An Econometric Analysis of Export Supply of Grains in Australia

U.S. Department of Agriculture

Economics, Statistics, and Cooperatives Service
Under Cooperative Agreement
With the University of Minnesota

Foreign Agricultural Economic Report No. 150

AN ECONOMETRIC ANALYSIS OF EXPORT SUPPLY OF GRAINS IN AUSTRALIA. By John Spriggs, University of Minnesota under contract with the Economics, Statistics, and Cooperatives Service; U.S. Department of Agriculture; Foreign Agricultural Economic Report No. 150.

ABSTRACT

Australia's production and consumption of wheat and feed grains is of major interest to the United States, since the U.S. share of world exports depends on the amount of grain exported by Australia, our major competitor. This study develops theoretical models reflecting price relationships for three grains in Australia. The models were then used in an example where U.S. farm prices for wheat, barley, and sorghum were hypothesized to drop 10 percent in a year, and the projected effect on Australia's exports of these grains was calculated. The models projected Australian barley and sorghum exports to decline 15 and 14 percent, respectively, while wheat exports were projected to decline 2 percent.

Key words: Australia, barley, exports, feed grains, grains exports, sorghum, wheat

Washington, D.C. 20250 June 1978

PREFACE

This publication is one of a series of foreign market studies being conducted by the Foreign Demand and Competition Division (FDCD); Economics, Statistics, and Cooperatives Service (ESCS); U.S. Department of Agriculture. These studies focus on countries that are major markets for U.S. agricultural exports and on countries whose farm exports compete with U.S. farm exports. The studies aim at providing a systematic and consistent basis for evaluating agricultural policies in these countries and projecting agricultural trade. They are being carried out either as in-house projects or by outside research institutions under contracts or cooperative research agreements. Francis S. Urban of FDCD is the project coordinator.

Objectives of the studies are:

1. To identify and, to the extent possible, quantify factors within each country which affect, or may affect, changes in its agricultural trade, especially trade with the United States.

2. To improve the capability of the U.S. Department of Agriculture to project the volume and value of agricultural trade in the short and medium term.

3. To enable the U.S. Department of Agriculture to better analyze and test fluctuations occurring in agricultural trade in response to changing economic conditions and policy considerations.

The studies concentrate on, but are not confined to, commodities in the grains-oilseeds-livestock sector, which constitute the most important commodities in the world agricultural trade. These studies necessarily depend on the quality and quantity of available data. Hence, some of the studies contain mainly descriptive and qualitative analysis. However, most include quantitative analysis involving econometric models.

The research for this publication was conducted by John Spriggs under the general supervision of James P. Houck of the University of Minnesota. The author wishes to thank Maury Bredahl and William Meyers of the University of Minnesota, and Francis Urban, Bruce Greenshields, and Lynn Austin of ESCS for their assistance in preparing this study.

CONTENTS

	Page
SUMMARY	iii
INTRODUCTION	1
PRODUCTION AND MARKETING: WHEAT, BARLEY, AND SORGHUM	1
Production Patterns	1
Marketing Arrangements	3
MODEL DESCRIPTION	10
Previous Research	10
Theoretical Analysis	11
MODEL ESTIMATION	22
Wheat	22
Barley	44
Sorghum	54
Price Relations	59
MODEL SOLUTION	62
Solution Results over the Historical Period	62
Export Projections to 1980/81	63
Example of Model Use: Effect of an Arbitrary Change in World Grain Prices	76
DIRECTIONS FOR FURTHER RESEARCH	78
LITERATURE CITED	79
APPENDIX A--WHEAT PRICES	82
APPENDIX B--GRAIN MODELS, VARIABLES USED, AND THEIR DEFINITIONS	83
APPENDIX C--DEVALUATION AND COMMODITY PRICE CHANGES	88
APPENDIX D	89

SUMMARY

The study examines domestic supply and demand relationships for wheat, barley, and sorghum in Australia, a major competitor of the United States in world grain markets. Empirical models are developed to calculate the effect that a hypothetical change in world farm prices of the three grains would have on Australia's exports. Estimated exports as against actual exports showed that the models worked reasonably well. When U.S. farm prices were assumed to drop 10 percent in one year, barley and sorghum exports in Australia were projected to decline 15 and 14 percent, respectively, while wheat exports declined 2 percent. The difference between the effect on wheat and the effect on the other grains is due to the relatively greater insulation from world prices of Australia's wheat consumers and producers.

The models capture the differences in marketing arrangements of the three crops in Australia with behavioral relationships, a supply-distribution identity, and price relations to link Australia's grain prices to world prices. The study also describes the functions of Australia's grain marketing boards. Wheat is marketed solely by the Australian Wheat Board, which operates a pool in conjunction with a wheat price stabilization scheme. Four barley boards operating in different regions in Australia set the home consumption price for barley and market it on a pool basis. Sorghum is marketed primarily by statutory boards or a voluntary pool.

The behavioral and price relations that comprise the theoretical models were estimated. Certain variables, including the price of wheat, technological change in the wheat model, the effect of wheat quotas, and the index of intensive livestock production, as well as data series on barley and sorghum feed use and stocks, were of special concern in the estimating equations.

An Econometric Analysis of Export Supply of Grains in Australia

by John Spriggs*

INTRODUCTION

Australia is an important exporter of grain and consequently a competitor of the United States in world markets. The country ranked fourth in world wheat exports and sixth in world feed grain exports during 1971/72-1975/76. 1/ Although Australia produced about as much oats as sorghum in recent years, it exports only a third as much oats. 2/

This study examines how demand and production of three grains in Australia, as well as their marketing arrangements, affect Australia's share of world export markets.

Empirical models are developed for Australian wheat, barley, and sorghum exports. Such an examination will be useful to U.S. policy analysts and others involved with predicting Australian and U.S. export levels, and to those analyzing world trade in these commodities.

The study begins with a description of production patterns and marketing arrangements for the three grains. A theoretical framework for analyzing these grains is then developed, followed by an estimation of the behavioral and price relations that comprise the theoretical models. Finally, the three models are solved and projections are made to 1980/81. An attempt is made to measure the effect of an arbitrary change in world grain prices on Australia's grain exports. Directions for further research are also included at the conclusion of the study.

PRODUCTION AND MARKETING: WHEAT, BARLEY, AND SORGHUM

Production Patterns

Australia's main grain belt extends from central Queensland in the north down through central New South Wales and on south to western Victoria and lower South Australia. A smaller belt runs through the southwest of Western Australia (fig. 1). The main grain belt lies in an area receiving about 10 to 20 inches of rainfall per year. In the southern part of Australia, where reliable rains occur during winter, the winter-growing cereals--wheat, barley, and oats--predominate. In central Queensland, rains occur during summer, so the summer crops, especially sorghum, predominate. In southern Queensland and northern New South Wales, there is some overlap of summer and winter rains, and both summer and winter crops may be grown. Winter crops are planted in the fall, generally April through June, and harvested in early summer, November through December. Sorghum is planted during spring or early summer (September to January) and harvested in April through June.

To alleviate soil depletion and erosion, the land must be rotated between crops and pasture. Hence, most grain producers carry livestock for grazing the pasture.

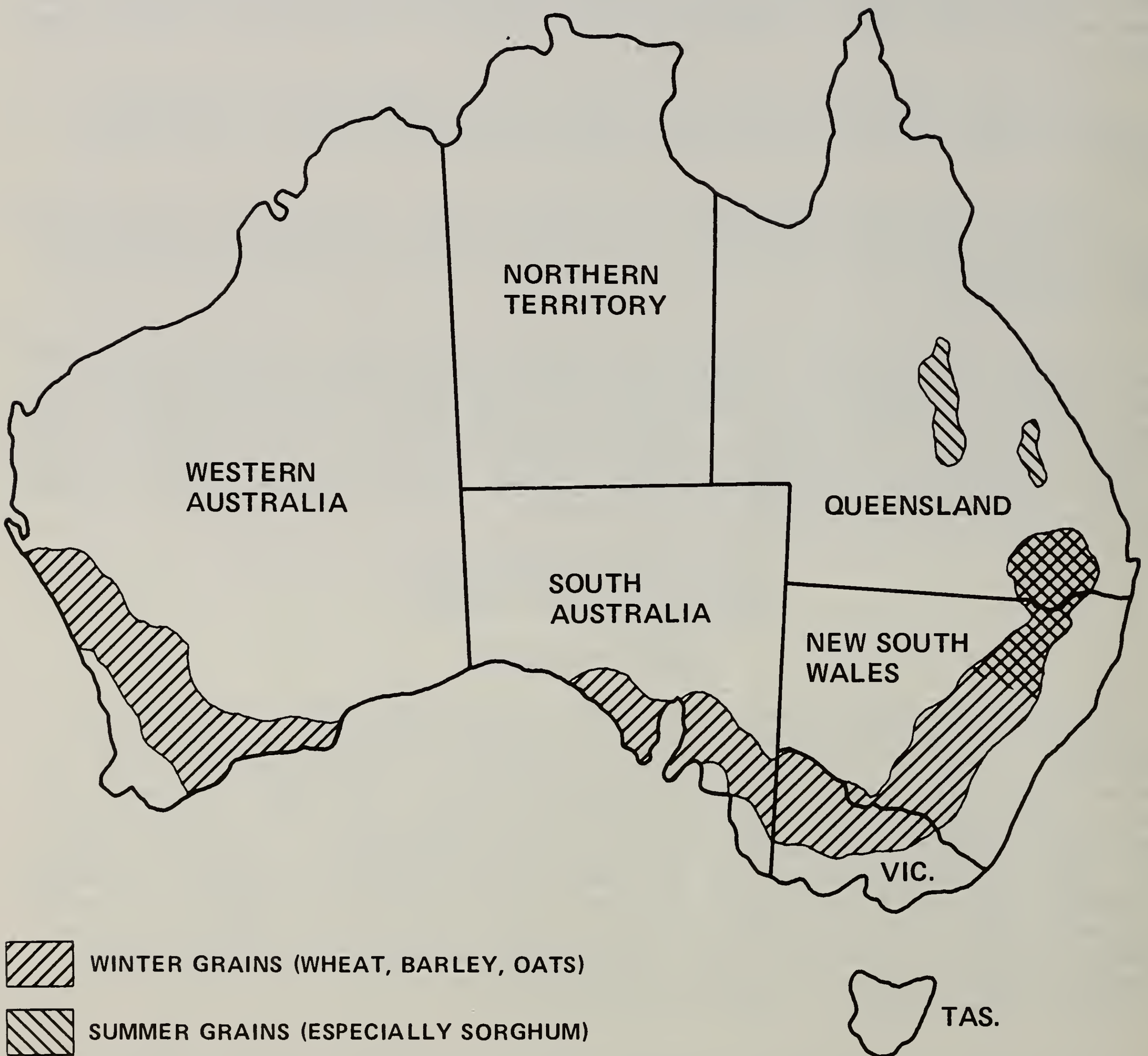
---

* The author is an assistant professor, Purdue University. The research was conducted while he was a research assistant, University of Minnesota.

1/ The higher ranked wheat exporters are, in descending order, the United States, Canada, and France. The higher ranked feed grain exporters are the United States, France, Argentina, Canada, and South Africa.

2/ This is based on an average of the 5 years ending 1974/75.

FIGURE 1--GRAIN AREAS OF AUSTRALIA



Sheep have historically been the grazing stock in the winter grains area, which has commonly been known as the wheat-sheep zone or cereals-sheep zone. 3/ In central Queensland, where summer crops (especially sorghum) are more important, beef cattle have been preferred. Grazing stock to an extent, therefore, are complementary with the cropping enterprise. However, because any rotation is flexible the farmer can adjust the proportion of his land under crop as the relative prices of crop to livestock change. Thus grazing stock may also be competitive.

In terms of area sown, Australia's most important grain has been wheat, followed by barley, oats, and sorghum. During 1956/57 to 1975/76, the area sown to these crops generally trended upward (fig. 2). Area sown to oats, on the other hand, appears to have trended upward to the middle 1960's, then declined. With regard to wheat and barley, one notes dramatic changes occurring in 1970/71 through 1972/73. These may be associated with the very difficult marketing situation for wheat and the associated imposition of wheat quotas during this time.

From a production standpoint, it would seem that oats have been more important than sorghum (fig. 2). In recent years, however, sorghum exports have far exceeded those of oats (fig. 3).

Crop yields are sometimes used to indicate technological advance in an industry. Sorghum yields appear to have trended upward slightly in Australia over the past decade, but there is no apparent trend for wheat and barley yield (fig. 4). This does not mean there was no technological advance in these cropping enterprises. Improved seed varieties, improved rotational practices, and increased use of fertilizers are well-documented advances. However, these very advances (among other economic incentives) have increased production in previously submarginal tracts of land, resulting in a depressing effect on average yield.

As indicated in table 1, wheat and barley yields are far more variable in Australia than in the United States. Note that the Australian grain yields vary about as much as sorghum in the United States, where sorghum is the most variable of the U.S. grains.

Table 1--Coefficients of variation for grain yields, 1950/51 to 1975/76

Country	Wheat	Barley	Sorghum
Australia	.16	.18	.17
United States	.08	.08	.15

Marketing Arrangements

In this section, attention is focused on the effects of different marketing arrangements on producer and domestic selling prices. These prices are important explanatory variables of supply and demand in the models to be developed later.

The typical method of marketing grains in Australia is through a statutory marketing board which has sole authority for buying, handling, and selling of a grain in a

3/ In the wheat-sheep zone during the late 1960's and early 1970's, when wool prices were low relative to beef, there was a slight shift from sheep to beef.

FIGURE 2--AREA PLANTED TO VARIOUS GRAINS, AUSTRALIA, 1956/57 to 1975/76

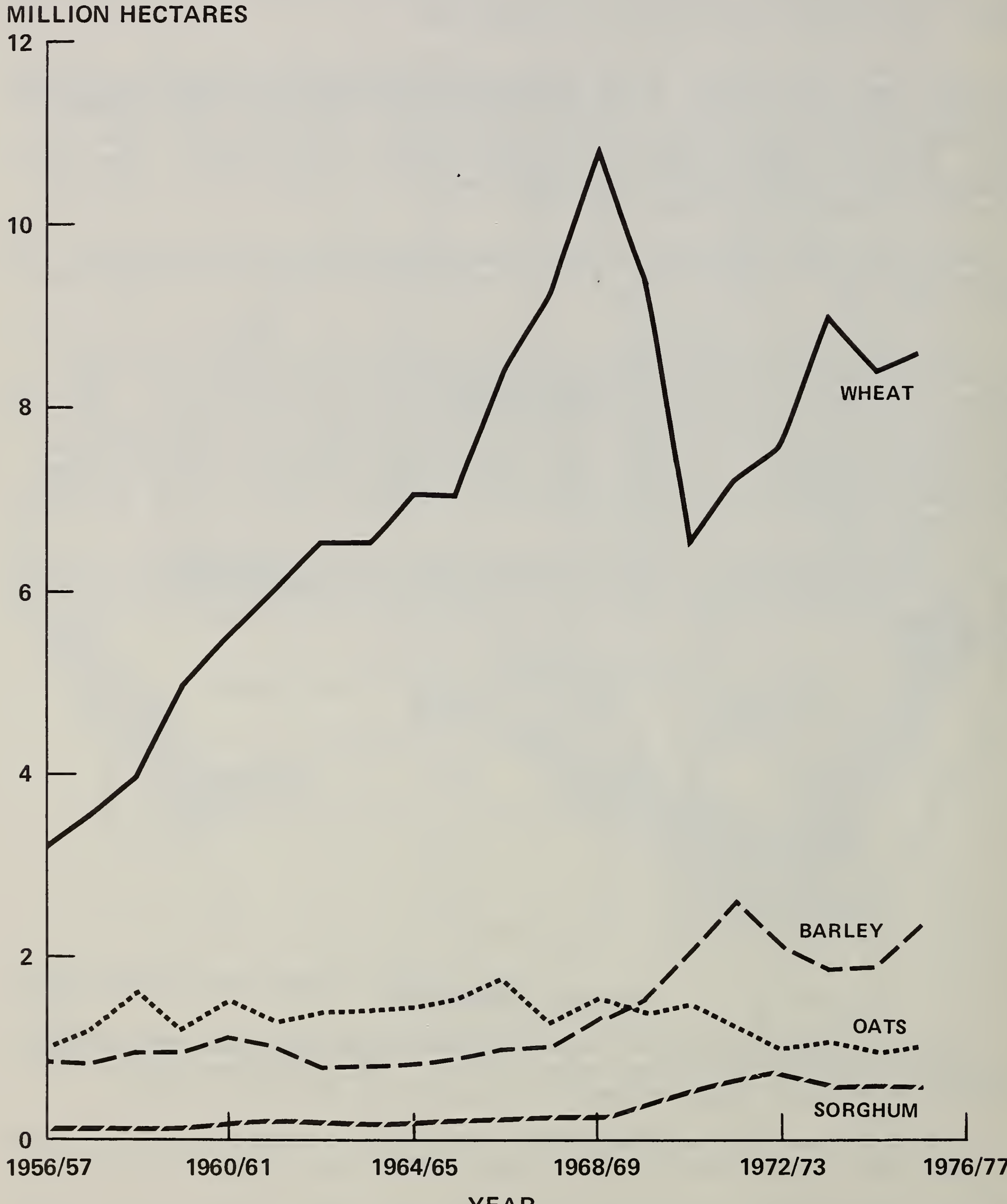


FIGURE 3--GRAIN EXPORTS FROM AUSTRALIA, 1956/57 to 1975/76

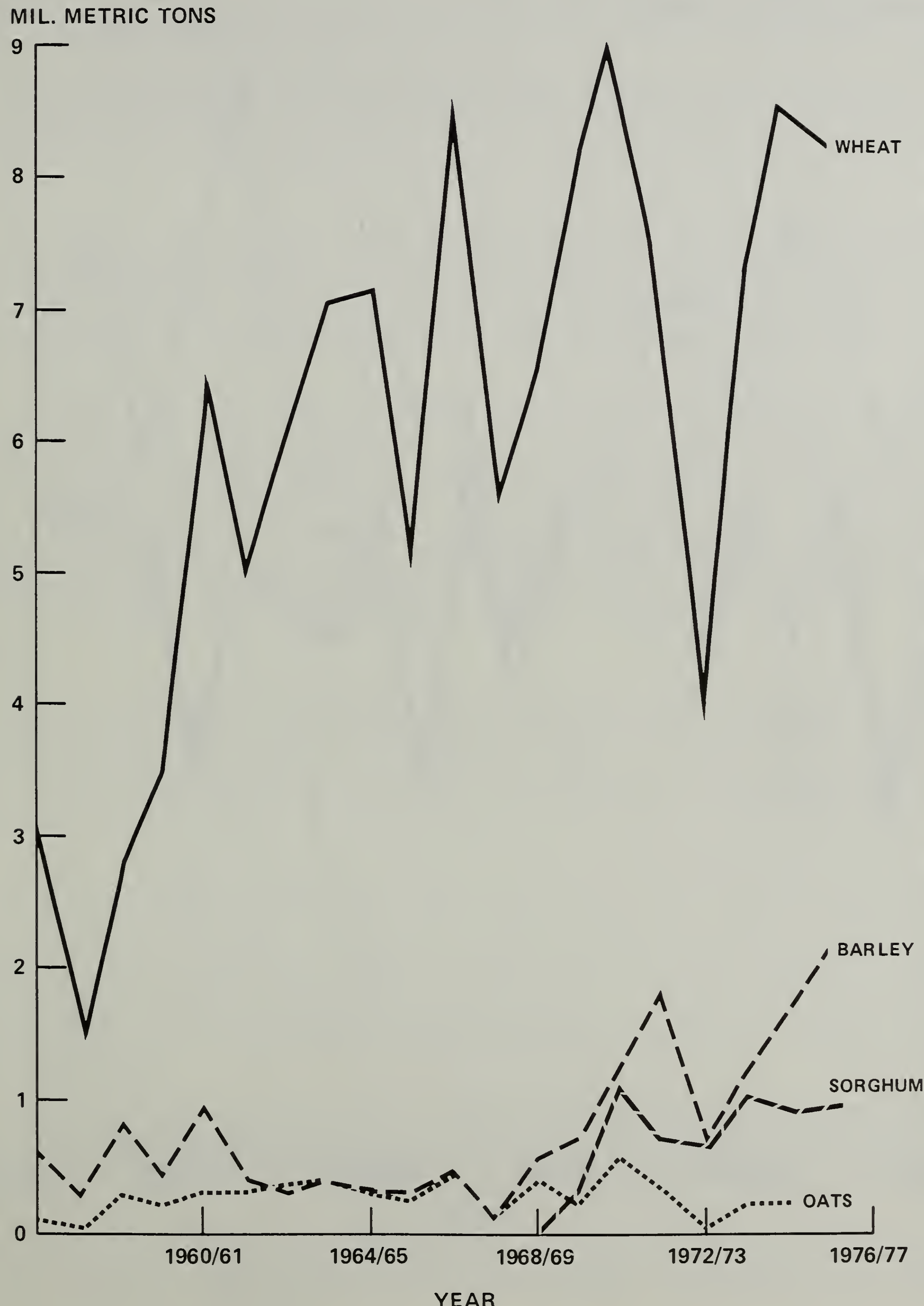
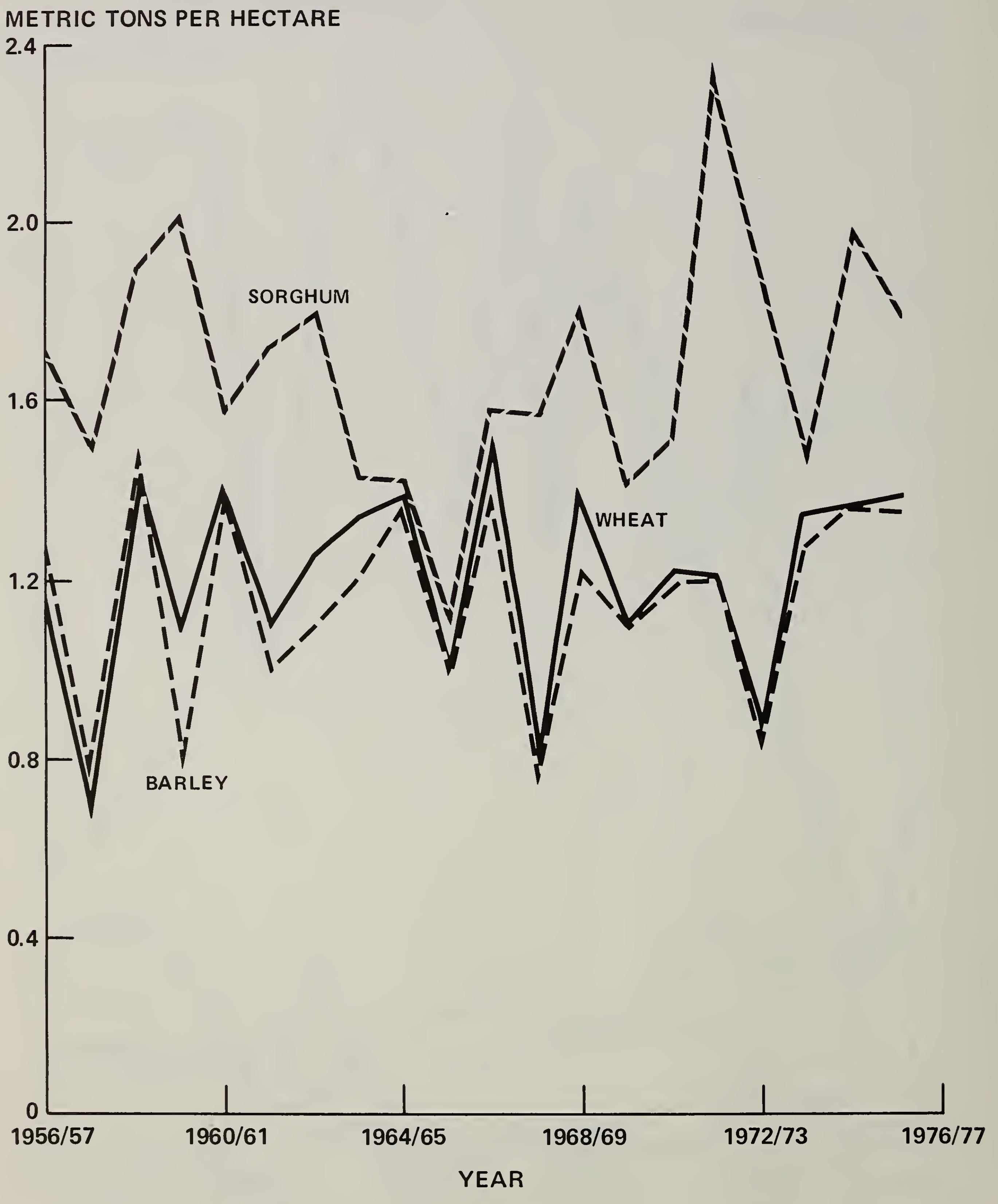


FIGURE 4--YIELDS OF VARIOUS GRAINS, AUSTRALIA, 1956/57 TO 1975/76



particular region. All the grain in any given region goes into a pool, is sold either domestically or overseas, and the grower receives a pooled price. It usually takes 1 to 2 years for all the crop in a pool to be sold. But the grower does not wait until all the grain is sold before he receives a return. He is paid in a series of payments. The first, known as a "first advance," is paid on delivery of the harvested crop to the board's handling agent.

This is the basic system of marketing for wheat and most of the barley and sorghum grown in Australia. Oats are still sold via the private trade or through voluntary pools.

Wheat

The statutory wheat board, called the Australian Wheat Board (AWB), has sole authority throughout the country for the buying, handling, and selling of wheat. In general, growers may not legally sell outside the Board but may retain wheat for use on the farm where grown. 4/ Upon delivery, the grower is paid a first advance, which amounts to about 70 to 80 percent of total payment (except since 1973/74, when the first advance has lagged behind the very large increase in total payment).

The total payment for wheat is affected by the operation of a wheat price stabilization scheme. This scheme, administered by the AWB, has evolved through a series of six 5-year plans to the one in operation today. It is financially backed by the Federal Government and aims to protect growers from the potentially large swings in export market prices. Since this scheme affects total payments for wheat, it may also affect planting intentions (the scheme is discussed in detail below). With regard to domestic sales of wheat, the price is determined by the Federal Agriculture Minister in consultation with the State Ministers of Agriculture. It is set at the beginning of each marketing year and is based primarily on cash costs of production.

Barley

There are four statutory marketing boards for barley, each operating in a different region of the country. The largest, the Australian Barley Board (ABB), operates in South Australia and Victoria. Taken together, these two States account for about 50 percent of Australia's total barley area. In addition to the ABB, there are State barley boards operating in Western Australia, New South Wales, and Queensland. These three States account for 25, 17, and 8 percent of total barley area, respectively.

All barley boards except the one in New South Wales (NSW) have existed in their presently constituted form since 1949. The New South Wales Barley Marketing Board began operations in the 1973/74 crop year. Prior to that, all barley in NSW was handled by private merchants. Currently, all barley produced in NSW, as in other States, is vested in the Board. However, unlike other States, merchants are licensed and some growers exempted from mandatory delivery so that most feed barley for domestic consumption is still handled by the private trade. The Board handles all barley exports (except those transshipped through Queensland) as well as all domestic sales of malting barley.

In general, barley growers (unless exempted) must deliver to their board all grain not intended for use on the farm where grown. The exception is that growers may legally sell their grain to individuals in another State under protection of the Australian Constitution. Section 92, which applies to all tradeable commodities, states:

4/ It is legal for growers to sell their wheat privately interstate under protection of Section 92 of the Australian Constitution guaranteeing free trade between States. However, for wheat, the quantities involved have generally represented a very small proportion of total production.

. . . trade, commerce, and intercourse among the States, whether by means of internal carriage or ocean navigation, shall be absolutely free (5). 5/

Section 92 poses a potential problem for all statutory grain marketing boards. Some growers choose to use section 92 to circumvent their statutory board, so that the boards do not have complete control over supplies. This hampers the boards' attempts to raise average grower returns through price discrimination between the domestic and overseas markets. Among the three grains examined in this study, section 92 sales are potentially important only in wheat and barley. With regard to sorghum, there appears to be no opportunity for price discrimination irrespective of section 92. One reason is that much of the domestic trade in sorghum is still carried on by private merchants and, except in central Queensland, there is far from complete control over supplies.

The problem has been relatively more important for the barley marketing boards than it has been for the Australian Wheat Board. This is indicated in table 2, where receivals by the various statutory boards are expressed as a percentage of total production in their respective regions. Roughly, the lower the percentage figure, the lower the degree of control over supplies.

Table 2--Receivals as a percent of production, 1955/56 to 1974/75

Item	Percent
Australian Wheat Board	91
Australian Barley Board	81
West Australian Barley Board	78
Queensland Barley Board	52

Source: Bureau of Agricultural Economics, Coarse Grains Situation (various issues).

Bain (9, pp. 32-33) advances a number of possible reasons for the success of the AWB in gaining control over supplies, despite section 92. His reasons are:

(a) The illegality of intrastate trade;
(b) Threat of action (undefined) by the AWB against farmers selling across State boundaries;
(c) Informal agreements between the AWB, flour millers, and other substantial purchasers of wheat for the home market;
(d) Emphasis to farmers of the likelihood of the whole stabilization system breaking down if substantial quantities of wheat were traded privately;
(e) The understatement of wheat production by some farmers at the annual census; more wheat may have been traded privately than the official statistics suggested; and
(f) The additional costs and organizational difficulties involved in private selling.

5/ Underscored numbers in parentheses refer to literature listed at the end of this report.

Apart from (d), it appears all these reasons could equally apply to the barley marketing boards; hence they do not explain why the AWB has been singularly more successful in obtaining control over supplies. One observer offered a possible explanation:

> Large domestic buyers of wheat would not want to antagonize the AWB and jeopardize their ability to obtain grain from the Board. But for the coarse grains, section 92 is more important because no one is there with a big stick.

The apparent implication is that if the AWB were to cut off supplies to a large domestic wheat buyer, he would have no alternative stable supplier, but if a coarse grain marketing board were to cut off supplies, there are other marketing boards from which to obtain supplies.

The differential effects of section 92 are disregarded in the model for wheat but maintained for barley.

Malting barley supplies are more closely controlled than feed barley supplies. This is probably because there are relatively fewer buyers of malting barley than of feed barley. The malting barley price is determined by negotiation between the barley board and the brewers and maltsters. According to one industry spokesman, it is set equal to the home consumption price (on a tonnage basis) of Australian Standard White (ASW) wheat plus loading costs of up to 10 percent at the discretion of the individual board. The data are consistent with this claim. Domestic feed barley prices tend to move with export prices. This is partly due to the section 92 escape clause, and partly to competition from other feed grains (especially oats) for which there are no statutory boards. The average grower return is a weighted average of the domestic malting and feed barley prices and the average export return. The domestic malting price is varied arbitrarily while the domestic feed and export prices tend to move with world market conditions.

Sorghum

About 99 percent of Australia's sorghum is grown in Queensland and New South Wales. From 1956 to 1965, the marketing of Queensland's sorghum was solely in the hands of the Queensland Grain Sorghum Marketing Board. In 1965, the Board was reorganized into the Central Queensland Grain Sorghum Marketing Board (CWGSMB). The CWGSMB became sole marketer for the central regions of Queensland only, and did not cover the southeastern corner of the State. When Australia's sorghum production began to expand rapidly beyond domestic requirements in 1970, the Queensland Graingrowers Association (QGA) formed a sorghum export committee to handle the export marketing of the large crop from the southern areas. The QGA still acts as a voluntary organization, yet it handles about one-half of Queensland's sorghum production and a little over half of its sorghum exports. It operates a pool each year and pays growers in a series of payments.

In NSW, all sorghum was marketed by private merchants until 1970. In that year, the Australian Coarse Grain Growers' Association, a voluntary organization which marketed a large proportion of the NSW crop, was formed. However, following a grower referendum in NSW in 1971, a statutory marketing board was formed to handle sorghum produced in NSW. Today, the NSW Grain Sorghum Marketing Board (NSWGSMB) licenses merchants to handle the domestic sorghum market while it handles all exports.

Since 1969/70 Australia has, on the average, exported 80 percent of its sorghum production. Hence, the average grower return depends heavily on world prices. In addition, the domestic selling price of sorghum moves closely with world prices. There appears to be little opportunity for price discrimination by the sorghum boards or the QGA, since much of the domestic sorghum in NSW and south Queensland is still handled by private trade. However, industry representatives have claimed that the appearance of the QGA sorghum export committee and the NSWGSMB forced the private trade to increase domestic prices closer to export parity. The claim may or may not be true, but domestic sorghum prices probably have become more closely aligned to world prices in recent years. During 1960/61 to 1968/69, sorghum exports represented only 14 percent of production, so the domestic price was probably largely determined within Australia. The rapid rise in production and exports since 1969 has turned sorghum into an export-oriented crop, and the domestic price has become determined largely outside of Australia.

MODEL DESCRIPTION

Previous Research

Wheat has received the most attention in previous economic research on Australian grains. Of particular relevance are those pieces of research which come to grips with the peculiarities of the wheat marketing system. These peculiarities include the wheat price stabilization scheme, the question of a supply-inducing price when producer returns are received over a number of years, and the analysis of stockholding or exports when all grain stocks are controlled by a single marketing agency.

Two useful graphic analyses of the Australian wheat economy which incorporate the price stabilization scheme are by Longworth (29) and Watson and Duloy (43). They were concerned with the allocation and distribution effects of the scheme. The present study incorporates the stabilization scheme in the supply-inducing price of wheat. These graphic analyses will be useful to the reader who wishes to understand in more depth the effects of the stabilization scheme. 6/

The question of the supply-inducing price has been a problem for all Australian wheat supply analysts. One of the earlier studies to come to grips with the problem is the one made by Powell and Gruen (34). They developed a "liquidity sensitive" and "liquidity insensitive" supply-inducing price. The effective price series for wheat developed in the present study is quite similar to their "liquidity insensitive" series.

Almost all salable stocks of wheat are held by the Australian Wheat Board or its licensed agents. Thus, in order to explain stocks in an Australian wheat model, it is necessary to understand the stockholding policy of the Australian Wheat Board. An early attempt was by McCalla (1966), who assumed that Australia was on the competitive fringe of a duopolistic world market for wheat, where the duopoly was comprised of Canada and the United States (32). As such, he assumed Australia could sell sufficiently below the price of the duopolists and clear its current crop. A more recent article by Alaouze, Watson, and Sturgess analyzed the market implications of a triopoly in which Australia had moved up from the fringe (1).

Fisher (1977) explained Australia's wheat exports by a model based on an oligopolistic world wheat market (17). In this model, exports by the major exporters are determined by market share. Australia's share primarily depends on its export availability relative to the total export availability of other major exporters. This differs from the approach in the present study, where the oligopolistic nature of world wheat marketing is reflected in an Australian wheat stocks relation.

6/ However, it is important to realize that the details of the scheme have been modified considerably since these analyses were performed. Those modifications are discussed on pp. 24-25.

Few studies have been made on the feed grains. One notable study is Bain's (1972), a comprehensive investigation of the structure and conduct of the market for feed grains in Australia (9). In connection with his investigation, Bain developed a set of feed demand equations. In those equations, he specified a drought index and an index of intensive livestock production; these have been incorporated in the present study. Anderson (1974) made an econometric analysis of barley supply response (2). His suggestion for the use of cultivated area as a proxy for technological advance has been incorporated in the wheat model of the present study.

Mention should also be made of two ambitious attempts at longrun supply and demand projections for Australian agricultural commodities. They are by Gruen and others (21) and the Bureau of Agricultural Economics (11). Both studies contain interesting approaches to the supply side specification.

In the 1966 study, the authors, recognizing the multiple-enterprise character of the typical Australian farm, combined wheat, coarse grains, and livestock products into a single supply model. Assuming that product substitution involves movement around a production-possibility frontier, they imposed a specific symmetry condition on the model. This condition is that the transformation elasticity going in one direction around the frontier be the same as the transformation elasticity going in the opposite direction. The authors projected demand and supply to 1980 on the basis of constant prices.

In the 1976 study, the supply analysis is novel in that it assumes a sequential decision process on individual properties. The first decision is regarding total cultivated area, while the second involves the allocation of this cultivated area among crops, pasture, and fallow. The third decision concerns the allocation of cropland between wheat and other crops; the fourth, the allocation of other cropland among the other crops. Supply and demand projections were made for 1979/80, where grain prices were assumed to be at levels similar to those of the late sixties. Projections of export availability were calculated as a residual of the supply minus the projections of demand.

These two studies provided useful input into the present study, but both attempt longrun projections (5 years or so) as opposed to the 1- to 2-year projections in the present study. The prime consequence of this different emphasis is the relatively greater role that prices are expected to play in the present study.

Theoretical Analysis

The basic theoretical constructs for wheat, barley, and sorghum are similar. Functional relationships need to be established for domestic demands (food and feed), carryover stocks, and production. In addition, since all three grains have a heavy export emphasis, it is necessary to specify how Australia interacts in the world grain economy. There are some differences among the models, resulting from the varying degrees of market power of the marketing agencies for the grains. The theoretical models focus on the role of prices in determining domestic demand, supply, and exports. It is primarily through the price mechanism that the various marketing agencies and the world market affect the Australian grain economy.

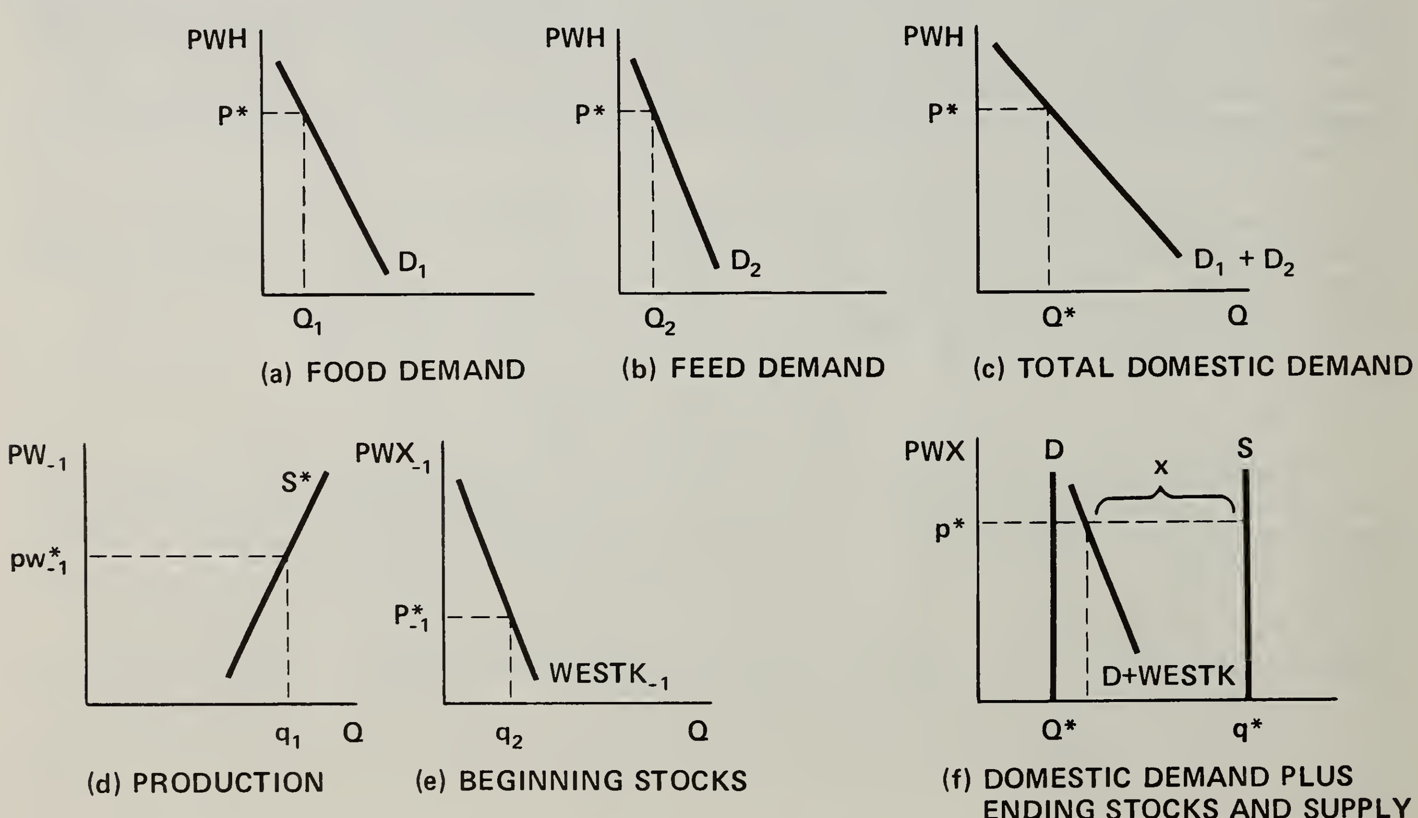
Wheat

The supply and demand for wheat in Australia is greatly affected by the operations of the AWB. Any model purporting to represent the workings of the Australian wheat economy must take into account the dominant role the board plays. On the domestic side, prices are set independently of the world market, since the AWB has virtually complete control over domestic supplies. Production is affected both by the AWB's method of payment to growers and the wheat price stabilization scheme. Since the AWB is sole export seller of wheat from Australia, its export policy (or alternatively, its stockholding policy) is crucial in determining exports from Australia.

The domestic demand plus stocks is represented in the theoretical model relating quantities to prices (fig. 5). This includes both domestic consumption as food (panel a), feed (panel b), and ending stocks (panel f). 7/ Domestic uses are postulated as functions of the home consumption price (PWH), while ending stocks are postulated as a function of the wheat export price (PWX). For a given value of PWH (P*), total domestic consumption is determined in panel (c) as ($Q_1 + Q_2$). This quantity is projected into panel (f) and the ending stocks function (WESTK) is then added horizontally. Quantity supplied equals production plus beginning stocks. Production (panel d) and beginning stocks (panel e) are postulated as functions of lagged grower price (PW) and lagged PWX, respectively. In the current season, production and beginning stocks are predetermined at say, q_1 and q_2, respectively. They are added ($q_1 + q_2$) to give the S curve in panel (f). For a given value of current PWX (p*), ending stocks are determined and exports (X) derived as the horizontal difference between S and (D + WESTK).

There are two special characteristics of this model. First, the domestic demand side is insulated from movements in world wheat prices. This diminishes the current period's impact of world wheat price changes on exports. Given supply, exports vary with current world wheat prices through only two mechanisms: directly through the price-stocks relation, and indirectly through simultaneous world price changes of feed grains which are shifters of the feed demand curve for wheat. Second, it is assumed that Australia is not a large enough exporter to influence world prices significantly.

FIGURE 5--WHEAT MODEL°



° IN PANELS (c) AND (f), $Q^* = Q_1 + Q_2$, AND $q^* = q_1 + q_2$.

7/ Seed is another domestic use. It will be treated as exogenous and is omitted from the graphical analysis for simplicity. Its effect would be to cause a horizontal parallel shift in the ($D_1 + D_2$) curve of panel (c). The reader may think of the ($D_1 + D_2$) curve represented as already incorporating this shift.

Over the 20 years to 1974/75, its exports averaged a modest 12 percent of the total exported by Australia, Canada, and the United States. Industry spokesmen supported this assumption, saying that export price quotations were heavily based on U.S. export prices for No. 2 western white wheat. Thus, the world wheat price is treated as exogenous. 8/ Currently, domestic demand prices are determined outside the market, domestic production is a function of lagged prices, and carryover stocks are a function of an exogenous world price. Thus, no price is endogenous to the model, and the model is recursive (in the econometric sense).

Domestic demand: panels (a) - (c).--Domestic demand for food and for feed are postulated as functions of the home consumption price (hcp). The hcp is generally the same, whether the wheat is intended for use as food or feed. The only deviation from this practice since 1953/54 came in 1969/70-1972/73, when feed wheat was priced below food wheat. During this period, wheat delivery quotas had been introduced to help counteract a serious wheat surplus situation. However, they also helped stimulate off-Board sales of over-quota wheat for feed. To meet the competition of these sales, the AWB substantially lowered its hcp on feed wheat.

The hcp is based on an assessed cost of production. The cost of production is assessed by survey at the beginning of each 5-year wheat price stabilization plan and the base level hcp is announced. Annual adjustments are made to the base level hcp in the years between each survey, based on movements in a cost index. Prior to 1968/69 (the start of the fifth stabilization plan), the annual adjustments were based on movements in total costs. From 1968/69 on, they referred only to movements in cash costs, thus excluding imputed costs such as interest on land and fixed capital.

Production: panel (d).--Wheat production equals yield times planted area. Yield is largely a function of factors which are difficult or impossible to foresee, such as soil moisture and the incidence of crop disease and weather damage during the growing season. Yet yield variability in Australia affects production significantly. One significant attempt to explain this variability in an economic study was made by Fisher (17).

Planted area is also important in explaining variation in production (fig. 2). Planted area abstracts largely from the uncertain effects of weather, allowing the economic factors affecting production to be isolated. Hence, planted area is used in this study as the dependent variable in supply relations. It is multiplied by an exogenous yield to obtain production.

Planted area is also postulated as a function of the price the producer expects to receive for his grain. There is nothing unusual about postulating this, but there is a special problem in determining the supply-inducing price. Because of the special arrangements for marketing wheat in Australia, the wheatgrower's return is based on a weighted average of the hcp and the average export value, modified by transactions involving the wheat price stabilization scheme. The grower's return is made in a series of payments spaced over a 2- to 4-year period. With all these factors impinging on the grower price, it is difficult for the supply analyst to isolate a single supply-inducing price.

Assuming naive expectations, current year planting is deemed to be influenced by some price that relates to the preceding crop. That price may be the first advance, the total realization per metric ton, or an anticipated effective price for the preceding crop.

(a) The first advance. This is the initial payment made to growers on delivery of their wheat to an AWB storage facility. The grower typically receives his first

8/ In an excess supply-excess demand framework, this is equivalent to assuming a perfectly elastic excess demand curve from the rest of the world.

advance on one crop in time to influence planting decisions on the next. The problem is that the first advance has shown very little variation in recent history. Between 1957/58 and 1972/73, it remained unaltered at $40.42 per metric ton. 9/

(b) The total realization per metric ton from each wheat pool. This has been used in past wheat supply studies such as Watson and Duloy's (43, p. 44), and Anderson's (2, p. 16), using various lag formulations of total realization as an explanatory variable. One problem, however, is that at time of planting, the total realization for the preceding season is unknown. Despite this fact, the studies employ the total realization variable on the assumption that at planting time, growers have some information (such as on the state of the international wheat economy) which provides subjective estimates of this variable. These studies seem to be using actual total realization as a proxy for the subjective estimates.

(c) An effective price series. This uses data known at the time of planting to construct a price series reflecting the grower's expected realization from the preceding crop. Such an approach had been used previously by Powell and Gruen (34, p. 124). Ignoring the price stabilization scheme, such an effective price series could be constructed as

$$PW = \frac{PWH \, . \, QWH + PWX \, . \, QWX}{QWH + QWX}$$

where

PW = effective wheat price
PWH = home consumption price of wheat for the current marketing year
PWX = expected average export return for the preceding crop
QWH = domestic quantity weight. Average quantity of wheat consumed domestically (say, over the previous 3 years)
QWX = export quantity weight. Average quantity of wheat exported (say, over the previous 3 years)

This approach has an advantage over approach (b) in that it attempts to measure the growers' subjective estimate of total realization directly. In addition, the export price is explicitly taken into account. This provides for a direct link between Australia's wheat planting intentions and world prices, and would be useful in integrating the Australian wheat model with a world grain model. Because of these advantages, this last approach was used to specify the supply-inducing price. To be at all realistic, the approach must take into account the effects of the wheat price stabilization scheme. The calculation of the effective price series incorporating the stabilization scheme is discussed on pages 24 and 25.

Wheat stocks: panels (e) and (f).--There is very little onfarm storage of wheat other than that used for seed and feed by the producing farm. Virtually all wheat for sale is stored off the farm in facilities owned by the AWB or its agents, the Bulk Handling Authorities. Growers hold only small stocks for two reasons. First, it is illegal for a grower to sell his wheat outside the AWB unless the sale is interstate. In addition, he is given no incentive to store grain on his property for delivery to the AWB at a later date.

Since virtually all salable stocks are held by the AWB or its agents, it is important to understand the AWB's policy on wheat stocks in attempting to formulate a wheat stocks relation. According to industry people, it appears the AWB aims to have

9/ In regression analysis, if an explanatory variable exhibits no variation in itself, it is of no help in explaining the variation in a dependent variable.

a sufficient carryover to meet domestic requirements and sell the remainder on the export market at the going world price. These people agreed that in a normal year, about 500,000 metric tons is a desired carryover. The exact amounts are fixed by AWB on the basis of estimates for the new crop. If the crop does not appear sufficient to cover the State's domestic requirements in the coming marketing year, then the AWB limits further export sales from that State.

Such a policy seems to indicate the absence of any relationship between wheat stocks and world price, and appears consistent with the view of McCalla (32, p. 717). He argues that Canada and the United States act as duopolist sellers in the world wheat market and suggests, "the behavior of Argentina and Australia is more akin to that of the smaller exporters and can be characterized either as following the price set by the duopolists or as selling sufficiently below that price to clear their current crop. 10/

However, in preliminary analysis there appeared to be a significant inverse relationship between wheat stocks and price. Such an observed relationship would be consistent with the AWB holding stocks for speculative purposes. This position was not supported by people familiar with board operations, who generally argued that the AWB had no interest in being a speculator. Rather, it needed to free as much storage space as possible each year to make room for the following year's harvest.

An alternative explanation of the price-stocks relationship is McCalla's view. In McCalla's world, Australia was on the competitive fringe of the world wheat market. The apparent relationship between world price and stocks is explained by Australia's moving up from the fringe to join the United States and Canada in a triopoly. It is true that since McCalla's article (1966), Australia has become more important in the world wheat market. From 1960/61 to 1964/65, Australia's export availability as a percent of total export availability from the United States, Canada, and Australia was only 9 percent. In two subsequent 5-year periods, 1965/66 to 1969/70 and 1970/71 to 1974/75, this figure rose to 14 and 12 percent, respectively. 11/

Alaouze, Watson, and Sturgess have suggested a triopoly market solution in a recent paper. The authors put forward the argument that (1, p. 3):

> If duopoly pricing is consistently followed, the total market-shares of the duopolists (USA and Canada) cannot be maintained when the residual demand curve facing them shifts towards the price axis; other things being equal. When this happens, the market-shares of fringe suppliers increase at the duopolists' expense.
>
> Australia is the third largest wheat exporter. The formation of a triopoly with the USA and Canada is an obvious way in which the market-shares of the duopolists can be maintained when the residual demand curve of these three exporters shifts towards the price axis; or when the Australian exportable surplus is large with respect to the residual demand facing the duopolists.

10/ But see Freebairn (20, p. 118) on this point. He argues that if the submarkets for hard and soft wheats can be considered independent, then McCalla's duopoly argument applies to hard but not to soft wheat. In the case of soft wheat, there is an oligopoly situation involving Australia, the United States, and France. Whether or not we can extend McCalla's argument to all wheat (both hard and soft) seems to turn on the degree of interdependence between the hard and soft submarkets.

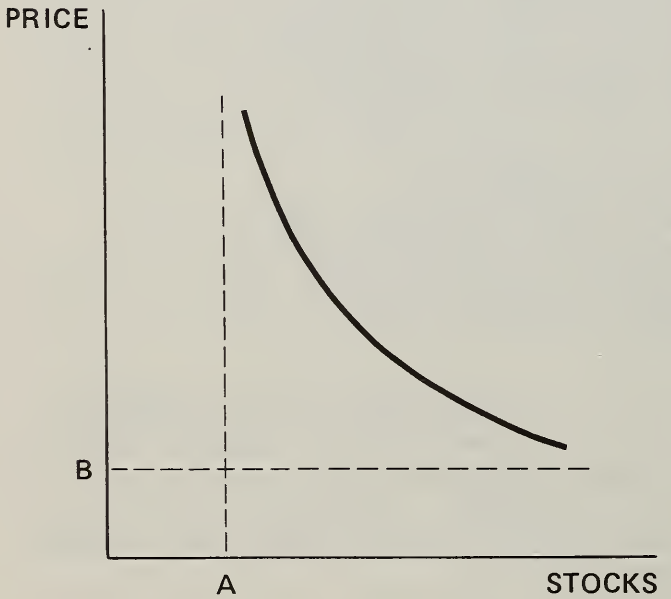
11/ Export availability includes exports plus ending stocks (41).

This type of triopoly implies collusion, though not the typical textbook collusion Henderson and Quandt, (24) where total supply is under the control of the oligopolists who work together to maximize joint profits. The collusion envisaged here is much less powerful. The countries involved do not control total world supplies of wheat, so they cannot completely determine world price. While they may influence world price, this is limited by their ability to hold stocks. In addition, the very desire of these countries to act collusively probably varies over time. This desire comes from a mix of political and economic pressures which tend to increase as world prices decrease. Roughly speaking, the desire to act collusively varies inversely to the level of world prices.

For analytical purposes, assume the triopolists have a preconceived idea of the world price they wish to maintain, perhaps based on the notion of covering production costs. In years of ample supply when world prices tend to move below the preconceived price, the triopolists accumulate stocks in an attempt to maintain price. In years of tight supply, as world prices tend to move above the preconceived price, competitive forces of supply and demand begin to supersede the oligopoly forces, resulting in stock depletion and prices being determined competitively. Such an arrangement would result in an inverse relation between world price and wheat stocks for all triopolists, including Australia.

The question that remains is: Why would Australia enter such an arrangement? If Australia were treated as a minor competitor by the United States and Canada, as McCalla suggests, it would face a very elastic export demand curve, enabling it to expand exports with impunity. Australia would maximize total returns by exporting all of its surplus without entering an oligopoly arrangement. However, it is suggested that Australia is treated as a major rather than a minor competitor. The United States and Canada, by threat of price war, could force Australia to consider its export demand curve as being very inelastic in the downward price direction. Hence, ignoring storage costs, Australia's total returns would decrease as exports were expanded. It would be to Australia's advantage to cooperate with the United States and Canada to maintain price, hold stocks, and enter some form of tacit agreement to allocate market shares.

FIGURE 6--POSTULATED RELATIONSHIP BETWEEN THE WHEAT EXPORT PRICE AND STOCKS



The inverse relationship between world price and Australian wheat stocks is not a strict economic relationship but a hybrid, reflecting both market forces and political pressures (fig. 6). (This representation was suggested by the plot of actual values reproduced in app. D.) The curve is asymptotic to the dotted line passing through point A, which represents the minimum desired carryover by Australia. As price falls, the pressure applied on the AWB to hold stocks above the desired quantity becomes greater, and in line with an oligopoly agreement, stocks increase. The curve flattens out and is asymptotic to the dotted line passing through point B. This point represents the minimum price acceptable to the duopolists.

WHEAT MODEL

Behavioral Relations

(1) AW: PW_{-1}, $\overline{X1}$, e1 (planted area)

(2) QWDH: $\overline{PWH}$, $\overline{X2}$, e2 (food demand)

(3) QWDF: $\overline{PWH}$, $\overline{X3}$, e3 (feed demand)

(4) WESTK: PWXA, $\overline{X4}$, e4 (ending stocks)

Identities

(5) $QW = AW \cdot \overline{YW}$ (production)

(6) $QWX = QW + WESTK_{-1} - QWDH - QWDF - \overline{QWDO} - WESTK$ (exports)

(7) $$PW_{-1} = \frac{\overline{a} \cdot \overline{PWH_{-1}} + \overline{b} \cdot (PWXA_{-2} + \overline{STAB})}{\overline{a} + \overline{b}}$$ (effective price)

where a, b are quantity weights.

Price Relation

(8) PWXA: $\overline{PWUS}$, e5 (export price quotations, wheat)

The dependent variables are defined in parentheses to the right of each relation. In addition,

e1 . . . e5 = random disturbance terms
PWH = home consumption price, wheat
PWUS = U.S. price, wheat
QWDO = wheat used for seed
STAB = per unit transactions involving stabilization fund. Payments are in negative while out are positive.

X1 . . . X4 = vectors of other exogenous variables, as follows
X1 = prices of competing enterprises, wheat quotas, technological advance
X2 = income, population
X3 = domestic feed grain prices, drought index, index of intensive livestock production
X4 = transactions demand for stocks, capacity constraints of the marketing system
YW = wheat yield.

With regard to notation in the model, the symbol (:) means "is a function of." The overlined variables are treated as exogenous to the model. The variables with subscripts are lagged variables.

Barley

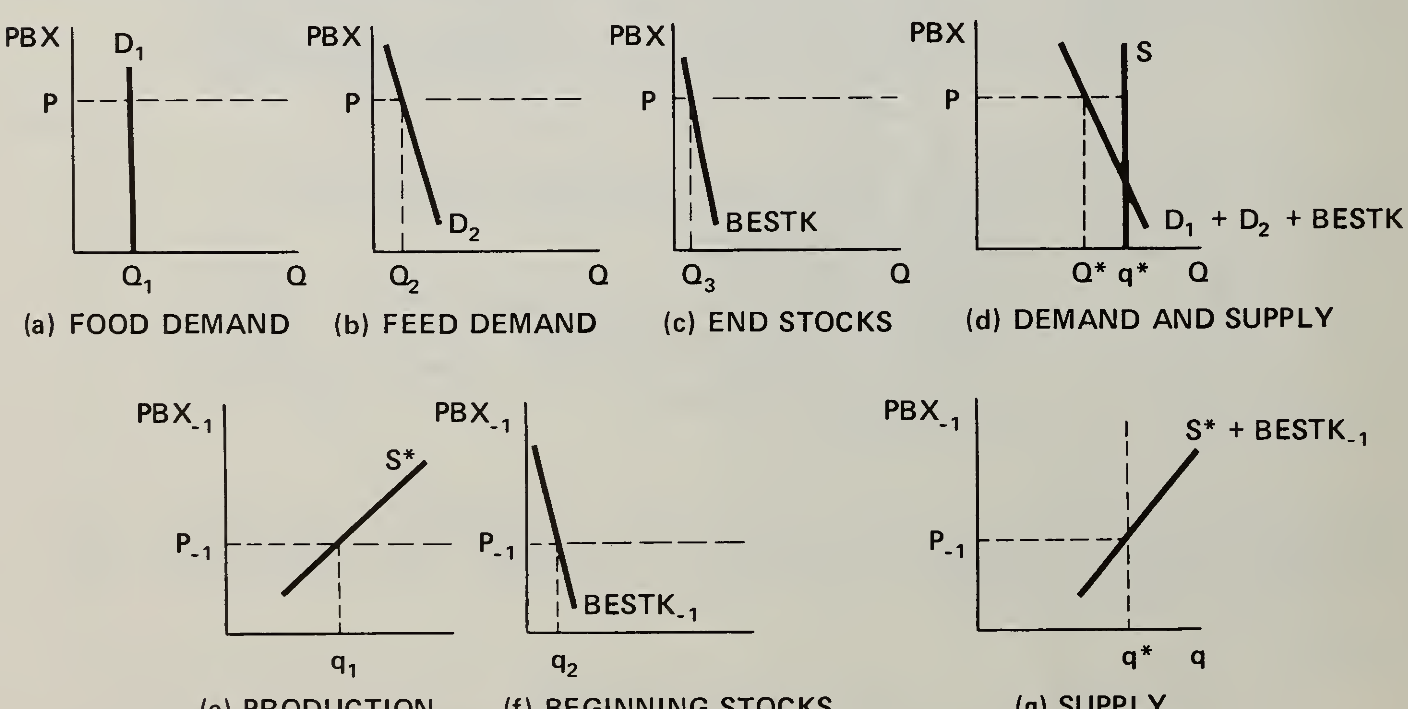
Most barley grown in Australia is marketed through one of the four marketing boards set up for this purpose, each covering a different geographical region. They are the Australian Barley Board (South Australia and Victoria), the West Australian Barley Board, the New South Wales Barley Board, and the Queensland Barley Board. Based on investigation, it is assumed that they have only a limited influence on domestic demand and supply decisions. The hcp of malting barley is assumed to be set independently of world prices, while the hcp of feed barley is not. While planting decisions may be affected by the method of pool payment, they are still assumed to be strongly related to export prices.

The barley model reflects all these assumptions (fig. 7). Panels (a) through (c) represent food and feed demand and ending stocks as functions of the export price of barley. Since food demand is a function of the independently set home consumption price and not export price, curve D_1 is vertical. The horizontal summation of curves D_1, D_2, and BESTK appears in panel (d). In panels (e) and (f), production and beginning stocks are postulated as functions of the barley export price lagged 1 year. Curves S* and $BESTK_{-1}$ are horizontally added in panel (g). For a given export price, lagged 1 year (P_{-1}) supply is determined for the current year (q* in panel g). This quantity is projected into panel (d) where it appears as curve S. From this is subtracted domestic disappearance ($D_1 + D_2 +$ BESTK), a function of current price, to obtain exports. For the given current price (P), domestic disappearance is Q* and exports equal (q*- Q*).

Note that as for wheat, Australia is not assumed to be a large enough exporter of barley to influence world prices significantly. This assumption is particularly relevant for a feed grain like barley whose international price is likely to be largely determined within the market for all feed grains. Australia's barley exports represent only a very minor fraction of total world trade. As a result, world barley price is treated as exogenous. This assumption leads to a recursive model.

Domestic demand: panels (a) and (b).--It was explained earlier that the barley marketing boards set the hcp for both malting and feed barley. However, it was argued

FIGURE 7--BARLEY MODEL°



° IN PANELS (d) AND (g) $Q^* = Q_1 + Q_2 + Q_3$ AND $q^* = q_1 + q_2$.

that while the boards could force a wedge between the hcp of malting barley and world price, they had no such power in the case of feed barley.

Production: panel (e).--For the same reasons as advanced for wheat, planted area is used as the dependent variable in the supply relation for barley. This is multiplied by an exogenous yield to obtain production.

The supply-inducing price of barley is also a consideration. Over the period of review, 1955/56 to the present, most of the barley has been grown in States where it is marketed through a statutory marketing board. Under such a marketing arrangement, all barley harvested in a season enters a pool, and the grower is paid in a series of payments. Even though there is no stabilization scheme to complicate matters, the method of payment, similar to wheat, creates a problem in determining the supply-inducing price. Like wheat, the first advance paid by the barley boards typically represents about two-thirds of the total payment, but unlike wheat it has varied from year to year, reflecting movements in average total payment. For example, in South Australia and Victoria, which together account for half the total barley area, the correlation (r) between the first advance and total payment is 0.98 (1955/56 to 1974/75). Hence, in the empirical analysis, the first advance for barley was used as the supply-inducing price. In panel (e), production is expressed as a function of lagged PBX (average export value, barley) and not the barley first advance (fig. 7). This represents a simplification of the estimating model which includes a price relation between the barley first advance and PBX.

Barley stocks: panels (e) and (f).--In preliminary analysis, there appeared to be a significant inverse relationship between barley stocks and world barley price. Although most barley is marketed through one of the four barley marketing boards, it is extremely unlikely that the triopoly argument applied to wheat could also apply to barley. As a barley exporter, Australia is ranked fourth behind France, Canada, and the United States. One may be tempted to consider the oligopoly argument. However, the four barley marketing boards do not speak with a common voice in the international marketing of their grain. In fact, they compete with each other on the export market.

Moreover, as already mentioned, the world price for barley is primarily determined within the larger world market for all feed grains. In this larger market, Australia is much less important as an exporter.

In light of this, it would seem that the various barley boards could act as "fringe" competitors, selling sufficiently below the price of the major feed grain exporters to clear the current crop. If this is true, then the barley boards' policies do not contribute to the establishment of a price-stocks relation. However, it may still be possible to explain the apparent relation in terms of speculative behavior on the part of nonboard holders of stocks. Nonboard holdings of stocks are far more significant for barley than for wheat. Recall table 2 which showed that the various barley boards receive a lower percentage of total production in the areas under their jurisdiction than the Australian Wheat Board. The wide difference between production and receivals indicates the probable existence of some form of private domestic market in barley. Such a market would involve the private holding of stocks which would respond to the speculative motive. In addition, it should be remembered that until 1972/73, all marketing of barley in NSW was in the hands of private merchants. Even today, most feed barley for domestic consumption in that State is handled by private trade, which can be expected to hold some stocks.

It appears the price-stocks relation for barley can be explained in terms of speculative behavior by nonboard holders of stocks. Unfortunately, it is not possible to research the matter more deeply because there is no breakdown of stocks into categories by type of holder. Indeed, the accuracy of the whole data series on barley stocks is questionable.

The barley model is summarized in equation form as:

BARLEY MODEL

Behavioral Relations

(1) $AB : PBA_{-1}, \overline{X1}, e1$ (planted area)

(2) $QBDH : \overline{PBH}, \overline{X2}, e2$ (food/factory demand)

(3) $QBDF : PBX, \overline{X3}, e3$ (feed demand)

(4) $BESTK : PBX, \overline{X4}, e4$ (ending stocks)

Identities

(5) $QB = AB \cdot \overline{YB}$ (production)

(6) $QBX = QB + BESTK_{-1} - QBDH - QBDF - \overline{QBDO} - BESTK$ (exports)

Price Relations

(7) $PBA : PBX, e5$ (first advance, barley)

(8) $PBX : \overline{PBUS} \cdot e6$ (average export value, barley)

The dependent variables are defined in parentheses to the right of each relation. In addition,

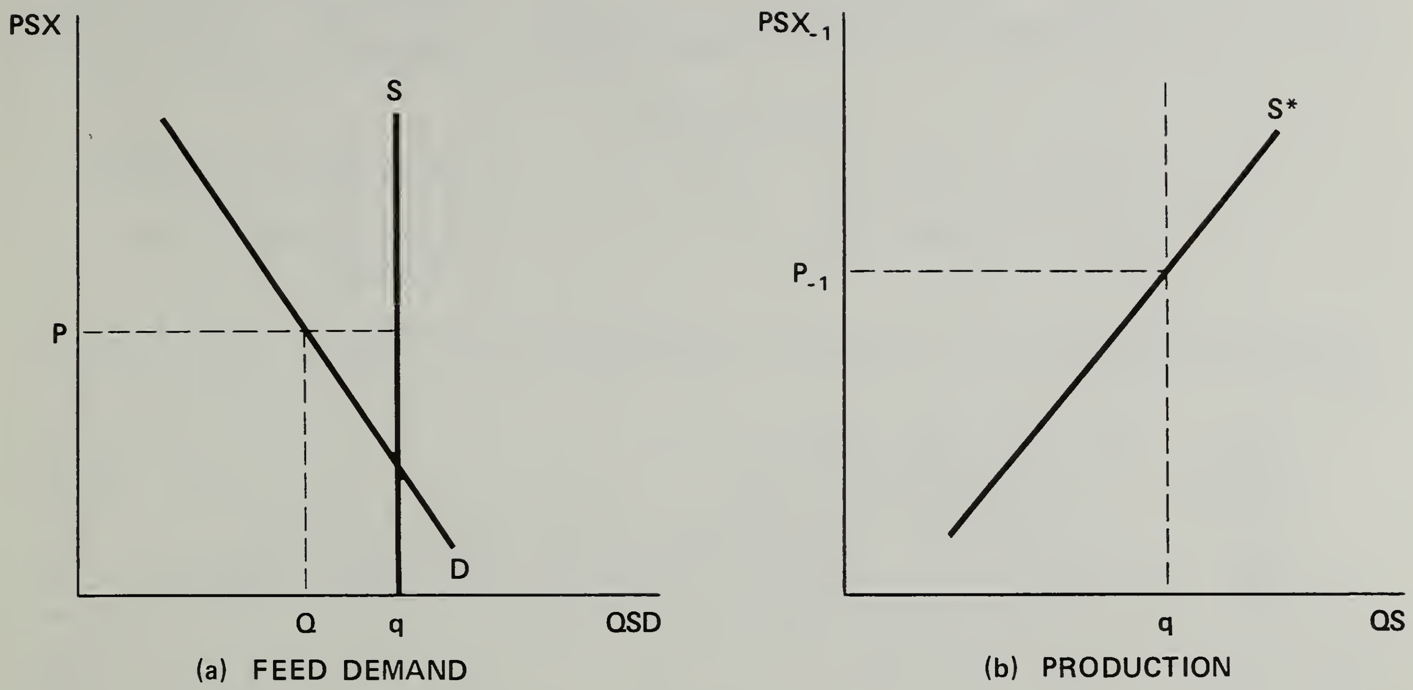
e1 . . . e6 = random disturbance terms
PBH = home consumption price, malting barley
PBUS = U.S. price, barley
QBDO = quantity barley used for seed
X1 . . . X4 = vectors of other explanatory variables, as follows
X1 = prices of competing enterprises, wheat quotas, technological advance
X2 = income, population
X3 = prices of competing feed grains, drought index, index of intensive livestock production
X4 = transactions demand for stocks, capacity constraints of the marketing system

Sorghum

Ninety-nine percent of Australia's sorghum is grown in Queensland and New South Wales. In southern Queensland, most sorghum is marketed through the voluntary Queensland Graingrowers Association. Statutory marketing boards operate in central Queensland and in New South Wales, the latter marketing all sorghum destined for export while licensing private merchants to handle the domestic sorghum market.

The theoretical sorghum model relating quantities to prices (fig. 8) is somewhat simpler than those developed for wheat and barley. As in those models, seed use was omitted for simplicity, but in this case the relations for food use and ending stocks are also omitted. Food/factory use of sorghum is omitted because it is negligible, while ending stocks are omitted because data for them have only been collected since the 1968/69 marketing year by the U.S. agricultural attache in Canberra. Over the short time series available, no clear price-stocks relation was observed. Hence, stocks were treated as exogenous, and assumed to be zero prior to 1968/69.

FIGURE 8--SORGHUM MODEL



In panel (b), sorghum production is postulated as a function (S*) of the lagged export price of sorghum (PSX). For a given price, lagged 1 year (P_{-1}) supply is determined for the current year (q). This quantity is projected into panel (a) where it appears as curve S. From this is subtracted domestic feed use, a function (D) of current export price, to obtain exports. For a given current price (P), domestic feed use is Q, and exports equal (q - Q).

Unlike the wheat and barley models, this model assumes that the domestic sorghum price is in no way insulated from the world price. In the estimating model, domestic feed demand is expressed directly as a function of the export price of sorghum. With regard to the supply side, most sorghum is marketed through a pool and the grower is paid in a series of payments. The supply-inducing price was assumed to be the lagged average grower return from the Central Queensland Grain Sorghum Marketing Board (CQGSMB). The CWGSMB, formerly Queensland Grain Sorghum Marketing Board, is no longer the largest marketing agency for sorghum in Australia, but for data purposes, it has the advantage of being the oldest. This board has operated a pool since 1956, while the other sorghum marketing agencies have been in operation only since 1970.

The model is summarized in equation form below.

SORGHUM MODEL

Behavioral Equations

(1) AS : PS_{-1}, X1, e1 (planted area)

(2) QSD : PSX, $\overline{X2}$, e2 (domestic use)

Identities

(3) $QS = AS \cdot \overline{YS}$ (production)

(4) $QSX = QS + \overline{SESTK}_{-1} - QSDF - \overline{SESTK}$ (exports)

Price Relations

(5) PS : PSX, e3 (total payments, sorghum)

(6) PSX : $\overline{PSUS}$, e4 (average export value, sorghum)

The dependent variables are defined in parentheses to the right of each relation. In addition,

e1 . . . e4	=	random disturbance terms
PSUS	=	U.S. price, sorghum
SESTK	=	sorghum ending stocks
X1, X2	=	vectors of other explanatory variables, as follows
X1	=	prices of competing enterprises, technological advance
X2	=	prices of competing feed grains, drought index, index of intensive livestock productions
YS	=	sorghum yield

MODEL ESTIMATION

The method of estimation of the behavioral and price relations for the wheat, barley, and sorghum models is ordinary least squares. Ignoring any "errors in variables" questions, this method should yield consistent estimates, since the models are recursive. With regard to the efficiency of the estimates, serial correlation is taken into account when it appears to be a problem, but no account is taken of any possible "seemingly unrelated regressions" problems.

Wheat

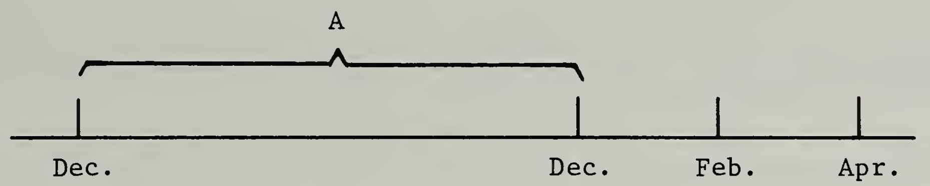
The various estimating equations--supply (planted area), domestic demand (food and feed), and stocks--are discussed.

Wheat Supply

Ninety-nine percent of wheat grown in Australia comes from five States: New South Wales, Queensland, Victoria, South Australia, and Western Australia. Separate wheat supply equations were estimated for each, allowing for regional differences in supply response. Planted area is used as the dependent variable in the supply equations. This abstracts largely from the uncertain effects of weather, allowing the economic factors affecting supply to be isolated.

Explanatory variables.--The explanatory variables common to all five equations--the supply-inducing prices of wheat and wool, technological advance, and wheat quotas--must be discussed before proceeding with the estimation. Those explanatory variables peculiar to individual States will be discussed as the individual equations themselves are discussed.

The wheat price variable to be used is the effective price series. The effective price is a weighted average of the hcp and expected export price, modified by expected transactions involving the wheat price stabilization fund. Before the effective price series can be calculated, it is necessary to explain its components: the hcp, the expected export price, and the wheat price stabilization scheme. With regard to the expected average export price, naive expectations are assumed. Hence, the appropriate variable is the <u>expected</u> average export return for the preceding crop. To clarify this, consider the following diagram.



Suppose it is February when planting decisions for the coming season are being finalized. The preceding crop was harvested in December and planting of the next crop will begin in April. By February, the hcp for the preceding crop is made public and one should have a fairly good idea of the stabilization price, since it does not change much from year to year. The crop is far from being all sold on the export market, however; thus, the average export return on the preceding crop cannot be known. It is assumed that the grower forms an expectation of the average export return based on the general state of the world market in the recent past. In this study, the simple annual average of export price quotations for the year ended the December before planting is used to reflect growers' expectations about the average export return on the preceding crop. In the time-frame diagram, the annual average of export price quotations refer to the year spanning distance A. The relationship between PWX (average export return) and PWXA (annual average export price quotations) was estimated by regression analysis. The results were:

$$\text{OLS:} \quad PWX = .841 \cdot PWXA + 469.$$

$$t: \quad (11.6) \qquad (.98)$$

$$R^2 = .839 \qquad N = 27 \ (1947/48 \text{ to } 1974/75)$$

Because the intercept had a low t-value, the equation was re-estimated assuming a zero-intercept. Following Gillingham and Heien's approach, the newly estimated equation through the origin is:

$$PWX = .9160 \cdot PWXA$$

Thus, in calculating the effective price, the expected average export return was approximated by .916, multiplied by the annual average of export price quotations. The difference between the adjustment factor (.916) and 1 largely reflects the fact that the price quotations, because they are selling quotations, will exceed realized prices.

The third component of the effective price series is the wheat price stabilization scheme. The scheme has endured through a series of five 5-year plans to the one operating today. The first five plans which spanned the years 1948/49 to 1973/74 were basically similar with minor modifications from one plan to the next. The current (sixth) plan operating from 1974/75 to 1978/79 represents a major change from the preceding plans.

The basic ingredients of the first five plans were a stabilization fund and a guaranteed price. All wheat received by the Australian Wheat Board from a given harvest entered a pool and was sold on the domestic market at the home consumption price or on the export market at world prices. Returns to the grower were based on an average price from all sales.

Under the stabilization scheme, however, if the average return from export sales exceeded the guaranteed price, growers would be required to pay a tax on all exports, the proceeds of which would enter the stabilization fund. In most plans, the tax per unit of wheat exports was equal to the difference between the average export return and the guaranteed price up to a specified maximum of $5.51 per metric ton. If the average return from export sales fell short of the guaranteed price, then payments would be made out of the stabilization fund sufficient to raise the average export return on a guaranteed quantity of exports to the guaranteed price. If the stabilization fund became exhausted, the Federal Government would pay into the fund to the extent necessary to meet obligations. 12/

Given this basic makeup, the effective price was calculated from the formula:

$$PW = \frac{PWH \cdot QWH + PWXG \cdot QWXG + PWX \cdot (QWX - QWXG)}{QWH + QWX}$$

if $PWXG > PWX$, and

$$PW = \frac{PWH \cdot QWH + (PWX - T) \cdot QWX}{QWH + QWX}$$

if $PWXG < PWX$

where

PWH = home consumption price, preceding crop
PWX = expected average export return, preceding crop
PWXG = guaranteed price, preceding crop
QWH = domestic quantity weight
QWX = export quantity weight
QWXG = guaranteed quantity, preceding crop
T = expected export tax, preceding crop

For more detail regarding these first five plans, see the references in footnote 12. Some useful graphical analyses have also been carried out by Watson and Duloy (43) and Longworth (29).

The current (sixth) plan has retained the stabilization fund but replaced the guaranteed price with a "stabilization price" calculated on a different basis. Annual adjustments to the guaranteed price reflected movements in costs of production, while

12/ For further details on the first five plans, see the following issues of the Official Year Book of Australia: Plan 1, issue No. 40, pp. 841-842, Plan 2, issue No. 44, p. 861; Plan 3 issue No. 48, pp. 903-904; Plan 4 issue No. 54, pp. 868-869; and Plan 5 issue No. 55, pp. 834-835.

the stabilization price is adjusted annually to reflect trends in world wheat prices. 13/ As in previous plans, if average export return exceeds the stabilization price, growers are required to pay an export tax which enters the stabilization fund. This is to equal the difference between the two prices up to a specified maximum ($5.51 per metric ton). The sixth plan differs from its predecessors when the average export return falls below the stabilization price. Then, payments are made from the stabilization fund on all exports up to a specified maximum of $5.51 per metric ton (5). This contrasts with the previous plans which had no specified maximum payment per metric ton, but the payments were limited to a specified quantity of exports.

Given this basic makeup, the effective price for the sixth plan is calculated as:

$$PW = \frac{PWH \cdot QWH + (PWX + S) \cdot QWX}{QWH + QWX}$$

where S = expected stabilization payment per metric ton into or out of the fund, preceding crop,

and the other variables are as previously defined.

There are other parts to the scheme that affect producer returns but which have not been incorporated into the effective price. These include size limits on the total contribution or withdrawal from the fund, and operating costs of the AWB. In the current plan, there is a limit of $80 million on both the size of the fund and the size of any Federal obligation in the event of the fund drying up. A $30 million limit is also set on the total annual contribution or payment out of the fund. Operating costs of the AWB (such as for rail freight handling and storage) are deducted from pool receipts to obtain the amount distributed to growers.

To incorporate these other parts of the scheme would make the calculation of the effective price very cumbersome. The effective price is only a simple attempt to include the influences of both domestic and world prices on grower behavior. It falls far short of including all possible influences on expected grower returns. To the extent that these other influences have a bearing on grower planting decisions, the effective price will be in error. The calculated effective price series is reproduced in appendix A.

13/ For the first four plans, the guaranteed price based on costs of production was set at the same level as the home consumption price of wheat. At the start of each plan, a survey assessed costs of production. Between each survey, cost adjustments were made by the Wheat Index Committee. At the start of the fifth plan, the guaranteed price was set on the basis of world market prices at the time and adjusted annually according to movements in cash costs only. At the start of the sixth plan, the stabilization price was set at $73.49 per metric ton and is adjusted annually according to the formula:

$$SP = SP_{-1} + \frac{PWX - (PWX_{-1} + SP_{-1})/2}{4}$$

where SP = stabilization price, current crop
SP_{-1} = stabilization price, preceding crop
PWX = average export return, current crop
PWX_{-1} = average export return, preceding crop

The main competing alternative in production over Australia as a whole is probably wool. The so-called wheat-sheep zone of Australia, which encompasses over 90 percent of all sown wheat area in Australia, also carries over 40 percent of the nation's sheep. 14/ Thus, wheat planting intentions are assumed to be influenced by the expected price of wool. To some extent, sheep and wheat may be considered complementary in a pasture-crop rotation system. In discussions with industry people in Western Australia, such an opinion was expressed with regard to that State during the sixties. During this period in Western Australia, there was a rapid expansion in land brought under cultivation. It was suggested that the expansion outpaced the natural increase in sheep numbers, leading to a shortage of grazing animals for the pasture phase of the rotation. However, when an equilibrium has been established between sheep and wheat with respect to the rotational requirements, a grower may be expected to adjust his area under crop versus pasture, depending on changes in the relative prices of wheat and wool. The wool price used is the average fiscal year price of all greasy wool sold in Australia. In specifying the wool price variable, various linear distributed lag formulations were tried involving up to three period lags.

Over the period to be studied, 1955-74, a strong upward trend in wheat area in all States appears that apparently cannot be explained by competitive influences. This may be attributed largely to technological advance. Of major importance during this period has been the development of improved crop and temperate pasture species, increased application of fertilizers (especially superphosphate), and improved rotational practices (13).

Perhaps an additional reason for the upward trend in area under crop and pasture has been the introduction of various government tax incentives for clearing and developing land, as well as for investment in capital items. An explanation of these can be found in Rural Industry in Australia, (13, p. 64).

To handle the question of technological advance (and perhaps tax concessions), one could simply impose a linear trend throughout the time series for each State. There is, however, an alternative approach. We may assume that the prices of wheat and its competitors in production are held fixed. As a rough approximation then, it may also be assumed that the area devoted to each enterprise is a constant percentage of total cultivated area (that is, area under crop, pasture, and fallow). Thus, the areas devoted to each enterprise would move over time in proportion to movements in cultivated area. Such movements are in response to technological advances and tax incentives. In a supply equation, wheat area would be specified as a function of the price of wheat, the prices of competing outputs, and total cultivated area.

This last assumption can easily be flawed for being too simplistic. It may be expected to capture the effects of tax incentives and technological advance applied equally across enterprises. However, it cannot capture the technological advance which is specific to an individual enterprise. Such an advance may be expected to lead to a change in the proportion of total cultivated area devoted to each enterprise. One further doubt about this variable concerns the importance of wheat in total cultivated area. If wheat area is a major part of cultivated area, then a regression of the former against the latter would not be very useful. In fact, wheat area does not dominate cultivated area. Over the 10 years to 1975, wheat area as a proportion of total cultivated area averaged less than 30 percent in every State. Moreover, while wheat area fluctuates from year to year, cultivated area has been dominated by an upward trend. In Queensland, this trend has been approximately linear over the past 20 years, while in the other States the trend was approximately linear until the late sixties, after which it tapered off.

14/ These figures are based on data obtained from Scobie (38, pp. 188-189), and Lawrence (28, p. 221).

The use of cultivated area as an explanatory variable has a precedent in a supply study by the Bureau of Agricultural Economics (11). With regard to the present study, the "cultivated area" variable produced better statistical results than a linear trend in the wheat model, but not in the barley or sorghum models. Hence, while cultivated area was used in the wheat model, a linear trend was used to reflect technological advance in the other models.

The final explanatory variable to be considered is wheat quotas. They were introduced to help ease the severe grain storage and marketing problems in 1969, a time when Australia had just recently had an exceptionally large wheat harvest, and markets were experiencing a wheat glut worldwide. Wheat quotas were announced for the 1969/70 crop on April 30, 1969. At the time, planting decisions had already been largely made and much of the crop planted. Hence, the effect of wheat quotas in that first year was assumed to be zero.

Wheat quotas were announced in advance of subsequent seasons until the 1975/76 crop, when they were suspended. Whether quotas were actually effective in holding down wheat area in any of the States during the seasons 1970/71 to 1974/75 is the issue here. The quotas were actually imposed on deliveries to the Australian Wheat Board and not on area planted. Hence, the procedure used here is to divide the effective quota in any season by average yield to determine an effective quota area. This is then compared with actual area. (Note that the effective quota is actual quota less any excess of deliveries for the previous year. This is because excess deliveries from a grower were applied against his quota for the following year.) Average yields were calculated for each State using the period 1946/47 through 1975/76. No attempt was made to allow for a yield trend because no significant trend was discerned. Table 3 shows the ratio of effective quota area to actual area sown for each of the wheat-producing States for the seasons 1970/71 through 1974/75.

Table 3--Ratio of effective quota area to actual area of wheat by State, 1970/71 to 1974/75

Item	New South Wales	Queensland	South Australia	Victoria	Western Australia
			Metric tons/hectare		
Average yield	1.1873	1.2697	1.1287	1.3787	.9781
			Ratio		
1970/71	.99	2.31	.76	.80	.98
1971/72	1.21	1.46	.90	1.04	.81
1972/73	1.37	1.73	1.03	1.05	.95
1973/74	1.54	2.34	1.23	1.44	1.05
1974/75	1.67	1.89	1.45	1.58	.98

To use table 3, it is necessary to determine an arbitrary cutoff ratio above which quotas are deemed ineffective and below which they are deemed effective. A natural break occurs in the ratios between 1.05 and 1.21. It seems reasonable that the cutoff ratio should lie somewhere in this range. When the effective quota area was only 5 percent above actual area, quotas were probably effective. But at 21 percent above actual area, quotas were probably ineffective. In the various supply equations, dummy variables were used in the years when quotas were deemed effective. Thus for NSW, a dummy variable was used which equaled 1 in 1970/71 and 0 otherwise. For Queensland, it appears quotas were never effective. For South Australia and Victoria, a dummy variable was included for quotas which equaled 1 for the years 1970/71 to 1972/73 and 0 otherwise.

With regard to Western Australia, the situation is slightly more complex. For the years 1973/74 and 1974/75, the Australian Wheat Board issued contingency quotas of 544,000 metric tons and 2 million metric tons. These quotas were available to any State which filled its original quota allocation. If these quotas are added to Western Australia's original quota, the ratios for 1973/74 and 1974/75 become 1.24 and 1.67, respectively. This calculation takes Western Australia out of the quota effective range for these 2 years. Thus for Western Australia, a dummy variable was included for quotas which equaled 1 for the years 1970/71 through 1972/73 and 0 otherwise.

New South Wales.--Planted wheat area in NSW is postulated as a function of the effective wheat price, the lagged price of wool, and technological advance. In certain years, wheat area was also adversely affected by a major drought and in one year wheat quotas were assumed to be effective.

The main competing enterprise with wheat is grazing livestock. Sheep have historically been far more important than beef cattle. Over the 10 years ended 1973, beef cattle (in sheep equivalents) required only an average of 54 percent of the grazing area of sheep. Hence, the estimating equation includes only the price of wool. In very recent years, however, beef cattle numbers have increased tremendously in NSW in response to relative price changes between wool and beef. In 1976, for example, beef cattle in sheep equivalents required 127 percent of the grazing area of sheep. In future research, it would be worthwhile to pay some attention to beef price. In the time series used in the present study (1955-74), however, beef price was not significant as an explanatory variable.

It is hypothesized that the 1965/66 drought which had a very severe effect on the agriculture of NSW also had a substantial lagged effect on wheat area. This effect is the result of the very marked decline in grazing livestock numbers during the drought. In terms of sheep equivalents of sheep and beef cattle, grazing livestock in NSW declined 15 percent in 1 year between March 1965 and March 1966. 15/ This is the largest annual drop since at least 1946 (fig. 9). Grazing livestock numbers failed to return to the trend line until 1970. It is suggested that the drought resulted in a shortage of available livestock so that much land was turned from pasture to cereal production, with wheat in particular. To incorporate the drought effects in the estimating equation, a dummy variable is included which equals 1 for the years 1966 through 1969 and 0 otherwise.

The final estimated equation (table 9) was fitted over the period 1955/56 to 1974/75 and projected for 1975/76 and 1976/77. The estimated and projected values are plotted against actual values (fig. 10).

15/ Sheep equivalents are determined by adding 8 times the number of beef cattle to the number of sheep.

FIGURE 9--SHEEP EQUIVALENTS OF SHEEP AND BEEF CATTLE, NEW SOUTH WALES, 1950-1976

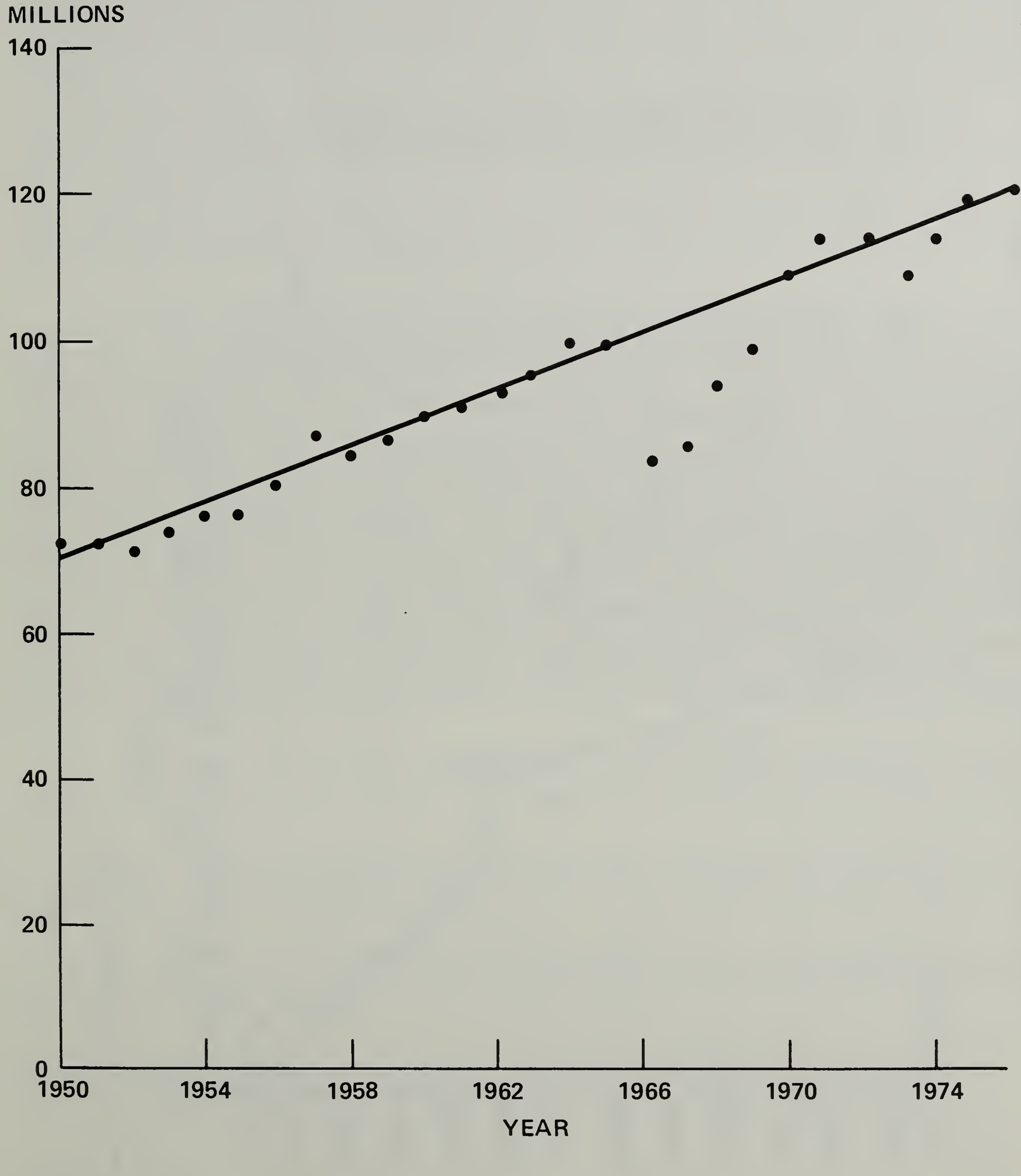
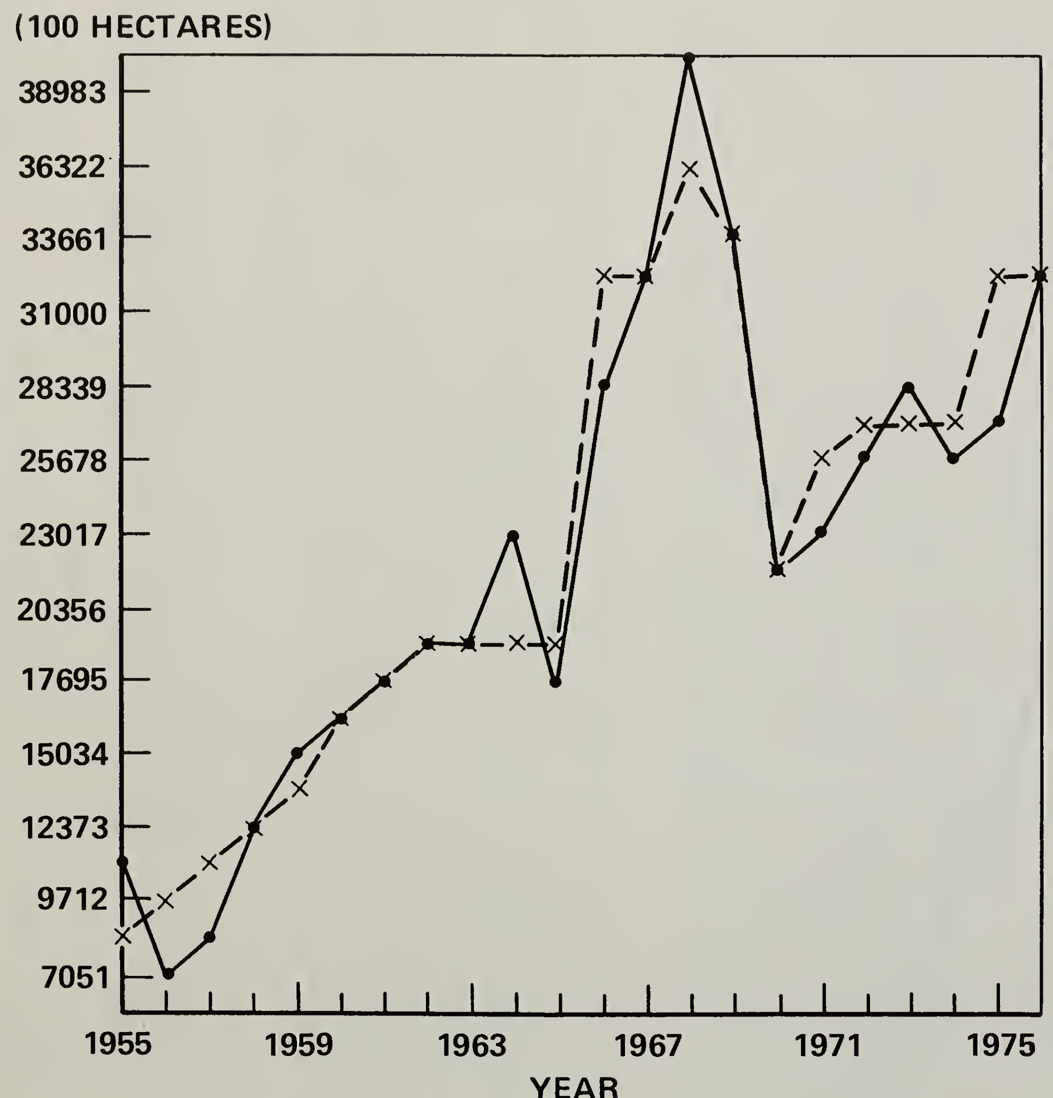


FIGURE 10--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 1-AWN



NOTE: DATA DIVIDED BY 100.0

YEAR	LEVELS (•)	(×)
1955	11888	8629
1956	7051	9966
1957	9135	11196
1958	12861	13029
1959	15987	14379
1960	16495	16692
1961	18204	17850
1962	20266	19206
1963	20088	19788
1964	23310	20190
1965	18521	20266
1966	28875	32663
1967	33245	33392
1968	40314	36525
1969	34895	34748
1970	22157	22156
1971	24263	25998
1972	26181	27244
1973	28830	27734
1974	26463	27379
FORECAST		
1975	27741	32781
1976	32830	33234

Queensland.--Planted wheat area in Queensland is postulated as a function of the effective wheat price, lagged wool price, and technological advance. In addition, it is argued that a recent structural change occurred as the result of a rapid expansion in grain sorghum production.

Over 75 percent of Queensland's wheat is grown in the Darling Downs. 16/ This is a statistical division located just north of the NSW border. The main alternatives to wheat in this area are sheep, barley, and in more recent years, sorghum. To some extent, sorghum is a backup crop in case adequate soil moisture is not available for planting wheat and barley. While wheat and barley are sown at similar times in April through July, sorghum is not planted until much later, in September through February. Thus, if rain fails to come in time for planting of the winter crops (wheat and barley), growers will wait for spring rains in order to sow sorghum and other summer crops. The need for a backup crop apparently occurred in 1969 and 1970, when conditions for planting winter crops were poor. This, together with good prices for sorghum relative to earlier years, led to a very rapid expansion in sorghum area. In the 5 years 1970-74, Queensland's sorghum area averaged 373,000 hectares, compared with an average of only 156,000 hectares for the 5 years to 1968. Queensland's wheat area averaged 449,000 hectares during 1970-74.

As a result of those 2 poor years for wheat planting, many growers who had never previously considered sorghum now turned to it. It is argued that this in turn broadened their choice of enterprises for future seasons, and helped to create a structural change in Queensland's grain industries. A possible contributing factor to structural change was the change in the method of marketing sorghum in southern Queensland, an area which produces about two-thirds of Queensland's grain sorghum. Prior to 1970, the crop in southern Queensland was marketed by private merchants and sold primarily on the domestic market. In 1970, the Queensland Graingrowers Association formed its Grain Sorghum Export Committee (GSEC) to market the huge increase in sorghum production coming from southern Queensland. The GSEC possibly contributed to the structural change by providing services to farmers which made sorghum production more attractive than before. Its very success in attracting grain from the growers is evidence that it is providing services not previously offered by private merchants. Since the GSEC operates a voluntary pool, growers still have the choice of whether to market privately or through the pool. In fact, over the 5 years 1970/71 to 1974/75, an average of two-thirds of the sorghum produced in southern Queensland was marketed by GSEC. Of the remainder, some would have been kept for use on the farms where grown and some would have been marketed privately.

To incorporate the structural change effect in the estimating equation, a dummy variable was included which equaled 1 for the years up to 1968/69, .5 in 1969/70, and 0 thereafter.

The final equation estimated for Queensland was fitted for 1955/56 to 1974/75 and projected for 1975/76 to 1976/77 (table 4). The estimated and projected values are plotted against actual values (fig. 11.)

South Australia.--Area planted to wheat in South Australia is postulated as a function of the effective price of wheat, lagged prices of wool and barley, technological advance, and wheat quotas.

In South Australia, unlike the other wheat States, barley appears to be an important competing crop. Its importance relative to wheat can be seen in table 5, which shows the average ratio of barley to wheat area for the five wheat States.

16/ This statistic is an average for 1970/71 to 1974/75 (35).

Table 4--Estimated wheat supply equations

AWN:	PW	PW01	CANSW	D70	D6669	CONSTANT
	186.764	-12.7588	26108.9	-259114.	961680.	-838900.
t:	1.16	-1.12	3.97	-.99	5.42	
e:	.47	-.26				
$\bar{R}^2$ = .929			D.W. = 1.87		N = 20 (1955/56 to 1974/75)	

AWQ:	PW/PW02	CAQ	SC	CONSTANT
	393984.	15788.1	324195.	-605829.
t:	3.29	8.58	5.88	
e:	.52			
$\bar{R}^2$ = .861			D.W. = 3.00	N = 20 (1955/56 to 1974/75)

AWS:	PW/PW01	PBA	CASA	D7072	D68	CONSTANT
	1816507.	-48.9170	28093.0	-352548.	253629.	-423585.
t:	1.24	-1.01	6.57	-4.57	5.36	
e:	.24	- .16				
$\bar{R}^2$ = .909			D.W. = 1.60		N = 20 (1955/56 to 1974/75)	

AWV:	PW	PW03	CAV	D7072	D68	CONSTANT
	72.4742	-31.3151	9215.44	-639620.	147742.	657083.
t:	1.05	-3.66	4.56	-6.31	1.17	
e:	.36	-.63				
$\bar{R}^2$ = .804			D.W. = 1.51		N = 20 (1955/56 to 1974/75)	

AWW:	PW/PW03	CAWA	D7073	CONSTANT
	1635501.	26656.2	-764264.	-508251.
t:	1.81	17.0	-5.87	
e:	.20			
$\bar{R}^2$ = .949			D.W. = 1.49	N = 20 (1955/56 to 1974/75)

t: t-statistic
e: elasticity evaluated at the mean

The variables in table 4 are as follows.

AWN = planted area of wheat, New South Wales (ha)
AWQ = planted area of wheat, Queensland (ha)
AWS = planted area of wheat, South Australia (ha)
AWV = planted area of wheat, Victoria (ha)
AWW = planted area of wheat, Western Australia (ha)
CANSW = cultivated area, New South Wales (100,000 ha)
CAQ = cultivated area, Queensland (100,000 ha)
CASA = cultivated area, South Australia (100,000 ha)
CAV = cultivated area, Victoria (100,000 ha)
CAWA = cultivated area, Western Australia (100,000 ha)
D6669 = dummy variable. It equals 1 for 1966/67 to 1969/70 and 0 otherwise.
D68 = dummy variable. It equals 1 for 1968/69 and 0 otherwise.
D70 = dummy variable. It equals 1 for 1970/71 and 0 otherwise
D7072 = dummy variable. It equals 1 for 1970/71 to 1972/73 and 0 otherwise.

Table 4 (continued)

PBA = barley first advance, Australian Barley Board (cts/mt), preceding crop
PW = effective price of wheat (cts/mt), preceding crop
PWO1 = $PWO_{-1} + 2.PWO_{-2} + PWO_{-3}$
PWO2 = PWO_{-1}
PWO3 = $PWO_{-1} + PWO_{-2}$
PWO_{-i} = average price of all greasy wool sold in Australia (July-June year) lagged i years.
SC = structural change variable. It equals 1 prior to 1969/70, .05 in 1969/70 and 0 thereafter.

Table 5--Barley/wheat area ratio, by State, average 1955/56 - 1974/75

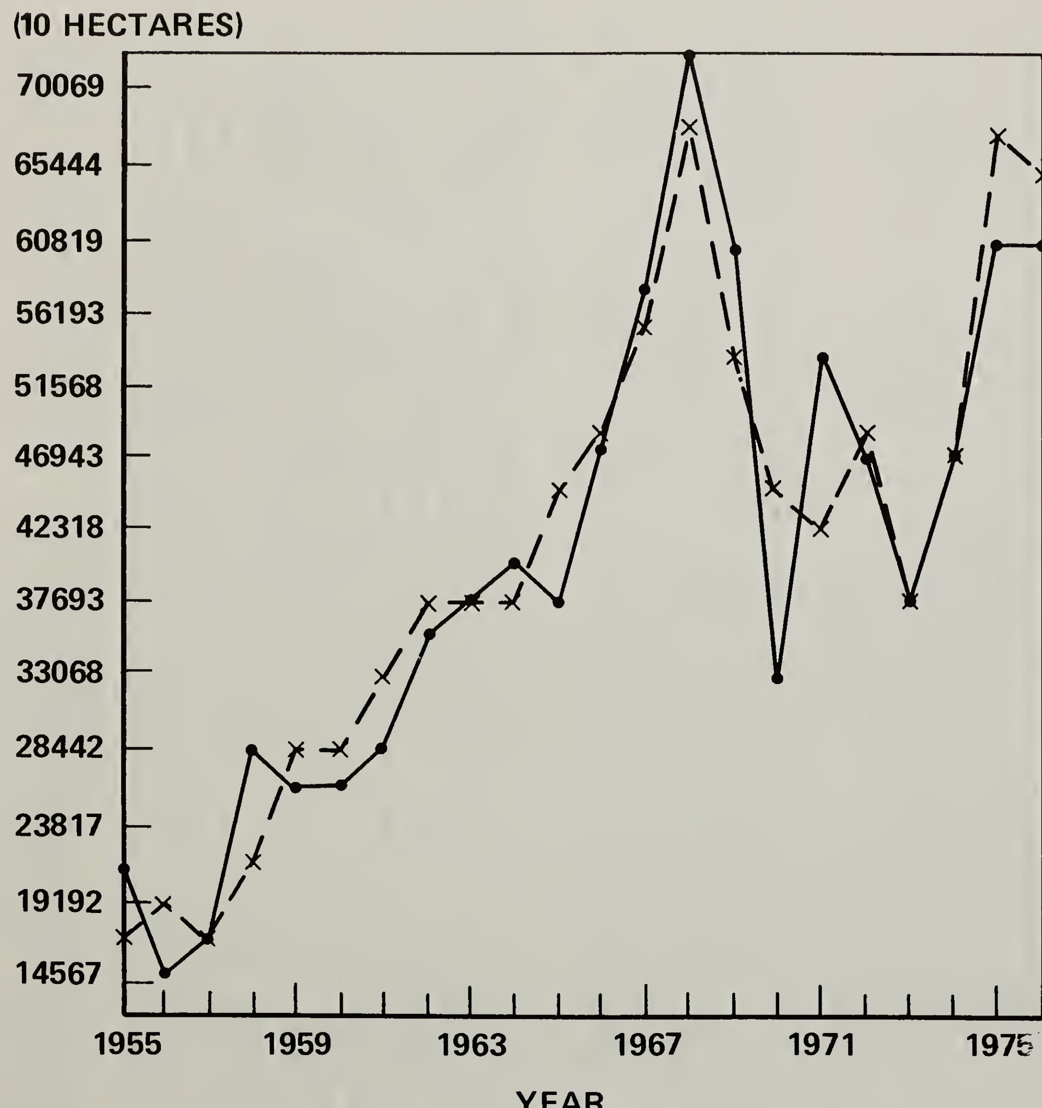
State	Ratio
South Australia	.55
Queensland	.27
Victoria	.14
Western Australia	.14
New South Wales	.07

In addition, there appears to be a strong inverse relation between the area sown to wheat and that sown to barley in South Australia. Thus, barley price was included as an explanatory variable in the wheat supply equation for South Australia. In the description of the barley model, the supply-inducing price of barley was discussed. It was argued that the barley first advance was an appropriate price variable. Since the Australian Barley Board has jurisdiction in South Australia, the barley price variable is the lagged first advance paid by the Australian Barley Board.

In 1968/69, wheat area in South Australia took an unprecedented jump which could not be explained by price movements or technological change. As a result, that year was excluded by use of a dummy variable that equaled 1 in 1968/69 and 0 otherwise. One likely explanation for this rise lies in a combination of drought the previous year and depressed farm incomes at the time. The 1967 drought was largely responsible for the 9-percent decline in sheep and beef cattle (in sheep equivalents) in South Australia between March 1967 and March 1968. The smaller livestock population permitted some land to be diverted from pasture to cash crops. Yet the drought reduced not only livestock numbers, but net farm income (which was already suffering from low product prices and high input prices) as well. In 1968, many growers needed the quick return that a cash crop offered. In addition, since the wheat price was being supported by the Government's stabilization plan while other cash crops were not, the added price security in wheat made this a relatively more attractive alternative.

The final estimated equation was fitted for 1955/56 to 1974/75 and projected for 1975/76 and 1976/77 (table 4). The estimated and projected values are plotted against actual values (fig. 12).

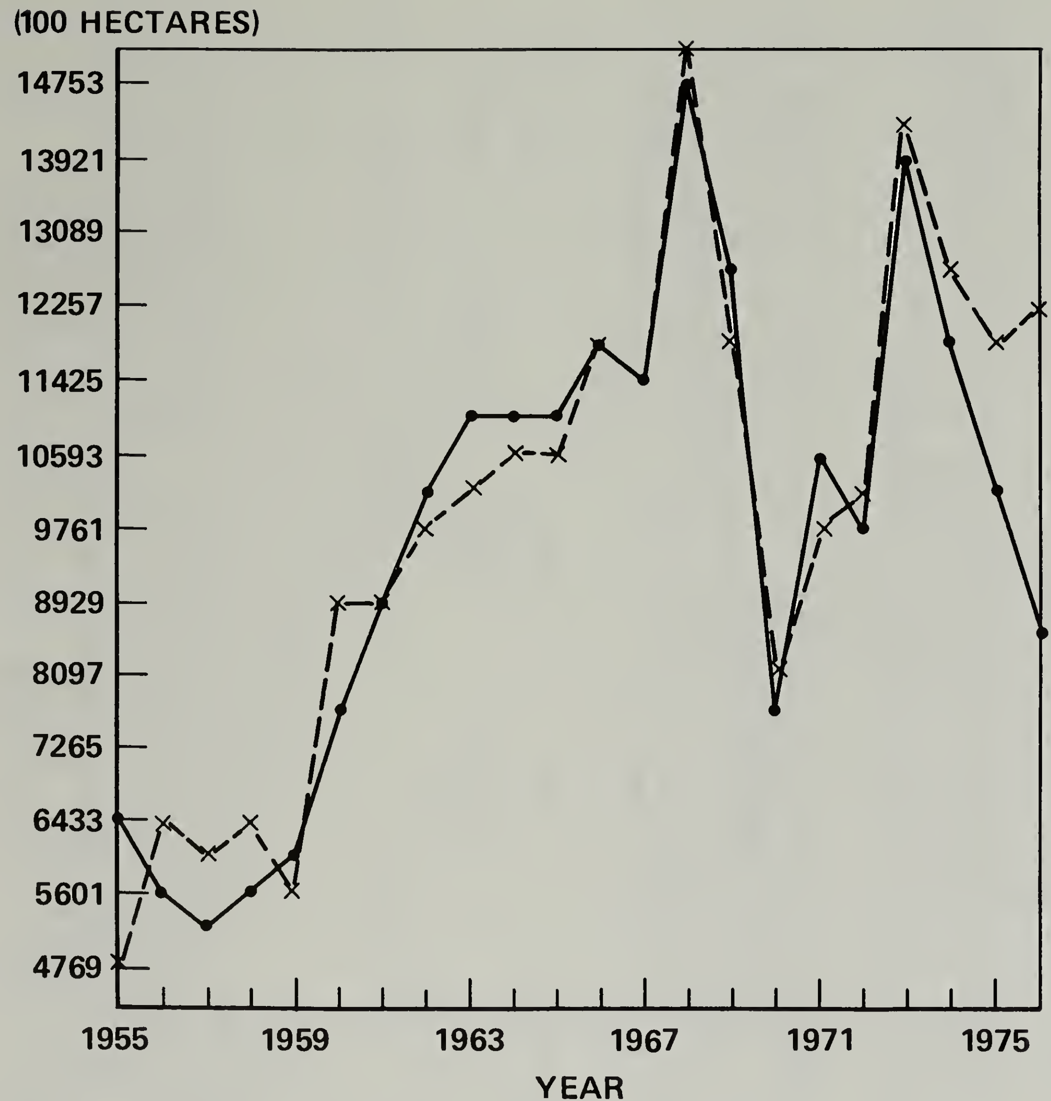
FIGURE 11--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 2-AWQ



NOTE: DATA DIVIDED BY 10.00

YEAR	LEVELS (·)	(×)
1955	23542	17193
1956	14567	20053
1957	18641	17303
1958	28490	22976
1959	27646	30072
1960	28028	29267
1961	30339	34097
1962	37187	38905
1963	37944	39871
1964	41501	39019
1965	38597	46632
1966	49670	49706
1967	59756	58367
1968	72382	68065
1969	60867	54410
1970	33390	45906
1971	55599	43100
1972	47062	51490
1973	39470	38462
1974	48850	48636
FORECAST		
1975	59456	67913
1976	59400	67147

FIGURE 12--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 3-AWS



NOTE: DATA DIVIDED BY 100.0

YEAR	LEVELS (•)	(×)
1955	6512	4769
1956	5821	6496
1957	5388	6411
1958	5696	6753
1959	6271	6007
1960	7970	9018
1961	9021	9194
1962	10502	9875
1963	11340	10289
1964	11035	10794
1965	11108	11000
1966	11980	11883
1967	11591	11471
1968	15169	15169
1969	12989	12193
1970	8023	8478
1971	10686	9857
1972	9861	10234
1973	14319	14521
1974	12204	13075
FORECAST		
1975	9867	12107
1976	8560	12413

Victoria.--Planted wheat area in Victoria is postulated as a function of the effective price of wheat, lagged wool price, technological advance, and wheat quotas. 17/ In addition, as in South Australia, wheat area was abnormally high in 1968/69. It, too, may be explained in terms of the 1967 drought which had a severe effect throughout most of southeastern Australia. To account for this abnormal year, a dummy variable was included in the estimating equation which equaled 1 in 1968/69 and 0 otherwise.

The final estimated equation was fitted for 1955/56 to 1974/74 and projected for 1975/76 and 1976/77 (table 4). The estimated and projected values are plotted against actual values (fig. 13).

Western Australia.--Planted wheat area in Western Australia is postulated as a function of the effective price of wheat, lagged wool price, technological advance, and wheat quotas. The final estimated equation was fitted for 1955/56 to 1974/75 (table 4). The estimated and projected values are plotted against actual values (fig. 14).

Wheat Demand

Australia consumes roughly 30 percent of its annual production of wheat. Of this, about half is consumed as food, a third as feed, and the remainder as seed. 18/ Three equations are estimated, corresponding to the domestic demand for food use, the domestic demand for feed use, and a relation to explain ending wheat stocks. Seed use is treated as exogenous in the wheat model.

Wheat demand for food use.--Of the wheat consumed as food, 97 percent is transformed into flour, and of this, two-thirds is used to make bread. Four variables were used to explain the consumption of wheat as food: the price of wheat, income, population, and a variable to allow for changing food habits.

The price series used for wheat was the home consumption price of wheat, deflated by the consumer price index (CPI) adjusted for the crop year. The income variable was private consumption expenditures deflated by the CPI and then adjusted for the crop year. Population was handled differently. Both the dependent variable (quantity of wheat consumed as food) and the income variable were divided by population so that the equation was expressed on a per capita basis. The variable to explain changing food habits was a simple linear trend. The final estimated equation is:

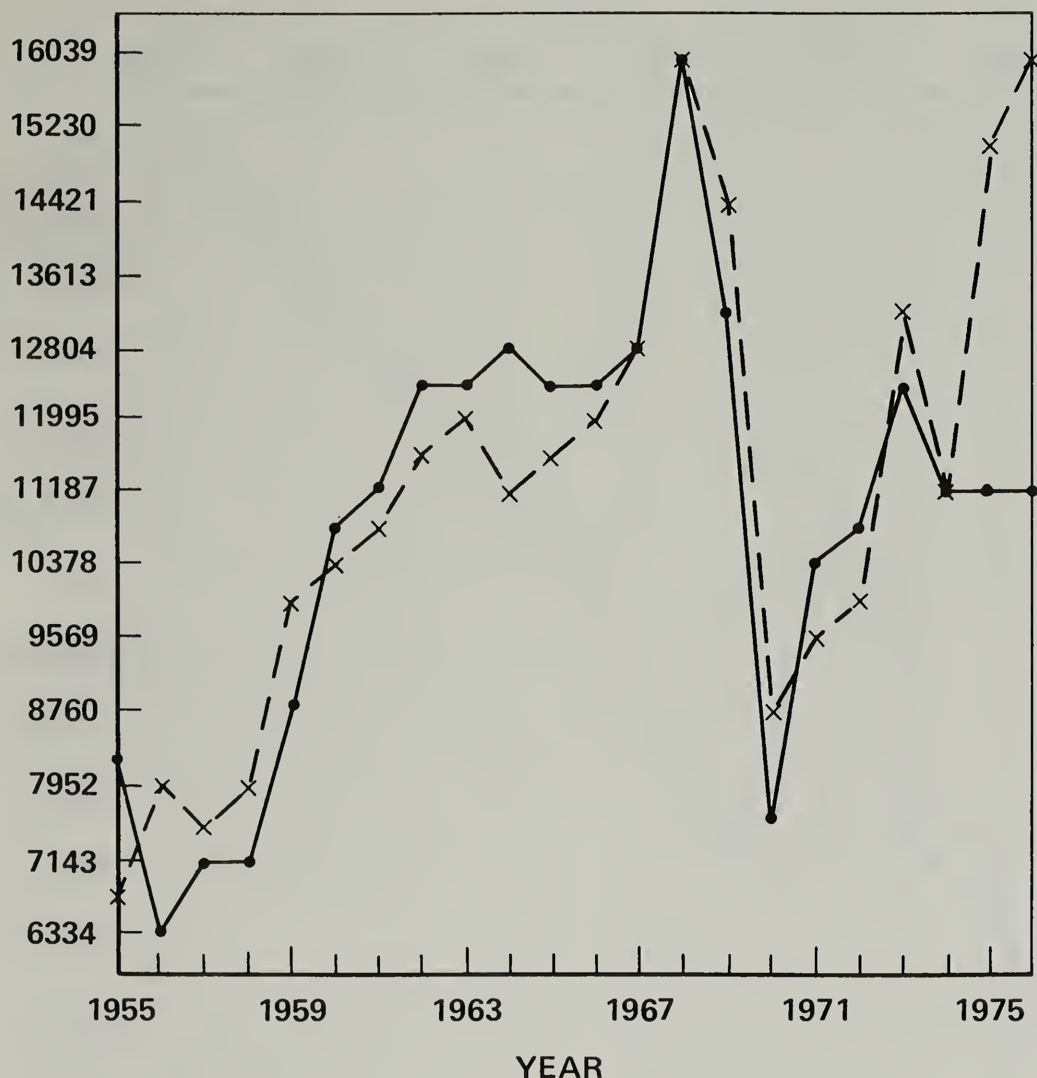
QWDHPC:	PWH	INCOME	T	CONSTANT
	-8.72399	-13967	-1.34084	261.26
t:	-5.93	-1.33	-4.50	
e:	-.47	-.14		

$\bar{R}^2 = .938$ D.W. = 2.30 N = 21 (1952/53 to 1972/73)

17/ With regard to the variable representing technological change, there is a small problem using cultivated area in Victoria. Beginning with 1972/73, cultivated area in Victoria was calculated differently than prior to 1972/73 (7). This resulted in a substantial drop in the announced cultivated area. To offset this, the difference in cultivated area between 1971/72 and 1972/73 was added on to the cultivated area data for 1972/73 on.

18/ This is based on average production and consumption data for the 10 years ending 1974/75.

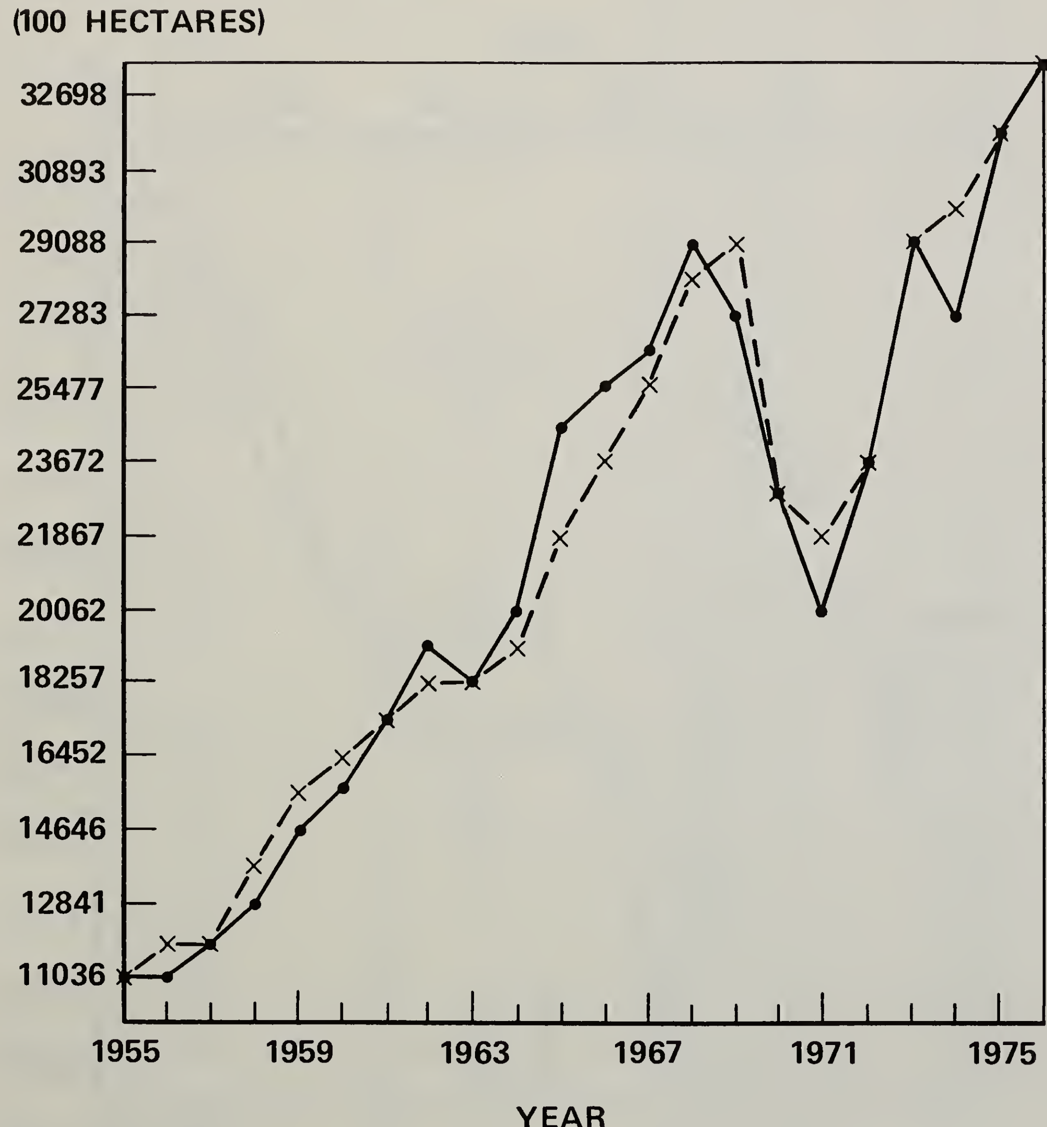
FIGURE 13--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 4-AWV



YEAR	LEVELS (.)	(×)
1955	8666	6999
1956	6334	8036
1957	7425	7847
1958	7325	8310
1959	9149	10186
1960	10812	10652
1961	11529	11172
1962	12646	11971
1963	12582	12075
1964	13096	11257
1965	12440	11616
1966	12699	12351
1967	13047	13126
1968	16123	16123
1969	13348	14622
1970	7604	8770
1971	10402	9797
1972	10874	10312
1973	12579	13583
1974	11407	11280
FORECAST		
1975	10952	15324
1976	11090	16317

NOTE: DATA DIVIDED BY 100.0

FIGURE 14--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 5-AWW



YEAR	LEVELS (•)	(×)
1955	11694	11036
1956	11188	12101
1957	11967	12546
1958	13322	14378
1959	15049	16141
1960	16273	17095
1961	17724	17479
1962	19440	18928
1963	18779	18553
1964	20846	19554
1965	24887	22151
1966	25684	24438
1967	26900	26283
1968	29522	28511
1969	27471	29102
1970	23611	22467
1971	20419	22186
1972	24374	23751
1973	29779	29621
1974	28099	30710
FORECAST		
1975	31909	32670
1976	33640	33601

NOTE: DATA DIVIDED BY 100.0

where,

QWDHPC = per capita wheat consumption as food (mt/head)
PWH = home consumption price of wheat divided by the CPI (1966/67 = 100) adjusted for crop years (cts/mt).
INCOME = per capita private consumption expenditures divided by the CPI (1966/67 = 100) and adjusted for crop year ($1,000/head).
T = linear trend. It equals 52 in 1952/53 and rises to 72 in 1972/73.

The final equation was fitted for 1952/53 through 1972/73 and projections made for 1973/74 and 1974/75. The estimated and projected values are plotted against the actual values (fig. 15).

The price elasticity of demand looks reasonable while the negative income elasticity may not at first glance. However, a negative income elasticity seems justifiable for a good such as bread and its principal raw material wheat. Honan (25, p. 156) cites a U.K. survey which found an income elasticity on bread of -0.05. He argues that a negative income elasticity "is consistent with the proposition that in a period of rising real incomes, when the basic need for food has been fully met, additional purchasing power can be allocated to more expensive foods and to the various forms of services attached to food."

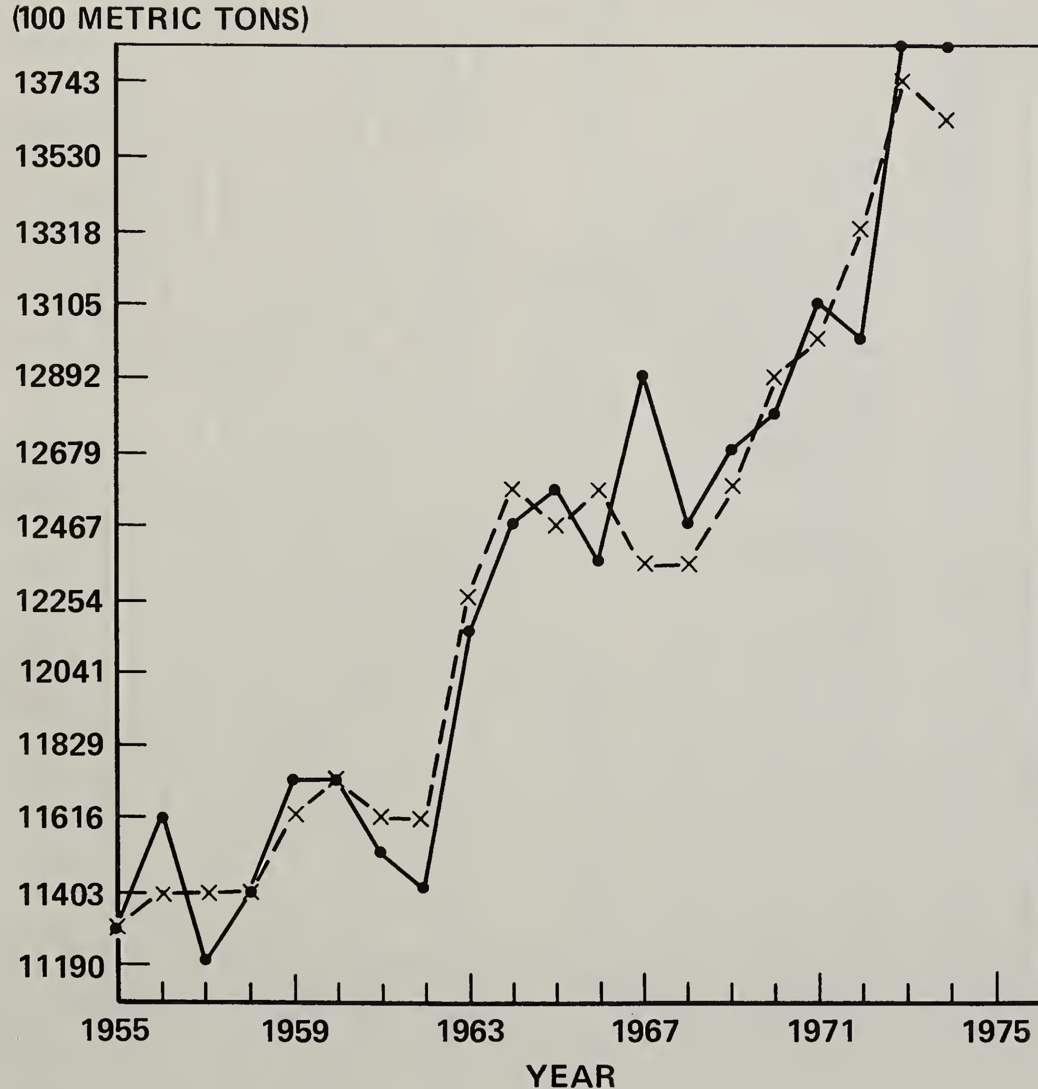
With regard to the importance of the variable to account for changing food habits, Honan says (25, p. 157):

> It is probable that the consumption of bread is subject to secular trends which may not be explained entirely in terms of rising real incomes. Thus, demand may be influenced to some extent by a reduction in manual work, by increased emphasis on weight control and dieting, by changes in the age structure, geographic distribution between city, town and country, and ethnic composition of the population.

Honan further explains that these factors are all expected to lead to a secular decline in the per capita consumption of bread (and hence wheat). The negative sign on this variable is certainly consistent with his proposition.

Wheat demand for feed use.--Of the various classes of livestock to which wheat is fed, Gruen and others (21, p. 137) estimated that in 1965 (but corrected for the abnormal effects of drought that year), 64 percent was fed to the intensive livestock industries (layers, pigs, and poultry), while 34 percent was fed to the extensive livestock industries, primarily sheep. All the intensive livestock industries have grown substantially in recent years. During 1965-75, poultry production expanded 150 percent, while egg and pigmeat production each expanded 30 percent. The expansion in these intensive livestock industries led to an associated expansion in feed grain use. To take account of this in the feed demand equation, an "index of intensive livestock production" was developed for use as an explanatory variable. Such a variable has been used before in helping to explain feed wheat demand in Australia; see, for example, Bain (9, p. 124) and the Bureau of Agricultural Economics (11, App. 2A). Three products are entered in the index: eggs, pigmeat, and poultry. Gruen and others (21) have suggested the following grain requirements per unit output of these products: 1.65 metric tons of grain per 1,000 dozen eggs, 2.5 metric tons of grain per metric ton of pigmeat, and 2.7 metric tons of grain per metric ton of poultry meat. In the absence of more up-to-date information, these figures were used as a basis for the index. The index (I) used was:

FIGURE 15--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 18-QWDH



NOTE: DATA DIVIDED BY 100.0

YEAR	LEVELS (•)	(×)
1955	11305	11329
1956	11716	11472
1957	11190	11424
1958	11454	11483
1959	11735	11635
1960	11735	11741
1961	11521	11641
1962	11446	11631
1963	12154	12350
1964	12528	12596
1965	12669	12561
1966	12431	12591
1967	12912	12422
1968	12568	12425
1969	12740	12623
1970	12850	12911
1971	13130	13069
1972	13080	13350
FORECAST		
1973	14080	13849
1974	13890	13669

I = 2/3 · EGGS + PIGMEAT + POULTRY

where,

EGGS = total (commercial and noncommercial) egg production (100,000 dozen).

PIGMEAT = pigmeat, carcass wt. (100 metric tons)

POULTRY = poultry, dressed wt. (100 metric tons)

The other main use of wheat for feed is in the extensive livestock industry. Most of the wheat here goes to sheep, with a very minor proportion going to beef cattle.

As Bain suggests (9, p. 67), graziers feed wheat in times of drought as a last resort. To incorporate this effect, a variable is included to reflect the effects of drought. There are a number of possible candidates for this variable: lambing percentage, fleece weight, and sheep deaths. For the present study, lambing percentage gave statistically reasonable results and thus was used.

The price of wheat for feed is determined by the Federal Government at the start of each marketing year. It is generally fixed at the same level as the home consumption price of wheat for food use. The exception to this in recent years was the period during which wheat quotas were imposed. The domestic price of wheat for feed was cut below that of wheat for food to help deter wheat sales being made outside the Australian Wheat Board.

In addition to the wheat price, the home consumption price (hcp) of barley as established by the Australian Barley Board is included. This price stands as a surrogate for all other grains that compete with wheat as a feed, where the main competitors are barley and oats. This barley price, though not strictly established in the marketplace, appears to follow the market closely from year to year. This is unlike the home consumption price of wheat. The reason for this is that while the hcp of wheat is fixed at the start of a marketing year to apply for the whole year, the hcp of feed barley may be adjusted monthly in accordance with changing market conditions. It bears a close relationship to feed grain export prices, being correlated 0.93 and 0.90 with the average export values for barley and oats, respectively (6). 19/

An attempt was also made to include a price variable for feed oats. The annual price series used was constructed from monthly price data on feed oats at the Alexandria market, Sydney. When both the barley and oats prices were included, the oats price variable had the "wrong" sign. When each was used separately, the results were similar in terms of signs of coefficients, elasticities, t-values, and R^2. It was thus arbitrarily decided to use only the barley price. In further research, one may wish to attempt a specification that incorporates the prices of both barley and oats, perhaps in a combined index.

19/ The correlation coefficients were obtained from data for 1955/56 to 1974/75.

The final estimated equation is:

QWDF:	PWF/PBF	LAMBPER	I	CONSTANT
	-460947	-276.085	185.366	2510278
t:	-2.51	-3.35	6.75	
e:	-.725			
$\bar{R}^2$ = .702		D.W. = 1.99	N = 24 (1949/50 to 1972/73)	

where,

QWDF = quantity of wheat demanded for feed (mt)
PWF = home consumption price of wheat for feed (cts/mt)
PBF = home consumption price of barley for feed, Australian Barley Board (cts/mt)
LAMBPER = percent of lambs weaned per ewe joined
I = index of intensive livestock production.

The final equation was fitted for 1949/50 through 1972/73 and projections made for 1973/74 and 1974/75. The estimated and projected values are plotted against the actual values (fig. 16).

Wheat stocks relation.--An inverse relation was postulated between world wheat price and Australian wheat stocks (fig. 6). In that figure, the postulated relation was asymptotic both to point A, which represented Australia's minimum desired carryover, and to point B, which represented the minimum price acceptable to the duopolists. In the estimating equation, this relationship is represented by a hyperbolic function as:

$$(\text{Stocks}_t - A) = a + b\ (1/(\text{Price}_t - B)) + c\ Z_t = e_t$$

or,

$$\text{Stocks}_t = a^* + b\ (1/(\text{Price}_t - B)) + c\ Z_t + e_t$$

where,

A and B are the asymptotes of figure 6

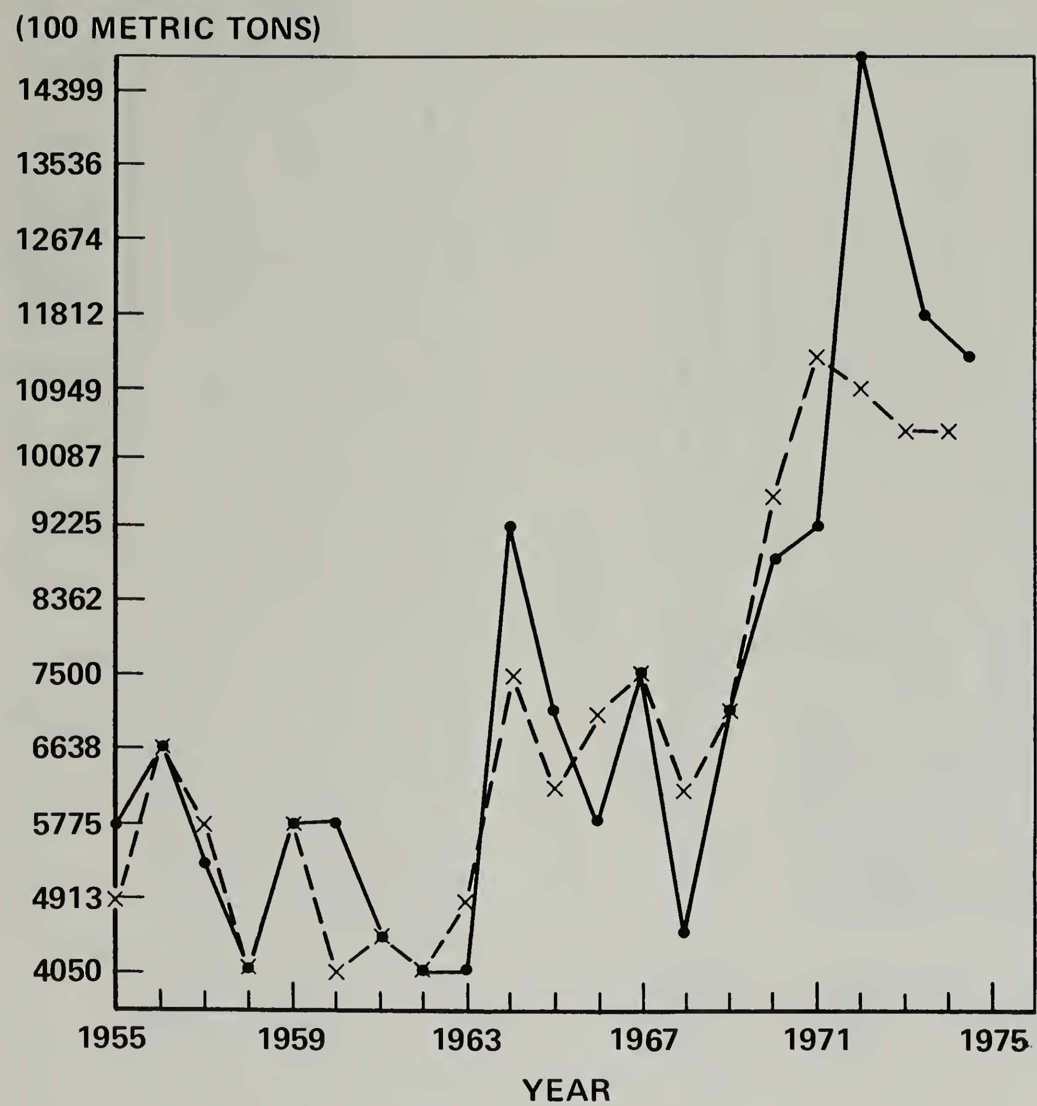
$a^* = a + A$, and

Z = other explanatory variables.

There was no need to select an arbitrary level for A since it is incorporated in the constant term. The size of B was set at the level which produced the highest R^2 for the estimated equation in a series of iterations. Its value was found to be $45.

Apart from the foregoing price effect, stocks may be large in any year as the result of logistical problems owing to a large harvest. It is hypothesized that a large harvest taxes the ability of the grain handling system to move grain to the export markets. This in turn leads to larger carryover stocks. Since the Bulk Handling Authorities accept other grains as well as wheat, a large harvest of these other grains may also contribute to the logistical problems in handling wheat. These other grains are primarily barley and sorghum. The effect of logistical problems on wheat stocks was included in the estimating equation as a variable which was the sum of the quantities of wheat, barley, and sorghum harvested.

FIGURE 16--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 19-QWDF



NOTE: DATA DIVIDED BY 100.0

YEAR	LEVELS (·)	(×)
1955	6046	4929
1956	6741	6756
1957	5494	6118
1958	4166	4223
1959	5989	5812
1960	5892	4221
1961	4755	4648
1962	4050	4429
1963	4194	4982
1964	9428	7676
1965	7219	6465
1966	6006	7207
1967	7613	7632
1968	4499	6296
1969	7220	7355
1970	9050	9825
1971	9300	11466
1972	14830	11240
FORECAST		
1973	11930	10669
1974	11310	10842

The final explanatory variable is a dummy variable for 1968/69 and 1969/70 when ending wheat stocks were extremely large. Although world prices were very low in these years and the harvests very large, the price and quantity harvested variables could not explain more than half the enormous stocks in these years. It is suggested that the reason lies largely in the choice of a hyperbolic function between price and stocks. As the price asymptote is approached, the stock level is very sensitive to small changes in price. Had the actual price been slightly lower, it would have meant a large increase in estimated stocks. Perhaps price was not lower than it was because the International Grains Agreement (1968/69-1970/71) had price floor provisions which may have added to the pressure of the duopolists to shore up world wheat prices.

The final estimated equation was:

WESTK:	PRICE	QWBS	D6869	CONSTANT
	5806304	.17145814	4513628	-1171477
t:	2.94	2.91	6.82	
e:	-.841 [20]			

$\bar{R}^2 = .895$ D.W. = 1.61 N = 19 (1955/56 to 1973/74)

where,

WESTK = wheat ending stocks (metric ton)
PRICE = 1/(PWXA - 45.00)
PWXA = average wheat export price quotations by the AWB for marketing year ($/metric ton)
QWBS = QW + QB + QS
QW = quantity wheat harvested in Australia (metric ton)
QB = quantity barley harvested in Australia (mt)
QS = quantity sorghum harvested in Australia (mt)
D6869 = dummy variable. It equals 1 in 1968/69 and 1969/70 and 0 otherwise.

The final equation was fitted for 1955/56 to 1973/74 and projected for 1974/75 and 1975/76. The estimated and projected values from the final equation are plotted against actual values (fig. 17).

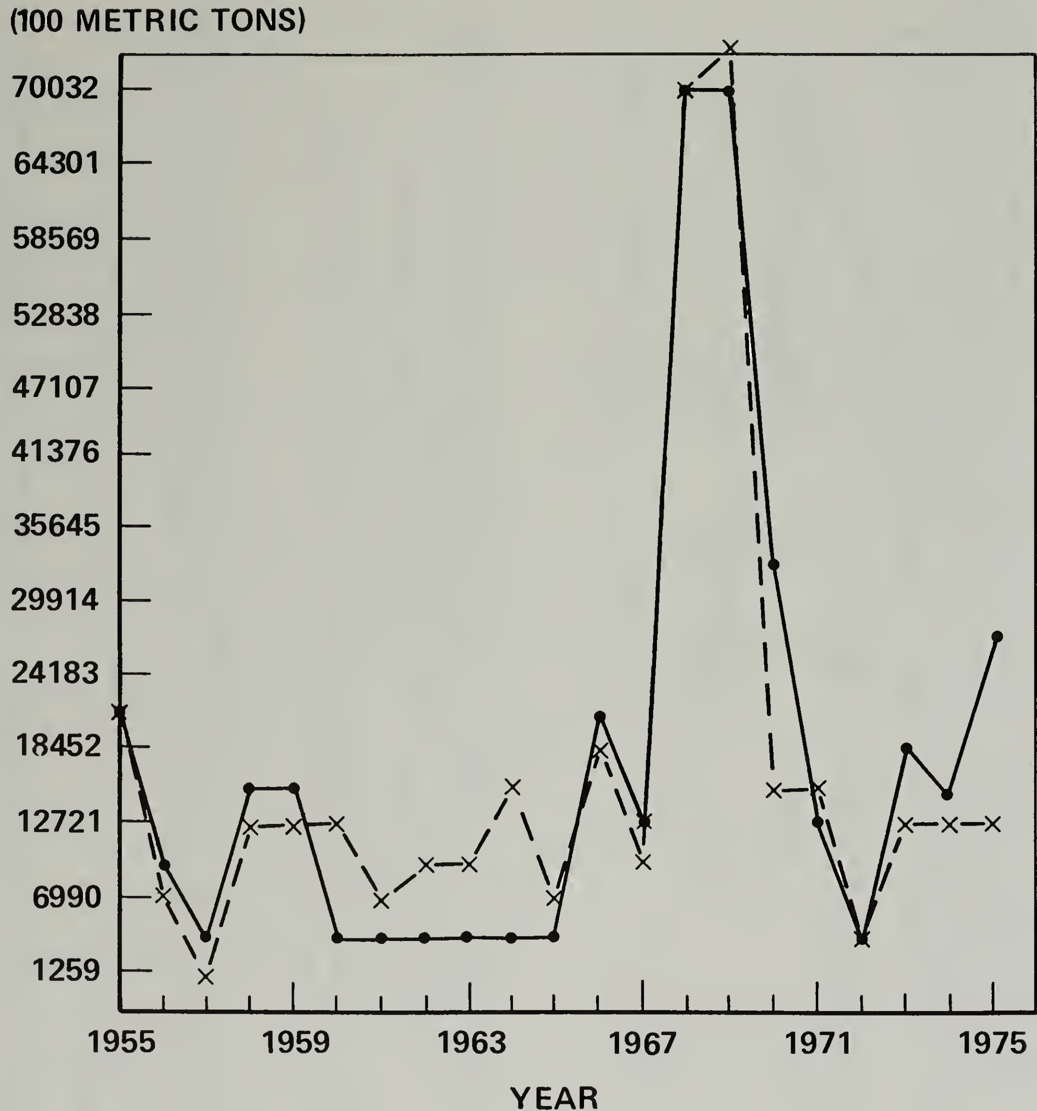
Barley

Barley Supply

A single area equation was estimated for all Australia. Many specifications were tried involving prices for barley, wheat, and wool, but the specification which performed best in the projection interval included only the price for barley. In the final equation, the lagged barley first advance was used as the supply-inducing price. The first advance is for 2-row malting barley paid by the Australian Barley Board (ABB). This advance applies both to South Australia and Victoria, which together account for about half the total barley area in Australia (table 6). The ABB first advance is highly correlated with average grower returns throughout Australia. Table 6 shows the correlation coefficients (r) between the ABB first advance and the average grower returns in the barley producing States.

20/ The elasticity value applies to changes in PWXA and not PRICE. It is calculated at the mean of observations.

FIGURE 17--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 21-WESTK



NOTE: DATA DIVIDED BY 100.0

YEAR	LEVELS (•)	(×)
1955	22910	24173
1956	11292	7001
1957	4477	1259
1958	17789	13967
1959	16520	13179
1960	6629	14891
1961	4817	8451
1962	6334	11763
1963	5555	10597
1964	6636	17218
1965	4503	8442
1966	21915	18777
1967	14113	11401
1968	72600	71923
1969	72220	72897
1970	34040	16696
1971	14510	17001
1972	4780	5414
1973	18820	15413
FORECAST		
1974	16580	14415
1975	28190	14750

Table 6--Correlation coefficients between the ABB first advance and average grower returns, 1955/56 to 1974/75

Item	Average grower return				
	South Australia	Western Australia	New South Wales	Victoria	Queensland
ABB 1st advance	.98	.88	.86	.98	.90
Percentage of total barley area	36	25	17	13	8

Throughout the period of review, 1955/56 to 1974/75, barley was marketed through a statutory board in each of the barley-producing States except New South Wales. The average grower returns in table 6 are for 2-row malting barley in all the States except New South Wales. There, the average return is the December-November annual average of the average monthly quotations of cape barley, Alexandria market, Sydney.

The final estimated equation for barley supply included the first advance lagged 1 year, a linear trend to reflect technological advance, and a dummy variable to reflect the effect of wheat quotas. Wheat quotas appear to have had a stimulating effect on barley area planted, particularly in Western Australia. The dummy variable equaled 1 for the effective quota years, 1970/71 to 1972/73, and 0 otherwise.

The final estimated equation used was:

AB:	PBA	T	QUOTA	CONSTANT
	175.985	39457.9	873751.	-1982925
t:	2.13	2.88	4.61	
e:	.46			

$\bar{R}^2$ = .846 D.W. = 1.28 N = 21 (1955/56 to 1975/76)

where,

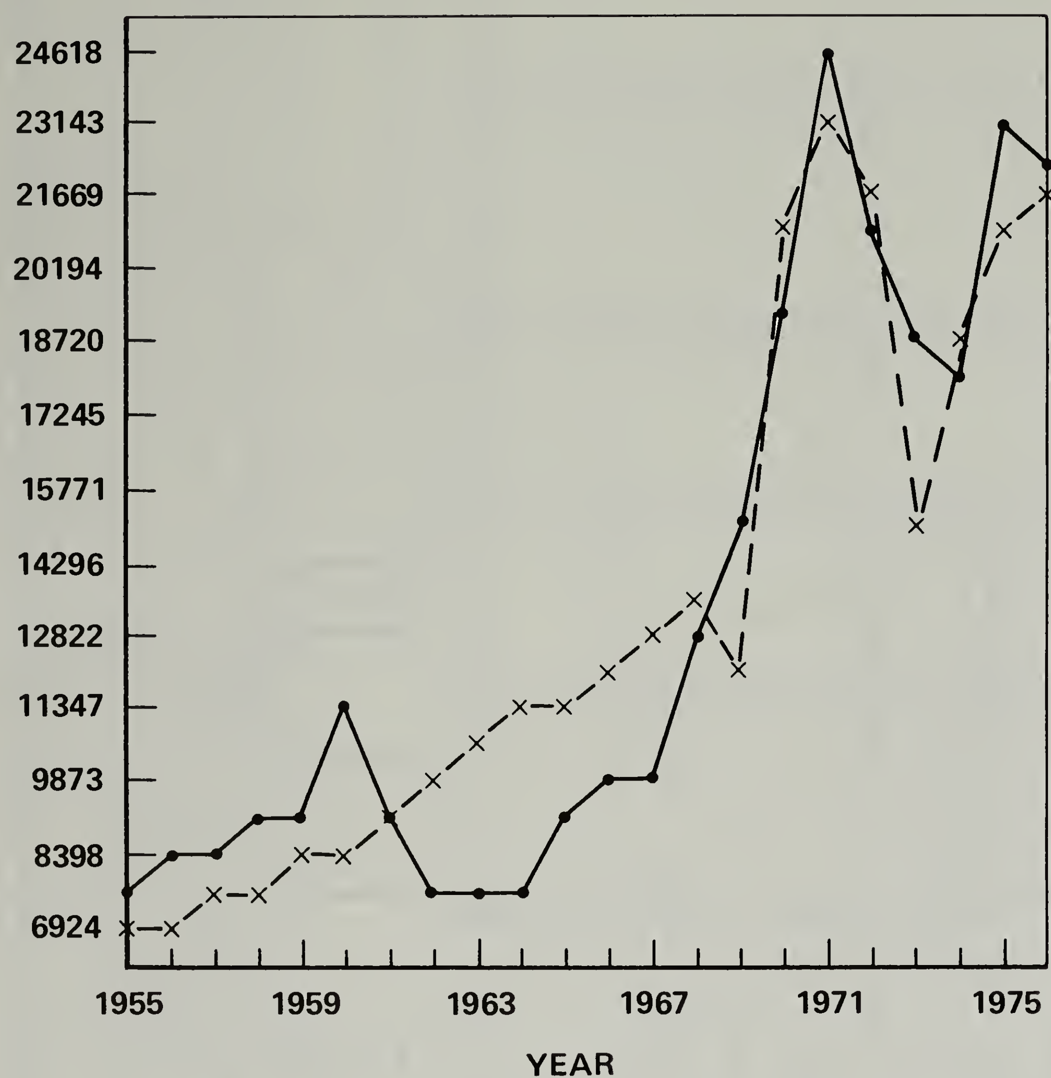
AB = area sown to barley, Australia (ha)
PBA = barley first advance, paid by Australian Barley Board on 2-row malting barley, lagged 1 year (cts/mt)
T = linear time trend. It equals 55 in 1955/56 and rises to 75 in 1975/76.
QUOTA = dummy variable which equals 1 in 1970/71 to 1972/73 and 0 otherwise.

The equation was fitted for 1955/56 to 1975/76 and projections made for 1976/77. The estimated and projected values from the equation are plotted against actual values (fig. 18).

Barley Demand

In recent years (1971/72 to 1975/76), Australia has consumed 40 percent and exported 60 percent of its barley output. Domestically, barley is used for seed,

FIGURE 18--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 32-AB



YEAR	LEVELS (·)	(×)
1955	7665	7303
1956	8471	6924
1957	8583	7705
1958	9634	8100
1959	9630	8495
1960	11452	8889
1961	9645	9284
1962	8205	9911
1963	8148	11236
1964	8353	11372
1965	9299	11962
1966	10108	12420
1967	10568	13203
1968	13410	13598
1969	15212	12518
1970	20001	21029
1971	25355	23364
1972	21399	22362
1973	18945	15486
1974	18256	19137
1975	23253	21291
FORECAST		
1976	22510	22126

NOTE: DATA DIVIDED BY 100.0

livestock feed, and as raw material in the production of malt for human consumption. In this section, equations are estimated for barley used as feed and food, and an equation is estimated to explain stocks.

Before discussing the equations, it is necessary to discuss some data problems with barley and how these problems were handled. Adequate data appear to be available on barley used for human consumption, but such is not the case for barley used for seed or feed. In addition, there are problems with the data series on barley stocks.

With regard to barley used for seed, the Australian Bureau of Statistics (ABS) publishes an estimate which is equal in a given year to the next year's sown area of barley, multiplied by an assumed seeding rate of 70 kg/ha. In the absence of better information, the present study uses the same method.

With regard to barley stocks, the ABS published data until 1963/64 on "net change in recorded stocks." Beginning with the 1966/67 season, the Foreign Agricultural Service of the USDA published "barley ending stocks, local marketing year" for Australia. An attempt was made to combine these two data series into a single series, "barley ending stocks." Note that the two series do not overlap and while one series concerns stock changes, the other involves stock levels.

Let the basic estimating equation to explain barley ending stocks in year T be:

$$BESTK_T = b_o + b_1 X_T + e_T \qquad \ldots (i)$$

where, $BESTK_T$ = barley ending stocks, year T
X_T = one or more explanatory variables
e_T = disturbance term.

Stock levels can be expressed algebraically in terms of stock changes as:

$$BESTK_T = a + S_T \qquad \ldots (ii)$$

where, $a = BESTK_o$

$$S_T = \sum_{t=1}^{T} (BESTK_t - BESTK_{t-1}).$$

Hence, equation (i) may be alternatively written as:

$$S_T = b_o + b_1 X_T - a + e_T \qquad \ldots (iii)$$

Since data is available on S_T from 1955/56 to 1963/64 and on $BESTK_T$ from 1966/69 onward, the barley stocks equation can be estimated in the form:

$$\begin{bmatrix} S \\ \hline BESTK \end{bmatrix} = \begin{bmatrix} L \; X & \begin{matrix} 1 \\ \hline 0 \end{matrix} \end{bmatrix} \cdot \begin{bmatrix} b_o \\ b_1 \\ -a \end{bmatrix} + e \qquad \ldots (iv)$$

where, $S = (S_1 \ldots S_n)'$ and subscript n refers to 1963/64
$BESTK = (BESTK_{n+3} \ldots BESTK_N)'$
$L = (1 \ldots 1)'_{1.(N-3)}$
$X = (X_1 \ldots X_n \; X_{n+3} \ldots X_N)'$
$e = (e_1 \ldots e_n \; e_{n+3} \ldots e_n)'$

Given this estimating procedure, a longer data series on barley stocks may be obtained. For the years 1955/56 to 1963/64, the estimated value of "a" is added to the actual values for S_T (as in equation (ii)). For 1964/65 and 1965/66, equation (iv) is solved given the estimated values for b_0, b_1, and a. For subsequent years, the actual data on barley stock levels are used.

The data series on barley used for feed is obtained as a residual in the supply-utilization identity. Thus, barley used for feed is equal to production less the sum of exports, use for human consumption, use for seed, and stock change.

Using actual data plus the estimated data series on seed use, stocks, and feed use, a supply-utilization table for barley was derived (table 7).

Table 7--Supply-utilization of barley, Australia, 1955/56 to 1974/75

Year	Production	Exports	Domestic consumption			Ending stocks 1/
			Food	Feed 1/	Seed 1/	
	1,000 metric tons					
1955/56	945	641	182	60	59	209
1956/57	1118	633	186	156	66	285
1957/58	691	299	196	165	63	252
1958/59	1428	854	189	243	67	327
1959/60	773	457	199	117	81	246
1960/61	1542	943	209	251	72	312
1961/62	941	419	237	206	63	328
1962/63	898	274	238	284	62	368
1963/64	984	392	279	192	63	427
1964/65	1119	371	270	471	70	362
1965/66	949	223	302	422	71	292
1966/67	1397	460	320	327	83	500
1967/68	835	128	304	481	94	327
1968/69	1646	549	329	539	107	450
1969/70	1699	684	324	500	140	501
1970/71	2351	1228	350	607	178	489
1971/72	3065	1784	363	896	150	362
1972/73	1727	676	377	673	133	230
1973/74	2397	1168	390	728	130	211
1974/75	2513	1656	402	317	163	186

1/ Estimated data series. See text for details.

Barley ending stocks.--Barley ending stocks have been postulated as a function of the export price of barley. This relation was explained in terms of speculative behavior by nonboard holders of stocks. Another explanatory variable in the barley stocks equation was the sum of the quantities of wheat, barley, and sorghum produced. For wheat, this variable was included to reflect the logistical problems in moving the grain to markets. Since all three crops use the same transportation system and in many cases the same storage facilities, this was thought to be an appropriate variable. A third explanatory variable was an intercept-shifter whose coefficient would be an estimate of an in equation (iv) of the preceding subsection. In some specifications, a barley quantity variable was also used in an attempt to capture the transactions demand for holding stocks. However, this variable had a very low t-value, and was not used in the final specification.

The final equation used is:

BSTK:	PBX	QWBS	D5563	CONSTANT
	-46.1755	.020051	-202341	360408
t:	-4.35	2.76	-3.92	
e:	-.99			

$\bar{R}^2 = .828$ D.W. - 1.40 N = 18 (1955/56 to 1974/75 but exc. 1964/65, 1965/66)

where,

BSTK = barley stocks variable. Prior to 1964/65, it equals net change in recorded stocks (S), while from 1966/67 on, it equals barley stock levels (BESTK).
PBX = average export value, barley for year starting July (cts/mt)
QWBS = QW + QB + QS (mt)
QW = quantity wheat produced (mt)
QB = quantity barley produced (mt)
QS = quantity sorghum produced (mt)
D5563 = zero-one dummy variable. It equals 1 prior to 1964/65 and 0 otherwise. The coefficient on this variable is an estimate of a in equation (ii).

The equation was estimated for 1955/56 through 1974/75, but excluding 1964/65 and 1965/66, for which no data existed on the dependent variable. Solving the equation for these 2 years resulted in estimated values for barley ending stocks of 362,192 and 292,415 metric tons, respectively. The equation was projected for 1975/76. The estimated and projected values are plotted against actual values (fig. 19).

Barley demand for human consumption.--Approximately one-third of the barley consumed domestically is for food and factory use in the production of malt.

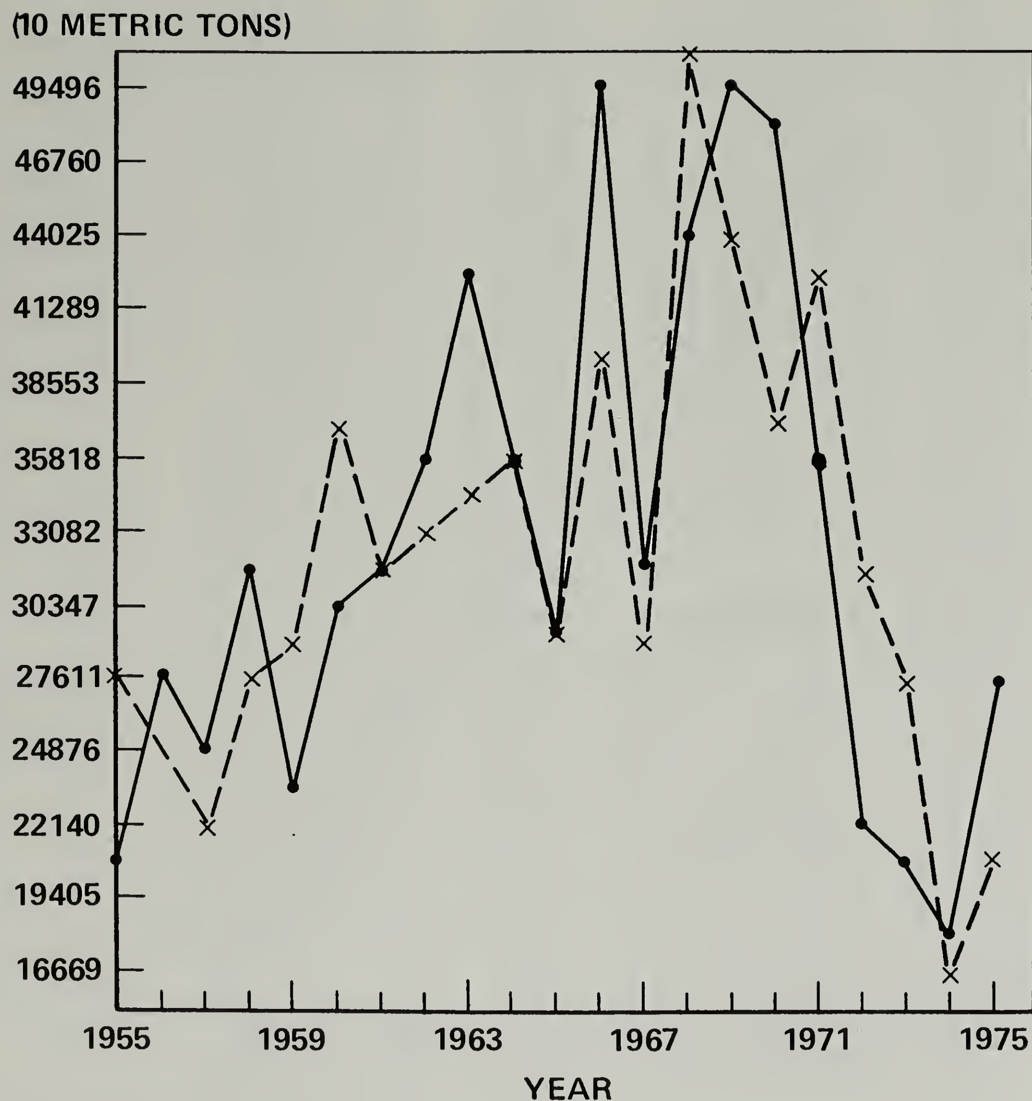
All malting barley in Australia is marketed through one of the four barley boards. The price is fixed each season at the same level as the home consumption price of ASW wheat, plus a loading of up to 10 percent at the discretion of the individual boards. In the estimating equation, the malting barley price quoted by the Australian Barley Board and deflated by the consumer price index was tried as an explanatory variable. However, it had a low t-value (about 1.0) and the "wrong sign" (positive). Income was the only explanatory variable included in the final equation. The income variable was private consumption expenditures deflated by the consumer price index.

The final estimated equation is:

QBDH:	INCOME	CONSTANT
	20099.0	10519.8
t:	19.9	
e:	.960	

$\bar{R}^2 = .956$ D.W. = 1.10 N = 20 (1953/54 to 1972/73)

FIGURE 19--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 40-BESTK



NOTE: DATA DIVIDED BY 10.00

YEAR	LEVELS (·)	(×)
1955	20851	28564
1956	28456	26224
1957	25158	23061
1958	32681	28019
1959	24571	29906
1960	31187	37315
1961	32815	32546
1962	36834	34327
1963	42661	35252
1964	36219	36219
1965	29242	29242
1966	50000	41045
1967	32700	30111
1968	45000	50863
1969	50100	45068
1970	48900	38281
1971	36200	43011
1972	23000	32644
1973	21100	27907
1974	18600	16669
FORECAST		
1975	27800	21278

where,

QBDH = barley for food/factory use (mt)
INCOME = Y/CPI
Y = private consumption expenditures ($ million)
CPI = consumer price index (1966/67 = 100)

The Durbin-Watson statistic indicates the presence of positive first-order autocorrelation. Using Durbin's procedure (Johnston, (26, p. 263)) to correct for this, the estimated autoregressive parameter (r) is r = .49605. The corrected equation used in the barley model is:

QBDH:	$QBDH_{-1}$	INCOME	$INCOME_{-1}$	CONSTANT
	.49605	19316.2	-9581.80	10064.6
t:		11.4		
e:		.926		

$\bar{R}^2$ = .872 D.W. = 2.39 N = 20 (1953/54 to 1972/73)

The final equation was fitted for 1953/54 through 1972/73 and projected for 1973/74 and 1974/75. The estimated and projected values are plotted against actual values (fig. 20).

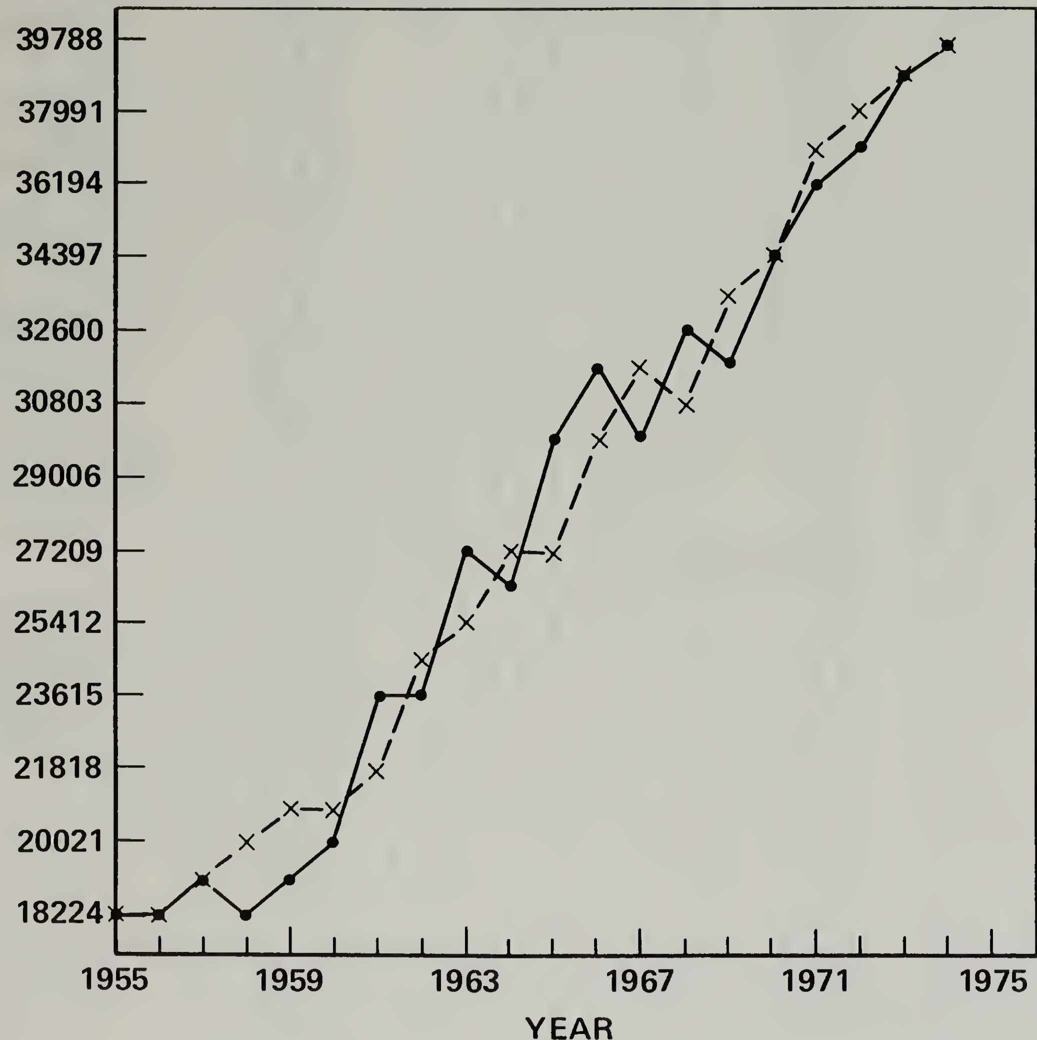
Barley demand for feed use.--Four variables were used in the equation to explain barley feed use--the feed prices of barley and wheat, an index of intensive livestock production, and a drought effects variable.

The domestic price of barley for feed is set in each State by the particular barley board operating there. Historically, however, the feed barley prices have been highly correlated with export prices. For example, the average annual feed barley price established by the Australian Barley Board was correlated 0.93 with average export value of barley (1955/56 to 1974/75). Thus, the barley price variable used in the equation is the average export value of barley. The wheat price variable is the home consumption price of feed wheat. This price is determined by the Federal Government using a cost of production formula.

Of the various classes of livestock to which barley is fed, Gruen and others (21, p. 137) estimated that in 1965, about 65 percent went to the intensive livestock industries (pigs, layers, and poultry) and 20 percent to the extensive industries, primarily sheep. The remainder was fed to dairy cattle.

As mentioned earlier with regard to the feed demand for wheat, the intensive livestock industries, especially poultry, have undergone a rapid expansion in the last decade. This is incorporated in the barley feed demand equation in the index of intensive livestock production, described earlier to explain feed wheat use. Outside of the intensive livestock industries, most barley is fed to sheep, particularly in times of drought. The effect of drought is included via the lambing percentage variable used already in the wheat feed use equation.

FIGURE 20--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 37-QBDH



NOTE: DATA DIVIDED BY 10.00

YEAR	LEVELS (·)	(×)
1955	18224	18712
1956	18612	18817
1957	19626	19595
1958	18866	20410
1959	19939	20995
1960	20855	21252
1961	23688	22072
1962	23826	24647
1963	27902	25516
1964	27031	27754
1965	30230	27383
1966	31950	30140
1967	30400	31707
1968	32930	31660
1969	32410	33966
1970	35020	34514
1971	36270	37113
1972	37710	38556
FORECAST		
1973	39000	39709
1974	40200	40686

The final equation used is:

QBDF:	PBX/PWF	LAMBPER	I	CONSTANT
	-380638.	-114.478	187.458	806523
t:	-2.19	-1.41	7.89	
e:	-.847			

$\bar{R}^2$ = .762 D.W. = 2.20 N = 20 (1955/56 to 1974/75)

where,

QBDF = quantity of barley demanded for feed (mt)
PBX = average export value of barley (cts/mt)
PWF = home consumption price of wheat for feed (cts/mt)
LAMBPER = percent of lambs weaned per ewe joined
I = index of intensive livestock production

The final equation was fitted for 1955/56 through 1974/75 and projected for 1975/76. Estimated and projected values are plotted against the actual values (fig. 21).

Sorghum

Sorghum Supply

A single area equation was estimated for all Australia, primarily referring to Queensland and New South Wales, which together account for 99 percent of the total grain sorghum area.

The final equation included supply-inducing prices for sorghum, wheat, and barley. Other explanatory variables included a linear trend to account for technological change, and a dummy variable to reflect structural change in the industry.

The supply-inducing price of sorghum was assumed to be the lagged average grower return from the Central Queensland Grain Sorghum Marketing Board (CQGSMB). The actual price variable is total payments per metric ton on the crop harvested the year before planting. Thus, for a given September planting, this return refers to the crop harvested around April of the previous calendar year. In 1969 no pool existed, owing to the drought-affected harvest in central Queensland. Thus, total payments by the CQGSMB were zero. To prevent this having an undue effect on the regression, zero payment was replaced by the mean of the observations on total payments. The other explanatory price variables included the effective price of wheat and the barley first advance paid by the Queensland Barley Marketing Board. Both prices relate to the preceding crops of wheat and barley harvested around December.

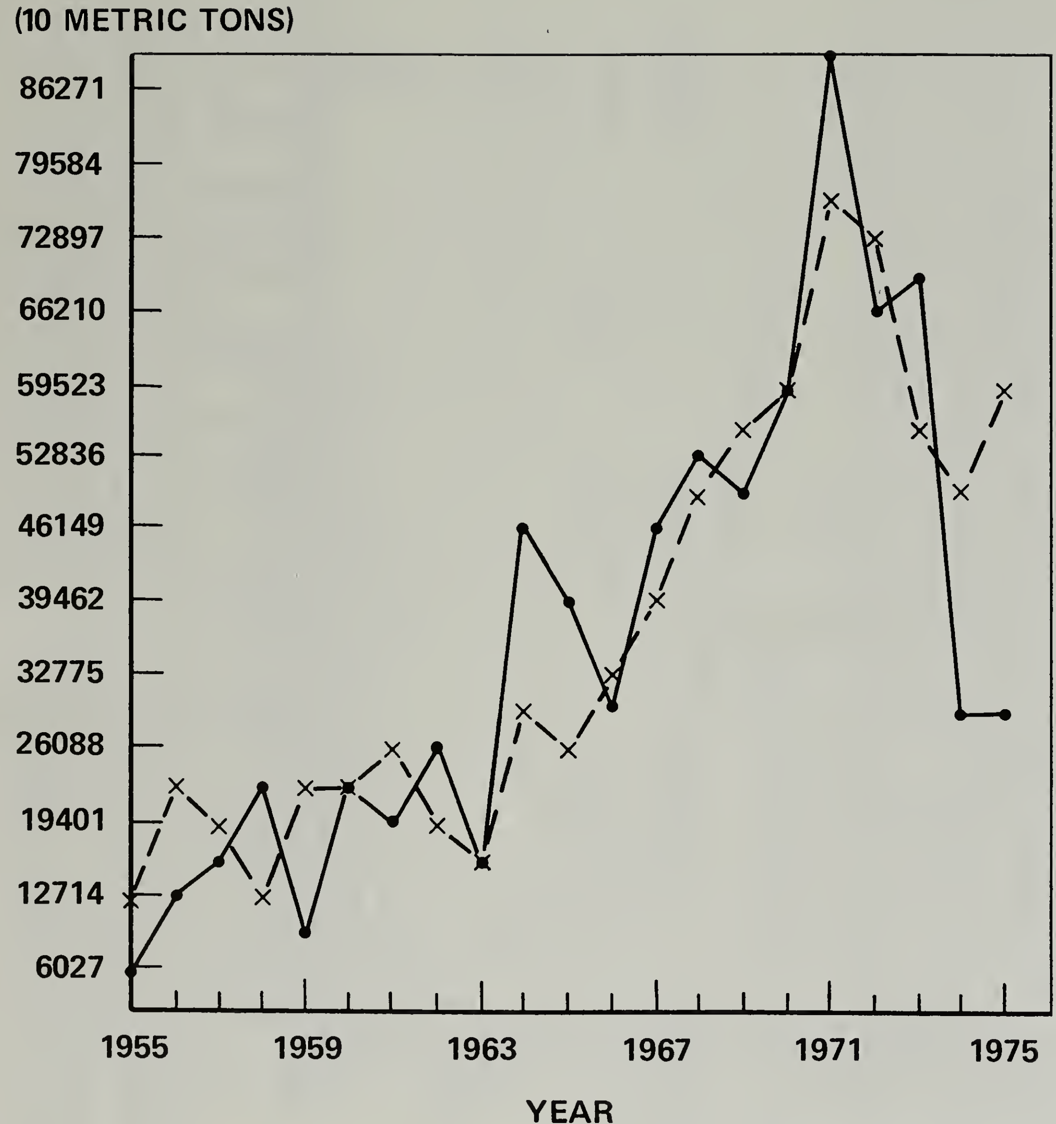
The structural change variable was used earlier in the wheat area equation for Queensland. To incorporate the structural change effect in the estimating equation, a dummy variable is included which equals 1 for 1968/69, .5 in 1969/70, and 0 thereafter.

The final estimated equation is:

AS:	PS	PW	PBQA	SC	T	CONSTANT
	56.7433	-56.9736	-30.3711	-267756.	18871.0	-530733.
t:	2.94	-3.92	-2.56	-7.19	5.97	
e:	.64	-1.10	-.34			

$\bar{R}^2$ = .980 D.W. = 2.34 N = 18 (1957/58 to 1974/75)

FIGURE 21--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 38-QBDF



YEAR	LEVELS (·)	(×)
1955	6027	13705
1956	15603	23571
1957	16496	20617
1958	24320	13033
1959	11667	24866
1960	25139	25878
1961	20610	28154
1962	28369	22234
1963	19247	19071
1964	47131	30608
1965	42230	28185
1966	32685	35231
1967	48138	42691
1968	53894	50144
1969	49977	58674
1970	60702	61781
1971	89614	79229
1972	67336	74766
1973	72841	58581
1974	31696	52707
FORECAST		
1975	29100	61523

NOTE: DATA DIVIDED BY 10.00

where,

AS = area sown to sorghum, Australia (ha)
PS = total payments per metric ton made by CQGHMB (cts/mt) on crop harvested the calendar year prior to planting
PW = effective price of wheat (cts/mt), preceding crop
PBQA = first advance paid by Queensland Barley Marketing Board (cts/mt), preceding crop
T = linear time trend. It equals 57 in 1957/58 rising to 74 in 1974/75
SC = structural change variable. It equals 1 prior to 1969/70, .5 in 1969/70, and 0 thereafter.

The equation was fitted over the period 1957/58 to 1974/75 and projected for 1975/76 and 1976/77. The estimated and projected values are plotted against the actual values (fig. 22).

Sorghum Demand

Almost all grain sorghum destined for the domestic market is used for feed. Small amounts (perhaps 5-6 percent) are used for food and seed (12). 21/ Thus, total domestic demand is assumed to be a function of variables which help to explain the feed use of sorghum. The data series on total domestic demand is calculated as a residual of production minus exports and changes in stocks.

The explanatory variables include prices for sorghum and wheat, a drought index, and an index of intensive livestock production. The sorghum price is the Australian average export value of sorghum. However, in 2 years of the data series (1963/64 and 1965/66), sorghum exports were negligible. For these years, then, the mean of the observations on average export values was used. The wheat price is the home consumption price of feed wheat. The drought index (lambing percentage) and the index of intensive livestock production are the same as those used and discussed earlier in the feed demand equations for wheat and barley.

The final estimated equation is:

QSD:	PSX/PWF	LAMBPER	I	CONSTANT
	-321605.	-150.708	70.4185	1321200.
t:	-2.70	-2.77	3.52	
e:	-1.10			

$\bar{R}^2$ = .542 D.W. = 2.12 N = 14 (1960/61 to 1973/74)

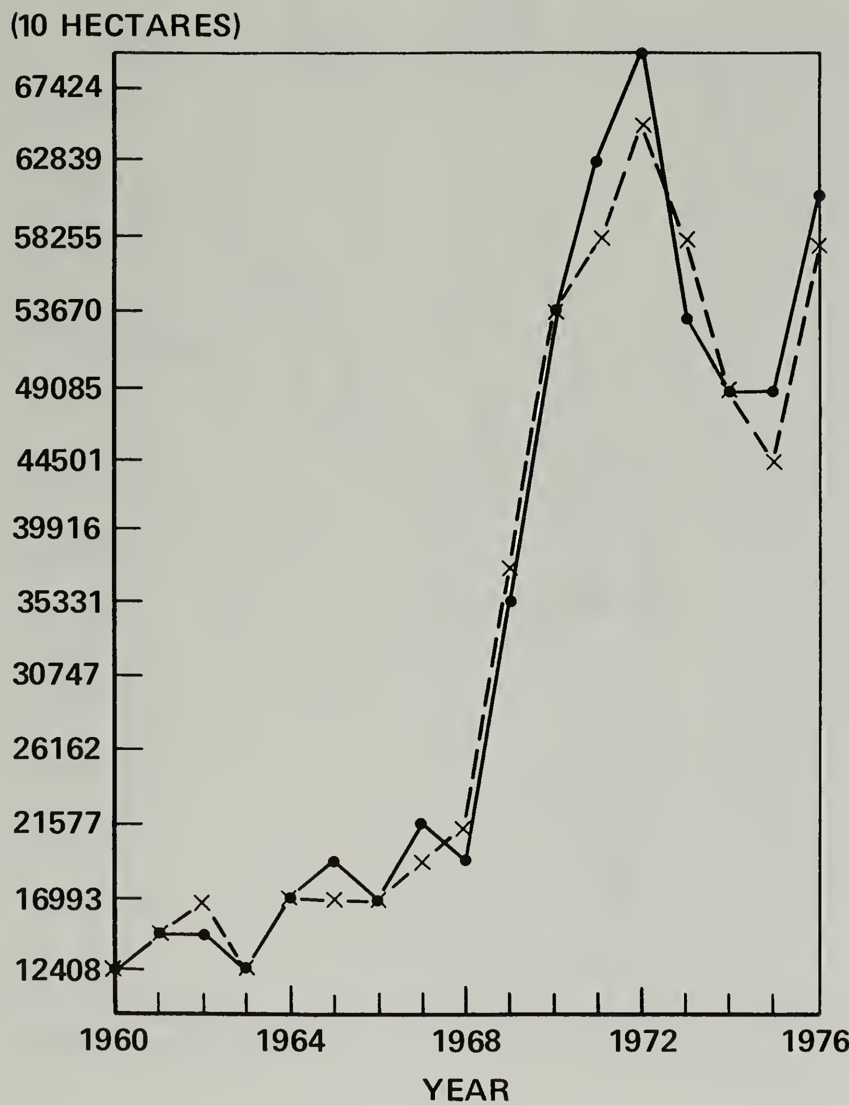
where,

QSD = domestic use of sorghum (mt)
PSX = average export value, sorghum (cts/mt)
PWF = home consumption price, wheat for feed (cts/mt), preceding crop
LAMBPER = lambs weaned per ewe joined (percent)
I = index of intensive livestock production.

The equation was fitted for 1960/61 to 1973/74 and projected for 1974/75 and 1975/76. The estimated and projected values are plotted against actual values (fig. 23).

21/ Seed use appears to be about 2 percent and food use about 4 percent of total domestic use in recent years.

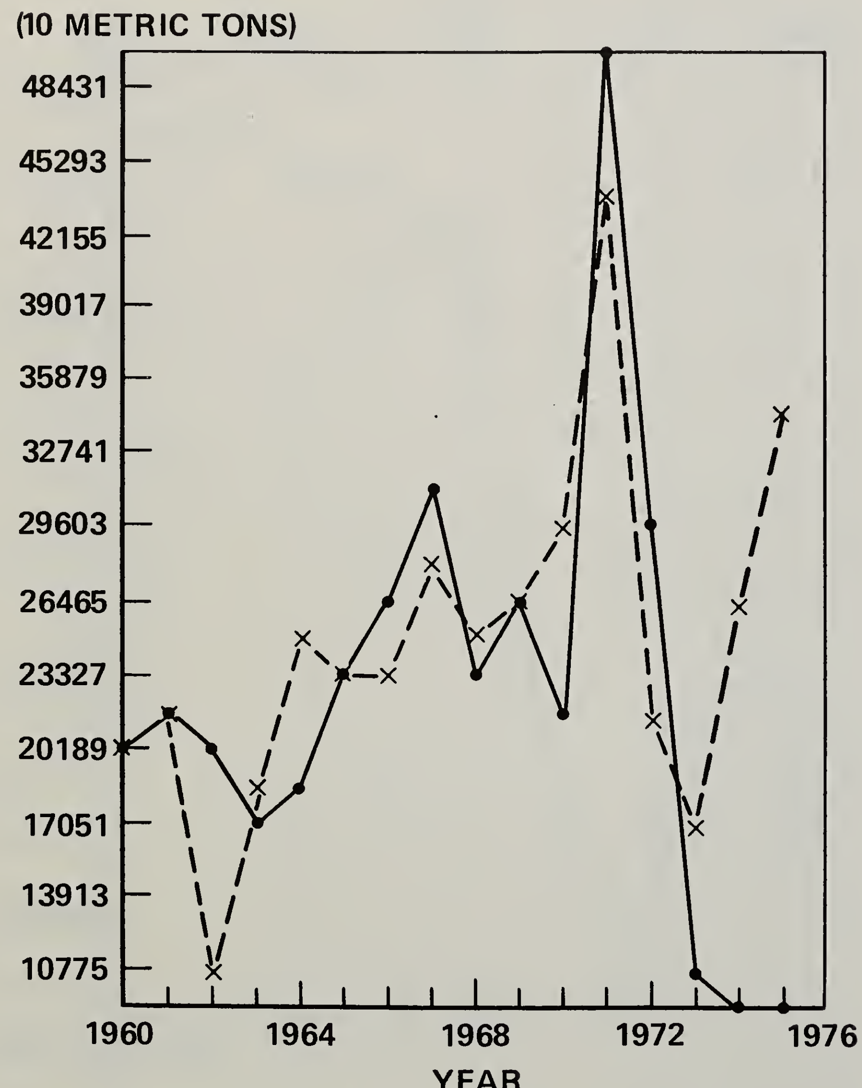
FIGURE 22--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 48-AS



NOTE: DATA DIVIDED BY 10.00

YEAR	LEVELS (·)	(×)
1960	14679	12408
1961	15842	16863
1962	14774	17025
1963	13966	13001
1964	17548	17425
1965	20346	18784
1966	18658	18388
1967	22130	19695
1968	20969	22312
1969	35875	39016
1970	55211	55371
1971	63839	59999
1972	69716	66994
1973	53967	60080
1974	51109	49834
FORECAST		
1975	50400	46297
1976	60000	58827

FIGURE 23--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 50-QSD



NOTE: DATA DIVIDED BY 10.00

YEAR	LEVELS (·)	(×)
1960	21600	20920
1961	21900	22395
1962	20700	10775
1963	17600	19431
1964	19300	26185
1965	24800	24560
1966	26600	23980
1967	31800	28407
1968	24300	26164
1969	26800	28004
1970	22200	30326
1971	50000	43777
1972	29900	22233
1973	11500	18106
FORECAST		
1974	8900	27582
1975	8200	35520

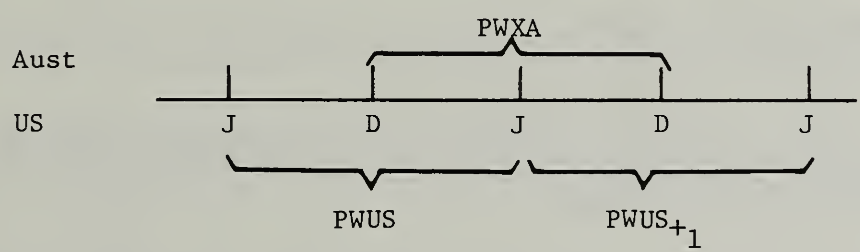
Price Relations

The world prices used in the estimated price relations are U.S. season average farm prices. Baseline projections of these prices are available from econometric models of the U.S. grain economy, developed and maintained by the Forecast Support Group, U.S. Department of Agriculture. Through the various price relations estimated, these baseline projections were used to assist in projections on the three Australian grain models.

In the behavioral equations, seven Australian price series were used which were assumed to be strongly influenced by world prices. They were PWXA (annual average of export wheat price quotations), PBA (barley first advance, Australian Barley Board), PBQA (barley first advance, Queensland Barley Board), PBF (home consumption price of feed barley, Australian Barley Board), PBX (average export value of barley), PS (average grower return for sorghum, Central Queensland Grain Sorghum Marketing Board), and PSX (average export value of grain sorghum).

As expected, there seemed to be a very close price relation between PWXA and the U.S. export price of wheat. 22/ But between PWXA and the U.S. farm price of wheat, the relation is slightly more complex. Apart from domestic transportation costs, the U.S. export price diverged from the U.S. farm price in many years (that is, until 1972) as a result of U.S. farm price and income programs, which required an export subsidy. In the estimated price relation, this divergence was taken into account in the explanatory variable, which was PWUS less any export payment. This variable was expected to be more closely related to the U.S. export price and hence also to PWXA.

A problem in estimating price relations is that the price variables are often calculated over different years. For example, PWXA was calculated over a December-November year, while PWUS was calculated over a July-June year. The diagram below illustrates this overlap.



To allow for this, the price relation was postulated as:

$$PWXA = a + b\,(c \cdot PWUS + (1-c)\,PWUS_{+1})$$

or

$$PWXA = a + bc\,(PWUS - PWUS_{+1}) + b \cdot PWUS_{+1}$$

This leads to the following estimated equation.

PWXA:	$(PWUS - PWUS_{+1})$	$PWUS_{+1}$	CONSTANT
	14.3941	41.7397	480.064
t:	4.11	21.2	

$\bar{R}^2 = .965$ D.W. = 1.89 N = 20 (1955/56 to 1974/75)

22/ Regressing PWXA on a simple annual average of the monthly export prices for No. 2 western white wheat yielded a regression with $R^2 = .996$ (data for 1956/57 to 1973/74).

where,

PWXA = AWB export price quotations (Aust cts/mt)
PWUS = U.S. farm prices less any export payment (US cts/bu) and divided by the exchange rate ($US/$Aust).

The estimated equation implies that c in the postulated price relation equals .34.

Four barley prices were assumed to be influenced by world prices. They were PBA, PBQA, PBF, and PBX. The procedure for estimating the barley price relations was as follows. First, relations are estimated between PBA and PBX, PBQA and PBX, and PBF and PBX. Then a relation is estimated between PBX and PBUS (U.S. season average farm price of barley).

The first two estimated relations (table 8) each involve a barley first advance as the dependent variable. The two first advances are received around January following harvest. They are postulated as functions of PBX for the July-June year in which they are received.

The third estimated price relation is between PBF and PBX. PBF was calculated over a December-November year, while PBX was calculated over a July-June year. As for the wheat price relation, this led to the postulated relation:

$$PBF = a + b\,(c \cdot PBX + (1-c)\,PBX_{+1})$$

However, the regression equation yielded an estimate of c equal to 0.95. Since this was not significantly different from 1, it was decided to use the simpler relation: $PBF = a + b \cdot PBX$.

The fourth estimated price relation is between PBX and PBUS. They were both calculated over a July-June year.

Two sorghum prices, PS and PSX, were assumed to be influenced by world prices. Sorghum price relations were estimated between PS and PSX, and between PSX and PSUS (U.S. season average farm price of sorghum).

With regard to the first relation, PS is based on sales from a given grain harvest (March-June). It is assumed all sales from a given harvest are made during the following marketing year (April-March). Thus, PS is assumed to be related to export prices over an April-March year. PSX, on the other hand, is calculated over a July-June year. This led to the postulated relation:

$$\begin{aligned} PS &= a + b\,(c \cdot PSX + (1-c)\,PSX_{-1}) \\ &= a + bc\,(PSX - PSX_{-1}) + b \cdot PSX_{-1} \end{aligned}$$

The postulated price relation is assumed to be complicated by another explanatory variable--structural change in the sorghum industry. Structural change (SC), discussed earlier in this chapter, is assumed to have caused an upward shift in PS for each given value of PSX.

The final estimated equation used was:

Table 8--Estimated barley price relations

1.	PBA:	PBX	CONSTANT
		.569712	626.593
	t:	15.2	
	e:	.82	
$\bar{R}^2$ = .924	D.W. = 1.35	N = 20 (1955/56 to 1974/75)	
2.	PBQA:	PBX	CONSTANT
		.513367	1227.08
	t:	6.64	
	e:	.69	
$\bar{R}^2$ = .797	D.W. = 2.64	N = 12 (1963/64 to 1974/75)	
3.	PBF:	PBX	CONSTANT
		.640373	2036.74
	t:	11.0	
	e:	.61	
$\bar{R}^2$ = .863	D.W. = 1.98	N = 20 (1955/56 to 1974/75)	
4.	PBX:	PBUS	CONSTANT
		54.1701	-102.174
	t:	18.2	
	e:	1.02	
$\bar{R}^2$ = .946	D.W. = 180	N = 20 (1955/56 to 1974/75)	

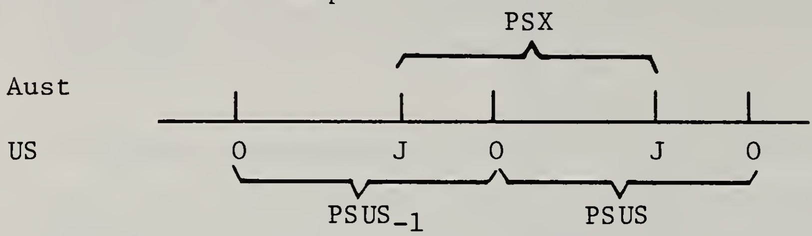
PBA = Australian Barley Board first advance (cts/mt)
PBF = Australian Barley Board home consumption price of feed barley (cts/mt)
PBQA = first advance paid by the Queensland Barley Marketing Board (cts/mt)
PBUS = U.S. average farm price barley (US cts/bu) divided by the exchange rate ($US/$Aust)
PBX = average export value, barley (cts/mt)

PS:	$(PSX - PSX_{-1})$	PSX_{-1}	SC	CONSTANT
	.469152	.903448	-949.136	-291.328
t:	5.49	8.26	-3.26	
$\bar{R}^2$ = .902	D.W. = 2.45	N = 18 (1957/58 to 1975/76 exc. 1969/70)		

where,

PS - total pool payments by the CQGSMB (cts/mt)
PSX = average export value of sorghum (cts/mt)
PSX_{-1} = PSX lagged one year
SC = structural change variable. It equals 1 prior to 1969/70, .5 in 1969/70, and 0 thereafter.

The second price relation between PSX and the U.S. farm price of sorghum (PSUS) also needs to allow for overlapping years. While PSX is calculated over a July-June year, PSUS is calculated over an October-September year. The following time-frame diagram illustrates the overlap.



This overlap leads to the postulated relation:

$$PSX = a + bc\ (PSUS - PSUS_{-1}) + b \cdot PSUS_{-1}$$

The final estimated equation used was:

PSX:	$(PSUS - PSUS_{-1})$	$PSUS_{-1}$	CONSTANT
	35.5147	49.4102	-313.145
t:	4.73	5.35	

$\bar{R}^2$ - .861 D.W. = 1.31 N = 16 (1955/56 to 1974/75, exc. 1957/58, 1960/61, 1963/64, 1965/66)

where, PSX = average export value, sorghum (cts/mt), July-June year
PSX_{-1} = PSX lagged one year
PSUS = U.S. average farm price, sorghum (US cts/bu) divided by the exchange rate ($US/$Aust).

The data series for this regression excluded 4 years in which Australia's exports of sorghum were less than 500 metric tons.

MODEL SOLUTION

Exports of wheat, barley, and sorghum from Australia are explained here by using empirical models of the three grains based on theoretical models and the estimated behavioral and price relations established previously. Their actual construction is straightforward. The empirical models are reproduced in appendix B.

Exports are first estimated over the historical period. This provides a test of the performance of the empirical models over this period. Second, exports are projected to 1980/81, and the projections are compared with those obtained in other studies. Third, the empirical models are used to analyze the effect of changes in world grain prices on exports. It is an example of how the models may be used to generate information useful for policy analysis.

Solution Results over the Historical Period

The empirical models for wheat, barley, and sorghum were used to estimate exports of those grains over the historical period, 1960/61 to 1974/75. All behavioral and price relations were solved simultaneously for the estimation. This allows for cross-equation effects not only within but also between models. For example, ending wheat stocks are expressed as a function of the total quantity of wheat, barley, and sorghum produced. Those equations in the barley and sorghum models which help explain barley and sorghum production then also help explain wheat stocks. Since the price relations are also used, movements in U.S. grain prices are reflected in the estimation of Australia's grain exports.

Actual values are used for those variables which are not themselves expressed as functions of other variables. These include, for example, yields, income, and the U.S. farm prices.

The estimated exports of wheat, barley, and sorghum were plotted against actual values, 1960/61 to 1974/75 (figs. 24, for wheat; 25, barley; and 26, sorghum).

Export Projections to 1980/81

Before proceeding with the projections exercise, it is useful to discuss the assumptions made about the exogenous variables over the projection period.

Exogenous Variable Assumptions

Some of the variables require little attention. They are the zero-one dummy variables which are assumed to be zero over the projection period, and the linear trends which are assumed to continue. The assumed values for the remaining exogenous variables appear in table 9.

The cultivated area variables are proxies for technological change in the wheat area equations. In recent years (1960 on), cultivated area has been increasing at a decreasing rate in all wheat States except Queensland, where it has been increasing at an approximately linear rate. For New South Wales, South Australia, Victoria, and Western Australia, cultivated area was fitted to a logarithmic trend. In Queensland, cultivated area was fitted to a linear trend. The estimating equations used are:

$$CANSW = 72.1274 + 15.1113 \cdot LN(T1) \qquad \bar{R}^2 = .913$$
t: (12.6) N = 16 (1960/61 to 1975/76)

$$CAQ = -124.117 + 2.45966 \cdot T2 \qquad \bar{R}^2 = .970$$
t: (21.9) N = 16 (1960/61 to 1975/76)

$$CASA = 41.0633 + 6.57708 \cdot LN(T1) \qquad \bar{R}^2 = .768$$
t: = (7.13) N = 16 (1960/61 to 1975/76)

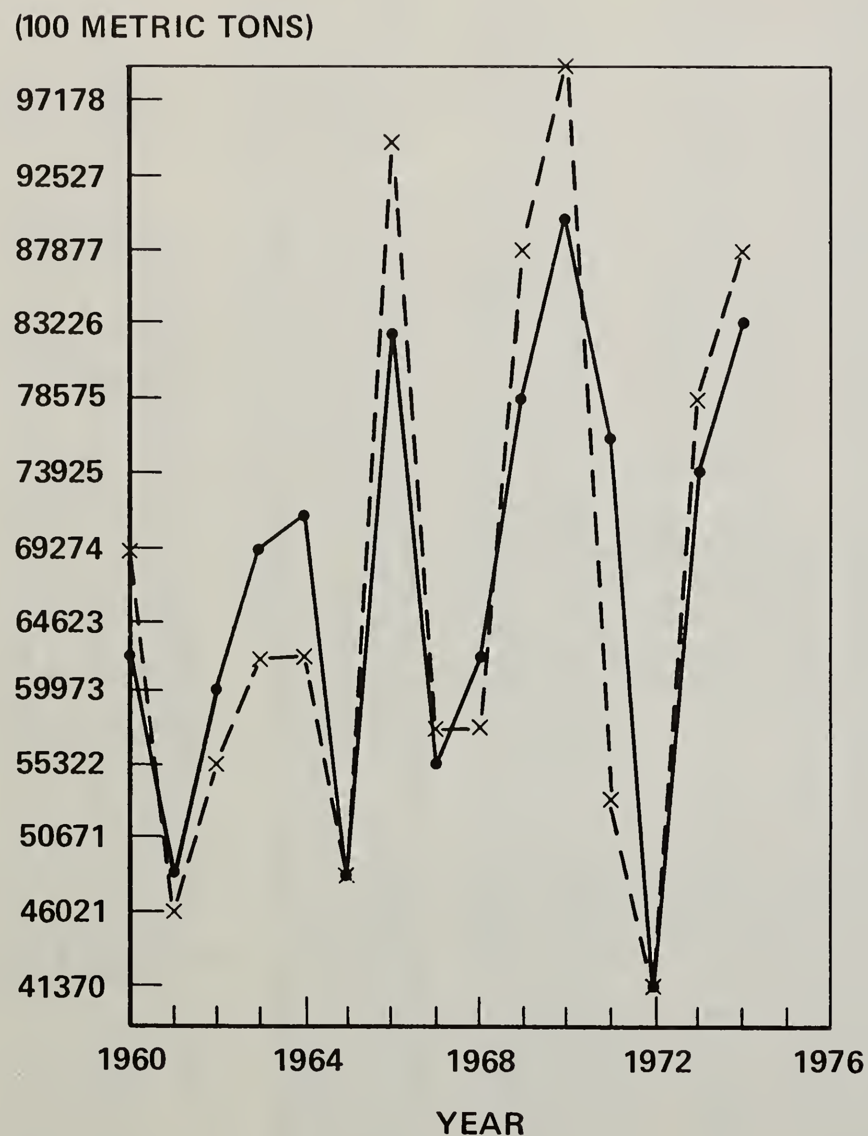
$$CAV = 63.0122 + 18.9427 \cdot LN(T1) \qquad \bar{R}^2 = .940$$
t: (15.4) N = 15 (1960/61 to 1975/76)

$$CAWA = 69.1642 + 19.9456 \cdot LN(T3) \qquad \bar{R}^2 = .956$$
t: (15.5) N = 12 (1963/64 to 1974/75)

In these equations, the dependent variables are as defined in table 9. In addition,

LN(T) = natural log of variable T
T1 = linear trend which equals 1 in 1960/61 and rises to 16 in 1975/76
T2 = linear trend which equals 60 in 1960/61 and rises to 75 in 1975/76
T3 = linear trend which equals 1 in 1963/64 and rises to 12 in 1974/75.

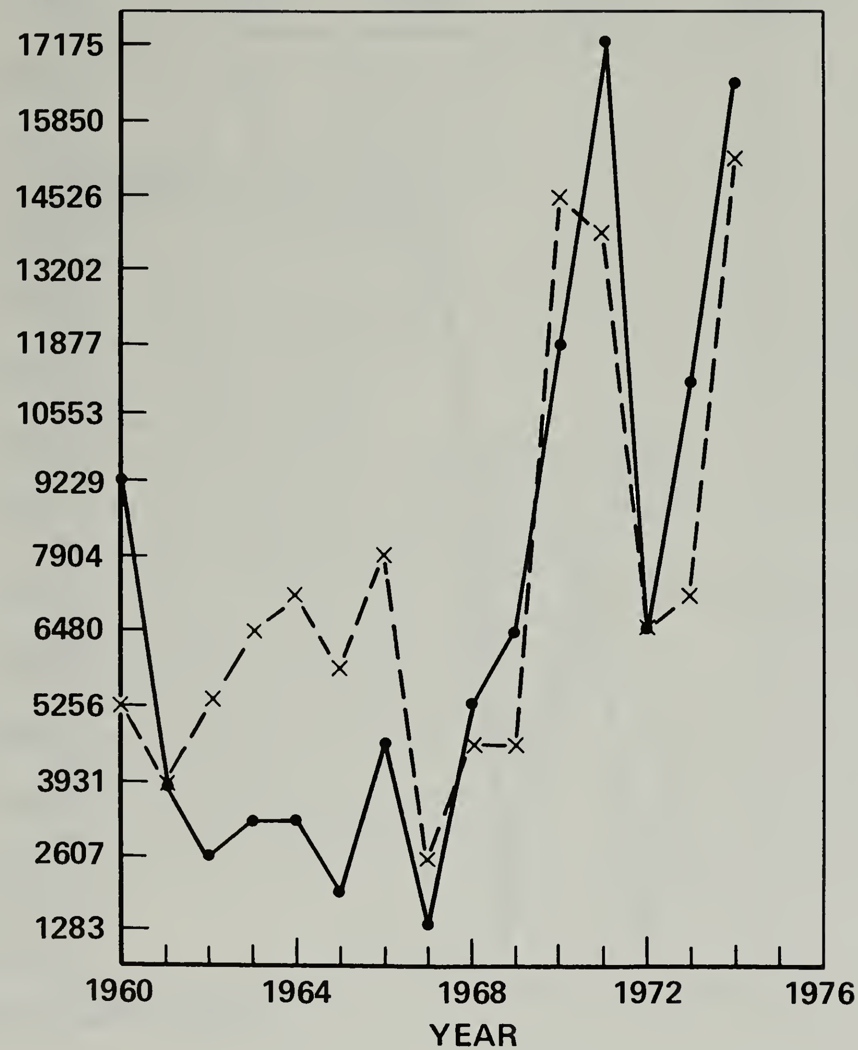
FIGURE 24--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 17-QWX



NOTE: DATA DIVIDED BY 100.0

YEAR	LEVELS (·)	(×)
1960	64556	71095
1961	49497	47755
1962	61549	57145
1963	69827	63821
1964	73176	64578
1965	48981	48417
1966	85476	95182
1967	56545	59652
1968	64197	59462
1969	80830	87907
1970	90490	99503
1971	77600	54739
1972	41370	41372
1973	74180	80543
1974	85500	88594

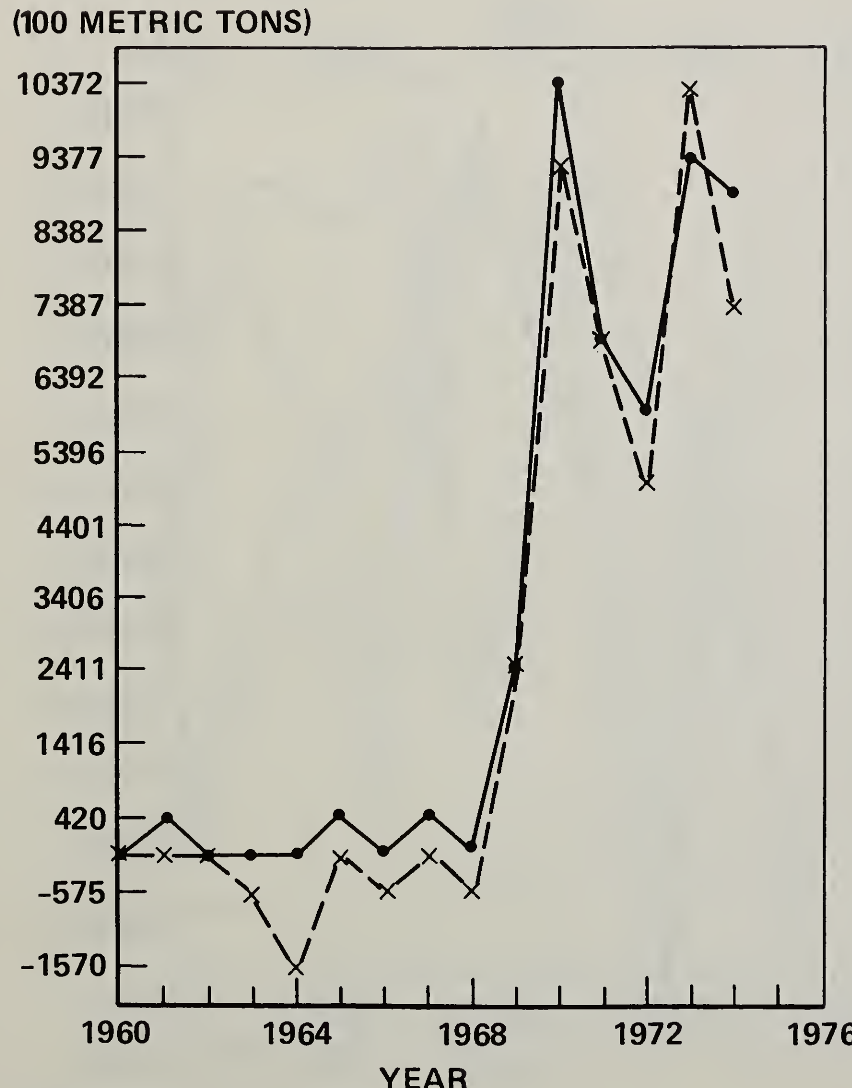
FIGURE 25--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 35-QBX



NOTE: DATA DIVIDED BY 100.0

YEAR	LEVELS (·)	(×)
1960	9431	5531
1961	4194	4274
1962	2737	5575
1963	3915	7167
1964	3711	7834
1965	2232	5952
1966	4598	8294
1967	1283	2886
1968	5486	5230
1969	6840	4837
1970	12282	14654
1971	17837	14338
1972	6762	6797
1973	11681	7627
1974	16560	15702

FIGURE 26--ACTUAL (•) AND ESTIMATED (×) VALUES FOR 49-QSX



NOTE: DATA DIVIDED BY 100.0

YEAR	LEVELS (·)	(×)
1960	390	155
1961	610	260
1962	80	91
1963	190	-146
1964	20	-1570
1965	720	-35
1966	220	-115
1967	800	182
1968	170	-406
1969	2780	2767
1970	10870	9742
1971	6920	6984
1972	6330	5292
1973	9840	10617
1974	8970	7503

Table 9--Exogenous variable assumptions over the projection period

Variable	Description	1976/77	1977/78	1978/79	1979/80	1980/81
CANSW	Cult. area, NSW (100,000 ha)	114.9	115.8	116.6	117.4	118.1
CAQ	Cult. area, QLD (100,000 ha)	62.8	65.3	67.7	70.2	72.7
CASA	Cult. area, SA (100,000 ha)	59.7	60.1	60.4	60.8	61.1
CAV	Cult. area, VIC (100,000 ha)	116.7	117.8	118.8	119.8	120.7
CAWA	Cult. area, WA (100,000 ha)	121.8	123.2	124.5	125.7	126.8
YWNSW	Wheat yield, NSW (mt/ha)	1.386	1.399	1.412	1.425	1.438
YWQ	Wheat yield, QLD (mt/ha)	1.270	1.270	1.270	1.270	1.270
YWSA	Wheat yield, SA (mt/ha)	1.129	1.129	1.129	1.129	1.129
YWV	Wheat yield, VIC (mt/ha)	1.548	1.559	1.570	1.581	1.592
YWWA	Wheat yield, WA (mt/ha)	1.150	1.161	1.172	1.183	1.194
YB	Barley yield (mt/ha)	1.149	1.149	1.149	1.149	1.149
YS	Sorghum yield (mt/ha)	1.848	1.864	1.880	1.896	1.912
PBUS	U.S. ave. farm price, barley (US cts/bu)	233	190	165	155	150
PSUS	U.S. ave. farm price, sorghum (US cts/bu)	211	180	160	155	155
PWUS	U.S. ave. farm price, wheat (US cts/bu)	289	250	230	229	235
PWO	Ave. price greasy wool (cts/10 gm)	15427	16559	16559	16559	16559
PWH	Home cons. price, wheat (cts/mt)	10540	11172	11843	12553	13307
POP	Population at June 30 (1,000 hd)	13751	13957	14167	14379	14595
Y/CPI	Real private cons. exp. ($b.)	21.84	22.71	23.62	24.56	25.54
CPI	Consumer Price Index (1966/67=1000)	2049	2172	2302	2440	2587
EXCH	Exchange rate ($US/$Aust)	1.17	1.09	1.09	1.09	1.09
I	Index of intensive l'stock prodn.	5825	5914	5996	6074	6147
LAMBPER	Lambing percent	74.8	75.0	75.2	75.4	75.6
QWDO	Wheat use for seed (1,000 mt)	550	550	550	550	550
QBDO	Barley use for seed (1,000 mt)	168	168	168	168	168

These equations were projected to 1980/81 with T1, T2, and T3 continuing to rise linearly. The projected values appear in table 9.

The next set of variables are grain yields against a linear trend (1946/47 to 1975/76) in the five wheat States produced significant coefficients for New South Wales, Victoria, and Western Australia. In these States, the linear trend was projected to 1980/81 and the resulting yield values were used in table 9. For Queensland and South Australia, the trend coefficient had a t-value of less than 1. Hence in these States, the mean yield averaged over 1945/46 to 1975/76 was used in the projection period. Regressing barley and sorghum yields against a linear trend yielded a significant coefficient for sorghum, but not for barley. Over the projection period, linear trend values were assumed for sorghum yield, while the mean yield (1946/47 to 1975/76) was assumed for barley.

The assumed values for U.S. average farm prices of barley, sorghum, and wheat were USDA projections. They are the baseline projections developed from the U.S. domestic grain models maintained by the Forecast Support Group, USDA. 23/ These prices all exhibit a marked downward trend over the projection interval.

The next exogenous variable is the annual average price of all greasy wool sold in Australia. Without Australia's recent devaluation, the projected price would have been assumed to equal that for 1975/76. This is because there does not appear to be a clear price trend either up or down. In a recent USDA Cotton and Wool Situation (July 1977, pp. 18-19), the Australian Wool Corporation was reported as having forecast raw wool prices to rise by as much as 10 percent when the 1977/78 season opened in July. On the other hand, the Cotton and Wool Situation regards the current wool textile market as "sluggish." This ambivalence suggests that no change in the wool price would be as reasonable an assumption as any. However, one legitimate modification to this assumption results from Australia's recent devaluation of its currency. Recall that the wool price is used along with grain prices in the wheat area equations. The devaluation effect is automatically incorporated in the grain prices through the Australian-U.S. price relations. But it is not so incorporated in the wool price. If the devaluation effect on wool price is not taken into account, the wheat model's projection of wheat area planted would be biased upwards.

Grain growers were assumed to face a completely elastic excess demand curve from the rest of the world. Hence, the total effect of the devaluation was reflected in the Australian grain export prices. It is not realistic to assume that Australia's wool growers also face an elastic excess demand curve, since Australia is by far the largest single producer and exporter of wool in the world. However, it may still be reasonable to assume that the full devaluation effect is reflected in the Australian wool price. This would be true if Australia's excess supply of wool were very inelastic. Appendix C shows that for linear excess supply and demand curves, the price change following devaluation can be approximated by:

$$P_2/P_1 = \frac{e_{ES} - e_{ED}}{e_{ES} - D \cdot e_{ED}}$$

where,

P_1 = price prior to devaluation
P_2 = price following devaluation
e_{ES} = elasticity of excess supply

23/ These are not official USDA projections. They are intended only as background for departmental use.

e_{ED} = elasticity of excess demand
D = devaluation effect. It equals the new value of the Australian dollar (in terms of U.S. dollars) divided by the old value.

In the case of grains, where $e_{ED} \rightarrow \infty$, $P_2/P_1 = 1/D$. Thus, for example, if the Australian dollar was devalued by 15 percent, D = 1/1.15 and $P_2/P_1 = 1.15$. Hence, the full devaluation effect is reflected in the price. Similarly, if $e_{ES} \rightarrow 0$, then it is also true that $P_2/P_1 = 1/D$.

For wool, estimates of the elasticities of excess supply and demand were obtained from Schufft (37, p. 136) to figure the price effect of devaluation. The assumed (short-run) excess supply elasticity was .05 and the assumed excess demand elasticity, -.3. 24/ Using the expression for P_2/P_1 along with an assumed 15-percent devaluation resulted in a value for $P_2/P_1 = 1.126$, which is very close to the full effect of devaluation. It was thus decided to simply assume that the full devaluation effect was reflected in the wool price.

The home consumption price of wheat was assumed to increase at 6 percent per year, population at 1.5 percent, real private consumption expenditures at 4 percent, and the consumer price index at 6 percent. These assumptions are based on historical trends.

The U.S.-Australian exchange rate takes into account Australia's devaluation in November 1976. It is assumed to remain at the same post-devaluation level through 1980/81.

The index of intensive livestock production (I) is a measure of structural change in the intensive livestock industries which underwent rapid expansion in the sixties. The variable I was fitted to a logarithmic trend (1963/64 to 1975/76) and projected to 1980. The fitted equation was:

$$I - 2445.69 + 1280.56 \cdot LN(T) \qquad \bar{R}^2 = .894$$
$$t: \qquad (10.1) \qquad N = 13 \text{ (1963/64 to 1975/76)}$$

where,

T = linear trend which equaled 1 in 1963/64, rising to 13 in 1975/76.

The projected values from this equation appear in table 9.

Lambing percent was fitted to a linear trend (1946/47 to 1975/76) and projected to 1980/81. The quantities of wheat and barley used for seed have been assumed constant over the projection period at 550,000 and 168,000 metric tons, respectively. In addition to the exogenous variables (table 9), sorghum ending stocks were assumed to equal 6 percent of sorghum production over the projection period.

Projected Exports

On the basis of these exogenous variable assumptions and the estimated behavioral and price relations, exports of wheat, barley, and sorghum are projected to 1980. The export projections appear next to the year in which the crop was planted (table 10). Thus, for example, the 1976 projections for wheat and barley refer to the crop

24/ In Schufft's article, the excess demand elasticity of -.3 was applied only to the world excluding the U.S. But incorporating the U.S. demand elasticity made very little difference to the value.

marketed December 1976-November 1977. For sorghum, the projection refers to the crop marketed April 1977-March 1978. In addition to the export projections from the "full model run," actual exports for the 1975 crop plus export projections for 1976 when production is exogenized are shown (table 10).

Table 10--Projections of exports of crops planted in 1975-80

Item	Wheat	Barley	Sorghum
	Million metric tons		
Actual:			
1975	8.52	2.23	.97
Projected:			
1976 (using actual production date)	9.00	1.55	.60
Projected:			
1975	10.04	1.73	.75
1976	10.63	1.24	.60
1977	10.38	1.15	.70
1978	10.24	.96	.76
1979	10.37	.83	.77
1980	10.69	.77	.72

Perhaps the most striking feature of table 10 is the marked decline in projected barley exports. This is primarily a reflection of the projected decline in world barley price. The lower barley price has a depressing effect on projected barley area. In addition, the domestic feed use of barley is projected to increase. This is the result both of the lower barley price and an assumed higher home consumption price (hcp) for wheat.

In contrast to barley, the wheat and sorghum export projections show little or no noticeable trend. For wheat, the projected decline in world price had little effect in reducing the projected area planted. Recall that the grower is insulated to some extent from world price by price pooling and the stabilization scheme. As it happened, world price in 1978 and 1979 was assumed to have no effect because in these 2 years, the expected average export return was projected within $5.51 per metric ton of the expected stabilization price.

If world prices had little negative effect on exports via the supply side, they had some positive effect via the domestic demand side. Feed use of wheat was projected to decline as a result of the assumed higher hcp for wheat and a lower projected hcp for feed barley.

With regard to sorghum, a lower world price led to a projected increase in domestic use, as expected. However, projected supply, rather than decreasing, actually increased. In the sorghum area equation, the negative effect of a lower sorghum price was canceled out to some extent by lower prices for the substitute enterprises, wheat and barley. Moreover, any net negative effect that may have been present was outweighed by the positive effect of a trend representing technological advance.

Table 10 includes for comparison both actual and projected exports for 1975. Projected wheat exports for 1975 significantly exceeded actual exports. The problem arose from the supply side, for the wheat area equations for South Australia and Victoria in particular. The two equations fare poorly over the projection interval 1975/76 and 1976/77 (figs. 12 and 13). One possible reason for the discrepancy between projected and actual values was the incidence of wheat-stem rust in 1973/74 and 1974/75. This caused many growers to subsequently switch to alternative crops, and barley in particular. The effect on wheat area may have been substantial, but it is not incorporated in the estimating equations. Since wheat supply is very important in determining wheat exports, additional research would be useful in improving the specification of these area equations.

Contrary to wheat, the barley and sorghum export projections for 1975 fall short of the actual values. In both cases, the discrepancy can be largely explained in domestic feed use relations. The projected feed use of barley, 1975, and the projected domestic use of sorghum, 1975, both exceeded actual values by about 300,000 metric tons (figs. 21 and 22). One possible explanation for the high projection levels for both grains lies in the problem with data. Feed use for both grains is calculated as a residual in the supply-distribution (S-D) data series. Hence, the data on feed use contain the net effect of errors made in all the other S-D data series. In particular, the data on ending stocks for barley and sorghum are questionable, since there are no official Australian statistics on ending stocks. The stocks data (except for barley prior to 1964) are rough estimates made by the U.S. agricultural attache in Canberra.

Projected Exports: A Comparison

In tables 11 to 13, comparisons are made between the projections of this study and those of the USDA and Australia's Bureau of Agricultural Economics (BAE). The USDA projections are for the current and next marketing years for each crop. They are taken from the USDA's Foreign Agriculture Circular: Grains, FG-11 (July 19, 1977). For the first year projected (1976/77 for wheat and barley; 1977/78 for sorghum), actual data were already available on area and production. The actual values were included in the tables, and the only comparisons made were in domestic use, exports, and stock change. The BAE's projections come from a 1976 study that gave projections only for the 1979/80 marketing year (11). In that study, projections were made under the alternative assumptions of wheat quotas and no wheat quotas. The projections appearing in tables 11-13 assume no wheat quotas.

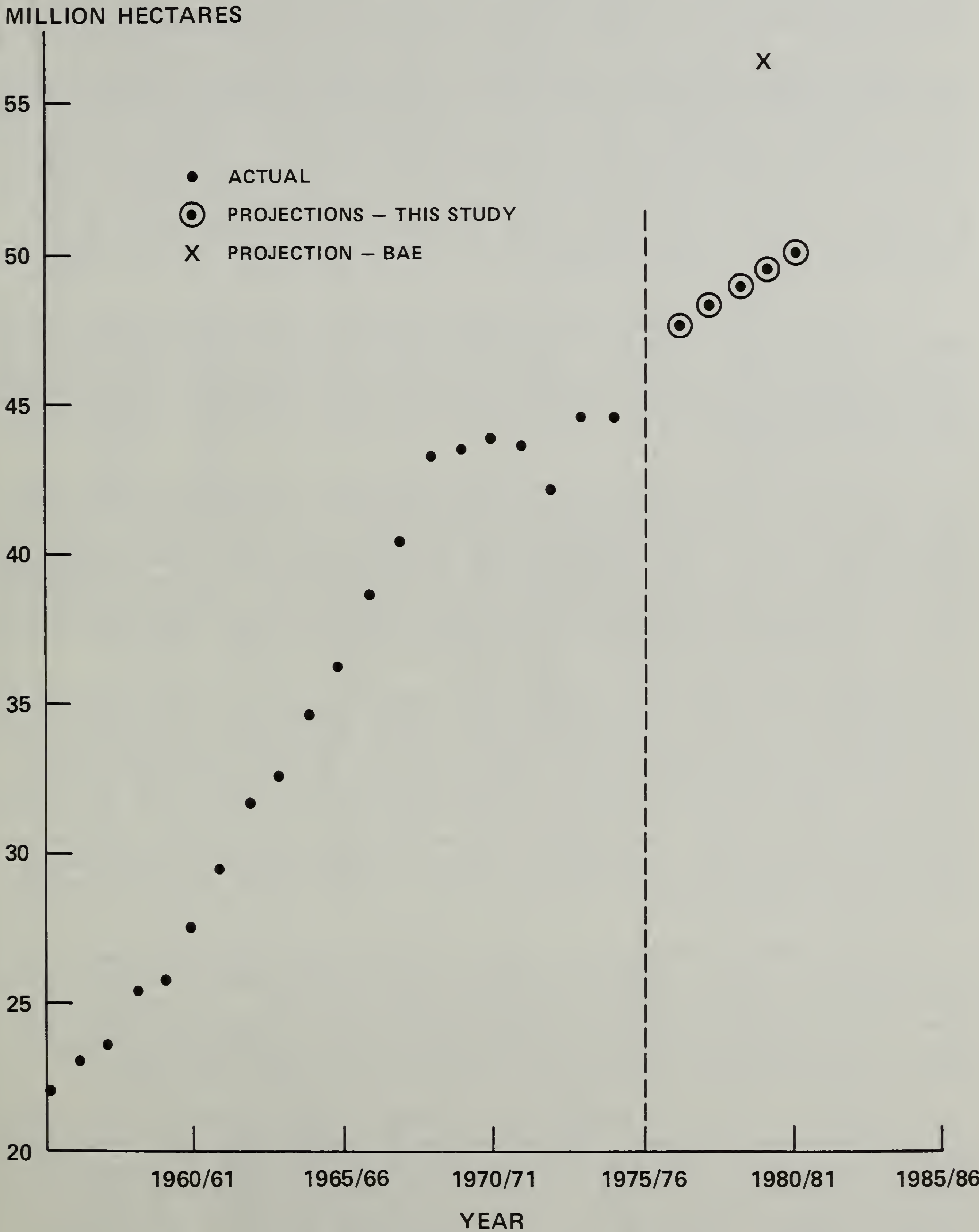
Wheat export projections.--In the 1976/77 projections (table 11), both the USDA and this study projected increases in domestic use and little change in stocks. The result is similarly projected export levels. For 1977/78, output and domestic use projections are very close. The difference in projected exports is largely explained by the difference in the projected stock change. With regard to 1979/80, the area and output projections of this study are significantly below those of the BAE. The reason probably lies in the different assumptions regarding the rate of growth of cultivated area. This is an explanatory variable in the area equations of both the BAE study and the present one. The difference between the assumptions is illustrated by figure 25. The actual path to 1975 is increasing at a decreasing slope. While this study assumes a continuation of this trend in the projection interval, the BAE study does not. That study attributes the flatter part of the curve to lower real farm income in the early 1970's. This is assumed to be a temporary phenomenon which does not affect the 1979/80 projection of cultivated area.

In addition to projecting a lower output than the BAE in 1979/80, this study also projects a moderately lower domestic use. The difference occurs almost entirely in domestic feed use. In the present study, wheat use for feed is curtailed because of the assumed high home consumption price of wheat relative to the price of other

Table 11--Wheat projections, marketing year

Item	Actual 1975/76	Projected 1976/77		Projected 1977/78		Projected 1979/80	
		USDA	This study	USDA	This study	BAE	This study
	Million hectares						
Area	8.56	8.90		9.90	10.10	12.70	9.86
	Million metric tons						
Production	11.98	11.84		13.00	13.16	15.10	12.97
Domestic use	2.48	2.53	2.88	2.86	2.79	3.40	2.60
Exports	8.52	9.30	9.00	9.50	10.38	11.70	10.37
Stock change	+.99	+.02	-.04	+.64	-.01	0	0

FIGURE 27--CULTIVATED AREA IN THE FIVE WHEAT STATES, A COMPARISON OF TWO PROJECTIONS



feed grains. It is not clear what the BAE study assumed about the price relationship between the home consumption price of wheat and the domestic prices of other grains. However, the study itself argues that wheat feed use would be higher than in earlier years as a result of the continued expansion of the intensive livestock industries. As a result of the projected differences in output and domestic use, this study projects wheat exports in 1979/80 at about 90 percent of the BAE projected level.

Barley export projections.--For 1976/77, this study projects domestic use at a substantially higher level than does the USDA (table 12). Although the USDA projection is not broken down into type of use, the difference very likely is in the feed use projection. As already mentioned, the estimated feed use of barley in the present study (fig. 21) substantially overestimated actual feed use in 1974/75 and 1975/76. In 1976/77, it appears the USDA projects feed use at about 300,000 metric tons, the same level as actual 1974/75 and 1975/76 levels. The present study projects feed use in 1976/77 at 650,000 metric tons, about the same level as the estimated 1975/76 level. The result of a higher projected feed use in this study is that exports are projected at a lower level.

For 1977/78, the present study projects both barley area and production at below USDA projected levels. While the USDA projection represents the continuation of an upward trend in barley area (fig. 18), this study's projection represents a leveling off in response to a lower projected world barley price. The domestic use projections for 1977/78 differ widely. As in 1976/77, the reason is very likely the difference in projected feed use.

As a result of the projected lower output and higher domestic use, this study projects exports substantially below the U.S. Department of Agriculture. For 1979/80, both this study and the BAE projected area and output to be substantially below the actual 1975/76 level. This is attributable to a projected lower world barley price. Domestic use in both studies is projected to increase. Again, this is attributable to a lower barley price associated with a higher assumed home consumption price for wheat. As a result of these output and domestic use projections, both studies project a substantial decline in exports from the actual 1975/76 level.

Sorghum export projections.--These are compared in table 13. For the 1977/78 marketing year, the main discrepancy between the two projections is in domestic use. This results in a similarly wide difference in projected exports. Domestic use in 1974 and 1975 was estimated in this study to be substantially above actual levels (fig. 23). While the USDA projection for 1976 (marketing year, 1977/78) was similar to the actual 1975 level, the present study's projection was similar to the estimated 1975 level. One problem with domestic sorghum use is the data series. Further research would be useful in attempting to improve the specification of the domestic use equation. However, an important constraint to improvements may be the questionable data series available.

For the 1978/79 marketing year, domestic use was still projected higher in this study than by the USDA. However, the gap was much narrower than for 1977/78. Output was projected 15 percent lower by this study than by the USDA. This results both from a lower projected area (by 9 percent) and by a lower assumed yield (by 6 percent). As a consequence of the larger domestic use and lower output, the level of exports projected by this study is only 70 percent of the USDA projection.

For 1979/80, there is a significant difference between the BAE and this study's projections of area and output. The BAE projected a modest decline in area from the actual 1977/78 level, while this study projected a modest increase. One possible reason for the difference is the inclusion of the structural change variable in the estimating equation of this study. No such variable was included in the BAE's comparable equation. Domestic use is projected almost the same in both studies.

Table 12--Barley projections, marketing year

Item	Actual 1975/76	Projected 1976/77		Projected 1977/78		Projected 1979/80	
		USDA	This study	USDA	This study	BAE	This study
				Million hectares			
Area	2.33	2.27		2.50	2.24	1.70	2.06
				Million metric tons			
Production	3.18	2.79		3.50	2.57	2.06	2.36
Domestic use	.86	.91	1.26	.91	1.36	1.40	1.51
Exports	2.23	1.83	1.55	2.60	1.15	.66	.83
Stock change	+.09	+.05	-.02	-.01	+.06	0	+.02

Table 13--Sorghum projections, marketing year

Item	Actual 1976/77	Projected 1977/78		Projected 1978/79		Projected 1979/80	
		USDA	This study	USDA	This study	BAE	This study
				1,000 hectares			
Area	504	550		650	594	490	636
				1,000 metric tons			
Production	1,124	1,056		1,300	1,107	960	1,197
Domestic use	82	96	362	220	403	452	428
Exports	972	950	602	1,000	699	505	763
Stock change	+70	+10	+49	+80	+6	0	+5

Hence, because of the larger projected output in this study, exports are also projected higher.

Example of Model Use: Effect of an Arbitrary Change in World Grain Prices

One potential use of the empirical models is in policy analysis. Basic to some policy questions is the responsiveness of Australia's grain exports to changes in world grain prices. For example, suppose the U.S. loan rate for wheat was changed, or the U.S. dollar was devalued. It would be useful to know what effect this might have on Australia's exports, since a large change in Australia's exports may have repercussions on the U.S. ability to export. In this section, world grain prices are arbitrarily changed in 1 year and the subsequent effects on Australia's grain exports analyzed.

World grain prices are represented by U.S. annual average farm prices. U.S. farm prices for wheat, barley, and sorghum in 1977/78 are assumed to be respectively, \$2.50, \$1.90, and \$1.80 per bushel (U.S. currency). These prices were then arbitrarily cut 10 percent and the effect on Australia's projected grain exports observed. This temporary (that is, single-year) price cut typically affects Australia's exports over more than 1 year. Hence, the total change in exports over the 4 marketing years, 1977/78 to 1980/81, is calculated. The total change for each grain is expressed as a percent of the average projected exports without the price change (table 14). Thus,

$$\text{Percent change in exports of A} = \frac{\sum_{i=1}^{4} \text{(annual change in projected exports of A)}}{\frac{1}{4} \cdot \sum_{i=1}^{4} \text{(projected exports of A without the price change)}} \times 100$$

where,

i = 1 in 1977/78, rising to 4 in 1980/81.

With respect to the same table, the numbers in parentheses are the averages of projected exports, 1977/78 to 1980/81, without the price change. They represent for each grain the denominator in the above expression. In addition to showing the export effects of separate U.S. price falls, table 14 (final column) also shows the combined effect of a 10-percent fall in all three prices.

Table 14--Total percentage change in Australia's grain exports, 1977/78 to 1980/81, due to a 10-percent fall in projected U.S. farm prices, 1977/78

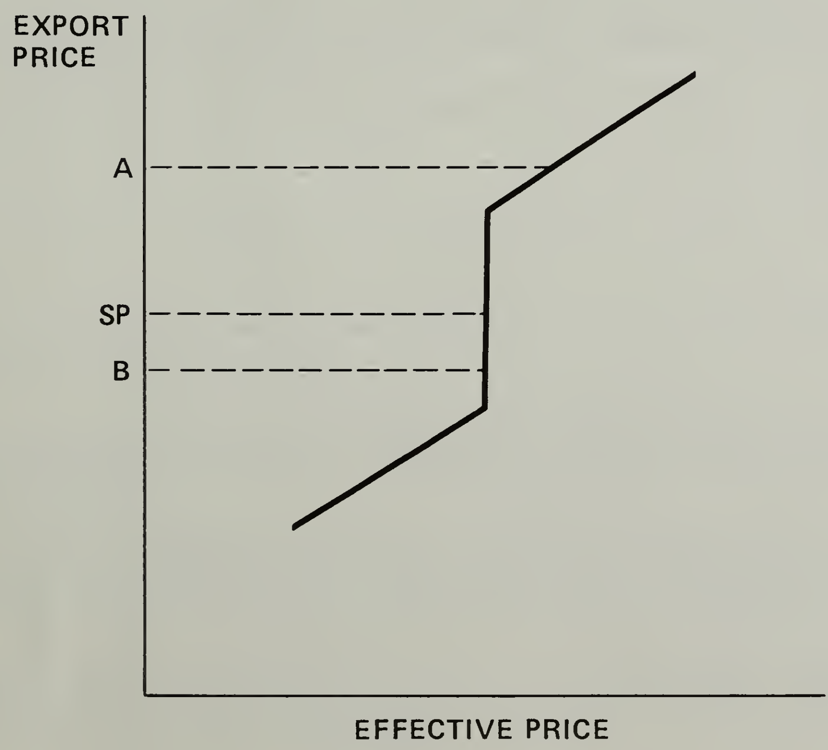
Grain	Australia's exports, estimated, 1977/78	Effect on Australia's 1980/81 exports of a 10-percent fall in the U.S. price of --			
		Wheat	Barley	Sorghum	All three grains
	Mil. m.t.	- - - Percentage change - - -			
Wheat	10.4	-2	+1	0	-1
Barley	.927	0	-15	0	-15
Sorghum	.708	+5	+4	-14	-5

Perhaps the most striking feature of table 14 is the contrast in the "own-price effects." For wheat, the own-price effect is only 2 percent as opposed to 15 and 14 percent, respectively, for barley and sorghum. The contrast may be explained in part by the different marketing arrangements for the three grains. As explained earlier, domestic consumers of wheat are totally insulated from the effect of world prices by the Government-determined home consumption price. With the other grains (except malting barley), domestic consumption is assumed to be directly insulated from world prices by price pooling and the stabilization scheme. In the empirical model, for example, when the assumed 1977/78 U.S. wheat price was cut 10 percent, the Australian export price also fell 10 percent. However, the supply-inducing price of wheat only fell 5 percent (fig. 28).

The wheat price stabilization scheme produces a discontinuous relationship between Australia's export price and its effective (grower) price. For the present plan, the discontinuity occurs in a range $5.51 above and below the stabilization price (SP). This dollar value is the maximum payment per metric ton into or out of the stabilization fund. In 1977/78 and prior to the price change, the export price was projected above this discontinuity, say at A in figure 28. Following the 10-percent price fall, the export price fell below SP to a point on the vertical section, say point B. Because the export price change went through at least part of the vertical section, the change in effective price was less than what it would have been otherwise.

The supply effect for wheat contrasts markedly with that for barley and sorghum. When the projected U.S. barley price was cut 10 percent, the supply-inducing price of barley fell 9 percent. When the projected U.S. sorghum price was cut 10 percent, the supply-inducing price of sorghum fell 12 percent.

FIGURE 28--GRAPHICAL REPRESENTATION OF THE RELATIONSHIP BETWEEN AUSTRALIA'S EXPORT AND EFFECTIVE PRICES FOR WHEAT



DIRECTIONS FOR FURTHER RESEARCH

The empirical models developed in this study provide a framework for analyzing Australia's exports of wheat, barley and sorghum. As a framework, they should not be considered the final word. Much can be done to enrich the models.

First, there is scope for improving the specification of some equations. Of particular importance in their effect on export projections were the feed use equations for barley and sorghum and the wheat area equations for South Australia and Victoria. Second, research on a continuing basis is necessary to update the models and to test the theoretical bases for the models against actual experience.

Each model may also be integrated into a system of country models to analyze world trade in these grains. A possible framework for accomplishing this within the USDA has been outlined by M. Bale (10). He basically uses an excess supply-excess demand approach. In the present study, the export-price relationships may be considered as excess supply curves for Australia. A useful direction for further research may be to undertake similar studies on other major grain exporters and importers. The excess supply and demand curves thus obtained may perhaps be combined in the way Bale suggests to project world trade and prices in these grains.

LITERATURE CITED

1. Alaouze, C. M., Watson, A. S., and Sturgess, N. H. Storage Policy for the Australian Wheat Industry. Unpublished paper presented at the 20th annual meeting of the Australian Agricultural Economics Society, Armidale, Australia, February 1976.

2. Anderson, Kym. An Econometric Study of Supply Response in the Australian Barley Industry. Extension Branch Report No. 8, Department of Agriculture, Adelaide, South Australia, February 1974.

3. ______. "Distributed Lags and Barley Acreage Response Analysis." Australian Journal of Agricultural Econ. 18(2) (August 1974):119-32.

4. Australian Barley Board. Annual Report. Various issues, Adelaide, Australia.

5. Australian Bureau of Statistics. Official Year Book of Australia. Various issues, Canberra, Australia.

6. ______. Overseas Trade Bulletin. Various issues, Canberra, Australia.

7. Australian Bureau of Statistics: Victorian Office. Land Utilization and Crops, 1975/76. Melbourne, Australia, January 1977.

8. Australian Wheat Board. Annual Report. Various issues, Melbourne, Australia.

9. Bain, Robert A. The Australian Feed Grains Market. Unpublished M.Ec. theses, Monash University, Clayton, Australia, March 1972.

10. Bale, Malcolm D. ERS Country Market Studies: A System for Projecting U.S. Agricultural Exports. Working paper for Foreign Demand and Competition Division, March 8, 1976.

11. Bureau of Agricultural Economics. Agricultural Supply Projections: Australia 1979/80, Preliminary Results for Grains. Canberra, Australia, July 1976.

12. ______. Coarse Grains Situation. Various issues, Canberra, Australia.

13. ______. Rural Industry in Australia. Canberra, Australia, 1971, 1975.

14. ______. Statistical Handbook of the Meat Industry, 2nd ed. Canberra, Australia, 1975.

15 ______. The Australian Wheatgrowing Industry: An Economic Survey, 1972-1973. Canberra, Australia, 1975.

16. Cumming, J. N. "The Effects of the 1965-66 Drought on Sheep Numbers, and the Expected Rate of Recovery." Quarterly Review of Agricultural Econ. 19(4) (October 1966).

17. Fisher, B. S. An Analysis of the Export Market for Australian Wheat. Unpublished paper presented at the 21st annual meeting of the Australian Agricultural Economics Society, Brisbane, Australia, February 1977.

18. ______. An Analysis of Storage Policies for the Australian Wheat Industry. Unpublished Ph.D. Thesis, Department of Agricultural Economics, University of Sydney, Australia, March 1977.

19. _______. "Supply Response in the Wheat-Belt of South-Eastern Australia: The Impact of Delivery Quotas on Wheat Plantings." Australian Journal of Agricultural Econ. 19(2) (August 1975):81-93.

20. Freebairn, J. W. "Competitive Behavior in the International Wheat Market." Review of Marketing and Agricultural Econ. 36(2) (September 1968):111-24.

21. Gruen, F. H. and others. Long Term Projections of Agricultural Supply and Demand, 1965 and 1980. Department of Economics, Monash University, Clayton, Australia, October 1966.

22. Harris, Stuart and others. Rural Policy in Australia. Canberra, Australia: Australian Government Publishing Service, May 1974.

23. Hellier, W. L. "Australian Wheat Delivery Quotas." Wheat Situation, No. 35, Bureau of Agricultural Economics (1972):38-44.

24. Henderson, James M., and Quandt, Richard E. Microeconomic Theory, a Mathematical Approach, 2nd ed. New York: McGraw-Hill, 1971.

25. Honan, N. D. "Wheat Consumption in Australia." Quarterly Review of Agricultural Econ. 15(4) (October 1962):153-59.

26. Johnston, J. Econometric Methods 2nd ed. New York: McGraw-Hill, 1972.

27. Kite, Rodney. General Analytical Simulation Solution Program (GASSP) Manual. Economic Research Service, USDA.

28. Lawrence, M. J. "The Australian Sheep Industry Survey 1967-68 to 1969-70." Quarterly Review of Agricultural Econ. 24(4) (October 1971):217-35.

29. Longworth, John W. "Commodity Marketing Boards." Journal of the Australian Institute of Agricultural Science (June 1973):94-97.

30. _______. "The Australian Wheat Industry Stabilization Scheme: An Analytical Model." Economic Record 42 (June 1966):244-55.

31. _______. "The Stabilization and Distribution Effects of the Australian Wheat Industry Stabilization Scheme." Australian Journal of Agricultural Econ. 11(1) (June 1967).

32. McCalla, Alex F. "A Duopoly Model of World Wheat Pricing." Journal of Farm Econ. 48(3) (August 1966):711-27.

33. Mules, T. J. Supply Analysis for Australian Agricultural Products with Applications to Farm and National Income Estimation. Unpublished Ph.D. Thesis, Economics Department, University of Adelaide, January 1973.

34. Powell, Alan A., and Gruen, F. H. "Problems in Aggregate Agricultural Supply Analysis: 1--The Construction of Time Series for Analysis." Review of Marketing and Agricultural Econ. 34(3) (September 1966):112-35.

35. Queensland Department of Primary Industries. Second Report on Winter Grains and Seeds, 1976/77 Season. Marketing Services Branch, Brisbane, Australia, August 1976.

36. Rosenthal, B. E. Barley: A Review of World and Australian Markets. Marketing Services Branch, Queensland Department of Primary Industries, May 1972.

37. Schufft, R. "United States Wool Policy and Australia's Wool Export Trade." Quarterly Review of Agricultural Econ. 23(3) (July 1970):122-45.

38. Scobie, G. M. "Trends in Production from Sheep Properties: A Brief Review and Medium Term Projection of Sheep Numbers." Quarterly Review of Agricultural Econ. 22(4) (October 1969):185-98.

39. Traill, W. B. "Supply Response in the Australian Grains Industries." Coarse Grains Situation and Outlook. Bureau of Agricultural Economics, 1974, pp. HA17-HA31.

40. U.S. Department of Agriculture. Australia: Growth Potential of the Grain and Livestock Sectors. Foreign Agricultural Economic Report No. 80, Economic Research Service, May 1972.

41. _______. Foreign Agricultural Circular, Grains. Various issues, Foreign Agricultural Service, Washington, D.C.

42. _______. The Australian Wheat Marketing System. Foreign Agricultural Service, December 1965.

43. Watson, A. S., and Duloy, J. H. Wheat Stabilization Policy--A Supply Study. New England Marketing Studies No. 2, Faculty of New England, Armidale, Australia, January 1968.

APPENDIX A--WHEAT PRICES

The effective price series for wheat was discussed as the supply-inducing price for wheat. Table 15 lists the calculated price series. The calculations are made according to the algebraic expression No. 7 of the wheat model, Appendix B.

Table 15--Effective price of wheat, 1954-75

Year	Effective price 1/	Year	Effective price 1/
	Cents/m.t.		Cents/m.t.
1954	4868	1969	5324
1955	4860	1970	5280
1956	5042	1971	5665
1957	5237	1972	5990
1958	5358	1973	7897
1959	5477	1974	10702
1960	5341	1975	10147
1961	5492		
1962	5509		
1963	5209		
1964	5314		
1965	5363		
1966	5486		
1967	5772		
1968	5354		

1/ Effective price, year t incorporates price and quantity information available prior to planting, year t+1 on the wheat crop harvested in year t.

APPENDIX B--GRAIN MODELS, VARIABLES USED, AND THEIR DEFINITIONS

The data bank has the supply-distribution variables addressed by the year in which the particular crop was planted. Thus for example, 1969 exports of wheat refer to exports between December 1969 and November 1970 (the marketing year). For wheat and barley, there is no confusion because the marketing year begins in the same year as planting. For sorghum, however, the marketing year begins in the calendar year following planting. Thus, for example, the data bank regards 1969 sorghum exports as those occurring between April 1970 and March 1971. These exports relate to the crop planted, September (or later) 1969.

The price and structural variables may refer either to a particular point in time (such as population on June 30) or to a period (such as the annual average price of greasy wool). Those variables which occur at a particular point in time are addressed by the calendar year in which that point occurs. Those variables which refer to a period are addressed by the calendar year at the start of the period. Thus, the 1969 home consumption price for wheat refers to wheat consumed in the marketing year December 1969-November 1970. However, some care is needed with sorghum. The 1969 total payments to sorghum growers, for example, refers to the crop marketed April 1969 to March 1970. This crop is addressed in the data bank as the 1968 crop. Hence, 1969 total payments refer to the 1968 crop.

WHEAT MODEL

Behavioral Equations

1a Area planted, New South Wales (ha)
$AWN = 186.764\ PW_{-1} - 12.7588\ (PWO_{-1} + 2PWO_{-2} + PWO_{-3}) + 26108.9\ CANSW - 259114\ D70 + 961680\ D6669 - 838900$

1b Area planted, Queensland (ha)
$AWQ = 393984\ PW_{-1}/PWO_{-1} + 15788.1\ CAQ + 324195\ SC - 605829$

1c Area planted, South Australia (ha)
$AWS = 1816507\ PW_{-1}/(PWO_{-1} + 2PWO_{-2} + PWO_{-3}) - 48.9170\ PBA_{-1} + 28093\ CASA - 352548\ D7072 + 253629\ D68 - 423585$

1d Area planted, Victoria (ha)
$AWV = 72.4742\ PW_{-1} - 31.3151\ (PWO_{-1} + PWO_{-2}) + 9215.44\ CAV - 639620\ D7072 + 147742\ D68 + 657083$

1e Area planted, Western Australia (ha)
$AWW = 1635501\ PW_{-1}/(PWO_{-1} + PWO_{-2}) + 26656.2\ CAWA - 764264\ D7072 - 508251$

2. Domestic food use (mt)
$QWDH = NJ_{+1}\ (261.257 - 8.72399\ PWH - 1.34084\ T) - 1163.94\ (5Y + 7\ Y_{+1})$

3. Domestic feed use (mt)
$QWDF = -460947\ PWF/PBF - 276.085\ LAMBPER + 185.366\ I \pm 2510278$

4. Ending stocks (mt)
$WESTK = 580630420/(PWXA - 4500) + .171458\ (QW + QB + QS) + 4513628\ D6869 - 1171477$

Identities

5. Production, Australia (mt)
$QW = AWN \cdot YWN + AWQ \cdot YWQ + AWS \cdot YWS + AWV \cdot YWV + AWW \cdot YWW + QWO$

6. Exports (mt)
$QWX = QW + WESTK_{-1} - QWDH - QWDF - QWDO - WESTK$

7. Effective price (cts/mt)
(a) to 1973/74:
(i) where $PWX < PWG$
$PW = (a \cdot PWH + b \cdot PWF + e \cdot PWG + (c - e) \cdot PWX)/d$
where, $a = (QWDH + QWDH_{-1} + QWDH_{-2})/3$
$b = (QWDF + QWDF_{-1} + QWDF_{-2})/3$
$c = d - (a + b)$
$d = (QW + QW_{-1} + QW_{-2})/3$
$e = QWXG$
(ii) where $PWG < PWX < (PWF + TAX)$
$PW = (a \cdot PWH + b \cdot PWF + c \cdot PWG)/d$
(iii) where $PWX > PWG + TAX$
$PW = (a \cdot PWH + b \cdot PWF + c\ (PWX - TAX))/d$
(b) after 1973/74
(i) where $PWX < SP - STAB$ $\quad PW = (a \cdot PWH + b \cdot PWF + c\ (PWX + STAB))/d$
(ii) where $/PWX - SP/ < STAB$ $\quad PW = (a \cdot PWH + b \cdot PWF + c \cdot SP)/d$
(iii) where $PWX > SP + STAB$ $\quad PW = (a \cdot PWH + b \cdot PWF + c\ (PWX - STAB))/d$
(c) expected average export return $\quad PWX = .9160\ PWXA_{-1}$
(d) expected stabilization price $\quad SP = (7SP_{-1} + PWX_{-1})/8$

Price Relations

8. Australia's export price quotations
$PWXA = 14.3941\ (PWUS/EXCH - PWUS_{+1}/EXCH_{+1}) + 41.7397\ PWUS_{+1}/EXCH_{+1} + 480.064$

9. Australian Barley Board, home consumption price feed barley (cts/mt)
$PBF = .640373\ PBX + 2036.74$

BARLEY MODEL

Behavioral Equations

1. Area planted (ha)
   $AB = 175.985\ PBA_{-1} + 39457.9\ T + 873751\ D7072 - 1982925$

2. Domestic food use (mt)
   $QBDH = .49605\ QBDH_{-1} + 19316.2\ Y - 9581.80\ Y_{-1} + 10064.6$

3. Domestic feed use (mt)
   $QBDF = -380638\ PBX/PWF - 114.478\ LAMBPER + 187.458\ I + 806523$

4. Ending stocks (mt)
   $BESTK = -46.1755\ PBX + .020051\ (QW + QB + QS) + 360408$

Identities

5. Production (mt)
   $QB = AB \cdot YB$

6. Exports (mt)
   $QBX = QB + BESTK_{-1} - QBDH - QBDF - QBDO - BESTK$

Price Relations

7. First advance, Australian Barley Board (cts/mt)
   $PBA = .569712\ PBX + 626.593$

8. Average export value (cts/mt)
   $PBX = 54.1701\ PBUS/EXCH - 102.174$

SORGHUM MODEL

Behavioral Equations

1. Area planted (ha)
   $AS = 56.7433\ PS_{-1} - 56.9736\ PW_{-1} - 30.3711\ PBQA_{-1} - 267756\ SC + 18871\ T - 530733$

2. Domestic use (mt)
   $QSD = -321605\ PSX_{-1}/PWF - 150.708\ LAMBPER + 70.4185\ I_{-1} + 1321200$

Identities

3. Production (mt)
   $QS = AS \cdot YS$

4. Exports (mt)
   $QSX = QS + SESTK_{-1} - QWD - SESTK$

Price Relations

5. Total payments, Central Queensland Grain Sorghum Marketing Board (cts/mt)
   $PS = .469152\ (PSX - PSX_{-1}) + .903448\ PSX_{-1} - 949.136\ SC - 291.328$

6. Average export value (cts/mt)
   $PSX = 35.5147\ (PSUS/EXCH - PSUS_{-1}/EXCH_{-1}) + 49.4102\ PSUS_{-1}/EXCH_{-1} - 313.145$

7. First advance, Queensland Barley Board
   $PBQA = .513367\ PBX + 1227.08$

VARIABLE DEFINITION

Note: Subscripts on variables ($\pm i$) indicate values which are lagged (-) or carried forward (+) by i years.

AB = barley area, Australia (ha)
AS = sorghum area, Australia (ha)
AWN = wheat area, New South Wales (ha)
AWQ = wheat area, Queensland (ha)
AWS = wheat area, South Australia (ha)
AWV = wheat area, Victoria (ha)
AWW = wheat area, Western Australia (ha)
BESTK = barley ending stocks (mt)
CANSW = cultivated area, New South Wales (100,000 ha)
CAQ = cultivated area, Queensland (100,000 ha)
CASA = cultivated area, South Australia (100,000 ha)
CAV = cultivated area, Victoria (100,000 ha)
CAWA = cultivated area, Western Australia (100,000 ha)
D6669 = zero-one variable. It equals 1 for 1966/67 to 1969/70 and 0 otherwise
D68 = zero-one variable. It equals 1 for 1968/69 and 0 otherwise
D6869 = zero-one variable. It equals 1 for 1968/69 and 1969/70 and 0 otherwise
D70 = zero-one variable. It equals 1 for 1970/71 and 0 otherwise
D7072 = zero-one variable. It equals 1 for 1970/71 to 1972/73 and 0 otherwise
EXCH = US - Australian exchange rate ($US/$Aust)
I = index of intensive livestock production
LAMBPER= lambing percent (lambs marked per ewe mated)
NJ = Australian population at June 30 (1,000 hd)
PBA = barley first advance, Australian Barley Board (cts/mt)
PBF = barley (feed) home consumption price, Australian Barley Board (cts/mt)
PBQA = barley first advance, Queensland Barley Board (cts/mt)
PBUS = barley, US season ave. price (US cts/bu)
PBX = barley ave. export value (cts/mt), July-June year
PS = sorghum total payments, Central Queensland Sorghum Board (cts/mt)
PSUS = sorghum, US season ave. price (US cts/bu)
PSX = sorghum ave. export value (cts/mt), July-June year
PW = wheat, effective price (cts/mt)
PWF = wheat for feed, home consumption price (cts/mt)
PWG = wheat guaranteed price (cts/mt), to 1973/74 only
PWH = wheat for food, home consumption price (cts/mt)
PWO = wool, season ave. price of all greasy (cts/10 gm)
PWUS = wheat, US season ave. price (US cts/bu)
PWX = wheat, expected ave. export return (cts/mt)
PWXA = wheat, annual ave. of export price quotations (cts/mt)
QB = barley production (mt)
QBDF = barley feed use (mt)
QBDH = barley food/industrial use (mt)
QBDO = barley seed use (mt)
QBX = barley exports (mt)
QS = sorghum production (mt)
QSD = sorghum domestic use for all purposes (mt)
QSX = sorghum exports (mt)
QW = wheat production (mt)
QWDF = wheat feed use (mt)
QWDH = wheat food use (mt)
QWDO = wheat seed use (mt)
QWO = wheat production, other states (mt)
QWX = wheat exports (mt)
QWXG = wheat guaranteed export quantity (mt), to 1973/74 only

SC	= structural change variable. It equals 1 prior to 1969/70, .5 in 1969/70, 0 otherwise
SP	= wheat, expected stabilization price (cts/mt), from 1974/75 only
SESTK	= sorghum ending stocks (mt)
STAB	= maximum payment into or out of stabilization funds (cts/mt), from 1974/75 only. In current scheme it equals $5.51/mt.
T	= linear trend. It equals 55 in 1955/56 and rises to 80 in 1980/81
TAX	= maximum export tax payable into stabilization fund (cts/mt), to 1973/74 only. In most years it equaled $5.51/mt.
WESTK	= wheat ending stocks (mt)
Y	= private consumption expenditure ($ million), July-June year
YB	= barley yield (mt/ha)
YS	= sorghum yield (mt/ha)
YWN	= wheat yield, New South Wales (mt/ha)
YWQ	= wheat yield, Queensland (mt/ha)
YWS	= wheat yield, South Australia (mt/ha)
YWV	= wheat yield, Victoria (mt/ha)
YWW	= wheat yield, Western Australia (mt/ha)

The expression for the price change of a commodity resulting from a devaluation is used in chapter on Model Solution. Suppose, initially, a commodity produced in Australia has excess demand and supply curves as represented by ED_1 and ES in figure 27. The axes are quantity (Q) and price (P) expressed in Australian dollars. The curves may be expressed algebraically as,

$$ES = a + bP$$
$$ED_1 = c + dP$$

At equilibrium, $ES = ED_1$ and price, $P_1 = (c - a) / (b - d)$. Now suppose Australia devalues its dollar by $(1/D - 1) \times 100$ percent where D = new value (in terms of U.S. dollars)/old value. Then the excess demand curve shifts to say ED_2 where,

$$ED_2 = c + dD\,P$$

At equilibrium, price is $P_2 = (c - a) / (b - dD)$.

Hence, $P_2/P_1 = (b - d) / (b - dD)$.

Now, $b \approx e_{ES} \cdot \frac{Q1}{P_1}$

$d \approx e_{ED} \cdot \frac{Q1}{P_1}$

and so, $P_2/P_1 \approx (e_{ES} - e_{ED}) / (e_{ES} - e_{ED} \cdot D)$.

FIGURE 29--EXCESS SUPPLY (ES) AND DEMAND (ED) CURVES FOR A HYPOTHETICAL COMMODITY PRODUCED IN AUSTRALIA

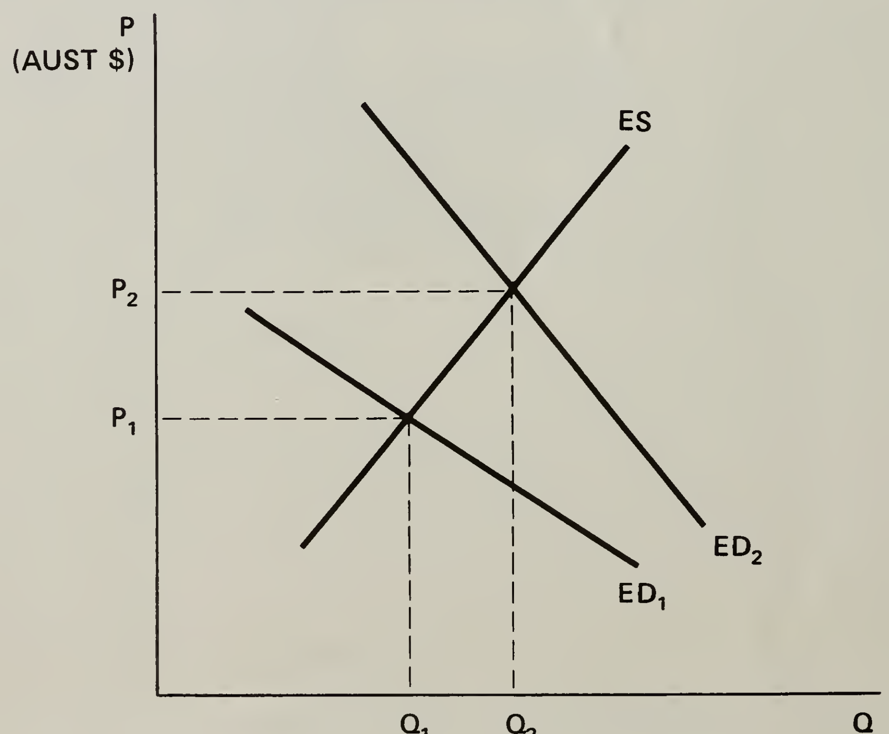
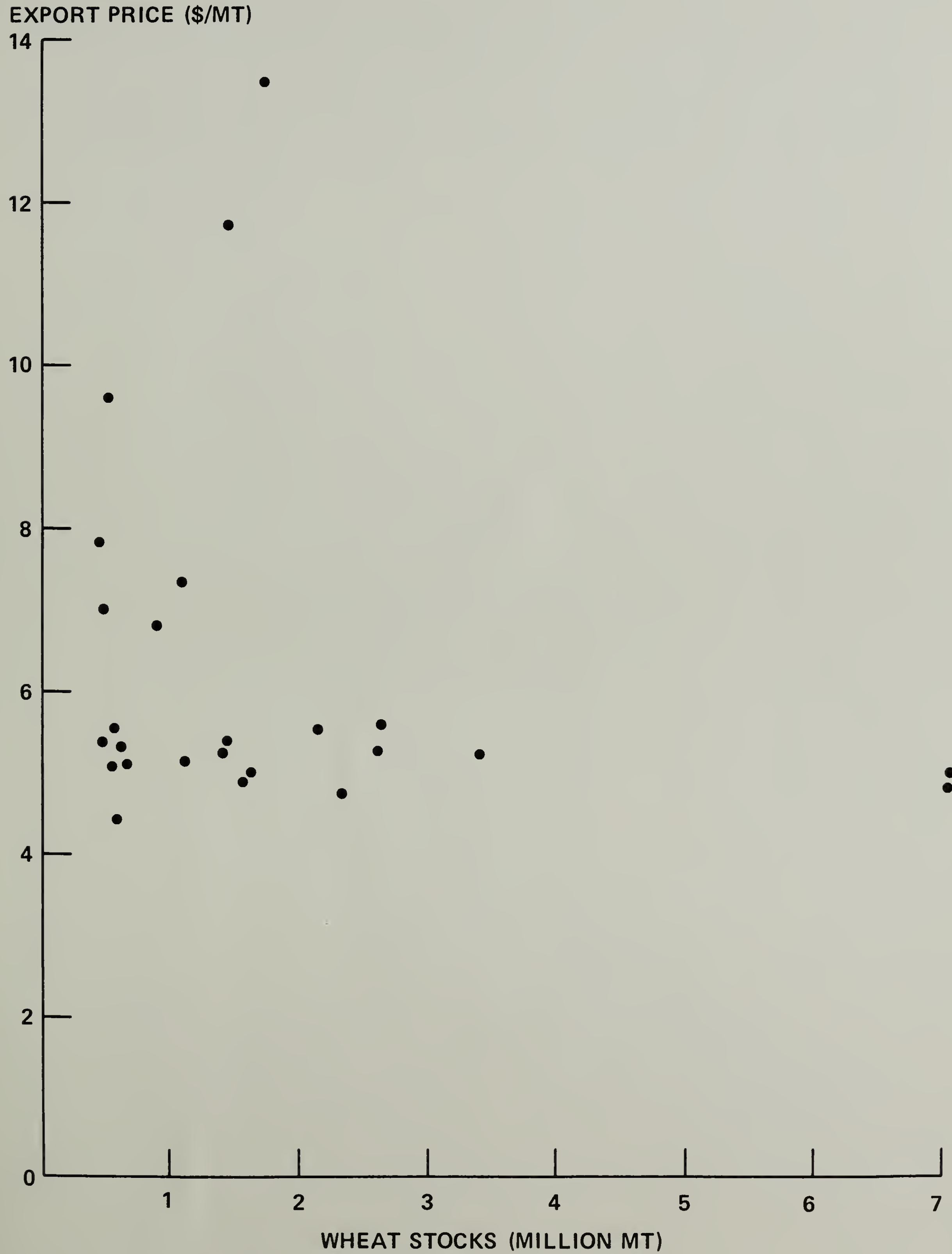


FIGURE 30--PLOT OF THE ANNUAL AVERAGE OF AWB EXPORT PRICE QUOTATIONS AGAINST AUSTRALIAN CARRYOVER WHEAT STOCKS, 1949/50 to 1974/75



☆ U. S. GOVERNMENT PRINTING OFFICE : 1978 261-296/85

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

POSTAGE AN[D FEES PAID]
U.S. DEPA[RTMENT OF]
AGRICULTURE
AGR 101
THIRD CLASS

U.S.MAIL