PROBLEMS IN AGGREGATE AGRICULTURAL SUPPLY ANALYSIS: I—THE CONSTRUCTION OF TIME SERIES FOR ANALYSIS*

ALAN A. POWELL† and F. H. GRUEN†

In this paper we are concerned with the following six major rural products:

(1) Wheat.
(2) Wool.
(3) Coarse Grains.
(4) Lamb.
(5) Beef and Veal.
(6) Dairy Products.

For a complex of reasons associated with the suitability and availability of data (but especially in order to eliminate the influence of the disastrous pastoral drought of 1945–46), we have chosen the crop years 1947–48 to 1964–65 as our sample period.

Our present aim is to construct (and to document, as scientifically as possible, the construction of) price and output indicators which are suitable for aggregative supply analysis. In a later paper[1] we present tentative empirical results for simultaneous supply equations covering the wheat, wool and coarse grains sectors.[2]

Raw production statistics usually are not appropriate for empirical supply analysis. Patently, they may not reflect producers' intentions accurately because of the erratic influence of climate. Again, production statistics to some extent include trends in productivity which are not likely to be very responsive to prices—the improvement of wheat yields over time provides an example. Moreover, productivity trends of this kind must be allowed for somewhere. If the output series are not adjusted in advance, explicit allowance must be made within the supply model itself. This suffers from at

* Based largely on a paper delivered to the Tenth Annual Conference of the Australian Agricultural Economics Society at Melbourne University, February, 1966. This research was financed, in part, under contract to the United States Department of Agriculture.

We wish to acknowledge the generous co-operation of the Commonwealth Bureau of Census and Statistics in supplying us with many items in advance of publication. We are especially grateful to the Bureau of Agricultural Economics for making available indexes on prices received by farmers. Without these series, our analyses could scarcely have been attempted. The Australian Wheat Board also supplied us with a quantity of unpublished information which turned out to be particularly valuable in our estimation of wheatgrowers' price responsiveness. Finally, we must record our appreciation of Mrs Terry Pez to whose resolute patience the construction of most of our time series must be attributed.

† Monash University.

[1] "Problems in Agricultural Supply Analysis: II—Preliminary Results for Cereals and Wool", this *Review* (in press).

[2] In a projected third paper, we shall address ourselves to the (more ambitious) task of fitting as many as six supply equations simultaneously.

least two disadvantages. First, to the extent that they failed to be incorporated successfully into explicit shift variables (and thence were attributed to price influences), trends in productivity would cause a supply system to lack symmetry with respect to upward and downward changes in price. Second, the introduction of further parameters to be estimated in the ultimate (and most critical) stage of analysis may cause "needless" embarrassment in the matter of degrees of freedom.[3] Hence below we have attempted to correct output indicators to allow for climate and autonomous trends in productivity.[4]

These very adjustments to quantity series have dictated complementary adjustments to price series. For if intended output of grains is quoted in "acres", then price must be quoted in "dollars per acre" rather than in dollars per bushel. And if the intended output of wool is measured by number of fleeces, then its price will be measured in dollars per fleece. Moreover, we assume that the historical revenues per acre (or per fleece) would not enter the producers' price extrapolations in their crude form. If seasons were below average, then producers would realize that their revenue per acre (or per fleece) would have been greater if only they had achieved average physical productivity. Also, yields have been rising secularly over time ; presumably producers would be aware of this and make some allowance for it in their estimates of future revenues. What we assume the grower does *not* take into account, however, is the falling marginal revenue schedule confronting his industry: as in the classical model of perfect competition we assume each producer to treat product prices as given—irrespective of seasons.

On to price series generated from considerations of this sort, we have—with one exception—superimposed the Koyck/Nerlove distributed lag model of price expectations.[5] However, details of the generation of the expected price series themselves (as distinct from the adjusted actual price series upon which these are based) shall be discussed in part II of this paper.

The exception so far as our treatment of price expectations is concerned, is that of wheat. In this case, we have attempted to allow directly for the impact of the complexities of institutional pricing upon producers' price expectations.

One further feature of our treatment of prices must be noted. In conventional supply analysis, the units in which prices are recorded are of no consequence—thus price index numbers with arbitrary bases are just as suitable for analysis as money amounts per unit of output. However, it is

[3] Whilst the embarrassment may be unnecessary, the underlying statistical uncertainty may in reality be inevitable, depending upon the quality or otherwise of the information used to effect the prior adjustment of the series.

[4] Analogous to autonomous trends in productivity would be "autonomous" trends in the basic psychological make-up of farmers—due possibly to improvements in education and extension—which could conceivably affect farmers' basic responsiveness to prices. Needless to say, we have been unable to correct our series to allow for any such trends in the basic parametric structure of the supply response. The results reported in Part II of this paper, then, are to be interpreted as an average for the sample period.

[5] Marc Nerlove, *The Dynamics of Supply: Estimation of Farmers' Response to Price* (Baltimore: The Johns Hopkins Press, 1958).

our intention here to use a newly developed technique,[6] in which the value shares of different products in gross revenue are critical. Thus where our primary source of data has been B.A.E. indexes of prices received by farmers, we have been obliged to convert these series back to money terms. Ideally, we would have done so on the basis of average local values of production; i.e., we would have recorded prices net of freight and marketing costs. However, for certain products, this was not feasible. As a result, we have been forced to work with price series which correspond more closely with the concept of unit *gross* value of production.

Planned Output—Wheat

Over the past thirty years the national average wheat yield has increased by upwards of sixty per cent. This long term trend is unlikely to be very responsive to short—or even long run changes in price. Rather it reflects advances in plant breeding and the steady adoption of "best-practice" techniques of cropping. On this view we are justified in treating the trend value of yield per acre as a "normal" or "weather-free" variable. Relevant results from a least-squares regression of yield per acre on time are given below in Table 3. This regression was based on data for 1930–31 to 1963–64, a period of apparently uniform technological improvement. Fluctuations about the trend value are ascribed to weather, not to the conscious planning of the wheat-farmer. This is an oversimplification, but we believe a very good first approximation.

The annual Agricultural and Pastoral census (*A & P* census) occurs at the beginning of autumn, during which season all sowing must be carried out: wheat is a winter crop in Australia (although the varieties used correspond more closely to spring wheats in the northern hemisphere). One question asked on the *A & P* census return relates to planned wheat acreage. The published official statistics collate these data over the period of interest for four States, whilst for one of the remaining two States (Victoria) we were able to obtain unpublished data. Queensland, for which planned acreage data are not available, accounts for less than ten per cent of the national acreage in all post-war years. The planned acreage figures refer to wheat sown for all purposes and hence include some two to four per cent which subsequently is used for hay or green fodder.

Table 1 gives the planned acreage of wheat and the actual area sown for the aggregate of five states with data on plans available. Table 2 gives national figures on the actual acreages of wheat used for grain and for other purposes.[7]

Use of the planned acreage series is open to a number of objections. In the first place, weather conditions prior to the date of the census may very well affect farmers' intended plantings. It may be claimed that

[6] Alan A. Powell and F. H. Gruen, "The Constant Elasticity of Transformation Production Frontiers and Linear Supply Systems", *International Economic Review* (in press).

[7] Over the period 1947–48 to 1963–64 grain acreage as a percentage of the total showed a rise of one (perhaps two) percentage points from 96 per cent at the beginning to 97 (perhaps 98) per cent at the end. Significant deviations *downwards* occurred in 1954–55 (93 per cent) and 1957–58 (94 per cent), in which years abnormally large acreages were used as green fodder. However, the uniformly high percentage of wheat acreage harvested for grain seems to warrant a simplified treatment which we adopt below.

TABLE 1

Planned and Actual Wheat Acreages for Five Australian States:* 1946–47 to 1964–65

Crop Year	Million Acres		Ratio (Actual/ Planned)
	Planned†	Actual‡	
			per cent
1946–47	13·440	13·180	98·07
1947–48	14·057	13·418	95·45
1948–49	13·136	11·975	91·16
1949–50	12·327	11·640	94·42
1950–51	11·850	11·104	93·70
1951–52	10·402	9·929	95·45
1952–53	10·130	9·485	93·63
1953–54	10·479	10·171	97·06
1954–55	10·508	9·985	95·02
1955–56	9·991	9·584	95·92
1956–57	8·494	7·514	88·46
1957–58	9·119	8·387	92·08
1958–59	9·714	9·695	99·80
1959–60	12·034	11·489	95·47
1960–61	12·905	12·746	98·76
1961–62	14·141	13·973	98·81
1962–63	15·776	15·550	98·56
1963–64	16·643	15·536	93·34
1964–65	17·432	17·180	98·55
Mean	12·241	11·713	95·69

* Data excludes Queensland.

† All purposes—includes area for hay and green fodder.

‡ Planted for grain.

Sources:

(1) Published data for New South Wales, Tasmania, South Australia and Western Australia from: Commonwealth Bureau of Census and Statistics, *Production Bulletin, Primary Industries*, Bulletins Nos 42-56, 1947-48 to 1961–62 (Canberra).
Unpublished data for Victoria supplied by Commonwealth Bureau of Census and Statistics.

(2) Commonwealth Bureau of Census and Statistics, *Statistical Bulletin: The Wheat Industry*, 1946–47 to 1964–65 (Canberra).

seasonal conditions at sowing time may be relatively less important than conditions during the several months prior to sowing. As a generalization this may be true, but nevertheless, there were undoubtedly years (i.e., 1956–57) in our post-war experience during which conditions at sowing time did have a significant impact upon acreages; and at all events, we do not have any series from which we might make additional corrections.

It is clear, however, from Table 1 that farmers on average say that they plan to sow more wheat than they actually do. This is as would be expected; decisions affecting the maximum area that can be planted in any sowing season have to be taken well in advance of the census date: farmers' plans thus tend to specify a maximum performance, rather than an average. But we are essentially interested in an average. Con-

sequently, our adjusted acreage series should take account of farmers' propensity to overstate what can be achieved under average weather conditions.[8]

TABLE 2

Area of Wheat Crop Harvested for Grain and Used for Other Purposes: Australia, 1947–48 to 1963–64

Crop Year	Area used for—			Grain as a Percentage of Total
	Grain	Hay	Green Fodder	
	Million acres			
1947–48	13·880	0·524	0·113	96
1948–49	12·583	0·365	0·124	96
1949–50	12·240	0·336	0·138	96
1950–51	11·663	0·259	0·123	97
1951–52	10·384	0·277	0·178	96
1952–53	10·209	0·245	0·116	96
1953–54	10·751	0·295	0·148	96
1954–55	10·673	0·637	0·160	93
1955–56	10·166	0·245	0·121	97
1956–57	7·874	0·145	0·104	97
1957–58	8·848	0·412	0·187	94
1958–59	10·399	0·244	0·117	97
1959–60	12·172	0·239	0·164	97
1960–61	13·439	0·248	0·208	97
1961–62	14·723	0·207	0·239	97
1962–63	16·469	0·219	0·221	97
1963–64	16·474	0·165	0·201	98

Source: Commonwealth Bureau of Census and Statistics, *Production Bulletin, Primary Industries*, Bulletin Nos 42–56, 1947–48 to 1961–62 (Canberra).

To eliminate the bias which would otherwise pertain, we should like to estimate β in

(1) $(actual\ acreage) = \beta\ (planned\ acreage) + error,$

where β is less than unity. However, in view of the fact that the variable on the right hand side can in no real sense be claimed to be measured accurately, a least-squares estimate $\hat{\beta}$ of β in (1) would be statistically

[8] It cannot be claimed that any compensating tendency exists by virtue of our failure to consider conditions prior to the census. The area of land potentially croppable in any given year at March 31st (the census date) depends on preceding weather conditions, which may have been average, favourable or adverse. The potentially croppable area, whilst setting the maximum to the area actually cropped, is not in itself the minimum of another distribution, but rather an average.

To this must be added the simpler explanation that the "actual" figures refer only to wheat "planted for grain".

inconsistent and an underestimate.[9] One can, however, set limits for β by considering also an estimate $\beta^* = 1/\hat{\alpha}$ where $\hat{\alpha}$ is the least-squares estimate of α in

(2) $(planned\ acreage) = \alpha\ (actual\ acreage) + error.$

We have

$$\left.\begin{aligned} (3)\quad \hat{\beta} &= \Sigma A_t P_t / \Sigma P_t^2 \\ (4)\quad \beta^* &= \Sigma A_t^2 / \Sigma A_t P_t \end{aligned}\right\} \quad t = 1947\text{–}48 \text{ to } 1963\text{–}64$$

where A_t = actual acreage in t,

and P_t = acreage planned for t.

Provided our sample were large enough β would lie between $\hat{\beta}$ and β^*—in this instance between 0·954 and 0·955! Of course, the closeness of these limits may be spurious in view of the sample size.

Multiplying the planned acreage series through by our estimate of β (say 0·955) produces a series of acreages which could have been achieved under average weather conditions. It reflects both farmers' plans and farmers' capabilities in an "average" season. But we are only able to make this adjustment for states other than Queensland; i.e., for some 90–95 per cent of acreage. We have had no plausible alternative but to add in the *actual* Queensland figure, neglecting any further errors which might be introduced in this way. Such errors, at all events, do not introduce a systematic bias. That is to say, the resultant figures tend neither to under- nor to over-state actually achievable performance, on average. This adjusted acreage variable is used below as our index of planned output for the wheat industry.

Before proceeding to derive an expected-price series for wheat, it is necessary to review briefly the impact of post-war legislation on wheat prices.

Provisions of the Wheat Stabilization Scheme

As a result of the "stabilization" machinery enacted early in the post-war period, the Australian wheat supply is channelled through a semi-governmental marketing agency. Australian consumers are charged a fixed domestic price (different from export parity), whilst the surplus is exported on whatever terms can be obtained by the central marketing authority, the Australian Wheat Board.

A stabilization fund was created at the inception of the scheme, with the purpose of raising growers' incomes if (and when) export parity should fall below the domestic price. The fixed domestic price was hence known as the "guaranteed" price. However, as will be explained presently, the extent of the Government's liability was limited.

The guaranteed price itself was (and continues to be) fixed on the basis of the so-called "cost of production". This figure is determined at the time of each renewal of the scheme (i.e., every five years) from a sample

[9] J. Johnston, *Econometric Methods* (New York: McGraw Hill, 1963), pp. 148–50.

TABLE 3

Estimates of Wheat Farmers' Intended Production, Australia: 1946–47 *to* 1964–65

Crop Year	Area*			"Normal" Yield§	Planned Output‖
	Planned for Five States†‡	Actual in Queensland	Total		
	million acres			Bushels per acre	Million bushels
1946–47 ..	12·835	0·248	13·083	14·524	190·0
1947–48 ..	13·424	0·462	13·886	14·766	205·0
1948–49 ..	12·545	0·608	13·153	15·008	197·4
1949–50 ..	11·772	0·600	12·372	15·250	188·7
1950–51 ..	11·317	0·599	11·916	15·492	184·6
1951–52 ..	9·982	0·455	10·437	15·734	164·2
1952–53 ..	9·674	0·724	10·398	15·976	166·1
1953–54 ..	10·007	0·580	10·587	16·218	171·7
1954–55 ..	10·035	0·688	10·723	16·460	176·5
1955–56 ..	9·541	0·582	10·123	16·702	169·1
1956–57 ..	8·118	0·350	8·478	16·944	143·6
1957–58 ..	8·709	0·461	9·170	17·186	157·6
1958–59 ..	9·277	0·704	9·981	17·428	173·9
1959–60 ..	11·493	0·683	12·176	17·670	215·1
1960–61 ..	12·324	0·693	13·017	17·912	233·2
1961–62 ..	13·505	0·750	14·255	18·154	258·8
1962–63 ..	15·066	0·919	15·985	18·396	294·1
1963–64 ..	15·894	0·938	16·832	18·638	313·7
1964–65 ..	16·648	1·026	17·674	18·880	333·7
1965–66 ..	..	..	17·5 ¶	..	..

* Includes some 2 to 4 per cent used for hay and green fodder.

† Excludes Queensland.

‡ Adjusted to correspond to achievable performance in an "average" year.

§ Values "predicted" from a linear regression of yield on time, 1930–31 to 1963–64. No significant departure from linearity could be detected in the yield series.

‖ Product of preceding two columns.

¶ Our preliminary estimate.

Source: See Table 1.

survey conducted by officers of the Bureau of Agricultural Economics. The figure called "cost of production" is obtained by applying a formula to items of expense (fixed and variable) recorded by wheat farmers in the sample selected by the Bureau. Annual adjustments are made to the guaranteed price on the basis of movements in indicators of cost during the year.

During the initial years of the scheme, export prices were at an unprecedented level; as a consequence the guaranteed price was well below export parity. During this period, the producer was taxed by the amount per bushel by which the export price exceeded the guaranteed cost of production in the season in which the grain was harvested, except in the event that this figure exceeded 15 cents, in which case the latter amount constituted the tax. Under the plan of 1948 (but which was operating,

in effect, from 1946), no limit was placed on the size of the stabilization fund. In 1954 and at the subsequent renewal in 1958 a limit of $40 million was set to the total of growers' contributions. This was far less than the $151.2 million collected between 1945–46 and 1951–52, and subsequently refunded to growers. The limit was raised to $60 million in 1963.

In the later versions of the plan, the balance in the fund at the time of renewal was carried forward. When the fund reached ceiling level, refunds were made to growers on the "first in, first out" principle.

TABLE 4

Details of Instalments Paid to Growers by the Australian Wheat Board: 1940–41 *to* 1961–62

Crop Year	Waiting Period* (Years)						
	Instalment Number						
	1	2	3	4	5	6	7
1940–41† ..	0·72	1·28	1·65	2·21	2·61	5·36§	..
1941–42† ..	0·75	2·21	2·78	3·15	4·18§	..	..
1942–43† ..	0·73	2·04‖	2·69‖	3·23‖	3·70	5·16¶§	..
1943–44† ..	0·72	1·69‖	2·28‖	3·18‖	3·18	3·51	3·88§
1944–45† ..	0·72	1·28‖	2·29‖	2·29	3·12§	..	..
1945–46‡ ..	0·72	1·41	1·70	2·12	2·52	3·72§	..
1946–47‡ ..	0·68	1·23	1·63	1·97	2·41	3·14§	..
1947–48‡ ..	0·67	1·17	1·41	1·63	1·94	2·61	3·93§
1948–49 ..	0·75	1·45	1·66	1·94	2·44	3·70§	..
1949–50 ..	0·68	1·44	1·70	2·05	2·30	3·35§	..
1950–51 ..	0·68	1·39	1·54	1·89	2·19	3·71§	..
1951–52 ..	0·69	0·99	1·61	1·88	2·10	2·34	3·11§
1952–53 ..	0·67	1·96	2·31	2·55	2·96§	..	..
1953–54 ..	0·67	2·45	2·68	3·41§	..	..	..
1954–55 ..	0·68	2·45	2·56	3·64§	..	..	..
1955–56 ..	0·68	2·24	2·52	2·95§	..	..	..
1956–57 ..	0·67	2·16	2·52	2·63	2·90§	..	..
1957–58 ..	0·67	1·98	2·23§	..	..	..	..
1958–59 ..	0·67	2·21	2·47§	..	..	..	..
1959–60 ..	0·67	2·13	2·32§	..	..	..	..
1960–61 ..	0·67	1·00	1·95	2·24	2·51	2·95§	..
1961–62 ..	0·67	1·87	2·02	2·12	2·44§	..	..

* Calculated from the approximate date of sowing; i.e., from March 31st in the year of planting.

† Wartime arrangements.

‡ Interim arrangements pending the adoption of the Wheat Stabilization plan.

§ Final payment.

‖ Instalment paid in respect of non-quota wheat only.

¶ Instalment paid in respect of "quota" wheat only.

Source: Australian Wheat Board, *Annual Report* 1962–63 (Melbourne), pp. 29–30; supplemented by unpublished statistics made available by the Australian Wheat Board.

Likewise, the financial liability of the Federal Government had varied over the years. During periods when the fund is exhausted, the Treasury is pledged to put up a subsidy of sufficient size to secure the guaranteed price. However, this guarantee does not extend to all (potential) exports, but only to the first 150 million bushels. Prior to 1963–64, the limit covered only the first 100 million bushels exported.

In fact, the stabilization fund first ran out in 1961. Subsidies of the order of $61 million were paid to support the prices received for the crops of 1959–60 through 1962–63.[10]

TABLE 5

Details of Instalments Paid to Growers by the Australian Wheat Board: 1940–41 *to* 1961–62

Amount of Instalments* (cents per bushel)

Crop Year	Instalment Number						
	1	2	3	4	5	6	7
1940–41† ..	29·3	3·3	2·5	2·5	0·8	0·5§	..
1941–42† ..	29·1	2·5	3·3	2·5	1·5§	..	..
1942–43† ..	33·2	10·0‖	5·0‖	4·2‖	6·3‖	0·8‖§	..
1943–44† ..	35·1	10·0‖	5·8‖	4·2‖	10·0	3·2	0·2§
1944–45† ..	38·5	7·5‖	3·6‖	7·9‖	1·3§	..	..
1945–46‡ ..	42·0	10·0	5·0	5·0	1·7	11·7§	..
1946–47‡ ..	41·7	15·0	10·0	10·9	4·6	9·6§	..
1947–48‡ ..	47·1	20·0	20·0	20·0	15·0	6·4	17·4§
1948–49 ..	51·8	15·0	10·0	20·0	3·5	15·2§	..
1949–50 ..	61·9	20·0	15·0	15·0	5·5	16·0§	..
1950–51 ..	68·0	10·0	10·0	21·6	6·9	14·3§	..
1951–52 ..	81·2	15·8	10·0	15·6	8·7	1·8	13·3§
1952–53 ..	122·3	10·0	15·8	3·3	1·7§	..	..
1953–54 ..	101·1	10·4	10·0	6·6§	..	..	..
1954–55 ..	104·7	10·0	4·5	2·9§	..	..	..
1955–56 ..	96·3	7·5	13·2	5·5§	..	..	..
1956–57 ..	101·3	10·0	10·7	3·3	2·0§	..	..
1957–58 ..	111·1	15·4	5·0§	..	..	..	..
1958–59 ..	111·1	10·0	12·4§	..	..	..	..
1959–60 ..	110·8	15·3	9·7§	..	..	..	..
1960–61 ..	90·8	20·0	10·0	5·3	7·5	4·1§	..
1961–62 ..	110·7	10·2	10·0	7·5	7·2§	..	..

* Weighted average figure for bagged and bulk deliveries.

† Wartime arrangements.

‡ Interim arrangements pending the adoption of the Wheat Stabilization Plan.

§ Final payment.

‖ Weighted average figure for quota and non-quota categories, computed on the assumption that bagged and bulk deliveries have equal relative frequencies for both categories of wheat.

Source: As for Table 4.

[10] Australian Wheat Board, *Annual Report* 1962–63 (Melbourne), p. 22.

Expected Price Series for Wheat

The picture is further complicated by the Australian Wheat Board's practice of paying growers in multiple instalments. Thus in the late 1940's and early 1950's, growers received typically six payments (rarely five or seven) in respect of a single crop, extending over a period of somewhat more than thirty-six months from the date of harvesting. In the mid-1950's this pattern changed to one of typically four instalments, terminating rather earlier. In 1960–61 the payment pattern showed signs of changing once again. Details of number of instalments, amounts paid, and waiting periods for payment are given in Tables 4 and 5.

In this context it is seen that the formulation even of a naive model of price expectations is by no means straightforward. One extreme position would be to ignore price altogether, concentrating rather on the income receipts of wheatgrowers during preceding production periods. But this surely is going too far: wheat producers are made aware through a multitude of channels (in the press and elsewhere) of prospective wheat prices. Moreover, they are certainly able to identify income coming from different crops, if only they care to keep some simple records.

An important requirement for a realistic model of how wheat farmers make their judgments about future prices is that price expectations should be a function only of variables whose values are already known at the time when the expectations are formulated. In fact, at the time of sowing a crop, more or less final information on receipts may only be available for crops sown two or more years previously. This was particularly true of the period prior to 1952–53, as may be verified from Tables 4 and 5. Since that time a more substantial proportion of total receipts has been made in the first instalment (see Table 6).

If one were to defer judgment about total receipts from a given crop until the last cheque came in, the *shortest* lag in a model of price expectations would often exceed three years (see Table 4). This would imply discarding information about initial payments received in respect of more recent crops, which hardly seems rational. A simple (albeit arbitrary) expectations rule which avoids such long lags is cast in terms of the date by which, typically, an arbitrarily high proportion of total receipts from a given crop may be expected to accrue. In six of twelve crop years prior to 1952–53, 80 per cent or more of total receipts had been received in time to be included in farmers' price calculations for the crop planted two years later—this on the assumption that March 31st is the critical date for wheat sowing. In five of the remaining instances, the lag on this basis would be three years. In the case of 1943–44, a lag of four years would be involved. The crops involving a three-year lag tended to occur early in the sub-period (1941–42, 1942–43, 1944–45, 1945–46, and 1949–50). Allowing for a two-year learning period beyond 1945–46 would suggest use of a three-year lag until 1947–48, a two-year lag being more appropriate for 1948–49 through 1951–52.

TABLE 6

First Instalments, "Ex Post" Present Values, and Total Receipts: Australian Wheat Industry* 1940–41 *to* 1961–62

Crop Year	(1) Total Receipts Obtained from Crop †	(2) First Instalment †	(3) *Ex Post* Present Value †	(4) First Instalment as a Proportion of Total Receipts 2/1	(5) *Ex Post* Present Value as a Proportion of Total Receipts 3/1
	Cents per bushel				
1940–41 ..	39·0	29·3	35·4	0·75	0·91
1941–42 ..	39·0	29·1	34·6	0·75	0·89
1942–43 ..	59·5	33·2	51·1	0·56	0·86
1943–44 ..	68·6	35·1	58·9	0·51	0·86
1944–45 ..	58·8	38·5	52·8	0·66	0·90
1945–46 ..	75·4	42·0	65·9	0·56	0·87
1946–47	91·8	41·7	80·8	0·45	0·88
1947–48 ..	145·8	47·1	126·8	0·32	0·86
1948–49 ..	115·5	51·8	99·9	0·45	0·87
1949–50 ..	133·4	61·9	116·6	0·46	0·87
1950–51 ..	130·7	68·0	114·8	0·52	0·88
1951–52 ..	146·5	81·2	130·5	0·55	0·89
1952–53 ..	153·2	122·3	139·7	0·80‡	0·91
1953–54 ..	128·1	101·1	115·6	0·79	0·90
1954–55 ..	122·1	104·7	111·6	0·86	0·91
1955–56 ..	122·5	96·3	110·8	0·79	0·91
1956–57 ..	127·3	101·3	115·6	0·80	0·91
1957–58 ..	131·5	111·1	121·0	0·84	0·92
1958–59 ..	133·5	111·1	122·1	0·83	0·92
1959–60 ..	135·8	110·8	124·3	0·82	0·92
1960–61 ..	137·8	90·8	125·0	0·66	0·91
1961–62 ..	145·6	110·7	132·4	0·76	0·91

* Present values computed under perfect foresight with an assumed annual rate of interest of ten per cent (compound).

† Weighted average of bagged and bulk deliveries.

‡ New payments policy adopted by Wheat Board.

Following a policy change, for the crop years of 1953–54 through 1959–60, the first instalment paid by the Wheat Board represented at least 79 per cent of total receipts in all cases. As the first payment is made at harvest time, this information is available when decisions are made for the following crop year. Again allowing for a two-year learning period, we suggest retaining the two-year lag for 1952–53 and 1953–54, but adopting a lag of a single year thereafter.[11]

[11] For the crop of 1960–61 the first instalment amounted to only 66 per cent of total receipts; however, the second instalment, bringing the cumulative percentage to 80 per cent, was made before 31st March in the following year. The first instalment in 1961–62 was down to 76 per cent.

TABLE 7

Two Conjectural Series for Australian Wheatgrowers' Price Expectations: 1947–48 to 1964–65

Crop Year	Data Upon Which Series II is Based				Price Expectations Series	
	Official "Cost of Production" (1)	Domestic Consumption (2)	Export Price (3)	Expected Total Production (4)	I (liquidity sensitive) (5)	II (liquidity insensitive) (6)
	cents per bushel	million bushels	cents per bushel	million bushels	cents per bushel	
1946–47 ..	50·0*	73·7	123·5	186·0	..	..
1947–48 ..	62·5*	71·0	170·1	232·4	72	100†
1948–49 ..	66·7	73·8	167·3	229·4	80	128‡
1949–50 ..	70·8	72·8	162·0	192·4	103	129
1950–51 ..	78·3	77·8	175·0	174·4	156	138
1951–52 ..	100·0	75·8	176·6	176·9	140	133
1952–53 ..	119·2	70·5	182·2	152·9	137	139
1953–54 ..	125·8	64·4	166·5	150·8	153	152
1954–55 ..	125·8	67·4	144·6	178·0	131	152
1955–56 ..	130·8	64·7	131·2	183·8	105	138
1956–57 ..	136·7	71·8	132·4	168·5	120	131
1957–58 ..	141·7	67·2	144·6	116·3	127	139
1958–59 ..	145·0	65·7	141·8	133·2	139	143
1959–60 ..	149·2	70·9	134·9	192·8	139	145
1960–61 ..	151·7	68·2	133·7	247·1	139	143
1961–62 ..	157·5	67·7	143·0	273·1	114	145
1962–63 ..	158·3	66·8	144·2	283·2	138	152
1963–64 ..	144·2	73·0	144·2	333·7	138	151
1964–65 ..	..	..	144·2	333·0	138	144

Sources and Notes:

Column 1: Australian Wheat Board, *Annual Report*, 1963–64 *Season* (Melbourne), pp. 13–14.

Column 2: Commonwealth Bureau of Census and Statistics, *Yearbook of the Commonwealth of Australia* (Canberra), issues for 1964 (No. 50) and earlier.

Column 3: Figures for 1947–48 to 1961–62 based on the *Wheat* component of the official *Export Price Index* (Commonwealth Bureau of Census and Statics, *Monthly Index of Australian Export Prices* (Canberra, mimeo), issue for July, 1962, p. 2).

Figures for 1962–63 and later based on the *Cereals* component of the same index, which in these later years replaced the former Wheat component, but in which wheat predominates [*CBCS, Export Price Index* (Canberra, mimeo), issue for June 1965, p. 2]. The two indexes were linked in the usual fashion using 1961–62 as pivot. Finally, the figures were converted to current value terms by multiplying the index (base, average of 3 years ended June, 1939 = 100) by the factor 0·405. This conversion factor was obtained by comparing the only current-value export price series for wheat which is available on a financial-year basis [Commonwealth Bureau of Agricultural Economics, *The Wheat Situation*, No. 16 (Canberra, June, 1960), p. 26] with the *Wheat/Cereals* series obtained from the official export price index over the limited number of years (1953–54 to 1958–59) for which the current value series is published.

Column 4: Expected total production has been taken as the product (ay), where a is a sliding linear trend projection (least-squares method), based on the preceding three years' actual acreages; and y is expected yield based on a least-squares regression of yield on time (see Table 3).

Column 5: Based on Tables 4 and 5. For sources and methods see text.

Column 6: Obtained by applying formula (5) in the text (page 124) where P_H is the domestic "cost of production" (Column 1) lagged one year; Q_H is domestic wheat consumption (Column 2) lagged one year; Q_G is the quantity of exports for which the guaranteed price operates (for 1949–50 to 1962–63, Q_G = 100 m. bushels; for later years Q_G = 150 m. bushels); P_E is export price of wheat (Column 3) lagged one year; and Q is expected total production (Column 4).

* Guaranteed minimum return under wartime arrangements. [Source: J. G. Crawford *et. al., Wartime Agriculture in Australia and New Zealand* (Stanford University Press, 1954), Table XI (A), p. 229].

† Figure obtained by putting $Q_G = 0$ in formula (5) and by treating figure in Column 1 as P_H.

‡ Computed under assumption that growers would have expected "cost of production" figure to be the previous year's guaranteed minimum return.

How might these speculations be employed to infer farmers' price expectations? Whilst it is true that because payments come in discrete amounts, the lags postulated above refer to the dates at which *rather more* than 80 per cent of the total receipts had accrued, nevertheless our model seems too rough to justify further refinement. Thus we will work on the hypothesis that farmers inflate actual payments up to a certain "cut-off" date by the factor 1.25; that these cut-off dates occur three years after planting for the period 1940–41 through 1947–48; two years after planting for 1948–49 through 1953–54; and one year after planting for the crops of 1954–55 through 1961–62. The most naive model takes as expected price the last value available from the series generated in the manner described above. This series is shown in Table 7. Because it attempts to make some allowance for the pattern of receipts in time (and hence for wheat farmers' liquidity problems), this series has been labelled "liquidity sensitive" in that table. However, it is clear that the allowance made for differences in the pattern of payments is rather minimal. In particular, no attempt has been made to discount the income streams accruing from the various crops to a present value at the time of planting. Some idea of the potential importance of this criticism can be gleaned from Table 6, where a series on the *ex post* present values of the income streams is given. This series is based on "perfect foresight" about the income streams, and in view of this the 10 per cent discount rate assumed may be none too high. On this basis the income streams atributable to different crops have varied between 86 and 92 per cent of their nominal values, with a low point in the mid-forties. In view of approximations elsewhere, we have ignored this aspect of the time pattern of receipts in constructing our series.

As an alternative to the above, we have also approached the problem somewhat differently. If liquidity problems may be ignored, then an appropriate price indicator can be constructed from a knowledge of the government-sponsored "stabilization" machinery reviewed above. Such an approach concentrates on current average realizations, but completely ignores the timing of their disbursements. In crudest outline, the wheat stabilization plan results in a price to growers

$$(5) \qquad P = \frac{Q_H P_H + Q_G \operatorname{Max}(P_H, P_E) + (Q - Q_H - Q_G) P_E}{Q}$$

where Q_H is domestic consumption of wheat; P_H is the fixed domestic price, equal to the official "cost of production" estimate; Q_G is the quantity of exports upon which a minimum price of P_H is guaranteed (for 1949–50 to 1962–63, Q_G = 100 m. bushels; for later years, Q_G = 150 m. bushels); P_E is the export price; and Q is total production.[12] A conjectural price expectations series based on this formula is recorded in Table 7 (Series II—"liquidity insensitive"). Whilst our assumptions concerning wheatgrowers' estimates of the various elements of the formula (5) have been documented in the footnotes to Table 7, we make the following points by way of explanation.

[12] In this formulation, we have ignored the additional complication that in times of high export price, on that part of the crop not consumed locally, growers in fact received not the export price, but that amount less a levy paid into the stabilization fund. However, in view of the facts that the levy has never exceeded 15 cents per bushel; that refunds were made to growers from the fund on a "first in, first out" basis after a target ceiling had been reached; and that, at all events, the fund itself has been liquidated in supporting the price of wheat in later years; we feel that what we have neglected is of minimal import—especially since we have opted to ignore problems of payment timing here.

(1) All variables except estimated total production Q and the limit of the government's liability Q_G have been taken on the most naive model, consisting of actual values lagged one year.

(2) The size Q_G of exports upon which the guaranteed price would operate was taken to be known exactly, since this information is well publicised. Moreover, the value of Q_G has changed only once, notice being issued well in advance of planting time for the first crop on which the new limit would operate.

(3) Total production has been estimated by combining extrapolative models of both *actual*[13] acreage and of yield. For the former variable, we used a three year sliding trend projection

$$(6) \qquad \hat{a}_t = \frac{-2}{3} a_{t-3} + \frac{1}{3} a_{t-2} + \frac{4}{3} a_{t-1},$$

where $\hat{a}_t$ is the estimated aggregate acreage for t, and the a_{t-1} etc., are the actual acreages in $(t - 1)$ etc. Equation (6) is, in fact, the least-squares estimate of a_t based on a linear trend fitted to the preceding three years. Our yield estimate, on the other hand, was taken as the least-squares estimate obtained by regressing actual yield on time over the period 1930–31 to 1963–64 (Table 3). Whilst it is true that growers would not, in principle, have had access to all of this information until the end of our period of study, the rate of productivity increase in wheat has been uniform over a long period and we have adopted this approach on the grounds of expediency.

The final adjustment which must be made to our conjectural series for wheatgrowers' price expectations is to convert them to a basis consistent with our measure of output. Here again we use the notion of a "normal" yield (Table 3). By multiplying normal yield by expected price we obtain an estimate of expected return per acre. These adjusted series are given in Table 8.

Planned Output and Expected Price—Wool

In attempting to assess intended aggregate wool production, immediately we are able to remove one element of extraneous variation by working in terms of numbers of adult sheep shorn rather than in units of weight. Variation in fleece weight devolves on two factors, one random and one systematic. The random component reflects climatic conditions, whilst genetic improvement generates a slight upward trend in fleece weights. Quantitatively, the secular gain in fleece weight for Australia as a whole has been estimated to be of the order of 0.07 lb per annum, or approximately 7/10ths of one per cent.[14] This systematic element explains about

[13] Our procedure here is not formally inconsistent with our use of farmers' statements of intention as an output variable. In particular, we draw the distinction between the aggregate of farmers' intended acreages for a given crop year on the one hand, and what farmers "on average" think total acreage will be in that year, on the other.

[14] This percentage figure has been obtained by C. M. Donald in "The Progress of Australian Agriculture and the Role of Pastures in Environmental Change", *Australian Journal of Science*, Vol. 27, No. 7 (January, 1965), pp. 187–198. With average fleece weight at about 10 lb in recent years, Donald's figure is thus consistent with the estimated gain of 0.07 lb per annum which we obtained from the regression equation (adult sheep fleece weight in lb, year t) = 5.97 + 0.0704 t ($R^2 = 0.65$), fitted to annual data for the period 1938–39 to 1963–64 (t = 39 for 1938–39).

TABLE 8

Two Conjectural Series for Australian Wheatgrowers' Price Expectations (Acreage Basis): 1947–48 to 1964–65

Crop Year	Expected Return	
	Series I (liquidity sensitive)*	Series II (liquidity insensitive)†
	Current $ per acre	
1947–48	10.64	14.76
1948–49	12.00	19.22
1949–50	15.70	19.68
1950–51	24.16	21.38
1951–52	22.02	20.92
1952–53	21.88	22.20
1953–54	24.82	24.66
1954–55	21.56	25.02
1955–56	17.54	23.04
1956–57	20.34	22.20
1957–58	21.82	23.88
1958–59	24.22	24.92
1959–60	24.56	25.62
1960–61	24.90	25.62
1961–62	20.70	26.32
1962–63	25.38	27.96
1963–64	25.72	28.14
1964–65	26.06	27.18

* Column 5 of Table 7 multiplied by fourth column of Table 3 and resulting figure expressed in $.
† Column 6 of Table 7 multiplied by fourth column of Table 3 and resulting figure expressed in $.
Sources: Tables 3 and 7 *supra*.

65 per cent of the observed variation in fleece weights over the years 1938–39 to 1963–64.[15] There is evidence that lagged climatic variables could be expected to explain a substantial proportion of the residual variation.[16]

[15] These national average figures conceal important variations between the States. In New South Wales the annual poundage gain for the period 1938–39 to 1963–64 was estimated from a least-squares regression on time to be less than half the national average rate. The proportion of variance of fleece weight for this State explained by a linear trend was of a much lower order (16 per cent) than the national figure.

[16] G. P. Doepel was able to explain a total of about 65 per cent of the variation in fleece weights for New South Wales by using three lagged climatic variables in addition to trend (as against 16 per cent explained by a regression on time alone fitted by these authors). See G. P. Doepel, Appendix in G. P. Doepel and Helen Newton Turner, "Causes in Variation in Average Fleece Weight", *Quarterly Review of Agricultural Economics*, Vol. 12, No. 2 (April, 1959) pp. 50–60.

TABLE 9

Wool Prices and Numbers of Adult Sheep Shorn: Australia, 1940–41 *to* 1964–65

Year	Adult Sheep Shorn (millions)	Average Wool Price (cents per lb greasy)	"Normal" Fleece Weight (lb)	Average Wool Price After Removal of Seasonal Effects (cents per fleece)
	(1)	(2)	(3)	(4)
1940–41	107·9	11·29	8·8564	100·00
1941–42	108·6	11·36	8·9268	101·40
1942–43	109·8	13·03	8·9972	117·26
1943–44	108·3	13·12	9·0676	118·92
1944–45	102·9	13·13	9·1380	119·94
1945-46	89·5	13·07	9·2084	120·32
1946–47	83·4	20·41	9·2788	189·36
1947–48	84·5	32·92	9·3492	307·74
1948–49	90·4	40·06	9·4196	377·34
1949–50	97·7	52·79	9·4900	501·00
1950–51	98·1	120·16	9·5604	1,148·76
1951–52	102·0	60·35	9·6308	581·22
1952–53	108·9	68·17	9·7012	661·30
1953–54	109·3	67·92	9·7716	663·66
1954–55	114·3	59·07	9·8420	581·34
1955–56	117·2	51·22	9·9124	507·68
1956–57	129·3	66·38	9·9828	662·70
1957–58	133·5	52·04	10·0532	523·18
1958–59	137·6	40·48	10·1236	409·76
1959–60	139·2	48·15	10·1940	490·84
1960–61	136·8	43·38	10·2644	445·30
1961–62	138·9	45·11	10·3348	466·18
1962–63	140·5	49·13	10·4052	511·24
1963–64	144·2*	58·08	10·4756	608·46
1964–65	150·3*	47·83	10·5460	504·46
1965–66	141·7†	49·41†	10·6164	524·62†

* Subject to revision.

† Preliminary; our estimate.

Sources:

(1) Commonwealth Bureau of Census and Statistics, *Production Bulletin, Primary Industries*, Bulletins Nos 40–56, 1945–46 to 1961–62 (Canberra); and C.B.C.S., *Wool Production and Utilization*, Statistical Bulletin No. 12, 1963–64 (Canberra).

(2) Bureau of Agricultural Economics, *Statistical Handbook of the Sheep and Wool Industry* (Third Edition, Canberra, 1961); and *Supplement to the Statistical Handbook of the Sheep and Wood Industry* (Canberra, June, 1964).

(3) Estimated from a least-squares regression of fleece weight on time (see text).

(4) Product of columns (2) and (3) (discrepancies due to rounding).

Official statistics of adult sheep shorn are given for 1941–42 to 1964–65 in Table 9.[17] Also given are official statistics on annual national average prices for greasy wool as well as a tabulation of "normal" or expected fleece weight (i.e., the average fleece weight which would be

[17] Because of our parametric treatment of distributed lags—we have actually generated hypothetical expected price series for a range of assumptions about the relevant value of Nerlove's coefficient of expectations, β—our tabulated prices have been extended seven years further back than the initial year (1947–48) in our sample period. [This treatment is standard in the tables below.]

realised in an "average" growing season). The normal fleece-weight figures have been combined with the actual average wool price realisations to obtain a climatically adjusted series on average return per fleece.

Coarse Grain Output

Barley, oats, and maize have been aggregated by simply adding their actual acreages. Although it would only be roughly applicable to oats and barley, and not at all to maize, we have used the intended wheat acreage data discussed previously as the basis of a seasonal correction for our aggregate coarse grain series. The data and resultant weather-corrected acreage series are shown in Table 10.

TABLE 10

Production Data for Coarse Grains, Australia: 1946–47 *to* 1964–65

Fiscal Year	(Acreage ('000 acres)				Seasonal Index*	Seasonally Adjusted Total Acreage of Coarse Grains† ('000 acres)
	Barley	Oats	Maize	Total Coarse Grain		
1946–47 ..	748·0	1,728·0	259·7	2,735·7	1·027	2,664
1947–48 ..	838·6	2,105·2	222·8	3,166·6	1·000	3,167
1948–49 ..	1,011·8	1,769·8	182·0	2,963·5	0·955	3,104
1949–50 ..	1,040·1	1,747·6	193·6	2,981·2	0·989	3,015
1950–51 ..	1,078·7	1,757·2	169·3	3,005·3	0·981	3,063
1951–52 ..	1,118·0	2,364·9	169·5	3,652·4	1·000	3,652
1952–53 ..	1,376·6	2,764·3	174·1	4,314·9	0·980	4,401
1953–54 ..	1,803·9	2,137·0	179·0	4,118·9	1·016	4,053
1954–55 ..	1,691·4	2,574·2	169·7	4,435·3	0·995	4,458
1955–56 ..	1,893·9	3,353·8	167·4	5,415·2	1·004	5,391
1956–57 ..	2,093·1	2,556·0	181·6	4,830·7	0·926	5,215
1957–58 ..	2,120·8	2,958·5	184·1	5,263·4	0·964	5,459
1958–59 ..	2,380·5	3,974·2	179·5	6,534·3	1·045	6,253
1959–60 ..	2,379·5	3,029·9	184·9	5,594·3	1·000	5,593
1960–61 ..	2,829·8	3,636·9	184·6	6,651·3	1·034	6,432
1961–62 ..	2,383·3	3,096·7	210·5	5,690·5	1·035	5,500
1962–63 ..	2,027·5	3,292·1	209·5	5,529·1	1·032	5,358
1963–64 ..	2,013·3	3,392·2	214·8	5,620·3	0·977	5,753
1964–65 ..	2,064·1	3,497·2	212·6	5,773·9	1·032	5,595
1965–66 ..	2·1 m.‡	3·3 m.‡	213·0‡	5·6 m.‡	0·950‡	5·9 m.‡

* Based on the ratio of actual and planned wheat acreages (Table 1) with a ratio of 95·45 taken as "normal".

† Total coarse grain acreage divided by seasonal index.

‡ Preliminary estimate.

Source: Commonwealth Bureau of Census and Statistics; *Production Bulletin, Primary Industries,* Bulletins Nos 42–56, 1947–48 to 1961–62 (Canberra). Most recent figures from C.B.C.S., *Rural Industries* Bulletin No. 1, 1962–63 (Canberra, 1965), or supplied privately by the Bureau.

Prices of Coarse Grain

Two of the three coarse grains considered here are subject in varying degrees to institutional pricing. In the case of barley, a labyrinth of marketing legislation operates through three Barley Boards[18] operating in four States. These Boards are compulsory marketing channels for barley in the States in which they operate. However, no Board has power under the Constitution to interfere with the disposal of grain entering into interstate trade. This has robbed the Australian Barley Board (operating in South Australia and Victoria) of much of its effective power. Growers prefer to sell direct to interstate merchants at a discount rather than sell to the local authority which disburses receipts in instalments in much the same way as the Australian Wheat Board discussed earlier.[19] In Western Australian a State authority is involved in marketing oats; however, its use by growers is voluntary.

Ideally then, a careful analysis of price expectations for coarse grains would require a detailed consideration of these institutional features. Unfortunately, so formidable a task could not be attempted within the limitations of the present study. We have, however, had access to B.A.E. indexes of prices paid for these three coarse grains, and we have treated them much as if they were market prices.

To convert to unit values, we regressed official series of unit gross values of production on the individual B.A.E. indexes, constraining each relationship to pass through the origin. The resultant regression coefficients—.0096, .0066, and .0064 respectively for barley, oats and maize—were used to express the B.A.E. indexes in current value terms (per bushel basis). These new series were converted to a per acreage basis using estimates of "normal" yield per acre, the latter being obtained from least-squares linear trend regressions. The resulting three series on weather corrected output valuations per acre were aggregated using actual acreages as weights. Our data and the resulting series are given in Table 11. Ancillary data on yield regressions, etc., are given in Table 12.

Lamb Output

Official statistics on tonnages of lamb produced are readily available.[20] They have not been refined further in view of the fact that no significant trend in carcass weights was perceptible over the period of study.[21] Unlike mutton, the influence of weather on production can definitely be assumed to be adverse. In poor years lambs will fail to reach a minimum acceptable

[18] In Western Australia, the W.A. Barley Marketing Board; in South Australia and Victoria, the Australian Barley Board; in Queensland, the Queensland Barley Marketing Board.

[19] That growers exhibit this preference establishes a *prima facie* case for use of the liquidity sensitive price series (Series I) in the analysis of the supply of wheat. (See discussion of wheat prices, *supra.*)

[20] Australian Meat Board, 30*th Annual Report* (Sydney, 1965), p. 96.

[21] Even in a situation where such a trend existed, the response could, of course, be due to factors other than the technological influence which we are seeking to remove here. For example, the response might reflect changing use of inputs and/or a change in consumers' tastes favouring meat from a carcass of different weight.

TABLE 11

Price Series for Coarse Grains, Australia: 1940–41 *to* 1963–64*

Financial Year	Estimated Product Valuation (seasonally corrected)†			Weight (based on acreages)‡			Composite Price Series§
	Barley	Oats	Maize	Barley	Oats	Maize	
	per acre						per acre
	$	$	$				$
1940–41 ..	7.64	3.06	10.20	0·266	0·606	0·128	5.20
1941–42 ..	4.98	2.58	10.40	0·308	0·574	0·118	4.24
1942–43	6.74	2.94	15.64	0·202	0·671	0·127	5.32
1943–44 ..	8.96	3.14	16.82	0·207	0·661	0·132	6.16
1944–45 ..	10.68	6.98	16.98	0·211	0·700	0·088	8.64
1945–46 ..	10.62	6.04	14.14	0·242	0·676	0·082	7.82
1946–47 ..	14.70	7.06	14.78	0·273	0·632	0·095	9·88
1947–48 ..	27.54	9.34	14.22	0·265	0·665	0·070	14.50
1948–49 ..	14.74	8.90	22.54	0·341	0·597	0·061	11.74
1949–50 ..	19.20	11.80	20.50	0·349	0·586	0·065	14.94
1950–51 ..	21.26	16.98	33.96	0·359	0·585	0·056	19.48
1951–52 ..	29.92	21.38	44.06	0·306	0·647	0·046	25.04
1952–53 ..	29.72	14.56	35.26	0·319	0·641	0·040	20.24
1953–54 ..	25.62	16.16	38.02	0·438	0·519	0·043	21.24
1954–55 ..	23.66	19.88	34.00	0·381	0·580	0.038	21.86
1955–56 ..	24.72	14.76	35.60	0·350	0·619	0·031	18.88
1956–57 ..	21.14	17.60	37.04	0·433	0·529	0·038	19.86
1957–58 ..	22.56	22.70	44.04	0·403	0·562	0·035	23.38
1958–59 ..	22.62	16.04	29.50	0·430	0·537	0·032	19.32
1959–60 ..	20.88	17.58	35.10	0·425	0·542	0·033	19.56
1960–61 ..	20.32	16.42	46.68	0·425	0·547	0·028	18.92
1961–62 ..	21.98	16.28	34.26	0·419	0·544	0·037	19.34
1962–63 ..	24.54	17.50	37.02	0·367	0·595	0·038	20.82
1963–64 ..	24.78	17.86	40.10	0·358	0·604	0·038	21.18
1964–65 ..	26.18‖	19.32‖	40.46‖	0·357	0·606	0·037	22.56
1965–66 ..	26.22‖	19.34‖	61.58‖	0·370‖	0·590‖	0·040‖	23.56

* For detailed information on sources and methods, see text and Table 12.

† Based on unit gross values of production (1940–41 to 1944–45) and on Bureau of Agricultural Economics (B.A.E.) indicators of prices received (1945–46 to 1963–64). B.A.E. indicators have been converted to current value terms. Conversion to acreage basis has been made using estimates of "normal yields".

‡ Based on official statistics of actual acreages [Source: Commonwealth Bureau of Census and Statistics, *Production Bulletin, Primary Industries*, Bulletins Nos 42–56, 1947–48 to 1961–62 (Canberra). Latest figures from C.B.C.S., *Rural Industries*, Bulletin No. 1, 1962–63 (Canberra, 1965), or supplied privately by the Bureau.]

§ Weighted average of three grains.

‖ Our estimate; preliminary.

slaughter weight before the onset of the seasonal feed shortage in summer. Over the summer they cannot be fattened under Australian conditions of grassland feeding— consequently, they are held until the following autumn. If at that time the animals are not too old, they may be fattened and sold as heavyweight lambs. Otherwise they will probably be held and sold as hoggets (i.e., sheep aged between approximately one and

two years). Since they are a special cross-bred animal, sheep bred as fat-lambs have little prospect of alternative use. Rather than attempt to eliminate climatic effects at this juncture, we decided to make explicit allowance in our supply equation for the influence of drought.[22]

TABLE 12

Summary of Regression Equations Used in Construction of Composite Price Series for Coarse Grains

I. Linear Trend Regressions for Yields of Barley, Oats and Maize

Product	Regressand	Constant	Coefficients (and Student's *t*-values) of Regressor (Sample period: 1940–41 to 1962–63; $t = 41$ in 1940–41)	Standard Error of Estimate	R^2
Barley	Annual yield per acre.	6·5395	0·2396 (1·645)	4·635	0·1141
Oats	Annual yield per acre.	— 5·6573	0·3881 (3·502)	3·525	0·3687
Maize	Annual yield per acre.	0·8870	0·5391 (7·361)	2·330	0·7207

II. Summary of Homogeneous Regressions of Unit Gross Values of Production on B.A.E. Price Indicators

Product	Regressand	Coefficients of Regressor (and Student's *t*-values) (Sample period: 1945–46 to 1962–63)	Standard Error of Estimate	R^2
Barley	$ per bushel ..	0·0096 (30·149)	0·1619	0·6822
Oats	$ per bushel ..	0·0066 (12·963)	0·3230	0·2621
Maize	$ per bushel ..	0·0064 (13·370)	0·3448	0·4228

Sources of data:

I—The yields (bushels per acre) of the three coarse grains from 1940–41 to 1962–63 have been obtainep from Commonwealth Bureau of Census and Statics, *Rural Industries*, Bulletin No. 1, 1962–63 (Canberra, 1965).

II—The average gross values have been obtained from C.B.C.S., *Part II—Non-Rural Industries and Value of Production*, Bulletin Nos 40–56, 1945–46, 1945–46 to 1961–62 (Canberra), and C.B.C.S., *Non-Rural Primary Industries and Value of Production*, Bulletin No. 1, 1962–63 (Canberra, 1965). The B.A.E. Index of Prices Received for the three cereals have been privately supplied by Bureau of Agricultural Economics, Canberra. These data, supplied partly on a semi-annual and partly on a quarterly basis, have been weighted by production figures for the corresponding periods in order to obtain annual series for use in the analysis reported above.

Lamb Price

The production period for fat lambs consists of a six month gestation period followed by a period of fattening which may be typically about four months. Therefore, producers' price expectations should reflect market conditions in previous years, but could scarcely depend very highly on the current value of an annual price series. In the distributed-lag model for lamb prices used in this study we have acted on this assumption.

[22] This explicit allowance is made by incorporating a drought index as a shift variable into our supply equation for lamb.

The price series used was (with the exception of five early years) based on a B.A.E. index of prices received for lamb. Consonant with our treatment elsewhere, we have converted this series to a cash basis. These official series are recorded in Table 13.

TABLE 13

Price Data for Lamb, Australia: 1940–41 *to* 1963–64

Fiscal Year	Weighted Index of Prices Received for Lamb*	Current Value Price Series†
	Base: average of 5 years ended June, 1950 = 100	Per ton of carcase weight $
1940–41	not available	148.00
1941–42		153.40
1942–43		144.60
1943–44		156.20
1944–45		193.40
1945–46	76	220.40
1946–47	90	261.00
1947–48	102	295.80
1948–49	93	269.80
1949–50	125	362.60
1950–51	189	548.20
1951–52	167	484.40
1952–53	182	527.80
1953–54	196	568.40
1954–55	220	638.00
1955–56	213	617.80
1956–57	213	617.80
1957–58	199	577.20
1958–59	168	486.20
1959–60	166	481.40
1960–61	192	556.80
1961–62	176	510.40
1962–63	173	501.80
1963–64	190	551.00
1964–65	223	646.80
1965–66	..	734.00‡

Sources and Notes:

* Based on semi-annual (1945 to 1952) and quarterly (1953 to 1965) series supplied by Bureau of Agricultural Economics. Annual series have been computed by weighting the B.A.E. semi-annual and quarterly indicators by official estimates of production for the corresponding periods. [Source of production figures: Commonwealth Bureau of Census and Statistics, *Production Bulletin, Primary Industries*, Bulletins Nos 42–56, 1947–48 to 1961–62 (Canberra). Latest figures from C.B.C.S., *Rural Industries*, Bulletin No. 1, 1962–63 (Canberra, 1965), or supplied privately by the Bureau.]

† Figures for 1940–41 through 1944–45 are simple averages of monthly prices at Homebush saleyards, each monthly price being itself a simple average over three recorded grades. [Source: Deputy Commonwealth Statistician, Sydney, and New South Wales Government Statistician, *New South Wales Statistical Register* (various issues—published annually, Sydney).] Later figures are B.A.E. index on a cash basis. The conversion was made using a factor 2.90, which was obtained by the method of least-squares using four years' overlapping data.

‡ Preliminary; our estimate.

Output of Beef and Veal

We have aggregated these two commodities along the simplest lines possible; i.e., we have taken 1 ton veal = 1 ton beef equivalent. Attempts to aggregate with value weights were aborted because of difficulty in obtaining adequate value series. Such series as were available, however, indicated that value differences per unit weight were very slight.

TABLE 14

Price Data for Beef, Australia: 1940–41 *to* 1964–65

Fiscal Year	Weighted Index of Prices Received for Beef*		Cash Price Series†	
	Current	Lagged 6 Months	Current	Lagged 6 Months
	Base: average of 5 years ended June, 1950 = 100		$ per ton of carcase weight	
1940–41 ..	not available		93.60	89.40
1941–42 ..			92.40	89.20
1942–43 ..			98.60	98.00
1943–44 ..			103.80	104.20
1944–45 ..			116.00	106.60
1945–46 ..	79	n.a.	107.40	116.80
1946–47 ..	90	88	122.40	119.60
1947–48 ..	92	87	125.20	118.40
1948–49 ..	110	101	149.60	137.40
1949–50 ..	130	119	176.80	161.80
1950–51 ..	160	143	217.60	194.40
1951–52 ..	215	190	292.40	258.40
1952–53 ..	191	200	259.80	272.00
1953–54 ..	216	204	293.80	277.4
1954–55 ..	229	200	311.40	272.00
1955–56 ..	211	215	287.00	292.40
1956–57 ..	200	207	272.00	281.60
1957–58 ..	243	217	330.40	295.20
1958–59 ..	281	256	382.20	348.20
1959–60 ..	326	303	443.40	412.00
1960–61 ..	331	345	450.20	469.20
1961–62 ..	257	289	349.60	393.00
1962–63 ..	277	264	376.80	359.00
1963–64 ..	274	276	372.60	375.40
1964–65 ..	....	303	428.00‡	412.00
1965–66 ..	....	....	514.00‡	460.00‡

Sources and Notes:

* Based on semi-annual (1945 to 1952) and quarterly (1953 to 1965) series supplied by Bureau of Agricultural Economics. Annual series have been computed by weighting the B.A.E. semi-annual and quarterly indicators by official estimates of production for the corresponding periods. [Source of production figures: Commonwealth Bureau of Census and Statistics, *Production Bulletin, Primary Industries*, Bulletins Nos 42–56, 1947–48 to 1961–62 (Canberra). Latest figures from C.B.C.S., *Rural Industries*, Bulletin No. 1, 1962–63 (Canberra, 1965), or supplied privately by the Bureau.]

† Figures for 1940–41 through 1944–45 are simple averages of monthly prices at Homebush saleyards, each monthly price being itself a simple average over recorded grades. [Source: Deputy Commonwealth Statistician and New South Wales Government Statistician, *New South Wales Statistical Register* (various issues—published annually, Sydney.)] Later figures are B.A.E. index on a cash basis. The conversion was made using a factor 13.6, which was obtained by the method of least-squares using four years' data for which overlapping series were available.

‡ Preliminary; our estimate.

TABLE 15

Price and Output Data for Dairy Products, Australia: 1940–41 *to* 1964–65

Fiscal Year	B.A.E. Index of Prices Received for Dairy Products*	Current Value Series (gallonage basis)‡	"Normal" Yield§	Current Value Series (per cow basis)‖	Output Variable—Number of Dairy Cows¶
	Base: average of 5 ended June, 1950 = 100	cents per gallon	gallons per cow	per cow $	'000
1940–41 ..	57†	6·726	326·0	21.94	**
1941–42 ..	59†	6·962	330·6	23.02	**
1942–43 ..	67†	7·906	335·1	26.50	**
1943–44 ..	78†	9·204	339·7	31.28	**
1944–45 ..	79†	9·322	344·4	32.10	**
1945–46 ..	83	9·794	349·2	34.20	**
1946–47 ..	87	10·266	354·1	36.36	3,057
1947–48 ..	101	11·918	358·9	42.78	3,134
1948–49 ..	111	13·098	363·9	47.66	3,209
1949–50 ..	120	14·160	369·0	52.26	3,244
1950–51 ..	137	16·166	374·1	60.46	3,197
1951–52 ..	181	21·358	379·3	81.02	3,019
1952–53 ..	203	23·954	384·5	92.10	3,134
1953–54 ..	203	23·954	397·2	95.14	3,259
1954–55 ..	198	23·364	395·3	92.36	3,282
1955–56 ..	197	23·246	400·7	93.14	3,404
1956–57 ..	192	22·656	406·3	92.06	3,451
1957–58 ..	199	23·482	411·9	96.72	3,362
1958–59 ..	204	24·072	417·7	100.54	3,283
1959–60 ..	204	24·072	423·5	101.94	3,243
1960–61 ..	200	23·600	429·3	101.32	3,162
1961–62 ..	198	23·364	435·3	101.70	3,230
1962–63 ..	200	23·600	441·3	104.14	3,263
1963–64 ..	201	23·718	447·4	106.12	3,296
1964–65 ..	201	23·718	453·6	107.58	3,288
1965–66 ..	..	23·200††	459·8	106.60††	3,230††

Sources and Notes:

* Series [apart from items marked †] supplied by Bureau of Agricultural Economics, Canberra.

† Based on J. G. Crawford *et. al.*, *Wartime Agriculture in Australia and New Zealand* (Stanford University Press, 1954), Table XX (A), p. 234. The butter and cheese components there shown have been combined with weights 0·769 and 0·231 respectively, these weights themselves being based on average production of the two products over the period 1946–47 to 1949–50. [For production data, see official statistics.] Gallons to lb weight conversion factors for butter and cheese respectively are: 1 gallon = 0·468 lb; 1 gallon = 1·144 lb. The series derived in this manner has been linked with the B.A.E. index, using 1945–46 as pivot.

‡ Previous column multiplied by 0·118. This conversion factor was obtained by a homogeneous regression of unit gross value of production [gallonage basis—source: Commonwealth Bureau of Census and Statistics, *Non-Rural Primary Industries and Value of Production*, Bulletin No. 1, 1962–63 (Canberra, 1965)] over the period 1953–54 to 1962–63 on the B.A.E. series.

§ Trend values obtained from a regression of log (yield per cow) on time over the period 1946–47 to 1963–64. See equation (7), *infra*.

‖ Product of preceding two columns.

¶ March 31st of second year shown. Source: Commonwealth Bureau of Census and Statistics, *Statistical Bulletin, Livestock Numbers*, Bulletin Nos 9–23, 31st March, 1951 to 31st March, 1965 (Canberra).

** Data not required for analysis of supply over sample period (1947–48 to 1964–65).

†† Our estimate; preliminary.

For much the same reasons as in the case of lamb we have used tonnage output figures in our analysis. These official series are readily accessible.[23]

Price Series for Beef and Veal

Again we have been fortunate enough to have access to an index supplied by the Bureau of Agricultural Economics. Apart from five early years for which this series was not available, we have used a current unit value series based on the B.A.E. index of prices received for beef. These series are recorded in Table 14. Unlike lamb, however, intra-annual decisions affecting the supply of beef can be taken—i.e., it can be decided to slaughter rather than retain for breeding stock and/or for later slaughter. Our series allow for the possibility of introducing distributed lags which begin six months prior to the end of recorded production periods.

Dairy Output and Price Data

Our treatment of dairy output closely parallels the case of wool. Numbers of dairy cows are used to measure intended output, whilst price series are adjusted to take account of improved milk yields. Once again, our primary source of data is a B.A.E. index of prices received by farmers. To remove seasonal effects, "normal" milk yields have been used to compute estimates of "normal" product valuations per cow. These seasonally adjusted yields have been obtained from the following semi-logarithmic regression equation, fitted by Mr L. E. Ward.[24]

$$(7) \qquad \log_{10} y_t = 2{\cdot}268 + {\cdot}00598t \; (R^2 = {\cdot}779),$$

where y_t is milk yield (in gallons per cow per annum),
and t is time (in years from fiscal 1946–47 through 1963–64; $t = 47$ in 1946–47).[25]

Our adjusted price and quantity indicattors are given in Table 15.

---

[23] Australian Meat Board, *op. cit.*, p. 95.

[24] We wish to record our appreciation of Mr Ward's contribution to two further aspects of this study: (i) The series recorded in Table 15 were, in large measure, initially compiled by him. (ii) Our inclusion of dairy products within the framework of this study was largely brought about by his success in explaining the supply of dairy products using single-equation techniques. In particular, his discovery of the high explanatory power of the beef/dairy price ratio in the case of dairy output provided a very important lead for our treatment of both the supply of beef and the supply of dairy products within a simultaneous equations model.

[25] The regression coefficient of log yield on time was highly significant, its Student's |t|-value being in excess of seven.