



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

## APMAA'74: A MINIMUM-LEVEL AGGREGATIVE PROGRAMMING MODEL OF NEW SOUTH WALES AGRICULTURE\*

J. Richard Monypenny and Neal Walker†

### SUMMARY

An Aggregative Programming Model of Australian Agriculture (APMAA) is being developed by a research team at the University of New England. This paper presents a minimum-level version of APMAA, known as APMAA'74 which was developed as a framework for further model development. In addition to insights gained with APMAA'74, the paper presents an example of its application to the State of New South Wales. In this application, a comparison is made of farm plans and their aggregative effects generated under the contrasting assumptions of producers holding expectations of there being a slump or there not being a slump in the price of wool.

### 1. INTRODUCTION

Empirical work on supply response of agricultural production based on aggregative programming models, of one type or another, has been undertaken by a number of authors and groups in various countries during the last two decades with varying degrees of success, e.g., Duloy and Norton [3], Heady [4], Intriligator [6], Judge and Takayama [7], Wegener [11]. These studies have provided a framework for further ventures, one of which is the development of an Aggregative Programming Model of Australian Agriculture (APMAA) by a research team at the University of New England, which commenced in 1972. Figure 1 shows in broad terms the general outline of APMAA as defined at October, 1975.

The main features of APMAA so far as they relate to this paper are:

- (a) The use of some five hundred representative farms to act as surrogates of Australia's actual extensive non-irrigated crop and livestock farms.

---

\* Manuscript received December, 1975.

† Research Fellows, Department of Agricultural Economics and Business Management, University of New England, Armidale. The research reported in this paper was financed by the Economics Research Committee of the Wool Research Trust Fund. As well, the authors are grateful to John Dillon, John Guise, John Kennedy and Emilio Francisco for assistance and critical comment. The work could not have been undertaken without the assistance of the Australian Bureau of Statistics, Agricultural Business Research Institute of the University of New England and the Bureau of Agricultural Economics in providing much of the necessary data. We wish to thank *Review* referees Roley Piggot, Trevor Mules and David Godden for their comments.

(b) The use of behaviourally-modified linear programming (LP) to simulate the production decisions and expected financial outcomes of each of the representative farms. A representation of the farmer's decision behaviour is incorporated into the LP routine applied to each representative farm.

(c) The incorporation of a weather (rainfall and yield) simulator to obtain a realized outcome of the farmer's annual plan in physical terms and thus also in financial terms.

(d) A spatial equilibrium submodel to equate the supply and demand of certain farm resources.

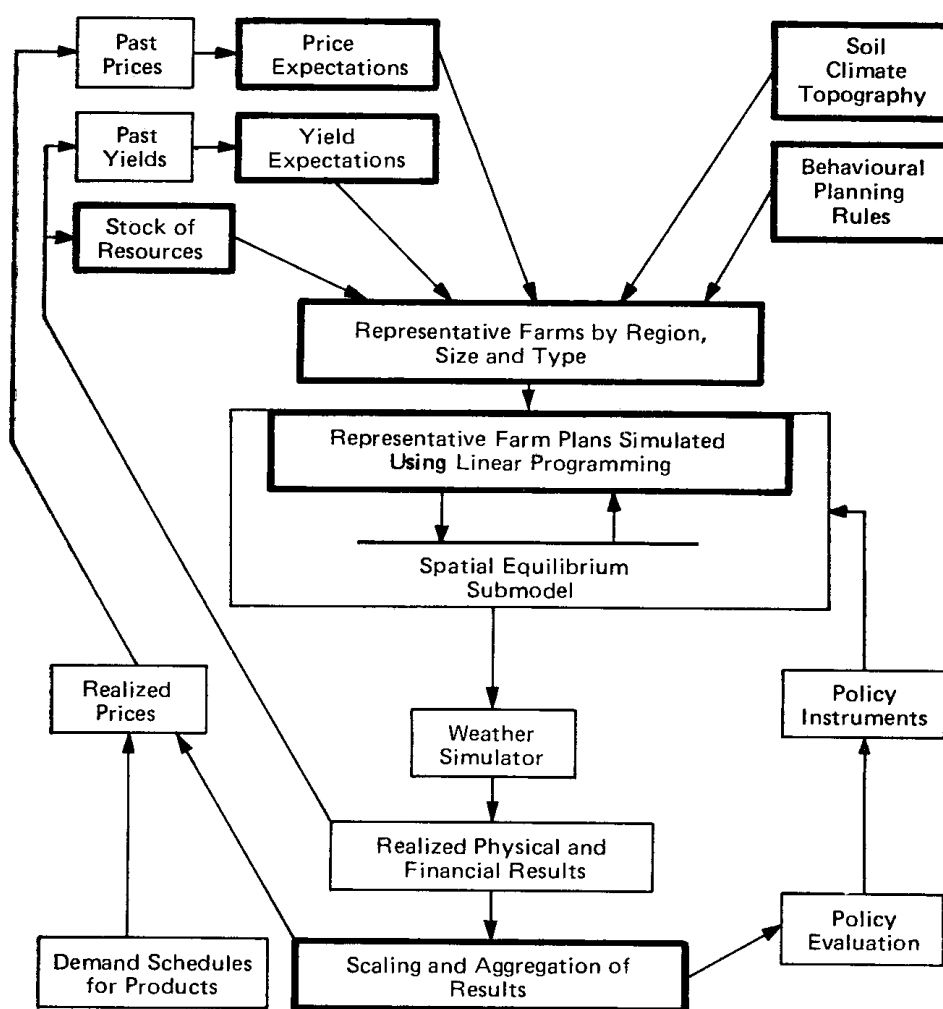


FIGURE 1: Flow Diagram of the Structure of the APMAA Model as at October, 1975

The planned work of the APMAA Research Team can be divided into three sections: first, the development of APMAA as such, together with its computer algorithm; second, the collection of data for the synthesis of representative farms for all non-metropolitan Statistical Divisions of Australia, together with collation of other data needed for empirical specification of the model; and third, the use of APMAA for policy appraisal and evaluation.

An account of the general methodology that APMAA has developed is outside the scope of this paper. Thus, research reported refers to a minimum-level version of APMAA called APMAA'74 (shown in heavy lines in Figure 1), and its application to New South Wales (excluding Sydney and the two Western Statistical Divisions) (Monypenny [9]). The purpose of development of APMAA'74 was to test the feasibility and potential usefulness of the broad project and to provide guidance towards its development. To accomplish these aims, APMAA'74 endeavoured to:

- (i) Develop and specify the model sketched in heavy lines in Figure 1;
- (ii) Specify a computer algorithm to run APMAA'74 on the University of New England's ICL 1904A computer;
- (iii) Use APMAA'74 to determine the representative farmers' plans via LP subject to constraints of land, labour, feed, plant, livestock, cash, debt, maximum borrowing, tax, consumption, and behaviour (risk aversion);
- (iv) Following (iii), to aggregate the results of the representative farm plans and their financial implications to Statistical Division and State levels;
- (v) Use data from one Statistical Division of New South Wales to test APMAA'74;
- (vi) Present a summary of the results produced by APMAA'74 for New South Wales under the assumption of a permanent slump in the price expectation of wool, using as contrast the results obtained with the assumption of a no-slump wool-price expectation.

While the empirical aspects presented in this paper relate only to New South Wales and are primarily intended for illustrative purposes only, the work is relevant in principle to the rest of Australia in that the components of APMAA that have been developed (along with further extensions of the model) will be used for all States as soon as the required data have been collected.

## 2. APMAA'74

APMAA'74, and its associated computer algorithm, were developed bearing in mind that they were to be a minimum-level version of the model. Thus some unrealistic and simplifying assumptions were incorporated when necessary in order to achieve an operational minimum-level model in a short period of time.

For APMAA'74, a representative farm is defined as a synthetic construct designed to react to changes in input variables in a way similar to actual holdings in the group represented. Representative farms were divided

up by region, size and type in order to give justification to the assumption of homogeneity. APMAA'74 defines farm type by the activities that produce the greatest proportion of net receipts, and farm size by acreage relative to other farms of the same type within the region. The definitions of farm type used were based on those of the Australian Bureau of Statistics (ABS) because the data were readily available on this basis and prior knowledge of Australian agriculture suggested that it would be adequate for APMAA's current needs.<sup>1</sup> APMAA'74 uses six of the ABS farm types: (i) sheep-grain, (ii) sheep, (iii) cereal grain, (iv) meat cattle, (v) milk cattle and (vi) multipurpose.

Representative farms were developed, for each Statistical Division of New South Wales, such that at least 75 per cent of all commercial holdings classified by ABS in each Statistical Division were represented. These representative farms are usually in three or four farm types, (See Monypenny [9] for details).

Within each farm type in each Statistical Division, small, medium and large size representative farms were defined based on the ABS size categories.

In specifying the LP matrices of the representative farms, it was necessary to detail the gross margins and input-output coefficients of production activities, the farm-level stock of physical and financial resources, and the values of the behavioural constraints. Published secondary data were used to specify the 129 representative farms in New South Wales. Major data sources included publications by the Australian Bureau of Statistics, the Agricultural Business Research Institute of the University of New England and the Bureau of Agricultural Economics.

Each of the 129 representative farm matrices for New South Wales is made up of four segments: production, behaviour, finance and resources. The production segment contains up to 12 production activities, specified as appropriately required on a regional basis in the representative farm matrices. Crop, livestock and pasture activities are included. No provisions are made for technological change within a year, nor for economies or diseconomies of size.

The behavioural segment of the LP matrices is used to incorporate the farmer's perception of production riskiness into an LP framework. It represents an attempt to overcome the standard LP disadvantage of assuming profit maximization. APMAA'74 assumes that the representative farm's decision maker is risk averse and that he maximizes his expected income subject to a requirement that there be a 0.9 probability of obtaining his desired specified minimum income.<sup>2</sup> (Details of the type of matrix used in APMAA'74 are given in Appendix 1.)

---

<sup>1</sup> Procedures to develop representative farms based on primary data were discarded because of excessive resource requirements.

<sup>2</sup> The actual procedure used is based on Boussard and Petit [2] as modified by Kennedy and Francisco [8]. For discussion and details see Monypenny [9].

The financial segment of the LP matrices incorporates a yearly cash flow, payment or postponement of debt, maximum borrowing constraint and allocation of cash for tax and family consumption.

The resource segment of the LP matrices contains constraints on crop land, grazing land, labour, plant and machinery, and breeding stock. Two feed pools are defined, as dry and wet season feed periods.

### 3. TESTING OF APMAA'74: VERIFICATION

For the purpose of this study, verification was taken to be achieved when the output of APMAA'74 was consistent with a certain subset of *a priori* criteria, outlined below, that theory and/or experience suggest should be met. APMAA'74 is a model of supply response of agricultural production. The usual way to appraise supply response is via supply curves developed under various *ceteris paribus* conditions. This verification was used in APMAA'74 considering the broadness of the minimum-level approach, even though verification is conceptually never complete.

Representative farm wool and beef supply curves were developed holding all other prices and model elements constant.

The criteria for successful verification, in terms of supply response, used in this study were:

- (a) The regional supply curves of wool and beef should have non-negative slopes.
- (b) The regional supply curves of wool, for three prices of beef, should not intersect.
- (c) The regional supply curves of beef, for three prices of wool, should not intersect.
- (d) The slope of a regional supply curve should be steeper at the top and bottom ends of the price scale than in the middle.

The justification of this last criterion (d) is based on *a priori* reasoning. At very low prices of wool, some farms would have no possibility of moving out of wool and thus as the price drops there will be only minor changes in the supply of wool. At high prices of wool, stocking rates will be near carrying capacity and thus increases in the price of wool will have only minor supply response.

Economic theory suggests that slope is a poor measure of responsiveness and that elasticity is preferable. However, as changes in prices under study were considerable, and because an overall measure of response was being sought, the slope was considered an adequate measure.

Five verification tests of APMAA'74 were carried out (Monypenny [9]). In general, the investigations indicated that APMAA'74 complies satisfactorily with the listed criteria.

### 4. TESTING OF APMAA'74: SENSITIVITY ANALYSIS

Sensitivity analysis is the study of the sensitivity of output levels (i.e., production, income, resources and behaviour) to changes in levels of

input variables (i.e., the coefficients of the objective function and the constraints specified in the right-hand side values of the representative farm LP matrices). In general, it can be said that output variables are sensitive to the levels of input variables if small changes in the levels of input variables produce proportionally larger changes in the levels of output variables. Such sensitivity was studied by comparing the activity levels in the optimum LP solution and in the solution at the first change of basis using a parametric LP procedure.

The input variables relative to which output sensitivity measures were derived were the elements in the objective function and in the right-hand side of the LP matrices.

Objective function and constraint parametrizations were undertaken for the 12 representative farms in the Central Tableland Statistical Division of New South Wales. (This sensitivity analysis was not undertaken for all Statistical Divisions because of limited research resources.)

In general, the sensitivity analysis undertaken with the Central Tableland Statistical Division indicated that only 31 per cent of the coefficients in the objective function and 19 per cent of the right-hand side coefficients required an increase of less than 20 per cent in their values to produce a change of basis in the LP solution. These levels of sensitivity are considered acceptable by the authors, given the data used by APMAA'74.

## 5. VALIDATION AND UTILITY OF APMAA'74

Traditional validation techniques involve comparison of model results with actual data for a specific time period. Two problems arise in applying such a method to APMAA'74. Firstly, APMAA'74 is a normative model. In order for predicted results to approximate actual results, the unit (or aggregate) being modelled would have to be in an equilibrium situation and pursue the same objective function subject to the same constraints as those postulated by the model. Most economic units, especially when operating in an uncertain environment, are constantly adjusting toward some equilibrium but never actually reach that point. Secondly, APMAA'74 produces results based on farm plans. No data for use in validation are available on farm plans. Thus validation of APMAA'74 remains largely an open question.

A model is a representation of part of the real world. It may be said to be valid if it is an adequate representation (however measured) of the part of the real world it is designed to represent. The model has utility if it answers questions of interest to the model's users (Sears [10]).

The utility of APMAA'74 has as yet been assessed only in terms of information it has produced for guidance in the development of APMAA by the other members of the Research Team. The potential utility of APMAA'74 to users, other than the members of the Research Team, is that the range of questions which can be treated and the level of disaggregation are great.

## 6. AN APPLICATION OF APMAA'74—A SLUMP IN THE PRICE EXPECTATION FOR WOOL

The objective of this application was to estimate the effects on New South Wales agriculture at both the farm and regional levels of a permanent slump in the expected price of wool and its directly related products and resources, i.e., wool, lambs, cull ewes and replacement ewes. Expected prices of all other products and resources were taken to remain unchanged. Farm plans were developed for the representative farms of the 12 Statistical Divisions of New South Wales excluding Sydney and the two Western Divisions for two contrasting assumptions: first, a slump wool-price expectation (continuing into the long term) and, second, a no-slump (but steady into the long term) wool-price expectation.<sup>3,4</sup> These plans were compared on a Statistical Division basis. To obtain greater insight, the plans of the Central Tableland Statistical Division were also compared on a representative farm basis.

A slump in the price of wool was represented by the expected price of wool products (i.e., wool, lambs and cull sheep) and of wool resources (i.e., breeding stock) being taken as equal to those of 1970/71, i.e., 0.66\$/kg wool greasy, 6.45\$/lamb, 3.22\$/cull, 3.42\$/ewe for breeding stock. (During the financial year 1970/71 there was a disastrous slump in the price of wool sold at auction in Australia.)

For a no-slump situation the expected prices were set equal to the average price at the major auction centres in Australia of the three years 1967/68 to 1969/70, i.e. 0.92\$/kg greasy, 6.92\$/lamb, 3.50\$/cull, 5.00\$/ewe for breeding stock.

There are three levels of information available from APMAA'74: first, by farm type and size; second, by representative farm scaled by the number of farms they represent; and third, by Statistical Division.<sup>5</sup>

Information on changes in farmers' plans can be analysed for the absolute change in activity levels or it can be used to study the distribution of change itself. In comparing changes in activity levels between slump and no-slump plans, Table 1 uses an index that expresses the no-slump activity level as 100. An index greater than 100 means the activity level was higher in the slump plan; one less than 100, that it was lower in the slump plan than in the no-slump plan. For example, in Table 1, the number 113 in row one, column four indicates that the level of the wheat activity in the sheep-grain small representative farm in the slump situation was 13 per cent higher than in the no-slump situation.

---

<sup>3</sup> Each representative farm was run independently without transfers between representative farms or Statistical Divisions.

<sup>4</sup> The slump and no-slump price expectations have no variability.

<sup>5</sup> A fourth level of information could also be obtained by aggregating results to the State or (eventually) the National level.



TABLE 1: *Indexed Changes in Production, Income and Resources due to a Wool-Price Slump Expectation: 12 Representative Farms: Central Tableland Statistical Division of New South Wales*

Changes*	Sheep-grain			Sheep			Meat cattle			Multipurpose		
	Sm	Me	La	Sm	Me	La	Sm	Me	La	Sm	Me	La
Production—												
Wheat ..	100	100	100	113	115	120	100	100	100	104	93	93
Oats ..	100	100	100	55	52	46	..	..	..	ND+	1200	720
Lucerne ..	100	100	100	25	21	17	100	100	100	23	27	30
Improved pasture ..	100	100	100	24	21	17	100	100	100	23	27	30
Unimproved pasture ..	100	100	100	ND-	ND-	ND-	..	..	..	28	34	37
Sheep ..	100	100	100	ND+	ND+	ND+	100	100	100	..	..	..
Vealers ..	..	..	..	..	..	..	..	..	..	..	..	..
Yearlings ..	..	..	..	..	..	..	..	..	..	..	..	..
Income—												
Borrow ..	..	32	..	..	..	..	..	..	100	ND-	..	48
Bank ..	79	100	80	45	53	58	100	96	..	85	81	100
Pay debt ..	119	..	117	202	209	146	100	100	100	ND+	114	..
Postphone debt ..	85	95	96	37	35	26	100	99	100	39	38	51
Net receipts ..	93	95	98	91	91	91	100	99	100	88	91	93
Net worth ..	..	..	..	..	..	..	..	..	..	..	..	..
Resource—												
Buy cow ..	..	100	100	ND+	ND+	ND+	100	100	100	..	ND-	ND-
Buy ewe ..	..	..	..	ND-	..	ND-	..	..	..	100	100	100
Sell cow ..	100	..	..	507	1 066	ND+	..	100	..	148	ND+	ND+
Sell ewe ..	100	100	100	..	..	..	..	..	..	..	..	..

Key: ND+: index is not defined because of a division by zero, but activity level increases in the slump plan; ND-: index not defined because of a zero activity level in the slump plan; Sm: small; Me: medium; La: large; ..: the activity is not in the optimal solution.

\* The following rows are excluded from the table because they had no non-zero entries: barley, rapeseed, sheep, sell plant or because there were no changes; tax, consumption and buy plant.

Production effects are measured by changes in the levels of planned production activities. The units are hectares for crops and pasture, breeding ewes for sheep, and breeding cows for cattle. Production effects by farm type, as shown in Table 1, are:

- (a) Sheep-grain farms: no effect because there are no sheep in either the no-slump or slump solutions.<sup>6</sup>
- (b) Sheep farms: eliminate sheep and replace by vealers, decrease pasture, increase wheat.
- (c) Meat cattle farms, no effect because there are no sheep.
- (d) Multipurpose farms: decrease sheep but do not acquire beef, decrease wheat in medium and large farms.

Income effects are measured by changes in planned financial activities (i.e., borrow, bank, pay debt, postpone debt, tax and consumption), by changes in farm income (measured in net receipts); and by changes in net worth. Income effects by farm type, as shown in Table 1, are:

- (a) Sheep-grain farms: increase in postpone debt or decrease in bank activities. This is due to changes in the receipts from the sale of ewes together with a decrease in the level of net receipts and of net worth.
- (b) Sheep farms: major increases in postpone debt and major decreases in net receipts and net worth activities.
- (c) Meat cattle farms: minor changes due to changes in the receipts from the sale of ewes.
- (d) Multipurpose farms: increase in postpone debt or decrease in bank and considerable decrease in net receipts and net worth activities.

Resource effects are measured by the changes in the levels of the activities related to the buying and selling of the quasi-fixed resources (i.e., plant and machinery, breeding cows, and breeding ewes). The resource effects by farm type, as shown in Table 1, are:

- (a) Plant and machinery: activity levels are unchanged by the slump.
- (b) Cows: sheep farms buy in increased numbers, other farms do not change. Cows are sold by sheep, small and multipurpose farms.
- (c) Ewes; farms decrease the number of ewes in the slump plan by not buying replacements and/or by selling existing stock.

By comparing the information produced by farm type and size and that produced by Statistical Division, the difference between the effect of a slump on an individual holding and the effect on a Statistical Division

---

<sup>6</sup> The fact that there are no sheep in the sheep-grain farm is apparently a specification error. It has been left in the paper to show one of the errors likely to occur in this type of model, and at the same time to show one of the advantages of APMAA (in that these errors can be exposed) compared to other models, e.g., Heady *et al.* [5]. Hopefully, the improved data sources that are being developed by other members of the APMAA Research Team will overcome such errors. It is logical to expect that if sheep were specified in the farm plan the effect of the slump in wool prices on the sheep-grain farms would be different.

may be appreciated. To facilitate the presentation, it was assumed that changes in farm net worth are a reasonable proxy for all other changes. Table 2 shows the changes in net worth for the 12 representative farms of the Central Tableland Statistical Division. The number -2271 in column one, row one, means that in the sheep-grain small farm, the net worth was \$2,271 less in a slump situation than in a no-slump situation. The magnitude of these changes at the farm level can be appreciated by expressing them as a percentage of the no-slump farm net worth, as shown in the centre column. For example, the decrease of \$2,271 is seven per cent of the no-slump farm net worth of the sheep-grain small farm. However, at the Statistical Division level, based on scaling weights reflecting the number of farms of each size type, these farms only account for 2.8 per cent of the change in Statistical Division net worth. At the Statistical Division level, the sheep farms account for 83 per cent of the change in net worth.

TABLE 2: *Distribution of Change in Net Worth by Representative Farm and by Statistical Division due to a Wool-Price Slump Expectation: 12 Representative Farms: Central Tableland Statistical Division of New South Wales*

Farm	Change due to a slump	Change as percent of no-slump farm net worth	Scaling weights	Percent of decline in Statistical Division
	\$			
Sh Gr Sm ..	- 2,271	- 7	387	2.8
Me ..	- 3,692	- 5	185	2.2
La ..	- 2,290	- 2	357	2.6
				7.6
Sh Sm ..	- 3,281	- 9	1 259	13.4
Me ..	- 6,679	- 9	479	10.3
La ..	- 16,189	- 9	1 135	59.3
				83.0
Mt Sm ..	- 36	- 0	152	0.0
Me ..	- 267	- 1	91	0.0
La ..	- 324	- 0	39	0.0
				0.0
Mu Sm ..	- 3,577	-12	293	3.4
Me ..	- 5,821	- 9	62	1.1
La ..	- 14,753	- 7	103	4.9
				9.4

Key: Sh: sheep; Gr: grain; Mt: meat cattle; Mu: multipurpose; Sm: small; Me: medium; La: large.

In the previous paragraphs, some effects of a slump on representative farm plans were presented. We now turn to Statistical Division effects. The New South Wales model was run under slump and no-slump conditions and indexed changes in production, income and resources, due to a slump were calculated for each activity as shown in Table 3.

In general, in a slump situation, as would be expected, the level of wheat and beef activities increase and those of sheep and pasture decrease. However, there was considerable variation in results among Statistical Divisions. For example, some have very few production changes: North Coast and North Central Plain; others have many changes: Riverina and Southern Tableland; some, such as South Coast increase lambs, while the rest show a decrease.

TABLE 3: *Indexed Changes in Production, Income and Resources due to a Wool-Price Slump Expectation: 12 Statistical Divisions of New South Wales*

Activity	Statistical Division											
	NC	HM	SC	NT	CT	ST	NWS	CWS	SWS	NCP	CP	RIV
Production												
Wheat .. ..	100	..	..	..	98	ND+	51	97	117	..	100	121
Feed oats .. ..	100	100	..	100	101	..	101	..	..	100	..	..
Grain oats .. ..	..	..	..	116	..	100	..	..	100	100	..	86
Feed barley .. ..	..	..	100	..	..	96	..	173	84	100	..	120
Malt barley .. ..	..	..	..	96	..	..	..	..	100	..	..	89
Sorghum .. ..	100	100	100	..	..	..	95	..	..	100	100	102
Maize .. ..	100	100	..	..	..	..	..	..	..	..	..	..
Lupin .. ..	..	..	..	..	..	..	..	..	100	..	..	..
Lucerne .. ..	..	..	..	..	..	..	..	36	..	100	..	ND-
Improved pasture ..	100	100	..	..	100	99	100	100	105	..	..	92
Unimproved pasture ..	100	100	100	46	100	101	..	..	97	100	100	98
Lambs .. ..	..	66	144	ND-	86	99	..	84	..	..	..	98
Sheep .. ..	..	..	ND-	30	..	75	80	..	8	100	..	83
Wethers .. ..	..	..	..	..	..	..	..	..	..	100	..	..
Vealers .. ..	..	..	..	..	105	..	..	..	100	..	..	..
Yearling .. ..	100	112	105	165	100	100	290	ND+	..	100	100	100
Steer .. ..	100	100	..	..	..	104	..	..	112	100	..	96
Dairy .. ..	100	100	..	..	..	..	..	..	..	..	..	..
Income												
Borrow .. ..	..	..	..	ND+	412	266	..	..	128	..	..	135
Bank .. ..	100	100	100	..	2	28	87	34	..	75	56	97
Pay debt .. ..	98	97	92	87	70	93	68	88	72	88	82	93
Postpone debt .. ..	101	104	111	112	113	165	168	103	125	105	107	105
Tax .. ..	100	100	100	100	100	100	100	100	100	100	100	100
Consumption .. ..	100	100	100	100	100	100	100	100	100	100	100	100
Net receipts .. ..	99	99	99	81	91	81	85	84	97	92	99	84
Net worth .. ..	99	99	98	97	97	91	95	95	97	97	99	96
Resource												
Buy plant .. ..	100	100	100	100	100	101	100	100	118	100	100	128
Buy cow .. ..	100	102	110	354	104	109	388	ND+	115	100	100	96
Buy ewe .. ..	..	..	102	ND-	19	99	69	64	..	100	..	96
Sell plant .. ..	100	100	100	..	..	..	..	..	100	100	100	100
Sell cow .. ..	100	..	100	84	53	100	43	90	..	100	..	..
Sell ewe .. ..	100	109	..	185	103	119	151	151	114	100	100	116

Key: NC: North Coast; HM: Hunter and Manning; SC: South Coast; NT: North Tableland; CT: Central Tableland; ST: Southern Tableland; NWS: North Western Slope; CWS: Central Western Slope; SWS: South Western Slope; NCP: North Central Plain; CP: Central Plain; RIV: Riverina; ND+: index is not determined because of a division by zero, but there is an increase in the activity level due to the slump; ND-: as above but a decrease.

The distribution of change in net worth due to a slump wool-price expectation by Statistical Division, is shown in Table 4. The importance of this type of information is in determining which Statistical Divisions suffer the greatest impact, under the assumption of APMAA'74, of a slump in wool-price expectations.

# REVIEW OF MARKETING AND AGRICULTURAL ECONOMICS

TABLE 4: *Distribution of Change in Net Worth, due to a Wool-Price Slump Situation: 12 Statistical Divisions of New South Wales*

Statistical Division	Change due to a slump	Change as percent of no-slump net worth	Per cent of total decline
	(000's \$)		
North Coast .. ..	— 654	1	0.4
Hunter and Manning .. ..	— 1,391	1	0.8
South Coast .. ..	— 1,976	2	1.1
Northern Tableland .. ..	— 9,179	3	5.1
Central Tableland .. ..	— 11,591	3	6.5
Southern Tableland .. ..	— 33,771	9	18.9
North Western Slope .. ..	— 22,507	5	12.6
Central Western Slope .. ..	— 16,925	5	9.5
South Western Slope .. ..	— 17,129	3	9.6
North Central Plain .. ..	— 10,163	3	5.7
Central Plain .. ..	— 5,700	1	3.2
Riverina .. ..	— 47,314	4	26.6
Total .. ..	— 178,300	2.94	100.0

The first column of figures in Table 4 is the amount of change, in Statistical Division net worth, due to a slump. For example, in the North Coast the decrease is \$654,000. Column 2 gives an indication of the importance of the change by expressing it as a percentage of the net worth in a no-slump situation. The Southern Tableland has a big change (nine per cent) within the Statistical Division but Riverina accounts for 26.6 per cent of the total change. The overall fall in net worth, due to a fall from 0.92\$/kg to 0.66\$/kg was 2.94 per cent.

The model results presented above suggest that APMAA'74 can produce representative farm and regional information of use in policy decision making. Of course, the particular data presented in Tables 1 to 4 above should be interpreted very cautiously. At best, given the minimum-level nature of APMAA'74, they are illustrative rather than definitive. Nonetheless, given the lack of alternative mechanisms for rapidly generating such information, they must complement decision makers' prior information (however intuitive) and add to the decision making process.

The results presented also illustrate that APMAA produces great quantities of information (only a portion of which has been presented). Tables could be expanded almost indefinitely with various levels of aggregation and different breakdowns of information.

## 7. CONCLUDING REMARKS

APMAA'74 is only part of the work of the APMAA Research Team, and must be judged in the light of its contribution to the whole project.

In assessing the work to date, the following points deserve emphasis:

- (a) APMAA'74 has explored modelling of agricultural supply and income along somewhat different lines to those followed in models developed in other countries. This is mainly due to characteristics of Australian agricultural production, such as the export orientation of the production of beef, wheat and wool, and the prevailing weather uncertainty.
- (b) APMAA'74 as a minimum-level model of APMAA has been useful in that it has provided the Research Team with insights into modelling methodology and an operational model, both of which can be used as a basis for further model development.
- (c) Data availability is a problem which becomes more restrictive as the level of disaggregation increases. However, the usefulness of model results is directly related to the level of model disaggregation.
- (d) Use of representative farms (differentiated by geographical production characteristics, farm size, and farm type) generates results on the distributional effects of agricultural policies and situations as well as their aggregate effects. Both of these effects are important in assessing alternatives.

## 8. POSSIBLE DIRECTIONS OF FUTURE WORK

Some of the directions of further development of APMAA that are indicated (apart from its extension to other States and the incorporation of more refined data) include:

- (a) Separation of the effects of price and yield uncertainty on farmer behaviour. The current use of the behavioural LP modification does not separate behavioural uncertainty by sources. It is especially desirable to separate price and yield uncertainty since the policy instruments affecting uncertainty depend on the source of the variation. For example, policies which are intended to affect variation on wheat farms would need to take account of the fact that a large amount of the historical variation in the unit gross margin of wheat is explained by the variations in the *yield* of wheat which is, of course, related to weather: whereas policy directed towards variation on wool farms should be directed towards *price* stabilization.
- (b) Validation of the model. Validation of large scale models is an open question. Traditional methods of validation are not satisfactory because of the normative aspects of models like APMAA. One avenue that has not (as yet) received much attention is validation in terms of value of information produced, i.e., a validation assessment on decision theoretic grounds (Anderson *et al.* [1]).
- (c) Incorporation of policy alternatives. APMAA'74 has primarily been used, by other members of the APMAA Research Team, as a base for further *model development*. However, work is required on the *use* of APMAA'74 (with its extensions) for policy analysis. Conceptually, incorporation of policy alternatives to APMAA'74 involves determining the level of parameters consistent with these alternatives. The policy

alternatives that are of most interest to the future users are rarely simple. Methods of incorporating these complexities are necessary if APMAA is to reach its potential as a tool for policy analysis.

(d) Long range planning. One particularly appealing use of APMAA would be a long run assessment of Australia's agricultural productive capacity with varying assumptions about levels of land, water (irrigation) and technological (improved pastures and fertilizer) development.

## REFERENCES

- [1] ANDERSON, J. R., B. HARDAKER and J. L. DILLON, *Decision Theory in Agricultural Management*, (Ames: Iowa State University Press, 1976), Ch. 5 (in press).
- [2] BOUSSARD, J. M. and M. PETIT, "Representation of Farmer's Behaviour Under Uncertainty with a Focus-Loss Constraint", *Journal of Farm Economics*, Volume 49 (1967), pp. 869-80.
- [3] DULLOY, J. H. and R. D. NORTON, "CHAC a Programming Model of Mexican Agriculture", in L. M. Goreux and A. S. Manne, eds., *Multi-level Planning: Case Studies in Mexico*, (Amsterdam: North-Holland, 1973), Part IV, Ch. 1.
- [4] HEADY, E. O. (ed.), *Economic Models and Quantitative Methods for Decision and Planning in Agriculture*, (Ames: Iowa State University Press, 1971).
- [5] HEADY, E. O., H. C. MADSEN, K. J. NICOL, and S. H. HARGROVE, "National and Interregional Models of Water Demand, Land Use and Agricultural Policies", *Water Resources Research*, Volume 9, No. 4 (1973), pp. 777-91.
- [6] INTRILIGATOR, M. D. (ed.), *Frontiers of Quantitative Economics*, (Amsterdam: North-Holland, 1971).
- [7] JUDGE, G. G. and T. TAKAYAMA (eds.), *Studies in Economic Planning over Space and Time*, (Amsterdam: North-Holland, 1973).
- [8] KENNEDY, J. O. S. and E. M. FRANCISCO, "On the Formulation of Risk Constraints for Linear Programming", *Journal of Agricultural Economics*, Volume 25, No. 2 (1974), pp. 129-45.
- [9] MONYPENNY, J. R., *APMAA'74: Model, Algorithm, Testing, and Application*, (University of New England, Faculty of Economic Studies: Aggregative Programming Model of Australian Agriculture, Research Report No. 7, November, 1975).
- [10] SEARS, D. W., "Utility Testing of Urban and Regional Models", *Policy Sciences*, Volume 3, No. 2 (1972), pp. 235-47.
- [11] WEGENER, M. K., *Prediction of Resource Use in the Fitzroy Region: A Recursive Programming Approach*, (University of Queensland: Unpublished Masters Dissertation, 1973).



APPENDIX 1: Detailed LP matrix of an APMAA '74 representative farm

	RHS	Sign	Production activities				Behavioural section			Financial activities						Resource activities				
			Crops ac	Beef cow	Sheep ewe	Pasture ac	Loss \$	Mini-negative	Mini-positive	Borrow	Save	Pay debt	Postpone debt	Tax	Consumption	Buy plant	Buy cows	Buy ewes	Sell plant	Sell cows
Objective function			GM	GM	GM	GM	0	-0.5	0.5	0	IRS	0	-IRB	0	0	0	0	0	0	0
Crop land	..	+	1																	
Grazing land	..	+				1														
Labour	..	+		+	+	+														
Wet season	..	0	+	+	+	-														
Dry season	..	0	-	+	+	-														
Behavioural constraints	..	0	+	+	+		-													
	0	0					-													
Mini	..	0	GM	GM	GM	GM	-1	1	-1		IRS		-IRB							
Debt	..	=								-1		1								
Maximum borrowing	..	=								1		1								
Cash	..	=																		
Tax	..	+	-GM	-GM	-GM	-GM					+IRS	1	IRB	1	1	+	+	+	-	-
Consumption	..	=													1					
Plant	..	+	1	1	1										-1	-1	-1	1	1	1
Cows	..	+																		
Ewes	..	+																		

Key: + or - indicates the sign of the matrix element; -GM: means the negative of the gross margin; -IRB: means the negative of the borrowing interest rate; IRS: saving interest rate.