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To the Graduate Council:

I am submitting herewith a dissertation written by Vaithilingam Rajagopalan entitled "Supply response for irrigated crops in Madras State, India." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

Irving Dubov, Major Professor

We have read this dissertation and recommend its acceptance:

Tong H. Lee, Merton B. Badenhop, Luther H. Keller, William P. Ranney

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

May 11, 1967

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Irving G. Dubow
Major Professor

We have read this dissertation and recommend its acceptance:

Tong Hun Lee

Luther H. Keller

M. B. Bradshaw

W. P. Ramsey

Accepted for the Council:

Hilton A. Smith
Vice President for
Graduate Studies and
Research

SUPPLY RESPONSE FOR IRRIGATED CROPS IN MADRAS STATE, INDIA

A Dissertation

Presented to

the Graduate Council

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

---

by

Vaithilingam Rajagopalan

August 1967

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TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
	Problem	3
	Objective	4
	Characteristics of the Area Studied	5
	General	5
	Agro-climatic complex	6
	Agricultural production and marketing	8
II.	SUPPLY RESPONSE--CONCEPTUAL FRAMEWORK	12
	Introduction	12
	Decision Framework	15
	Elements of the decision milieu	15
	Decision on objective and production plan	17
	Decision on altering the production plan	21
	Decision on disposal of products	23
III.	SUPPLY RESPONSE--ANALYTICAL FRAMEWORK	30
	Introduction	30
	Supply Response Models	31
	Dynamic models	32
	Supply response models used in the present study	38

CHAPTER PAGE

IV. DATA: REQUIREMENT, AVAILABILITY, AND ADJUSTMENT PROCEDURES 44
Introduction 44
Area Delineation and Bases 46
Evaluation of Data Situation 53
Agricultural Prices 53
Acreage of Irrigated Crops 56
Crop Yields and Production 58

V. SUPPLY RESPONSE--EMPIRICAL RESULTS 60
Introduction 60
Empirical Results - Region I 66
Empirical Results - Region II 77
Empirical Results - Region III 84
Supply Response--Regional Differences 90

VI. SUMMARY AND CONCLUSION 94
Review of Procedure 94
Summary of Results 95
Implication of Results 99

BIBLIOGRAPHY 101

APPENDIX 107

LIST OF TABLES

TABLE PAGE

I. Normal Rainfall and Source of Irrigation During 1961-62, Madras State, India 7

II. Area Under Major Crops and Variations Over the Period from 1957-58 to 1961-62, Madras State, India 9

III. Classification of Regions and Regional Characteristics, Madras State, India 47

IV. Price Relatives of Principal Crops, 1938-39 to 1949-50, Madras State (Base Year 1938-39 = 100) 55

V. Crop Substitutes for Major Crops, Madras State, India 64

VI. Alternative Regressions for Major Crop Acreages, 1939-40 to 1961-62, Region I, Madras State, India 67

VII. Regressions for Major Crop Acreages, 1939-40 to 1961-62, Region I, Madras State, India Model (5.3) 68

VIII. Alternative Regressions for Major Crop Acreages, 1939-40 to 1961-62, Region II, Madras State, India 78

IX. Regressions for Major Crop Acreages, 1939-40 to 1961-62, Region II, Madras State, India Model (5.3) 79

TABLE PAGE

X. Alternative Regressions for Major Crop Acreages, 1939-40 to 1961-62, Region III, Madras State, India 85

XI. Regressions for Major Crops, 1939-40 to 1961-62, Region III, Madras State, India Model (5.3) . . 86

XII. Estimates of Partial Elasticities of Supply of Major Crops, 1939-40 to 1961-62, Madras State, India 92

XIII. Adjusted Crop Acreage for Major Irrigated Crops, Region I, Madras State, India 108

XIV. Adjusted Crop Acreage for Major Irrigated Crops, Region II, Madras State, India 109

XV. Adjusted Crop Acreage for Major Irrigated Crops, Region III, Madras State, India 110

XVI. Crop Yields per acre for Major Crops, Region I, Madras State, India 111

XVII. Crop Yields per Acre for Major Crops, Region II, Madras State, India 112

XVIII. Crop Yields per Acre for Major Crops, Region III, Madras State, India 113

XIX. Annual Average Prices per Maund (82.29 lb.) for Major Farm Commodities, Region I, Madras State, India 114

XX. Annual Average Prices per Maund (82.29 lb.) for Major Farm Commodities, Region II, Madras State, India 115

TABLE PAGE

XXI. Annual Average Prices per Maund (82.29 lb.) for Major Farm Commodities, Region III, Madras State, India 116

XXII. Net Irrigated Acre Relatives (Base Year: 1939-40), Region III, Madras State, India . . .117

XXIII. Net Irrigated Acre Relatives (Base Year: 1939-40),Region II, Madras State, India 118

XXIV. Net Irrigated Acre Relatives (Base Year: 1939-40), Region I, Madras State, India 119

XXV. National Income, and Per Capita Income, at 1948-49 Prices, India 120

XXVI. Estimated Acreage Changes for Specified Rates of Changes in Product Prices, 1939-40 to 1961-62, Region I, Madras State, India 121

XXVII. Estimated Acreage Changes for Specified Rates of Changes in Product Prices, 1939-40 to 1961-62, Region II, Madras State, India 122

XXVIII. Estimated Acreage Changes for Specified Rates of Changes in Product Prices, 1939-40 to 1961-62, Region III, Madras State, India . . .124

XXIX. Districtwise Calendar of Agricultural Operations for Important Crops, Madras State, India 125

CHAPTER I

INTRODUCTION

The economic development in India depends in large measure on the rising productivity of its agriculture. This agricultural productivity can be increased only by increased use of such capital inputs as fertilizers, pesticides, and machinery which are produced in the nonagricultural sectors. This sectoral interdependence has been realized increasingly in planning for economic development in India.

It has been argued that the performance of agricultural sector, especially during the present decade, was handicapped by poor monsoon rains, failure of nonfarm sectors to supply enough agricultural inputs, and lack of proper price policy.[1] Policies for increasing productivity must have four strategies. First, the tenure structure of agricultural production must be reorganized to provide motivation for greater efficiency in production. Land reform measures embracing all aspects of tenure are relevant cases in point. Second, improved methods of production, based on new technology, must be developed. The prime objective must be to reduce the lag

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[1]Asoka Mehta, "Presidential Address: Towards an Agricultural Revolution," Indian Journal of Agricultural Economics, 20 (1):15, 1965.

between development and adoption, and this can be accomplished only through intensive extension education programs. Third, the supply of the specialized inputs required for greater production must be provided. Fourth, a comprehensive price and income transfer policy to provide income incentives and to guarantee a minimum annual income by minimizing the price uncertainties must be formulated.[2]

The four strategies of the policy for stepping up productivity in Indian agriculture should be pursued in a coordinated fashion. Different strategies require more or less emphasis at the different stages of agricultural development. The initial transformation of a stagnant agriculture into a dynamic one requires abandonment of the old feudal framework and substitution of new and improved techniques for trandtional methods of production. At the same time this is accomplished, strategies for increasing the supplies of

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[2]The old myth that the farmers of the less developed nations do not respond to economic incentives such as prices has been exploded. For the case of overpopulated nations, see Walter P. Falcon, "Farmers' Response to Price in an Underdeveloped Area: A Case Study of West Pakistan" (Unpublished Ph.D. thesis, Harvard University, Cambridge, 1962), and Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region," Economic Journal, 73:676-687, September, 1963.

specialized inputs (i.e., moving their supply functions rightward), and for creating price incentives should be activated.[3]

I. THE PROBLEM

The foregoing discussions aimed to incate that a well-defined policy for creating price incentives is a necessary condition for far greater efficiency and output expansion in developing agriculture. In order to develop a coherent price incentive policy, however, we must first develop pertinent data pertaining to the quantitative nature of the supply-response process. One way to generate such quantitative information is to assume that given a set of prices as parameters in an atomistic agriculture, it is possible to estimate farmers' response to price changes in terms of price elasticity of output for a given period. What are desired are reliable estimates fo farmers' response to price changes under specific sets of circumstances.

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[3]Myint points out that during the decade 1950-1960, the volume of agricultural production increased by 45.5 per cent or about 4.5 per cent annually. This was twice the annual rate of increase in population during the same period. The production growth rate tapered off since 1960, presumably because of reasons given in footnote (1). For discussion of other types of economic incentives and the need for the balanced growth, see H. Myint, The Economics of the Developing Countries (London: Hutchinson University Library, 1964).

II. OBJECTIVE

The general objective of the present study was to estimate the indicated kinds of information on farmers' response to prices for major commodities produced in Madras State during the period from 1939-40 to 1961-62.[4] The Season and Crop Reports published by the Government of Madras were available for this period only. The data availability, therefore, limited the study to this period. To achieve this general objective it was necessary:

1. to delineate specific regions for crop production on the basis of agro-climate characteristics,
2. to estimate the price elasticity of supply of the products of rice, ragi,[5] cumbu,[6] sugarcane, groundnuts,[7] and cotton by regions of two or more districts in Madras State.
3. to explain any differences by regions in estimates of the price elasticity of supply of commodities noted in (2) above.

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[4]The year is referred to agricultural year which starts on July 1 and ends at June 30 of the calendar year. In the discussion that follows, the year refers always to the agricultural year, unless otherwise indicated.

[5]Millet crop - Eleusine coracan.

[6]Millet crop - Pennisetum typhoideum.

[7]Peanut crop - Arachis hypogea.

Ten of the thirteen districts in Madras State were selected as study areas for the present analysis.[8] The districts comprised, in 1961-62, 98 per cent of total cropped area, and 98.2 per cent of area under irrigated crops in Madras State.[9]

III. CHARACTERISTICS OF THE AREA STUDIED

General

The total geographic area of Madras State is 50,331 square miles.[10] The State is situated in the Southeastern extremity of the Indian peninsula. The population of the State in 1961 was 33.7 millions, of which 73.31 per cent was rural.[11] The average cultivated area per capita was 0.57 acres; the average cultivated area per household was 4.6 acres and per male cultivator was 3.48 acres.[12]

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[8] Of the remaining three districts, one (Madras district) is a metropolitan area. Another (Nilgris district) has subtropical and temporate climate; and the main crops are plantation crops such as tea, coffee, subtropical fruits and vegetables. The third (Kanyakumari district) was transferred to Madras State in 1956, and no data for earlier period were available.

[9] *Season and Crop Report, Madras State*, 1961-62 (Madras: Government Press, 1963).

[10] *Census of India*, 1961 (Madras: Superintendent of Census Operations, 1964), Vol. 9, pt. 2-BI.

[11] *Ibid.* [12] *Ibid.*

Agro-climatic Complex

The State, except in the western mountains, has a tropical climate with a temperature range of 65°F to 110°F. The annual average rainfall within the State ranges between 25 and 75 inches.[13] The average annual rainfall and its distribution are given in the first section of Table I. The major sources of irrigation are canals, tanks, and wells; and the importance of these sources is summarized in Table I as per cent of the total net area irrigated in the State during 1961-62.

The Southwest monsoon visits the State during June and August inundating the major rivers of the State. The sowing of crops in light soils[14] begins at the onset of these monsoon rains. The Northeast monsoon brings heavy rains along the coastal districts and fills tanks and reservoirs. Cultivation in heavy soils begins. Irrigation by wells is important in Salem, Coimbatore, Thiruchirapalli, and Madurai districts. Wells also supplement the regular source of irrigation water for summer crops.

The main types of soils in the State are red, black, and alluvial soils. Red soils occupy a large part of central

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[13]National Council on Applied Economic Research, Techno-Economic Survey of Madras (Madras: Government Press, 1960).

[14]Soils are called light and heavy soils on the basis of loam and clay contents of the soils.

TABLE 1

NORMAL RAINFALL AND SOURCE OF IRRIGATION DURING 1961-62, MADRAS STATE, INDIA

Districts	Rainfall (in inches)[a]				Source of irrigation (per cent)[b]			
	Southwest monsoon June-Sept.	Northeast monsoon Oct.-Dec.	Dry and hot weather Jan.-May	Total	Canals	Tanks	Wells	As per cent of net area sown[c]
Chingleput	15.8	28.2	2.5	46.5	2.05	80.23	15.79	76.5
South Arcot	16.6	25.9	3.5	40.0	25.30	48.96	21.08	50.9
North Arcot	18.1	15.9	4.1	38.1	6.84	52.49	37.02	40.1
Salem	14.8	11.6	6.3	32.7	18.29	17.89	61.28	16.8
Coimbatore	8.4	12.2	6.0	26.6	43.10	2.65	53.37	36.3
Thiruchirapalli	12.1	16.6	5.7	34.4	46.87	29.55	20.72	33.5
Thanjavur	12.4	28.5	4.0	44.9	93.85	5.20	0.83	85.8
Madurai	9.0	16.1	6.3	31.4	32.12	28.37	37.43	33.9
Ramanathapuram	7.5	18.5	5.0	31.0	0.15	89.24	10.58	40.7
Thirunelveli	3.3	20.5	5.2	29.0	13.91	58.97	26.61	33.7
Weighted Average for all Districts	12.25	17.80	5.95	36.0	36.93	37.53	23.57	41.59

[a]Normal rainfall is the average of 50 years ending on 1939-40.

[b]Related to year 1961-62; expressed as per cent to net irrigated.

[c]Per cent of net area irrigated to net area sown in 1961-62.

Source: Season and Crop Report (1961-62), Madras State (Madras: Government Press, 1963).

districts and the alluvial soils are found along the east coast with some breaks in Thanjavur and Ramanthapuram districts. The black clayey alumina-rich soil is seen in parts of the Coimbatore, Madurai, and Thirunelveli districts.

The major crops grown in the State are rice, millets, pulses, sugarcane, groundnut, cotton, tobacco, and oil seeds. The importance of each of the major crops in terms of proportion to total area sown is summarized in Table II. Details about sowing and harvesting dates for each of the major crops and for each district of the State are given in the Appendix.

Agricultural Production and Marketing

According to the 1961 census, the average size of farm holding per household in Madras State was 4.6 acres. In terms of tenure status, the average sizes of holdings under owner cultivation, pure tenancy, and part ownership and part leasing were, respectively, 4.70, 2.77, and 5.46 acres.[15]

Rice, sugarcane, and cotton are the major crops grown on the smaller irrigated farms. As would be expected, the intensity of cultivation tends to vary inversely with size of farm. On the larger farms, the enterprise systems are expanded to include the millets and pulses in order to make better

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[15] Census of India, 1961, op. cit.

TABLE II

AREA UNDER MAJOR CROPS AND VARIATIONS OVER THE PERIOD FROM 1957-58 TO 1961-62, MADRAS STATE, INDIA

Crops	1957-58	1958-59	1959-60	1960-61	1961-62
	Per cent[a]				
Rice	33.5	32.8	32.9	34.4	34.9
Cholam	10.3	11.4	11.0	10.6	10.6
Cumbu	7.2	7.2	7.4	6.7	6.7
Ragi	5.1	5.3	5.2	5.0	4.6
Sugarcane	0.9	0.8	0.8	1.1	1.0
Total Cereals	63.8	63.9	64.0	63.9	64.4
Pulses	3.3	3.0	3.0	2.9	3.0
Subtotal Food Crops	76.0	75.3	75.7	75.4	75.7
Groundnuts	11.5	11.7	11.9	11.0	13.2
Gingelly	1.7	2.2	1.6	1.7	1.5
Castor	0.1	0.2	0.2	0.2	0.2
Coconut	0.8	0.8	0.8	0.8	0.8
Cotton	6.1	5.8	5.8	5.4	5.4
Tobacco	0.1	0.2	0.2	0.3	0.2
Subtotal Non-food Crops	24.0	24.7	24.3	24.6	24.3

[a]Per cent is expressed as a relation to total area sown.

Source: Season Crop Reports (1957-58 to 1961-62), Madras State (Madras: Government Press).

year-round use of the total family labor supply. And additional motivation for this diversification, the minimization of risks in crop production.

The major input items produced on the farms are seeds and manures. Varying amounts of fertilizers and pesticides are purchased. Family labor supplemented by hired labor when required during the planting and harvesting periods.

Farm products produced for sale are generally sold in local primary markets, each of which may serve a group of 20 to 25 villages. At these markets, local traders and commission agents act as intermediaries between farmers and the larger wholesale traders who sell to retailers in principal urban markets (having populations of 20,000 or more people). The trade practices of these local traders are regulated under provisions enacted by the State legislature. Price information is made available to farmers either by market committees that represent grower, trader, and public interest or by contacts in the market with other farmers who are likewise selling their products.

Farm level production and marketing decisions are made generally by the entire family consulting together, or, at least, by the family members who are most directly involved with managing the farm.

As will be elaborated in Chapter III, farm production decisions are concerned with outputs that have two utilizations--(1) home consumption to sustain farm family living and/

or (2) sale through normal commercial markets. The fact that varying amounts of the products whose supply response was studied can move into home consumption is an important consideration since it can obscure, distort, or hide the kinds of relations (between prices and production responses) that the analysis attempted to uncover. More will be said of this in the sections dealing with evaluation and interpretation of the analytical results (see Chapter V).

CHAPTER II

SUPPLY RESPONSE - CONCEPTUAL FRAMEWORK

I. INTRODUCTION

In the neo-classical tradition, the supply of a commodity is conceptualized in three alternative temporal contexts: very short-, short-, and long-run. The time dimension is related to the operational flexibility of the supplying firms. In the very short-run, the time is so short that the firms cannot alter the supply; and the price of the commodity is determined by the existing demand conditions in the market reacting to the perfectly inelastic supply. In the short-run, the supplying firms have greater operational flexibility in altering the supply depending on the degree of flexibility the firms can enjoy in changing the pattern of resource utilization. In the long-run the firms have perfect flexibility for decisions on resource adjustment and use. The time dimension is thus related to flexibility for making decisions and this decision behavior is implied in the concept of supply and supply response with reference to changes in one or more decision variables such as price and costs.

The supply of a commodity is also distinguished as the

"production" and "sales" supply.[1] The former defines the supply of a commodity which reflects the rate of adjustment in production and, hence, the stream of supply. The latter defines the decisions in the market on sales and inventories. The "production" supply may be related to the concept of agricultural supply which may be defined as the amount of farm commodity available, for a given point in time, either at the farm or at the nearby primary market. The short-, and long-run supply definitions may be incorporated in the concept of agricultural supply so that the decision behavior can further be specified.

An agricultural supply function is defined[2] as, ceteris paribus, a relationship between price and quantity produced and offered for sale. Implicit in this definition is that input rates for one or more, not all factors can be varied during the production process. An agricultural supply response function is defined as the price-quantity relationship when the production can be adjusted by changing input rates of all factors and technology.[3]

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[1]Wiles, P. J. D., Price, Cost and Output (Oxford: Basil Blackwell, 1956), p. 151.

[2]Willard W. Cochrane, "Conceptualizing the Supply Relation in Agriculture," Journal of Farm Economics, 37(5):1161-1176, 1955.

[3]Supply response function is defined to imply complete flexibility in resource use and adjustments in the technology of production in response to changes in product prices of substitute crops, and factor prices.

Alternatively, the supply of a commodity at a given point in time may be viewed as a result of a sequence of decisions on production and resource use. The major decisions are made on the objectives, and production plans at the beginning of production period; later, during the period of production decisions are made to alter production planned earlier. A series of decisions thus underlie the supply response behavior. The concept of supply response will be recast into a decision framework. These ideas are relevant to the discussion:

1. Planning horizon--the point in time on which price and production expectations, and production decisions are focused. A planning horizon marks the end of a planning period; e.g., a crop or agricultural year.
2. Threshold--the point time at the beginning of a planning period, at which time goals, expectations, and decisions are formulated.[4]
3. Farm--the complete production-consumption decision-making unit. It includes the household and implies correlation of consumption and

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[4]For a similar approach see Willard F. Williams, "An Empirical Study of Price Expectations and Production Plans," Journal of Farm Economics, 35(3):355-370, 1953.

production decisions.[5] It also implies multiple criteria of choice for setting the goal of the farm.[6]

4. Farmer--the decision-maker in the farm enterprise. Inter-related production-consumption decisions are assumed to be made with the concurrence and cooperation of other members of the family and in recognition to their utility-disutility preferences.[7]

II. DECISION FRAMEWORK

Elements of the Decision Milieu

The decision milieu for a planning period constitutes the technical constraints, level of technology, resource availability and the perception of the individual farmers, and expected future product and factor prices. Decisions are made in sequence during the planning period on the basis of subjective response of the farmer to stimuli from decision environs. These sequential decisions are related to major phases of production and marketing and consumption.

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[5]Consumption includes leisure. See, Gary S. Becker, "A Theory of the Allocation of Time," The Economic Journal, 75:498, September, 1963.

[6]Robert L. Clodius, "The Theory of the Kinked Output Path Response," Journal of Farm Economics, 35(3):427-436, 1953.

[7]Amartya K. Sen. "Peasants and Dualism with or without Surplus Labor," Journal of Political Economy, 74(5):425-450, 1966.

In the traditional Indian agriculture, the farmer is characterized as the standard-bearer of traditions and customs in an agriculture which is not absolutely stagnant but which may have discrete secular shifts. Changes in cropping patterns, and cultivation practices are examples of such shifts. The decisions on farm production and marketing are closely related to family labor supply and family consumption. The amount of capital available for production, for example, is influenced by the consumption needs of the family; and, therefore, some degree of capital rationing becomes inevitable.

The number of alternative processes of production available for a farm for a planning period is quite limited since technical constraints such as soil, climate, and topography limit the number and kinds of crops that can be grown in a given period and region. Recognition of potential alternatives depends on the knowledge of the farmer, which, in turn, is the result of farmer's training and exposure to innovations and the rate of diffusion of new suggestions. Thus, technology of production used can vary among farms, among regions, and over time. The aggregate level of technology used at a given point of time is a function of investment in research and extension in agriculture.

The resource base of the farm is another element of the decision milieu that operates as a limiting factor. It is possible to augment the existing resources by either leasing

in or by purchase. In the over-populated countries land per capita and capital per acre are extremely limited and these resource constraints are serious handicaps for output expansion in agriculture. More often the farmer attempts to optimize the use of existing resources.[8]

Decision on Objective and Production Plan

One might initially postulate that the objective motivating farmer decisions is maximization of expected net income (expected total receipts minus out-of-pocket production and marketing costs). Questions have been raised, however, regarding the validity of this profit maximizing assumption. The theory of firm, as it has developed, recognizes other more-or-less inter-related objectives or motivations: market performance and survival strategies, leisure, safety or risk reduction.[9] These kinds of additional motivations serve to

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[8]W. David Hopper, "Allocation Efficiency in a Traditional Indian Agriculture," Journal of Farm Economics, 47(3): 611-624, 1965.

[9]A number of studies are available on this problem. For excellent theoretical exposition especially for oligopolistic markets see William J. Fellner, Competition Among the Few (New York: Augustus M. Kelley, 1960); idem, Probability and Profit--A Study of Economic Behavior Along Beysian Lines (Homewood: Richard D. Irwin, 1965), William J. Baumol, Business Behavior, Value and Growth (New York: Macmillan and Co., 1959), and P. W. S. Andrews, On Competition in Economic Theory (London: Macmillan and Co., 1964). For a comprehensive survey, see Herbert A. Simon, "Theories of Decision-making in Economics and Behavioral Science," Surveys of Economic Theory, Resource Allocation (New York: St. Martin Press, 1966), pp. 1-28.

constrain and/or alter decision process from what they would be if only the single objective of profit maximization were operative.

Accordingly, even if the farmer is the "price taker"[10] or the "quantity adjuster" and operates in an essentially atomistic competitive milieu, it may be more realistic that the individual farmer does not maximize his profits *in vacuo* but, instead maximizes an aggregate of variables denoted as "his family welfare or utility."[11] The utility is an aggregate, and it may not be logically consistent to say that one maximizes all the elements of the aggregate; and, therefore, one can specify the goal of the farmer as the maximization of profit subject to given constraints.[12]

More specifically, let us assume that there are n-objectives to be considered and m-ways of achieving these objectives. Let x_i be the "intensity" of achieving *i*th objective and y_j be the "intensity of applying the *j*th mean. Then, the decision of the farmer on the particular intensity

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[10]Price taker or quantity adjuster is one who takes price as given and decides to adjust the quantity to be produced and supplied at that given price. See Ragnar Frish, *Theory of Production* (Chicago: Rand McNally and Company, 1965), pp. 138-139.

[11]"Satisfice" is the term suggested by H. A. Simon, *op. cit.*

[12]Martin Shubik, "Objective Functions and Models of Corporate Optimization," *Quarterly Journal of Economics*, 75(3):345-375, 1961. See also, Jose Encanacion, Jr., "Constraints and the Firm's Utility Function," *Review of Economic Studies*, 31:113-120, 1964.

of a given objective can be specified as:

$$x_i = b_i (y_1, y_2, \ldots, y_m); \; i = 1, 2, \ldots, n;$$

where b_i's are parameters. All the y_j need not appear in b_i.

There are resource restrictions for each of m means of achieving a given objective. The family labor, the availability of credit, and the suitability of land impose restrictions on the means of achieving a given objective with a desired intensity. Then, the farmer optimizes his set of objectives as:[13]

$$\underset{y_1}{\text{Max}}, \underset{y_2}{\text{Max}}, \ldots, \underset{y_m}{\text{Max}}; \; U \left[b_1, (y_1, \ldots, y_m), b_2, \ldots, b_n\right]$$

subject to $\quad A_j \leqq y_j \leqq B_j$

where U is a complex aggregate utility function of x_i; and A_j and B_j are the resource restrictions.

The decision of the farmer regarding the set of activities which will maximize his utility subject to resource constraints and goals involves solution of an appropriately specified programming problem.

An equilibrium point for n-objectives can thus be derived; and it implies, given resource base and expected prices of factors and products, an output configuration which maximizes the expected utility of the farmer. In the preceding

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[13] Ibid.

discussions perfect foresight in formulating the prices and yields was implicit. However, certainty or perfect foresight is an exception rather than a rule in real world. Added to this is the uncertainty about prices in markets.

The problem of uncertainty with respect to product prices bears crucial significance to the farmer since, by assumption, he is the price taker and quantity adjuster, and also risk averter. The farmer in atomistic agriculture is weak against the impersonal market forces. Price uncertainty is crucial to him as it affects the income prospects and, therefore, his motivation and plan for increasing productivity of his farm.

Yield uncertainties in agriculture are generated by seasonal conditions such as excessive rainfall and drought, and by the outbreak of plant pests and diseases. Under certain conditions of assured irrigation facilities, a situation relevant to parts of the present study, variations in yields due to extreme weather conditions can reasonably be assumed to be small with little influence on threshold decision. This simplifying assumption does not rule out the adjustment in resource use during production and which will be discussed shortly.

One might also note the relation between factor price uncertainties to the threshold decision. The wages of hired labor and price of feeds, fertilizers, and pesticides are

major items of out-of-pocket factor costs. They may be assumed less uncertain during the threshold decision either because of small variations or by contractual agreements. Larger variations, if noted after the threshold decision, may be recognized by the farmer for subsequent decisions during the planning period. The above arguments for simplifying assumptions on yield and factor price uncertainties do not belittle their significance for threshold decisions. The profit maximization model can be specified to include these types of uncertainties. Nevertheless, for the peasants of the traditional agriculture, who use mostly family labor and home grown feed and manure, the assumption that product price uncertainties have greater relevance to threshold decisions seems to be reasonable and realistic.

In sum, the farmer makes threshold decisions to maximize the profit subject to certain constraints in view of his ultimate concern with maximizing the welfare of the farm and in the context of uncertainty in product market. Such threshold decisions may be called the decisions of the first kind.

Decisions on Altering the Production Plan

The decisions of the first kind are modified depending on the magnitude and direction of changes in the decision milieu. This may happen in two ways: first, an increase in knowledge about product markets would result in a decrease in price uncertainty, and, therefore lead to adjustment and

supply of products. Changing the rates of inputs such as fertilizer, feeds, and labor, are the cases in point. Second, incidence of pests and diseases and occurrence of extreme weather conditions would alter the production and supply. To be sure, these contingencies are unexpected in the sense that they are beyond the level of risks realized for threshold decisions. The rates of inputs are altered to meet such contingencies.

Under extreme conditions, the farmer faces the well-known dilemma, "to harvest or not to harvest," which can only be solved by marginal relations, holding the investment up to that point as fixed; i.e., equality between added costs and added returns. It might, however, be noted that changes are made in rates of input to alter production in response to changes in market conditions; and decisions on such changes are made with almost perfect foresight about market conditions depending on its vintage to planning horizon.

The product price uncertainty, as argued earlier, would be more relevant to threshold decisions. The analytical advantage of relating the yield uncertainty to the decisions subsequent to threshold decisions becomes clear if we note that under such conditions certainty of prices can reasonably be assumed. Put differently, expectational error of prices tends to be less, as one moves toward planning horizon, and as more information on ensuing market conditions, and errors of estimates of threshold decisions are recognized.

The decisions on altering the planned output by modifying the threshold decisions may be called the decisions of the second kind.

Decision on Disposal of Products

Disposal of products, at the completion of production processes selected by the decisions of first and second kind, may be viewed as disposals over space and time. Another familiar concept is the transfer costs which include, specifically for disposal over space, costs of transport and other incidentals such as tolls, and other personal expenditure in the market. It also includes, for disposal over time, the cost of storing and the required cost of processing and packing to minimize the storage costs.

The disposal of products may be defined as a function of the size of the marketable surplus, transfer costs, current market prices and expected changes in prices. The size of the marketable surplus of product(s) is determined by the size of the farm, productivity, and needs for domestic consumption. The farmer may have certain debts to be repaid and may have to incur certain expenses deferred till harvests.[14] If the marketable surplus is large and the future prices are

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[14]The credit terms, especially for crop farms, require that loans, advanced during the production period, must be repaid immediately after harvests.

expected to be relatively high, the farmer can sell part of the stock to discharge his financial commitments and store the rest of it.[15]

At the planning horizon, the farmer decides on sales and inventory of the stock of the products. The extent to which the deferred selling is possible, especially for farm products, depends on facilities available for processing, packing, and storing which are generally provided by the market intermediaries; namely, traders at the primary (village) markets, and wholesale traders in the central markets. The large farms are few[16] in the peasant agriculture; it is reasonable to assume that the deferred sales are likely to be of very small magnitude. In sum, the farmer makes decisions to dispose of the products through immediate sales or deferred

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[15]It might also happen that, with a product-mix in the marketable surplus, some products for which market conditions are favorable would be sold to ward off the immediate financial exigencies.

[16]In Madras State 73.23 per cent of households owning less than five acres cultivated only 33.90 per cent of the total area while 4.62 per cent of the households owning more than 15 acres cultivated 27.88 per cent of the total area. It is possible to store grains without processing for a longer period; but not with the case of sugarcane, cotton, and groundnut. The holding power of the farmer seems to be the crucial factor which determines the amount of deferred sales. For information on structural distribution of farms, see P. S. Sharma, "A Study of the Structural and Tenurial Aspects of Rural Economy in the Light of 1961 Census," Indian Journal of Agricultural Economics, 20(4):46-82, 1965.

sales depending on his expectations regarding demand rates in succeeding periods. Such decisions may be termed as decisions of the third kind. If there are no alternatives to immediate disposal, then, the decision of third kind does not exist as the decisions without choice do not exist.

The decisions of the first, second, and third kind may be viewed as threshold, preharvest, and post-harvest manipulations of resources of the farm to maximize the welfare of the farm. This decision framework can be related to the traditional classification of supply. The threshold decision of the farmer explains long-run supply response behavior while the pre- and post-harvest decisions explain, respectively, the short- and very short-run supply.

The crucial difference is the decisions on the long-run supply, in the conventional theory, concern more than one planning period; but in the present framework they correspond to a given planning period. This difference lies in the concept of fixed resources and the adjustment of production in response to price changes.

Suppose that the farmer expects an increase in the price of a given product. Furthermore, the increase may be assumed relative to the price of other products of the farm. Three alternatives to adjust the supply of the given product are available: first, additional resources may be acquired for increasing the production. If capital is one of the

limiting resources of the farm, credit availability and the existing burden of debt determine the possibility for resource augmentation through direct acquisition. Second, resource substitution between products, depending on relative product prices, may be resorted to. The degree of substitution is determined by the versatility of resources and to the extent factor segmentation is possible. Under practical conditions ensuing in agriculture, it is possible to substitute resources with slight changes at some costs. Third, the increase in production of the product may be spread over more than one production period through resource acquisition in stages.[17]

The farmer decides on these three alternatives depending on the rate of relative price changes and the decision milieu, defined earlier, relevant to threshold decisions. Whether the first and/or second alternative or the third alternative is relevant to threshold decisions, it must be decided by empirical verification.

One might also note that the concept of distributed lags in adjustment is based on the definition of normal price as a component part of the observed price incorporating in it the permanent changes in the determinants of price formation.

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[17]This is the implication of the concept of distributed lag in adjustment. See Marc Nerlove, Dynamics of Supply: Estimation of Farmers' Response to Price (Baltimore: The John Hopkins Press, 1958).

It is further specified that the decision maker revises his concept of normal price at the threshold based on his experience with anticipated and realized normal price in the preceeding planning period. It would seem incongruous to expect the farmer to spread his adjustment plans over a number of planning periods when his threshold decisions are postulated to entail the revision of his concept of normal price every period.

A priori, with reference to the traditional agriculture at least, one might reasonably suppose that the second alternative is more relevant, because the fixed resources are not specialized but more versatile.[18]

One might also point out that the psychological factors such as risk aversion, habit persistence and sheer inertia on the part of the farmer would lead toward the third alternative. Nevertheless, the significance of the concept of normal price in this context must be clearly recognized. Since the idea of normal price itself is a subjective phenomenon, it seems that psychological factors have more impact on the farmer's response to changes in normal price than the economic factors imbedded in the three alternatives above. This is plausible if the configuration of normal price itself is the product of interaction between the psychological factors and consideration of uncertainties.

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[18]For different conclusion see Raj Krishna, op. cit.

With the above discussions in mind, the decisions of the first and second kind are related to long- and short-run supply. This formulation is also equivalent to intrayear and interyear classification.[19]

When the supply response behavior of individual farmers is set in the decision framework, the next problem, relevant to the macro analysis of farmers' response to supply, is the aggregation problem. How close is the behavior of the farmers as a whole to the behavior of the individual behavior? One might define the micro theory as the one which explains the individual behavior and micro variables as the determinants of such behavior. Similarly, the macro theory explains the behavior of farmers as a whole and the aggregates of the variables determining the macro behavior.

The theory of aggregation, yet to be developed fully in the literature, states that a given method of aggregation is consistent if, given micro theory and properties of the macro theory, it ensures the aggregation of micro variables whose properties are consistent with micro theory and the properties of the macro theory.[20] Expressed differently,

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[19]Earl O. Heady, Economics of Agricultural Production and Resource Use (Englewood Cliffs: Prentice-Hall, Inc., 1954), pp. 674-588.

[20]Lawrence R. Klein, "Remarks on the Theory of Aggregation," Econometrica 14(4):303-312, 1946.

the closer the estimated coefficients of micro variable to that of the macro variables, the less is the aggregation bias.[21]

Aggregation bias can be minimized through efficient aggregation procedures. For homogeneous regions of similar agro-climatic characteristics and socio-cultural patterns, the aggregation of micro variables to analyze the macro behavior such as the supply response behavior of farmers is likely to yield the estimates with minimum aggregation bias.

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[21]Henry Theil, Linear Aggregation of Economic Relations (Amsterdam: North-Holland Publishing Company, 1954), also H. A. John Green, Aggregation in Economic Analysis - An Introductory Survey (Princeton: Princeton University, 1964).

CHAPTER III

SUPPLY RESPONSE - ANALYTICAL FRAMEWORK

I. INTRODUCTION

In any empirical analysis of aggregate supply behavior, the problems of aggregation, identification, and simplifying assumptions must be solved if the analysis is to generate useful and valid results. Since the problem of aggregation was dealt with in the preceding chapter, attention is turned to the other conceptual issues.

An identification problem can arise, if a set of data are generated by the interaction of two or more functions (or processes). For example, market prices are determined by the simultaneous interaction of market supply with market demand.[1] Therefore, for any given set of prices and quantities it is necessary to determine if the data trace out (a) a supply curve, (b) a demand curve, or (c) the intersections of a whole series of market supply and market demand curves. This problem is solved by appropriate specification of the demand and supply functions in terms of variables in addition to

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[1]For detailed discussions on the related problems see, Arthur S. Goldberger, Econometric Theory (New York: John Wiley and Sons, 1964), and E. Malinvaud, Statistical Methods in Econometrics (Amsterdam: North-Holland Publishing Company, 1966).

price variables. One approach is to define quantity supplied as a function of lagged prices, weather, and technology. In the case of analyses based on threshold decisions that are reflected later in market supply, acreage is used in place of quantity of product produced.

In social sciences, the data for empirical investigations are not always in the desired form and do not always possess the desired degree of precision. Modification of research model specifications often are necessary to accommodate data limitations.[2] Also, the statistical models used in the empirical analysis should conform as closely as possible to the assumptions of the conceptual model.

Analysis of agricultural supply behavior employs empirical models which use time-series and/or cross-section data to test hypotheses, and/or estimate parameter values. The types of models that are relevant to the current problem are discussed below.

II. SUPPLY RESPONSE MODELS

Introduction

This discussion is limited to the more recent developments in respect to models for analyzing time series data

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[2]For the related discussions, see Irving Dubov, "Research Model Attributes, and Data Needs Implied by Theory," Odell Walker, ed., Southern Farm Management Committee Workshop on Interregional Competition (Oklahoma State University, November, 1966).

for two reasons: First, excellent reviews of the earlier works are readily available.[3] Second, a closer study of the analytical models currently used to study agricultural supply behavior in the developed nations is necessary if these models, with appropriate modifications, are to be used for the study of agricultural supply behavior in the developing nations.

Dynamic Models

Dynamic models for agricultural supply behavior assume that farmers make decisions on production and supply in response to changes in expected product prices; and that farmers modify their expectations on prices for every planning period on the basis of their past experience. Furthermore, the dynamic models assume that the decisions are also conditioned by lags in the adjustment of supply in response to prices. These models are essentially of the type developed by Nerlove.[4] The dynamic models of agricultural supply response behavior

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[3] R. L. Mighell and R. H. Allen, "Supply Schedules--'Long-time', and 'Short-time'," Journal of Farm Economics, 22(3):544-557, 1940; Dale A. Knight, "Evaluation of Time Series as Data for Estimating Supply Parameters," Earl O. Heady et al., eds., Agricultural Supply Functions (Ames: Iowa State University Press, 1961), and Marc Nerlove, Dynamics of Supply: Estimation of Farmers' Response to Price (Baltimore: John Hopkins Press, 1958).

[4] Nerlove, op. cit.

will be examined, and note will be made of any empirical results reported from their application that are relevant to the present discussion.

The dynamic supply response model is specified as:

$$p^*_t - p^*_{t-1} = \beta \left[p_{t-1} - p^*_{t-1} \right] \quad ; 0 < \beta \leq 1 \quad . \quad . \quad . \quad (3.1)$$

where

p^*_t = expected normal price in period, t

p^*_{t-1} = expected normal price in period, t-1

p_{t-1} = realized price in period, t-1

β = coefficient of expectation.

The expected normal price is postulated as a subjective concept which cannot be observed, but around which the realized price would fluctuate;[5] and this level of price would be some "average" level of prices of the past. The term in the parentheses in the right-hand side of equation (3.1) shows the expectational error of the preceding period. Since the current changes in the expected normal price is a function of the past error, the former is specified as a function of the latter. The parameter of this function is bounded and is termed as a "coefficient of expectation." This coefficient is positive and less than or equal to unity. If the coefficient equals unity, then, the current expected normal price is the realized price of the preceding period. To solve

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[5] Ibid., p. 25.

the equation for realized prices, Nerlove assumed (3.1) to be a first order difference equation in p_t^* and solved as

$$p_t^* = \beta \sum_{\lambda=0}^{\infty} (1-\beta)^{\lambda} \; p_{t-1-\lambda} . \qquad (3.2)$$

Equation (3.2) implies that the current expected normal price is a geometrically weighted average of past prices, and the weights indicate that the prices of distant past have less significance to current expected normal price. This model is the "adaptive expectation" model, and it describes the way the farmers formulate their price expectations in response to price uncertainties and discount current information on the basis of their past experience.

Another related question is: how do farmers respond to changes in the expected normal price? Consider the model:

$$y_t - y_{t-1} = \gamma \left[y_{t-1}^* - y_{t-1} \right] ; \quad 0 < \gamma \leq 1 \; . \; . \; . \qquad (3.3)$$

where

y_t = realized production in period, t

y_{t-1} = realized production in period, t-1

y_{t-1}^* = desired production in period, t-1

γ = coefficient of adjustment.

This model simply explains that changes in current production are proportionate to the difference between the desired production and the realized production in the preceding period. The parameter of this function is termed the "coefficient of

adjustment" which may reflect institutional, technical and/ or resource rigidities against the desired adjustment. Equation (3.3) can be solved as

$$y_t = \gamma \sum_{\lambda=0}^{t} (1-\gamma)^{t-\lambda} y^*_\lambda . \qquad (3.4)$$

The model (3.4) may be termed a "partial adjustment" model.

The relationship between expected normal price and desired output is proportional as the secular changes in prices are, by definition, are excluded. Then,

$$y^*_t = \alpha p^*_t \qquad (3.5)$$

where α is a parameter and other notations mean as usual.

Combining (3.2) and (3.4) through (3.5) and adding disturbance term to account for residual effects a generalized model can be derived as

$$y_t = \alpha\beta\gamma p_{t-1} + \left[(1-\beta)\ (1-\gamma)\right] y_{t-1} -$$

$$(1-\beta)\ (1-\gamma)\ y_{t-2} + u_t . \qquad (3.6)$$

The model (3.6) is a general model which implies a system or decision milieu generates both price expectations and lagged adjustment in supply.

If one assumes that the expectation model is relevant, then, the coefficient of adjustment, γ, is assumed to equal unity. Alternatively, if the partial adjustment model is

assumed to be the case, then, the coefficient of expectation becomes unity.

In sum: the general model (3.6) is a dynamic model which incorporates price expectations and lagged adjustment generated by a system or decision milieu. If the coefficient of expectation and coefficient of adjustment are equal to unity the model is static as the decision variables pertain to a single period.

The assumption that the decisions on agricultural supply of a commodity are determined by its prices alone is highly simplifying in that one could suspect a serious specification error in estimates.[6] Other decision variables should be included in the model so that useful conclusion can be arrived. In any case, it is reasonable to specify the general model and test the basic assumptions and, then, formulate alternative hypotheses for further empirical testing.

In 1958 Nerlove and Addison reported estimates of price elasticity of supply for vegetable crops. They used a partial adjustment model as follows:

$$y_t = a + b\gamma p_{t-1} + c\gamma T + (1-\gamma)\, y_{t-1} + u_t \qquad (3.7)$$

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[6] G. E. Brandow, "A Note on the Nerlove Estimation of Supply Elasticity," Journal of Farm Economics, 40(3): 719-722, 1958.

where

y_t = current acreage under a given crop

y_{t-1} = acreage under a given crop lagged one year

p_{t-1} = price of the commodity lagged one year

γ = coefficient of adjustment

T = trend variable

u_t = disturbance term

a, b, c are parameters.

The estimated coefficient of adjustment varied for different vegetable crops, and the range of variation was between 0.04 to 0.87. The authors reasoned the smaller coefficient of adjustment, which implied a longer period of adjustment, could be due to omission of other explanatory variables, i.e., specification error.[7] Halvorson noted that the coefficient of adjustment in supply approaching unity as more explanatory variables were included in his model.[8] Additional evidence in support of the hypothesis that the coefficient of adjustment in supply would not be significantly different from unity was provided by Dean and Heady,[9] and

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[7]Marc Nerlove and William Addison, "Statistical Estimation of Long-run Elasticities of Supply and Demand," Journal of Farm Economics, 40(4):861-880, 1958.

[8]Harlow W. Halvorson, "The Response of Milk Production to Price," Journal of Farm Economics, 40(5):1101-1113, 1958.

[9]Gerald W. Dean and Earl O. Heady, "Changes in Supply Response and Elasticity for Hogs," Journal of Farm Economics, 40(4):840-860, 1958.

Ferris.[10] Raj Krishna[11] reported the existence of lagged adjustment in supply in response to price changes in India.

Another type of specification error in using either the expectation model or partial adjustment model might be noted. Unless the empirical results of the general model (3.6) justify the use of either of the models, their use for partial analysis yields biased estimates due to specification error.[12]

While complete specification of supply response model is desirable, it is often impossible in practice to include all the relevant variables in the model since some of the variables are not quantifiable. The reliability of the estimates should be evaluated by analyzing the behavior of disturbance term in the model.

Supply Response Model Used in the Present Study

The models used by Zellner et al.[13] in the consumption

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[10] John N. Ferris, "Dynamics of the Hog Market with Emphasis on Distributed Lags in Supply Response," Unpublished Ph.D. dissertation, Michigan State University of Agriculture and Applied Sciences, 1960.

[11] Raj Krishna, "Farm Supply Response in India - Pakistan: A Case Study of the Punjab Region," Economic Journal, 73:476-484, September, 1963.

[12] Roger N. Waud, "Misspecification in the 'Partial Adjustment' and 'Adaptive Expectations' Models," Report 6507, Center for Mathematical Studies in Business and Economics, University of Chicago, Chicago, 1965.

[13] Arnold Zellner, D. S. Huang, and L. C. Chau, "Further Analysis of the Short-run Consumption Function with Emphasis on the Role of Liquid Assets," Econometrica, 33(3):571-573,1965.

studies were used in this study to describe the supply response behavior.

Consider the following hypothesis for a given crop:

$$y_t = \alpha_{10} + \alpha_{11} p_t^* + u_{1t} \tag{3.8}$$

$$y_t = \alpha_{20} + \alpha_{21} \left[p_t^* + \gamma p_{t-1}^* + \gamma^2 p_{t-2}^* + \ldots \right] + u_{2t} \tag{3.9}$$

$$y_t = \alpha_{30} + \alpha_{31} y_{t-1} + \alpha_{32} p_t^* + u_{3t} \tag{3.10}$$

$$p_t^* = (1-\beta) \left[p_{t-1} + \beta p_{t-2} + \beta^2 p_{t-3} + \ldots \right]$$
$$0 \leq \beta < 1. \tag{3.11}$$

These notations will be adopted for the rest of our discussions; and, therefore, the notations are explained and specified as follows:

1. y refers to the irrigated acreage sown under a given crop. The acreage is assumed to be a proxy of supply of a commodity decided at the threshold;
2. p refers to price of the commodity. The price, p, with asterisk superscript refers to expected price; and the p without asterisk superscript refers to realized price;
3. α's are the parameters in equation and which must be estimated statistically;
4. β refers to the coefficient of expectation of prices;

5. γ refers to the coefficient of adjustment in supply;[14]
6. u_i's are disturbance terms--random variables with mean zero and constant variance;
7. t's are in subscripts, and they refer to planning periods.

The basic assumption may be explicitly stated as:

1. The atomistic competition exists in agricultural production and prices of farm commodities are given, and they are parameters for decisions at the farms;
2. The acreage of a given crop is relevant for threshold decisions. Since the data on production are not available, it is assumed that acreage is the best proxy to production. The factors relevant to threshold decisions are only considered.

Equation (3.8) explains the relationship between supply decisions and expected price of a given commodity. The disturbance term is a "catch all" random variable which represents the variables not included in the equation and also random changes.

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[14]Note the specification of β and γ is different mathematically, but some conceptually. When β and γ equal zero, the model is static; and they are less than one implying their significance diminishes exponentially.

Equation (3.9) specifies that farmers make decisions on changing supply in response to prices with certain lags. This equation is equivalent to the general model (3.6) discussed earlier.

Equation (3.10) specifies that habits, customs, and traditions persist and influence farmers' decisions on supply of farm products. Equation (3.11) summarizes the process of price expectation; and it is equivalent to expectation model (3.2).

The equations (3.8), (3.9), and (3.10) can be solved for realized prices by substituting equation (3.11) in them and using Koyck[15] transformation as:

$$y_t = \alpha_{10}(1-\beta) + \beta y_{t-1} + \alpha_{11}(1-\beta)\, p_{t-1} + u_t - \beta u_{t-1} \qquad (3.12)$$

$$y_t = \alpha_{20}(1-\beta)(1-\gamma) + (\beta+\gamma)\, y_{t-1} - \beta\gamma y_{t-2} + \alpha_{21}(1-\beta)\, p_{t-1} + u_{2t} - (\beta+\gamma)\, u_{2t-1} + \beta\gamma u_{2t-2} \qquad (3.13)$$

$$y_t = \alpha_{30}(1-\beta) + (\alpha_{31}+\beta)\, y_{t-1} - \alpha_{31}\beta y_{t-2} + \alpha_{32}(1-\beta)\, p_{t-1} + u_{3t} - \beta u_{3t-1}. \qquad (3.14)$$

Equations (3.12), (3.13), and (3.14) are transformed equations which can be written, for statistical estimation as:

$$y_t = b_{10} + b_{11}\, y_{t-1} + b_{12}\, p_{t-1} \qquad (3.15)$$

$$y_t = b_{20} + b_{21}\, y_{t-1} - b_{22}\, y_{t-2} + b_{23}\, p_{t-1} \qquad (3.16)$$

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[15] Goldberger, op. cit., pp. 274-275.

$$y_t = b_{30} + b_{31} y_{t-1} - b_{32} y_{t-2} + b_{33} p_{t-1} \qquad (3.17)$$

where

$$b_{10} = \alpha_{10}(1-\beta);\ b_{20} = \alpha_{20}(1-\beta)(1-\gamma);\ b_{30} = \alpha_{30}(1-\beta)$$

$$b_{11} = \alpha_{11}(1-\beta);\ b_{21} = \beta+\gamma\ ;\ b_{31} = \alpha_{31} + \beta$$

$$b_{12} = \alpha_{11}(1-\beta);\ b_{22} = \beta\gamma\ ;\ b_{32} = \alpha_{31}\beta$$

$$b_{23} = \alpha_{21}(1-\beta)\ ;\ b_{33} = \alpha_{32}(1-\beta).$$

From the structure of equations (3.15), (3.16), and (3.17) the following criteria to test the significance of process of price expectation and lagged adjustment in supply to farmers' decisions can be formulated as: the necessary condition for the existence of lagged adjustment in supply is that the coefficient of y_{t-2}, i.e., α_{22} and α_{32} must be significantly different from zero and must be negative. The sufficient condition is that the coefficient of p_{t-1}, i.e., α_{23} and α_{33} must be significantly different from zero.

Alternative models with assumptions that β and γ equals zero, may also be formulated as follows:

$$y_{it} = \alpha_{10} + \alpha_{11} p_{it-1} + \alpha_{12} p_{jt-1} + \alpha_{13} T + u_{1t} \qquad (3.18)$$

$$y_{it} = \alpha_{20} + \alpha_{21}\left[\frac{p_{it-1}}{p_{jt-1}}\right] + \alpha_{22} T + U_{2t} \qquad (3.19)$$

where, with usual notations, the subscripts i and j refer to ith crop and its substitute jth crop; and A refers

to yield per acre. T is a trend variable.

Equation (3.18) describes that decision on acreage of a given crop is influenced by the price of the product and that of its substitute. If α_{10} is zero, then, acreage can be said to be homogeneous in prices.

The models discussed above were used to estimate the supply response behavior of farmers and the results were analyzed. The empirical results and discussions are given in the next chapter.

CHAPTER IV

DATA: REQUIREMENT, AVAILABILITY, AND ADJUSTMENT PROCEDURES

I. INTRODUCTION

As noted earlier, the objective of the study was to estimate the price elasticity of supply of major crops produced under irrigation--by regions in Madras State. Furthermore, the supply response behavior was examined in terms of threshold decisions of farmers. The decision variables were specified as the supply of irrigated acres, expected product and factor prices, expected yield per acre, and expected production. The expected magnitudes of decision variables were related to their past values through the adaptive expectation hypothesis.

To achieve the objective, data on irrigated acreage, yields per acre for irrigated crops,[1] acreage sown for the major irrigated crops, prices received by farmers for their products, and prices paid by farmers for the factors used were required. It was not possible to obtain the ideal data required for the study because such information on cost of cultivation of crops was not collected and published for the

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[1] Reference to major irrigated crops is limited to irrigated rice, ragi, cumbu, sugarcane, groundnuts, and cotton crops unless otherwise specified.

period studied. Data on prices received by farmers were reported only for the part of the period under study; i.e., 1949-50 through 1961-62. The prices received by farmers for the period from 1939-40 to 1949-50 were estimated from published information on price relatives for major crop products available for the period. It was therefore necessary to modify the analytical model and specify it as a function of only product prices, yields, and acreage.

The implications of these adjustment procedures depend on the assumptions implicit in the procedure used to estimate the price data for the period 1939-40 to 1949-50. The assumption, for example, that the price relatives of a crop of a district would likely be the same as that of the state relies on the properties of the arithmetic mean. It might be plausible that the variations in prices between districts were minimal during at least part of the period since the prices during World War II and the period immediately following it were permitted to fluctuate only between statutory maxima and minima.

In general, the efficiency of testing the initial hypothesis is inversely related to the degree of simplifications the researcher had to make under different data limitations.[2] In interpreting the results of present study

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[2]Irving Dubov, "Research Model Attributes, and Data Needs Implied by Theory," Odell Walker, ed., Southern Farm Management Committee Workshop on Interregional Competition (Oklahoma State University, November, 1966).

the assumptions and adjustment procedures used must be borne in mind.

Area Delineation and Bases

The administrative structure of political entities in Madras State is composed of villages at the base, taluks (counties) and districts with the State at the apex. Data on agricultural activities pertinent to this study were available only for the districts and for the State. On the bases of geographical continuity, sources of irrigation water and cropping patterns three regions were delineated[3] with the district groupings as given in Table III.

Region I includes four Northeastern districts along the east coast of the State. The agriculture of the region depends on the Northeast monsoon rains that occur in October, November, and December. The cropping pattern for both irrigated and nonirrigated agriculture is generally similar within and between all districts of the region. Thanjavur district is in the Cauvery delta, and the main enterprise is rice which is grown on more than 85 per cent of the cultivated area under canal irrigation system. This system

[3]An alternative grouping adopted by the National Council on the Applied Economic Research was examined. The Council used the value of gross output per acre--an aggregate measure of all crops, as a criterion for grouping the districts. The Council also recognized that for a more meaningful classification, information at village and county level would be necessary. Nevertheless, such information was not available for the present study.

TABLE III

CLASSIFICATION OF REGIONS AND REGIONAL CHARACTERISTICS, MADRAS STATE, INDIA

Region	Districts	Main Crops[a]	Main sources of irrigation[b]	Location
I	Chingleput, South Arcot, North Arcot, Thanjavur	Rice, groundnuts, sugarcane, millets, and tobacco	Canals, tanks, and wells	Northeastern coastal districts
II	Salem, Coimbatore, Thiruchirapalli, Madhurai	Millets, cotton, rice, sugarcane, groundnuts, and tobacco	Wells, canals and tanks	Central districts
III	Ramanathapuram, Thirunelveli	Cotton, rice, millets, groundnuts, pulses, and sugarcane	Tanks, wells, and canals	Southern districts

[a]Crops are given in their descending order of importance.

[b]Irrigation sources are given in their descending order of importance.

draws its water from the Southwest monsoon rains during June, July, August, and September. In the other three districts rice is grown mostly under tank irrigation, supplemented, when necessary, by well irrigation. July and August are the main months for sowing all crops.[4]

Region I produces a surplus of rice (above normal regional consumption needs) and exports with this regional surplus to meet the needs of other regions in Madras State, and in other states.

Groundnuts are grown mostly in the South Arcot and North Arcot districts as both irrigated and rainfed (unirrigated) crop. Groundnuts are grown as a commercial crop, i.e., for sale to oil processing industries.

Sugarcane can be grown only on farms that have irrigation facilities that can provide water for at least ten months out of the year. Sugarcane is also a commercial crop and is processed into two distinct products, viz., white sugar crystals, and brown sugar cubes or granules. White sugar crystals are processed by sugar factories which have their own supply zones for raw materials. They arrange with farmers for a regular supply of canes to factories for processing through either tacit or formal contractual

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[4]Techno-economic Survey of Madras, pp. 69-79.

agreements. The policy of the Government that encourages the organization of both proprietary and cooperative sugar factories for each district has served also to encourage an expansion in sugarcane production in Region I.

Brown sugar, on the other hand, is processed on the farm and is sold at the primary markets to commission agents and traders. A small amount of brown sugar is also sold at the weekly sales fairs. Sesame seeds and castor beans are grown mainly as rainfed crops when consistent with the existing cropping system for main crops.

The Neiveli industrial complex, in South Arcot, with its thermal power, chemical, and engineering industries is in its early stages of development. The development of this complex and its ancillary industries will generate new forces which will eventually bring changes in the agriculture of this region similar to those experienced when Region II industrialized. However, the growth of the South Arcot complex was not very far along during the period covered by this study. And so unemployment and underemployment were serious endemic factors affecting both the effective demand for all products and the supply of labor inputs.

Region II includes the Salem, Coimbatore, Thiruchirapalli, and Madurai districts. This region depends on both the Southwest and Northeast monsoon rains. The main sources of irrigation water are wells. New river valley projects,

viz., the Lower Bhavani, Amaravathi, Vaigai, Krishnagiri, and Parambikulam and Aliyar river projects, and Pullambadi and Kattalai canal scheme, have added irrigated acres in which rice and sugarcane are grown. However, only the first two projects affected conditions during the period covered by this study. Millets (such as sorghum, ragi, and cumbu), groundnuts, rice, and sugarcane are grown all year round. Cotton is planted mainly in September, but some cotton is sown during February and March.

This region is industrially well advanced. Textile mills and cotton gins at Coimbatore and Madurai support cotton farming in this region. Since this region is predominantly under well irrigation, there is a good market for the products of industries specializing in electric motors, pumpsets, and related machine tool industries. Consequently, these industries are well developed in the region and are concentrated around Coimbatore.

The industrial development in the region caused labor shortages, which, in turn, led to the adoption of partial mechanization in agriculture. Some labor, formerly employed in agriculture, moved to factories; and this resulted in the use of labor saving production techniques and higher wages for farm labor. Thrashing grains and processing sugarcane on farms, for instance, are carried through increasingly as 'custom' work with machinery. This system is in vogue around

the Coimbatore industrial conurbations. In other parts of this region the degree of mechanization varies with the degree of industrial development. Due to the cropping patterns and the relatively advanced industrialization, the problem of unemployment and underemployment tends to be less severe in this region as a whole than the other regions of the State.

Region III includes the Ramanathapuram and Thirunelveli districts which depend on rainfed tanks for irrigation. Tanks are filled by the Northeast monsoon rains; and, therefore, cropping in irrigated farms is irrigated by canals, viz., in the tail end of Vaigai River in Ramanthapuram district, and in the Thambirabarani River Basin in Thirunelveli district. Farms irrigated by water from wells are mostly in the western parts of Ramanthapuram districts where most of the irrigated cotton of this region is grown. Millets, rice, cotton, sugarcane, and groundnuts are the major crops of this region. With timely rains, rice is grown extensively in area under tanks. Otherwise millets are sown. Irrigated cotton is sown in February and March. Other crops are sown all year round, depending on the amount of irrigation facilities available.

Industrial development is rather low in this region. The cotton textile mills are concentrated mostly in the Thirunelveli district. Match factories are confined to the

western part of Ramanathapuram district. Seasonal rainfall uncertainties in agriculture, coupled with a low rate of industrial development, result in severe unemployment and underemployment. Except for a few areas of industrial development, this region is economically backward. The development of the Sethusamudram Canal Project, the Tuticorin Port development, and the marine chemical industries, which are in various stages of progress, will transform the economic picture of this region.[5] This region was, however, backward during the period under this study.

The regional grouping of the districts was based on cropping patterns, sources of irrigation, water and geographical continuity. However, an examination of the other factors discussed above shows that the agricultural develop- is related to the degree of economic development of the region in general, and to industrial development in particular. Implied in this formulation is that the degree of supply response to prices tends to be directly affected by the degree of industrial development of the region. Industrialization would be associated with a move away from subsistence agriculture to one that is oriented more to commercial market opportunities.

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[5] Ibid., pp. 37-50.

Evaluation of Data Situation

Data on land use patterns, acreage, yield per acre, and production of all field crops, for India, are published monthly, semi-annually, and annually by the Directorate of Economics and Statistics, Government of India. The Agricultural Situation in India, a monthly bulletin, is the chief medium of publication. In addition, Statistical Abstracts and Special Reports also are issued annually. In Madras State, the principal source of data on agricultural activities is the Season and Crop Report released annually by the Government of Madras up through 1962-63. Since 1962-63, the Annual Statistical Abstract of Madras State publishes information on agriculture of the State.

Agricultural Prices

To estimate farmers' response to price changes, the ideal data would be the prices received by farmers for their products at the point of first sale. Unfortunately, such price data in Madras State were published only since the 1949-50 crop year. Prior to this, two series of prices of farm commodities were published. One series covered the wholesale prices at principal markets of each district and the other contained the retail prices of farm products, such as dehusked grains. The prices of these three series were annual averages for each district. State averages of prices

were given also. In sum: A wholesale price series for the period from 1939-40 to 1949-50 was available as follows: annual average prices of sugarcane for six districts, of cotton for three districts, of groundnut for four districts, and of rice for five districts; annual average prices received by farmers were available for the period from 1949-50 to 1961-62. When the price of a commodity was not reported for a given year, the missing price was interpolated as the average of the prices of four years--the two preceding and the two following the year for which data were not available.

It became necessary to estimate a series of prices received by farmers for the period from 1939-40 to 1949-50. Information on the price relatives of major commodities for the period, as given in Table IV, were available from a different source.[6] The price relatives were based on the annual average prices for the State. This average was the average of the annual average prices reported for each district.

It was assumed that the annual average price of the major commodities in each district would, on the average, have the price relatives similar to that of the State. On this

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[6]B. Natarajan, Food and Agriculture in Madras State (Madras: Government Press, 1954), p. 157.

TABLE IV

PRICE RELATIVES OF PRINCIPAL CROPS, 1938-39 TO 1949-50, MADRAS STATE
(BASE YEAR 1938-39 = 100)

Year	Crops							
	Rice	Cholam	Cumbu	Ragi	Cotton	Sugar-cane[a]	Tobacco	Groundnut
1938-39	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1939-40	109.0	108.0	109.0	116.0	130.4	103.7	98.5	121.3
1940-41	121.0	109.0	111.0	117.0	124.1	64.9	103.1	105.5
1941-42	144.0	123.0	121.0	126.0	155.1	64.1	106.5	115.4
1942-43	209.0	217.0	220.0	226.0	198.6	158.7	117.3	222.8
1943-44	259.0	320.0	309.0	326.0	305.7	189.9	244.4	353.9
1944-45	253.0	284.0	291.0	317.0	211.9	154.8	379.1	300.4
1945-46	267.0	285.0	289.0	322.0	233.3	185.6	332.6	317.3
1946-47	282.0	301.0	300.0	330.0	275.8	257.6	341.3	415.0
1947-48	374.0	381.0	387.0	409.0	279.3	203.5	467.4	573.3
1948-49	506.0	487.0	525.0	565.0	406.7	194.0	580.6	638.5
1949-50	425.0	406.0	384.0	425.0	455.4	366.7	445.5	681.6

[a]Prices are related to jaggery (brown sugar).

Source: Food and Agriculture in Madras State, (Madras: Government Press, 1954), p. 157.

assumption a price series was synthesized as follows: the price of a commodity received by farmers in 1949-50 was divided by the price relative and multiplied by 100 to arrive at the price at the base period (1938-39). Then, the prices for the period from 1939-40 to 1949-50 were derived using the base period price and corresponding price relatives.

The prices of the major crop products were thus estimated for each district for the period from 1939-40 to 1961-62. The next step was to aggregate the prices of the major crop products for the regions to arrive at the regional prices. Production of major irrigated crops would be an ideal measure as weight for aggregation; but no separate information on production of irrigated crops was reported. Data on total production of irrigated and unirrigated crops were, however, available. Since total production of a crop would influence its price, the difference in prices among districts could be due to difference in total output. The price of a given crop for the region was aggregated using the share of each district in the total production of the region as weight for aggregation.

Acreage of Irrigated Crops

Farmers' decisions on allocation of irrigated acreage for a given crop depends, apart from its prices, on total irrigated land available at a given point in time. Expressed

differently, the area under a given crop was influenced partly by the availability of irrigated lands. This availability was influenced by two major factors.

First, there were changes in the geographical boundary of the State in 1952 and, again, in 1956 and 1959 which resulted in a smaller state comprised of 13 districts whose population spoke the Tamil language. Most of the boundary changes followed district lines with some relatively minor adjustments in the boundaries of border districts. Information on actual changes in the boundary of these districts was not published when the present study was undertaken.

Second, area under irrigation in the district might also vary annually depending on seasonal conditions and rainfall. Irrigated area increased during the study period because of new irrigation projects started during the period. Since the objective was to estimate farmers' response to price changes, the crop acreage must be adjusted for boundary changes and seasonal variations. The adjustment procedure used it as follows:

The net area under irrigation for each district in 1939-40 was taken as the base and a series of area relatives for the rest of the period were computed with reference to the area in 1939-40; and this series was used to deflate the irrigated crop acres in each district. That is,

$$y^*_{it} = y_{it}/w_t \qquad (4.1)$$

where

y^*_{it} = adjusted irrigated acres of ith crop in year t,

y_{it} = actual irrigated acres of ith crop in year t,

w_t = weights which were computed as

$$w_t = \frac{\text{Net area(acres) irrigated in year t}}{\text{Net area(acres) irrigated in 1939-40}}.$$

Crop Yields and Production

Data on yields per acre, seasonal conditions, and total production for the major crops were available for the period from 1939-40 to 1961-62. The crop yields were based on "crop-cutting experiments" designed to estimate crop yields from sampled crop fields, and the estimates of average crop yields reported by village officials. Total production of a crop was estimated from the data on crop yields and crop acres, and the seasonal factors reported by the officials of Revenue and Agriculture Departments. The production data published were, however, unserviceable in regard to the present study since it furnished total production for both irrigated and unirrigated crops without separate information for each category. The published production data, therefore, were not used.

The data on the crop acreage, yields per acre, product prices, net irrigated area relatives used for the analysis in

this study are given in the Appendix Tables XIII through XXIV.

The results of the analysis based on the above data will be reported and discussed in the next chapter.

CHAPTER V

SUPPLY RESPONSE: EMPIRICAL RESULTS

I. INTRODUCTION

Three alternative hypotheses were tested empirically in respect to supply response behavior: First, the decision millieu would have generated the supply response behavior which would include adaptive expectation of prices (geometric mean of past prices) and partial adjustment (lagged adjustment over time) in supply of a given period. Second, the supply response behavior would have been generated with adaptive expectation of prices but not with partial adjustment in supply of a given product. Third, the supply response would have been influenced by prices and yield of a given crop of preceding period.

To test the three hypotheses, three estimating equations were specified for each crop:

$$y_t = b_o + b_1 y_{t-1} - b_2 y_{t-2} + b_3 p'_{t-1} + b_4 T_t + e_t \quad (5.1)$$

$$y_t = b_o + b_1 y_{t-1} + b_2 p'_{t-1} + b_3 T_t + e_t \quad (5.2)$$

$$y_t = b_o + b_1 y_{t-1} + b_2 A_{t-1} + b_3 p_{rt-1} + b_4 p_{st-1} + b_5 T_t + e_t \quad (5.3)$$

where

Y - crop acres of the reference crop[1]

p' - relative price for the reference crop

i.e. - p_{rt-1}/p_{st-1}

p_r - price of reference crop

p_s - price of the substitute crop

A - yield per acre of reference crop

T - trend variable

b's - parameters in equation

e - disturbance term

The subscript, t, specifies the relevant period for variables in equation.

The substitute crop which competes with reference crop for land resources is selected on the bases of technical feasibilities with reference to soils and their drainage properties, and to market potential for substitute crops.

In the abstract, farm-level decisions in respect to the optimal allocation of available resources are influenced by the technically feasible alternatives that are available, relative factor and relative product prices, and by the constraints imposed by resource availabilities, and economic and non-economic goals and motivations. In applying this to the problem of choosing so-called "substitute" crops for

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[1] Reference crop is the one whose acreage is the dependent variable.

purposes of this analysis, two categories of considerations are relevant: First, a substitute crop may compete directly with a reference crop for available resources. In such a case, all aspects of the technical substitution relationship should be taken into account. Rice, for example, can be grown on swamp land as well as on drained irrigated soils. If sugarcane is, in fact, an economically feasible production substitute for rice, an increase in sugarcane prices normally will be associated with a substitution of sugarcane acreage for rice acreage. However, the extent of the replacement is constrained by the availability of well drained, irrigated land that is absolutely required for planting sugarcane. Therefore, this substitution process is effective only over the range defined by the technical requirements of the crops and the availability of specific and non-specific resources.

Second, home consumption requirements of particular products also can impose limits on the substitution process.

With this background, the selection of substitute crops for a given reference crop in this study was based on the technical conditions for substitution. An assumption was made that the type of soils and irrigation facilities available in the State might provide a large potential for crop substitution over a wide range.

The specific procedure adopted was as follows: first, for each region, the major irrigated crops were listed; and second, the sowing and harvesting for each crop were examined. A priori information on the cropping patterns and cultivation practices were considered. After examining the above factors the substitute crops were selected and specified for each reference crop, as specified in Table V. Implied in this selection procedure was a tentative hypothesis on crop substitute relationships which could be verified by the empirical results of regression analysis.

Equation (5.1) is the estimating equation of the general model (3.13), and equation (5.2) is the estimating equation of adaptive expectation model (3.13). Equations (5.1), (5.2), and (5.3) are linear functions. In the preliminary analysis, an exponential function was examined; but it did not yield regression estimates that were any more significant than those derived by fitting linear functions to the data. Conceptually, the exponentional function is not appropriate to the models which include lagged variables since this may give rise to multicollinearity. The linear functions, therefore, were used in this study.

In equation (5.3), the dependent variable lagged by one period was used as an explanatory variable as it would summarize the technical feasibilities and institutional

TABLE V

CROP SUBSTITUTES FOR MAJOR CROPS, MADRAS STATE, INDIA

Reference crop	Substitute crop		
	Region I	Region II	Region III
Rice	Sugarcane and groundnuts	Sugarcane	Sugarcane
Ragi	Groundnuts	Groundnuts	Groundnuts and cotton
Cumbu	Groundnuts	Groundnuts	Groundnuts
Sugarcane	Rice	Rice	Rice
Groundnuts	Ragi	Ragi and rice	Ragi and rice
Cotton	---	Sugarcane, groundnuts and rice	Sugarcane and groundnuts

limitations, if any, of the preceding period relevant for current decisions.[2]

Expected yields of the reference crop were assumed to be the yield of preceding period. While normal yield, defined as the yield discounted for random influences, such an excess rainfall, drought, and the incidence of pests and diseases, would be an ideal measure, the yield of preceding period could, by first approximation, be an estimate of expected yield.

The relative prices were the prices of the reference crop divided by the prices of its substitute crop. It was necessary to estimate the coefficient of relation between the acreage of a crop, the price of the crop and that of its substitute in order to identify the potentials for adjustment in the crop-mix. Both prices were, therefore, included in equation (5.3).

The time variable was specified as an explanatory variable to account for the trend over time in the variables of the equation. The coefficient of this variable would indicate a composite index of supply shifters such as changes in costs, technology, and preference of a given crop over the period.

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[2] A related concept is that it represents 'resource constraint.' For discussion, see James M. Henderson, "Utilization of Agricultural Land: A Theoretical and Empirical Inquiry," Review of Economics and Statistics, 41(3):242-259, 1959.

In sum: farmers' decisions on a given crop acreage were specified in equation (5.3) as a function of the crop acreage lagged by one period, the price of the crop and its substitute, the yield of the crop, time, and a disturbance term showing the random influences and effects of omitted variables.

For estimating the parameters of equations (5.1), (5.2) and (5.3), simple least square regression single equation techniques were used. The computer program designed by Zellner et al. was adopted for computer analysis.[3]

II. EMPIRICAL RESULTS - REGION I

Alternative regression estimates of rice, ragi, cumbu, sugarcane, and groundnut are given in Tables VI and VII.

The criterion for accepting the first hypothesis is that the dependent variable lagged by two periods must have a negative coefficient significantly[4] different from zero, and the coefficient of price must also be significantly different from zero. Applying this criterion to the regression estimates of equation (5.1), given in Table VI, one finds that the data do not support the first hypothesis.

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[3] H. Thornber and A. Zellner, "Program for Computing Two- and Three-Stage Lease Squares Estimates and Associated Statistics," revised, System Formulation and Methodology Workshop Paper 6308, Social System Research Institute (Madison: University of Wisconsin, 1965), (Mimeographed).

[4] The significance level is 5 per cent, unless stated otherwise.

TABLE VI

ALTERNATIVE REGRESSIONS FOR MAJOR CROP ACREAGES, 1939-40 TO 1961-62, REGION I, MADRAS STATE, INDIA

Crops	Model	Independent variables					R^2	DW	SE^2
		Constant	y_{t-1}	y_{t-2}	p_{t-1}	T_t			
Rice	5.1	862.90*	0.1761	-0.2264	-76.42	2.634	0.1498	2.117**	818.9
		(307.90)	(0.2259)	(0.2809)	(65.60)	(2.530)			
Rice	5.2	664.90**	0.1901	---	-39.32	1.215	0.1235	2.031**	844.2
		(188.50)	(0.2287)		(47.46)	(1.845)			
Ragi	5.1	76.36**	0.5514**	-0.2059	-49.21**	0.3958	0.7175**	2.248**	39.63
		(17.31)	(0.1702)	(0.1863)	(11.94)	(0.2490)			
Ragi	5.2	65.67**	0.4599	---	-44.42**	-0.3828	0.7011**	2.015**	41.93
		(14.76)	(0.1529)		(11.45)	(0.2559)			
Cumbu	5.1	11.96**	0.2478	-0.1847	-2.959	-0.1971**	0.5030	2.007**	1.993
		(3.911)	(0.2272)	(0.1819)	(2.531)	(0.07586)			
Cumbu	5.2	10.00*	0.1975	---	-0.2519	-0.1598*	0.4786	1.949**	2.091
		(3.486)	(0.2271)		(2.554)	(0.06795)			
Sugarcane	5.1	-1.518	-0.2107	-0.1852	7.478**	1.016**	0.6789**	1.824**	9.940
		(4.459)	(0.1436)	(0.1329)	(1.328)	(0.1709)			
Sugarcane	5.2	-4.476	-0.2375	---	7.731**	0.9898**	0.6492**	1.826**	10.86
		(4.099)	(0.1487)		(1.375)	(0.1776			
Groundnut	5.1	41.48**	0.1635	-0.5893**	-0.4601	-0.2967	0.3557	2.010**	34.14
		(5.646)	(0.1791)	(0.1809)	(2.801)	(0.2230)			
Groundnut	5.2	23.29*	0.1079	---	0.7519	-0.1229	0.0301	1.796*	51.39
		(9.652)	(0.2187)		(3.406)	(0.2657)			

*Significant at 5 per cent level

**Significant at 1 per cent level.

TABLE VII

REGRESSIONS FOR MAJOR CROP ACREAGES, 1939-40 TO 1961-62,
REGION I, MADRAS STATE, INDIA
MODEL (5.3)

Variables	Crops				
	Rice	Ragi	Cumbu	Sugarcane	Groundnuts
Constant	323.20	49.030	8.4780**	12.4500**	31.2800**
	(221.20)	(34.760)	(2.3860)	(3.4230)	(9.434)
y_{t-1}	0.2887	0.2866	0.1004	-0.3003	0.3440
	(0.2147)	(0.2614)	(0.2263)	(0.1833)	(0.2331)
A_{t-1}	14.7400**	-0.3177	-0.0053	-0.0090	-1.4560
	(5.5520)	(1.8110)	(0.1124)	(0.0336)	(0.7987)
p_{it-1}	-4.2660	-1.4150	0.0971	0.9932**	-0.1735
	(6.3940)	(1.1920)	(0.2051	(0.2375)	(0.6171
p_{jt-1}[a]	9.7990**	1.6370*	(0.1371)	-2.5920*	0.8201
	(2.8620)	(0.5675)	(0.0906)	(1.0070)	(0.7987)
T	-5.9170	-0.9484	-0.3124	1.4810	-1.0150
	(4.4980)	(0.6779)	(0.1169)	(0.5632)	(0.5908)
R^2	0.4240	0.7218**	0.5372*	0.5545*	0.1838
DW	2.091**	2.0430**	2.073**	1.795**	1.780**
SE^2	554.8	39.04	1.856	13.79	43.25

*Significant at 5 per cent level.

**Significant at 1 per cent level.

[a]Substitute crops are: groundnuts for rice, ragi, and cumbu; sugarcane for groundnuts; and rice for sugarcane.

For accepting the second (alternate) hypothesis, the estimate of coefficient of the dependent variable lagged by one period must be positive and significant. The results of fitting equation (5.2) to the data does not support the second hypothesis. The regressions were tested for autocorrelation among the residuals. Durbin-Watson statistics (DW)[5] were computed and tested by using critical limits given by Theil and Nagar.[6] No significant autocorrelation was noted among the residuals at 5 per cent level of significance. Multicollinearity among the explanatory variables is suspected when the coefficient of determination is very high, e.g., 0.99, and the standard errors of the regression estimates are also high, with the result that no meaningful inference could be drawn on the reliability of the regression estimates.[7] The results indicated that multicollinearity was not present since the coefficient of determination of the regressions varied between 0.14 to 0.71.

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[5] J. Durbin and G. S. Watson, "Testing for Serial Correlation in Least Squares Regressions I," Biometrica, 37:409-428, 1950; idem., "Testing for Serial Correlation in Least Squares Regression II," Biometrica, 38:159-178, 1951.

[6] Henri Theil and A. L. Nagar, "Testing the Independence of Regression Disturbances," Journal of American Statistical Association, 56(296):793-806, 1961.

[7] J. Johnston, Econometric Methods (New York: McGraw-Hill Book Company, Inc., 1963).

The regression coefficients of the relative prices of rice, cumbu, and groundnuts, as given in Table VI, were not significant. But the regression coefficients of ragi and sugarcane prices were significant. Ragi acreage showed a negative relation with ragi price. That is, an increase in ragi crop acreage would be associated with a decrease in price of ragi, and/or increase in price of groundnuts. The relation in terms of relative prices was hard to interpret as the decrease in the relative price of ragi could have resulted from an increase in the price of ragi being offset by an even greater increase in price of groundnuts. Consequently, the relative variability of prices would influence the direction and magnitude of changes in relative prices.[8]

The regression coefficients estimated for sugarcane were significant for relative prices and the trend variable, with positive signs as expected. A positive trend is consistent with increases in sugarcane acreages in this region because price uncertainty was reduced by guarantees of a minimum price for the sugarcane by the government empowered commodity committees. Also, the demand for sugarcane was augmented by the establishment of new sugar mills in this region.

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[8]The coefficients of variation of prices of ragi and groundnuts were not different, i.e., 37.5 per cent and 37.7 per cent, respectively. Then, the direction of change of price of groundnuts, in this case, could have influenced the sign of the regression coefficient of relative prices.

Groundnuts are grown in this region mainly for commercial purposes, i.e., for sale to vegetable oil processing industries. The regression coefficient of price, however, was not significant. No firm conclusion could be drawn since the coefficient of determination was very low and not significant.

The intercept was significant for all crops except sugarcane, presumably because of habit persistence manifested in patterns of cropping and the stagnant resource level of the farms of this region. Further analysis in terms of product price, instead of relative prices, would give more information on these relations. When the first and second hypothesis could not be accepted, the third hypothesis would be relevant for further analysis.

The regression coefficients given in Table VII, page 67, show that regressions for rice and groundnuts were not significant as the coefficients of multiple determination were low and not significant.[9] When income is included as one of the explanatory variables with ragi as a substitute, the price of groundnuts became significant. This will be discussed shortly.

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[9]Alternative regressions with sugarcane as substitute for rice; and ragi and rice as substitute for groundnuts did not show any better fit than presented in Table VI and the coefficient of multiple determination were very low and therefore they were not reported.

Earlier in our discussions on the significance of relative price on ragi acreage, the problem of interpreting the regression coefficients in equation (5.1) was encountered. The results of fitting equation (5.3) to the data indicates that ragi acreage were not significantly related to ragi prices; instead, ragi acreage was positively related to groundnut prices.[10]

It is plausible that groundnut prices could be a proxy variable which would influence the substitution between irrigated and unirrigated ragi crop acreages. This could happen because the acreage under unirrigated groundnuts and ragi was larger than that of irrigated groundnuts and ragi.[11] If one could assume that farmers would prefer certain amount of ragi for home consumption, then it would be probable that an increase in price of groundnuts would have increased the acreage under unirrigated groundnuts replacing the acreage under unirrigated ragi. The decrease in unirrigated ragi acreage, in turn, would increase the acreage of irrigated ragi to compensate for the loss in

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[10] Since the groundnut price variable was inverted in the relative price of ragi i.e., price of ragi/price of groundnuts, in equation (5.1), the sign of the regression coefficient of relative price of ragi was negative.

[11] The average acreages of irrigated ragi and groundnut crops, for the period 1957-58 through 1961-62 were, respectively, 244 and 138 thousand acres; and the corresponding figures for unirrigated ragi and groundnuts were 302 and 1146 thousand acres in this region.

production of ragi in the process of replacement of the unirrigated ragi acreage.[12] The compensating variations in irrigated crop acreage are possible in farms with irrigated and unirrigated land resources. It must also be noted that prices of ragi, groundnuts, and cotton, as reported in the Season and Crop Reports, are averages of prices of irrigated and unirrigated crop products. Prices of unirrigated ragi and groundnuts command, in general, a premium over that of irrigated products. The reverse is true in the case for cotton.

The regression for cumbu acreage did not show any response to changes in the price of cumbu or groundnuts. The intercept was significant. This crop is normally sown in black soil which is not ideally suited to either groundnuts or regi, even though some degree of substitution between the two crops cannot be ruled out completely. One might interpret the significance of the intercept and the lack of significance of the trend variable as an indication

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[12] For example 50 to 60 per cent of total ragi acreage is sown during June-August and 25-30 per cent is sown during January-March. No separate break-down of data for irrigated and unirrigated ragi is available. June-August sowing in this region may be assumed to be mainly of unirrigated crop. Seventy to eighty per cent of the unirrigated groundnuts is sown during June-August and less than 20 per cent of acreage is sown during January-March. The seasonal sowings may facilitate the acreage substitution between irrigated and unirrigated crops in response to changes in prices.

that cumbu was mainly sown in this region on certain types of soils, and therefore, prices would have little influence on crop acreage.

Since the coefficients of determination have a wide range of variation among the crops, one might suspect a specification bias for the estimates of the regression coefficients. More information on the decision variables--quantifiable and non-quantifiable--would be required. Income, national and per capita, would be variables which would represent demand conditions. The basis for using the income variables in this fashion is as follows: An increase in national income would increase the demand for a given commodity. The magnitude of increase would depend on whether a given commodity is "inferior" or otherwise. For agricultural products, e.g., rice and millets, an increase in national income would increase the aggregate demand for rice; and decrease the demand for millets. Per capita incomes also would be a relevant variable in analyzing the demand for farm commodities. The per capita income would indicate habits and propensities in consumption. At the subsistence level with low per capita income, the demand for food commodities such as rice and millets is larger than non-food commodities. As the per capita income increases, food habits change, and propensity to save and invest changes. Hence, two hypotheses were formulated as: (1) that the

national income would influence the supply of major crops produced in the State, or alternatively, (2) that the per capita income would influence the supply of major crops produced in the State. To test these hypotheses the crop acreage was specified as a function of acreage lagged by one period, prices of the crop and its substitute crop, time, and (1) national income and (2) per capita income.

The data on national income and per capita income for India were published for the period 1950-51 through 1961-62 by the Central Statistical Organization.[13] For the period 1939-40 through 1949-50 the data on national income and per capita income were taken from the estimates computed by Mukerji.[14] All the series were published in terms of both current and constant (1948-49 100) prices. The deflated series of national and per capita incomes were used for the analysis in this study.

Alternate regression equations for crop acreage were fitted and the significance of the income variable was tested. The income variables were not significant for all

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[13] Long-term Projections of Demand for and Supply of Selected Agricultural Commodities 1960-61 to 1975-76 (New Delhi: National Council on Applied Economic Research, 1962).

[14] Kshitimohan Mukerji, Levels of Economic Activity and Public Expenditure in India: A Historical and Quantitative Study (Bombay: Asia Publishing House, 1965).

crop acreages, except in the case of groundnuts. For groundnuts acreages, the regression estimates are[15]

$$y_t = \underset{(24.18)}{-45.16} + \underset{(0.2044)}{0.0002}y_{t-1} + \underset{(0.5253)}{1.1810^{*}}p_{it-1} - 0.2552\,p_{jt-1}$$

$$+ \underset{(2.9710)}{8.9060^{**}}ni - \underset{(0.9381)}{2.4760}T_t^{*} \quad . \quad . \quad . \quad . \qquad (5.4)$$

$$R^2 = 0.3812,\ DW = 1.810^{*},\ SE^2 = 43.16$$

$$y_t = \underset{(32.00)}{-97.20^{**}} - \underset{(0.1847)}{0.03787}\,y_{t-1} + \underset{(0.4068)}{0.9484^{*}}p_{it-1} - \underset{(1.0630)}{0.3239}p_{jt-1}$$

$$+ \underset{(11.71)}{45.31^{**}}pi_t - \underset{(0.5113)}{0.7411}\,T_t \quad . \quad . \quad . \quad . \qquad (5.5)$$

$$R^2 = 0.5007^{*},\ DW = 2.043^{**},\ SE^2 = 34.82$$

where notations are as usual; ni represents national income and pi represents per capita income.

Equation (5.5) is better than equation (5.4) and per capita income is a better measure of demand conditions as the coefficient of multiple determination is significant. This result has reduced the specification bias found in earlier results and signifies farmers' response to groundnut prices.

The income variable, representing aggregate demand conditions, was not significant for acreage decisions for rice and millet. One explanation might be that when demand

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[15] A single asterisk superscript indicates significance at 5 per cent level and a double asterisk indicates significance at 10 per cent level.

for food was increasing, its effect, through increased prices, could not be recognized for acreage decisions because of statutory price controls.

III. EMPIRICAL RESULTS - REGION II

Alternative estimates of regression coefficients for rice, ragi, cumbu, groundnuts, sugarcane, and cotton crop acreages are given in Tables VIII and IX. The regressions were tested, using the procedures discussed earlier, for autocorrelation among residuals, and multicollinearity among the explanatory variables. The Durbin-Watson statistics indicated that there was no significant autocorrelation between the residuals; nor there was evidence for the existence of multicollinearity since the coefficients of multiple determination varied between 0.39 to 0.93.

One notes in Table VIII that the regression coefficients of crop acreage lagged by one and by two periods, and the relative price lagged by one period show that the data did not generate results consistent with either the partial adjustment or the adaptive expectation models of decision behavior; and, therefore, the first and second hypothesis were not acceptable.

The coefficient of multiple determination for the equations fitted to data on rice was not significant and, therefore, no firm conclusion could be drawn about the

TABLE VIII

ALTERNATIVE REGRESSIONS FOR MAJOR CROP ACREAGES, 1939-40 TO 1961-62, REGION II, MADRAS STATE, INDIA

Crops	Models	Independent variables					R^2	DW	SE^2
		Constant	y_{t-1}	y_{t-2}	p_{t-1}	T_t			
Rice	5.1	153.900	0.2391	0.1492	15.920	-0.9733	0.3899	2.050**	151.3
		(79.34)	(0.2567)	(0.2492)	(19.550)	(0.8009)			
Rice	5.2	182.200**	0.2811	---	16.930	-1.1440	0.3752	2.129**	145.6
		(62.52)	(0.2422)		(19.100)	(0.7342)			
Ragi	5.1	33.550**	0.3783	0.0050	8.459	-0.9079**	0.8153**	1.559**	16.43
		(11.18)	(0.2352)	(0.2158)	(12.27)	(0.2963)			
Ragi	5.2	33.660**	0.3814	---	8.424	-0.9088**	0.8153**	1.568**	15.47
		(9.912)	(0.1889)		(11.810)	(0.2852)			
Cumbu	5.1	49.550	0.8059**	-0.3409	-26.71	-0.3797	0.4896*	2.414**	63.62
		(27.620)	(0.2467)	(0.2552)	(25.71)	(0.3003)			
Cumbu	5.2	33.490	0.6100**	---	-16.120	-0.3576	0.4327*	1.828*	66.56
		(25.430)	(0.2029)		(25.010)	(0.3066)			
Groundnuts	5.1	7.145	-0.1138	-0.2675	- 0.4393	0.8504*	0.5520*	2.104**	18.35
		(7.483)	(0.2525)	(0.2421)	(1.403)	(0.3032)			
Groundnuts	5.2	7.501	-0.1091	---	- 0.6706	0.6510*	0.5178*	2.032**	18.59
		(7.524)	(0.2541)		(1.397)	(0.2452)			
Sugarcane	5.1	0.1164	0.1664	-0.3752	3.0160*	0.7551**	0.8036**	1.360	4.434
		(3.343)	(0.2010)	(0.2138)	(1.0890)	(0.1466)			
Sugarcane	5.2	-3.321	0.06985	---	3.560**	0.6979**	0.7658**	1.326	4.977
		(2.870)	(0.2408)		(1.106)	(0.1514)			
Cotton	5.1	92.710	0.2638	-0.2008	15.210	-2.1800*	0.4883*	1.807**	305.8
		(43.05)	(0.2433)	(0.2311)	(15.980)	(0.8642)			
Cotton	5.2	72.270	0.2369	---	16.280	-1.9120*	0.4642*	1.701**	301.4
		(35.790)	(0.2396)		(15.820)	(0.8014)			

*Significant at 5 per cent level.

**Significant at 1 per cent level.

TABLE IX

REGRESSIONS FOR MAJOR CROP ACREAGES, 1939-40 TO 1961-62,
REGION II, MADRAS STATE, INDIA, MODEL (5.3)

Variables	Crops					
	Rice	Ragi	Cumbu	Groundnuts	Sugarcane	Cotton
Constant	228.800**	49.510**	44.33**	13.340	-22.530**	152.100**
	(55.560)	(6.747)	(13.85)	(14.760)	(6.510)	(36.270)
y_{t-1}	-0.2018	0.2830*	0.4528*	0.0143	-0.2293	-0.0176
	(0.2328)	(0.1162)	(0.1614)	(0.2015)	(0.1478)	(0.1745)
A_{t-1}	5.2770**	-0.1217	-1.6350*	-0.5992	0.4169**	-5.2030
	(1.2830)	(0.3208)	(0.6740)	(1.2560)	(0.0975)	(13.700)
p_{it-1}	3.1760*	-0.6687	3.3600*	-0.1802	0.7287**	0.04903
	(1.3840)	(0.3193)	(1.2350)	(0.1677)	(0.1297)	(0.9104)
p_{jt-1} [a]	0.5296	-0.4197**	-0.6079*	-1.3120*	-1.5490**	-3.3110**
	(0.6969)	(0.0869)	(0.2470)	(0.6115)	(0.2898)	(0.9845)
T	-4.5640**	-0.1679	-1.8850**	1.5860**	1.0790**	-0.5996
	(0.9958)	(0.2383)	(0.6184)	(0.4338)	(0.1974)	(0.6425)
R^2	0.6889**	0.9291**	0.6608**	0.6184**	0.8793**	0.7074**
DW	2.443**	2.482**	2.027**	2.190**	2.401**	1.797**
SE^2	58.70	4.810	32.21	11.91	2.077	133.30

*Significant at 5 per cent level.

**Significant at 1 per cent level.

[a]Substitute crops are as follows: sugarcane for rice; groundnut for ragi and cumbu; rice for groundnut and sugarcane; and sugarcane for cotton.

regression estimates. The level intercept and the coefficient of trend variables were significant for ragi. The estimates of regression coefficients of relative prices in the crop acreage equations for cumbu, groundnuts, and cotton were not significant. However, equation fitted to data for sugarcane resulted in an estimated coefficient for price that was significant and had the "right" sign.

The results, given in Table IX, show that all regressions were significant at 1 per cent level and that the series were not autocorrelated.

Estimates of the regression coefficients for variables in the rice acreage equation were significant for yields and rice prices.[16] Rice acreages declined over the time during 1939-40 to 1961-62. This was associated with the increasing trend in sugarcane acreages. A significant relation between rice prices and acreages is logical, since this region is deficit in rice production. There are pockets of surplus in rice production around the rivers Cauvery and Vaigai but this region has an over all deficit in rice production and farmers of this region are cognizant of fluctuations in rice prices for decisions in rice acreage. A large rice surplus in

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[16] Alternate regressions with groundnuts and cotton as substitute crop prices did not give any better results. The groundnut and cotton prices were not significant.

Region I may influence rice prices and rice acreage in Region II.

The regression of ragi acreages indicate that ragi prices were not significant for decisions on ragi acreages. Estimates of the trend coefficient was also not significant. Prices of groundnuts, however, were significant and had a negative sign.[17] The estimated regression coefficients for acreage lagged by one period, for yield, and for the intercept were significant. This suggests persistence of habit in acreage decisions. The fact that the coefficient of price of groundnut was significant and negative implies that groundnut prices would be relevant for decisions on ragi acreage over a certain range--a range determined by the level of resources, beyond which groundnut acreage could be substituted for ragi acreages.

The decision on cotton acreage have a pattern similar to that of ragi. The estimated regression coefficient for the intercept, and for prices of substitute (sugarcane) were significant; but the estimated coefficient of other variables were not significant. Groundnut prices, and rice prices were used instead of sugarcane prices in alternate

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[17] Cumbu and cotton prices were used instead of groundnut prices in the alternative regressions of ragi acreage. Cotton prices were not significant and cumbu prices were significant at the 5 per cent level. Groundnut prices were also significant and the regression estimate was higher than that of cumbu.

regressions. In the regression with groundnut, as the substitute crop, the regression estimates of both groundnut and cotton prices were not significantly different from zero. In the regression with rice, as the substitute crop, the regression coefficient of rice price was not significant; and the regression coefficient of cotton prices were significant but with negative sign. One might note, from the behavior of cotton prices with respect to its substitutes' prices both in magnitude and sign, the limitations of the price data used. The cotton prices reported were average of prices of both irrigated and unirrigated cotton. More refined data, not available for analysis in this study, could possibly reveal more meaningful relations between cotton acreage and cotton prices.

For cumbu acreage decisions, all the variables were significant and, except the yield, had the "right" signs.[18] The results contradicted the results of equation (5.1) whose regression estimates were biased because of the use of a price ratio, i.e., relative prices. Cumbu acreage was inversely related to its yield per acre but directly related to its price. In terms of partial elasticities, a 10 per

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[18] Prices of ragi were used as an alternative to prices of groundnuts; but the results were not satisfactory. Both prices of ragi and cumbu were not significant.

cent change in the price of cumbu, other things being equal, was associated with an 8 per cent increase in cumbu acreage. Similarly, the response to yield of cumbu, and prices of groundnuts were, respectively, a 3.8 per cent and a 4.8 per cent decrease in cumbu acreage. The negative response to yields might be interpreted as a tendency to limit the acreage of crops grown for home consumption when alternative crops are attractive pricewise.

The regression estimates for sugarcane acreages indicate that farmers of this region were responsive to changes in prices and yields of sugarcane and also the rice price. The trend was also rising over time which was expected since the number of sugar mills increased from two to six in this region and thus, the demand for sugarcane was increasing. Minimum prices were announced well ahead of planting time and price uncertainties were minimized.

When income variables were included as explanatory variables in the crop acreage regressions, they were significant only for acreage decisions for rice. Prices of rice were not significant. The regression estimates are:

$$y_t = \underset{(69.19)}{150.20^{*}} + \underset{(0.2543)}{0.1701}\, y_{t-1} + \underset{(1.8070)}{2.5440}\, p_{it-1} - \underset{(0.8043)}{0.2984}\, p_{jt-1} + \underset{(3.5340)}{9.0380^{*}}\, ni_t - \underset{(1.2630)}{4.0010^{**}}\, T_t \quad . \quad . \quad . \quad . \qquad (5.5)$$

$$R^2 = 0.6156^{**},\ DW = 2.372^{**},\ SE^2 = 98.78$$

$$y_t = \underset{(75.66)}{109.70} + \underset{(0.2614)}{0.1690}\, y_{t-1} + \underset{(1.8440)}{2.6820}\, p_{it-1}$$

$$\underset{(0.8007)}{-0.6507}\, p_{jt-1} + \underset{(17.58)}{41.31^{*}}\, pi_t - \underset{(1.0570)}{2.2920}\, T_t \quad \ldots (5.6)$$

$$R^2 = 0.5974^{*}, \; DW = 2.229^{**}, \; SE^2 = 103.5$$

where the notations are as usual; a single asterisk indicates 5 per cent level of significance and a double asterisk indicates 1 per cent level of significance.

The inclusion of the income variable in the regression equations for rice did not improve the fit; and the estimate of the coefficient of rice price was also not significant. The regression estimates of equation (5.3) for rice show the estimate of rice price was significant; and therefore, these estimates are used for interpretation of supply response behavior.

IV. EMPIRICAL RESULTS - REGION III

Alternative estimates of regression coefficients for rice, ragi, cumbu, groundnuts, sugarcane, and cotton are given in Tables X and XI. The regressions were tested, using the procedures discussed above, for autocorrelation among residuals, and multicollinearity among the explanatory variables. The Durbin-Watson statistics indicated that there was no significant autocorrelation between residuals; nor there was evidence for the existence of multicollinearity

TABLE X

ALTERNATIVE REGRESSIONS FOR MAJOR CROP ACREAGES, 1939-40 TO 1961-62, REGION III, MADRAS STATE, INDIA

Crops	Models	Independent variables					R^2	DW	SE^2
		Constant	y_{t-1}	y_{t-2}	p_{t-1}	T_t			
Rice	5.1	341.90*	-0.2020	-0.1709	28.17	-1.3520	0.1219	2.127**	162.3
		(81.05)	(0.2074)	(0.1804)	(20.19)	(0.8165)			
Rice	5.2	281.50**	-0.1324	---	22.71	-1.0640	0.0844	2.239**	169.3
		(51.22)	(0.1981)		(19.76)	(0.7740)			
Ragi	5.1	18.84*	0.5842*	-0.08276	-0.3315	-0.3341	0.5925*	2.068**	19.07
		(8.615)	(0.2216)	(0.2148)	(4.462)	(0.2332)			
Ragi	5.2	17.26*	0.5426*	---	-0.6904	-0.2993	0.5896*	1.964**	19.20
		(7.601)	(0.1941)		(4.3790)	(0.2158)			
Cumbu	5.1	-0.8035	0.2265	0.4125	2.1190	-0.00645	0.2519	1.563*	3.633
		(3.832)	(0.1998)	(0.2214)	(3.0860)	(0.0689)			
Cumbu	5.2	2.969	0.3536	---	-0.3059	0.00169	0.1283	2.116**	4.233
		(3.512)	(0.2027)		(3.021)	(0.07428)			
Groundnut	5.1	-0.1764	0.3500	-0.08515	1.1170	0.1133	0.3719	1.865**	3.442
		(1.728)	(0.2554)	(0.2281)	(0.8693)	(0.0854)			
Groundnut	5.2	-0.3072	0.3077	---	1.1700	0.1039	0.3678	1.714**	3.464
		(1.6970)	(0.2184)		(0.8601)	(0.08195)			
Sugarcane	5.1	-0.4620	-0.1833	-0.4554	0.06434	0.1749**	0.7332**	1.960**	0.1836
		(0.6258)	(0.2170)	(0.4146)	(0.2191)	(0.04348)			
Sugarcane	5.2	-0.8226	-0.1068	---	0.2020	0.1408**	0.7179**	1.880**	0.1941
		(0.5802)	(0.2114)		(0.1848)	(0.03135)			
Cotton	5.1	9.316	0.6006**	-0.3169	1.090	-0.01203	0.3133	2.021**	12.56
		(4.817)	(0.2035)	(0.2016)	(1.666)	(0.1393)			
Cotton	5.2	6.009	0.4620*	---	1.783	-0.0680	0.2324	1.756**	14.04
		(4.581)	(0.1939)		(1.699)	(0.1424)			

*Significant at 5 per cent level.

**Significant at 1 per cent level.

TABLE XI

REGRESSIONS OF MAJOR CROP ACREAGES, 1939-40 TO 1961-62,
REGION III, MADRAS STATE, INDIA
MODEL (5.3)

Variables	Crops					
	Rice	Ragi	Cumbu	Groundnut	Sugarcane	Cotton
Constant	306.900**	39.910**	1.603	1.326	-0.2084	6.6120
	(53.470)	(8.470)	(3.251)	(1.050)	(0.3157)	(4.005)
y_{t-1}	-0.2972	0.6388	0.3098	0.2693	-0.0773	0.3673*
	(0.2362)	(0.1146)	(0.1811)	(0.2110)	(0.2394)	(0.1626)
A_{t-1}	1.7150	-2.2680**	-0.0102	-0.0176	-0.0024	-0.0073
	(1.5470)	(0.5288)	(0.0271)	(0.0096)	(0.0040)	(0.2694)
p_{it-1}	3.1690	0.1495	0.0981	0.2230	0.0071	0.8029*
	(2.0800)	(0.3959)	(0.2613)	(0.1057)	(0.0261)	(0.1867)
p_{jt-1} [a]	-0.4816	0.2642	0.3046*	-0.3597	-0.0416	-0.8828**
	(0.9355)	(0.1330)	(0.1101)	(0.3009)	(0.0806)	(0.2490)
T	-2.3760	-0.9033**	-0.2360	-0.1812	0.1488*	-0.3532
	(1.2950)	(0.2408)	(0.1214)	(0.1919)	(0.0581)	(0.1824)
R^2	0.2188	0.8429**	0.4727	0.5079	0.7115	0.5794
DW	2.5270**	2.037**	2.539**	1.565	1.997**	2.323
SE^2	144.40	7.349	2.561	2.697	0.1985	7.691

*Significant at 5 per cent level.

**Significant at 1 per cent level.

[a]Substitute crops are: sugarcane for rice; cotton for ragi; groundnut for cumbu; rice for groundnut and sugarcane; and groundnut for cotton.

since the coefficients of multiple determination ranged between 0.12 and 0.84.

The regression estimates in Table X do not support the first and second hypotheses on supply response behavior. None of the coefficients of relative prices of the crops are significant. The regressions of ragi and sugarcane acreage are significant; but others are not.

The results of the test of third hypothesis, as given in Table XI, indicates that regressions of rice, cumbu, and groundnut acreage were not significant; and no meaningful conclusions can be drawn.

The intercept, the coefficient of yield, and that of trend were significant in the ragi acreage equation. The yield had a negative relation with acreage decisions for ragi. Since ragi was a millet crop, this relation might be explained by the subsistence nature of ragi production and the lack of a significant reaction to market price stimuli. Also, the declining trend might result from the decreasing importance of ragi in food. No firm conclusions could be made since the trend in the ragi acreage regression, with either national income or per capita income as one explanatory variable, showed that neither income nor time significantly influenced decisions on ragi acreage.

The regression estimates of the price coefficient of sugarcane prices were significant for the first and second

regions but not significant for the third region. The increasing trend in sugarcane acreage indicated its growing importance. The number of acres under sugarcane, for example, increased from 300 acres in 1939-40 to 3675 acres in 1960-61. The sugarcane acreage was, however, less than 1.5 per cent of rice acres sown in 1960-61.

Cotton was the third major crop of the region in terms of acreage, but constituted only 11.7 per cent of the acreage under unirrigated cotton. The irrigated cotton was grown during February-June and rice and groundnuts were included in the regression analyses as possible substitute crops. The regression with groundnuts as one of explanatory variables was better fit as the coefficient of multiple determination increased to 0.58 which was significant.[19] The estimates of the regression coefficients of acreage lagged one period, prices of cotton, and prices of groundnuts were significant and had the "right" signs. Nevertheless, the data limitations, noted in discussions on probable bias of price coefficients for irrigated cotton in the second region, must be borne in mine while interpreting the price coefficient of cotton in this region.

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[19] When rice price was used as an explanatory variable in cotton regression equation, the regression estimate of coefficient of rice price was not significant. The coefficient of multiple determination was 0.33 and it was also not significant.

When an income variable was included as an explanatory variable, the income was significant for decisions on acreage of sugarcane and cotton only. The regression estimates are: for sugarcane,

$$y_t = \underset{(1.701)}{3.922^{*}} - \underset{(0.2446)}{0.2987}\, y_{t-1} + \underset{(0.0332)}{0.0483}\, p_{it-1} - \underset{(0.0846)}{0.0849}\, p_{jt-1}$$

$$+ \underset{(0.1995)}{0.4550^{*}} ni_t + \underset{(0.0641)}{0.0809}\, T_t \quad . \quad . \quad . \quad . \qquad (5.7)$$

$$R^2 = 0.7783^{**},\ DW = 1.931^{**},\ SE^2 = 0.2090$$

$$y_t = \underset{(2.576)}{-4.329} - \underset{(0.2519)}{0.2088}\, y_{t-1} + \underset{(0.0300)}{0.0213}\, p_{it-1} - \underset{(0.0087)}{0.0634}\, p_{jt-1}$$

$$+ \underset{(0.9118)}{1.508}\, pi_t + \underset{(0.0622)}{0.1530}\, T^{*}_t \quad . \quad . \quad . \quad . \qquad (5.8)$$

$$R^2 = 7491^{**},\ DW = 2.004,\ SE^2 = 0.2365$$

and for cotton,

$$y_t = \underset{(10.13}{-19.69} + \underset{(0.1825)}{0.4028} y^{*}_{t-1} + \underset{(0.1775)}{0.4938^{*}}\, p_{it-1} + \underset{(0.5801)}{0.2512}\, p_{jt-1}$$

$$+ \underset{(1.224)}{3.238} ni^{*}_t - \underset{(0.5283)}{1.347}\, T^{*}_t \quad . \quad . \quad . \quad . \qquad (5.9)$$

$$R^2 = 0.5142^{*},\ DW = 2.021,\ SE^2 = 11.74$$

$$y_t = -35.04 + 0.3931^{*} Y_{t-1} + 0.3891^{*} p_{it-1} + \underset{(0.5791)}{0.1769}\, p_{jt-1}$$

$$+ \underset{(5.883)}{15.27^{*}} pi_t - \underset{(0.3907)}{0.6128}\, T_t \quad . \quad . \quad . \quad . \qquad (5.10)$$

$$R^2 = 0.5085^{*},\ DW = 2.103^{**},\ SE^2 = 11.85.$$

* Significant at 5 per cent level.
** Significant at 1 per cent level.

V. SUPPLY RESPONSE - REGIONAL DIFFERENCES

Empirical study of acreage decisions by farmers in Region I shows that product prices were relevant for decisions on groundnut and sugarcane acreages. No firm conclusions were possible on the relation between product prices and acreage decisions for rice, ragi, and cumbu. This region is predominantly a rice area and one would expect some degree of response to changes in price of rice, which in turn, would generate changes in millet acreages. That this was not so may be explained in terms of the price policies of government. Price regulations and compulsory procurement of rice, (this region is surplus in rice production) could have prevented price from acting as an incentive.[20] Nevertheless, this could not have been the only cause. The farmers did respond to prices of sugarcane and groundnuts which would involve inter-crop substitution. The rising trend in sugarcane acreage is the case in point. Another plausible explanation could be that reported prices of rice, ragi, and cumbu could have underestimated the actual prices--an inevitable problem of price controls. The low coefficient of multiple determination for rice acreage regression could be the result of this factor.

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[20] B. Natarajan, op. cit., 168.

It is noteworthy that prices of sugarcane and groundnuts were significantly related to supply decisions of farmers in this region in respect to acres sown.

Millets and cotton are the main crops grown in the second region. This region is, apart from the Madras metropolitan area, the most industrialized area. Textile industries, sugar mills, and machine tool factories provide market incentives for agricultural production. Farmers of this region were responsive to product prices. The partial price elasticies of supply given in Table XII show that the response of farmers of this region to price changes was generally greater than in the first and third region. Obviously, no comparison for all crops in three regions is possible because the significance of estimates is different for different crops between regions.

Region III is a comparatively backward region economically, depending mainly on millets, and unirrigated cotton for home consumption, and for income. The main source of irrigation was tanks which depends on rainfall. When rainfall is heavy, all the tanks are full and rice is sown. In other periods millets and cotton are sown. The pattern of decision behavior seems to be heavily influenced by rainfall. Irrigated cotton is mainly confined to west Ramanathapuram district and is grown under well irrigation. Farmers of that part of the region were responsive to price changes through inter-crop allocation of resources.

TABLE XII

ESTIMATES OF PARTIAL ELASTICITIES* OF SUPPLY OF MAJOR CROPS, 1939-40 TO 1961-62, MADRAS STATE, INDIA

Crops and Variables	Regions		
	I	II	III
Rice			
a) Price	**	0.1058	**
b) Yield	0.2780	0.3842	**
c) Substitute's Price	0.1697	**	**
Ragi			
a) Price	**	**	**
b) Yield	**	**	-0.9609
c) Substitute's Price	0.3656	-0.2827	**
Cumbu			
a) Price	**	0.8283	**
b) Yield	**	-0.3886	**
c) Substitute's Price	**	-0.4754	0.8973
Groundnut			
a) Price	0.4972	**	**
b) Yield	**	**	**
c) Substitute's Price	**	-0.8737	**
Sugarcane			
a) Price	0.6751	0.7447	**
b) Yield	**	2.1223	**
c) Substitute's Price	-1.0609	-0.9901	**
Cotton			
a) Price		**	1.2766
b) Yield		**	**
c) Substitute's Price		-0.5058	-0.7641

*Partial elasticities are computed around means.

**The regression estimates are not significantly different from zero; and no partial elasticity is computed.

In sum: the regional differences in supply response decisions were mainly determined by government policies on food prices and procurement, the degree of industrialization, regional variations in sources of irrigation water, and the degree of their dependence on rainfall. There is enough evidence to indicate that farmers were responsive to product prices but the degree of response varied among regions depending on the decision milieu in which relative prices were important.

CHAPTER VI

SUMMARY AND CONCLUSION

I. REVIEW OF PROCEDURE

The objectives of this study were (1) to estimate price elasticities of supply for rice, ragi, cumbu, groundnuts, sugarcane, and cotton--all produced under irrigation, and (2) to identify any regional differences in price elasticities of supply for these crops. The period considered was 1939-40 to 1961-62.

Because of limitations in the availability of data, some adjustments were necessary in the data that were available in order to make them to fit in with the analytical framework that was used. The details of the procedure are as follows:

First, three regions were delineated on the bases of cropping patterns, sources of irrigation water, and socio-cultural characteristics. Second, the crop acreages reported in the Season and Crop Reports for each district were deflated by a measure of net area relatives derived with 1939-40 as base year. This procedure was necessary to adjust the crop acreages for changes in geographical boundary of outlying districts during the State Reorganizations which took place in 1952, 1955, and 1959, and for variations in rainfall. The

district crop acreages were aggregated to obtain the figures on regional crop acreages.

Third, since no price series were published for the 1939-40 through 1949-50, a series of prices received by farmers was estimated as follows: The information on price relatives for major crops, based on the State's averages of prices, reported for the period from 1938-39 to 1949-50 was used. The district prices for each crop for each year were extrapolated using the price relatives; and the district prices were aggregated for the regions using annual reported production as weights.

The crop yields for each region were the average of yields reported for each crop for all districts in the region. Since aggregate income statistics are reported for the country as a whole, annual data on national incomes and on per capita incomes for the entire nation were used to represent total income and per capita income variables for each of the regions.

The estimation procedures used the single equation least squares estimation methods and Zellner's computer program written up for IBM 7040.

II. SUMMARY OF RESULTS

Farmers of Madras State, in general, formulated their decisions on supply adjustment in response to changes in

prices of a given crop and/or changes in prices of its substitute crops in production. There was no evidence to support the hypothesis that farmers' decision behavior could be explained by adaptive expectation model for prices, and the partial adjustment models for supply. The product prices of preceding period appeared to offer an adequate explanation of resource allocation and use in the current period. The degree and pattern of supply response varied among the regions.

The results suggest that farmers in Region I were responsive in adjusting crop acreages of groundnuts and sugarcane to changes in product prices. But no statistically significant relations between crop acreages and product prices were noted for rice, ragi, and cumbu crops in this region. The latter crops were food crops and their prices were subject to statutory regulations by the State for larger part of the period studied. This could have prevented prices acting as an effective incentive. Rice was the major crop of this region and sugarcane crop appeared to be increasingly competing with rice acreage. The sugarcane crop acreage increased overtime, possibly as a result of appearance of new sugar mills in this region. The associated effects of 5, 10, 15, 20, and 25 per cent increases in the prices of sugarcane and groundnuts on the acreage of sugarcane and groundnuts for Region I were computed around the respective mean values

and are given in Table XXVI in the Appendix. The relationship between sugarcane acreage and sugarcane and rice prices can be stated as follows: a 10 per cent increase in sugarcane prices, with rice prices remaining constant, would, on the average, be associated with a 6.7 per cent in sugarcane acreage. Similarly, a 10 per cent increase in the rice price, with sugarcane prices remaining constant, would, on the average, be associated with a 10.6 per cent decrease in the sugarcane acreage. For groundnuts, a 10 per cent increase in groundnut prices would, on the average, be associated with a 4.9 per cent increase in groundnut acreage.

In respect to Region II, the results suggest that farmers were more responsive to changes in product prices than are farmers in other regions. Statistically significant relations between acreage of rice, sugarcane, and cumbu and prices were found whereas the acreages of ragi, and groundnuts were significantly related to prices of their substitute crops. The result that the price of cotton was not statistically significant for cotton acreage was unexpected. This could possibly be because of limitations in cotton price data and no meaningful conclusion could be made. The relationships between the acreage and product prices for specified degrees of changes in product prices, viz., 5, 10, 15, 20, and 25 per cent, are given in Table XXVII in the Appendix.

The relationship between acreage and prices were: a 10 per cent increase in rice prices would, on the average,

be associated with a 1.1 per cent increase in rice acreage. A 10 per cent increase in groundnut prices would, on the average, be associated with a 2.8 per cent reduction in ragi acreage. For cumbu, a 10 per cent increase in cumbu prices, with groundnut prices remaining constant, would, on the average, be associated with an 8.3 per cent increase in the cumbu acreage. On the other hand, a 10 per cent increase in the groundnut prices, with cumbu prices remaining constant, would, on the average, be associated with a 4.8 per cent reduction in cumbu acreage.

A 10 per cent increase in sugarcane prices, with rice prices remaining constant, would, on the average, be associated with an increase of 7.5 per cent in sugarcane acreage; a 10 per cent increase in the rice prices, with sugarcane prices remaining constant, would, on the average, be associated with a 9.9 per cent decrease in sugarcane acreage.

In respect to Region III, the results suggest that farmers were plagued by seasonal uncertainties which could have conditioned their supply response behavior. This was evident when cotton acreage response is examined. The cotton acreage, under irrigation by wells, appeared to have statistically significant relation with price of cotton.

The associated efforts on cotton acreages in response to specified degrees of changes in cotton, and groundnut prices, viz., 5, 10, 15, 20, and 25 per cent are given in Table XV in the Appendix.

Meaningful relationships between cotton acreage and cotton, and groundnuts prices was noted in this region. A 10 per cent increase in cotton prices, with groundnut prices remaining constant, would, on the average, be associated with a 12.8 per cent increase in the cotton acreage; on the other hand, a 10 per cent increase in groundnut prices, with cotton prices remaining constant, would, on the average, be associated with a 7.6 per cent decrease in cotton acreage.

In relative terms, price elasticities of supply of farm products, as the results suggest, were high in Region II, medium in Region I, and low in Region III.

III. IMPLICATION OF RESULTS

The implication of results of this study can be considered in two aspects. First, implication to policies for agricultural development; second, implication to future research on supply response behavior.

The State can participate actively in farmer motivation for better efficiency in agricultural production through a well-defined price policy which may include formulation of floor and ceiling prices of major crops such as rice, sugarcane, cotton, and groundnuts. The State may also participate in open market operations, through building buffer stocks, in order to stabilize prices within the range of maximum and minimum formulated. The desired output-mix, consistent

with the national food budget, can be sought through structuring of the relative prices.

Future research may be designed to estimate supply response by organizing cross section studies of the decision framework at the farm level. The results of such studies could be supplemented with those of time series studies.

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APPENDIX

TABLE XIII

ADJUSTED CROP ACREAGE FOR MAJOR IRRIGATED CROPS, REGION I, MADRAS STATE, INDIA

Year	Rice	Ragi	Cumbu	Sugarcane	Groundnuts
		thousand acres			
1939-40	762.797	66.654	15.308	12.416	31.056
1940-41	755.367	72.677	11.065	17.823	27.580
1941-42	773.152	66.227	7.895	9.789	21.145
1942-43	813.085	73.149	11.315	10.616	21.301
1943-44	793.676	58.808	9.270	14.665	37.107
1944-45	796.122	56.195	6.999	16.279	47.258
1945-46	854.524	66.378	7.862	16.736	24.742
1946-47	773.472	55.560	8.786	18.987	15.199
1947-48	806.781	63.450	8.356	29.255	25.272
1948-49	851.439	79.681	9.775	14.683	22.664
1949-50	836.437	72.568	11.560	16.136	24.579
1950-51	858.121	77.500	9.876	32.876	30.054
1951-52	838.304	74.607	8.512	23.663	28.262
1952-53	804.002	85.850	9.138	15.164	18.071
1953-54	765.057	70.147	9.028	13.322	18.073
1954-55	800.530	64.648	7.562	22.218	37.062
1955-56	752.835	51.326	9.449	18.016	23.225
1956-57	762.032	47.477	4.887	14.333	18.571
1957-58	843.175	54.738	4.501	20.304	26.924
1958-59	823.716	54.414	5.534	17.009	21.251
1959-60	831.802	60.276	5.914	21.333	25.556
1960-61	817.666	48.623	6.110	24.350	26.225
1961-62	807.716	36.944	4.890	20.199	28.232

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XIV

ADJUSTED CROP ACREAGE FOR MAJOR IRRIGATED CROPS, REGION II, MADRAS STATE, INDIA

Year	Rice	Ragi	Cumbu	Ground-nuts	Sugar-cane	Cotton
	thousand acres					
1939-40	256.236	43.350	37.905	5.042	9.559	87.234
1940-41	260.247	39.876	36.816	5.740	9.229	113.254
1941-42	268.289	53.024	40.652	5.285	5.915	126.515
1942-43	267.464	50.572	41.958	6.721	7.474	130.984
1943-44	260.209	51.783	33.754	9.224	9.953	113.146
1944-45	274.080	50.921	38.299	7.259	8.549	76.258
1945-46	243.316	48.921	43.083	7.905	9.431	91.704
1946-47	267.515	52.950	33.681	6.583	12.296	99.975
1947-48	250.831	45.487	34.054	14.993	15.990	64.440
1948-49	243.287	43.919	31.922	13.650	9.778	95.560
1949-50	233.483	33.959	35.336	11.973	10.242	111.647
1950-51	238.710	32.959	23.087	5.450	16.714	66.390
1951-52	228.351	34.049	32.678	7.709	16.254	78.532
1952-53	216.678	38.089	26.648	21.555	11.153	62.460
1953-54	245.402	33.539	41.434	9.370	9.090	71.058
1954-55	256.350	35.264	57.470	15.310	13.080	95.247
1955-56	243.370	37.309	54.544	10.750	13.425	88.502
1956-57	244.767	36.561	38.263	7.701	12.616	77.408
1957-58	247.601	37.984	25.760	19.867	15.429	100.180
1958-59	238.334	35.361	29.029	21.515	14.360	77.235
1959-60	241.761	35.891	22.108	19.537	16.119	74.359
1960-61	246.322	30.148	21.625	18.878	21.617	59.025
1961-62	246.390	24.372	20.653	19.134	21.732	52.810

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XV

ADJUSTED CROP ACREAGE FOR MAJOR IRRIGATED CROPS, REGION III, MADRAS STATE, INDIA

Year	Rice	Ragi	Cumbu	Ground-nuts	Sugar-cane	Cotton lint
			thousand acres			
1939-40	219.326	45.442	4.685	1.064	0.300	8.599
1940-41	285.544	44.439	6.705	2.156	0.454	14.191
1941-42	270.925	43.294	3.610	1.133	0.302	15.355
1942-43	244.312	36.742	3.723	2.416	0.320	14.358
1943-44	239.827	33.359	3.442	3.769	0.675	20.274
1944-45	282.716	40.887	3.318	1.924	0.356	24.852
1945-46	231.331	27.459	2.703	3.705	0.422	19.760
1946-47	263.015	24.388	2.917	2.635	0.858	10.725
1947-48	239.108	22.620	2.776	6.222	1.295	10.029
1948-49	238.243	30.220	2.142	4.023	0.366	7.406
1949-50	244.343	29.081	7.959	6.378	0.621	12.824
1950-51	231.396	30.309	5.296	6.099	1.553	13.651
1951-52	239.002	35.402	11.503	7.239	1.567	15.158
1952-53	236.884	36.130	6.633	3.142	0.817	22.095
1953-54	261.867	40.483	6.040	2.126	1.529	19.455
1954-55	257.677	29.910	3.875	3.472	1.066	13.512
1955-56	261.253	24.452	4.203	1.792	1.609	17.112
1956-57	240.840	24.731	2.396	1.466	1.700	15.479
1957-58	244.765	22.690	3.199	6.746	1.766	13.897
1958-59	256.213	24.460	2.706	7.976	1.871	14.688
1959-60	231.364	23.309	5.067	9.145	1.509	22.793
1960-61	246.869	20.471	3.158	6.991	3.675	16.571
1961-62	253.848	20.722	2.321	3.173	2.706	13.266

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XVI

CROP YIELDS PER ACRE FOR MAJOR CROPS,
REGION I, MADRAS STATE, INDIA

Year	Rice	Regi	Cumbu	Sugarcane	Groundnut
			pounds		
1939-40	1597	1038	866	5760	896
1940-41	1641	1133	980	6309	894
1941-42	1680	1129	959	6366	979
1942-43	1430	1085	923	5932	905
1943-44	1613	1189	983	6031	986
1944-45	1582	1130	950	6361	994
1945-46	1315	951	813	5764	868
1946-47	1493	1082	888	6256	868
1947-48	1314	1013	842	5867	860
1948-49	1057	919	755	6073	818
1949-50	1176	934	793	5953	924
1950-51	1052	822	526	5775	868
1951-52	1210	785	544	5609	868
1952-53	1379	830	498	5510	826
1953-54	1660	1005	647	6516	1073
1954-55	1705	1056	694	6339	997
1955-56	1583	1325	557	6346	1047
1956-57	1777	1329	576	6516	1077
1957-58	1934	1438	675	6451	1075
1958-59	1762	1377	711	6387	1036
1959-60	1884	1397	718	6065	1075
1960-61	1823	1453	761	7704	1100
1961-62	2030	1457	740	7575	1123

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XVII

CROP YIELDS PER ACRE FOR MAJOR CROPS,
REGION II, MADRAS STATE, INDIA

Year	Rice	Ragi	Cumbu	Ground-nuts	Sugar-cane	Cotton lint
			pounds			
1939-40	1879	1450	1175	1095	6046	251
1940-41	1946	1499	1216	1123	6919	265
1941-42	1932	1439	1154	1131	6598	266
1942-43	1803	1415	1083	1019	6614	250
1943-44	1764	1370	1003	1047	6631	245
1944-45	1808	1384	1065	1036	6555	258
1945-46	1574	1219	940	980	6398	239
1946-47	1746	1226	940	994	6539	235
1947-48	1520	1196	789	921	6227	245
1948-49	1474	1168	888	935	6682	250
1949-50	1502	1115	849	868	6041	290
1950-51	1485	984	418	840	6108	258
1951-52	1467	882	485	924	5961	244
1952-53	1438	848	419	840	5722	242
1953-54	1836	1066	560	1072	6665	252
1954-55	1874	1060	578	1070	6730	248
1955-56	1902	1375	623	1056	6607	228
1956-57	2184	1392	645	1053	6731	257
1957-58	2199	1391	825	1039	6798	265
1958-59	2023	1277	885	1064	6914	263
1959-60	2199	1443	904	1069	6543	316
1960-61	2197	1453	986	1073	8086	295
1961-62	2305	1440	990	1106	8026	292

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XVIII

CROP YIELDS PER ACRE FOR MAJOR CROPS,
REGION III, MADRAS STATE, INDIA

Year	Rice	Ragi	Cumbu	Ground-nuts	Sugar-cane	Cotton lint
			pounds			
1939-40	1446	1250	965	963	3872	212
1940-41	1839	1294	950	1098	5255	217
1941-42	1801	1349	950	1087	5064	281
1942-43	1764	1260	850	1036	4992	246
1943-44	1430	1280	800	1036	5128	242
1944-45	1750	1408	900	1036	5287	255
1945-46	1340	1165	775	952	5168	233
1946-47	1710	1278	800	1008	5009	233
1947-48	1010	975	525	756	4850	245
1948-49	1522	1318	855	1003	5446	255
1949-50	1060	1125	675	896	4768	306
1950-51	1057	903	454	784	4730	257
1951-52	1164	1062	448	952	4890	272
1952-53	1228	823	480	924	4611	227
1953-54	1855	1220	435	1092	5505	266
1954-55	1844	1221	430	1008	5387	270
1955-56	1670	994	574	980	4906	195
1956-57	1885	1105	653	1036	5269	255
1957-58	2012	1015	825	1081	5506	280
1958-59	1822	990	645	1047	4787	225
1959-60	1793	1138	773	1078	5503	310
1960-61	1697	1075	836	1070	6950	245
1961-62	1773	900	840	1076	6830	245

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XIX

ANNUAL AVERAGE PRICES PER MAUND (82.29 LB) FOR MAJOR FARM COMMODITIES, REGION I, MADRAS STATE, INDIA

Year	Rice	Cumbu	Ragi	Sugarcane	Groundnuts
			rupees[a]		
1939-40	1.769	2.208	2.171	6.086	3.533
1940-41	1.967	2.296	2.188	3.746	3.079
1941-42	2.342	2.494	2.356	3.739	3.359
1942-43	3.382	4.547	4.208	9.279	6.093
1943-44	4.215	6.384	6.085	11.140	10.335
1944-45	4.113	6.009	5.916	9.210	8.813
1945-46	4.327	5.919	6.020	10.968	9.284
1946-47	4.583	6.140	6.146	15.191	12.143
1947-48	6.062	8.022	7.677	12.276	16.797
1948-49	8.090	10.868	10.602	11.459	18.733
1949-50	6.885	7.956	8.025	20.929	19.969
1950-51	6.868	7.799	7.914	20.934	22.790
1951-52	7.609	7.840	7.911	16.167	21.492
1952-53	10.957	14.306	13.188	20.276	17.637
1953-54	10.937	10.219	9.274	13.835	16.355
1954-55	9.203	8.095	8.809	9.085	12.033
1955-56	10.180	9.290	9.749	11.661	15.258
1956-57	11.753	11.507	11.230	12.397	16.777
1957-58	10.164	11.359	12.067	12.771	14.480
1958-59	10.629	12.331	11.134	12.596	15.969
1959-60	11.943	12.976	12.320	14.181	16.512
1960-61	13.390	11.868	12.258	13.227	16.551
1961-62	13.811	12.054	12.731	12.694	17.421

[a]At the current exchange rate $1 = 7.5 rupees.

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press); and B. Natarajan, Food and Agriculture in Madras State (Madras: Government Press, 1954), p. 157.

TABLE XX

ANNUAL AVERAGE PRICES PER MAUND (82.29 LB.) FOR MAJOR FARM COMMODITIES, REGION II, MADRAS STATE, INDIA

Year	Rice	Cumbu	Ragi	Cotton (Lint)	Sugar-cane	Ground-nuts
			in rupees[a]			
1939-40	2.239	2.145	2.154	10.634	5.930	4.762
1940-41	2.101	2.164	2.167	10.325	3.762	3.269
1941-42	2.500	2.442	2.336	12.952	3.663	3.583
1942-43	3.623	4.303	4.191	16.901	9.011	6.886
1943-44	4.491	6.351	6.047	26.061	10.822	10.896
1944-45	4.400	5.634	5.877	18.225	8.867	9.179
1945-46	4.640	5.649	5.968	20.035	10.610	9.771
1946-47	4.910	5.971	6.108	23.901	14.383	12.872
1947-48	6.511	7.574	7.581	24.423	11.326	17.760
1948-49	8.654	9.677	10.479	35.460	10.921	19.801
1949-50	7.326	8.064	7.891	39.859	20.547	21.197
1950-51	7.317	8.062	7.893	39.835	17.077	22.715
1951-52	7.335	8.067	7.890	30.315	16.544	18.123
1952-53	13.750	16.374	11.735	28.302	22.363	18.817
1953-54	11.215	11.193	11.126	25.907	14.773	12.694
1954-55	10.893	9.313	9.966	28.574	11.819	13.006
1955-56	12.411	11.175	10.305	25.242	15.826	13.706
1956-57	12.609	11.799	10.908	29.527	13.294	15.645
1957-58	10.443	11.525	11.230	25.208	12.058	16.139
1958-59	11.851	12.019	11.753	29.366	13.520	16.234
1959-60	12.358	13.785	13.382	35.784	18.606	19.089
1960-61	14.020	13.674	14.146	41.566	17.375	21.703
1961-62	14.597	13.946	13.767	40.092	14.083	21.948

[a]At the current exchange rate $1 = 7.50 rupees

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press); and B. Natarajan, Food and Agriculture in Madras State (Madras: Government Press, 1954), p. 157.

TABLE XXI

ANNUAL AVERAGE PRICES PER MAUND (82.29 LB.) FOR MAJOR FARM COMMODITIES, REGION III, MADRAS STATE, INDIA

Year	Rice	Cumbu	Ragi	Cotton lint	Sugar-cane	Ground-nuts
			rupees[a]			
1939-40	1.929	2.370	2.080	9.614	6.598	3.548
1940-41	2.138	2.420	2.090	9.077	4.126	3.043
1941-42	2.554	2.640	5.000	11.302	4.035	3.369
1942-43	3.699	4.790	4.050	14.281	10.125	6.472
1943-44	4.609	6.730	5.840	22.192	12.204	10.379
1944-45	4.439	6.340	5.680	15.322	9.833	8.846
1945-46	4.759	6.290	5.770	16.940	11.803	9.300
1946-47	4.963	6.530	5.910	20.122	16.479	12.013
1947-48	6.675	8.430	7.320	20.202	12.956	16.776
1948-49	8.900	11.430	10.120	29.131	12.363	19.103
1949-50	7.588	8.360	7.610	33.444	23.469	20.397
1950-51	7.701	8.360	7.610	35.969	19.586	22.562
1951-52	7.569	8.360	7.610	33.656	17.215	13.155
1952-53	14.218	13.511	14.700	26.520	21.175	13.933
1953-54	11.145	10.118	9.882	25.907	15.350	16.692
1954-55	10.295	8.320	8.400	27.371	14.970	16.513
1955-56	11.211	10.154	9.956	27.423	19.142	12.099
1956-57	11.550	12.270	9.264	25.651	14.156	16.134
1957-58	9.902	11.028	9.414	32.480	12.633	15.313
1958-59	12.267	11.891	12.403	34.530	12.588	16.018
1959-60	13.094	11.787	12.121	33.166	11.550	16.188
1960-61	13.547	13.252	12.358	32.707	14.941	20.147
1961-62	14.165	12.946	12.592	33.866	13.836	20.183

[a]At the current exchange rate $1 = 7.5 rupees.

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press); and B. Natarajan, Food and Agriculture in Madras State (Madras: Government Press, 1954), p. 157.

TABLE XXII

NET IRRIGATED ACRE RELATIVES (BASE YEAR: 1939-40), REGION III, MADRAS STATE, INDIA

Year	Districts	
	Ramanathapuram	Tirunelveli
1939-40	1.0000	1.0000
1940-41	1.0055	1.0493
1941-42	1.0420	1.1376
1942-43	1.1491	1.3223
1943-44	1.0964	1.3381
1944-45	0.9868	1.3973
1945-46	1.2262	1.3320
1946-47	1.5000	1.3848
1947-48	1.1121	1.2883
1948-49	1.2929	1.4195
1949-50	1.1391	1.1960
1950-51	1.0443	1.2250
1951-52	1.4641	1.3432
1952-53	0.9529	1.0747
1953-54	1.3475	1.2620
1954-55	1.6183	1.2840
1955-56	1.3626	1.2851
1956-57	1.6810	1.2016
1957-58	1.8560	1.2855
1958-59	1.5464	1.3634
1959-60	1.9275	1.3873
1960-61	2.0014	1.5411
1961-62	1.8159	1.6038

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XXIII

NET IRRIGATED ACRE RELATIVES (BASE YEAR: 1939-40), REGION II, MADRAS STATE, INDIA

Year	Districts			
	Salem	Coimbatore	Thiruchi-rapalli	Madurai
1939-40	1.0000	1.0000	1.0000	1.0000
1940-41	1.0902	1.1772	1.0622	1.1661
1941-42	1.0483	1.1460	1.0437	1.0067
1942-43	1.0292	1.2063	1.0487	1.0381
1943-44	1.1130	1.1885	1.0745	1.1352
1944-45	1.2416	1.1613	1.0240	1.1930
1945-46	1.0307	1.2721	0.9989	1.1301
1946-47	1.0103	1.1797	1.0289	1.1398
1947-48	1.3217	1.2524	1.0962	1.2200
1948-49	1.1539	1.2118	1.4500	1.2241
1949-50	1.1267	1.1250	1.4629	1.3845
1950-51	1.1384	0.8676	1.4477	1.1612
1951-52	1.0394	1.0060	1.4380	1.2986
1952-53	1.1153	0.8309	1.3393	0.9754
1953-54	1.4445	1.1189	1.7288	1.0623
1954-55	1.5652	1.1746	1.4924	1.1957
1955-56	1.4205	1.1058	1.7120	1.1896
1956-57	1.5209	1.1159	1.7780	1.1952
1957-58	1.5138	1.2250	1.6863	1.1963
1958-59	1.4476	1.4089	1.5343	1.2310
1959-60	1.4632	1.3661	1.4945	1.2559
1960-61	1.5734	1.4382	1.6133	1.3305
1961-62	1.5435	1.4409	2.0070	1.2566

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XXIV

NET IRRIGATED ACRE RELATIVES (BASE YEAR: 1939-40), REGION I, MADRAS STATE, INDIA

Year	Districts			
	Chingle-put	South Arcot	North Arcot	Thanja-vur
1939-40	1.0000	1.0000	1.0000	1.0000
1940-41	1.0534	1.0171	1.1849	1.0101
1941-42	1.0789	1.0093	1.0858	1.0273
1942-43	0.9890	1.0588	0.9345	1.0477
1943-44	1.0199	1.0717	1.1731	1.0627
1944-45	0.9666	1.0544	1.1019	1.0921
1945-46	0.8013	1.0476	1.0733	1.0544
1946-47	1.1159	1.0471	1.2589	1.0776
1947-48	0.8984	1.0657	1.0867	1.0981
1948-49	0.9588	1.0232	1.0090	1.1137
1949-50	0.8824	0.9933	0.9560	1.1216
1950-51	0.8500	0.7871	0.7048	1.1241
1951-52	0.7073	1.0452	0.8346	1.1285
1952-53	0.7695	1.1515	0.9505	1.0565
1953-54	0.8115	1.3192	1.2564	1.1170
1954-55	0.8666	1.0695	1.1817	1.1255
1955-56	0.8569	1.1863	1.3120	1.0988
1956-57	0.9727	1.2452	1.4396	1.1054
1957-58	0.9240	1.2002	1.1605	1.1232
1958-59	0.9812	1.2469	1.3364	1.1227
1959-60	1.0632	1.2116	1.1317	1.1245
1960-61	1.2540	1.3920	1.3159	1.1507
1961-62	1.2574	1.4416	1.3658	1.1612

Source: Season and Crop Reports, 1939-40 through 1961-62 Issues (Madras: Government Press).

TABLE XXV

NATIONAL INCOME, AND PER CAPITA INCOME,
AT 1948-49 PRICES, INDIA

Year	National Income	Per Capita Income
	ten million rupees[a]	rupees[a]
1939-40	8568	280
1940-41	8645	279
1941-42	8712	277
1942-43	8752	276
1943-44	9131	284
1944-45	9798	302
1945-46	8683	265
1946-47	8251	250
1947-48	8551	256
1948-49	8650	257
1949-50	8820	257
1950-51	8850	265
1951-52	9100	255
1952-53	9460	260
1953-54	10030	266
1954-55	10280	268
1955-56	10480	268
1956-57	11000	276
1957-58	10890	267
1958-59	11650	280
1959-60	11860	279
1960-61	12730	293
1961-62	13060	294

[a]At the current exchange rate $1 = 7.50 rupees.

Source: For the period from 1930-40 to 1952-53, Kshitimohon Mukerji, Levels of Economic Activity and Public Expenditure in India - A Historical and Quantitative Study (Bombay: Asia Publishing House, 1965), p. 58; for the period 1953-54 to 1960-61, Long term Projections of Demand for and Supply of Selected Agricultural Commodities, 1960-61 to 1975-76 (New Delhi: National Council on Applied Economic Research, 1962), p. 189; for the period 1961-62, Eastern Economist, Annual Number, 1967, p. 1372.

TABLE XXVI

ESTIMATED ACREAGE CHANGES FOR SPECIFIED RATES OF CHANGES IN PRODUCT PRICES, 1939-40 TO 1961-62, REGION I, MADRAS STATE, INDIA

Prices			
Product	Per cent increase	Prices[a] in rupees	Acreage in thousand acres
			(i) Sugarcane
Sugarcane	5	13.25	837.07
	10	13.89	864.35
	15	14.52	891.72
	20	15.15	919.01
	25	15.78	946.38
Rice	5	7.98	766.79
	10	8.36	725.49
	15	8.74	680.88
	20	9.12	637.96
	25	9.50	594.97
			(ii) Groundnuts
Groundnuts	5	8.46	26.39
	10	8.86	27.03
	15	9.27	27.67
	20	9.67	28.31
	25	10.07	28.95

[a]Price in rupees ($1 = 7.5 rupees) per maund of 82.29 lb.

TABLE XXVII

ESTIMATED ACREAGE CHANGES FOR SPECIFIED RATES OF CHANGES IN PRODUCT PRICES, 1939-40 TO 1961-62, REGION II, MADRAS STATE, INDIA

Product	Prices		Acreage in thousand acres
	Per cent increase	Prices in rupees[a]	
			(i) Rice
Rice	5	8.67	249.05
	10	9.08	250.37
	15	9.49	251.68
	20	9.91	252.99
	25	10.32	254.31
			(ii) Ragi
Groundnuts	5	28.39	39.58
	10	29.74	39.00
	15	31.09	38.44
	20	32.44	37.88
	25	33.80	37.30
			(iii) Cumbu
Cumbu	5	8.95	35.99
	10	9.38	37.44
	15	9.80	38.87
	20	10.23	40.30
	25	10.65	41.73
Groundnuts	5	28.39	33.75
	10	29.74	32.93
	15	31.09	32.11
	20	32.44	31.29
	25	33.80	30.46
			(iv) Sugarcane
Sugarcane	5	13.86	13.40
	10	14.52	13.88
	15	15.18	14.43
	20	15.84	14.84
	25	16.50	15.32

TABLE XXVII (continued)

Product	Prices: Per cent increase	Prices: Prices in rupees[a]	Acreage in thousand acres
Rice	5	8.67	12.28
	10	9.08	11.64
	15	9.50	11.00
	20	9.91	10.36
	25	10.32	9.72
			(v) Groundnuts
Rice	5	8.67	11.85
	10	9.08	11.31
	15	9.50	10.77
	20	9.91	10.23
	25	10.32	9.69

[a]Prices in rupees ($1 = 7.5 rupees) per maund of 82.29 lb.

TABLE XXVIII

ESTIMATED ACREAGE CHANGES FOR SPECIFIED RATES OF CHANGES IN PRODUCT PRICES, 1939-40 TO 1961-62, REGION III, MADRAS STATE, INDIA

Product	Prices: Per cent increase	Prices: Prices in rupees[a]	Acreage in thousand acres
			(i) Cumbu
Cumbu	5	9.15	9.67
	10	9.59	10.13
	15	10.02	10.58
	20	10.46	11.04
	25	10.89	11.49
			(ii) Cotton
Cotton	5	26.37	16.89
	10	27.63	17.90
	15	28.88	18.92
	20	30.14	19.93
	25	31.19	20.95
Groundnuts	5	14.42	15.26
	10	15.11	14.66
	15	15.80	14.06
	20	16.48	13.45
	25	17.17	12.84

[a]Prices in rupees ($1 = 7.5 rupees) per maund of 82.29 lb.

TABLE XXIX

DISTRICTWISE CALENDAR OF AGRICULTURAL OPERATIONS FOR IMPORTANT CROPS, MADRAS STATE, INDIA

District	January	February	March	April	May	June	July	August	September	October	November	December
					1. Crop - Rice							
Sowings												
Chingleput	6.0	6.2	3.5	2.2	1.0	1.6	2.3	12.1	28.9	17.0	11.9	7.3
South Arcot	1.7	5.0	3.3	1.7	1.7	3.3	5.0	8.3	15.0	21.7	28.3	5.0
North Arcot	9.4	6.3	3.1	...	3.1	6.3	6.2	9.4	20.3	20.3	10.9	4.7
Salem	4.6	5.2	1.3	0.9	1.7	6.9	9.4	11.8	11.6	22.5	14.3	9.8
Coimbatore	3.0	...	...	...	3.0	15.0	10.0	17.0	11.0	22.0	14.0	5.0
Tiruchirappalli K	1.4	1.3	3.2	...	0.1	0.3	2.9	2.4	0.9	...	...	1.4
S	...	0.1	0.2	...	...	...	2.7	6.2	14.7	31.7	24.3	6.2
Tanjore	0.6	0.3	0.2	...	0.1	0.2	4.3	15.5	34.5	26.6	13.6	4.1
Madurai	2.0	...	4.0	4.0	1.0	...	4.0	7.0	12.0	33.0	28.0	5.0
Ramanathapuram	3.0	1.0	4.0	3.0	1.0	...	1.0	3.0	20.0	26.0	26.0	12.0
Tirunelveli	8.0	2.0	2.0	2.0	2.0	7.0	13.0	3.0	1.0	5.0	25.0	30.0
Harvests												
Chingleput	21.2	30.6	16.1	2.2	10.4	3.5	...	2.1	3.6	3.2	4.3	2.8
South Arcot	15.0	21.7	28.3	5.0	1.9	4.8	3.3	1.7	2.5	2.8	8.0	5.0
North Arcot	6.3	20.3	12.5	9.4	6.3	3.1	4.7	1.5	4.7	4.7	14.0	12.5
Salem	19.0	20.3	8.8	4.1	3.0	1.9	0.4	2.1	6.3	7.2	9.5	17.4
Coimbatore	23.0	29.0	8.0	3.0	1.0	...	...	...	4.0	16.0	9.0	7.0
Tiruchirappalli K	0.3	1.4	...	1.4	4.5	...	...	...	...	5.7	0.4	0.2
S	17.6	55.0	10.4	...	...	...	0.3	...	...	...	...	2.8
Tanjore	19.0	52.4	13.8	1.2	0.1	...	0.1	0.1	0.9	6.2	3.4	2.8
Madurai	6.0	20.0	37.0	18.0	...	4.0	5.0	1.0	...	3.0	5.0	1.0
Ramanathapuram	18.0	29.0	28.0	13.0	1.0	2.0	2.0	1.0	...	...	1.0	5.0
Tirunelveli	2.0	21.0	30.0	9.0	3.0	3.0	1.0	1.0	6.0	14.0	7.0	3.0

TABLE XXIX (continued)

District	January	February	March	April	May	June	July	August	September	October	November	December
					2. Crop - Cumbu							
Sowings												
Chingleput	11.2	1.3	2.5	1.3	1.3	14.5	27.9	12.9	14.5	1.3	1.3	10.0
South Arcot	7.0	1.0	4.0	...	...	7.0	24.0	27.0	17.0	10.0	1.0	2.0
North Arcot	...	...	...	...	9.3	6.3	31.3	28.1	25.0	...	...	...
Salem	0.6	3.2	1.2	0.1	4.5	20.0	14.1	15.7	14.5	13.2	7.0	5.9
Coimbatore	...	...	...	1.0	15.0	17.0	12.0	12.0	25.0	15.0	3.0	...
Tiruchirappalli	0.4	2.2	0.1	...	0.2	3.4	5.9	13.3	23.9	36.6	11.2	2.8
Tanjore	4.5	...	...	...	...	...	6.1	45.5	39.4	4.5	...	...
Madurai	...	...	...	...	...	...	...	75.0	25.0	...	...	...
Ramanathapuram	8.0	7.0	8.0	6.0	1.0	2.0	...	...	7.0	21.0	33.0	7.0
Tirunelveli	5.0	1.0	1.0	1.0	1.0	...	...	...	...	6.0	50.0	35.0
Harvests												
Chingleput	1.4	1.6	9.3	13.3	1.7	2.2	6.1	5.8	11.7	21.1	12.5	13.3
South Arcot	10.0	1.0	2.0	7.0	1.0	4.0	...	...	7.0	24.0	27.0	17.0
North Arcot	...	...	...	...	...	...	...	12.5	12.5	25.0	25.0	25.0
Salem	11.6	10.6	4.8	0.5	0.7	2.7	2.5	9.9	16.6	15.4	13.0	11.7
Coimbatore	11.0	3.0	...	...	...	...	6.0	12.0	15.0	3.0	15.0	35.0
Tiruchirappalli	26.7	27.8	5.9	0.2	1.9	0.6	0.1	2.0	2.9	7.7	6.6	17.6
Tanjore	4.5	...	4.5	...	...	...	...	...	3.0	47.0	16.7	24.3
Madurai	...	...	...	...	...	...	...	...	...	...	...	100.0
Ramanathapuram	12.0	20.0	17.0	5.0	11.0	7.0	7.0	17.0	1.0	...	...	3.0
Tirunelveli	5.0	46.0	38.0	5.0	4.0	1.0	...	...	1.0	...	...	...

TABLE XXIX (continued)

District	January	February	March	April	May	June	July	August	September	October	November	December
					3. Crop - Ragi							
Sowings												
Chingleput	8.6	2.8	...	...	...	12.1	28.3	27.9	7.0	9.3	4.0	...
South Arcot	17.0	16.0	9.0	...	...	1.0	23.0	16.0	4.0	7.0	3.0	4.0
North Arcot	15.6	14.0	6.3	6.3	3.1	6.3	12.5	18.7	4.6	6.3	6.3	...
Salem	1.8	1.7	0.5	0.5	1.2	2.1	6.1	50.4	15.7	12.0	5.7	2.3
Coimbatore	3.0	...	2.0	3.0	8.0	9.0	21.0	20.0	17.0	10.0	4.0	3.0
Tiruchirappalli	0.4	0.4	...	...	...	8.7	25.8	12.7	13.3	23.6	9.6	5.5
Tanjore	3.5	1.1	2.3	1.1	...	0.6	2.3	34.7	40.5	5.8	5.2	2.9
Madurai	...	...	...	...	...	40.0	51.0	9.0	...	...	...	...
Ramanathapuram	2.0	2.0	1.0	...	1.0	4.0	5.0	9.0	32.0	19.0	20.0	5.0
Tirunelveli	1.0	1.0	3.0	4.0	5.0	13.0	19.0	12.0	20.0	22.0	...	...
Harvests												
Chingleput	5.2	5.7	4.6	2.6	5.7	1.4	...	...	23.5	33.9	16.7	0.7
South Arcot	4.0	7.0	3.0	4.0	17.0	16.0	9.0	...	...	1.0	23.0	16.0
North Arcot	6.3	3.1	12.5	12.5	18.8	...	3.1	6.3	18.8	9.3	3.1	6.2
Salem	10.6	6.5	3.3	3.5	...	...	0.3	1.5	1.9	2.7	10.7	59.0
Coimbatore	4.0	3.0	6.0	...	...	2.0	1.0	10.0	13.0	26.0	22.0	13.0
Tiruchirappalli	29.8	20.6	1.2	...	...	...	...	...	14.5	17.5	6.2	10.2
Tanjore	4.1	5.8	7.0	...	1.1	...	1.1	1.1	1.1	8.1	39.9	30.7
Madurai	...	...	...	...	...	...	...	...	...	40.0	51.0	9.0
Ramanathapuram	18.0	21.0	7.0	7.0	1.0	1.0	...	...	1.0	7.0	1.0	36.0
Tirunelveli	4.0	...	1.0	1.0	3.0	3.0	2.0	5.0	12.0	19.0	19.0	31.0

TABLE XXIX (continued)

District	January	February	March	April	May	June	July	August	September	October	November	December
4. Crop - Groundnut												
Sowings												
Chingleput	10.8	3.3	1.7	...	8.9	...	8.8	25.6	22.6	11.2	7.1	...
South Arcot (i)	20.0	5.0	3.0	2.0	4.0	3.0	5.0	17.0	8.0	8.0	8.0	17.0
South Arcot (u.i.)	...	...	...	...	...	3.0	17.0	33.0	33.0	10.0	3.0	1.0
North Arcot	3.1	9.4	...	...	...	...	9.4	40.6	31.3	6.2	...	...
Salem	...	...	...	4.4	3.9	46.0	42.6	3.1	...	...	...	...
Coimbatore	1.0	...	6.0	5.0	19.0	8.0	15.0	16.0	23.0	6.0	1.0	...
Tiruchirappalli	...	...	...	...	...	...	4.1	4.5	35.7	44.6	11.1	...
Tanjore	1.3	3.3	0.7	10.0	...	...	9.6	32.3	39.3	2.6	0.8	0.1
Madurai	...	...	...	11.0(i)	...	...	...	89.0 (u.i.)	...	...	...	...
Ramanathapuram	...	...	...	1.0	...	...	24.0	38.0	37.0	...	...	...
Tirunelveli	5.0	...	3.0	1.0	1.0	1.0	...	...	...	15.0	53.0	21.0
Harvests												
Chingleput	22.2	14.3	6.3	5.6	5.7	2.3	...	...	5.4	4.3	11.2	22.7
South Arcot (i)	8.0	8.0	8.0	17.0	20.0	5.0	3.0	2.0	4.0	3.0	5.0	17.0
South Arcot (u.i.)	33.0	33.0	10.0	3.0	1.0	...	...	...	...	...	3.0	17.0
North Arcot	6.3	...	...	...	6.3	6.2	...	...	...	6.2	25.0	50.0
Salem	...	...	...	...	...	...	5.6	2.7	1.2	47.6	42.9	...
Coimbatore	9.0	8.0	...	...	...	...	...	9.0	20.0	2.0	19.0	33.0
Tiruchirappalli	22.0	2.8	...	...	...	...	...	3.0	5.6	4.6	23.4	38.6
Tanjore	36.9	0.5	...	...	4.7	1.2	9.4	...	0.5	0.3	2.0	44.5
Madurai	...	...	...	...	...	...	11.0(i)	...	...	...	...	89.0 (u.i.)
Ramanathapuram	47.0	11.0	...	...	...	...	...	...	...	...	9.0	31.0
Tirunelveli	15.0	53.0	21.0	5.0	...	3.0	...	1.0	2.0	1.0	1.0	...

(i) - Irrigated. (u.i.) - Unirrigated.

TABLE XXIX (continued)

District	January	February	March	April	May	June	July	August	September	October	November	December
					5. Crop - Cotton							
Sowings												
Chingleput	...	...	...	...	...	...	...	...	...	...	...	...
South Arcot	4.0	3.0	3.0	8.0	21.0	17.0	21.0	8.0	10.0	3.0	2.0	...
North Arcot	...	...	...	...	...	...	...	...	...	...	...	...
Salem	...	...	...	...	...	...	...	...	...	...	...	...
Coimbatore	1.0	...	...	...	...	...	1.0	...	4.0	45.0	44.0	5.0
Tiruchirappalli	...	...	...	...	...	...	4.1	4.5	35.7	44.6	11.1	...
Tanjore	...	...	...	...	...	...	...	...	...	...	...	...
Madurai	...	...	...	...	...	...	...	...	33.0	67.0	...	...
Ramanathapuram	6.0	...	...	2.0	2.0	...	...	...	18.0	46.0	16.0	10.0
Tirunelveli	6.0	2.0	...	2.0	2.0	1.0	4.0	...	...	13.0	37.0	33.0
Harvests												
Chingleput	...	...	...	...	...	...	...	...	...	...	...	...
South Arcot	7.0	11.0	9.0	1.0	2.0	1.0	5.0	...	1.0	15.0	40.0	8.0
North Arcot	...	...	...	...	...	...	...	...	...	...	...	...
Salem	...	...	...	...	...	...	...	...	...	...	...	...
Coimbatore	...	...	50.0	31.0	9.0	...	...	6.0	3.0	1.0	...	...
Tiruchirappalli	...	5.8	5.8	2.0	...	3.9	5.0	77.5	...	...	...	...
Tanjore	...	...	...	...	...	...	...	...	...	...	...	...
Madurai	...	...	...	50.0	50.0	...	75.0*	25.0*	...	...	...	...
Ramanathapuram	...	20.0	32.0	33.0	8.0	1.0	2.0	2.0	2.0	...	...	...
Tirunelveli	4.0	...	8.0	37.0	32.0	8.0	2.0	2.0	2.0	2.0	2.0	1.0

* - Second picking.

TABLE XXIX (continued)

District	January	February	March	April	May	June	July	August	September	October	November	December
6. Crop - Sugarcane												
Sowings												
Chingleput	...	...	...	...	...	...	...	...	...	...	...	...
South Arcot	12.0	6.0	6.0	12.0	23.0	12.0	12.0	2.0	12.0	2.0	...	1.0
North Arcot	...	...	28.1	18.8	34.3	18.8	...	...	...	...	...	...
Salem	14.2	23.2	30.9	12.3	...	...	...	...	...	2.4	5.7	11.3
Coimbatore	...	2.0	4.0	3.0	16.0	6.0	39.0	19.0	8.0	3.0	...	...
Tiruchirappalli	...	...	20.7	25.9	25.9	27.5	...	...	...	...	...	...
Tanjore	...	...	...	...	...	...	62.8	17.2	14.3	5.7	...	...
Madurai	...	...	...	...	...	...	...	...	...	...	...	...
Ramanathapuram	...	...	...	30.0	50.0	20.0	...	...	...	...	...	...
Tirunelveli	...	...	...	...	6.0	34.0	47.0	2.0	8.0	3.0	...	...
Harvests												
Chingleput	...	...	...	...	...	...	...	...	...	...	...	...
South Arcot	12.0	23.0	23.0	6.0	...	...	...	...	12.0	...	12.0	12.0
North Arcot	9.4	25.0	25.0	21.8	9.4	9.4	...	...	...	...	...	...
Salem	25.5	27.3	29.4	3.9	...	...	...	...	...	3.3	2.4	8.2
Coimbatore	8.0	24.0	34.0	...	...	6.0	9.0	12.0	5.0	2.0	...	...
Tiruchirappalli	24.0	24.0	32.0	...	...	...	...	...	...	...	...	20.0
Tanjore	20.0	62.8	11.6	5.6	...	...	...	...	...	...	...	...
Madurai	...	...	...	...	...	...	...	...	...	...	...	...
Ramanathapuram	30.0	32.0	25.0	11.0	2.0	...	...	...	...	...	...	...
Tirunelveli	68.0	22.0	1.0	1.0	1.0	...	...	...	...	...	3.0	4.0

Source: Season and Crop Report, Madras State, 1960-61 (Madras: Government Press, 1962).