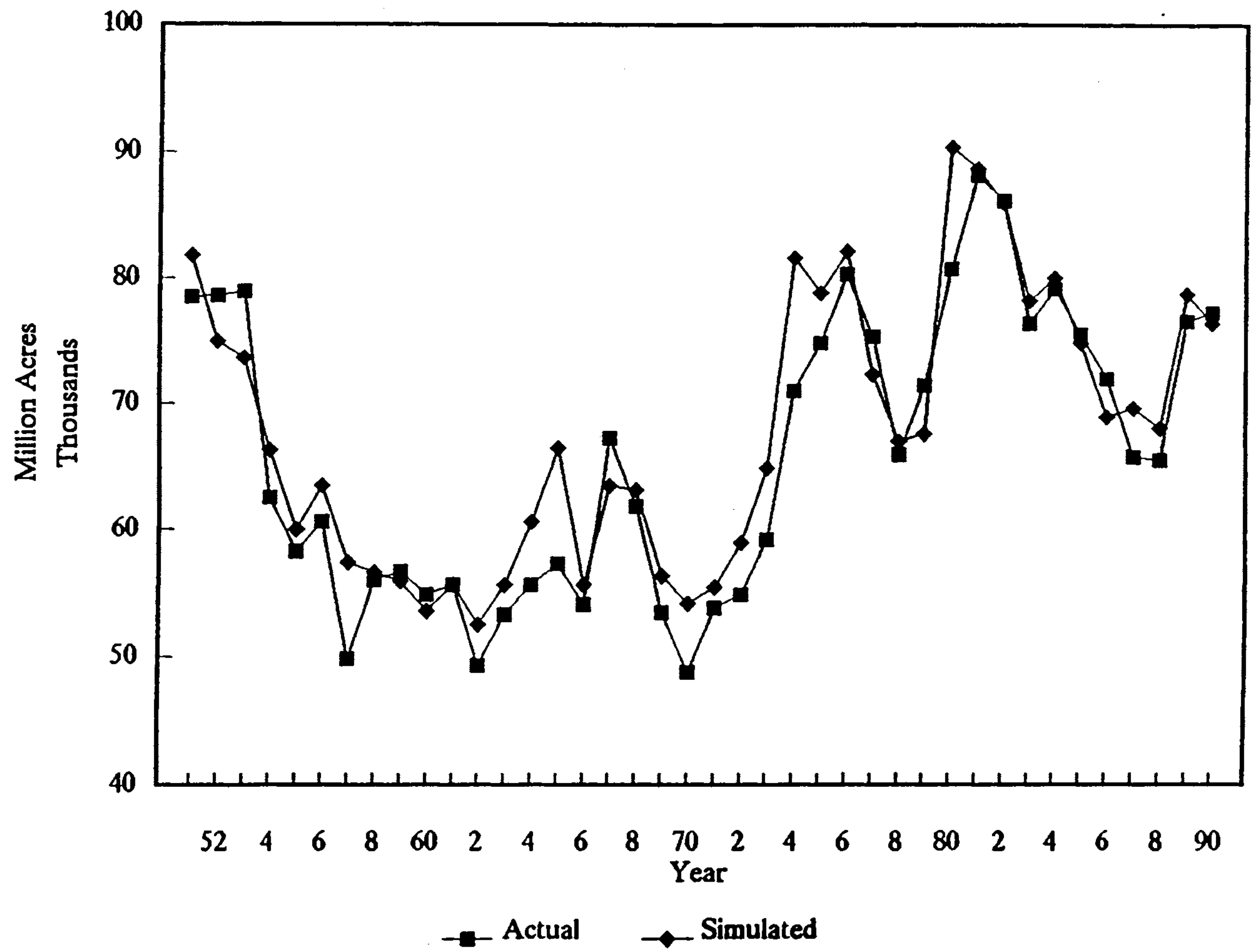

Figure 19. Simulation Results for Wheat Area Planted

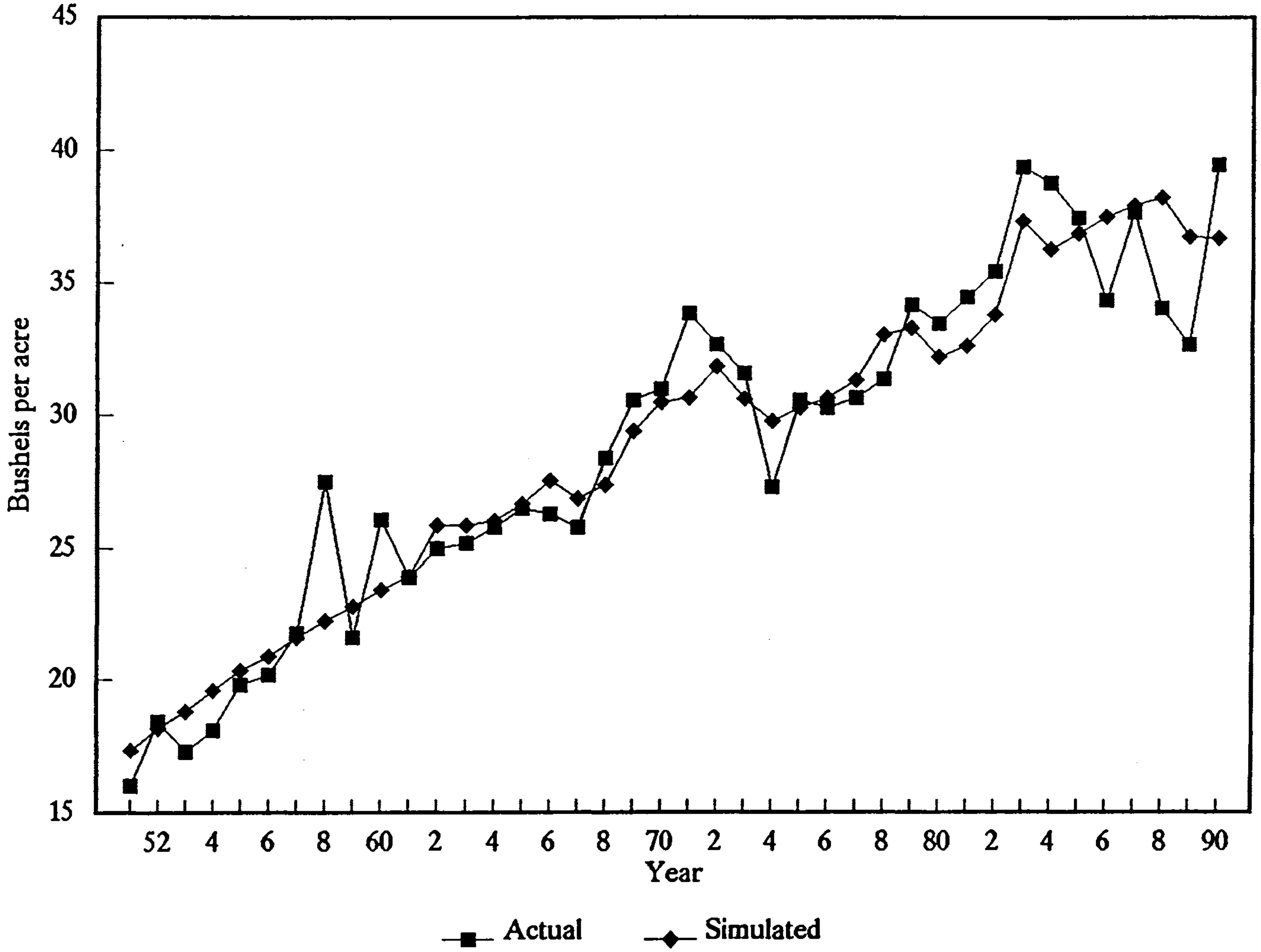

Figure 20. Simulation Results for Wheat Yields

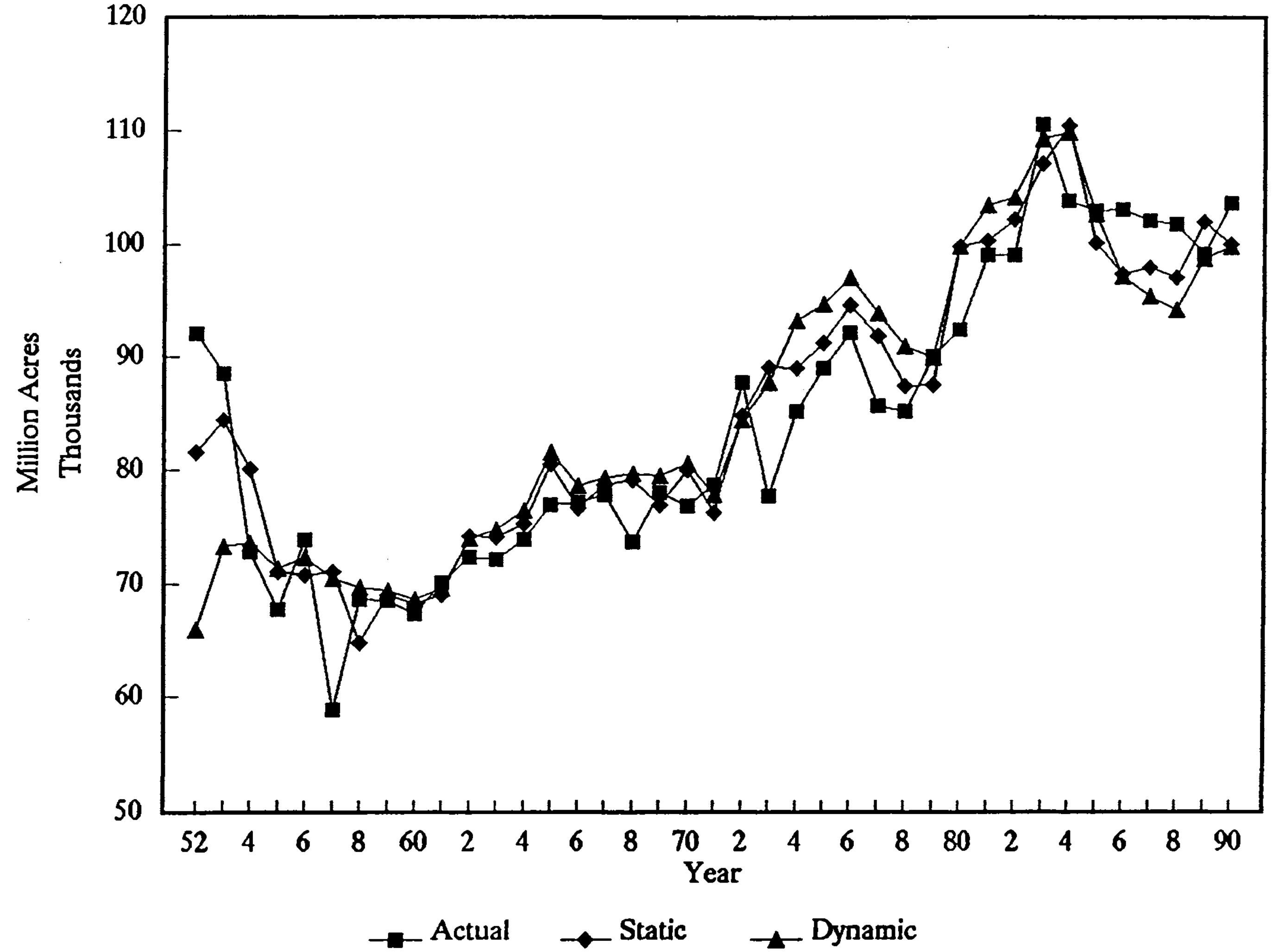

Figure 21. Simulation Results for Wheat Cropland Available

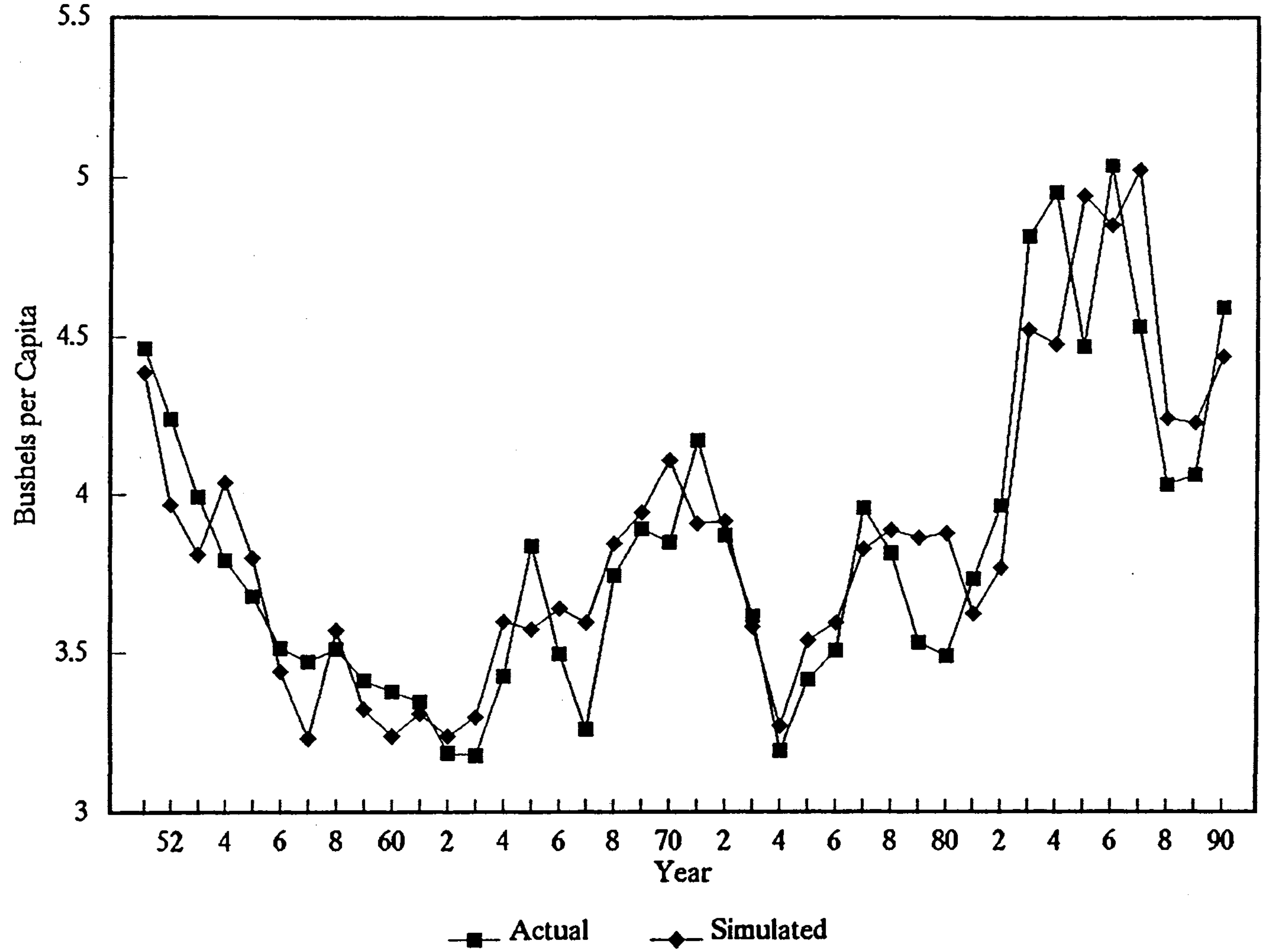

Figure 22. Simulation Results for Domestic Wheat Use

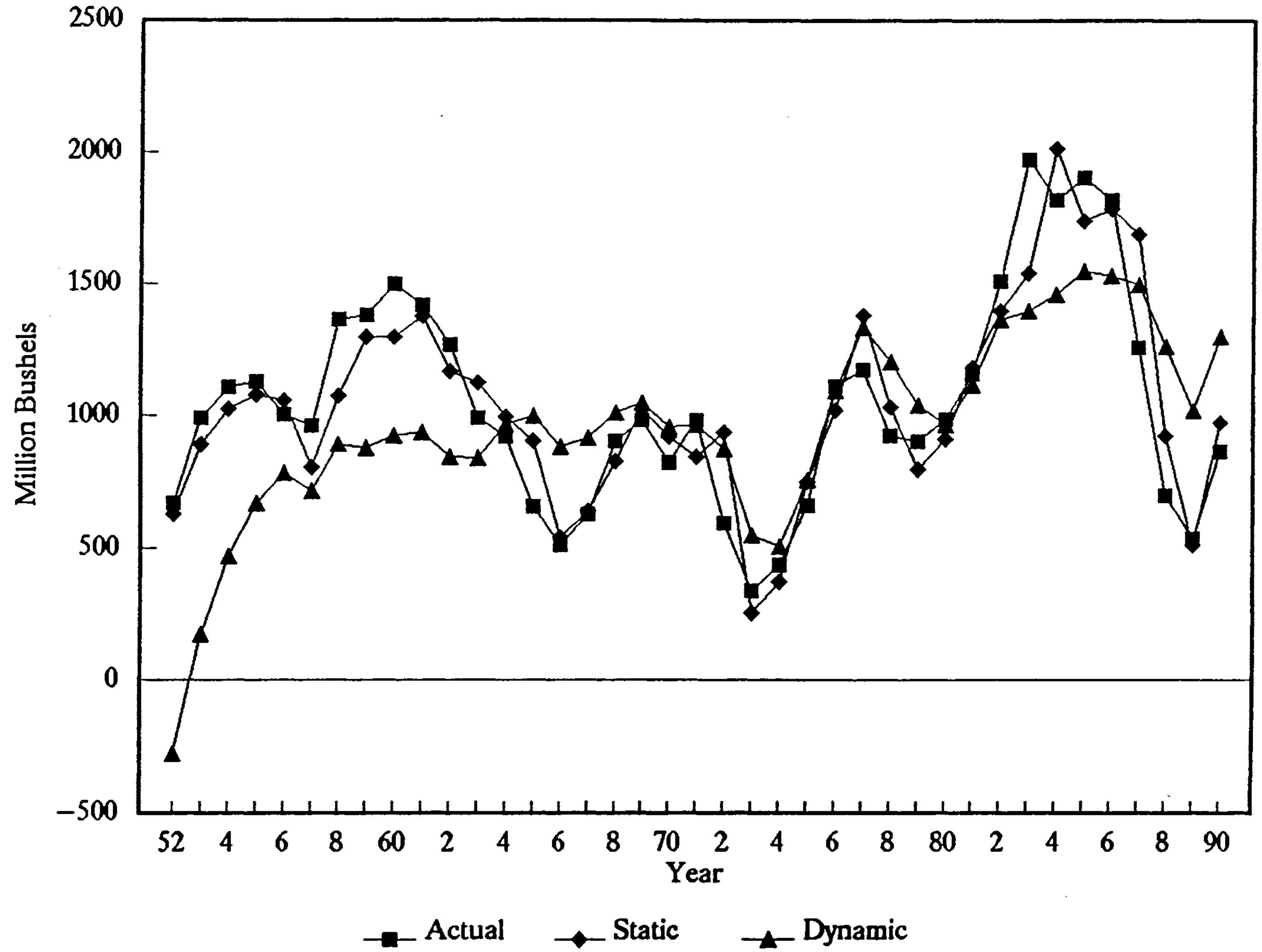

Figure 23. Simulation Results for Ending Wheat Stocks

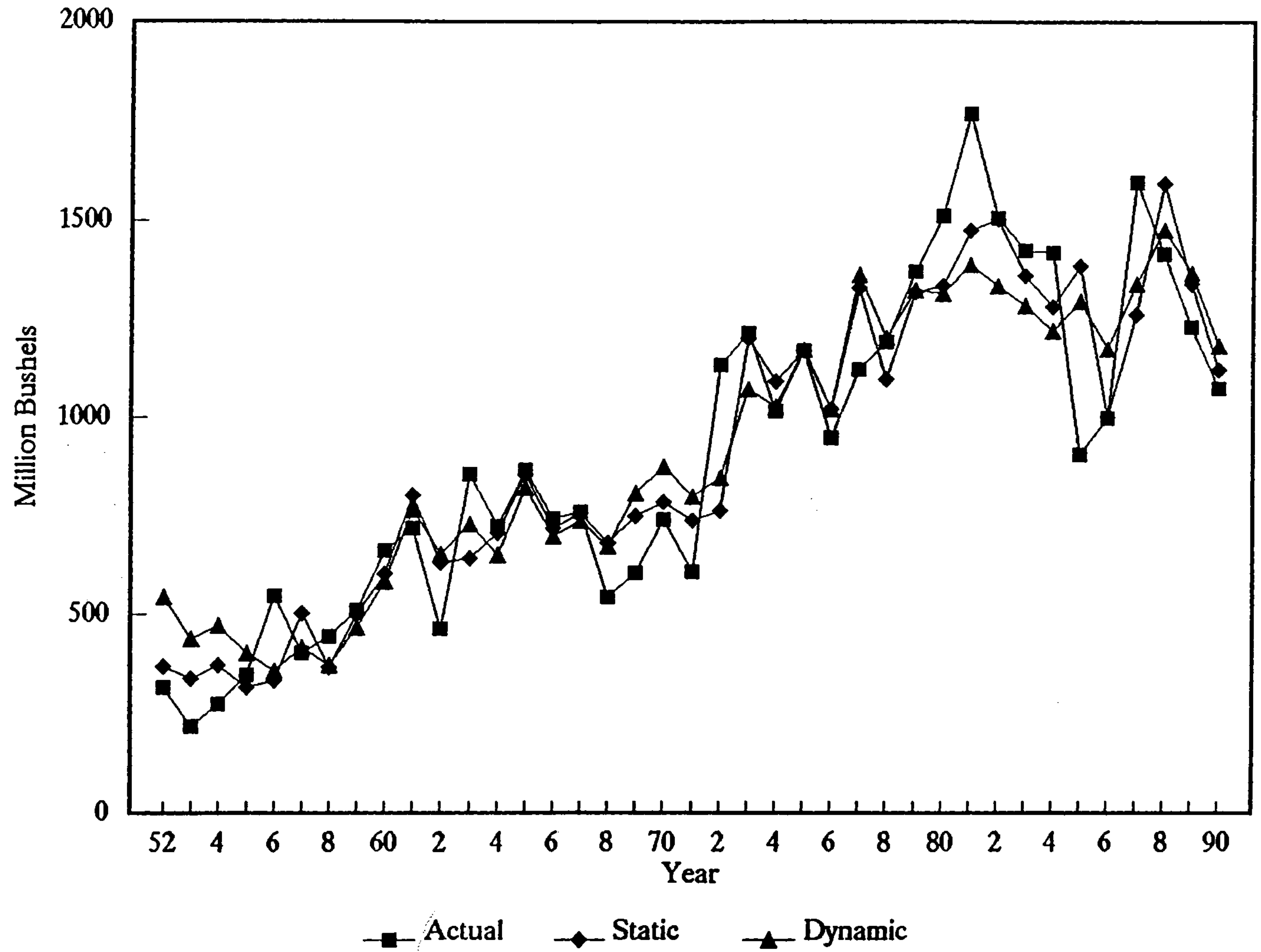

Figure 24. Simulation Results for Wheat Exports

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