

A SELECT REVIEW OF LITERATURE ON
SUPPLY RESPONSE OF FARMERS TO
AGRICULTURAL PRICES
WITH REFERENCE TO INDIA

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CHAPTER I

INTRODUCTION

Supply response means the response of the supplier in terms of the quantity supplied to the stimulus of price. This stimulus-response relationship between the independent and dependent variables is crystallized in the supply curve. The supply curve thus represents the quantity supplied at each hypothetical price, given the technology and the prices of the related products and factors.

The magnitude of supply response depends upon the extent to which the factors of production can be varied as well as on the dimension of the initial stimulus provided by the price. The response also depends upon the expectation about the nature of the price change. If the change in price is expected to be temporary there may be some change in the retention and sales in the stock period. But if this change is expected to persist, there will be adjustments not only in the stocks but also in the plans of output for the next production period. If the dimension of the price change is substantial and is likely to persist over long period, it may also influence the farmer's investment decisions.

The response of farm products to changing agricultural prices has been the subject of discussions since the beginning of the 1950s all over the economically developed world.

Scholars have constructed models in order to probe into the basic relationship between the price stimulus and response to it in terms of the quantity supplied. Over the years the empirical studies have provided better insights into the producer's behaviour and their economic decision-making, thereby helping the policy-makers in taking policy decisions.

However, doubts were expressed at the same time about the relevance of this formulation to the underdeveloped economies, where farmers were thought to be more tradition bound.

Three alternative hypotheses have been advanced about supply response of farmers in underdeveloped countries:

- 1) The farmers in underdeveloped countries respond quickly and efficiently to price stimulus: Positive Supply Response.
- 2) The farmers in underdeveloped countries respond inversely to the price stimulus: Negative/Perverse Supply Response.
- 3) The farmers in underdeveloped countries do not react to price stimulus: Zero Supply Response.

In order to isolate the actual nature of supply response a systematic analysis of some other underlying factors is necessary. These factors are: Technological improvement, organization and expansion of the market for the commodity, availability of supporting facilities (like irrigation, credit, etc.) and the nature of risks and uncertainties faced by the market operators. The impact of these factors should

be separated if the extent of supply response to price is to be estimated.

Some researchers in developed countries alleged that agriculture in developing and underdeveloped countries was not response ^{we} to price.¹ But till then no systematic efforts had been made in India to verify this supposition. Dharam Narain's pioneering work "Distribution of Marketed Surplus of agricultural produce by size level of holding in India in 1950-51"² and his Ph.D. thesis [Impact of Price Movements on Area Under Selected Crops in India 1900-39] marked the beginning of an era of research in the area of supply response. However the publication of this book was delayed until 1965, by which time some empirical exercises on the topic were published in professional journals.

The first set of studies took a more conventional approach, using the graphical, tabular and other simple quantitative techniques of analysis. Most of these studies used acreage under a crop as a proxy for 'output' response. This was due to the fact that in agriculture the plans of production seldom materialize, as these are always unpredictably altered by the variation in uncontrollable inputs like rainfall (which affects total production via the per acre yield), while the area planted under a crop was thought to give a better indication of the planned output.

1 Olson (1960), Walter Neale (1959).

2 Dharam Narain (1961).

Over the years the techniques adopted for the purpose of gauging supply response improved, from simple graphical analysis of the 1950s to the complicated econometric models in the later years. The analysis became more and more sophisticated, with every researcher making modifications to improve upon the previous models.

The present study attempts both a summary and a review of these exercises on measurement of supply response of farmers to agricultural prices in India between 1950 and 1988.

The chapter scheme of this study is as follows:

The first chapter introduces the topic.

The second chapter deals with the acreage response studies which account for the major portion of the literature on the topic. This chapter is divided into two parts: the first deals with the early pre-Nerlovian studies, while the second part consists of the applications of the main Nerlovian model and the modified versions of it.

The third chapter deals with the response of the farmers to price change in terms of the marketed quantum of the commodity, essentially all foodgrains.

The fourth chapter deals with the aggregate supply response of the farmers and the total farm sector in terms of total farm production in response to changing aggregate farm products' price. The innate complexity of the problem has caused this area of research to be relatively neglected.

The fifth and final chapter contains summary and conclusions.

CHAPTER II

ACREAGE RESPONSE STUDIES

The bulk of the studies in the area of supply response of farmers to agricultural prices consists of studies which use "area planted" or sown rather than the physical output as an indicator of the supply of a crop. The realized output in agriculture is the net resultant of a whole array of factors, controllable and uncontrollable. It is due to the impact of the uncontrollable environmental factors like weather that output plans are seldom realized. As no estimate of planned level of output is available, researchers look out for a proxy for it. In underdeveloped countries, with slow technological change and low level of application of non-land inputs (especially of the purchased type) the acreage planted is often considered a suitable proxy for planned output. Since the acreage under a particular crop is to a greater degree under control of the farmer, it is expected to reflect his output plans more appropriately.

It must, however, be noted that the acreage response will not necessarily reflect the magnitude of production response intended, except under following conditions:

- 1) All non-land inputs are varied in proportion to variation in land area.
- 2) Land is a homogeneous factor of production

i.e. all pieces of it give equal output per unit given equal application of all other inputs.

3) There are constant returns to scale.

The first and third conditions may be much less significant constraints to the use of area as a proxy than the second, under technologically primitive agriculture, prevailing conditions of farm size, and year to year variation in area under any particular crop in a farm in India. While allocating land amongst crops the farmer generally uses the most suitable land (suitability being measured in terms of yield). Hence only if the rise in the relative price of the crop is so large as to more than compensate for lower yield will the less suitable land be brought under the crop.

In order to measure the impact of prices on the output we need to identify the relevant price which acts as the stimulus. The absolute price would give inadequate information as it does not tell us anything about the product's price vis-a-vis prices received for competing crops and paid for inputs. Both these are necessary for a profit maximizing producer's decision-making. So the relevant price is the price received by the producer relative to the price paid by him.

There is considerable time lag between the farmer's decision to plant a crop and the time of harvesting the crop for marketing, the lag varying from a few weeks for certain vegetables to more than a year for crops like sugarcane, not

to talk of meat animals like pigs, cattle which take longer time, and plantation crops which are in the nature of capital investment with long gestation period. This interval makes it necessary for the farmer to anticipate the harvest time price at the time of planting. Economists have used different formulations in order to estimate the expected price of the producer to which he is supposed to respond in terms of planted acreage.

In this chapter we shall deal with the acreage response studies which form the major part of the literature on this topic. Almost all these studies consider supply response of individual crops in areas where more than one crop is grown.

These acreage response studies are divided into two broad groups on the basis of the formulation about the nature of the expected price:

- 1) Where the expected price of a crop in the next harvest season is considered to be the same as in the pre-sowing season or in the preceding post-harvest season. $P_t^e = P_{t-1}$.
- 2) Where the next season's expected price is thought to depend in some manner on the prices that prevailed in several seasons preceding: distributed-lags model of price expectation.

$$P_t^e = P_{t-1}^e + B (P_{t-1}^e - P_{t-1}).$$

We deal with the first set of studies in the first section and the second set of studies in the next section of this chapter.

2.1 Studies Seeking to Establish Qualitative Relations

The studies reviewed in this section assume that the farmers' expectation at the sowing time about the price that is likely to prevail at the harvest time depends essentially upon the relative price actually received by him in the previous season.

At the heart of these studies was the quest for rationality of the Indian farmer. The quantity of the agricultural produce supplied by the farmer in developed countries was considered to be responsive to change in prices. Would this simple relationship hold in the Indian context? Or, was the Indian farmer following farming as a way of life to the exclusion of economic consideration of the best income possibility?

Dharam Narain (1962): Dharam Narain was a pioneer in the area of supply response studies in India. His study in this area began with his article "Marketed Surplus of Agricultural Producer by Size-level of Holding in India in 1950-51"¹ (Dharam Narain, 1961). His Ph.D. thesis "Impact of Price Movements on Area Under Selected Crops in India 1900-39" was submitted in 1962 and published in 1965. We take up his published book here for discussion.

In this study Dharam Narain covered six different crops viz: rice, wheat, cotton, jute, groundnut and sugarcane in

1 Dealt with in Chapter III.

British India for which relevant data were available for the period 1900 to 1939.

The data used for this study were taken from various published official sources reporting area under crops, farm harvest prices and rainfall, irrigated area, per acre yield, etc.

Dharam Narain visualized the changes in acreage of these crops to vary with the changes in the expected relative prices of these crops. The expected price was treated as equal to the actual price that prevailed in the just completed crop season. The price of the crop was related to the price of the competing crops in the field. For all these crops he used the Farm Harvest Prices reported in official publications.

Besides relative prices of the crops, Dharam Narain considered some other factors which may affect the farmer's decision about planting a certain acreage under it. These were: rainfall at the sowing time, extent of irrigation available, the relative per acre yield of the crop, the relative proceeds (value of output per acre), and a trend factor which may stand for any steady technological change and/or such other factors that may have a trend effect on acreage.

The methodology adopted by the author was fairly simple. He used graphs and charts. He plotted the relative farm harvest price of the previous year against the current year's acreage by measuring time on horizontal axis and area and price data on two different vertical scales (as price and acreage are measured in different units).

Similar graphical presentation was followed in depicting the relationship between acreage and rainfall, or yield rate, or value of output.

The method of examining the relationship between the two phenomena was visual examination of the direction of change in the two time series. In order to facilitate this, Dharam Narain followed a procedure described by him as follows:

"For purpose of comparison two or more time series are brought together often placed one over the other on the same chart. And since the series so compared relate to different things measured in different units, the choice of scale to which they are plotted on an arithmetic grid is arbitrary. In this choice we have been guided by facility of comparison." (Dharam Narain, 1965, p. 23.)

Such procedure can at best help the researcher make a qualitative judgement: whether relative price and acreage moved in the same direction or otherwise most of the time. This is indeed what Dharam Narain does: he counted the number of times (years) in which the two series moved together. And if this was most often the case, he concluded that acreage was influenced by the relative price in the preceding season.

Besides this the author has also tried to judge the degree of closeness of correspondence between the variables plotted. This he explains as follows: "Here our justification for doing so is in what follows. When two variables are

linearly correlated it should be possible graphically to approximate the relationship that obtains between them. This (on the assumption of linearity) by varying the scale of the curve portraying one series, given the scale of the curve portraying the other that we obtain in principle the best fit (in practice, an approximation of the best) between the two. The act of varying (for this purpose) the scale of one series relative to the scale of the other is then akin to that of approaching, through successive approximations the value of the constant 'b' in an equation of the type $Y = ax + b$ representing the line of best fit fitted to a scatter diagram" (Dharam Narain, 1965, p. 23).

In order to establish an inverse relationship between the two variables like the area of two competing crops, he plots one against the other plotted with inverted scale; e.g., jowar acreage is plotted against inverted bajra acreage, autuman rice area against inverted jute acreage.²

The comparison, by changing of scale, should be strictly restricted to the identification of directional affinities. However Dharam Narain does use it to compare the relative magnitude of the influence of the independent variable on the dependent variable. For example, he says that

² It may be noted that the areas of the competing crops are related inversely through the relative price which is the cause. Changes in acreages are mere effects or responses. Therefore, plotting of two acreages by itself is not very meaningful unless price is also plotted.

foodgrains are influenced to a greater extent by rainfall than by price. Now what is plotted on the graph is price and acreage or rainfall and acreage. The variation in the acreage is a composite effect of all the independent factors affecting it. So if this 'gross change' in acreage is plotted against any one of these variables the results cannot say much, because even if such an exercise were to estimate the slope or extent of covariance - this would be the combined effect of all factors, not just of prices.

The adjustment of the scales of the two time series in order to make them come visually as close as possible in order to examine the frequency of change in a given direction was a rather painful exercise. The same could have been easily done by expressing the two series as indices with a common base year (we have tried it with his series and obtained identical results, see Appendix I). *at the end of chapter II*

It has the further advantage of being able to compare percentage changes in the two variables, though this by itself cannot give a quantitative estimation of the degree of association.

The findings of Dharam Narain for six different crops in different Presidencies and Provinces are summarized below.

Cotton : Cotton acreage and price showed maximum correspondence for Madras followed by Bombay and Sindh. The Punjab data showed simultaneous movement of the variables till 1924-25; after this, however, there was a rise in the

relative area under cotton without a rise in its relative price. This is explained by an increase in irrigation and the introduction of the new American variety of cotton. Since marked increase in irrigation facility was predominantly concentrated in Punjab, this State had the largest adoption of this variety.

Dharam Narain superimposed the cotton acreage graphs for this period for India and USA, and found them to be moving together: "The two curves bear to each other a striking resemblance. What impuse other than price could possibly account for this high sympathy in the tenor of their movements?" (Dharam Narain, 1965, p. 57). "It demonstrates not only to sceptics but even to the surprise of those who expect a measure of price response from the farmer, that the Indian cotton grower is about as responsive to commercial stimuli as his counterparts engaged in highly commercial agriculture in USA" (Dharam Narain, 1965, p. 57).

Groundnut: Groundnut was found to be very responsive to price. Besides this even the market was sensitive to Indian production, as India was its single major producer in the world market. As a result, overproduction led to a fall in price while shortages increased it. Groundnut was first introduced in India in 1913-14. Being a new crop which was gradually accepted it showed an overwhelmingly large impact of the trend. The detrended acreage and price series were found to be the most responsive to price for groundnut.

Sugarcane: The acreage was plotted against both one and two year lagged prices. In the initial years the sugarcane acreage was observed to be moving together more with the two-year lagged price than with the one-year lagged price. In the later years the situation reversed and one-year lagged price looked more relevant. Compared to other provinces the acreage of sugarcane in the United Province was observed to be the most responsive to the price of sugarcane.

Jute : The area curve moved together with the price ratio curve. But the graph for Bengal (unlike that for Bihar and Orissa) showed that the acreage did not fall as much as (in percentage terms) the fall in the relative price. However, no explanation is attempted of this finding.

Rice/Paddy : Here the acreage moved more with the rainfall than with the price. Dharam Narain compares paddy area in Madras Presidency with area under cotton. Here the area under paddy was mostly irrigated while that under cotton was unirrigated. It was, therefore, not appropriate to compare these two crops as they were not competitive.

It must, however, be noted that the increase in the irrigated area (which is beyond the control of a single individual except for well irrigation) puts an ultimate limit on the acreage response to paddy. Further increase in production in response to increase in price can be obtained by increasing the application of non-land inputs. Therefore, acreage is a poor proxy for output in such situations.

Indeed the paddy growing regions in our country were mostly monoculture region (except for jute in Bengal parts of Bihar, Orissa and Assam). Acreage response to prices in these regions would be either in terms of more (new) area being brought under cultivation when price rose, or keeping more land idle when price declined. As the opportunity cost of land, and even labour, during this season is zero, the farmer is likely to sow it with paddy irrespective of the price, so long as it covers the cost in terms of non-land inputs and leaves something for him. Thus the acreage response to fall in price is sure to be poor. Similarly, there is also a severe limit to an increase in area when prices are increasing. This limit is in terms of the availability of cultivable uncultivated land, and irrigated land, where paddy is grown only under irrigation.

Wheat : Dharam Narain's conclusions for wheat are similar to those for paddy. He says area under wheat is more responsive to rainfall than to price. However his handling of the data leaves certain things to be desired and hence the conclusions may not be quite acceptable. He has clubbed together the wheat acreage in Bombay and Sindh; but the bulk of the area under wheat in Sindh was irrigated, while the area under wheat in Bombay was predominantly unirrigated. Such clubbing together would not reflect the response in either region.

Secondly he has compared wheat acreage with the acreage under gram. While gram happens to be a substitute for wheat

in the North, it is mainly under unirrigated condition. It is not clear if gram was a real competitor with irrigated wheat in areas like Sind. Rabi jowar would be the more appropriate competing crop with wheat in Bombay.

Although wheat has been compared with sugarcane in U.P., a look at the graph shows that the wheat acreage fluctuates more than the sugarcane acreage. This indicates the existence of more competing crops.

The simple two variable analysis of acreage and price series is inadequate to isolate the exact relationship that operates between the two variables. Measuring this relationship is not feasible unless the impact of other factors is isolated. Any comment about the relative importance of the two determinants of acreage, viz. price and rainfall, without multivariate analysis cannot give reliable results.

Dharam Narain subscribed to the subsistence doctrine as far as foodgrains are concerned. He believed that the decisions to choose between food crops rested on their physical yield. Now, so long as alternative crops are available, the farmer would produce the most profitable crop, sell it and buy his domestic requirement. This would work so long as the marketing margins are not prohibitively high and the risks attached to his net income are not so high as to be disincentive for such trading. Dharam Narain appears to rule it out completely.

Dharam Narain with his deep insight identified the interrelationships amongst the variables under consideration.

Dharam Narain's work was the first attempt at trying to examine the responsiveness of Indian farmers to price changes.

A few propositions emerged from his study: The cash crops, which occupied proportionally a much smaller part of the total cultivated area were more responsive to price changes than food crops. (In fact, arithmetic of elasticity would suggest this; for the crop occupying a smaller proportion of land and with fair substitutability would show greater price elasticity of supply than a crop which occupies a very large proportion of the total cultivable land.) Of course where a crop was irrigated, its price responsiveness depended upon availability of competing irrigated crops; the extension of irrigation rather than price was then the main governing factor in explaining changes in acreage.

Monoculture crops are unsuitable for study of acreage response to price changes.

Weather is often a more important factor than price since it affects expected gross (and net) farm returns to a greater extent.

Dharam Narain, however, used graphical presentation to establish correlation among his variables, this can at best help make only a qualitative judgement. Even this becomes difficult when more than one factors are likely to be influencing acreage.

It is possible that statistical multivariate analysis of the same set of data would give rather different results.

This is what was attempted by A. Parikh with the help of Dharam Narain's data. Parikh's article is reviewed in the next section.³

"Farmers' Response to Price and Marketing Policies Affecting Sugarcane and Paddy" : Gupta and Majid (1962)

The authors study the change in acreage under sugarcane and paddy in response to a change in their prices in Deoria district of Uttar Pradesh during 1951-52 to 1961-62.

The price data used for the purpose were the wholesale prices of the crops in the Deoria district for the previous year.

The authors divide the sugarcane price by paddy price to get the relative price of sugarcane, and compute the relative acreage in a similar fashion. It was observed that the price rose only for seven years out of 11, while the relative acreage always increased.

It was observed that during this period the yield/ha of paddy was rising and that of sugarcane was falling. The gross value of cane was found to be 2 to 3 times that of paddy. The authors could not compute 'net returns' due to absence of cost data. Due to this data limitation the analysis stops at relative prices and gross returns.

The authors try to explain the secular upward trend in sugarcane as follows:

³ Parikh's study of wheat and rice confirmed Dharam Narain's conclusions.

- 1) The area under consideration is prone to periodic floods and droughts. While both these damage paddy completely, sugarcane remained relatively unaffected. This implies that paddy was mainly unirrigated, however sugarcane may have been irrigated.
- 2) The announcement of minimum support prices has removed most of the uncertainty involved in the marketing of the produce - uncertainty in selling of the cash crop produced in order to buy the domestic requirement.
 - 2a) There was an assured market for sugarcane in the region, in the form of the sugar factories located there to whom around 80 per cent of the produce was sold. Due to this assured market for their produce even smaller cultivators switched over to sugarcane.
 - 2b) The additional driving force in this direction was the provision of rice from the fair price shops. This removed the remaining uncertainty involved in commercializing i.e. producing for the market and buying the domestic requirement.

There were also some other factors like expansion of credit due to spread of cooperatives. This enabled the farmers to incur higher costs involved in taking the sugarcane crop.

The study does not specify whether irrigation is

available round the year and in all areas. Although it is clear that the Bhat Soil retains moisture to make even sugarcane feasible without irrigation, the study also includes villages with Bangar Soil. Therefore what happened to irrigation also becomes relevant.

The point seems to be that the soil may be more suitable for sugarcane and rather risky for paddy (with high water retention). Moreover, with extension of irrigation and rise in its relative price the net income from cane was higher than that of paddy in spite of the decrease, in per acre yield of cane. This may explain the increase in sugarcane area. But what stops a total switch over to cane? The authors do not enlighten us.

Jakhade and Mujumdar (1964) : Jakhade and Mujumdar tried to examine the nature and extent of acreage response of farmers to prices. The area chosen for the study consists of the eastern region of the country, viz, Assam, Bihar and West Bengal. The crops chosen for the study are jute and paddy, the price is taken as the ratio of the pre-sowing (January to April) months' price. The all India Index number of wholesale price of jute was divided by a similar price index of rice, since the State level indices were not available.

The ratio of the jute/rice price was compared to the actual acreage under jute and rice. It was observed that in 9 out of 14 years 1950-51 to 1963-64 the price and acreage moved together for both the crops (jute and paddy). The area

under other crops was considered in order to account for the impact of the other crops. This accounts for abnormal increase in area under rice in 1952-53 and marginal decline in case of jute in face of a heavy slump in jute/rice index this year had had an increase in the total cultivated area!

From 1959-60 the State level wholesale price indices became available and were used for a similar exercise. It was observed that the State level indices explained the acreage movements in respective States to a greater extent (larger number of years) than the all India Index.

On this basis the authors conclude that in spite of the limitations of the data, the acreage shifts between rice and jute have been in keeping with the variation in the relative prices. The authors are aware that an additional refinement could have been introduced in the above study by comparing only autumn (aus) paddy with jute.

Here one point should have been taken into account the planting of jute does not totally rule out the planting of paddy on aman (winter) paddy land, since aman paddy can be transplanted after jute is harvested in early August. Of course, this would be of little significance if most or all of the jute is grown on Aus (Autumn) paddy land. For such successive cropping of jute and paddy on such land is not possible. But the authors do not mention this possibility, much less examined it statistically.

Simple Regression Analysis

Kamaladevi and Rajgopalan (1965) tried to gauge the

supply response of farmers to groundnut prices relative to ragi prices, in terms of both the land and non-land inputs as reflected in acreage and yield respectively. The region chosen for the study is North Arcot district of Madras and the period chosen for analysis is 1934-35 to 1961-62

The authors fitted two regressions:

$$1) \text{ Acreage Response: } Y_t = 82.10 + 61.12 X_{t-1}$$

where the $X_{t-1} = \frac{\text{Groundnut Price } t-1}{\text{Ragi Price } t-1}$

and Y_t acreage under groundnut in time t .

$$R^2 = 0.55 \text{ significant at 1 per cent level.}$$

Although price was found to be a significant determinant of acreage, it did not explain around 45 per cent of the variation in acreage.

$$2) \text{ Yield Response: } Y_t = 0.30 + 0.059 X_{t-1}$$

where Y_t stands for yield/acre.

$$R^2 = 0.28 \text{ (insignificant).}$$

It is not surprising that the regression fit was poor in this case, for yields are subject to weather to a very great extent and price by itself can explain little.

P. Kamaladevi (1964): Kamaladevi tried to study the price-acreage relationship for the period 1937 to 1963 for rice, cholam, ragi, groundnut and cotton which together constituted 66 per cent of the cultivated area of the State of Madras.

For this purpose she computed the simple average prices

for every one of these commodities for two quinquenniums 1937-41 and 1959-63. The average price of each commodity was divided by the geometric mean of the average prices of the other commodities in order to find out the relative price. A similar exercise was carried out for the acreage data. The relative price of each crop (as also its relative acreage) in the second quinquennium was expressed as percentage of relative price (or acreage) of the first quinquennium. These indices were then ranked separately for prices and acreages. From the ranked indices of changes in relative prices and relative acreage of the five crops the author shows that the crop with the maximum rise in relative price also recorded the maximum rise in acreage, and the crops with minimum rise in price recorded minimum rise in acreage.

Basically what the author was doing was making a two point calculation of the percentage change in prices and acreage of every crop. For such purposes the appropriate thing to do would have been the calculation of the 'arc elasticity' of supply, rather than 'point elasticity' which underlines the author's comments. (She does not calculate the elasticities.) Using the author's data we calculate the elasticities for each of the crops. These are given in Table 2.1. These calculations show that the ranking of the crops according to elasticities of supply is somewhat different from what the author found out through comparison in terms of extent of percentage change in both acreage and price ranked.

Table 2.1 : ARC ELASTICITY ESTIMATES :

Crop	Arc elasticity	Our ranking	Her ranking
Rice	0.1690	1	2
Groundnut	0.1550	2	1
Cholam	0.0289	3	3
Ragi	-0.0457	4	4
Cotton	-0.1026	5	5

Kamaladevi's analysis, however, ignores the fact that there may be other factors that affect acreage. Although she does mention the rise in irrigation as a reason for rise in paddy acreage, she does not take into consideration how this rise in acreage under paddy is likely to affect the acreage under other crops.

P.V. John (1965): John chooses sugarcane and paddy in Uttar Pradesh for his study of supply response of farmers in terms of acreage to a change in relative price during 1954 to 1963. These two crops are generally known to compete with each other as they are grown on similar land.

The author firstly computes indices of the absolute price, the area and the output of both sugarcane and paddy. In case of sugarcane it was observed that the positive movement in the absolute price was associated with a positive rate of growth (4.06 per cent) of acreage and an even higher positive growth (8.01 per cent) of output. But absolute changes were

in fact misleading, as there was a fall in the relative price of sugarcane. It was observed that the acreage of sugarcane relative to paddy rose by 1.53 per cent and its relative output by 0.92 per cent during 1954-55 to 1962-63.

In order to look into these seemingly paradoxical results John computed the value of output/hectare for both the crops. The author also illustrates the relative profitable position of the two crops with the help of two years⁴ data from (1) a farm management study, and (2) a study by Gupta and Majid.⁵ The computations showed that the gross returns/hectare from sugarcane were between 4 and 5 times that of the gross returns from rice, while the cost of production was only 2-3 times that of the latter. Sugarcane was thus the more profitable of the two crops. Although it is clear that it is this gap in profitability that prompted the expansion of sugarcane area, the author states two reasons that impeded a total shift from paddy to sugarcane: (i) the dearth of capital with farmers and (ii) the subsistence character necessitating production of a subsistence crop, in this case paddy.

The author attributes the increase in the acreage of both the crops to an expansion of area under irrigation which is understandable. However he further comments that such an irrigation expansion has led to a rise in the size of holdings. It would have been useful to substantiate such a statement

4 1956-57 and 1960.

5 Dealt with in the beginning of the section.

with the appropriate empirical evidence. For it is more logical to expect a fall in the size of holding in face of rise in population. All States in India have been facing a decline in size of holding over the years. This does not then support the argument of increased size of holding and rise of farmers above the subsistence level.

Although the reason of subsistence cited by the author for the persistence of paddy cultivation he should have paused before jumping to this easy explanation of subsistence farming to clarify certain points.

(1) Firstly it is wrong to say anything about the profitability with merely 2 years' data obtained from the two studies mentioned above.⁶

(2) The authors should have specified whether the land under consideration was irrigated and how the irrigated area has changed over time. Whether the paddy considered is irrigated or not.

(a) If the paddy considered here is largely unirrigated then its substitution with sugarcane has to be ruled out.

(b) If merely protective/seasonal irrigation is available then such land cannot grow sugarcane.

(c) Even if paddy is perennially irrigated, the comparison between it and the annual crop of sugarcane is not valid. As account must also be taken of crops that can be

⁶ Gupta and Majid's study and the farm management study for U.P. during 1956-57 and 1960.

following paddy during the remaining period (when paddy is harvested but sugarcane stands on the field). John does not do this; he compares the profitability for the annual crop of sugarcane with the profitability of a single season's crop of paddy.

Thirdly, the author ignores the technical consideration of crop rotation which has its economic logic, as the repeated planting of the same crop depletes the soil's nutrient causing a decrease in yield/acre.

Fourthly, the author compares the acreage with the current year's price. This is improper, since production plans are carried out in anticipation of the market price.

Structure of Farm Prices in Punjab: A.S. Kahlon, S.S. Johl and H.N. Dwivedi (1965)

In this article the authors attempt three things:

- (1) The calculation of parity indices.
- (2) The computation of the cross-elasticities and own price elasticities of supply, by using arc elasticity measure.
- (3) Regression analysis to get an average response function for a single crop, viz., wheat.

The period of study is 1950-51 to 1962-63. The data for this purpose are obtained from the Statistical Abstract of Punjab 1963. The price used here is the farm harvest price of the same year for the first two exercises and of the preceding year for the last one.

[1] Calculation of a parity index: The authors have computed a parity index for each crop as follows:

Harvest Price Index of the (seven) crops in Punjab
General Wholesale Price Index for Punjab

This ratio of agricultural prices to the general price level in the economy is expected to affect investment going to farm and non-farm products. Higher farm prices (vis-a-vis the non-farm prices) would cause an increase in investment and production, while decrease in farm prices would cause a lowering of investment.

But their parity ratio appears grossly inadequate for this purpose. The numerator of this index is an index of seven crops Wheat, Maize, Rice, Jowar, Bajra, Cotton and Sugar-cane. The authors do not state whether these crops constitute the bulk of agricultural production - if they do then it may be a fair approximation of the 'prices received' provided their weights in the index are right. The authors do not specify whether the price index is weighted or not. Our calculations show that it is not an index of simple average but a weighted one. But the authors do not specify the weights that were used.

The denominator of the price index is the 'general wholesale price index'. This includes the agricultural prices in the country, as well as the prices of a number of products which do not enter into the purchased basket of the farmers either as farm inputs or as household needs. Thus the price index does not quite reflect the prices of the purchases from the non-agricultural sector or prices paid by agriculture.

As a result, the terms of trade index does not reflect either the net barter terms of trade nor the income terms of trade and hence any directional change in it is not likely to reflect changes in incentives to invest or produce.

The second terms of trade index computed by the authors is not likely to serve the purpose of indicating the change in the relative profitability which the authors say it does.

$$\text{Parity Index} = \frac{\text{Index of Individual Product Prices}}{\text{General Index of Agricultural Prices}}$$

The substitution between any two crops is normally restricted by their specific requirements in terms of the season, climate, type of soil, and irrigation. The substitutability between crops is thus limited to the set of crops which have the similar set of requirements. But the general index of agricultural prices includes all the agricultural commodities, with weights different from those which are relevant (in terms of substitutability) from the point of view of a particular crop under consideration.

Besides this the index does not take into account any changes in the profitability due to changes in the relative costs, yields and all other non-price factors. Thus this index again is far from adequate in reflecting the relative profitability of the crops under consideration.

[2] The computation of own and cross price elasticities:

The authors have computed the elasticity with the standard arc elasticity formula. But the manner in which they have chosen p_i s and q_j s is somewhat peculiar. The lowest actual farm

harvest price was taken as p_1 and the corresponding quantity as q_1 ; similarly the highest price was taken as p_2 and the corresponding quantity was taken as q_2 .

The first difficulty with such an elasticity is that it takes the same year's acreage as that of the price. Prices prevailing in a year cannot influence the acreage in the same year. Besides this elasticity is based on extreme observations; it would not give proper idea about the actual elasticity prevailing during this period. The period under study is also too long for a two point comparison.

Their results show the highest price elasticity for paddy (2.0058) and the lowest price elasticity for cotton (0.2378).

There are certain peculiar results in the computation of cross elasticities. While the production elasticity of Bajra with reference to price of maize is 0.6402 that of Maize with reference to price of Bajra is 0.8649. Similarly, the elasticity of production -

of Maize	with respect to	cotton price	is	-0.7648,	but
of Cotton	"	"	"	maize price	is 0.6468;
of Rice	"	"	"	bajra price	is -0.1655, but
of Bajra	"	"	"	rice price	is +0.4528.

The authors do not try to explain these opposite signs of the cross elasticities. The possible reason is that the years for which the acreage of one crop with respect to the prices of the other are chosen need not be the same when the

reverse order is to be calculated, since the highest and the lowest price years of a crop and the corresponding acreage are chosen for computation of elasticities, own or cross. Moreover, since the price and acreage relate to the same year, there is no reason to presume that the changes in acreage will be in the same direction expected according to changes in price. Furthermore, the prices used are absolute farm harvest prices, not relative prices. All these are serious shortcomings in their computation of own and cross elasticities by using the arc elasticity formula, beside which computational errors are minor flaws.

[3] We now turn to the last exercise in this article. Here the authors have fitted a log-linear type of function (which they wrongly call a Cobb-Douglas function) to price and acreage data. It stipulates acreage under wheat as a function of the wheat and gram (substitute crop) harvest prices lagged one year, the rainfall, and time.

In this function the two independent variables, prices of gram and wheat, are likely to be correlated especially because they compete with each other for area in the State under consideration (Punjab). Thus the problem of multicollinearity could arise giving a distorted high value of R (and high standard error).

A look at the result would shock anybody familiar with Indian agricultural economy: the elasticity of wheat acreage with respect to price was obtained as 3.4253. Disturbed by

this extraordinarily large elasticity, I checked the calculations (the results turned out to be different from those obtained by the authors.)

The authors would possibly have rechecked their calculations if they had noted the very wide gap between the production and acreage elasticities of the crop: the acreage elasticity being far higher (3.42) than the production elasticity (0.96). But nothing seems to have impressed them!

2.2 Dynamic Supply Response

All the studies reviewed so far tried to relate the acreage planted under a crop during a year to the relative (or absolute) price of that crop in the same or the preceding (harvest or pre-sowing) season. Such a hypothesis about the expected price appears too simplistic and rather unreal in view of the frequent experience of farmers that last year's price (absolute and relative) did not prevail this year.⁷

Marc Nerlove formulated a hypothesis about the expected price based on past experience. Nerlove uses the Hicksian definition of price expectations. The Hicksian notion may be expressed by saying that P_t is equal to the last period's expected normal price plus some factor B (depending upon the elasticity of expectation with respect to the current price) times the difference between the previous years actual and expected normal price

⁷ L.M. Koyck's model of price expectations, was also a distributed lag model - Koyck's model is discussed in Appendix II.

$$P_t^* = P_{t-1}^* + \beta (P_{t-1} - P_{t-1}^*)$$

where, P_t^* stands for farmers' expectation of the long run normal price at t and P_t for actual price at time t .

P_{t-1} is the actual price in year $t-1$.

The β is expected to be a fraction such that $0 < \beta < 1$.

If β is unity then it means that the farmers' expected price for the year t will be equal to the actual price in $t-1$. This kind of price expectation was assumed in the models used in the earlier studies.

If β is zero it will mean that no amount of change in the price this year will change the price expectations about the next year; the expected price for period t will be the same as the expected price for period $t-1$, which in turn will be the same as the expected price in year $t-2$, and so on. In this case the farmer is visualized to learn nothing from farm experience. In such a situation we will not be able to formulate his price expectations as it is not a function of any previous known price(s).

In reality, β is expected to be a fraction ($0 < \beta < 1$) implying the farmer tries to modify his expectation in terms of his experience. β is assumed to be a given fixed proportion (of the difference between the expected price, in the year $t-1$ and the actual observed price in year $t-1$) by which the expected price in year t changes over that of year $t-1$ (and so on).

This price expectation is the crux of the Nerlovian distributed-lags model. β being a positive fraction implies that

the expected price is a weighted average of the actual prices of the previous years. This can be seen from the following derivation starting with the expected price formulation in equation I above.

$$P_t^* = P_{t-1}^* + \beta (P_{t-1} - P_{t-1}^*) \quad \dots (1)$$

$$\text{or } P_t^* = \beta P_{t-1} + (1 - \beta) P_{t-1}^* \quad \dots (2)$$

$$\text{or } P_t^* = \beta P_{t-1} + (1 - \beta) [\beta P_{t-2} + (1 - \beta) P_{t-2}^*] \quad \dots (3)$$

$$\text{or } P_t^* = \beta P_{t-1} + (1 - \beta) \beta P_{t-2} + (1 - \beta)^2 P_{t-2}^* \quad \dots (4)$$

$$\text{or } P_t^* = \beta P_{t-1} + (1 - \beta) \beta P_{t-2} + (1 - \beta)^2 \beta P_{t-3} \\ + (1 - \beta)^3 P_{t-3}^* \quad \dots (5)$$

$$P_t^* = \sum_{\lambda=1}^3 \beta (1 - \beta)^{\lambda-1} P_{t-\lambda} + (1 - \beta)^3 P_{t-3}^* \quad \dots (6)$$

Therefore we can generalize as follows:

$$P_t^* = \sum_{\lambda=1}^n \beta (1 - \beta)^{\lambda-1} P_{t-\lambda} + (1 - \beta)^n P_{t-n}^* \quad \dots (7)$$

At $n = t$ we get:

$$P_t^* = \sum_{\lambda=1}^{n=t} \beta (1 - \beta)^{\lambda-1} P_{t-\lambda} + (1 - \beta)^t P_0^* \quad \dots (8)$$

Using t instead of n as the variable over which summation is taken we get:

$$P_t^* = \sum_{\lambda=0}^t \beta (1 - \beta)^{t-\lambda} P_{\lambda-1} - \beta (1 - \beta)^t P_{\lambda=-1} \\ + (1 - \beta)^t P_0^* \quad \dots (9)$$

But as $0 < \beta < 1$ we have $0 < (1 - \beta) < 1$; so as t becomes very large, $(1 - \beta)^t$ tends to zero. So we have

$$P_t^* \cong \sum_{\lambda=0}^t \beta (1-\beta)^{t-\lambda} P_{\lambda-1} \quad \dots (10)$$

Equation (10) shows that the expected price can be obtained as a weighted average of all the previous periods actual prices.

This P_t^* is then taken as the explanatory variable in the equation explaining acreage

$$x_t = a_0 + a_1 P_t^* + U_t \quad \dots (11)$$

Substituting (10) into (11) we obtain:

$$x_t = a_0 + a_1 \left[\sum_{\lambda=0}^t \beta (1-\beta)^{t-\lambda} P_{\lambda-1} \right] + U_t \quad \dots (12)$$

$$\text{or } x_t = a_0 + a_1 \beta P_{t-1} + a_1 (1-\beta) \left[\sum_{\lambda=0}^{t-1} \beta (1-\beta)^{t-\lambda-1} P_{\lambda-1} \right] + U_t \quad \dots (13)$$

$$\text{But } \left[\sum_{\lambda=0}^{t-1} \beta (1-\beta)^{t-\lambda-1} P_{\lambda-1} \right] = P_{t-1}^* \text{ (refer equation 10).}$$

Since $x_{t-1} = a_0 + a_1 P_{t-1}^* + U_{t-1}$, we have

$$P_{t-1}^* = -a_0/a_1 + x_{t-1}/a_1 - U_{t-1}/a_1 \quad \dots (14)$$

by substituting (14) into (13) we have :

$$x_t = a_0 + a_1 \beta P_{t-1} + a_1 (1-\beta) \left[-\frac{a_0}{a_1} + \left(\frac{x_{t-1}}{a_1} \right) - \left(\frac{U_{t-1}}{a_1} \right) \right] + U_t \quad \dots (15)$$

$$\text{or } x_t = [a_1 - a_0 (1-\beta)] + a_1 \beta P_{t-1} + (1-\beta) x_{t-1} + [U_t - (1-\beta) U_{t-1}]$$

which can be rewritten by redefining the coefficients.

$$x_t = a_0' + a_1' P_{t-1} + a_2' x_{t-1} + V_t \quad \dots (15)$$

where $a_0 = [a_1 - a_0 - a_0(1 - \beta)]$, $a_1' = a_1^* \beta$, $a_2' = (1 - \beta)$,

$$V_t = U_t - (1 - \beta) U_{t-1}.$$

Similarly an adjustment for equilibrium acreage was also estimated by Nerlove. It was stipulated that the farmer, for a variety of reasons, may not be able to plant the equilibrium acreage immediately in response to the expected price but gradually work up to it over years. This would mean in a period 't' the acreage will be somewhat lagged.

$$x_t - x_{t-1} = r[x_t^* - x_{t-1}] \quad \dots (16)$$

$$\text{So } x_t = \sum_{\lambda=0}^t r(1-r)^{\lambda} x_t^* \quad \dots (17)$$

where r is the coefficient of adjustment ($0 < r < 1$).

The reduced form of the above equation is obtained in a similar manner like that for the expectation lag model above.

Equation (16) can be rewritten as:

$$x_t = x_{t-1} + r(x_t^* - x_{t-1})$$

$$\text{or } x_t = (1 - r) x_{t-1} + r x_t^* \quad \dots (18)$$

$$\text{but } x_t^* = a_0 + a_1 P_{t-1} + U_t \quad \dots (19)$$

So substituting (19) into (18) we have:

$$x_t = (1-r)x_{t-1} + a_0^{r+(1-r)} + a_1^{r+(1-r)} P_{t-1} + U_t$$

$$x_t = a_0^{r+(1-r)} + a_1^{r+(1-r)} P_{t-1} + (1-r)x_{t-1} + U_t \quad \dots (20)$$

It may be noted that the reduced form for the adjustment-lag model is identical to the reduced form for the expectation lag model.

Nerlove tried to incorporate both these lags into a single model: $x_t = \sum_{\lambda=0}^t r(1-r)^{t-\lambda} a \sum_{\lambda=0}^{\infty} \beta(1-\beta)^{\lambda} P_{t-\lambda-1}$... (21a)

$$\text{or } x_t = a_0 + a_1 P_t^* + a_2 X_t^* + U_t \quad \dots (21)$$

$$\text{or } x_t = a_0 + a_1 \beta P_{t-1} + a_1 (1-\beta) P_{t-1}^* + a_2 X_t^* + U_t \quad \dots (22)$$

now substitute equation (14) into equation (22) we get:

$$x_t = a_0 + a_1 \beta P_{t-1} + a_1 (1-\beta) \left[-\frac{a_0}{a_1} + \frac{X_{t-1}}{a_1} - \frac{U_{t-1}}{a_1} \right] + a_2 X_t^* + U_t \quad \dots (23)$$

$$\text{or } x_t = [a_0 - (1-\beta)a_0] + a_1 \beta P_{t-1} + (1-\beta)X_{t-1} + a_2 X_t^* + [U_t - (1-\beta)U_{t-1}] \quad \dots (24)$$

now substitute equation (19) into equation (24)

$$x_t = [a_0 - (1-\beta)a_0] + a_1 \beta P_{t-1} + (1-\beta)X_{t-1} + a_2 [a_0 + a_1 P_{t-1} + U_t] + [U_t - (1-\beta)U_{t-1}]$$

$$2a_0 + a_2 a_0 \quad x_t = \underbrace{[a_0 - (1-\beta)a_0 + a_2 a_0]}_{2a_0 + a_2 a_0} + (a_1 \beta + a_2 a_1) P_{t-1} + (1-\beta)X_{t-1} + [U_t - (1-\beta)U_{t-1} + a_2 U_t] + a_2 U_t$$

$$x_t = A_0 + A_1 P_{t-1} + A_2 X_{t-1} + V_t \quad \dots (25)$$

The most important point to be noted about the above equation (21a) is that β and r enter symmetrically into it, so it becomes almost impossible to separate out their individual impacts. Nerlove suggests one way out: it is to find out whether the nature of the product is such that there is a larger lag between the expected normal price and the current price, than between the long run desired output and current output.

If the former lag is greater, then the difference between the products would depend upon the nature of the market the produce faces if the latter lag is greater than the differences in the relationship among products depended upon the differences in the supply conditions of particular inputs to individual firms.

One way out of the impasse of separate estimation of β and r is:

Given equation (15) the relationship between x_t^* and P_t^* we can solve for P_t^* . By substituting equation with one year lag into equation (1) we get:

$$P_t^* = P_{t-1} + (1 - \beta) \frac{x_{t-1}}{a} \quad \dots (26)$$

Now by substituting (26) into (15) we have

$$x_t^* = a\beta P_{t-1} + (1 - \beta) x_{t-1} \quad \dots (27)$$

Now substituting (27) into (13) we get :

$$\begin{aligned} x_t &= a\beta P_{t-1} + [(1 - \beta) + (1 - r)] x_{t-1} \\ &\quad - (1 - \beta) (1 - r) x_{t-2} \quad \dots (28) \end{aligned}$$

So now if either r or $\beta = 1$, then one term x_{t-2} drops out.

If we can say whether x_{t-2} is zero, this formulation of dependence of current output x_t on other variables allows the distinction between two cases: (1) neither β nor r are one and (2) either ' β ' or ' r ', or both, are one i.e. whether there is a lag in the formation of expectations about prices or in adjustment of output to the long run equilibrium or whether one or the other but not both occur.

Similar analysis is used to distinguish between the

expected in a truly random sequence. So there is a bias against discovering serial correlations.

One way to ensure the efficiency and consistency of parameters is to employ the non-linear maximum likelihood estimating techniques.

If simple least square techniques are used:

- (1) Even without the influence of the lagged dependent variable's influence, the estimators will be inefficient, as the errors will be serially correlated.
- (2) The simple least square estimates will be inconsistent.
- (3) The equation will be over-identified.

Almost all the empirical exercises relating to India and using OLS method to estimate the Nerlovian reduced form equation suffer from these limitations.

Rajkrishna (1963): Rajkrishna was the first to use the Nerlovian model in explaining and estimating supply response to price in Indian Agriculture. He used the data for the undivided province of Punjab for the period 1913-14 to 1945-46. This study was intended to put to test the widely prevalent notion that peasants in poor countries do not respond (or respond inadequately or negatively) to price movements.

He used the adjustment lag version of the Nerlovian model. This model was, however, modified to include the impact of the yield variable:

short-run and long-run phenomena. Such a distinction, however, depends upon the existence of an additional variable 'z_t' such that $x_t = a_1 P_t^* + a_2 z_t$. With the incorporation of Z_t into our system we have:-

$$\begin{aligned} x_t &= a_1 \beta r P_{t-1} + [(1 - \beta) + (-r)] x_{t-1} \\ &\quad - (1 - \beta) (1 - r) x_{t-2} + a_2 r Z_t \\ &\quad - a_2 (1 - \beta) r Z_{t-1}. \end{aligned} \quad \dots(22)$$

"as β and r enter equation (22) asymmetrically, we can, in principle, distinguish between the two types of lags provided 'Z_t' does not satisfy relationships similar to (1)." (Nerlove, 1958, p. 65).

ESTIMATION : Nerlove used two alternative procedures in order to estimate the equations: (1) Maximum likelihood (iterative) method, estimation a_1 for different values of β . (2) Non-iterative procedure to transforming the equation (12) (in case of expectation lag) into a relation between the observed past prices and actual ^{average} ~~average~~ prices. Since the expected values in the structural equations cannot be observed directly the reduced form equation has to be used.

Problems of Estimation of the Nerlovian Model

The first problem in estimating the coefficients of the equation was realized by Nerlove himself. It was the inability to distinguish between (β & r) the adjustment lag coefficient and the expectation coefficient, if either of them is equal to one, when least square techniques are used. He tried

to solve this by introducing Z_t - a non-market variable, whose non-symmetric entrance into the supply model does, in principle, enable the distinction between the two types of lags.

The second problem with the Nerlovian model relates to its estimation via the reduced form if ordinary least squares are used.

(i) The estimates are likely to be inefficient to the extent that the residual in the estimating equation may be serially correlated. One cannot get over this by assuming that V_t (the disturbance term) is independently distributed. Sawant (1978, p. 57) points out that the presence of serial correlation is a more serious problem in distributed lags than in a classical regression equation where all the explanatory variables are independent and non-stochastic. "In the latter case OLS method yields only inefficient estimates, while in the case of the distributed-lag model it gives not only biased but also inconsistent estimates. Moreover application of generalised least squares in the classical regression improves efficiency of the estimators considerably but this does not hold if some of the regressors are lagged endogenous as they are in the distributed-lags models."

(ii) In case of positive serial correlation OLS method over-estimates the value of β coefficient and hence the estimated average lags are biased upwards. In this case the Durbin-Watson 'd' statistics is not useful, because here the 'd' value generally tends to two, which is the value of 'd'

$$X_t = a_0 + a_1 P_{t-1} + a_2 Y_{t-1} + a_3 Z_{t-1} + a_4 W_t + a_5 X_{t-1} + V_t$$

where, X_t : stands for standard irrigated acreage actually planted to the crop in harvest year t . The standard irrigated acreage of the crop is the irrigated acreage plus the unirrigated acreage multiplied by a standardization factor.

P : is the relative price of the crop i.e. the index of the price in the post-harvest period of the crop deflated by an index of the post-harvest price of the alternative crop(s) (i.e. the crop(s) that could have been grown on the land at the same time).

Y_{t-1} : is the relative yield of the crop i.e. yield of one crop in $t-1$ deflated by an index of yields of alternative crops in $t-1$.

Z : is the total irrigated area under all crops during the season.

W : is the rainfall.

U : is the error term.

This is the reduced form of Nerlovian adjustment lag equation. (See the derivation of it our p.36 above.)

Rajkrishna studied 9 crops: Cotton, Maize, Sugarcane, Rice, Wheat, Jowar, Bajra, Gram and Barley. He used the adjustment lag model,⁸ as the technological and institutional constraints permit only a fraction of the intended change in the dependent variable.

⁸ Rajkrishna has, however, pointed out that the difference between the expectational and adjustment lag is important only in theory while both the methods of estimation lead to the same estimating equation. (Refer Section 2.2.)

The other variables include:

Irrigation: standard irrigated acres considered for maize, cotton, rice, wheat and sugarcane.

Yield: for cotton and rice, as yield had increased greatly for these two crops during this period.

Rainfall: was taken for all the rainfed crops, bajra, jowar, wheat, gram and barley.

The short run elasticities were observed to be lower than the long run elasticities.

The elasticities of the irrigated crops were found to be larger than those of the unirrigated crops.

American cotton (irrigated) showed maximum price elasticity followed by Desi cotton and sugarcane. Sugarcane acreage showed greater influence of P_{t-2} than of P_{t-1} .

Desi cotton and rice showed that acreage was significantly responsive to yield. The yields of these crops had registered a significant upward trend during 1913-14 to 1945-46.

Except for jowar all⁹ other crops had positive short run price elasticities: low elasticities of less than 0.1 for wheat, bajra, medium elasticities of 0.2 to 0.4 in case of maize, sugarcane and rice and between 0.6 and 0.7 in case of cotton. The corresponding long run elasticities ranged from 0.15 to 1.6 for wheat and cotton respectively.

9 Gram elasticity was insignificant.

Table 2.2 : LONG AND SHORT RUN ELASTICITIES

Commodity	Irrigated/ Unirrigated	Year	B	Short run price elast- icity	Long run price elast- icity	R ²
Cotton (American)	Irrigated	1922-41	0.44	0.72	1.62	0.96
Cotton (Desi)	"	1922-43	0.55	0.59	1.08	0.85
Maize	"	1914-43	0.40	0.23	0.56	0.79
Sugarcane	"	1915-43	0.56	0.34	0.60	0.66
Rice	"	1914-45	0.52	0.31	0.59	0.79
Bajra	Standardized	1914-45	0.24	0.09	0.36	0.92
Jowar	Unirrigated	1914-43	-	-	-0.58	0.59
Wheat	Irrigated	1914-43	0.59	0.08	0.14	0.92
Wheat	Unirrigated	1914-45	-	-	0.22	0.71
Barley	"	1914-45	0.77	0.39 ⁺	0.50 ⁺	0.54
Gram	"	1914-45	-	-	-0.33 ⁺	0.66

Note: '+' indicates not significant.

The rainfed crops showed greater impact of the rainfall variable (than of price) than do the irrigated crops. The larger price elasticity of the irrigated crops is due to the greater flexibility in cropping pattern under irrigation which reduces the differences in productivity among the crops that can be grown, thereby making greater supply response feasible.

Rajkrishna's paper had an important merit (besides

being the first to apply the Nerlovian model to the Indian context) in that it incorporated the yield as an additional explanatory variable. The yield variable catches the response of the farmers in terms of the application of the non-land inputs. Note however that the actual yield always differs from the planned one due to climatic factors, and that the yield also includes the impact of the changes in technology.

Rajkrishna's work began a new era of research in supply response in agriculture in India, using distributed lag models in statistical analysis. However unlike Rajkrishna most of the scholars did not distinguish between irrigated and un-irrigated crops in their analysis.

N. Rath (1961): Rath examined the supply response of the farmers in the old Central Provinces and Berar, during 1920-21 to 1940-41. The crops chosen for the analysis were cotton and jowar, both grown under unirrigated condition.

The author used the same Nerlovian adjustment-lag model as used by Rajkrishna. In addition to the lagged price and lagged acreage, the equation included the expected yield parameter Y_t^* . The expected yield for year t is equal to the mean relative yield in the three previous years.

The period under consideration included the years of the great depression, a period when both agricultural prices and wage rates declined sharply. The fall in wages benefited cotton production as labour use in cotton was much greater than in jowar. A dummy variable was introduced in the equation in order to capture these effects.

The author tried out seven different models in order to get an idea about the impact of each variable on acreage.

Both the price and yield were found to have the right sign and were significant. However, the yield variable was found to be more significant than the price variable. This was because, by its very nature, the yield variable captures three distinct effects: of varietal changes in crops, variations in weather and of expectations about weather based on past experience.

The Jowar case: Jowar is grown only in the Kharif season in this region. The jowar case showed that the simple model with lagged price was almost as good as the Nerlovian distributed lags model. The results did not improve even with inclusion of the yield variable.

The price elasticities, however, were very low (see Tables 2.3 and 2.4). Although these elasticities are both positive and significant (and the R^2 was high), their small dimension indicates that a very high percentage change (nearly 10 per cent) in price is required in order to get a 1 per cent change in acreage under cotton. This, the author suggested, shows that while farmers are responsive to price changes, such changes, thanks to the basic production conditions under un-irrigated agriculture, are so small (very low elasticities) that they may almost look like the farmers being unresponsive to price changes.

Table 2.3 : Alternate Regressions Explaining Cotton Acreage in C.P. and Berar (1920-21 to 1940-41)

Equations	Coefficients of											
	P_{t-1}	X_{t-1}	Y_t or Y_{t-1}	Y_{t-1}^*	T	B	r	n_{PS}	n_{PL}	n_{YS}	n_{YL}	R^2
Part 1 : Yield Variables are relative.												
5a	3.072	0.675	9.705	3.049		0.325		0.100	0.308		0.240	0.83
6a	3.221	0.730	9.373			0.270	0.270	0.105	0.389	0.261	0.967	0.882
7a	3.016	0.591	7.964		-20.245	0.409	0.409	0.098	0.240	0.222	0.543	0.905
Part 2 : where yield variables are absolute.												
5b	2.491	0.804	11.583	8.717		0.196		0.081	0.413		0.287	0.839
6b	2.118	0.794	5.298			0.206	0.206	0.069	0.335	0.148	0.718	0.864
7b	2.060	0.611	4.619		-24.47	0.389	0.389	0.067	0.172	0.129	0.332	0.897

Table 2.4 : Alternate Regressions Explaining Jowar Acreage in C.P. and Berar
(1920-21 to 1940-41)

Equations	Coefficients of											R^2
	P_{t-1}	X_{t-1}	Y_t or Y_{t-1}	Y_{t-1}^*	T	B	r	n_{PS}	n_{PL}	n_{YS}	n_{YL}	
1	7.339										0.138	0.62
2	7.422	0.230				0.770		0.159	0.181			0.675
3	7.366	0.251	2.581			0.749		0.138	0.184			0.70

Jaikrishna and M.S. Rao (1965, 1967): Jaikrishna and Rao were interested in the price expectations of the farmers. They argued that the supply response coefficient will be valid only to the degree that the hypothesis regarding price expectations are valid. It is, however, very difficult to capture this process of expectation formation and hypothesise accordingly. The only way to estimate how close each hypothesis comes to the realized price is to work out taking a number of hypothetical 'expected prices' and say that the price which explains the acreage variation the best, must have been the 'expected price'. This ex post analysis would give us an idea about the probable manner of expectation formation in future.

The authors were thus mainly concerned with an appropriate and effective measure of expected price that is supposed to determine the acreage planted. The Nerlovian distributed-lag model used by Raj Krishna and others implied a steadily reducing weight to the past prices in the formulation of the expected price. Jaikrishna and Rao did not enter into the statistical problems involved in the estimation of the elasticities from the model with the use of the reduced form equations which include the dependent variable with one year's lag as an independent variable, the question raised later on by other scholars. Instead, they formulated expected prices using different number of past years' prices with different weights attached to them.

Jaikrishna and Rao tried out 12 different models of expected prices in order to look for the best formulation of the expected price:

- I) Annual price in preceding year.
- II) Three-month average of pre-sowing (July-September) price.
- III) Simple average of prices prevailing in three preceding years.
- IV) Simple average of prices prevailing in three preceding sowing seasons.
- V) Modal price of all the previous years.
- VI) Modal price in all preceding years.
- VII) Average of prices in all preceding years.
(What exactly is meant by all preceding years is not clear, the authors do not mention whether it is for a specific period of study or a specific number of years before the relevant year for which the calculations are to be made.)
- VIII) Predicted price from the linear trend is fitted to past realized price.
- IX) Average price in the three post-harvest (April to June) months of the preceding year's price.
- X) Simple average of the three preceding years' post-harvest price.
- XI) Average of post-harvest and pre-sowing

prices (April to September) in the preceding year.

XII) Simple average of three preceding years' pre-sowing price.

The study was carried out for wheat acreage for U.P. It used data from various official publications. The period of study was 1950-51 to 1962-63. The difference between the expected prices and realized prices for each price expectational model were calculated. After this, the models were ranked according to: (i) Sum of ranks based on yearly deviations from realized prices; (ii) Average of absolute deviations from realized prices; (iii) Number of deviations from the realized prices; (iv) Correlation coefficient between the expected price from the model and realized price. And on this basis the overall ranking was determined. (Model VII was 1st, and Models VIII and I were 2nd in the ranking.)

After this, each of the price expectations models was used to estimate acreage response, by fitting it into the following model:

$$X = a + b_1 P_i^W + b_2 P_i^A$$

where X is acreage under wheat.

P_i^W is price index of wheat (with base 1952-53 = 100).

P_i^A is weighted average price index of competing crops (Barley, Gram, Sugarcane, Rape and Mustard) the weights being proportion of acreage under each of these crops in the base year (1952-53).

It was noted that there was a high (0.58 to 0.89) correlation between the wheat price index and the competing crop price indices. Thus the multicollinearity handicaps further analysis in terms of the signs and magnitudes of the coefficients. The regression coefficients of the wheat price index and alternative crop price index were found to be mostly insignificant. Nine out of the 12 models were found to have insignificant R^2 .

M.S. Rao and Jaikrishna (1967). In their next exercise in 1967, again they focused their attention on the formulation of alternative price expectation model and response equations for deriving acreage response coefficients for wheat in Uttar Pradesh.

This time they formulated nine price expectation models of these nine, the first five (P_1 to P_5) were model numbers I, II, V, IX and XI from the previous exercise (1965).

The remaining four P_6 to P_9 were price expectation models were model prices P_1 to P_4 (or I, II, V and IX) averaged for previous three years: So now the new models denoted by P_i for $i = 1 \dots 9$ are:

$$\begin{aligned}
 P_1 &= \text{model I, } P_2 = \text{model II, } P_3 = \text{model IX,} \\
 P_4 &= \text{model XI and } P_5 = \text{model V. Then} \\
 P_6 &= \frac{\sum_{j=1}^3 (P_{1jt-1})}{3}, \quad P_7 = \frac{\sum_{j=1}^3 (P_{2jt-1})}{3}, \\
 P_8 &= \frac{\sum_{j=1}^3 (P_{3jt-1})}{3}, \quad P_9 = \frac{\sum_{j=1}^3 (P_{4jt-1})}{3}.
 \end{aligned}$$

The authors have used nine different model specifications. Of these, the first three models are of the Nerlovian adjustment lag category, and the remaining belong to the traditional regression variety.

$$1. \quad X_t = a + b_1 P_{jt-1}^R + b_2 Y_{t-1}^W + b_3 W_t + b_4 X_{t-1}$$

$$j = 1 \dots 5$$

$$2. \quad X_t = a + b_1 P_{jt-1}^R + b_2 Y_{t-1}^R + b_3 W_t + b_4 X_{t-1}$$

$$j = 1 \dots 5$$

$$3. \quad X_t = a + b_1 (P_{jt-1} - Y_{t-1})^R + b_2 W_t + b_3 X_{t-1}$$

$$j = 1 \dots 5$$

$$4. \quad X_t = a + b_1 P_{jt-1}^R + b_2 Y_{t-1}^W + b_3 W_t$$

$$j = 1 \dots 5$$

$$5. \quad X_t = a + b_1 P_{jt-1}^R + b_2 Y_{t-1}^R + b_3 W_t$$

$$j = 1 \dots 5$$

$$6. \quad X_t = a + b_1 (P_{jt-1} Y_{t-1})^R + b_2 W_t$$

$$j = 1 \dots 5$$

$$4a. \quad X_t = a + b_1 \left(\sum_{j=1}^3 P_{jt-1} / 3 \right)^R + b_2 Y_{t-1}^W + b_3 W_t$$

$$j = 1, 2, 3, 4$$

$$5a. \quad X_t = a + b_1 \left(\sum_{j=1}^3 P_{jt-1} / 3 \right)^R + b_2 Y_{t-1}^R + b_2 W_t$$

$$j = 1, 2, 3, 4$$

$$6a. \quad X_t = a + b_1 \left(\sum_{j=1}^3 (P_{jt-1} Y_{t-1}) / 3 \right)^R + b_2 W_t$$

$$j = 1, 2, 3, 4$$

where X_t = Wheat area '000 acres in U.P. in year t .

P_{jt-1}^R = Index (1952-53=100) of wholesale prices of wheat in U.P. in year t-1, deflated by index of wholesale prices of substitute crops in year t-1. 1952-53 weights were used in constructing the price index of substitute crops. The subscript j refers to various concepts of price specified above (j = 1 ... 9).

Y_{t-1}^W = Per acre yield of wheat (in lbs) in year t-1.

Y_{t-1}^R = Index of wheat yield (1952-53=100) in year t-1, deflated by index of substitute crops in year t-1. Gross value of the output in 1952-53 was used as the weight in the construction of the yield index for substitute crops.

W_t = Total rainfall (in inches) in the State from June to October in year t.

$(P_{jt-1} Y_{t-1})^R$ = Index of gross income per acre (1952-53=100) from year t-1 deflated by the index of average gross income per acre from substitute crops.

The authors worked out models 1, 2 and 3 (Nerlovian models) with the five alternative price expectations (P_1, P_2, P_3, P_4 and P_5). And models 4, 5 and 6 with all the nine different price expectations (P_1 to P_9). (See Table 2.5.)

The wheat acreage was taken as the dependent variable in the models presented above. Here barley, gram, sugarcane, ~~q~~ ^{green}rape and mustard were considered as the crops competing for with wheat for acreage in region. Around 44 per cent of the area under wheat in the State was irrigated. The ratio of irrigated to unirrigated area differed for each of the competing crops, the unirrigated crops and the irrigated crops competing within their own irrigated or unirrigated group.

Table 2.5 : SUPPLY RESPONSE PARAMETERS FOR NERLOVIAN AND MULTIPLE REGRESSION MODELS (USING DIFFERENT PRICE EXPECTATIONS).

Price Expectation Model	Acreage Response Model																	
	Nerlovian Adjustment-lags								Traditional Model									
	I				II				III				IV and IVa		V and Va		VI and VIa	
	r	SR	Lk	R ²	r	SR	Lk	R ²	r	SR	LR	R ²	E	R ²	E	R ²	E	R ²
P ₁	0.33	0.21**	0.64*	0.87	0.41	0.18***	0.18	0.44*	0.39	0.09	0.22*	0.89	0.18	0.51	0.23	0.62	0.14	0.54
P ₂	0.31	0.16	0.51*	0.85	0.39	0.10	0.25*	0.88	0.38	0.05	0.13*	0.87	0.10	0.49	0.11	0.57	0.12	0.52
P ₃	0.31	0.13	0.51*	0.84	0.35	0.08	0.22*	0.88	0.35	0.03	0.09*	0.86	-0.07	0.48	-0.02	0.54	0.01	0.46
P ₄	0.28	0.16	0.51*	0.85	0.37	0.10	0.27*	0.88	0.36	0.04	0.13*	0.87	0.01	0.47	0.05	0.55	0.07	0.48
P ₅	0.30	0.09	0.30*	0.85	0.38	0.08	0.21*	0.90	0.37	0.06	0.16*	0.89	0.06	0.49	0.07	0.57	0.08	0.51
P ₆													0.46	0.61	0.43***	0.69	0.14	0.55
P ₇													0.72**	0.66	0.56**	0.71	0.29***	0.62
P ₈													-0.30	0.52	-0.19	0.56	0.05	0.46
P ₉													0.18	0.48	0.29	0.57	0.17	0.49

r = Coefficient of adjustment elasticity.
 SR = Short run elasticity.
 Lk = Long run elasticity.

*** Significant at 10 per cent.
 ** Significant at 5 per cent.
 * Significant at 1 per cent.

The data relating to the period 1950-51 to 1962-63 was obtained from the Directorate of Economics and Statistics. The results show that within the Nerlovian adjustment-lag models none of the five price expectation models considered in the study are distinctly superior to the others in terms of R^2 . Similarly given a price expectation model none of the three response equations [the one using absolute yield, relative yield (both used deflated price) and the third using relative gross income index] considered, had an edge over the other two.

The traditional models showed that not only the explanatory powers of R^2 but even the significance of the equations substantially changed with the use of different price expectation models. The best results were obtained with (P_7) - the three-year average pre-sowing price, the next best was (P_6) - the April-March prices for three previous years and the third best was the (P_1) average price realized in the previous year.

The elasticities obtained by traditional model were better than (especially by P_7) those obtained with the Nerlovian models. The R^2 of the traditional models in general were observed to be lesser than those obtained from the Nerlovian models. But the authors attribute these to the existence of a strong trend in acreage, which makes the Nerlovian models a better fit, as it has lagged acreage as one of its variables. However if the authors thought the trend was so important then it should have been incorporated in the traditional model and then compared it with the

Nerlovian model. They do not explain the reason for this rise in trend or discuss whether it is expected to catch the impact of any variable which is not incorporated here. Wheat area seems to be less responsive to the rainfall (pre-sowing) variable than it is to price or yield, in the Nerlovian and traditional models.

The models using gross income instead of price did not give satisfactory results. And of the nine price expectation models used in this study the model based on three-year average of pre-sowing prices proved to be decidedly superior to the other eight models.

The authors conclude, "The results of the study further indicate that traditional regression model for estimating supply response coefficients, if properly specified, can give as satisfactory if not, superior results as those obtained by using the adjustment-lag model of the Nerlovian type. Most of the short-run elasticities derived from the Nerlovian models were found to be non-significant. The elasticities obtained from some of the traditional model specifications were found to range between 0.02 and 0.72 (significant at 5 per cent). These elasticities compare favourably with those obtained from the adjustment-lag models of the Nerlovian types." (Jaikrishna and Rao, 1967, p. 52.)

John Thomas Cummings (1975): Cummings observed that macro level exercises on farm supply response for a large country like India was not desirable, he said 'Aggregate

Supply Analysis' (i.e. at the State or National level) in a country as vast and varied as India cannot hope to quantify the degree to which the market impulses motivate cultivators. Such analysis must be based on output and price data gathered from wide cross-sections, as aggregation masks important local diversities. To evaluate fully individual production decisions, a micro-economic approach would be needed, an impossibility under the present circumstances. A practical compromise is found in conducting supply investigations on the most disaggregated level possible - that of the district - and then proceeding to discuss market responsiveness in terms of patterns displayed by cultivators at this level."¹⁰

It appears that Cummings uses a single absolute price for gauging the supply response of farmers. This is not explicitly stated in this paper but in his subsequent paper (1977) reviewed below Cummings used the expectation lag cum-adjustment lag model. He also incorporates R_t^* as an expected water availability index and T as the trend variable besides P_{t-1} the absolute price and A_{t-1} the lagged acreage.

$$A_t - (1 - b)A_{t-1} = a_0bc + a_1bcP_{t-1} + (1 - c)[A_{t-1} - (1 - b)A_{t-2}] + a_2[R_t - (1-b)R_{t-1}] + a_3c[T - (1-b)(T-1)] + c[U_t - (1-b)U_{t-1}]$$

The problem of identification is avoided by separately estimating the above equation, with different values of 'b'

10 J.T. Cummings, 1975, p. 40.

within a specified range of 'b'. This range for 'b' is taken to lie between zero and two.¹¹ Of these that value of 'b' for which the regressor sum of squares was minimum was chosen as the best estimate. The author used the Cochrane-Orcutt technique of estimation incorporated in Ordinary Least Squares, in order to tide over the econometric problems encountered due to the existence of a lagged dependent variable, A_{t-1} , on the right hand side. The resulting regression process "was doubly iterative first over a range of price expectation coefficients and then using the Cochrane-Orcutt method for minimising the effects of the correlated disturbance term." (Cummings, 1977, pp. 26-27.)

In his study he ran regressions for 550 cases of acreage response in different crop-districts. For each crop, the States and districts important in its production were chosen.

The crops chosen for analysis were:

Cereals : rice, wheat, barley.

Fibers : cotton, jute.

Other cash crops: groundnut, sesamum and tobacco.

He however did not specify what price relative or absolute, he has used for this exercise. In a subsequent paper reviewed below he mentions that the prices used in this model are absolute prices and not relative prices.

¹¹ It is not clear why the range was fixed between 0 and 2. Because a value of B greater than one does not fit into the Nerlovian framework.

The time period used for this analysis was 1946-69. The results run into many pages so the entire table is not reproduced here.

Table 2.6 : Supply Parameters by States

	Time period	Price elasticity		Price expectation coefficient	Area adjustment coefficient	R ²
		Short run	Long run			
<u>Rice</u>						
A.P.	1950-67	+0.48 ^d	+0.62	+0.6	+0.78	0.90
Assam	1955-67	+0.07	+0.07	+1.1	+0.93	0.85
H.P.	1949-66	-0.07 ^a	-0.06	+0.9	+1.10	0.42
Kerala	1951-65	-0.14 ^d	-0.12	+1.0	+1.13	0.91
Karnataka	1951-67	0.06 ^a	0.07	+0.9	+0.92	0.94
Maharashtra	1955-67	-0.12 ^d	-0.04	+1.5	+0.84	0.90
Tamil Nadu	1946-67	+0.08	+0.08	+1.0	0.98	0.92
W.Bengal	1949-66	+0.09 ^a	+0.08	+1.0	1.12	0.88
<u>Wheat</u>						
Gujarat	1954-67	+0.93 ^c	+1.00	+1.1	+0.93	+0.39
Maharashtra	1955-67	+0.24 ^d	+0.23	+1.3	+1.05	0.64
Punjab	1950-67	0.10	0.13	+1.3	+0.76	0.98
Rajasthan	1951-68	+0.02	+0.03	+0.09	+0.62	0.87
<u>Barley</u>						
H.P.	1949-66	+0.10 ^a	-0.26	+1.5	+0.39	0.84
Punjab	1950-67	+0.22 ^a	+0.27	+1.3	+0.83	0.81
<u>Jute</u>						
Assam	1949-69	+0.07	+0.05	+0.7	+1.54	0.32
Bihar	1946-69	+0.12	+0.15	+0.7	+0.91	0.12
W.Bengal	1949-69	+0.40 ^c	+0.35	+0.9	+1.15	0.59

(continued)

Table 2.6 : (continued)

	Time period	Price elasticity		Price expectation coefficient	Area adjustment coefficient	R ²
		Short run	Long run			
<u>Cotton</u>						
A.P.	1951-69	+0.07	+0.11	+0.7	+0.64	0.35
Assam	1951-69	-0.09	-0.08	+1.3	+0.83	0.71
Gujarat	1954-68	+0.05	+0.08	+0.9	+0.59	0.63
Karnataka	1953-69	+0.29 ^a	+0.33	+1.2	+0.88	0.88
Kerala	1957-69	-0.39 ^a	-0.41	+1.0	+0.95	0.69
Punjab	1950-68	+0.37	+0.56	+0.5	+0.66	0.74
Tamil Nadu	1950-67	-0.29 ^c	-0.32	+0.5	+0.91	0.50
<u>Groundnut</u>						
A.P.	1951-67	+0.60 ^a	+0.52	+0.6	+1.33	0.47
Gujarat	1955-67	-0.11 ^a	-0.11	+0.9	+1.03	0.85
Karnataka	1953-67	-0.06	-0.06	+0.9	+1.05	0.45
Maharashtra	1955-68	-0.14	-0.14	+0.9	+0.99	0.49
Tamil Nadu	1950-67	-0.01	-0.01	+0.9	+1.03	0.71
<u>Sesamum</u>						
A.P.	1955-68	+0.29 ^a	+0.23	+0.9	+1.25	0.31
Bihar	1953-67	-0.74 ^d	-0.39	+1.3	+1.92	0.57
Maharashtra	1955-68	+0.23 ^d	+0.30	+0.5	+0.77	0.73
Tamil Nadu	1949-67	-0.15	-0.21	+1.1	+0.70	0.72
<u>Tobacco</u>						
A.P.	1950-68	+0.18 ^a	+0.19	+0.9	+0.96	0.52
Bihar	1950-68	-0.07	-0.08	+0.6	+0.85	0.10
Gujarat	1955-68	+1.16 ^a	+1.00	+1.3	+0.16	0.65
Karnataka	1953-68	-0.04 ^b	-0.05	+1.0	+0.84	0.91
Maharashtra	1954-68	-0.08	-0.12	+1.5	+0.66	0.93
Tamil Nadu	1951-68	+0.22	+0.25	+0.9	+0.89	0.23
Significance level: a - 30 per cent. c - 5 per cent. b - 10 per cent. d - 1 per cent.						

Results

Rice : The rice price had a positive coefficient in four of its largest producing States, viz., West Bengal, Andhra Pradesh, Tamil Nadu and Assam. Even here the price elasticities were quite small (except in Andhra Pradesh) and around half of the 100 districts had insignificant price elasticities. The results show that western Assam and northern West Bengal show negative and significant elasticities.

The price elasticities were negative in four States, Maharashtra (significant at 1 per cent), Gujarat (significant at 30 per cent), Kerala (significant at 1 per cent) and Himachal Pradesh (significant at 30 per cent).

Wheat: Wheat showed positive elasticities for all the States with Gujarat alone having high elasticity of 0.93 in the short run and elasticity of 1.00 in the long run.

But Punjab was observed to have low positive elasticities, between +0.10 and +0.13, and Rajasthan had elasticities between 0.13 and 0.3.

Barley : It had positive elasticities ranging from 0.22 to 0.27. These results show a stronger elasticity for barley vis-a-vis rice and wheat. A plausible explanation is its secondary role which makes it a second option and thus more elastic.

Jute : Jute was observed to have a strong market in four out of five States. The short run elasticities ranged from 0.45 to 0.75.

Cotton : Only three States (Assam, Kerala and Tamil Nadu) had negative elasticities (but they accounted for only 5 per cent of the country's cotton production). The elasticities for the other States were positive. In Gujarat a major producing State the elasticities were positive but small and statistically insignificant.

Oilseeds : Ten out of 19 States had negative elasticities. Amongst the major producing States only Andhra Pradesh had a positive and statistically significant elasticity for Groundnut. Gujarat, a major producer shows significant negative price elasticity. Sesamum had a negative and significant elasticity for Tamil Nadu, while the other States showed positive significant or negative but insignificant results.

The author does not carefully analyse the large number of elasticities churned out by this exercise. He had conducted the study in order to get a realistic (non-aggregative) picture of the supply response; but he did not comment on the nature of regional variation in the results obtained. The detailed data could have been probed in order to understand the nature of diversities for the same crop in different regions. No effort was made in this direction. Most important of all he did not clearly mention, much less justify, his use of absolute price in this models, raising questions about the logic of it.

Moreover the price expectation coefficient β turned out to be greater than one in many cases. This was due to the inappropriate specification of range for β (between zero

and two). This is not theoretically valid in the Nerlovian model that he uses. Given such a β , the elasticity estimates also become doubtful.

John Thomas Cummings (1977): Cummings follows up his earlier exercise with another in which he sought to stress the interrelationship between two competing crops. For this he chooses to study wheat and barley in Haryana, Punjab and Rajasthan during 1946 to 1969.

Once again (like his 1975 study) the author uses the adjustment-cum expectation lag model and estimates it with O.L.S. estimating procedure with the Cochrane-Orcutt procedure incorporated in it. He has two kinds of models: one for measuring response of yield per acre and the other for acreage response to price.

The price variable was taken as a relative price, either incorporated via the ratio of wheat price to price of barley or separate incorporation of both wheat and barley price separately. The first method avoids problems of multicollinearity, which can crop up in the second type of model. But it involves loss of information as it gives one coefficient as the inverse of the other.

The author uses the price ratio and separate price incorporation for both the crops, this gives four separate equations.

The results show that multicollinearity problem cropped up for all the models incorporating the two prices separately.

Very often the signs of the price coefficients in both the yield (per acre) and acreage response models bear opposite signs. So even if the 'correct sign' rather than level of significance was taken as the criterion for evaluation, only a handful of the districts showed consistency in most of the eight regressions run for each district.

The short and long run price elasticities computed with the relative price version in this paper were observed to be more significant statistically than the elasticities obtained in the previous paper (1975) with the single absolute price model.

The acreage response elasticity with respect to price was higher than the elasticity of yield response with respect to price.

A comparison of the acreage elasticities with respect to the relative price and single absolute price shows that the magnitude of elasticities for barley are greater for the absolute price model than for the relative price model.

The wheat results were peculiar in the sense that the elasticities computed using relative prices were of the sign opposite to those obtained in the previous exercise using the absolute prices. The elasticities with respect to the relative prices were of greater magnitude and mostly bore the right sign, and were significant for a larger number of observations.

Table 2.7 : Comparative Elasticities

State/ Districts	Single Price Elasticity				Relative Price Elasticity			
	Barley		Wheat		Barley		Wheat	
	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run
<u>Haryana</u>								
Bhatinda	+1.20 ^d	+1.15	+0.36 ^a	+0.55	+1.76 ^d	+1.64	+0.01	+0.02
Ferozpur	+0.93 ^d	+1.24	+0.06	+0.08	+1.11	+2.11	+0.09	+0.12
Hissar	+0.60 ^a	+0.66	-0.23	-0.30	-0.56	-0.68	+0.10	+0.13
Mahendragarh	+1.58 ^c	+3.95	+0.15	+0.15	+0.08	+0.07	+0.53	+0.40
Rohtak	+1.09 ^c	+3.30	+0.02	+0.02	+0.42	+0.56	+0.57	+0.05
<u>Rajasthan</u>								
Ajmer and Jaipur	+0.13	+0.15	-0.04	-0.08	-0.15	-0.15	+0.29 ^a	+0.67
Alwar	+0.56 ^c	+0.85	+0.23 ^b	+0.19	-1.90 ^a	-8.66	+0.51	+0.40
Bharatpur	+0.21 ^b	+0.29	+0.28 ^d	+0.30	-0.57	-0.39	+0.43 ^a	+0.32
Bhilwara	+0.13 ^a	+0.16	-0.01	-0.02	-0.17	-0.24	+0.28 ^a	+0.54
Bundi	+0.02	+0.04	-0.08	-0.11	+0.39 ^b	+0.44	+0.40 ^a	+0.60
Chitorgarh	0.50 ^c	+0.71	-0.27 ^a	-0.47	+0.93 ^a	+0.89	-0.01	-0.03
Dungarpur	-0.34	-0.36	-0.47 ^c	-0.43	+1.30 ^a	+1.64	+1.06 ^c	+1.01
Ganganagar	+0.84	+0.85	-0.21	-0.29	-2.03	-1.88	+1.19 ^b	+3.75
Pali	+0.21	+0.22	+0.40 ^c	+0.55	-0.72 ^c	-0.86	-0.23	-0.27
Sawai Madhopur	+0.41 ^d	+0.44	+0.03	+0.05	+0.18	+0.15	+0.77 ^c	+1.16
Tonk	-0.04	-0.04	0	0	-0.24	-0.37	+0.39 ^b	+0.92
Udaipur	+0.10	+0.12	+0.30	+0.59	+0.40	+0.53	-0.56	-1.01
Delhi	+0.52 ^d	+0.69	-0.17 ^c	+0.25	-0.23	-0.30	+0.09	+0.12

Levels of significance for the
price elasticity coefficients :

- a - 30 per cent.
- b - 10 per cent.
- c - 5 per cent.
- d - 1 per cent.

Barley exhibited the reverse phenomenon for long-run prices, with the elasticities computed with relative prices being mostly negative. Four districts showed significant negative short run elasticities for the relative price model, unlike the results of the absolute price version all the significant elasticities were positive.

Barley was on the whole more responsive of the two crops. This is not surprising, for barley is grown on lands which are considered inferior for wheat, ~~it also accounts for~~ a smaller area than wheat, it is inevitable that its elasticity is higher than that for wheat.

Dayanatha Jha (1970) wrote a note on the acreage response of sugarcane in the sugar factory areas of Bihar. He examined the data for the Tirhut division - a sugarcane tract which provides raw material for 25 out of 30 sugar factories in the State. In order to capture the effects of the price and non-price factors, his model - the Nerlovian adjustment lags model - was modified to include rainfall, yield and a dummy variable to pick up the effect of change in the method of estimation of acreage from chowkidari to complete enumeration introduced in 1949-50.

The period of analysis: In order to examine changes over time separate analyses were conducted for the period 1912-13 to 1964-65, 1933-34 to 1964-65 and 1950-51 to 1964-65. Similarly exercises were done for the separate segments 1912-13 to 1932-33, 1933-34 to 1949-50 and 1950-51 to 1964-65 for a more precise picture.

The model was worked out with both sugarcane and gur prices separately in order to check for the difference in the explanatory powers of the two variables

$$A_t = B_1 P_{t-1} + B_2 Y_{t-1} + B_3 C_t + B_4 W_t + B_5 T_t + B_6 D_t + B_7 A_{t-1}$$

where D_t is a dummy variable to pick up the extent of change in the method of estimation of acreage from the year 1949-50.

A_t long run equilibrium acreage under sugarcane, in 000 acres, in year t .

P_{t-1} price of sugarcane and gur relative to competing crop (wheat) in the post-harvest period.

Y_{t-1} yield of sugarcane in tons per acre in preceding period.

C_t area under competing crops.

W_t total rainfall during pre-sowing months, October to February, in period t , in inches.

The R^2 ^{$T_t = trend$} were fairly high ranging from 0.65 to 0.88.

The results are summarized in Table 2.7.

The post-1932-33 period showed a marked break from the previous years due to a rise in sugarcane demand by factories that led to an increase in the impact of prices. The period after 1950-51 to the end of the study 1964-65 showed greatest influence of price. The author felt that higher relative price of gur was an incentive to produce more; the 'floor' was, however, provided by the minimum support price for sugarcane. The author felt that expansion of acreage under sugarcane over what could be sold to sugar factories was determined

by price expectation about both sugarcane and gur, while the pre-sowing rainfall had positive and significant impact on acreages lagged yield was not very significant (refer Table 2.8).

The dummy variable showed a positive coefficient showing that the increase in sugarcane acreage around 1949-50 was largely due to the change in the area estimation method introduced at that time.

Over the years the results show a steady rise in the short-run elasticities while sugarcane prices always gave better elasticity results than gur prices.

The study obtained a high value of B, thus 5 to 6 years were adequate to have around 95 per cent of the effect of the price worked out (Table 2.8).

Chandresh Kumar (1970): The basic interest in this article was to study the response of planned production to price changes in case of sugarcane in Uttar Pradesh. While Raj Krishna and Dharam Narain found positive supply response for sugarcane, Gupta and Majid's study had not found any significant supply response. The author thus felt that a fresh look into this topic was necessary. Thus he chose three districts from the Meerut division (Shaharangpur, Muzzaffarnagar and Meerut) from Uttar Pradesh, during 1951-52 to 1966-67 in order to study the acreage response of sugarcane to its relative price.

The Nerlovian adjustment lags model was considered to be appropriate for the crop under consideration. His model

Table 2.8 : THE REGRESSION COEFFICIENTS OF THE SUGARCANE ACREAGE EQUATIONS

Time period	Constant	Regression coefficients							Elasticity	
		P_{t-1}	Y_{t-1}	A_{t-1}	C_t	W_t	T_t	R^2		
<u>Gur Prices</u>										
1912-13 to 1932-33	273.0684	-1.9282	-4.7433	0.0098***	-0.3181	-1.3629	2.1646***	0.7171***	Negative	
1933-34 to 1949-50	161.6906	74.4834***	1.3313	0.0673***	0.1310	-1.0449	-2.0496	0.7207**	0.2607	
1950-51 to 1964-65	378.5931	209.4967**	5.9281	0.9757	-0.0642	6.1335**	-13.0929*	0.7354**	0.6390	
<u>Sugarcane Price</u>										
1933-34 to 1949-50	180.3223	768.0454**	1.0917	0.0923***	0.0925	-0.8418	-2.3721	0.6630**	0.2765	
1950-51 to 1964-65	287.7389	2180.6220***	7.2190*	0.1683***	0.0137	5.2982**	-7.5456	0.8372***	0.6585	

* Significant at 10 per cent. ** Significant at 5 per cent. *** Significant at 1 per cent.

Source : Indian Journal of Agricultural Economics, Vol. 25, p. 86.

Table 2.9 : REGRESSION COEFFICIENTS OF THE SUGARCANE ACREAGE EQUATIONS

Time period	Constant	Regression coefficients							
		P_{t-1}	Y_{t-1}	A_{t-1}	C_t	W_t	T_t	P_t	R^2
<u>Gur Price</u>									
1912-13 to 1964-65	103.5560	50.7662***	-0.9319	0.5879***	-0.2791**	1.6512	1.8051**	29.40	0.8878***
1933-34 to 1964-65	125.6150	81.7155***	2.5131	0.3174***	-0.0427	3.2487*	-1.8313	57.0903**	0.6551***
<u>Sugarcane Price</u>									
1933-34 to 1964-65	128.9455	1006.3629***	3.5042	0.2104	-0.0729	3.0359*	-1.6934	61.2573**	0.7156***

Table 2.10 : Estimates of Elasticities of Acreage of Sugarcane with respect to Relative Price of Sugarcane or Gur, Yield, and Rainfall

Time period	Elasticity w.r.t. price		Elasticity w.r.t.		Coefficient of adjustment (B)	Years required for 95 per cent effect of price @
	Short run	Long run	Yield	Rainfall		
<u>Gur Price</u>						
1912-13 to 1964-65	0.2257***	0.5477	-0.0464	0.0343	0.4121	5.6
1933-34 to 1964-65	0.2710***	0.3970	0.0998	0.0559*	0.6826	2.6
1950-51 to 1964-65	0.6390**	18.6297	0.2324	0.0963*	0.0243	-
<u>Sugarcane Price</u>						
1933-34 to 1964-65	0.3508***	0.4443	0.1391*	0.0522*	0.7896	1.9
1950-51 to 1964-65	0.6585***	0.7917	0.2830*	0.0832*	0.8317	1.7

* Significant at 10%.
 ** Significant at 5%.
 *** Significant at 1%.

@ Calculated as $(1 - r)^n = 0.05$.

Source: Indian Journal of Agricultural Economics, Vol.25, p. 88. D. Jha (1970).

incorporated besides the index of relative price of gur (deflated by price of wheat), relative yield of sugarcane, total irrigated area under all crops, all lagged one year and the rainfall during the sowing season.

Muzzaffarnagar and Meerut had the highest concentration of sugar factories, while Sharangpur had less. The mill price in Meerut and Muzzafarnagar did not attract supply from Sharangpur due to the prohibitively high transport cost.

The results show positive and significant price elasticities, so the author concludes that the farmers in this area are responsive to prices. But the short-run elasticities are rather low, (0.2). The R^2 s were between 0.50 and 0.72, meaning there is a large chunk of unexplained variance. There is no knowing how the elasticity would be affected if other relevant variables had been incorporated in the equation. The small degrees of freedom (10) makes the short run elasticity significant only at 5 per cent level. Longer period data would have possibly improved the estimates. As it stands, the low price elasticity leaves little scope for one to say with enthusiasm that farmers are responsive to price.

J. Mahendra Reddy (1970): Mahendra Reddy restricts his analysis to Groundnut in one single district in Andhra Pradesh, Karnool. The period chosen was 1931 to 1943. The author chose groundnut as the main crop and jowar and cotton as the competing crops as their input requirements and the period of cultivation are quite similar, and they compete for the same area.

Table 2.11 : Supply Parameters

Districts	Regression coefficients of				Price elasticities		
	a_0	P_{t-1}	X_{t-1}	R^2	Short run	Long run	
Sharangpur	3.42	0.561**	0.713*	0.669	0.2865	0.2747	0.9590
Muzzafarnagar	15.24	0.359**	0.701*	0.729	0.2983	0.2019	0.6766
Meerut	36.70	0.352**	0.514**	0.507	0.4851	0.2166	0.4460
State (U.P.)	12.08	0.434**	0.654*	0.607	0.3159	0.2603	0.7525

* Significant at 1%.

** Significant at 5%.

Source : Chandresh Kumar (1970), p. 740.

The author used the Nerlovian distributed lags model.

The relative 'price' relevant for making decisions regarding the acreage was the relative price. For this purpose, he used the wholesale price index of the three crops. The price index of groundnut was deflated by the weighted average price index of jowar and cotton, the weights being their respective gross values of output.

A relative yield index was also computed by a similar procedure. These price and yield indices were used as explanatory variables in the Nerlovian distributed-lags model.

The first regression equation without the relative yield as a variable, show neither lagged price nor lagged acreage to be significant and the R^2 was very low, 0.30.

The second regression including relative yield as a proxy for technology, improved the R^2 (to 0.47). The coefficient of relative price turned out to be significant while the coefficient of lagged acreage was not significant.

The acreage data showed a secular decline in the Groundnut area. To remove this effect, the data were detrended. With this the R^2 value increased from 0.47 to 0.56 and the elasticity of acreage with respect to price was found to be 0.76 while that with respect to yield was even greater at 1.40.

With the help of these results the author drew the following conclusions: "From this we may conclude that the farmers in the area under study are responsive to relative

price changes and relative yield changes. The Nerlovian coefficient of adjustment, B , was taken as $= 1$; it would mean that farmers adjust immediately to the fullest extent to changing market conditions. The negative sign of the trend suggests a secular decline in acreage under Groundnut."

The author does not go into the reason for this declining trend; it could probably have been due to increase in the relative cost of production or a differential impact of irrigation, about which no information was presented. This point should have been further clarified. The low R^2 also leaves questions about the inadequate explanatory power of the model.

M.C. Madhavan (1972): The main objective of the paper was to gauge the acreage response to relative price, yield/acre and rainfall. For this the author studied four major commercial crops and four cereals in Tamil Nadu during 1947 to 1965, i.e., during the pre-green revolution period. During this period acreage response could be treated as a fairly good indicator of output.

Madhavan uses a different approach to the study of supply response. Since in agriculture the resources at the disposal of the farmer are limited, any decision to expand output of a crop can come about only by decreasing the resource use in some other use. The farmer seeks to maximize his net income given the resource constraint.

The author formulates a constraint-maximization function

using the Lagrangean multiplier. The production function used for this purpose is taken as a constant elasticity of substitution function. He simplifies it further by taking the yield/acre as a proxy for all non-land inputs.

He modifies this rather conventional function to allow for the fact that not all of the planned changes in acreage can instantaneously materialize. There is thus a time lag in adjusting the actual acreage to the planned acreage. By incorporating this lagged adjustment, he converts his model to an adjustment-lag model of the Nerlovian type.

After this he incorporates the weather variable with the help of a weather index. The ultimate functional form used for estimation is:

$$\begin{aligned} \log X_{it} = & a_0 + a_1 \log \frac{P_{it-1}}{P_{jt-1}} + a_2 \log E_{it-1} + a_3 \log E_{jt-1} \\ & + a_4 \log X_{jt-1} + a_5 \log X_{it-1} + a_6 W_i + V_{it} \dots(10) \end{aligned}$$

where X_i = desired acreage of crop i,

$\frac{P_{it-1}}{P_{jt-1}}$ = relative price of crop i with respect to crop j lagged one year,

E_{it-1} = yield per acre of crop i lagged one year,

E_{jt-1} = yield per acre of crop j lagged one year,

X_{jt-1} = acreage of competing crop lagged one year,

X_{it-1} = acreage of crop i lagged one year,

W_i = weather index for crop i.

The above equation incorporates both the relative yield

and relative price. It in effect captures the movements in gross income.

The Empirical Results: The R^2 s for the equation fitted for the different crops vary from 0.45 to 0.91 and the \bar{R}^2 sometimes falls as low as 0.28. Thus the extent of variance explained is small, and due to this small explanatory power of the equation the elasticity estimates cannot be relied upon. It could be that an important explanatory variable is excluded from the present formulation, now there is no guarantee that these elasticities would remain the same even after the incorporation of these excluded variables.

The cash crops were observed to have higher elasticities than the food crops. Even within the food crop group the cereal crops like ragi and sorghum had elasticity greater than rice and cumbu which are stable foodgrains.

In case of foodgrains the yield per acre and rainfall seemed to account for the entire variation in yield.

The cash crops like sugarcane were found to be more responsive to price. These crops had yield elasticity lower than elasticity with respect to price.

The cross elasticities were lower when both crops under consideration were food crops, than when only the competing crop was a cash crop and the crop whose acreage response was measured was a food crop. The acreage elasticity of the cash crop with respect to the price of a competing food crop was higher than the latter, while the elasticity was the highest

when both the crops under consideration were cash crops. The yield estimates had the right signs and were significant.

The rainfall variable turned out to have positive and significant impact. The speed of adjustment (indicated by the value of B) was greater for commercial crops than the food crops, e.g.

$0.1 < B < 0.4$ for cumbu; $0.5 < B < 0.6$ for ragi

$0.7 < B < 0.8$ for rice

while B for sugarcane and groundnut was between 0.4 and 0.9.

Thus Madhavan concludes that the price can be used to influence the acreage to a greater extent in case of a commercial crop than in case of a food crop.

Madhavan has claimed to have obtained better results than Raj Krishna in terms of significance of coefficients and goodness of the fit. Our observations show that Raj Krishna's R^2 were considerably higher than his, so his second claim is not valid, about the first argument about significance of the coefficients means very little in case of low R^2 s.

Ashok Parikh (1971): Using Dharam Narain's data for wheat and rice for 1900-1939 Parikh worked out the acreage response to price relative revenue. His hypothesis was that the farmers do not respond to the price but to the relative revenue. It must be recalled that Dharam Narain had used the graphical methods to establish interrelationships between the acreage and price and non-price variables.

Parikh tried out five different kinds of models in order

to qualify the acreage response to the lagged relative price, i.e. price deflated by prices of all other crops (P_{t-1}) or (P_{t-1}^*) where the lagged price of this crop is deflated by the prices of the competing crops.

The other variables considered here were the lagged acreage (A_{t-1}). Pre-sowing rainfall the per acre yield (Y_{t-1}) of the previous year or sometimes the value of proceeds per acre valued at the relative price of this crop to all other crops.

The models that were tried out can be classified into five categories: (1) Expectation lag model, (2) Nerlovian adjustment model, (3) Nerlovian expectation-lag model with two expectation variables, price and rainfall, (4) Kyock's second order lag function, and lastly the (5) Multiple regression models.

The expectation lags models: This set consisted of two models both the lagged acreage and the relative price with respect to all crops P_{t-1} for explaining acreage. But the second model had an additional variable (Z_{t-1}) i.e. the acreage under this crop in this season,

The second set of models consists of the adjustment-lag models (models 3 to 16). These models can be further classified into three sets. The first set (models 3 to 7) uses the P_{t-1} i.e. the price of the crop relative to prices of all other crops. All of them had lagged acreage and lagged relative price as explanatory variables. The first model with the only

these two variables considered is for all practical purposes the same as (model 1), as like the latter it explains the acreage in terms of merely the lagged acreage and lagged price.

The second equation in this set (i.e. model 4) adds to these two variables the yield variable. The next two (models 5 and 6) add the pre-sowing rainfall variable. While models 5 and 7 use the value of proceeds per acre valued at relative price (Y_{t-1}^*) the models 3 and 6 use merely (Y_{t-1}^*) or the physical yield.

The second sub-set of the set of adjustment lag models (models 8 to 12) were the same as the first set of five models (3 to 7) except that these models used the P_{t-1}^* price of this crop deflated by the prices of competing crops instead of P_{t-1} .

The third sub-set of adjustment lag models (12 to 16) differ from the first two sets by their incorporation of Z_{t-1} the total area under kharif or rabi crops in the previous season and the use of the pre-sowing rainfall. The first two models used the P_{t-1} which the next two used P_{t-1}^* .

The Nerlovian model with two expected variables of price and rainfall formed the third set of models. They consisted of models 21 to 34.

The fourth set was Kyock's second order lagged functions used the dependent variable with two year lags as an explanatory variable (Models 25-28).

The fifth set was of the Multiple Regression models

(models 7 to 24), they used trend and either physical yield or the value of output per hectare valued at the relative price of the crop under concern. The relevant price was taken as either the price of this crop relative to all crops P_{t-1} or relative to competing crop P_{t-1}^* .

All the models except for multiple regression and the adjustment lag models had various statistical problems. These two set of models, set 5 and set 2, were the only two sets with no such problems. The other models suffered from serial correlation and the models with two expectation variables suffered identification problems.

The comparison between different models became difficult as the author did not state the R^2 s and \bar{R}^2 s. He presented results of only those models which he considers to be 'the best', in terms of R^2 , expected signs of coefficients, their significant low standard error and absence of serial correlation and multicollinearity.

Results for the two crops with the various models show:

Rice: Bihar and Orissa: Bihar and Orissa showed considerable influence of the price variable and the pre-sowing rainfall. The R^2 for this region was best (0.95) for the sixth model. It however had not significantly different from zero. Model 13 which incorporated the shifter variable of area under kharif (Z_t) showed significant influence on area. The short run elasticity of rice with respect to price was 0.2372 and that with respect to rainfall was 0.1605 in model (6) which turned out to have the best fit.

Table 2.12 : Supply Parameters for Wheat for Different Regions

Region	Model No.	Average lag	Wheat Elasticities					
			Price	Yield per acre	Weather	Deflated proceeds per acre	Adjustment coefficient	Serial correlation
C.P. & Berar	6				0.1758 (0.3300)	0.1896	0.5360	No
C.P. & Berar	7			0.1755 (0.3250)	0.1772 (0.3901)		0.5400	No
C.P. & Berar	25	1.6 yrs	-4.6760 (-8.6600)		0.2179 (0.3295)		0.5600	Yes
Bombay & Sindh	7				0.3213 (0.7650)		0.4200	No
Bombay & Sindh	27	8.5 yrs			-		0.2000	No
United Provinces	7				0.093 (0.1520)		0.6537	No
United Provinces	25	2-3 yrs	Negative price elasticity				0.3870	No
Punjab	6		0.0638 (0.1012)				0.6300	Yes

Source : A. Parikh (1971), p. 71.

Table 2.13 : Supply Parameters for Rice for Different Regions

Region	Model No.	Rice Elasticities					
		Price	Rainfall	Area under Kharif	Time	Adjustment coefficient	Serial correlation
Bihar-Orissa	(6)	0.2372	0.1605 ^I	-	-	Not significant	No
Bihar-Orissa	(13)	0.1575 ^I	0.1380 ^I	0.5204 ^I	-	Not significant	No
Madras	(13)	-0.1394 (0.1469)	0.1022 (0.1229)	1.1394 (1.4690)	-	0.8237	No
Madras	(18)		0.0775	1.2766	14.8660	-	No

Notes: 1) 'I' indicates infinite elasticities.

2) Figures in the parentheses indicate long-run elasticities.

Source : A. Parikh. Bul. Ox. Univ. of Eco. & Stat., Vol. 33, 1971, p. 71.

West Bengal: None of the models for this region showed statistically good results, except the multiple regression model which showed significant impact of only the rainfall variable.

Madras: Two crops of paddy are taken in this region and the rainfall during April to August and September to January had significant influence on acreage. The adjustment coefficient was found to be high. But the influence of price was observed to be negative in this model (13). Model 22 showed significant trend effects and a negative price-acreage relationship.

Dharam Narain's results show that the acreage moved more with the rainfall than with price. The only difference between his results and those obtained for rice by Parikh is that he (Dharam Narain) finds insignificant influence of price even in Bihar and Orissa, ^{where as} Parikh finds that price significantly affects acreage in this area.

Wheat: C.P. and Berar: The wheat acreage response for this region showed that the rainfall and deflated proceeds per acre were found to be significant by Model 7.

The Kyock model showed a significant negative price coefficient (but the author does not comment on it). The Nerlovian Adjustment models had high coefficients of adjustment and low but significant coefficients for rainfall and yield or proceeds per acre.

Results for Bombay and Sind: The adjustment models did not have any auto-correlation problem but they did not show significant impact of price. The multiple regression model showed significant impact of trend which the author attributed to a rise in irrigation.

Dharam Narain's study noted some amount of association between the price and acreage in C.P. and Berar, while Bombay and Sindh results showed insignificant association between these variables.

The United Province results show that the acreage in this case was significantly affected by rainfall but not so by price. This was however not due to any rigidity or problems in the process of adjustment, because the adjustment coefficient was found to be as high as 0.66, indicating quick adjustment.

These models worked out for Punjab showed that the lagged acreage was a significant explanatory variable the rainfall variable was also significant but the price coefficient was insignificant. The adjustment coefficient was 0.62 indicating the farmers potential to adjust quickly.

The results with these models for Bihar and Orissa were very similar to those for Punjab with the rainfall and lagged acreage variable being significant, but price being insignificant. In Madras the rainfall variable alone was significant.

Writing a decade before Parikh, and using merely graphical analysis, Dharam Narain had also found significant

impact of rainfall which he illustrated as synchronous movement of the rainfall and acreage series. He said that the cereals show a close correspondence to the rainfall than to the price variable. This conclusion is in most provinces reinforced by the results obtained by Parikh.

Parikh's results showed that by and large farmers did not respond to price changes, in case of rice and wheat. Although there were high adjustment coefficients, the farmers seemed to respond to the non-price variables like weather and yield per acre.

Parikh did, however, get the proceeds per acre as a significant factor in case of C.P. while the price coefficient was significant in case of rice in Bihar and Orissa. But for the other regions for rice and for all regions for wheat the price variable failed to explain acreage variation.

Ashok Parikh's conclusions partially reinforced the generally accepted conclusions relating to these crops by Dharam Narain. Although Dharam Narain was exacting in his analysis, it was the limitation of his tools which undermined his conclusions. However, Ashok Parikh's finding of a significant impact of rainfall on these food crops validated Dharam Narain's conclusion.

Post-Green Revolution Studies

Acreage response to price, functions as a proxy for output response to price only as long as the relationship between the acreage and output remains constant. The relationship hinges upon the yield per acre; the yield per acre changes either if the applications of other inputs per acre change or when the underlying input-output relationship changes. This input-output relationship or production function changes when there is technological improvement.

Indian agriculture until 1966-67 was marked by slow or almost no change in technology. The period beginning 1966-67 was, however, marked by a break-through in the technology of production of cereals. This was a result of the development of special seeds which had the potential to transform plant nutrients into larger amount of grains than the earlier varieties, under condition of assured supply of moisture in the soil. It was also more responsive to doses of nutrients over a much larger range. The change marked a new era in the history of Indian agriculture and consequently in the research in agricultural economics. Increase in acreage no longer remained the only way to increase output; the use of acreage as a proxy thus led to an under-estimation of the actual response.

Madan Mohan Batra (1976): Batra pointed out the fact that acreage response does not adequately approximate the output response under conditions of changing technology. Keeping

this in mind he estimated both a yield and an acreage response function. For his study he took four districts of Gujarat: Kaira, Kutch, Banaskantha and Mehsana. The period chosen for his study was 1951-52 to 1964-65 representing the pre-high yielding variety (HYV) period and 1966-67 to 1971-72 the post-HYV period.

The crop chosen for analysis was bajra whose competing crops are taken as tobacco, jowar, cotton and groundnut.

The author proposed to answer the following questions:

- 1) How far do bajra producers respond to the price stimuli?
- 2) Is their behaviour in keeping with economic rationality?
- 3) Does the subsistence crop respond more to price or to non-price variables?

In order to get over the problem of degrees of freedom due to lesser number of years of data being available, the author pooled the cross section data with the time series.

He has worked out various regression equations with acreage, output and yield per acre as the dependent variables for the pre- and post-green revolution periods. He does not however discuss the relative change in the importance of the various variables affecting acreage in the two periods.

His models discussed below use the following variables:

- A_t area in ('00 ha) under bajra in year t,
 P_{t-1} farm harvest prices (Rs. per quintal) of bajra,

- Y_{t-1} per acre yield of bajra in kgs in year $t-1$
 I_{ct-1} gross income per hectare from competing crops in year $t-1$,
 O_{t-1} is the output ('00 metric tonnes) of bajra in year $t-1$,
 C_{t-1} cost of production of bajra per hectare in year $t-1$,
 W_{1t} is the rainfall (in mm) during the pre-sowing period,
 W_{2t} is the rainfall (in mm) during the maturing period of bajra,
 W_{3t} is the rainfall (in mm) during the vegetative growth period of bajra,
 F_t is the consumption of fertilizer in the district,
 H_t is area (in ha) under HYV of bajra in year t ,
 I_t irrigated area in year ' t ',
 N_{Bt} net income per hectare from bajra in year t ,
 V_t error term.

Acreage response:

Traditional period 1952-53 to 1965-66:

$$A_t = a_0 + b_2 P_{t-1} + b_3 Y_{t-1} + b_4 I_{ct} + b_5 W_{1t} + b_6 C_{t-1} + b_7 A_{t-1} + V_t$$

and $A_t = a_0 + b_2 P_{t-1} + b_3 I_{ct-1} + b_4 W_{1t} + b_5 C_{t-1} + b_6 O_{t-1} + V_t$

The price and cost of production were found to have significant and negative impacts on acreage. The pre-sowing rainfall and income from other sources were found to be insignificant. The coefficient of the yield variable was observed to be negative, which the author explains in terms of bajra being a subsistence crop with a minimum requirement, which can be satisfied with lower acreage when the yield is higher.

The lagged acreage variable was found to have a great positive influence on current acreage, this showed that the acreage allocation was largely determined by the traditional cropping pattern.

Acreage response under New technology:

He used different equations to estimate the acre response in new technology, they were:

$$A_t = a_0 + b_2 P_{t-1} + b_3 Y_{t-1} + b_4 I_{ct-1} + b_5 W_{1t} + b_6 C_{t-1} + b_7 A_{t-1} + b_8 H_t + V_t$$

$$A_t = a_0 + b_2 P_{t-1} + b_3 I_{ct-1} + b_4 W_{1t} + b_5 C_{t-1} + b_6 O_{t-1} + b_7 H_t + V_t$$

Five different variants of the above two equations were used dropping O_{t-1} , A_{t-1} , H_t or Y_{t-1} .

The results showed that the price coefficient was negative and significant at 1 per cent in each equation. This was surprising especially because the author explains it in terms of the increase in yield per acre while the yield coefficient in the equation was observed to be insignificant. There was besides this, negative, significant impact of the cost of production and income from competing crops, as expected.

Yield response under traditional technology:

$$Y_t = a_0 + b_2 W_{1t} + b_3 W_{2t} + b_4 W_{3t} + b_5 I_t + b_6 F_t + b_7 N_{Bt-1} + V_t$$

The yield per acre was sought to be explained by three

different variants of weather: the pre-sowing rainfall, rainfall at maturing time and rainfall during the vegetative growth period. Of these only the last was significant, but was observed to have a negative influence on yield. The author explains this by saying that bajra is a dry crop and needs little water. The fertilizer consumption was observed to affect yield positively and significantly, so did the net income per hectare. The irrigated area H_t was however observed to be insignificant.

Yield response during the New technology:

$$Y_t = a_0 + b_2 W_{1t} + b_3 W_{2t} + b_4 W_{3t} + b_5 I_t + b_6 F_t + b_7 H_t + V_t.$$

The yield response equation in this case had a very low R^2 which is probably because, the current formulation leaves out an important variable. It shows significant impact of only two variables, the fertilizer consumption and area under high yielding variety, both these variables affect yield positively as expected. The weather and irrigated area have been observed to have insignificant influence on yield.

Output Response under traditional technology:

$$O_t = a_0 + b_2 A_t + b_3 W_{1t} + b_4 W_{2t} + b_5 W_{3t} + b_6 I_t + b_7 F_t + V_t$$

The output responded the most to the acreage variable which affected it positively, the fertilizer consumption increased output, but the irrigation variable had a significant negative impact. The author explains this phenomenon as

follows: Bajra is a rainfed crop. In this region, it is given irrigation only in the absence of rainfall, but even then only 15 per cent of bajra is irrigated. Consequently when there is inadequate rain there is some expansion in area under irrigation but nevertheless such area being small, there is a decline in total production.

Output Response under New Technology:

$$O_t = a_0 + b_2 A_t + b_3 W_{1t} + b_4 W_{2t} + b_5 W_{3t} + b_6 I_t \\ + b_7 F_t + b_8 H_t + V_t.$$

The output was still significantly responsive to acreage but this significance showed decline. The area under high yielding variety was observed to have greater significance. But the other variables were observed to be insignificant.

It is generally known that the post-1966-67 period was marked by an increase in output due to rise in productivity, the yield variable which is an indicator of such productivity was not incorporated in the output response function by the author.

Secondly this study tries to get over the problem of the less degrees of freedom by pooling the cross section data along with the time-series data. This gets over the problem of the degrees of freedom but welcomes the econometric problem of hetroskedasticity, since now the independent variables and the error terms are likely to be correlated. Besides this the treatment of data from independent samples as one coherent set assumes they have no regional differences.

Secondly, with all his data, he could have computed the elasticities, or could have run log linear equations to get various elasticities as regression coefficients. This would have thrown adequate light on the change in importance of each factor after the introduction of the high yielding variety.

D.S. Tyagi (1974): Most studies on supply response are macro-level studies. Such studies make a critical assumption that most farmers within the area of study have similar price expectations, and that this expectation behaviour is invariant under different situations and over time.

D.S. Tyagi explored the process of expectation formation of farmers. In his study of decision making, he collected the farmer level information from 90 randomly chosen farmers from 3 villages in the Meerut division of U.P. This cross section data was collected by structuring a questionnaire through which information regarding the price expectation formation and the role of the price and non-price variables in it was sought. The data regarding acreage sown under various crops was obtained from the village Khasra records with the Patwari, in which he records the crops grown in different survey numbers.

Every one of the 90 respondents was asked to indicate his expected price or how he would react to a variety of possible situations exemplified by different permutations and combinations of the variables and their directions and magnitude which form the basis of his expectations. Details of this interview were noted down in a schedule. The questions

pertaining to expected future prices must be precise in three things viz: the time period, market and grade or quality of the product to which the expected price relate. In the first set of questions about expected future prices the latter two i.e. market and the grade of the commodity were not specified, the farmers were merely asked the expected prices. At the end the farmer was asked to which time period and to which grade of the commodity their expectations were related. The plan was that if the farmers reported the expected price for any other period or any other market or grade it could be checked. But the respondents gave exact information. The detailed survey was conducted in two rounds: in February-March 1970 and January-February 1971 and January-February 1972. The first was the pre-sowing period for Sugarcane. The second round was expected to collect expected future prices of gur and of wheat. The answers recorded during the course of interviews with the farmers for knowing their expectancy behaviours have been analysed in order to determine: (1) the variables entering into the formation of expected future prices, (2) the relative importance of these variables and methods of aggregation of effects of different variables, (3) the aggregation procedures adopted in different situations depend on the magnitude and direction of different variables.

On the basis of this analysis farmers have been classified into different expectancy groups and then the functional relationship between the expected future prices and the variables entering into the formation of these expectations are

developed for each expectancy group in such a way that the coefficients of different variables assume the values as found in (3) above.

The price expectations arrived after the processing of the questionnaires showed that some farmers project the future price while some do not, some allow for greater deviations from past prices, some do not. But most farmers form their own price expectations rather than follow a price leader, based on observed prices during the preceding two years. The price prevailing in the harvest period alone was considered important by farmers for the purpose of framing future price expectations. In most cases the expected price is the recent past price plus or minus some coefficient which is a function of other variables entering into formation of expectations.

The non-price variables like Government action, political change and crop prospects were also found to influence expectations to some extent.

Tyagi classifies the different expectation formations of the farmers into ten different groups according to their price expectations. These models are tested for their validity by 'predicting' the price for 15 years for the period 1955-56 to 1969-70. Their predictability was tested by taking deviations between observed and expected prices.

The 10 expectancy groups were reduced to 6 groups (as the test showed that the remaining 4 groups were not very different from other 6 groups).

The six different price expectations were:

$$(1) P_t^e = P_{t-1} + \frac{\alpha_1 d_1 + \alpha_2 d_2}{\beta}$$

for expectation groups 1 to 4 where $d_2 = P_{t-1} - P_{t-2}$ second yearly differentials; $d_1 = P_{t-2} - P_{t-3}$ first yearly differentials; and α_1, α_2 are coefficients.

$$(2) P_t^e = P_{t-1} + \frac{\alpha_1 d_1 + \alpha_2 d_2}{\beta} + \alpha_m d_m$$

for expectation groups 5 and 6.

d_m is the monthly differentials.

P_t is the farm harvest price.

$$(3) P_t^e = P_{t-1} + \frac{\alpha_1 d_1 + \alpha_2 d_2}{\beta} + \alpha_m d'_m$$

for seventh expectation group where $d' = d - \frac{1}{10} P_{t-1}$

$$(4) P_t^e = P_{t-1} + \frac{\alpha_1 d_1 + \alpha_2 d_2}{\beta} + \alpha_m d'_m$$

for eighth expectation group.

$$(5) P_t^e = P_{t-1} + \alpha_2 d_2 + \alpha_m d_m$$

for the ninth and tenth expectation groups.

Farm harvest price of wheat of any year is modal price of the prices of wheat prevailing during the months of May-June in that year. In case of gur it is the modal price of the prices of gur prevailing during the months of January-February of that year. Second year differentials: difference between the last farm harvest price and the farm harvest price of the year preceding the last farm harvest. First year differential is: the farm harvest prices of the two years preceding the last farm harvest price.

View Point Price: It is the modal price during the month preceding the view point e.g. if expectations are formed in March the view point price is the modal price during February.

Intra-year variation or Monthly differential in Prices: is the difference between the last farm harvest price and the price prevailing during the view point month. In case of wheat it is the differential between the modal price of May-June and the price prevalent in the view point month while in the case of gur it is the difference between November price and the price in the view point month.

Tyagi then uses these expected prices to estimate supply elasticities for sugarcane and wheat for the six expectancy groups above. He used the autoregressive model and compared it with the estimates obtained from the Nerlovian model.

Table 2.14 : Short run Elasticities of Planted Sugarcane and Wheat Area With Respect to Relative Expected Price

Expectancy Group	Wheat			Sugarcane		
	Expectation Model			Expectation Model		
	I	II	III	I	II	III
First	-0.011	0.266	0.294	0.646	0.446	0.321
Second	-0.087	0.413	0.491	0.472	0.535	0.386
Third	0.172	0.225	0.243	0.649	0.558	0.439
Fourth	0.124	0.352	0.305	0.902	0.499	0.566
Fifth	0.220	0.067	0.436	0.974	0.664	0.597
Sixth	0.098	0.261	0.335	0.596	0.601	0.417

Here Expectation model I relates to the estimates with average of pre-sowing prices in the preceding three years. Model II

relates to farm harvest prices lagged one year and model III relates to the models developed for each expectancy group in this study.

The Nerlovian adjustment lag model was not used because the author observed that the farmers were in a position to actually make all the shifts they wanted to, there was thus no distributed-lag observed in this sample, although the effect of lagged acreage prevails it does not get distributed over a number of years. So the author prefers the autoregressive model for this study.

To sum up the analysis of the expectancy behaviour of the selected farmers indicates that the past observed prices play an important role in comparison with any other non-price variable.

Tyagi's efforts at exploring the mechanism of expectation formation are commendable. There are however some limitations.

Tyagi classifies farmers according to the price expectation, clubbing together farmers of all size groups who have different income levels. This different resource endowment gives them different levels potentials to respond to the price incentive.

Secondly the author has pinned on the price expectations to different groups in such a manner that each expectancy group will always expect the same kind of price expectation year after year. This is ridiculous for if one

is trying to incorporate the actual decision making it must be granted that the farmers do have an error learning process, by which they incorporate latest information and revise their production plans.

In spite of all this we have to admit that Tyagi's work throws some "light in an obscure area pertaining to supply response in Indian agriculture" (Dharam Narain, Preface to Tyagi's book, 1974).

Risk, Uncertainty and Supply Response

Most articles dealt with so far talk about the price and quantity relationship as if there was perfect certainty. But the real world and especially the agricultural sector is plagued with various kinds of risks and uncertainties. So in order to identify the price-quantity relationship in its true sense, it should be distilled out from the empirical price-quantity data. Such data merely reflects the total impact which is the net resultant of the simultaneous operation of all other factors.

The most elusive of these other factors are the unpredictable uncontrollable factors. The process of separating out the impact of these factors becomes tricky due to the uncertainty associated with their occurrence.

In the following section we shall deal with the articles which have adopted various methods for dealing with risk and its impact on supply response.

Risk, Uncertainty and Supply Response

In agriculture there are two kinds of risks and uncertainties:

- 1) Price risk/uncertainty
- 2) Yield risk/uncertainty.

The price uncertainty stems from the fact that the price that is going to prevail in the market when the produce reaches it is the relevant price and that this price is not known, nor can it be accurately predicted (its probability distribution is unknown). If the distribution of the price variable were known with a certain probability it would have been a risk and not uncertainty.

Cochrane has effectively illustrated the price uncertainty as:

"A commodity price may rise one year fall in the next, may rise two years and fall in one year, may rise for one year and fall for two years. The combinations are not infinite in number but they are many and random. To the farmers the next year's price is uncertain; he does not know with any reasonable degree of probability whether the price of a particular commodity will go up or down next year and by how much. Thus he plans the next year's output pretty much in dark on a guess here and a hunch there" (Cochrane, p. 19).

Cochrane further points out that uncertainty about future causes inefficient allocation of resources as it blurs

the picture of relative profitability of various commodities that can be produced.

Yield Risk/Uncertainty: The yield/acre expected in any season is not known definitely or with any given probability. Almost all efforts at forecasting weather have always proved to be inadequate. The weather factor assumes greater importance in a tropical country like India, where the extent of irrigation facility available is small. Heavy dependence on the monsoon results in uncertainty regarding yield.

The payoff to the farmer is: Net Income = Revenue - Costs.

$$\text{Net Income} = [(\text{Price per kg}) \times (\text{Yield per ha in kgs}) \times (\text{No. of ha. s})] - \text{Costs.}$$

The net returns to be earned by the farmer are twice cursed with uncertainty: with uncertainty regarding yield and uncertainty regarding market price. Given such risks the farmers' natural reaction is risk aversion. Such risk aversion is not irrational. A risk averter would, given a choice between (1) a crop with higher expected return and a higher variation around the mean and (2) a crop with lower expected return but lower deviations from the average, choose the latter.

This was so far as the risk is concerned, as it has a given distribution, its outcomes are at least probabilistically measurable. Various studies starting with Behrman have incorporated a proxy of the riskiness of crops into their

supply response models. Behrman introduced the standard deviation to approximate price and yield variability, some others have used the coefficient of variation for this purpose. No study so far has used any proxy for uncertainty, this is because uncertainty does not have a given distribution, it is the total unpredictability of the variable which cannot be captured by means of any proxy. We proceed to review these studies dealing with the price/yield riskiness of various crops.

Behrman (1968): The first attempt in this direction was made by Behrman in his Modified Nerlovian Model.

$$A_t = a_{11} + a_{12} + P_t^e + a_{13}Y_t^e + a_{14} P_t + a_{15} Y_t + a_{16}N_t + a_{17}M_t + U_{1t}$$

Desired Acreage = f [expected normal price of this crop relative to other crops (P_t^e), the expected harvest product per planted acre (Y_t^e), the standard deviation relative price of the crop concerned (P_t) over the last three years, the standard deviation of the actual yield of the crop (Y_t) over the last three years, farm population N_t and annual malaria death rate (M_t)].

This model takes care of both the price risk and yield risk by incorporating their respective standard deviations. The farmers' rational conduct in this case would imply: given

the respective price and yield probability distributions the farmer would seek to maximize utility that maximizes the expected return for a given level of variation (Maji et al., 1971).

Maji-Jha-Venkatraman (1971): The authors tried to fit acreage-response function to the data on rice, maize and wheat in Punjab during 1948-49 to 1965-66. They used the log linear form of estimation. Here they have tried to incorporate the 'price risk', by introducing the P_{t-1} - the standard deviation of the prices of the respective crop in as an explanatory variable in the supply response model for the crop. The authors formulated eight different models, of which the first three were used for both wheat and maize while the remaining five were used for rice.

The models explain acreage (A_t) in terms of either (P_{t-1}) the relative price in t-1 or (P_{t-1}) absolute price, which is sometimes incorporated by itself and sometimes with (P_{t-1}) the prices of the competing crops. Besides this the lagged acreage (A_{t-1}), the yield of the crop in question along with that of competing crops (Y_{t-1}) and trend (T_t) is used. The rice equations use (Z_{t-1}) the total irrigated area in the season concerned.

Results

WHEAT

$$(1) \quad \log A_t = 0.0945 + 0.1086 \log P_{t-1} + 0.9786^{***} \log A_{t-1}$$

$$R^2 = 0.9319$$

$$(2) \quad \log A_t = 0.7977 - 0.5398^* \log P_{t-1} + 0.4723^@ \log A_{t-1} \\ + 0.1381^@ \log T_t, \quad R^2 = 0.9439$$

$$(3) \quad \log A_t = 1.9022 - 0.6692^{**} \log P_{t-1} + 0.0026 \log A_{t-1} \\ + 0.4093^{***} \log T_t - 0.0098 \log P_{t-1}, \quad R^2 = 0.966$$

*** Significant at 1%.

* Significant at 10%.

** Significant at 5%.

@ Significant at 20%.

The first and second equations showed insignificant impact of price on the wheat acreage, but it showed significant positive impact of the lagged acreage. The equation No.3 shows that the absolute price and trend are significant determinants of acreage, when the price variability was introduced by P_{t-1} . Although it had the right sign, the standard deviation of price remained insignificant. The incorporation of this variable also reduced the coefficient of lagged acreage.

Only the short run price elasticities calculated with absolute prices were significant. The elasticities with respect to price variability were negative (as expected), but insignificant.

MAIZE

$$(1) \quad \log A_t = 2.9864 + 0.5617^{**} \log P_{t-1} + 0.1545^{***} \log A_{t-1} \\ + 0.3887^{***} \log T_t, \quad R^2 = 0.7790$$

$$(2) \quad \log A_t = 2.8335 + 0.2839^{\textcircled{a}} \log P_{t-1} + 0.1801 \log A_{t-1} \\ + 0.5341^{***} \log T_t - 0.0027 \log \sigma P_{t-1}, \\ R^2 = 0.8920$$

$$(3) \quad \log A_t = 1.8505 + 0.4935 \log \bar{P}_{t-1} + 0.0892 \log A_{t-1} \\ - 0.2492 \sigma \bar{P}_{t-1}, \quad R^2 = 0.5439$$

The results for maize indicate positive and significant influence of relative prices on acreage, lagged acreage and trend were also observed to have significant positive impact on it. However the inclusion of the price variability variable (\bar{P}_{t-1}) led to a decline in the significance of the relative price variable. Another equation using absolute prices had very low R^2 .

The short run elasticity with respect to price (absolute) variability for maize was found to be significant and negative (-0.2492). Incidentally this was the only significant elasticity with respect to price variability in this study. The authors point out that the elasticity results for maize obtained here are comparable to those obtained by Raj Krishna.

RICE

$$(1) \quad \log A_t = 0.7991 + 0.4939^{\textcircled{a}} \log P_{t-1} + 0.6004^* \log Y_{t-1} \\ + 0.7560^{***} \log Z_{t-1}, \\ R^2 = 0.7991$$

$$(2) \quad \log A_t = 0.3090 + 0.1815 \log P_{t-1} + 0.2712 \log Y_{t-1} \\ + 0.2685 \log Z_{t-1} + 0.5344 \log A_{t-1} , \\ R^2 = 0.8122$$

$$(3) \quad \log A_t = 2.0088 + 0.3254 \log P_{t-1} + 0.1339 \log A_{t-1} \\ + 0.4128 \log T_t - 0.0095 \log \sigma P_{t-1} , \\ R^2 = 0.7585$$

$$(4) \quad \log A_t = 2.0343 + 0.1498 \log \bar{P}_{t-1} - 1.1479^{***} \log P_{t-1} \\ + 0.7770 \log A_{t-1} + 0.3575^{**} \log T_t , \\ R^2 = 0.8885$$

$$(5) \quad \log A_t = 0.7727 + 0.1131 \log \bar{P}_{t-1} - 0.1892 \log P_{t-1} \\ + 0.7998^{\textcircled{a}} \log A_{t-1} - 0.0010 \log \sigma \bar{P}_{t-1} \\ - 0.1224 \log P_{t-1} , \\ R^2 = 0.8055$$

The above results for rice show that the relative price coefficient was significant only in the static model (model 1). The prices of rice and its competing crops which were explicitly included in the fourth and fifth models the coefficient of the competing crops was found to be significant but that of own price was found to be insignificant. The risk measuring variable did not emerge significant, none of its elasticities was significant. In fact the only elasticity that was significant for rice was that computed with the static model (model 1).

Table 2.15 : Estimates of Long and Short Run Elasticities and Coefficients of Adjustment

Crop	Model	B	Price Elasticity		Elasticity w.r.t. price variability		R ²
			Short run	Long run	Short run	Long run	
Wheat	I	0.0214	0.1086	0.5075			0.93
	II	0.5277	0.5398*	1.0229			0.94
	III ⁺	0.9974	0.6692**	0.6709	-0.0098	-0.0098	0.96
Maize	I	0.8455	0.5617**	0.6643			0.779
	II	0.8199	0.2839@	0.3462	0.0027	-0.0033	0.89
	III ⁺	0.9108	0.4935	0.5418	-0.2492**	-0.2736	0.54
Rice	I	-	0.4939@				0.77
	II	0.4656	0.1815	0.3898			0.81
	III	0.8661	0.3254	0.3757	-0.0094	-0.0108	0.75
	IV ⁺	0.2230	0.1498	0.6718			0.88
	V ⁺	0.2002	0.1131	0.5649	-0.0010	-0.0049	0.805

+ These relate to absolute prices.

@ Significant at 20%. ** Significant at 5%.

* Significant at 10%. *** Significant at 1%.

Source : Maji et al (1971), p. 24.

The authors say that the relative (rather than absolute) prices are relevant for the farmers' decision making, except when the price of the crop under consideration is very high and the relative income obtained from this crop is a

great deal higher than that from the competing crop. In that case so long as the fall in the relative price of this crop does not close the gap in net profitability there is no problem of switch over to it, the relative price is not important here.

If this is the given payoff, what had stopped the complete switch over to this crop? Was it lack of adequate resources, supporting facilities, or simply lagged information? Is the wheat case due to this, or, are the competing crops grown merely in order to maintain the balance in the soil? The authors do not enlighten us on these questions. They conclude that: "The fact that relative price emerged significant in some cases and absolute price in others should not be accepted prima facie. It would be apparently inconsistent to assume, except perhaps in the case of very highly remunerative crops, that farmers base their expectation on relative price for one crop and on absolute price for others. A meaningful empirical work on acreage response must be based on more concrete information on this aspect." (Jha et al, 1971, p.27)

One basic exception to the above study was taken by Kaul and Sidhu (1971). They cite Stuart and Kendal (1961, p.375) to say that the incorporation of the standard deviation violates the basic assumption about the nature of explanatory variables in a multiple regression, namely, that the explanatory variables should be normally distributed. The standard deviation does not have a normal distribution. Thus

the estimates obtained by this method may not be 'best' (least variance) linear unbiased estimates.

J.K. Kaul and D.S. Sidhu (1971): Kaul and Sidhu postulated that acreage decisions depend upon the variations in relative profitability. The authors stressed that the farmers look to the harvest prices and not wholesale prices of the crops, as it is the farm harvest price at which they dispose of the major chunk of their output.

The State chosen for this analysis was Punjab and the period was 1960-61 to 1969-70. The crops chosen for this analysis were wheat, paddy, maize, groundnut, sugarcane and Desi cotton. The relative 'profitability index' was obtained for each crop by taking the gross revenue from this crop deflated by the gross revenue from competing crops. For this, competing crops for wheat were taken as gram and barley, while maize was taken for paddy. The relative profitability index for maize in turn used gross revenue from sugarcane and cotton, while that of groundnut used bajra as the competing crop.

The model used was the Nerlovian adjustment lag model fitted with an additional variable—the coefficient of variation. This coefficient of variation for three preceding years' gross profitability was expected to catch the 'risk' associated with price via its fluctuations. The authors pointed out that the standard deviation is not normally distributed and hence cannot be used as an explanatory variable in a

multiple regression, as it would give estimates which are not best linear unbiased estimates. They also run regressions with ' σ ' as the risk variable in order to compare these results with those obtained from using coefficient of variation (CV).

Wheat, maize, paddy, groundnut and Desi cotton showed significant impact of the lagged acreage. The revenue ('relative profitability') variable turned out to be significant for maize, groundnut and Desi cotton, while it only bore the right sign in case of paddy and wheat.

Both the 'risk' variables, the coefficient of variation (CV) and the standard deviation (σ), bore the right sign and were found highly significant in case of maize, groundnut and Desi cotton. While only (C V) was significant for paddy, it merely had the right sign but was not significant for wheat.

Regression coefficients, their standard errors, t values, values of R^2 for three different equations for all the crops (1960-61 to 1969-70) are given in Table 2.16.

The σ coefficient was significant for maize, groundnut and cotton but not for paddy and wheat. Wheat, however, showed insignificant impact even of the coefficient of variation. For all the other crops the coefficient of variation was significant. With the above results the authors conclude that the incorporation of risk by the coefficient of variation leads to improvements in results in terms of higher R^2 .

Table 2.16 : Supply Parameters and Price Elasticities of Acreage

Crop	Model	P_{t-1}	Y_{t-1}	P_{t-1}	CVP_{t-1}	B	Short run elasticity	Long run elasticity	R^2
Wheat	I	1.2780	0.8617**	-	-	0.1385	0.0808	0.5842	0.9102
	II	1.1610	0.8345*	-10.2130	-	0.1655	0.0734	0.4435	0.9144
	III	0.3780	0.8449*	-	-5.5280	0.1551	0.0234	0.1514	0.9203
Maize	I	0.4940*	0.1834	-	-	0.8166	0.1142	0.1398	0.9827
	II	0.5491*	0.2088	-0.8871*	-	0.7912	0.1269	0.1604	0.9950
	III	0.4581	0.1509	-	-1.2350*	0.8491	0.1267	0.1492	0.9958
Paddy	I	0.1439	0.1361*	-	-	0.8639	0.0463	0.0536	0.9065
	II	0.7562	0.6428*	-2.9632	-	0.2572	0.2434	0.6814	0.9094
	III	0.5911	0.7005*	-	-2.5597**	0.2995	0.1903	0.6354	0.9382
Groundnut	I	0.8630	0.8326*	-	-	0.1674	0.5118	3.057	0.8503
	II	1.2690***	0.7657*	-2.2850***	-	0.2343	0.7526	3.212	0.9416
	III	1.3070***	0.7615	-	-2.2370**	0.2384	0.7751	3.251	0.9445
Desi Cotton	I	1.6367*	0.4689**	-	-	0.5311	0.5350	1.0072	0.8756
	II	1.3915*	0.4273*	-1.8303***	-	0.5727	0.4549	0.7943	0.9326
	III	2.0907***	0.4178**	-	-8.8727**	0.5822	0.6834	1.1738	0.9632

* Significant at 1%.

** Significant at 5%.

*** Significant at 10%.

Source : Kaul and Sidhu, pp. 429-434.

It may, however, be noted that even the inclusion of σP_t has improved the R^2 but only marginally, except for Desi cotton which shows a significant impact. The authors say that these better results are also reflected in higher elasticities. It appears that the elasticities with model III using coefficient of variation are only marginally better than those computed with the second model which uses standard deviation, except for the cotton case.

The authors point out that maize, groundnut and Desi cotton are relatively high risk crops while paddy and wheat demonstrated lesser price variability and thus were classified as low risk crops.

The maize gross profitability is deflated by sugarcane gross profitability which is ~~which is much larger than~~ ^{that} of maize; for besides other reasons, maize competes with sugarcane for only a part of the season.

The main purpose of the authors in this study was twofold: (i) to incorporate and demonstrate the appropriateness and superiority of the coefficient of variation over the standard deviation as a measure of risk, and (ii) use of the more appropriate farm harvest prices in place of wholesale prices of crops. The results, however, do not show any significant difference in the results by inclusion of the coefficient of variation in place of the standard deviation of the price. The benefit of the use of the variability of relative profitability is that it encompasses both the price and yield variabilities.

Secondly it would have been worthwhile demonstrating that the wholesale price (or index) was showing different trend and year to year variations than farm harvest prices, before incorporating the latter as the superior measure. But they did not do so. The matter is not obvious because other scholars who have tried to check this point have not got any difference in the two price series of farm harvest prices and wholesale prices.

Further the use of (yield x price) gross value of output as profitability of a crop and its ratio to a similar measure for alternative crops as a measure of relative profitability can be justified if and only if the costs of the two crops change in the same proportion as their respective ratio of Gross Revenues. Nothing was said to demonstrate it.

Response of Sugarcane Producers to Price and Non-Price Factors: Jagdish Lal (1987)

The study tried to examine the relative impact of the price and non-price factors on sugarcane acreage in the 22 districts of U.P. which were further classified into four groups, (1) western group, (2) central group, (3) eastern group, and (4) Bareilly group.

The time period under consideration was 1950-51 to 1976-77. The requisite data for the purpose were obtained from published government reports (secondary).

The model used was the Nerlovian Adjustment-lag Model which has acreage as the dependent variable and the independent

variables are: the lagged acreage, the gross relative profitability of sugarcane, and the coefficient of variation for price (in order to incorporate price risks), besides rainfall during the pre-sowing months and a time trend. The variables are incorporated in a log-linear function so as to give the elasticities directly.

The Durbin-Watson test is not appropriate for such lagged models so the Durbin-h test was used. The results show no serious auto-correlation problems. There was also no multicollinearity.

The relative sugarcane profitability emerged as the most important factor determining sugarcane acreage in 16 out of the 22 districts. The western district had maximum impact of the 'profitability' followed by the central and eastern regions. The Bareilly group showed minimum influence of profitability.

The influence of price risk on production and productivity was quite significant. The impact of the price risk variable showed the expected negative impact in half the sample districts. It was more pronounced in the eastern and least pronounced in the Bareilly region.

The lagged acreage of sugarcane was observed to have high and positive influence on acreage. The adjustment process was observed to be slower in the western groups as compared to the other groups. The author felt this could have been due to the already large area under sugarcane which

may have caused a 'saturation' in its cultivation. This saturation phenomenon is not explicable in economic terms except under the technological crop-rotation constraints to maintain the soil balance.

Rainfall was found to be a significant influence on acreage in 7 out of the 22 districts under study. The 'catch all' variable of trend turned out to be significantly positive in 12 out of the 22 districts.

The coefficients of adjustment were between 0.19 and 0.71. The short run elasticities were between 0.0026 for Etah and 0.4206 for Bareilly district. The long run elasticity with respect to profitability was found to be between 0.0047 and 1.0496. Thus the profitability of sugarcane, rainfall during the sowing period and irrigated area were found to influence area under sugarcane positively, but a quick switch over to sugarcane was not possible. The given stimulus took anything from 2 to 13 years to get worked out.

Raj Krishna and Ray Chaudhari (1980) : This paper mainly deals with India's pricing and procurement policy for two major cereals, rice and wheat. In a part of this study the authors also estimated elasticities for these two crops.

The authors tried to directly estimate the output response instead of approximating it via the acreage response, as in earlier studies. The output response is arrived at as a summation of the acreage and yield responses. Since the post-independence period showed a substantial rise in the yield

per acre of these two crops, the acreage response by itself was considered to be an inadequate proxy of the output response.

Secondly, the 'relative price' used by the authors is the 'wholesale price of the crop (rice or wheat) deflated by an index of its inputs rather than by the prices of competing crops. This appears relevant in explaining changes in per acre yield.

The authors compare the elasticities for wheat obtained by various scholars in post-Independence years with those obtained by Raj Krishna (1963) for the pre-Independence data. They observe that almost all these studies (which have significant elasticities) have the elasticities falling in the range 0.08 to 0.24. Cummings obtains price elasticity estimates around 0.24. Even this elasticity the authors say is adequate to cause substantial variation in wheat production given the high share of wheat in the region.

The authors run regressions for rice for all India, and wheat for Punjab and all India for the period 1957-58 to 1969-70. The function for rice was:

$$Q_t = f(PW_{t-1}/IP_t, RN_t, Q_{t-1})$$

where Q_t is all India rice output for the crop year July-June;

PW_{t-1} is all India wholesale price index for the period January-June i.e. last 6 months of the previous crop year;

RN_t is the all India rainfall index (by S.K.Ray) for rice for the crop in year t ; and

IP_t is the input price index (5 States) for the crop year t .

The elasticity of output for rice with respect to relative price, i.e. PW_{t-1}/IP_t was 0.45 (in the short run) and 0.85 (in the long run). The elasticity with respect to rainfall was 0.62 and that with respect to lagged output was 0.45.

In case of wheat the function is:

$$Q_t = f(PW_{t-1}/IP_t, V_{t-1})$$

where V_{t-1} is the ratio of the irrigated area in wheat to the total lagged irrigated area.

P_{t-1} pre-sowing (October-September) wholesale price deflated by input index.

The authors have run regressions for all the three variables - output, acreage and yield - in order to demonstrate the additive relation between the elasticities. Their results for all India show that the output elasticity with respect to price turns out to be 0.59 (in the short run) which is fairly close to the sum of the acreage elasticity (0.221) and the yield elasticity (0.338). But the long run output elasticity 0.812 is larger than the addition of the acreage elasticity (0.211) and yield elasticity (0.575). The output elasticity with respect to irrigation is 0.812 of which a major chunk is accounted for by yield elasticity with respect to irrigation. The results for Punjab show that the output elasticity with respect to price was 0.824 and that with

respect to irrigation was as high as 0.95. Irrigation was observed to affect yield substantially (0.78). The output elasticity with respect to price for wheat in this study is 0.59, the acreage elasticity is 0.22. This result is very close to the elasticity of wheat obtained by Raj Krishna himself (1963).

The results show that the wheat output is more responsive to irrigation than to price. The authors say, "This finding shows the pointlessness of the superficial controversy which often turns up, about the relative price or technological variables alone being important determinants of output."¹² The point is that the rate at which the farmers adopt technological innovations (besides irrigation) is a function of the prevailing output-input ratio regimes. "So the policy implication is that, for sustaining a satisfactory rate of growth the policy makers must maintain both a satisfactory price regime and rapid rate of growth of irrigation capacity, inputs supplies and technical knowledge."¹³

R.S. Deshpande and H. Chandrashekar (1982) : Price response of pulses, and grain legumes in general have been neglected by researchers. In wake of the fact that the per capita availability of pulses in the country is steadily decreasing, a closer look into their supply response is necessary. The authors addressed themselves to the investigation

12 Raj Krishna and Ray Chaudhari (1980), p. 44.

13 Ibid.

of the causes of growth in production of pulses at State level, their pattern of growth across districts and the change in it after the introduction of new technology, and the factors governing the supply response of pulses at the district level.

The State chosen for analysis was Karnataka (the seven districts chosen for the study accounted for more than 5 per cent of the State's area) as it is an important pulse growing State. The period 1955-56 to 1977-78 was chosen for the study. The authors chose as their sample two districts for each pulse: one with the highest growth rate and the other with the lowest growth rate in production. In order to contrast and compare them by fitting a Nerlovian model, of the seven districts only four could be included in this exercise. The entire period was divided into two sub-periods: (1) 1955-56 to 1965-66 and (2) 1968-69 to 1977-78. The decomposition of factors contributing to growth in these two periods revealed that there had been a definite decline in the yield and area under pulses in the second period compared to the first.

After having calculated the growth rates the authors fit five different Nerlovian distributed lags model to the highest and lowest growth districts for each pulse. They incorporate the standard deviation of prices and that of yield in order to capture the yield and price risk.

$$(I) \quad A_t = a_0 + a_1 A_{t-1} + a_2 RP_{t-1} + a_3 W_t + U_t$$

$$(II) \quad A_t = a_0 + a_1 A_{t-1} + a_2 RP_{t-1} + a_3 Y_{t-1} + a_4 GI_{t-1} \\ + a_5 W_t + U_t$$

$$(III) \quad A_t = a_0 + a_1 A_{t-1} + a_2 RP_{t-1} + a_3 Y_{t-1} + a_4 GIC_{t-1} \\ + a_5 W_t + U_t$$

$$(IV) \quad A_t = a_0 + a_1 RLY_{t-1} + a_2 RLP_{t-1} + a_3 \sigma_y + a_4 \sigma_p \\ + a_5 W_t + U_t$$

$$(V) \quad A_t = a_0 + a_1 Y_{t-1} + a_2 FHP_{t-1} + a_3 \sigma_y + a_4 W_t + U_t$$

- where A_t = area sown under the crop at time t (in ha)
- RP_{t-1} = real price of the crop at time $t-1$ i.e. the farm harvest prices deflated by wholesale price index of all crops
- Y_{t-1} = yield/ha of the crop at time $t-1$
- GI_{t-1} = gross income/ha of the crop at time $t-1$ (Rs./ha)
- GIC_{t-1} = gross income/ha of the competing crop at time $t-1$ (Rs./ha)
- RLY_{t-1} = relative yield of the crop to competing crop at time $t-1$
- RLP_{t-1} = relative price of the crop to competing crop at time $t-1$ (ratio)
- FHP_{t-1} = farm harvest price of crop at time $t-1$ (in Rs./Quintal)
- σ_y = standard deviation for preceding three years in the yield of the crop (in kgs.)
- σ_p = standard deviations for preceding three years
- W_t = rainfall in the pre-sowing months (in mm).

ESTIMATED EQUATIONS:Bengal Gram

$$\begin{aligned} \text{Gulbarga } A_t &= 9122.46 - 0.68^{***} A_{t-1} + 99.03^{***} RP_{t-1} \\ &+ 120.33^{***} Y_{t-1} - 70.16 GI_{t-1} - 2.92 W_t \\ &\text{No S.C.} \quad R^2 = 0.87 \end{aligned}$$

$$\begin{aligned} \text{Belgaum } A_t &= 3726.61 + 0.45^* A_{t-1} + 5.28 RP_{t-1} \\ &+ 7.98^{**} Y_{t-1} - 2.48 GIC_{t-1} + 4.61 W_t \\ &\text{No S.C.} \quad R^2 = 0.61 \end{aligned}$$

Red Gram

$$\begin{aligned} \text{Gulbarga } A_t &= 101581.51^{***} - 0.13 A_{t-1} + 190.41 RP_{t-1} \\ &+ 43.12 Y_{t-1} - 109.23 GIC_{t-1} - 315.94 W_t \\ &\text{No S.C.} \quad R^2 = 0.65 \end{aligned}$$

$$\begin{aligned} \text{Belgaum } A_t &= 14089.41^* + 0.31 A_{t-1} - 12.47^{**} RP_{t-1} + 20.30 W_t \\ &\text{No S.C.} \quad R^2 = 0.47 \end{aligned}$$

Green Gram

$$\begin{aligned} \text{Bijapur } A_t &= 8495.05^{***} + 0.60 A_{t-1} - 6.67 RP_{t-1} \\ &- 67.57^{**} Y_{t-1} + 47.54^* GI_{t-1} + 17.30 W_t \\ &\text{No S.C.} \quad R^2 = 0.83 \end{aligned}$$

$$\begin{aligned} \text{Belgaum } A_t &= 7262.90 + 0.55 A_{t-1} - 4.74 RP_{t-1} - 17.05 Y_{t-1} \\ &+ 8.19 GI_{t-1} - 10.06 W_t \\ &\text{S.C. test inconclusive.} \quad R^2 = 0.21 \end{aligned}$$

Black Gram

$$\begin{aligned} \text{Bidar } A_t &= 78424.19^{**} - 5007.75 RLP_{t-1} - 30288.82^{**} RLY_{t-1} \\ &- 24.92^* \sigma_y + 87.79 \sigma_p - 43.37 W_t \\ &\text{S.C. test inconclusive.} \quad R^2 = 0.37 \end{aligned}$$

$$\text{Gulbarga } A_t = 38705.50^{***} + 21.76 Y_{t-1} - 146.74^{***} \text{FHP}_{t-1} \\ - 91.13^{**} \sigma_y + 98.74 \sigma_p - 51.05 W_t$$

S.C. test inconclusive. $R^2 = 0.79$

The results given above are briefly discussed below:

Bengal Gram and Red Gram: Both showed a significant price response to real price in all districts except Belgaum. Both the crops showed a negative coefficient of the lagged acreage variable for the three high growth districts and a positive coefficient in the three low growth districts. Bengal Gram had a negative coefficient of gross income from the crop for Gulbarga district, which the authors believed to have been caused by the subsistence nature of the crop. The Gulbarga equation showed negative influence of gross income but positive impact of price. This could be due to fact that gross income does not reflect the relative profitability of the crops. GIC could have also been incorporated to get a somewhat better picture of relative incomes.

Green Gram and Black Gram: Green gram did not show significant acreage response to price; its coefficient also had the wrong sign. However, the coefficient of yield was significantly negative for both the districts. The coefficient of gross income/ha was both positive and significant. This was said to be due to the fact that it is produced primarily for domestic consumption so a lower yield would mean that a greater acreage had to be sown to get a given output (consumption requirement).

Black gram showed a negative relationship between the yield risk (standard deviation of yield) and acreage as expected. But the price variability (σ_p) is associated positively with acreage which the authors ascribe to the probable entrance of subjectivity at the field level due to the small size of sample taken for this study.

The inverse relationship between relative yield and relative price is due to 'the role of competing crops'.

The authors conclude saying that, "The supply response analysis indicates a positive response to real price of the crop and its yield. Though the crop is sensitive to real prices, the role of market price in deciding the cropped area is limited and needs further testing."

The authors use gross income along with price in one equation and along with yield in another. As gross income consists of yield/ha x price/kg x acreage under crop, it is bound to be correlated to both price and yield. Thus the equations incorporating GI and Y or GI and RP are likely to face the problems of multicollinearity which affects the results. Besides this the inclusion of σ as a proxy for risk is controvertial as discussed above, in the article by Kaul and Siddhu.

Basavraja, H. and Hiremath, K.C. (1984): The authors analyse the supply response of cotton growers in six districts (Belgaum, Bellary, Bijapur, Dharwad, Gulbarga and Raichur) of Karnataka State which together account for 92 per cent of the

production and 95 per cent of the area under cotton in the State. Hence their results can be said to be applicable to the State as a whole.

In this study the authors do two distinct things, firstly they use the Nerlovian expectation-cum-adjustment lags model for estimating the acreage response, response of the per acre yield and response of production to price. Secondly, since the process of acreage allocation between cotton and its competitors is simultaneous, they also carry out an exercise using simultaneous equations for measuring acreage response to price and other variables.

I) Nerlovian Distributed Lags Model

Where expectation lag coefficient of different expectational variables are identical. So, $A_t^* = A_t + (1 - \beta)A_{t-1}$, $Y_t^* = Y_t + (1 - \beta)Y_{t-1}$ and so on.

Note this expectation format is definitely wrong, because if A_t were available there would be no reason to have this exercise. The right expectational expression is of the form:

$$A_t^* = \beta A_{t-1} + (1 - \beta)A_{t-1}^*$$

Note they call these (following) equations including expected variables as "estimating equations":

a) Their Acreage Response equation:

$$A_t^* = b_0 + b_1 P_{t-1} + b_2 A_{t-1}^* + b_3 Y_t^* + b_4 W_t^* + b_5 I_t^* + b_6 R_t^* + b_7 \Pi_t^* + e_t$$

b) Yield Response equation:

$$Y_t^* = b_0 + b_1 P_{t-1} + b_2 Y_{t-1}^* + b_3 P_{ft}^* + b_4 W_t^* + b_5 I_t^* \\ + b_6 R_t^* + b_7 T_t^* + e_t$$

c) Production Response equation:

$$Q_t^* = b_0 + b_1 P_{t-1} + b_2 Q_{t-1}^* + b_3 W_t^* + b_4 P_{ft}^* + b_5 Y_t^* \\ + b_6 R_t^* + b_7 T_t^* + e_t$$

where (these expected variables are approximated by):

$$A_t^* = (A_t - (1 - \beta) A_{t-1}) = \text{desired acreage}$$

$$Y_t^* = (Y_t - (1 - \beta) Y_{t-1}) = \text{desired yield} = \text{average of previous five years' yield}$$

$$W_t^* = (W_t - (1 - \beta) W_{t-1}) = \text{average of the actual rainfall received during the pre-sowing months (May-June-July) for acreage models. While for yield and production models the average of rainfall deviations from normal during cotton growing season was considered as a proxy for weather.}$$

$$I_t^* = \text{desired irrigation the ratio of the total cotton irrigated area to the total irrigated area in the respective districts.}$$

$$T_t^* = \text{trend variable included as a "catch-all-variable".}$$

$$P_{ft}^* = \text{fertilizer price was taken as a proxy for purchased inputs.}$$

$$P_{t-1} = \text{price of cotton relative to jowar and groundnut in the previous year.}$$

The identification problem due to the symmetric entrance of these variables was tackled as follows: "To identify the parameters each of the equations was separately estimated for

a range of specified values of β ". The coefficient of expectation (β), was expected to fall between zero and two. It was therefore assigned values with an interval of 0.1 in both linear and non-linear forms. The value of β for which the regressor error was minimised was chosen as the best estimate. The reason for fixing the range for β upto 2 is not clear, because any value of $\beta > 1$ does not fit into the Nerlovian framework.

II) Simultaneous Equation Approach

The simultaneous equation model was specified in three equations of planted area response for three different crops namely, cotton, jowar and groundnut.

$$\begin{aligned} A_{Ct} = & K_0 + K_1 A_{Jt} + K_2 A_{Gt} + K_3 A_{Ct-1} + K_4 A_{Gt-1} \\ & + K_5 Y_{Ct}^e + K_6 Y_{Jt}^e + K_7 K_{Gt}^e + K_8 P_{Ct-1} + K_9 P_{Jt-1} \\ & + K_{10} I_t + K_{11} W_t + e_{1t} \end{aligned}$$

$$\begin{aligned} A_{Jt} = & I_0 + I_1 A_{Ct} + I_2 A_{Gt} + I_3 A_{Ct-1} + I_4 A_{Jt-1} \\ & + I_5 Y_{Ct}^e + I_6 Y_{Jt}^e + I_7 Y_{Gt}^e + I_8 P_{Jt-1} + I_9 P_{Ct-1} \\ & + I_{10} I_t + I_{11} W_t + e_{2t} \end{aligned}$$

$$\begin{aligned} A_{Gt} = & m_0 + m_1 A_{Ct} + m_2 A_{Jt} + m_3 A_{Jt-1} + m_4 A_{Gt-1} \\ & + m_5 Y_{Gt}^e + m_6 Y_{Ct}^e + m_7 Y_{Jt}^e + m_8 P_{Gt-1} + m_9 P_{Jt-1} \\ & + m_{10} I_t + m_{11} W_t + e_{3t} \end{aligned}$$

Adjustment-lag model's results: The only districts which showed a linear aggregate supply relationship were Dharwad and Raichur while log linear functions were more

appropriate for the rest. The values of the R^2 s ranged from 0.46 in Dharwad to 0.93, Bellary. While for the State as a whole it was 0.69 (Dharwad 0.79).

The values of the B coefficient ranged from 0.9 to 1.3 while those for the coefficient of area adjustment from 0.41 to 0.91. Rainfall dominates acreage decisions to a greater extent than the price factor in the districts with uncertain rainfall. The short run price elasticity ranged from 0.02 to 0.57 for the positive elasticity districts, the negative price elasticities ranged from 0.009 (Belgaum) to 0.561 (Gulbarga). The long run price elasticities were also negative for these districts at -0.012 and -0.62 respectively. The other districts had long run price elasticity ranging from 0.005 to 0.887.

The relative yield coefficient was significant for all districts except Raichur. All the districts except Bijapur and Dharwad had significant and positive impact of trend.

Yield Response Model: This model showed a positive and significant impact of prices on yield for Belgaum, Bellary, Bijapur and Gulbarga. But Dharwad and Raichur districts showed negative influence of price. The fertilizer price had a significant and negative impact on yield. Deviations in rainfall also affected it adversely. The irrigation variable was significant only for Bellary district. The relative risk-return variable was significant in Belgaum, Bijapur and Raichur, but surprisingly it had a positive sign. The authors

explain this by saying that the cotton growers in this area take the risks involved in adoption of modern technology in order to improve their yield levels. However they have no variable besides trend which is mostly insignificant to capture the effect of technology.

The Estimates of Production Response Model : A major proportion of variation in cotton production in the selected districts was explained by the production response model. The R^2 values range from 0.74 in Belgaum to 0.83 in Gulbarga.

The estimates of the price factor turned out to be positive and statistically significant in Bellary and Bijapur while Dharwad showed a negative relationship in the other districts it was insignificant.

A significant negative relationship was marked between the deviations in rainfall and cotton production in most cases. It showed that the production of cotton was adversely affected by the deviation of rainfall from its normal.

II) Area Response by Use of Simultaneous Equations

The simultaneous equation showed higher R^2 s than those with the single equation models. Both jowar and groundnut had negative and significant coefficient, showing that they were important competitors.

Both the relative yield and pre-sowing rainfall variables were found to be significant and with positive signs.

The study shows that the above treatment of the explanatory factors is an improvement over the previous studies.

This was the first time that the two way effect of rainfall was taken into account.

The simultaneous equation model gives good results as it brings out clearly the simultaneously process of the acreage decisions.

R.K. Panday and B.S. Sarin (1984-85) : The authors studied acreage response to price of rice in Uttar Pradesh during 1955-56 to 1972-73. The requisite data were obtained from "Bulletin on Agricultural Statistics for U.P.", and other official sources.

They fit a Nerlovian adjustment lag function to explain change in acreage under rice. The study deals with the four regions separately (while the hill region which is not very important from the point of rice production is left out) these regions have their distinct agro-climatic features. This study covers only four of them viz the western, central, eastern and Bundelkhand.

The western region has deep fertile soil but less rainfall, the central region has loam and sandy loam, the eastern region comprises of the gangetic plane, some parts of the southern plateau, while the northern part of the eastern region has in parts, very heavy and very scanty rain.

They used the reduced form equation of the Nerlovian adjustment-lag model into which they added three more variables

to take account of changes in per acre yield, total area under irrigation and rainfall. Thus their estimating equation is the logarithmic form of:

$$A_t = C_0 + C_1 P_{t-1} + C_2 A_{t-1} + C_3 I_t + C_4 Y_t + C_5 R_t + U_t$$

- where A_t = current acreage under rice (000 ha)
 P_{t-1} = farm harvest prices of the crop (Rs./Qt)
 lagged by one year
 I_t = irrigated acreage under the crop in the
 current year ('000 ha)
 R_t = rainfall in the region over the entire
 crop season (mm)
 U_t = stochastic disturbance term and C_i s are
 coefficients
 Y_t = yield of the crop in current year (kg/ha).

The results show no serious serial correlation problems. But they are doubtful due to the use of absolute price. The authors do not give any specific reason for using absolute prices.

Similarly they use the rainfall for the entire season, but the acreage used is only of rice so is the irrigated area. Use of relative prices and acreage would have been more appropriate. It is due to this that their results price elasticities turn out to be negative in most cases. As observed in Cummings' case the use of absolute prices does not give adequate idea about the relative profitability conditions which govern the acreage decisions.

Their results show that the R^2 s obtained were very low, because of which around 32 to 77 per cent of variation in acreage is not explained. But the authors remain undisturbed. They do not even spell out the plausible reasons for such low results. They conclude by saying that the yield exerts an important influence on acreage, it affects it positively.

Table 2.17 : Estimates of Short-run and Long-run Elasticities

Region	Price elasticity of supply		Coefficient of adjustment	R^2	SC/NSC
	SRE	LRE			
Western	0.260	-	-	0.30	++
Central	-0.020	-0.050	0.442	0.44	NSC
Eastern	0.001	0.002	0.348	0.57	NSC
Bundelkhand	-0.010	-0.060	0.195	0.78	NSC
State	0.049	0.053	0.919	0.23	++-

SC stands for serial correlation,
NSC stands for no serial correlation,
the Durbin-h test was inconclusive.

Summary and Findings

The estimates of price elasticity of acreage response for various crops obtained from these studies are summarized in Table 2.18. Before proceeding to analyse the results obtained from different studies, it is necessary to note that they are not strictly speaking comparable.

Although most of them use the Nerlovian models, some use expectation lag models while most others use adjustment lag models. This is not very problematic because both the

models have an identical reduced form. The problems start cropping up in the cases where the adjustment-cum-expectation lag model is used. In this equation the coefficients of adjustment (γ) and that of expectation (β) occur together, and their separate estimation becomes difficult unless a third variable is incorporated, in order to make the coefficients enter non-symmetrically. But there are some studies (Cummings, 1975, and Basavraj and Hiremath, 1984) which do not do this. They substitute various values of β within a particular range and then compute γ . These authors have fixed the range for between zero and two. They do not explain the reason for allowing the β to rise above unity. (We have noted at the beginning of the chapter the implications of unit and zero values of β .) The value of β greater than unity does not fit into the Nerlovian framework. Let us see what happens when $\beta > 1$. If β equals two, for example, the expected price is:-

$$P_t^* = P_{t-1} + [1 - \beta] P_{t-2}^*$$

$$\text{or } P_t^* = P_{t-1} + (1 - \beta) P_{t-2} + (1 - \beta)^2 P_{t-3} \\ + (1 - \beta)^3 P_{t-4}^*$$

Now substitute value for β as = 2 then :-

$$P_t^* = 2P_{t-1} + (1 - 2)2P_{t-2} + 2(1 - 2)^2 P_{t-3} \\ + 2(1 - 2)^3 P_{t-4} + 2(1 - 2)^4 P_{t-5}$$

$$\therefore P_t = 2P_{t-1} + (-2)P_{t-2} + 2P_{t-3} + (-2)P_{t-4} + (2)P_{t-5}^*$$

So we have the coefficient of every even (2, 4, 6 ...) year below 't' as negative, and that of every odd year before t (1, 3, 5 ...) positive. Whether the expected price is negative or positive will depend upon the relative weightage of the odd and even prices.

Similar implications and results hold true for the (γ) coefficient of adjustment. Both these results are not in keeping with the Nerlovian framework. Moreover, such alternative positive and negative weights do not have any economic logic!

It is probably due to the above reason or due to the use of absolute prices, that Cummings gets negative elasticities, and sometimes long run elasticities that are smaller than short-run elasticities.

Another reason why the studies and their results are not comparable is that most studies did not clearly indicate whether the area under the crop under study was irrigated or not. Over the years the proportion of irrigated to unirrigated area has changed. The type of crops that can be taken changes according to the availability of irrigation.

Provision of irrigation greatly expands the possibility of alternative crops being grown on the land. Under unirrigated conditions such possibility is severely limited. If and when expansion of irrigation in a given region under study takes place, the set of crops competing with the particular crop goes on changing and the degree of overall substitution

would vary in keeping with the change in the proportion of irrigated to unirrigated area. With the change in the competing crops the relative price relevant to this crop would change. When a long time-period is taken, as under time-series analysis, such problems are bound to crop up; as both the 'relevant' prices and their relative positions would change, the effects of which are difficult to capture. These effects could, to some extent, be captured if the irrigation variable is incorporated within the model. Probably the breaking up of the time period into sub-periods might have helped. It may be better to carry out the analysis separately for the irrigated and unirrigated area under the crop. The analysis in terms of mixed (irrigated together with unirrigated) area throws up doubts about the stability of the coefficients and therefore the predictive power of the model.

The results for rice show that the price elasticity of rice in the short run ranged from 0.03 for Punjab during 1950-66 to 0.49 for the same State for the overlapping period of 1948 to 1965.

The highest long run elasticity was obtained by Cummings as 0.76.

On an average the elasticity of rice obtained by most studies ranged between 0.22 and 0.28. For the all India level, the estimate was 0.22. There is no definite trend for the elasticity. The regions of Tamil Nadu and Punjab which are irrigated show higher elasticities for the crop. This may

be due to larger options open before the cultivator through the availability of irrigation.

Wheat: Except for Cummings' result which due to his use of the absolute price (as high as 0.93 for Gujarat and as low as 0.02 for Himachal Pradesh), the elasticities obtained for wheat are on the low side, with the highest elasticity obtained with relative prices being 0.67 (by Maji et al.).

Raj Krishna and Ray Chaudhari's calculations for 1957-70 Punjab shows a higher price elasticity (0.59) than Raj Krishna's estimate for the pre-war undivided Punjab (0.08). This shows some indication of rise in the price elasticities over time. This could be due to the introduction of the High Yielding Variety and their spread. The massive rise in production would not get reflected in the higher price elasticities of acreage as this increase was due to the rise in ~~price~~ ^{price yield} ~~price~~. Besides even if wheat acreage rise to a large extent in absolute term it is relatively small vis-a-vis it already large acreage this means that when wheat has to gain area it is at the cost of a large number of smaller crops. Therefore, the larger the share of the crop in the total area, the lower would be its elasticity with respect to price.

Barley: Barley shows positive elasticities ranging from 0.10 to 0.39 in short-run and 0.27 to 0.50 in the long-run. The relatively higher elasticity of Barley may be due to its being a poor substitute of wheat, grown on less fertile

soil and under lower rainfall than wheat. The relatively smaller area under barley, therefore makes its price elasticity of acreage somewhat larger, for even the same absolute shift of acreage.

Maize: The price elasticities for maize ranges between 0.11 and 0.56 during the short-run and between 0.56 and 0.66 during the long run. Like in case of wheat there is some indication of a rise in elasticity of maize in the green revolution period due to hybrid variety of maize.

Gram: Both Raj Krishna and Kaul had obtained negative price elasticities for gram. Raj Krishna's results are not significant.

Jowar: The elasticity for both jowar and bajra were found to be negative in all exercises except NCAER.

Bajra: Elasticities for bajra were negative in some studies but positive in studies by Raj Krishna and N. Rath. Their magnitude was in all cases very small.

Sugarcane: Sugarcane acreage shows positive and substantial response. Its long run elasticities are much greater than the short-run ones. Bihar and Uttar Pradesh have elasticities which are much lower than those for Tamil Nadu and Punjab. Punjab shows the highest elasticities. The studies for the latter periods show elasticity estimates that are higher than those for the earlier period. This probably indicates the growing competition of high yielding variety like rice and wheat with sugarcane under irrigation. The

short run elasticity ranges between 0.39 and 1.36.

Cotton: Cotton was found to be substantially responsive to price, by all researchers since Dharam Narain (except Cummings who gets negative elasticities for Assam, Kerala and Madras). The elasticity for irrigated cotton is larger than that for the unirrigated cotton. Cotton is grown predominantly in unirrigated areas. The elasticities for cotton in the Punjab was higher than that in other States. Raj Krishna had got long run elasticities greater than unity for both American and Desi variety of cotton. None of the studies after Raj Krishna had such high elasticities for cotton.

Groundnut: Groundnut also shows substantial elasticities but they are negative (for Gujarat, Madhya Pradesh, Tamil Nadu, Maharashtra) according to Cummings' estimates as opposed to these Madhavan, NCAER and Mahendra Reddy had obtained positive elasticity estimates for groundnut.

Jute: Jute was found to be positively responsive to price. The estimated of price elasticities ranged between 0.07 and 0.80 in the short run and 0.05 and 1.03 in the long run.

To recapitulate we note that the crops in the dry area had elasticities of lower magnitudes than those of the crops grown in the irrigated areas. Many of the unirrigated crops showed very low price elasticities, their response to price changes is very small and negligible (e.g. bajra 0.05-0.06). For all practical purposes such a small elasticity results in

a situation similar to zero supply response.

There is however some evidence (although it is not conclusive) that the introduction of the high yielding variety and hybrid under irrigated conditions has raised the price elasticity of acreage response.

Furthermore the crops with smaller shares like barley, maize, etc., have elasticities which are relatively larger than those for the other crops. This is to a great extent due to the arithmetic point that the crops with relatively smaller shares have larger elasticities than those crops having larger shares. This is due to the fact that smaller crops have a smaller base, even a small change in absolute area is reflected as a higher elasticity.

There have been inadequate exercises that compare the price elasticities of the various crops over the various agro-climatic regions.

Table 2.18 : Short-run and Long-run Elasticities of Acreage With Respect to Price of Selected Crops

Region	Irrigated/ Unirrigated	Time Period	Study	Short run price elast- icity	Long run price elast- icity	R ²
<u>RICE</u>						
All India	-	1938-1957	NCAER	0.22	-	-
Assam	Unirrigated	1938-1957	NCAER	0.10	-	-
Bihar-Orissa	Unirrigated	1900-1939	Parikh	0.23	-	-
Himachal Pradesh	Unirrigated	1949-66	Cummings	-0.07 ^a	-0.06 ^a	0.42
Kerala	-	1951-65	Cummings	-0.14 ^a	-0.12 ^a	0.91
Madras	Irrigated	1900-39	Parikh			
Madras	Irrigated	1938-57	NCAER	(0.28)		
Madras	Irrigated	1946-67	Cummings	0.08		
Madras	Irrigated	1947-65	Madhavan	-0.05 to 0.03	-0.07 to 0.04	0.88
Madras	Irrigated	1952-65	Askari and Cummings	-0.46	0.76	N.A.
Orissa	Unirrigated	1938-51	NCAER	0.05		
Punjab	Irrigated	1914-46	Raj Krishna & Venkatraman	0.31	0.59	0.79
Punjab	-	1948-65	Maji, Jha & Venkatraman	0.11 to 0.49	0.38 to 0.67	0.79
Punjab	Irrigated	1950-66	Cummings	0.03 ^a	0.05 ^a	0.99
Punjab	Irrigated	1951-64	Kaul	0.24	0.40	
Punjab	Irrigated	1955-66	Askari and Cummings	0.18	0.42	-
Punjab	Irrigated	1960-69	Kaul and Sidhu	0.04 to 0.24	0.05 to 0.68	0.90
Uttar Pradesh	Irrigated	1955-56 to 1972-73	Pandey and Sarin	0.049 ^a	0.053 ^a	
West Bengal	-	1938-57	NCAER	(0.30)		
West Bengal	-	1949-66	Cummings	0.09 ^a	0.08 ^a	0.88
<u>WHEAT</u>						
All India		1939-1958	NCAER	(0.16)		
All India		1949-1966	Maji et al.	0.01 to 0.67	0.50 to 1.02	0.94
All India		1959-1970	Raj Krishna & Ray Chaudhari	0.59		0.82
Delhi		1948-67	Cummings	0.17 ^a	0.25 ^a	0.94
Bombay		1939-1958	NCAER	(0.64)		
Gujarat		1954-65	Cummings	0.93 ^a	1.00 ^a	0.39
Himachal Pradesh		1949-60	Cummings	0.02 ^a	0.01 ^a	0.79
Maharashtra	Irrigated	1957-70	Raj Krishna & Ray Chaudhari	0.59	-	0.82
Mysore		1954-1967	Cummings	0.23 ^a	0.33 ^a	0.94
Punjab	Irrigated	1914-1944	Raj Krishna	0.08	0.14	
Punjab	Unirrigated	1914-1946	Raj Krishna		0.22	
Punjab	Irrigated	1950-1967	Cummings	0.10 ^a	0.13 ^a	0.98
Punjab	Irrigated	1960-69	Kaul and Sidhu	0.02 to 0.08	0.15 to 0.58	0.91
Punjab	Irrigated	1957-70	Raj Krishna & Ray Chaudhary	0.276	-	-

(continued)

Table 2.18 : (continued)

Region	Irrigated/ Unirrigated	Time Period	Study	Short run price elast- icity	Long run price elast- icity	R ²
Rajaasthan		1951-68	Cummings	0.02 ^a	0.03 ^a	0.87
Rajaasthan		1951-68	NCAER	0.02	0.03	-
Uttar Pradesh	Irrigated	1939-58	NCAER	0.06	-	-
Uttar Pradesh	Irrigated	1950-51 to 1962-63	Rao and Jaikrishna	0.03 to 0.21	0.09 to 0.64	0.85 to 0.94
West Bengal		1946-1967	Cummings	0.23 ^a	0.20 ^a	0.34
<u>GRAM</u>						
Punjab	Unirrigated	1914-66	Raj Krishna	0	-0.33	0.66
Punjab		1951-64	Kaul	-0.30	-0.	
Punjab		1951-64	Kaul	-1.00 to 0.49	-1.52 to +1.38	0.77
<u>BARLEY</u>						
All India		1938-39 to 1951-52	NCAER	0.16	-	
Himachal Pradesh		1949-66	Cummings	0.10 ^a	-0.26 ^a	0.84
Punjab	Unirrigated	1914-1946	Raj Krishna	0.31	0.50	0.54
Punjab		1950-67	Cummings	0.20 ^a	+0.27 ^a	0.81
Punjab		1960-69	Kaul and Sidhu	0.11 to 0.13	0.14 to 0.16	0.77
Uttar Pradesh		1938-39 to 1951-52	NCAER	0.10		
<u>SUGARCANE</u>						
Bihar		1912-13 to 1964-65	Jha	0.22	0.54	0.88
Bihar		1933-34 to 1964-65	Jha	0.27	0.39	0.71
Punjab		1900-1939	Parikh	0.57	1.36	0.88
Punjab	Irrigated	1915-43	Raj Krishna	0.34	0.60	
Punjab		1951-64	Kaul (Model I)	0.09	0.73	
Punjab		1951-64	Kaul (Model II)	0.84	0.88	
Tamil Nadu (w.r.t. ragi)	Irrigated	1947-1965	Madhavan	0.52	1.21	0.43
Tamil Nadu (w.r.t. rice)	Irrigated	1947-1965	Madhavan	0.62	0.66	0.81
Tamil Nadu (w.r.t. groundnut)	Irrigated	1947-1965	Madhavan	0.62	0.76	0.75
Uttar Pradesh		1950-68	Rathod	0.25	-	-
Uttar Pradesh		1950-68	Rathod	0.12 to 0.85	-	-
Uttar Pradesh		1951-52 to 1966-67	Chandresh Kumar	0.26	0.75	0.60
Uttar Pradesh		1951-69	K.L. Rathod	0.28	-	0.84
<u>JOWAR</u>						
Punjab	Unirrigated	1914-46	Raj Krishna	0	-0.58	0.59
Sholapur	Unirrigated	1938-57	N.C.A.E.R.	0.50	-	N.A.
Madhya Pradesh	Unirrigated	1951-64	Kaul	-0.04	-0.06	-

(continued)

Table 2.18 : (continued)

Region	Irrigated/ Unirrigated	Time Period	Study	Short run price Elasticity	Long run price Elasticity	R ²
<u>BAJRA</u>						
C.P. and Berar	Unirrigated	1920-21 to 1940-41	N. Rath	0.081 to 0.067	0.172 to 0.335	0.831 to 0.897
Punjab	Unirrigated	1914-46	Raj Krishna	0.09	0.36	0.92
Punjab	Unirrigated	1915-1964	Kaul	-0.01	-0.6	-
Punjab	Unirrigated	1915-1964	Kaul	-0.01 to -0.5	-0.02 to -1.58	-
Punjab	Unirrigated	1915-1964	Kaul	-0.08	-0.16	-
<u>MAIZE</u>						
Punjab	Unirrigated	1914-46	Raj Krishna	0.23	0.56	-
Punjab	Irrigated	1948-65	Maji, Jha and Venkatraman	0.11 to 0.13	0.14 to 0.16	0.77
Punjab	Irrigated	1960-69	Kaul and Sidhu	0.28 to 0.56	0.35 to 0.66	0.99
<u>COTTON</u>						
C.P. and Berar	Irrigated/ Unirrigated	1920-21 to 1940-41	N. Rath	0.075 to 0.105	0.240 to 0.568	0.79 to 0.903
Andhra Pradesh (Karnool)	Unirrigated	1931-41	Mahendra Reddy	0.16	0.27	-
Andhra Pradesh	Unirrigated	1951-69	Cummings	0.07 ^a	0.11 ^a	0.35
Gujarat	Unirrigated	1954-68	Cummings	0.05 ^a	0.08 ^a	0.63
Kerala	-	1957-69	Cummings	-0.39 ^a	-0.41 ^a	0.69
Karnataka	Unirrigated	1953-69	Cummings	0.29 ^a	0.33 ^a	0.88
Tamil Nadu	Unirrigated	1950-67	Cummings	-0.29 ^a	-0.32 ^a	0.52
Punjab	Irrigated	1950-68	Cummings	+0.37 ^a	+0.56 ^a	0.74
Punjab	Irrigated	1922-23 to 1941-42	Raj Krishna	0.72	1.62	0.96
Punjab	Irrigated	"	Raj Krishna	0.59	1.08	0.85
Punjab	Irrigated	1950-68	Cummings	0.37 ^a	0.56 ^a	0.74
<u>GROUNDNUT</u>						
All India	-	1938-1952	NCAER	0.22	-	-
Andhra Pradesh	-	1931-1943	J. Mahendra Reddy	0.76	0.52	0.47
Andhra Pradesh	-	1951-67	Cummings	0.69 ^a	0.52 ^a	0.47
Bombay	Unirrigated	1938-1952	NCAER	0.21	-	-
Gujarat	Unirrigated	1954-1968	Cummings	0.05 ^a	0.08 ^a	0.63
Maharashtra	Unirrigated	1955-1968	Cummings	-0.14 ^a	-0.14 ^a	0.49
Mysore	Unirrigated	1953-1967	Cummings	-0.06 ^a	-0.06 ^a	0.45
Karnataka	Unirrigated	1953-1969	Cummings	-0.29	0.32	0.45
Madras	-	1938-39 to 1951-52	NCAER	0.23	-	-
Tamil Nadu	-	1947-1965	Madhavan	0.03 to 0.04	0.04 to 0.65	-
Tamil Nadu	-	1950-67	Cummings	-0.01	-0.01	0.71
<u>JUTE</u>						
Undivided India	-	1911-1938	Venkatraman	0.46	0.73	-
Assam	Unirrigated	1949-69	Cummings	0.07 ^a	0.05 ^a	0.32
Bengal Bihar Orissa	"	1911-12 to 1938-39	Stern	0.68	1.03	-
Bengal	"	1911-12 to 1938-39	Stern	0.68	1.03	-
Bihar	"	1946-1969	Cummings	0.12 ^a	0.13 ^a	0.12
Uttar Pradesh	"	1957-68	Cummings	0.14 ^a	0.14 ^a	0.42
Tripura	"	1949-69	Cummings	0.80 ^a	1.16	0.60
West Bengal	"	1949-69	Cummings	0.40 ^a	0.35 ^a	0.59

Problems of the Nerlovian Model

Like all models the distributed lag model is an abstraction from reality and its limitations stem from this process of abstraction.

The first major difficulty recognized even by Nerlove himself is that the two coefficients, γ adjustment lag coefficients and β the expectations lag coefficient - enter the model more or less symmetrically as a result of which their separate estimation is not possible and there is an Identification Problem.

The second difficulty with the model is that the price expectation model is too simplistic for it assumes that the expectations of this year are the past year's expected normal price plus a factor proportionate to the difference between the actual price and expected normal price of the previous year. Gleen Johnson examined the North Central Farm Management Committee data and found out that the process of expectation formation of the farmer was much more sophisticated than what Nerlove had formulated.

The third problem with this model is that it offers no clue about the length of the time required to 'work out' the long run reaction. As a result of which there are infinite number of variables involved, this makes estimation by direct least squares impossible.

One solution is to use a finite distributed lags model like the Jorgenson model, where the s have pre-assigned

values. But then such pre-assignment of values takes away the very purpose of having such a lagged model which is formulated to enquire into the possible shape of the lagged function.

The reduced form reduces the number of explanatory variables involved. But the estimation of the reduced form by ordinary least squares is not advisable, as it yields poor estimates in terms of statistical properties. The main problem lies in the existence of serial correlation in the composite disturbance terms $V_t = U_t - \rho U_{t-1}$. So in a reduced form the assumption that the V_t s are independent would be ad hoc. So the O.L.S. method in this case yields not only inefficient but also INCONSISTENT estimates for the distributed lags model (unlike the classical model where the estimates are merely inefficient). So there are problems of autocorrelation (serial correlation and heteroskedasticity). The way to avoid such inconsistent estimates is to use the technique of non-linear maximum likelihood.¹⁴

As one estimates the successive lags the degrees of freedom decreases and the statistical inference from it becomes risky. Note that whenever one is dealing with the time series data the successive values tend to be correlated as a result of which there is multicollinearity (defined as presence of linear relationship among the two or more explanatory variables).

¹⁴ See Hussain Askari and R. Cummings, "Agricultural Supply Response," p. 47.

If the explanatory variables are perfectly linearly correlated then the parameters become indeterminate, it is not possible to obtain numerical values for each parameter separately. Such multicollinearity is more likely when the lagged dependent variable occurs as one of the explanatory variables in this period. Due to this the standard error becomes very large. This may lead one to wrongly declare that the statistical coefficients are not significant when in fact they are significant.¹⁵

Autocorrelation: Autocorrelation is correlation between successive values of a variable. When the successive values of a random variable 'U' are temporally dependent i.e. when the value of 'U' in period t is related to values 'u' in period t-1 then there is autocorrelation of the random variable. Such an occurrence makes the estimation inefficient.

The Autocorrelation test, by 'Durbin-Watson' d statistics, does not reflect the true magnitude of the autocorrelation when the distributed lag model is used. So the Durbin-h test has to be used. Most studies draw their influence on the basis of the Durbin-Watson test which could sometimes be misleading.

Besides autocorrelation another problem of the reduced form equation is the over-identification. The equation over-

¹⁵ Kyock Transformation: In order to overcome this problem of multicollinearity replace X_{t-1} by a single variable Y_{t-1} . Kyock has assumed that Bs decrease geometrically.

identified as the structural parameters cannot be uniquely recovered from the estimated parameters of the reduced form. One way suggested to tackle this problem of efficiency and consistence is to maximize the likelihood function of the observed with respect to the β s. Under the assumption that the disturbance terms are distributed normally.

$N(0, \sigma^2 I)$ the maximum likelihood function is

$$L(A, X, b, \sigma^2) = -\frac{1}{2} \log(2\pi) - \frac{1}{2} \log \sigma^2 - \frac{1}{2\sigma^2} (A - XB)' (A - XB)$$

The likelihood function is maximized when the sum of the squared residuals is maximized. And the estimation of the β s can be obtained by solving:

$$\partial \omega' \omega / \partial \beta_i = 0$$

In his lecture to World Congress of Econometric Society 1972, Marc Nerlove himself pointed out the ad hoc nature of most distributed lags models used in empirical econometrics, including those relating to his own work.

Nerlove goes on to talk of how the distributed-lags formulation can be made less ad hoc in the sense of being on dynamic optimising behaviour.

This can be done by understanding the dynamics in the agricultural sector. "The complex of forces set in motion by technological improvement, public investment in infrastructure and development of markets and differential abilities of economic agents to deal with the resulting disequilibrium."

(Nerlove, 1979.)

The relevant price that motivates the farmers, the trade off in allocation of resources - all these aspects need to be considered, quantified and incorporated as determinants of farmers' supply response.

Research in the area of supply response under risk and uncertainty is still to begin in real earnest. The formation of expectation is an area so vital for supply response where very few (besides M.S. Rao and Jaikrishna and Tyagi) have even attempted to dwell the formation of expectations is one of the (two) basic ways in which dynamic elements are incorporated in the basic supply response model. There has been very few studies in the Indian context which tried to verify whether the Indian farmer has rational adaptive expectations. Binswinger's (1977) exercise with rural public and his insights about their risk aversion with the help of gamble games could be fruitfully incorporated in the area of supply response. There has also be inadequate focus on the manner in which supply response has been affected by Governmental intervention.

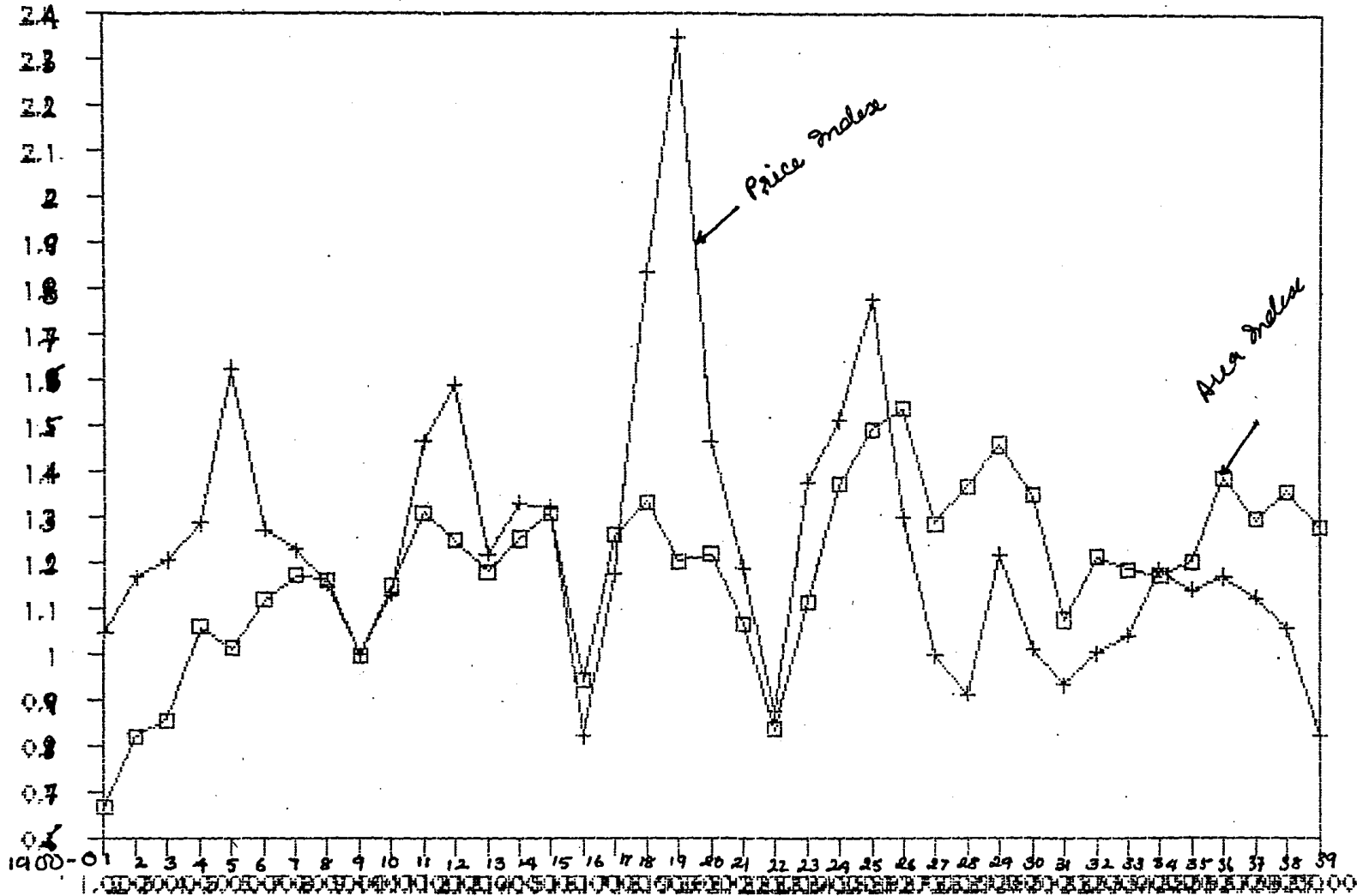
About his own model Nerlove¹⁶ comments that the simplistic and relatively ad hoc model used to study the response of U.S. farmers to price in the production of corn, cotton and wheat in the period prior to the introduction of price supports and acreage allotments is inadequate, despite the many ingenious modifications and additions other have

16 Nerlove (1979).

made to it, either to model dynamic optimization in response to changing prices or to understand the true nature of dynamic supply response in the context of a developing economy.

He says that the inadequacy of the basic supply response model to disentangle the force shaping agricultural supply in the context of a developing country is far more serious. What is lacking is both the necessary theoretical and economic tools and the basic data. So the studies at best can yield only a partial and limited understanding of the dynamics of supply in developing countries.

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Appendix I
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CHAPTER III

MARKETED SURPLUS RESPONSE TO PRICE

3.1

The marketed surplus (MS) in any year is the total quantity of production (Q) minus the quantity retained by the producers (R). This retention is for seed, feed and household consumption, etc.

The marketed surplus is thus a function of output and retention: $MS = f(Q, R)$; $MS = Q - R$. Hence in order to gauge the impact of the price on the marketed surplus, we need to know the impact of price on output and retention.

The determinants of marketed surplus are, therefore, the response of output to price, and the response of retention to price.

The response of output to price forms the major component of the marketed surplus. The more elastic the output response to price the greater is the possibility of a higher elasticity of marketed surplus with respect to price. It is well known that the degree of the response of output to price changes varies with the quickness with which inputs can be varied. The extent to which the resources can be shifted in favour of this crop would determine the ability of the farmer to respond to favourable prices.

The stock period is the time period between two harvests. During this period the output of any crop is given - and fixed. So during this period the response of the marketed surplus to price depends on the amount of stocks available, and the response of retention demand to change in relative prices. A change in the relative price of the produce causes a change in a real value of stocks. Such a revaluation changes the producers' income. This results in a change in demand for the commodity produced and the stocks retained by the farmer. Besides this there is a substitution effect. The total response to price change during this period depends upon the income and substitution effects. The short run is a period over which the inputs of some factors cannot be varied. These factors are relatively fixed factors. There can be different degrees of short-runs, depending upon how many factors are variable. During these runs the production varies according to variation in the quantities of the variable factors. As a result of this mobility of resources the output response is positive. The marketed surplus response is, therefore, greater in the short-run than in the stock period.

The long run is the period required for all the inputs to be varied. As a result of this total mobility, resources can be reallocated to the most profitable crop. During this period the entire effect of the price change is worked out. So the output response is more elastic with respect to price in the long run than in the short run.

The extent to which the change in output can be transmitted to the marketed surplus is inversely related to the extent of leakage via the change in retention demand.

The demand for retention consists of the demand for seed, feed and consumption by the farm household, and the building up of stocks.

The extent of retention for seed depends upon the total area proposed to be planted with this crop, in the ensuing season. The area to be planted would, in turn, depend upon the expectation about the relative price in the coming year.

Some farm products are used on the farm for feeding draught and milch animals. Under Indian conditions however the farmers' demand for this (except by-products like stalks, etc.) is very small.

The farmer may maintain stocks of his produce in the hope of a more opportune time (in anticipation of higher price) to dispose it off. The greater such retention the lower will be the marketed surplus.

Finally, the demand for household consumption affects marketed surplus. Of course, when the farm produce cannot be consumed by the farm household in its existing form, (or with processing within the household or in the village), or the demand for the product by the farm household is nil or negligible, then there is no practical difference between the marketed surplus and the output produced (e.g. non-edible oils, cotton, jute, mesta, etc., where the only retention is for seed).

On the other hand, the agricultural commodities which can be consumed in the form in which they are produced (or with minor domestic or local processing) are likely to have some retention for domestic use. Such retention can cause a significant difference between the output and marketed surplus calling forth a separate analysis of the marketed surplus.

The marketed surplus in this case is a function of the response of consumption to price changes and the response of production to price changes.

In case of the farm household the price of the produce and the farm income are inseparably linked. An increase in the relative price of the farm products leads to an increase in the farm income and a decrease in the relative price leads to a decrease in the farm income. This price effect can be decomposed into two distinct effects.

a) Substitution Effect: A relative fall in the price of this commodity makes it cheaper; hence the consumer substitutes it for other goods. The substitution effect of a change in price on quantity demanded is in the opposite direction of the change in relative price of the commodity.

b) Income Effect: Given the money income of any consumer, when the relative price of a commodity in consumption changes his real income (i.e. money income adjusted for price changes) changes in the opposite direction. This has a direct impact on the quantity of the commodity demanded by the consumer, the change in it being in the same direction

as the change in the real income except in the case of inferior goods.

The above holds in case of a consumer who has to purchase all his consumables in the market. But the income effect of the change in the price of the farm produce on the farm household whose source of income is this farm produce, a part of which is also consumed by the household, will, however, be different. The fall in the relative price of this farm product will reduce the value of the total farm produce and, therefore, the farmer's real income. This in turn will reduce the demand for the produce by the farm household, except when it is an "inferior" good for the household. If the income of the farm household is partly in terms of the farm produce concerned and partly in money from other sources, the income effect of a change in price of the produce would be a mixture of the above two effects. Thus:

(i) Where the income of the farm household consists entirely of the very produce which records a change in price, the real income of the household will move in the same direction as the change in relative price. Therefore, the income effect of a change in price of the commodity on the household demand for it will be in the same direction as the change in relative price except in case of an inferior good.

(ii) If the income of the farm household is partly in terms of money, and partly in terms of the farm produce concerned, a fall in relative price of the commodity produced on

the farm will lead to (a) a rise in the farmer's real income in so far as his money and other farm income go, and (b) a fall in his real income from this commodity, measured in terms of other commodities. The total change in real income would be a sum of the two opposite effects (a)+(b). This in turn will determine the change in the households' demand for consumption of the commodity. The total effect of a change in the price of farm product on the quantity demanded of it by the farm household is the sum of the substitution effect which is always negative and income effect which may be positive or negative depending upon the situation stated above. Therefore the total effect of a change in the price on quantity demanded may be in the same or opposite direction of the price rise depending upon the direction of the income effect.

We noted that the rise in price in the stock period may lead to an increase in the retention and thus a decrease in the marketed surplus. The stock period phenomenon of a backward bending supply curve of marketed surplus is a possibility which is, thus, explained within the realm of conventional economics. However, this backward bending supply curve during stock period would be a passing phase, for, as soon as the next season comes, the output can increase.

This basic theoretical background is useful in examining the studies in the area of response of the marketed surplus of foodgrains to changes in price in Indian agriculture.

Before proceeding to review the literature on this topic, it is necessary to keep in mind some limitations from which these studies suffer, often unavoidably.

Empirical studies of marketed surplus require quantitative estimation of the net quantity marketed by producers during a year. Unfortunately these data are not always available in a very reliable form. The usual data available for the purpose and used by scholars is the recorded quantity sold in the regulated markets in the country. But this suffers from certain serious limitations.

Not all markets in which the commodity is sold in the country are regulated. The number of regulated markets for which such data are reported, changes from time to time. Besides the unregulated markets where commodities are sold, there are sales in the villages to local consumers. No data from either of these are available. The use of data on sales in regulated markets alone under such conditions, amounts to presuming that what is true of changes in regulated market sales is also true of sales outside the regulated market. This would be a questionable presumption under Indian conditions.

Secondly, even if this information were available, the mere addition of the market arrivals would give us a gross figure from which the amount of grain bought back by the farmers themselves during the year should be deducted if we are to arrive at a figure of 'net marketed surplus'. This is just not available.

Thirdly, the output sold in the market may not be entirely out of this year's production. There may have been stocks carried over from the previous year and to the next year. In a year when the opening stocks are greater than the closing stocks, the current year's production has been supplemented by the previous year's stock to the extent of the difference between the two stocks; if the closing stocks are greater than the opening stocks then the opposite conclusion follows.

This carrying over of stocks from one year to the other blurs the relationship between the current year's output and the current marketed surplus. It is therefore more appropriate to compare the marketed surplus with the total production during the year plus the opening stocks. These difficulties regarding data have to be kept in mind while reviewing the few studies on the subject.

We start examining the articles on the topic with articles which subscribe to the hypothesis of the backward bending marketed surplus supply curve.

Mathur and Ezekeil (1961)

Mathur and Ezekeil put forth their hypothesis that the farmers in an underdeveloped country respond perversely to changes in prices of foodgrains. They said, "In the poor and uncertain economy of the underdeveloped countries, this analysis of the marketing process underlying the concept of marketable surplus hardly describes the true situation. It

would be much more accurate and certainly much more helpful in understanding the situation to say that farmers sell that amount of money needed to satisfy their cash requirements and retain the balance of their output for their own consumption. The residual is thus not the amount sold but the amount retained. If prices rise, the sale of a smaller amount of foodgrains provides the necessary cash and vice versa. Thus prices and marketable surplus tend to move in opposite directions." (Mathur and Ezekeil, p. 397).

It should be clear that the amount of foodgrains retained by the farmer in any year is not adequate to satisfy his needs. If in any year, therefore he is able to retain more than usual, the extra amount helps to satisfy his needs for food to a somewhat greater extent than usual. What has been said so far should not be taken to mean that the farmer's demand for cash income is necessarily completely fixed. With increase in consumption of foodgrains, there is likely to be an increase in the consumption of non-foodgrains too for which some additional cash income would be necessary, that demand for cash income is more nearly fixed than demand for food consumption and the use of the term marketable surplus, therefore tends to be misleading. So although the cash requirement by the farmers is not absolutely fixed, they treat it as fixed for all practical purposes. This fixed cash requirement is thus the kingpin of their hypothesis.

Here the cash requirement of the farmer was for payment of rent, land revenue and household consumption of non-

agricultural goods. The cash income of the farmers over and above these needs is said to be saved in kind. Sales of foodgrains thus tend to be determined by cash requirements independently of saving potentialities. They explain the saving in kind of the farmers as a reaction to the weather and price uncertainty. This behaviour they say may be construed as "the reaction of an intrinsically non-monetised economy operating on the margins of subsistence to the monetised world around". In such an economy "An increase in prices of agricultural products makes it possible for the cultivator to satisfy his monetary requirements by selling a smaller quantity of foodgrains than before" (Mathur and Ezekeil, p.399)

This hypothesis of fixed cash requirements by farm household means a zero elasticity of demand for cash with respect to income of the farm household. Since this cash is required not for its own sake but to enable the farm household to buy its requirements not produced on the farm, it implies that the household's income elasticity of demand for all such commodities is also zero. Therefore, the price of the commodity and its marketed surplus are expected to move in opposite directions.

Thus, the Mathur-Ezekeil thesis relates essentially to the response of the marketed surplus of foodgrains to change in their relative price.

V.M. Dandekar (Dandekar, 1964) examined their case systematically both on their empirical ground and on their analytical reasoning and demolished their entire case.

He firstly deals with the empirical basis of the article and later goes on to examine the economic logic or feasibility of the hypothesis on economic grounds.

Mathur-Ezekeil presented as their empirical evidence the data relating to 160 farmers in Akola and Amravati districts of Maharashtra in 1955-56 and 1956-57. They said that the data showed that the farm produce prices rose by 33 per cent during this period but the sales during this period registered a fall of 7.5 per cent, even when total output rose by 38 per cent.

Dandekar showed that the data used to establish the proposition was misleading and erroneous. On consultation with Prof. Mathur, Prof. Dandekar realized that the data referred to in the above article related not merely to food-grains but to 'all farm products'. Fifty per cent of these products of the sample farmers consisted of cotton and 10 per cent was accounted ^{for} by groundnut. So 60 per cent of these crops were cash crops which in any case are not retained for domestic consumption and were not relevant in case of Mathur-Ezekeil thesis. So far as cereals and even pulses were concerned, Mathur's own calculations in another paper relating to the same data [Mathur (1959)] showed that the price elasticities of marketed surplus were not only positive but quite high. Therefore the empirical evidence proved the contrary of the Mathur-Ezekeil thesis.

Turning to the logic of the hypothesis, Dandekar noted

that the Mathur-Ezekeil hypothesis was by the authors' own formulation not applicable to the section of the farmers who had sizable land holdings, whose consumption requirements of foodgrains were well met from their farm produce and whose response to price changes was like those of farmers in developed countries, not perverse. They said it applied to only small farmers. Dandekar however, pointed out that whatever the numerical strength of small farmers, they accounted for only a small proportion of the total area under foodgrains and an even smaller share in the total marketed quantity of it. The large farmers, on the other hand accounted for the bulk of the total marketed quantity. Dandekar illustrated the point with Mathur's own data relating to Akola and Amravati. The large farmers, with size of holdings above 50 acres, controlled 40 per cent of the total area and 60 per cent of the total sales of foodgrains! Given that, they had a positively sloping market supply curve, the aggregate market supply curve under the circumstance, is bound to be upward sloping.

Dandekar also pointed out that the small farmers, with less than 15 acres of cultivated land, constituted half of the total number of farmers; but their share in the marketed surplus was negligible. These size groups were in fact NET BUYERS of foodgrains, as their own production of foodgrains was not adequate to meet their needs. Therefore they sold little of it. They derived their cash incomes from other sources such as sales of other farm products or from wages earned.

The only group of farmers for which the Mathur-Ezekeil hypothesis may be relevant, Dandekar pointed out, is the group of semi-subsistence farmers who produce foodgrains on their small plots and have no (or very little) non-farm income, as a result of which they have a hand-to-mouth existence. The negative supply response or the backward bending supply curve would prevail in the market as a whole if and only if the share, in total marketed surplus of this group of semi-subsistence farmers were overwhelmingly large so as to outweigh the other two classes. It must be noted that the weightage of this group vis-a-vis the others is to be gauged not in terms of the number of farmers belonging to it, but by their share in the aggregate marketed surplus, which was negligible.

Thus, the Mathur-Ezekeil proposition could be valid for a small section of the farmers which was not of much quantitative significance, as it neither explained the behaviour of a large number of farmers nor the bulk of the marketed quantities of foodgrains. Even for the section for which the hypothesis holds, it does not require any new economics, said Dandekar.

Examining the logic of the marketed supply response of farmers whose entire income is in terms of their own produce of foodgrains, Dandekar argued that if the relative price of their produce declines their total real income declines. Therefore, normally the households will consume less of all

commodities including foodgrains (except inferior goods); ~~the~~ income effect, and would spend (relatively) larger amounts on foodgrains; substitution effect. So if the income effect is greater than the substitution effect, then perverse supply response follows. This is plain economic logic, and not "a reaction of an intrinsically non-monetized economy operating on the margins of the subsistence to the monetized world" (Mathur-Ezekeil (1961) p.399). Dandekar also examined the article of Khatkhate in this context.

Dina Khatkhate (1962)

Khatkhate supported the Mathur-Ezekeil hypothesis of the perverse supply response of the marketed surplus. Khatkhate believed that the small farmers have a perverse supply response and the large farmers have a normal supply response.

In subsistence agriculture, he argued, "Whatever is produced is barely sufficient to meet the consumption requirements of producers. And yet - paradoxically enough - farmers in this sector part with a portion of their produce against money payments. The pressures on farmers to sell produce despite a subsistence level of consumption, arises from certain fixed charges such as land revenue, rent, debt service and only to a small extent non-agricultural necessities which are inescapable. This paradox, we may call it a 'stinted consumption paradox', thus makes it imperative for farmers in subsistence sector to market a portion of their output against their will." (Khatkhate, 1962, p. 188).

Talking about farmers' response to price he said that the farmers on the small farm try to produce to the maximum extent their farm capacity permits. Secondly "their demand for cash income is more nearly fixed than their demand for food consumption so they try to increase their food consumption at every possible opportunity." (Khatkhate, 1962, p. 189).

Given the above two points, suppose price of agricultural output rise in relation to non-agricultural prices. "Since money requirements are a prior fixed charge on the farmer's output, he would be prone to market, a small proportion of his output for cash in view of price-rise and consequently the consumption of his output, which is already sub-normal, would increase. But this rise in price would not have any impact on production as he is already producing to the hilt to raise his consumption." (Khatkhate, 1962, p.189).

Khatkhate's argument was based on the notion that the small farmers had a predominant share in the total marketed surplus. Their supply of the marketed surplus, Dharam Narain had shown, was around 62.4 per cent of the total marketed surplus (Dharam Narain, 1961). So the perverse effect of these subsistence farmers, Khatkhate said, was expected to prevail over the effect of the non-subsistence farmers.

Now this proposition about the relative share of the subsistence farmers is empirically verifiable. Dharam Narain's data on the basis of which Khatkhate had drawn his conclusions, has been questioned by many authors, and it will be dealt with

in Section 3.3 where we discuss the relationship between size group of holdings and marketed surplus.

Coming back to the analytical points, Khatkhate's notion that the farmer is producing to his maximum capacity or 'to the hilt' is peculiar. He argued that the farmer is already producing the 'maximum' he can; so perhaps he does not need any more of purchased inputs, for they would probably not lead to any additional returns. Prof. Dandekar questioned this line of argument. He asked if the maximum output plausible would remain the same with and without resources. Would a little more input really result in no additional output? Would the farmer being better fed not increase his productivity, and, with better maintained equipment, not change the level of production?

Khatkhate ruled out several kinds of influences of prices. He said that the change in relative price also would not cause any change in the saving investment position of the farmer. He refused to allow for any change in the debt/saving position, even in the phase of falling prices. Khatkhate's farmer seemed to be a rare specie, because:

When the prices fall, he has to sell a larger amount to obtain his fixed cash requirements. This leaves less for satisfying his already inadequately satisfied consumption needs. Such a treatment of consumption of non-foodgrains as a residual by both Mathur-Ezekeil and Khatkhate implicitly assumes a very high elasticity of demand for consumption of foodgrains. In reality in a bad crop year even the greatest

parsimony cannot stop a deficit; for, when the already inadequate consumption decreases the farmer is forced to borrow. And when the prices rise the farmer's income and savings will rise. But Khatkhate's farmer has no change in his saving and investment in either period!

Prof. Dandekar concluded saying that although the backward bending supply is feasible, it is confined to the small section of subsistence farmers. The viable sector, with a normal supply curve, however, outweighs it in total market supply.

3.2 Elasticity of Marketed Surplus

There were few actual estimations of the elasticities of Marketed Surplus of foodgrains. Most papers in this section were mainly concerned with deriving formulae for price elasticity of the marketed surplus. These studies estimated the ranges within which the elasticity of marketed surplus would lie depending upon the production and consumption elasticities which in turn depend upon income and substitution effects. These models thus estimated the elasticity of market surplus indirectly.

T.N. Krishnan (1965)

Krishnan like Olson¹ explains variation in marketed surplus in terms of the income effect of prices vis-a-vis the substitution effect. Although T.N. Krishnan's conclusions may

1 Olson (1960).

appear to lend support to the Mathur-Ezekeil hypothesis of the inverse relationship between the marketed surplus and price, his analysis is more logical than the other articles in this set. He makes the least restrictive assumptions.

He criticises the earlier authors in this area for making assumptions about fixed cash requirements and savings in kind. He says that the only conditions that are necessary and sufficient for the inverse relationship between price and marketed surplus are :-

- (1) Agricultural income is directly proportional to foodgrain prices;
- (2) There exists a well defined demand function for foodgrains for the agricultural sector and the income elasticity is greater than the price elasticity; and
- (3) That the proportion of output marketed is positive.

Krishnan calculated the elasticity of marketed surplus for Punjab during 1960-61 taking the Marketed Surplus as a function of the income and price elasticities. The marketed surplus is Output minus Retention demand, if output is denoted by \bar{Q} and r is the proportion of output consumed, we have the marketed surplus as:-

$$MS = \bar{Q} - r\bar{Q} \quad \dots (1)$$

(as output in the stock period is fixed ^{hence} there is a bar sign on it).

$$MS = \bar{Q}(1 - r) \quad \dots (2)$$

$r\bar{Q}$ = quantity of output retained for consumption is a function of the price of this produce and the income of the farmer which is $\bar{Q}P$. So we have:

$$r\bar{Q} = f(P, \bar{Q}P) \quad \dots (3)$$

He specifies the demand function as:

$$r\bar{Q} = AP^{-\alpha} (\bar{Q}P) \quad \dots (4)$$

Simplifying (4) we get (5)

$$r = AP^{B-\alpha} \bar{Q}^{\beta-1}$$

or

$$1 - r = 1 - AP^{B-\alpha} \bar{Q}^{B-1} \quad \dots (5)$$

Substituting (5) into (2) we get

$$MS = \bar{Q}(1 - AP^{B-\alpha} \bar{Q}^{B-1}) = \bar{Q} - AP^{B-\alpha} \bar{Q}^B \quad \dots (6)$$

Now differentiating (6) with respect to P we get (7)

$$\frac{M}{P} = -A\bar{Q}^B P^{B-\alpha-1} (B - \alpha) \quad \dots (7)$$

$$\frac{M}{P} \cdot \frac{P}{M} = -A\bar{Q}^B P^{B-\alpha-1} (B - \alpha) \cdot \frac{P}{\bar{Q} - A\bar{Q}^B P^{B-\alpha}}$$

$$\text{Elasticity of Marketed Surplus} = \frac{-(B - \alpha) A\bar{Q}^B P^{B-\alpha}}{\bar{Q} - A\bar{Q}^B P^{B-\alpha}}$$

$$= -(B - \alpha) \frac{\bar{Q}(r)}{\bar{Q}(1-r)}$$

$$= -(B - \alpha) \frac{r}{(1 - r)}$$

Here $\frac{M}{P} \cdot \frac{P}{M}$ is the income elasticity and $\frac{\bar{Q}(r)}{\bar{Q}(1-r)}$ is the price elasticity of the farmers' demand function, 'r' will always be between

zero and one. He takes the price elasticity (0.3584) and the income elasticity (0.5216) from his Ph.D. thesis, while the r is taken as 0.35 because the rural credit survey says that around 35 per cent of the total production is sold by the cultivator. Here his calculation leads to a negative price elasticity, of marketed surplus, he says that this negative price elasticity is a stock period phenomena. The position is bound to change once production changes. In his next exercise he examines the market arrivals for four major wheat producing States, Punjab, Uttar Pradesh, Madhya Pradesh and Rajasthan for the period 1960-61 to 1963-64. On this basis, he says that although the preliminary analysis of the seasonal pattern of market arrivals seems to contradict this hypothesis, only econometric analysis would tell whether the farmers are becoming more price conscious or not. Krishnan's exercise gives a more logical and theoretically valid explanation of the occurrence of a perverse supply response in the stock period.

Raj Krishna (1962)

A systematic effort at estimating the elasticity of marketed surplus was made by Raj Krishna. Due to inadequate data regarding the actual marketed surplus, Raj Krishna resorted to the estimation of the elasticity of marketed surplus indirectly. In this exercise he derives an expression of the elasticity of the marketable surplus for a single subsistence crop and examines its plausible limits by assuming plausible limits for the Indian economy.

Notation: Q = the quantity of wheat produced; C = the quantity of wheat consumed; M is the quantity of wheat marketed; C/Q the consumption ratio; $m = M/Q$ the sales ratio; P = the relative price of wheat; Y = the total income of the peasants; e = the elasticity of the market supply with respect to P ; d = the total elasticity of home consumption with respect to P ; b = the elasticity of output with respect to P ; h = elasticity of the income effect.

Since the market supply is

$$M \cong Q - C \quad \dots (1)$$

it follows that $\frac{dM}{dP} = \frac{dQ}{dP} - \frac{dC}{dP}$

$$\text{or in terms of elasticity } e = rb - (r - 1)d \quad \dots (2)$$

The ratio r will be between zero and one. Raj Krishna further considers the range of this elasticity e depending on the different values which the other elasticities assume: (i) if b the elasticity of output is positive and d , the elasticity of home consumption is negative e will be positive. (ii) If b is positive and d is positive, e will be negative. (iii) If b and d are both negative, e will be positive so long as:

$$r |b| < (r - 1)d \quad \text{or} \quad |b| < c|d| \quad \dots (3)$$

where $c = \frac{r-1}{r}$ = the proportion of output consumed. (iv) If b and d are both positive, e will be positive so long as $rb > (r-1)d$ or $b > cd$.

He examines case (i) and (iv) further. He specifies the home consumption function as

$$\frac{dc}{c} = g \frac{dp}{p} + h \frac{dy}{y} \quad \dots (4)$$

where g is the elasticity of the substitution effect while h is the elasticity of income y .

If income from wheat forms a proportion 'K' of the farmer's income, an increase in price by say 10 per cent would raise his income by K 10%:-

$$\frac{dY}{Y} = \frac{dP}{P} \cdot \frac{QP}{Y} = K \frac{dP}{P} \quad \text{where } K = \frac{QP}{Y}$$

Since the farmer is a producer as well as consumer a change in his total income is:

$$\begin{aligned} \frac{dY}{Y} &= \frac{dP}{P} \left(\frac{PQ}{Y} - \frac{PC}{Y} \right) = \frac{dP}{P} \left[\frac{P}{Y} (Q - C) \right] = \frac{dP}{P} \cdot \frac{PM}{Y} \\ &= \frac{dP}{P} \cdot \frac{PQ}{Y} \cdot \frac{M}{Q} \end{aligned}$$

$$\frac{dY}{Y} = MK \frac{dP}{P} \quad \dots (5)$$

$$\text{hence 'd' } = \frac{dC}{dP} \cdot \frac{P}{C} = g + mhk \quad \dots (6)$$

equations (1), (4) and (5) constituted his simple model.

Nowshirwani has pointed out that Raj Krishna does not specify as to which kind of substitution effect he uses, is it the substitution effect with income kept constant or that with utility kept constant.

If he takes the substitution effect given that $Y = \bar{Y}$ we have a farmer's income as: income from other sources say Y_0 + income in terms of his revenue from the sale of this product, hence the farmer's income is $Y = \text{Constant} + QP$ (7)

By differentiating both sides of (7) we get:

$$\frac{dY}{dP} = Q \frac{dP}{dP} + \frac{dQ}{dP} \cdot P$$

$$\text{or } dY = QdP + \left[\frac{PdQ}{dP} \cdot dP \right] \quad \dots (8)$$

by substituting (8) into (4) Raj Krishna should have got:

$$\frac{dC}{C} = g \frac{dP}{P} + h \frac{[QdP + (P \frac{dQ}{dP} \cdot dP)]}{Y} \quad \dots (9)$$

$$\text{or } \frac{dC}{C} = g \frac{dP}{P} + h \left[\frac{QdP}{Y} \right] + h \left[\frac{P}{Y} \frac{dQ}{dP} \cdot dP \right]$$

$$\text{or } \frac{dC}{C} = g \frac{dP}{P} + h \left[\frac{QP}{Y} \right] \frac{dP}{P} + h \left[\frac{QP}{Y} \right] \left[\frac{dQ}{dP} \frac{P}{Q} \right] \cdot \frac{dP}{P}$$

$$\text{So } \frac{dC}{C} = g \frac{dP}{P} + hK \frac{dP}{P} + hK b \frac{dP}{P} \quad \dots (10)$$

$$\text{Thus } d = \frac{dC}{dP} \cdot \frac{P}{C} = g + hK + hKb \quad \dots (11)$$

instead of (11) Raj Krishna gets (6)

$$\text{So } d = g + mhk \neq ghk + hkb + hk \quad \dots (12)$$

This happens because Raj Krishna forgets the $dP \cdot \frac{dQ}{dP} \cdot P$ in equation (8).

But if he had taken the substitution effect keeping utility constant (i.e. movement along the same indifference curve) $U = \bar{U}$ he should have had:

$$U = \bar{U}$$

$$C = (P, Y)$$

$$dC = \left[\frac{dC}{dP} \right]_Y dP + \left[\frac{\partial C}{\partial Y} \right]_P dY$$

$$\frac{dC}{C} = g' \frac{dP}{P} + \frac{hdY - CdP}{Y}$$

$$d = g' + mhk + hkb$$

This again is not equal to Raj Krishna's expression of $d = g + mhK$.

Note that (due to its small value) omitting of hkb is not so serious a problem as having a wrong value of g . He gets

$$g' = g + \frac{C}{Y} P$$

Because of his different value for 'd' Raj Krishna gets a different expression for elasticity of home consumption with respect to P .

$$e = rb - (r - 1) (g + mKh)$$

Due to this expression of elasticity Raj Krishna gets a perverse supply response only when the elasticity of output (i.e. b) is negative and elasticity of consumption (i.e. d) is positive. He says even if b is positive the likelihood of a perverse market supply behaviour is extremely small. Hence he concludes that estimated market supply behaviour is mostly positively responsive. The backward sloping marketed supply response function may be as rare as the backward sloping total output function for individual crops. Raj Krishna's elasticity (see the Table 3.) has a lower negative range than that which is actually feasible according to the correct expression stated by Nowshirwani.

Now, besides the basic error of the omission of the partial derivatives, Raj Krishna made a further mistake; he treated the relative price (P_1/P_2) as if it were a single absolute price while taking derivatives.

Table 3.1: Plausible Ranges of the Price Elasticity of the Marketed Surplus of Wheat in Punjab

m value	m = 0.1	m = 0.5	m = 0.9
Raj Krishna	2.30 to 5.56	0.12 to 0.78	0.08 to 0.06
Nowshirwani	-2.74 to 5.56	-0.216 to 0.74	0.07 to 0.56
Behrman	-2.56 to 6.03	-0.19 to 0.85	0.07 to 0.26

Source: Behrman (1968), p.195, Nowshirwani

Secondly Raj Krishna's model does not make a distinction between short run and long run response, between actual and expected normal income and between actual and expected quantities.

Summing up, in spite of these errors in the formulation the Raj Krishna model remains the first systematic effort in this area. Its basic limitation however is, that it underestimates the probability of a perverse supply response due to the error in the term for the elasticity of marketed surplus.

Behrman had criticised Raj Krishna for the neglect of the time-dimension while computing elasticity, for if no such specifications are made it would imply that the time period was sufficient for complete adjustment to take place. For policy purposes, however, the response within a specified period is required.

Behrman has tried to incorporate this time dimension in his model, by making the partial derivatives a function of

the time allowed for adjustment. He takes the elasticity of the marketed surplus as the elasticity of output minus the elasticity of consumption.

But the marketed surplus, the output and consumption are all functions of price. So differentiating the above equation (1) with respect to price, Behrman gets different elasticities which are much higher than those obtained by Raj Krishna, and what is more important is that these elasticities have a much larger negative range (refer Table 3.1).

He gets the expression for elasticity of marketed surplus as:-

$$e = rb_1^* - (\dot{r} - 1)[g + hk(1 - b_1^*)] - (r - 1)hb_2(1 - k)$$

where b_1^* is $\frac{P}{QI} \times \frac{dQI}{dP}$ the price elasticity of the cash crop with respect to its market price and the b_2 is the price elasticity of the food crop demand all the other notations are the same as those specified in Raj Krishna's article.

Partly because of the computational error in Raj Krishna's computation and partly because of the inclusion of the 'time' element Behrman's expression for marketed surplus elasticity is different from that obtained by Raj Krishna.

Elasticity of marketed surplus according to Raj Krishna minus that according to Behrman is:-

$$(r - 1)hk(1 - m + b_1^*) + (r - 1)hb_2(1 - k).$$

The difference in the elasticity of marketed surplus results in a different plausible negative range and consequently a different policy implication.

3.3 Marketed Surplus and Size of Holdings

Dharam Narain (1961) Dharam Narain was probably one of the first researchers to estimate the interrelationship between the size group of holdings and the marketed surplus, in the Indian context.

Dharam Narain considered all agricultural product actually marketed by different size classes of operational holdings. The author arrived at the marketed surplus by a series of calculations from the first round of NSS (1950), the Agricultural Labour Enquiry Reports, Farm Management Surveys and the reports of the National Income Committee. He used the distribution according to size classes of per capita expenditure from the NSS to arrive at the distribution according to size-group of holdings, although he could not trace the exact nature of the relationship between the two.

"But although we do not know this exact relationship we can safely assume a property of it: that rising level of per capita expenditure will be associated with increasing size of per capita holding. This simple property is found on reflection to be highly significant. The starting point of the reflection is grounded in the fact that exactly the same population which lies interspread between different size-groups of holdings also lie interspread between different expenditure classes."²

2 Dharam Narain (1961), p. 7.

The above assumption is very restrictive as it does not visualize the existence of spenders who supplement their agricultural incomes with incomes from wages, and any non-agricultural incomes.

The author further assumed that all agricultural labour belongs to the lowest size-group of holdings. Here he forgets that even families with sizable land holdings may have their members working as agricultural labourers.

Dharam Narain first calculated the estimates of marketed surplus without any correction for the well known inconsistency of the NSS results with the official statistics. This estimate gave the marketed surplus as 22 per cent of the output. But the All India Rural Credit Survey had independently arrived at the estimate of 35 per cent. In order to reconcile his estimate (I) with that of the AIRCS, Dharam Narain drew another estimate (II), on the understanding that the NSS output figures were under-estimates. He revised the output figures for each size group upwards by 30 per cent. Along with this, even some retention items like seed, feed, rent and payment to artisans were also revised upwards. This 'correction' not only raised the proportion of the marketed surplus to the 'realistic level' of 33.6 per cent, but also had an impact of inflating the relative importance of holdings below 10 acres.

The results show the marketed surplus as a proportion to the value of produce declines upto 10-15 acres size-group

Table 3.2 : Size Distribution of Marketed Surplus (Estimate II
Dharam Narain)

Size Group	Total Gross Value of Output	Marketed Surplus	% of total Marketed surplus accounted by each size group	Marketed surplus as proportion of output
0 - 5	1678.6	564.0	33.6	26.0
5 - 10	1626.0	444.8	27.4	20.5
10 - 15	735.5	170.1	23.1	7.9
15 - 20	573.7	172.8	30.1	8.0
20 - 25	344.9	111.0	32.2	5.1
25 - 30	293.9	116.8	39.7	5.4
30 - 40	350.4	139.6	39.8	6.4
40 - 50	232.1	107.8	46.4	5.0
50 and above	661.4	339.9	51.4	15.7
Total	6496.5	2166.8	33.4	100.0

Source : Dharam Narain (1961).

after which it steadily increases. This peculiar U-shaped marketed surplus curve that Dharam Narain gets, could be due to the impact of a number of other factors like heterogeneity in productivity of land, size of the farm household, extent of non-farm income and proportion of land used for cash crop.

The crux of Dharam Narain's findings for 1950-51 lies in two findings: (1) Holdings below 15 acres in size contribute to 54.4 per cent of the marketed surplus, of which those below

10 acres contribute 46.5 per cent of total marketable surplus. (2) The marketed surplus as the proportion of the value of output declines till 10-15 acres after which it steadily rises. This was interpreted as "distress sale" by the farmers of the smallest size group, who sell a larger proportion of output than the middle size group farmers. Large farmers show a normal pattern with progressively higher share in the output that is marketed.

Utsa Patnaik (1975) has corrected Dharam Narain's estimates by making four alternative adjustments: (1) She uses three years' farm management data to 'correct' the 'yield' estimates arrived at by Dharam Narain's single year data. (2) The NSS consumption figures were known to be over-estimates, hence she scales them down by 15 per cent. (3) The Feed bill was revised downwards. (4) The foodgrains consumption of agricultural labour was taken to be one-third of the total consumption of the rural population as they constituted one-third of the population. This over-estimated their consumption, and under-estimated the consumption of the cultivators thereby inflating the estimate of their marketed surplus. She takes consumption of the agricultural labourers as (a) one-third of the lowest class of the rural population or (b) two-thirds of the lowest class of rural population. Of all these adjustments, adjustment 4 with both (a) and (b) gave best results. They gave realistic estimates of the marketed surplus of each size class which was consistent with the AIRCS estimate (of 0.35).

Table 3.3 : Size Distribution of Marketed Surplus

Size Group	Revised estimates for 1950		Estimates for 1960	
	Marketed surplus as % of output	Marketed surplus of each group as % of total marketed surplus	Marketed surplus as % of output	Marketed surplus of each group as % of total marketed surplus
0 - 5	14.0	10.3	23.8	16.4
5 - 10	21.0	16.3	21.0	15.2
10 - 15	33.8	14.9	33.8	13.9
15 - 20	32.7	10.0	32.7	9.3
20 - 25	38.2	7.4	38.2	6.9
25 - 30	41.0	6.3	41.0	5.9
30 - 40	47.3	9.6	47.3	8.9
40 - 50	50.3	6.4	50.3	6.0
50 and above	54.0	18.8	54.0	17.5
Total	31.0	100.0	32.6	100.0

Source : Utsa Patnaik (1975), p. A-98.

Ashok Rudra (1982) however criticised Dharam Narain for the restrictive nature of his assumption discussed above. About Utsa Patnaik he says "In a recent paper Utsa Patnaik claims to have arrived at results different from those of Dharam Narain by following basically the same kind of statistical manipulations carried out by the latter; but for that very reason her estimates are to be treated as equally unreliable" (Rudra, 1982, p. 287).

Another study in this area was by Raj Krishna (1965). Raj Krishna's study however was restricted to a single superior crop. His data was obtained from direct observation from the sample farmers from eight Indian villages, from various States.

Raj Krishna classified the data into three distinct size groups: large, medium and small, and tried to fit three different kinds of functions (linear, joint linear and quadratic) to the size of holding-marketed surplus data. He found that the linear relationship held for all the groups.

In some cases the quadratic function gave a good fit. Raj Krishna concludes, "These facts seem to suggest that very poor villages with very low dispersion of income (or output or holding-size) are more likely to be characterized by a non-linear marketable surplus function than other villages. In a general atmosphere of extreme poverty the marginal sales propensity of those few who produce more than the rest is likely to be greater than the rest ... relatively very rich villages are also likely to have a non-linear marketable surplus function. After a certain level of income is reached the cultivation of the subsistence crop becomes highly commercial and the marginal propensity to sell rises with output."

Commenting on this result N. Krishnaji (1965) said that the samples drawn are deliberately drawn to prove the validity of the 'linearity of the marketed surplus' hypothesis. According to Brahmanand Prasad greater weightage was given

to surplus States. M. Mujumdar points out that the elasticity results obtained by Raj Krishna are greater than unity to start with but later they go on decreasing, till they reach unity. However Raj Krishna does not explain this phenomena. C.H. Hanumanta Rao (1965) points out that by treating the kind payment by large farmers as marketable surplus, Raj Krishna has over-estimated the elasticity of marketed surplus because the quantum of kind payments increase with increase in farm size. The factor of family size was also known to affect the marketed surplus, Raj Krishna, however, had to drop it due to emergence of the problem of multicollinearity.

Note that Raj Krishna used these results obtained for a single superior crop as if they were the results of the entire marketed surplus. C.H.H. Rao (1975) pointed out that Raj Krishna's conclusions were likely to be misleading given the fact that the cash crops production has low or no retention for domestic use, and that the proportion of the land holding allocated to the cash crops increases with the size of holdings. His conclusion would be meaningful if it were shown that this crop (wheat) was the only or predominant crop in this area.

So the linear-relationship cannot be accepted, the constant MPC can be only discussed in the context of the total marketed surplus. Rao further says that the conclusion drawn by Raj Krishna have a lean theoretical base and could be as meaningless as those flowing from a policy notion lacking in factual evidence.

The important conclusion that emerges from the articles reviewed so far is that the marketed surplus response to price is affected by the size of holdings. A separate treatment of the supply response of different group of farmers is therefore necessary.

The first effort in this direction was made by Prof. P.N. Mathur in his article (1962). For examining the plausible differential supply response he examined the accounts of 112 farmers in Akola and Amravati districts of Vidarbha region, for the period 1955-56 and 1956-57.

He defines cultivators with holdings less than 15 acres as small and those with holdings greater than 15 acres as large farmers. For these two groups he calculates the index of prices received:prices paid. The prices received consists of prices received from sale of crops and sale of intangible labour. While the prices paid consists of a price index for domestic monetary expenditure, price index for business expenditure on goods and intangibles.

His 'results' show that during the two years under consideration the terms of trade i.e. prices received/prices paid were becoming favourable to agriculture. But the dimension of the favourable turn differed for the two size-groups. The terms of trade index for the big cultivators registered a rise of 53 per cent while that for the small cultivators rose by 23 per cent. The pasche index showed a 4 per cent rise for the big cultivators against a 3 per cent rise for the small cultivators.

Prof. Mathur says that this differential is due to the fact that a large proportion of the small farmers' income or price received arises from the 'wage component' which were observed to be stickier than prices.

Prof. Mathur however forgets to cite the most crucial reason for this, which is that the small farmers are net buyers of foodgrains, their terms of trade is thus adversely affected when prices rise. Besides this, the two year period chosen for the study is grossly inadequate to draw any conclusions of differential terms of trade.

A more systematic study of the topic was made by K. Pushpangadam.

K. Pushpangadam (1979) starts by distinguishing between the marketed 'distress' surplus and marketed 'commercial' surplus. After this he classifies the farmers into three distinct groups. The large farmers with enough land who contribute to the commercial surplus, with the production of other crops, the medium farmers with limited land who contribute to a portion of the distress surplus, with little production of other crops and the small farmers with practically fixed land who contribute the rest of distress surplus, with little or no production of other crops.

He has presented different models for the computation of the elasticity for these different size groups of farmers.

He says that the elasticity of marketed surplus of a food crop, partly grown for on-farm consumption and partly

for sales, is disaggregated into price elasticity of commercial and distress surplus. The stock element is included in the elasticity of the marketed surplus of the large farmers since this group contributed to the commercial surplus. The farmers who contribute the distress surplus are further divided into medium and small according to the acreage allocation. A farmer is considered to be medium if he allocates some land to crops other than the crop under consideration, and a small farmer if he cultivates only the crop under consideration. The author works out the elasticities for these categories with actual data from Thanjavur district of Tamil Nadu for the year 1968-69. .

He takes the marketed surplus elasticity as a function of the supply elasticity of the crop with respect to its relative price which in turn is a function of the time required for adjustment; stock elasticity with respect to price and consumption elasticity with respect to output; the consumption sales ratio; the output sales ratio and the stock sales ratio. This was for large farmers.

He does not include the stock variable and its elasticity for the other two categories, but instead used the ratio of value of production to income (in addition to the other variables mentioned above) for the small farmers. For the medium farmers he adds to these the yield variable.

The elasticity of the largest size-class was observed to be negative without stock but positive when stocks were

Table 3.4 : Size-Groupwise Price Elasticities

Units	Size (ha)			Aggregate
	Large (3.05 and above)	Medium (1.17 to 3.05)	Small (0 to 1.16)	
<u>Without Stocks</u>				
Minimum	-0.54	-2.09	-0.79	-0.79
Maximum	-1.38	+1.27	-1.51	+1.32
<u>With Stocks</u>				
Minimum	6.68	-	-	5.20
Maximum	10.12	-	-	8.23

considered while the medium farmers also had a negative range of elasticity, the small farmers' elasticity range was however only negative. But since the large farmers contributed around 83 per cent of the marketed surplus while the medium and small farmers contributed only 15 and 2 per cent, the effect that is bound to prevail is that of the large farmers. The aggregate elasticity computed with stocks is positive for the large farmer group.

The plausible reason for these results is pointed out by Dipti Prakash Pal (1980) who points out that the author's conclusions are tautological e.g. (1) he starts with the condition that the sum of commercial surplus and distress surplus is positive, and then goes on to derive conditions for it to be positive.

Secondly he assumes both commercial and distress surplus to be positive, this ensures the positivity of the total ^{Sales of the} of the small, medium and large farmers in the final equation.

In his reply to the above criticism Pushpangadam accepts the criticism, and tries to incorporate some cases where these assumptions are relaxed. This however does not cover all the cases.

On the whole the analysis is, well begun and half done. Its only utility lies in illustrating the need for a separate analysis of different size group of holdings and the need to incorporate the stock variable.

3.4 Direct Estimation of Elasticity of Marketed Surplus

Kalpana Bardhan (1970): Kalpana Bardhan used the cross section data from the socio-economic survey of 27 villages from Punjab and U.P. conducted by Agro-Economic Research Centre of the University of Delhi. She takes a 'closed village model', where the marketed surplus is taken as the difference between production and consumption. She explains marketed surplus of cereals and pulses as a function of total foodgrain output per adult cultivator; average price of foodgrains, income of the cultivators from non-crop sources; an index of concentration of land holdings and non-sales disposal minus other receipt of foodgrains. Thus the elasticity of the marketed surplus with respect to price (P_f) is the production (O_f) elasticity with respect to price minus the consumption (C_f) elasticity with respect to price. The sales or

marketed surplus is equal to:

$$S = O_f(P_f/P_c) - C_f(O, P_f)$$

or
$$S = \frac{S}{O_f} = 1 - \frac{C_f(O, P_f)}{O_f} - \frac{N}{O_f} \quad \dots (1)$$

where P_f is the price of the crop under consideration and P_c the price of the competing crop. The cultivator's total income is the income from his agricultural produce plus that from other sources so :

$$O = P_f O_f(P_f/P_c) + P_c O_c \quad \dots (2)$$

The elasticity of the marketed surplus with respect to price is arrived at by differentiating equation (1) with respect to P_f and multiplying it by P_f/S . So we have :-

$$\frac{\partial S}{\partial P_f} = \frac{-C_f}{O} \left[\frac{\partial C_f}{\partial O} \times \frac{\theta}{C_f} - \frac{\sigma_f}{P_f O_f} O \right] \quad \dots (3)$$

$$\frac{\partial S}{\partial P_f} = \frac{C_f}{O} \left[\frac{\sigma_f}{P_f O_f} O - e_f \right] \quad \dots (4)$$

where (σ_f) is cultivators' price elasticity of demand for foodgrains and (e_f) is the income elasticity of demand for foodgrains. The marketed surplus elasticity with respect to price is arrived at by multiplying the above equation (4) by P_f/S .

$$= \frac{\partial S}{\partial P_f} \cdot \frac{P_f}{S} = \frac{C_f}{O} \cdot \frac{P_f}{S} \left[\frac{\sigma_f}{P_f O_f} O - e_f \right] \quad \dots (5)$$

$$\text{Elasticity of MS} = \frac{C_f}{S} \cdot \frac{\sigma_f}{O_f} - \frac{C_f P_f}{O \cdot S} e_f \quad \dots (6)$$

The marketed surplus elasticity is less likely to be negative

if the e_f or the income elasticity for this commodity diminishes:

With this theoretical discussion, she goes on to run a regression to get the marketed surplus directly. In this model, she has taken the total amount of foodgrains sold by the cultivators in the village as a percentage of total production of foodgrains (Y) as the dependent variable where Y is a function of the following:

- 1) X_1 : foodgrain production per adult unit of cultivating population.
- 2) X_2 : average price of foodgrains for the cultivators in the village.
- 3) X_3 : value of production of commercial crops.
- 4) X_4 : average income of cultivators from non-agricultural sources.
- 5) X_5 : index of concentration of cultivated acreage.
(The index of concentration is equal to the sum of absolute difference between cumulated percentage of farm and cultivated area in each size-class divided by hundred.)
- 6) X_6 : other disposal of foodgrains minus other receipts of foodgrains as a proportion of total foodgrain production.

if the e_f or the income elasticity for this commodity diminishes.

Kalpana Bardhan estimates elasticity of the marketed surplus as between -0.72 and +1.37 for different districts. The income elasticity (e_f) was between 0.5 and 0.82, price elasticity (σ_f) was between 0.2 and 0.4 and $P_f Q_f / O$ was = 0.45 to 0.55.

The above results of the price elasticity of marketed surplus show that it has a significant negative range. The estimation of long-run elasticity involved various uncertainties regarding the sign of the corresponding short-run elasticity hence it was not attempted. There was no significant correlation between production and price of foodgrains for the same year (so she takes both of them as exogeneous variables but they are not really exogeneous variables hence her applications of OLS do not yield consistent result).

Kalpana Bardhan later extended the model taking a basket of commodities as a numeraire. Her results show that the signs of this linear estimation coefficients were right and they were significant. The model gave a good fit. The elasticity of marketed surplus with respect to output was positive but statistically insignificant.

$$= 0.8 \quad Q_n = 1.8.$$

The non-crop income and the prices had a negative impact on the marketed surplus; concentration of holdings were marginally significant, and positive.

Walter Hassel has criticised Kalpana Bardhan for assuming that the current year's output and price are unrelated. He points out that although the current year's price does not affect the current output, the sale of the current output affects the current price. So the line of causation is not absent, but runs in the opposite direction. He points out that this interrelationship between the price and output makes an estimation using OLS inappropriate. Bardhan however treats price and output as exogeneous variables. For all practical purposes this treatment is justified because the cultivator is insignificant to affect the market price with his sales.

Walter Haessel (1975): Haessel starts by critically examining Kalpana Bardhan's work, and then proceeds to present his own model and with it derives very different results using Kalpana Bardhan's data.

This model like Bardhan's model is a closed village model where P is determined within the system by the demand and supply for this crop. Where the total supply of food-grains (S) is allocated among consumption by cultivators (C), marketed surplus (M) and other net disposal to non-cultivators (T). So

$$S = C + M + T, \quad \dots(1)$$

where S is considered exogeneous as it does not depend upon the current price, and T is also exogeneous as it consists of contractual payments. Then the short run decision of the farmer is to allocate the output between consumption and sales. The consumption is a function of the relative price of this

commodity and the net income of farmers (Y) inclusive of imputation of retained grain. Hence (M) is a residual such that $M = Q - C[P, Y]$.

After dealing with supply, we now consider the demand side for foodgrains: The demand for foodgrains is a function of price of the foodgrain and income i.e. $N = N(P, Y^n)$. The market clearing equation is $N = M + T$. The gross income depends upon income from foodgrains PQ plus income from other sources (Y^o) i.e. $Y = PQ + Y^o$.

The income of non-farmers is $Y^n = f[Y, P, S, T, Y^o, LY, I]$ where LY is the percentage of Y^o derived from live-stock; I is the index of concentration of cultivated acreage; $C = a_0 + a_1P + a_2Y + e$, consumption is a function of income and price. Marketed surplus (M) is output (Q) minus consumption (C); $M = Q - C$; so $M - Q = -C$. So once the consumption and output are known the marketed surplus can be estimated. The consumption equation is estimated by using two stage least squares. As no data about Y^n could be obtained, Y^n was arrived at from the marketed surplus equation. $M = d_0 + d_1S + d_2LY + d_5I + e$. The computation of gross elasticity of marketing with respect to the quantity produced from the above equation captures both the income and price effects resulting from a change in output. These were used in the computation of the price elasticity of the demand for this crop by the entire community.

$$\text{Elasticity of marketed surplus} = \frac{dM}{dP} \cdot \frac{P}{M} = n_{\text{price}} + n_{\text{income}}$$

Thus gross short run elasticity of marketing of food-grains with respect to price is a mixture of pure price and an induced income effect and may be computed either using consumption or marketing elasticities.

Haessel's results show that the short run elasticities were slightly higher (equal to 3.0) for the large farmers than for the entire sample of farmers (equal to 2.7). Haessel's elasticities are positive and significant. The derivation of such results using the same data, contests Bardhan's results (of negative elasticity) obtained with different model.

Haessel obtains income elasticity of less than unity, while his elasticity of marketed surplus with respect to output is greater than unity.

Table 3.5 : Estimates Prices and Income Elasticities of Consumption and Marketing

Data	Estima- tion method	E_{CP}	E_{CY}	E_{MP}	E_{MY}	n_p	$1/r$	t ratios
Entire sample	1	-1.99	0.66	3.05	-0.91	2.74	-4.29	1.94
	2	-2.00	0.59	3.07	-0.90	2.76	-4.28	1.79
Large farmer sub- group	1	-2.49	0.87	3.21	-1.13	3.08	-5.98	1.68
	2	-2.67	0.88	3.45	-1.14	3.32	-6.51	1.48

This indicates that the marketed surplus increases with an increase in price but more so with an increase in output.

Pranab and Kalpana Bardhan (1971): After Kalpana Bardhan's efforts at directly estimating the short run elasticity of the marketed surplus from cross sectional data, the authors turn to the estimation of such elasticity from time series data for cereals. Here the authors construct a time-series for marketed surplus of cereals for India as a whole on the basis of the Census population figures, the (NSS) per capita consumption data and official data about cereals output and Government distribution after which they proceed to estimate the relevant price elasticities.

The Model: "The per capita consumption of cereals (C_x) by agricultural population, depends on their per capita income (I), and the price of the cereals (P_x) relative to the price of other consumables (P_y). The per capita output of cereals (O_x) depends on the price of cereals (P_x) relative to that of other crops and agricultural products (P_z) and on a non-price shifting parameter (A) - which represents factors embodying technological progress. So the sales (S) (or marketed surplus) of cereals by the agricultural population as a proportion of cereals output is given by the equation:" (Bardhan and Bardhan, 1971)

$$S = 1 - \frac{C_x(I, P_x/P_y)}{O_x(P_x/P_z, A)} \quad \dots (1)$$

The per capita income is:

$$I = P_x O_x(P_x/P_z, A) + P_z O_z(P_z/P_x, A)$$

where O_z is the per capita output of non-cereal commodities.

The marketed surplus is thus a function of two price ratios (P_x/P_y) and (P_z/P_x). Although the basic nature of the model here is the same as that used for the previous study (by Kalpana Bardhan), their main difference is that the first was a cross section study and this one is a time series analysis. Besides, this model has been modified to include three distinct variables: (1) The embodying of the technological progress (A), (2) Prices of other non-agricultural consumables (P_z), (3) the output of other agricultural products. The marketed surplus has been defined as:-

$$\begin{aligned} \text{MS} = & [\text{Per capita consumption (URBAN)} \times \text{Population (U)}] \\ & + [\text{Per capita consumption (Rural)} \times \text{Population (R)}] \\ & - [\text{Government disposal net of international} \\ & \quad \text{procurement}] \end{aligned}$$

This method overcomes the problem of estimation of the marketed surplus indirectly, and arrives at it directly through the transactions conducted in cereals in the economy.

In order to remove the impact of imports which supplement the domestic production they deducted from these transactions the amount of government distribution of cereals net of international procurement. Their estimating equation is:

$$\log Y = \log + B_1 \log X_1 + B_2 \log X_2 + B_3 \log X_3$$

where Y stands for (S); X_1 for (P_y/P_z) and X_3 for (A).

The authors estimated the marketed surplus using two different assumptions (a) and (b) for arriving at the cereal consumption of the rural non-agricultural population, (the estimate for

which is not available from the NSS), (a) assumes the consumption of this group equal to an average of the urban and rural consumption rates and (b) assumes it to be equal to that of the urban population.

$$(a) \quad \log Y = 4.462 + 0.909 \log X_1^{***} - 0.440 \log X_2^{**} \\ - 1.6272 \log X_3^{***}$$

$$R^2 = 0.896$$

$$(b) \quad \log Y = 4.515 + 1.065 \log X_1^{****} - 0.610 \log X_2 \\ - 1.673 \log X_3^{****}$$

$$R^2 = 0.893$$

**** Significant at 1 per cent.

*** Significant at 2.5 per cent.

** Significant at 5 per cent.

The elasticity of the marketed surplus with respect to price of cereals relative to manufactured consumables (P_y/P_z) bought by agricultural population is positive. $E_{ms} > 0$

Their signs confirm their initial hypothesis and indicate a marketed surplus elasticity close to unity. The elasticity with respect to the price of commercial crops relative to the cereals is negative, and has an absolute value significantly below unity. The elasticity with respect to technological progress was very significant, but negative.

Such a negative elasticity of technological progress is surprising, but not so in this case, as the authors had taken 'A' to be the per capita agricultural income index (with

base 1948-49). Such an index cannot be expected to reflect the unidirectional movement of the technological factors because it fluctuates widely with variation in weather. Besides the per capita income also embodies the impact of various other factors besides technology. The next point is regarding the treatment of the entire class of cultivators as net sellers. By doing this the authors have forgotten the marginal farmers and agricultural labourers who are net buyers of foodgrains.

The estimates for the cereal consumption of the rural non-agricultural population were not available. The authors estimate it using two alternate assumptions: (a) the average of urban and rural consumption rates or (b) consumption rates for urban population. The authors do not recognize that neither of these are appropriate, because, although the per capita cereal consumption of the urban non-agricultural population is lesser than that of the rural agricultural population, the per capita cereal consumption of the rural non-agricultural population is still lower. This is because the incomes of the rural non-agricultural population are lower than their urban counterparts. So it would have been more appropriate to take urban consumption of the relevant income groups as the consumption of the rural non-agricultural population.

Conclusion

In the first section of our chapter, we started with studies which advocate the existence of the backward bending

supply curve for foodgrains, by Mathur-Ezekeil and Khatkhate. These studies have been thoroughly analysed by Dandekar who shows that the so called 'backward bending supply curve' is an economic possibility restricted to a small size group of semi-subsistence farmers. The share of these farmers was however too small to overshadow the predominant impact of the 'normal' (upward sloping) supply curve of the large farmers.

T. N. Krishnan showed how the perverse supply curve was a distinct possibility in the stock period when the income effect outweighed the price effect. A detailed systematic analysis of the elasticity of the marketed surplus was undertaken by Raj Krishna, who arrived at this elasticity indirectly via the income and price elasticities. Raj Krishna's derivation however suffered from an error which was pointed out and corrected by Nowshirwani and Behrman. The modified results show that the negative elasticity range increased.

The third section deals with the relationship between marketed surpluses and the size group of holdings, which has been explored by various authors. Dharam Narain's famous U-shaped Marketed Surplus curve was found to be non-existent. Similarly Raj Krishna's linear relationship between output and marketed surplus came under heavy criticism. Utsa Patnaik and Ashok Rudra showed a close positive link between the output and marketed surplus.

The fourth section deals with studies directly esti-

mating the marketed surplus elasticities. The results obtained by Bardhan and Haessel from the same data are diametrically opposed; Haessel's approach appears more logical.

On the whole, there appears no definite reason to side with either the proponents of the negative or positive elasticity, except that the analysis of the latter was found to be more logical and analytically correct.

CHAPTER IV

THE AGGREGATE SUPPLY RESPONSE

The Aggregate Supply Response function is the "aggregate agricultural production forthcoming from the producer at different expected prices, holding the expected non-agricultural prices, state of technology and weather constant, with a given time horizon". (Robert Herdt, 1970)

The aggregate agricultural production response is not merely the summation of all the individual crops grown, as it is conceivable that although the "responsiveness may be positive and high for individual crops, that in aggregate it may be negative or zero, because the substitution of resources among the farm enterprises is easy, but between agricultural and non-agricultural sectors it is difficult."

The aggregate supply function relates the aggregate agricultural production to 'price'. The very first task of this analysis is the identification of this 'price'. In case of individual crop response, the price of the crop relative to the price of its inputs and to the prices of other competing crops is taken as the 'relevant price'. Similarly, the aggregate supply response is stimulated by the price received by the agricultural sector vis-a-vis the price paid by it. The price paid by this sector falls into two main categories: prices of the consumer goods required by the farm households

and prices paid for the farm inputs required for farm production. So in effect the stimulus is the 'terms of trade' between agriculture and the rest of the economy. A favourable terms of trade would lead to greater agricultural production, an unfavourable terms of trade may discourage it.

Since it is easier to shift resources for production within agriculture than into and out of it, it is only natural to expect that the magnitude of aggregate supply response will be lesser than that of the individual crop supply response. In Cochrane's words: "To an important degree agriculture represents a water-tight compartment within which there is considerable fluidity but the connecting valves between agricultural compartment and the rest of the economy work poorly or sometimes, not at all." (Cochrane, 1947, p. 11).

How well these 'valves' work or how much the aggregate supply responds to the 'price' change, can be effectively gauged by the Aggregate Supply Elasticity. This elasticity measures the sensitivity or responsiveness of aggregate farm output to changes in relative farm prices. It shows the direction and degree to which the output changes during a specified period, in response to a given change in price.

The dimension of the response depends upon a series of interactions among various determinants of the aggregate supply, with each factor pulling it in a different direction. The agricultural production forthcoming in any period is, therefore, a net result of the farmers' output plans and the influence of these determinants on it.

These influences, or the determinants of the aggregate supply are as follows: (a) The nature of the production function in the short period. (b) The nature of the markets of inputs including flexibility of prices and the elasticity of supply of inputs. (c) Cost structures, as regards fixed and variable costs. (d) The motivating factor or the stimulus, 'the price'. Besides these, there are certain exogeneous factors whose impact on Aggregate Supply Elasticity is substantial and uncontrollable: They are; weather changes and technological improvements which cause shifts in the production function, and thereby make difficult the distillation of the aggregate supply response to 'price'.

Empirically, the aggregate supply response is computed in two alternative ways (Griliches, 1959):

- 1) The direct approach of estimation of the Aggregate Supply Function for Agriculture.
- 2) The indirect approach of estimation on the basis of the production elasticities and the demand elasticities for the farm inputs.

Both these methods achieve the same goal, that of computing the elasticity of farm output with respect to the price received by the farmers.

The exercise of estimating the aggregate supply response had been carried out in most developed countries during the 1950s and early 1960s. These results show a low but definitely positive aggregate supply elasticity; e.g., Zvi

Griliches's study for U.S. agriculture gives elasticities between 0.10 and 1.3 for the period 1921-57, 0.5 during 1920 to 1936 and 0.17 during 1937-1957. These studies do not indicate any rising trend in the Aggregate Supply Elasticity. But the elasticity figures obtained are significantly different from zero.

Such analysis is virtually absent in most developing countries. One main reason advanced for this is lack of adequate data, regarding the aggregate output, other factors and a proper index for weather.

A thorough understanding of the efficacy of price incentives in agriculture is necessary in a developing economy faced with the task of feeding its teeming millions. Although it is, by now, a well-accepted fact that individual crops do respond to price incentives, would the aggregate supply also be price responsive? This aggregate production behaviour has remained more or less intractable due to relative neglect of the topic in the Indian literature.

Robert Herdt (1970): One of the first efforts in this direction was made by Robert Herdt in 1970. In this study he attempts to test the hypothesis that 'The aggregate agricultural supply function of traditional economies is positively responsive to price'.

For this he formulates a model which is of the type $Q_i = f(P_1, P_j, Z_1, \dots, Z_n)$ where P_j and P_i are the relevant prices and Z_i s are the relevant supply shifters, viz., the

weather, the technology and irrigation. The region chosen for the analysis was Punjab. The period chosen was 1907-1946 and 1951 to 1964. He estimates individual crop supply functions for area under different crops and yield per acre, for each district for each of the two periods stated above. Further four equations were attempted for each crop - two for irrigated area and yield and two for unirrigated area and yield of this crop. These were aggregated by Laspeyres' method of aggregation.

Herdt has taken the expected prices of all the 'n' crops and all the inputs so that we can have own price and cross price elasticities. In this model, the expected price of year t is:

$$P_t^e = \frac{[3P_{t-1} + 2P_{t-2} + P_{t-3}]}{6}$$

is influenced by previous prices, it is a distributed lags model. But in order to make the model manageable, he takes the expected price as a weighted average of the price of the three previous periods i.e. finite number of lagged price.

The expected product prices are used directly in the analysis, but the expected inputs prices and the expected prices of the consumption goods are combined into an index of prices paid by farmers which is used in the regression as an additional explanatory variable.

Supply Shifters: The procedure of arriving at the 'pure' supply response to price requires the separation of the

supply response to it from the numerous other impacts on acreage. These 'other factors' shift the acreage-price relationship. These supply shifters are: the canal irrigation (I), (W) the weather was approximated by the pre-sowing periods of rainfall for the various crops and the technological change approximated by the trend variable (T).

The impact of supply shifters is to be separated from the total effect if the suppliers response to price is to be arrived at. The individual direct and cross elasticities are combined into a single aggregate elasticity.

The disaggregate approach recognizes the potential for substitution between individual commodities, and hence could be more appropriate to represent the actual Aggregate Supply Response.

The Model: representing the basic supply function for each crop

Actual acreage = f(Prices, Weather, Irrigation and Trend)

$$Q = f(P, Z_1 \dots Z_n)$$

$$\text{Actual Acreage} = \sum_{j=1}^n a_{ji} P_j + a_{n+1} P_{n+1}^* + \sum K_i W + T + I + U_t.$$

Now a one per cent change in the aggregate price could consist of numerous different combinations of changes in prices of the different crops. This aggregate price rise may also consist of a large change in some crop prices and no change in other crop prices. A small rise in the price of a crop with a large share may work out to be more important than a large rise in the price of the crop with a small share in the total output.

So specification of the change is necessary. The aggregate supply response elasticity with respect to price is a weighted average of the individual supply response elasticities of the various crops with respect to their input prices and the price of the competing crops. The weights here are taken as the average values of production of the respective crops. Thus the elasticity of aggregate supply response is the weighted average of the own and cross price elasticities of the different crops, the weights being equal to the share (of this crop) in the total output. He says that, theoretically the same results follow when there is a 1 per cent fall in price of inputs which the farmers have purchased as when there is a 1 per cent rise in the price of the product.

The results show that the first period 1907 to 1946 had positive supply elasticities while the second period 1951 to 1964 did not give conclusive results. The elasticities computed for the different districts and different equations for the first period range between -0.39 and 0.73 and their average was 0.22. For the second period the elasticities ranged between -0.09 and 2.93 with the average being -0.06.

The author says that the second period did not show significant supply response to price because: (1) this was a period during which output was secularly rising; (2) the total number of inputs was increasing. So there was a need for a greater analytical effort to distil the supply response out of the combined effect of all factors. The data relating to this

period used for the exercise were obtained from the then recently set up Punjab Department of Agriculture, and hence were not very reliable.

The disaggregated approach that Herdt adopted called for a separate estimation of individual crops and yields per acre, separately for irrigated and unirrigated variables. This, in addition to the fact that the expected prices are averages of some previous prices increased the number of variables to an unmanageable extent. The finite distributed lags models was chosen in order to reduce the number of variables involved even at the cost of having no separate estimates of the long and short run elasticities. Yet the number of variables remained large and the threat of multicollinearity continued to affect the statistical significance of the price coefficients. S. Sawant later showed the inherent difficulty in this model as the expected prices were the weighted averages of the three lagged prices of the crop and competing crop and inputs, the corresponding reduced form equation in observable variables included more than twice the number of regressor variables than in the structural relation implying more than one estimate of structural parameters. "Thus the problem of inter-correlation among variables and interpretation of their coefficients becomes extremely difficult with postulation of distributed lags. In fact, the model becomes implausible in the situation where the number of variables included in the response function is more than two. Besides, it seems that the estimate of aggregate elasticity arrived through this approach would be

sensitive to changes in relative shares of different crops in total production, unless these changes are small and imperceptible." [S. Sawant (1978), p. 9.]

S.L. Bapna (1980): In this study, the author tried to study the aggregate supply response of farmers to a change in agricultural prices. He proposed to verify three hypotheses: (1) The Aggregate Supply elasticity of total agricultural production in Ajmer district of Rajasthan is positive and low. (2) The supply elasticity of the aggregate production in technologically changing agriculture is more than it is in traditional agriculture. (3) The elasticity of supply is more than the elasticity of yield.

Ajmer district of Rajasthan was selected due to its low variability in rainfall and good infrastructural facilities.

The data on area and prices were obtained from the Patwari records, the data for prices paid for inputs and prices of consumer items were obtained from the farm management study of Pali, a neighbouring district. The cost of living index was taken as a proxy for the index of agricultural wages.

The aggregate price index was calculated by using the farm management data. The prices were taken as the farm harvest prices during six to eight weeks after harvest. The index number of aggregate production, area and yield were constructed using the Laspeyres method, i.e., fixed base index. The aggregate price received was constructed by using the harvest price (weighted by production) of each crop.

The author uses five alternate specifications of the expected prices; where the expected price is taken as (1) the previous years actual price plus some differential in the last two years' price from their expected levels, (2) the trend of the three previous years' prices; (3) the previous years price plus some fraction of the differential of the previous two years; (4) the weighted average of the previous three years' price where the previous year has 50 per cent weightage the one before than 33.33 per cent, while P_{t-3} has a weight of 16.77 per cent; (5) the previous year's price plus the deviations in the two previous years' price from their previous prices.

The expected real prices were obtained by deflating the expected farm prices by an average of expected input and consumer prices 'expected' in the same fashion as the farm prices.

Other Variables: The average rainfall of a number of stations in the district was chosen to represent the weather variable. The irrigated area did not fluctuate much. F, the Fertilizers variable, was expected to represent the technological change.

The author worked out the Nerlovian distributed lag model with an adjustment lag, but it did not give good preliminary results. So, for ultimate estimation, an ordinary multiple regression model was used.

The results show that most equations gave significant elasticities and the magnitudes of the elasticities were fairly

stable. The log linear form of the model made elasticities directly available.

The model:

$$Q = b_0 W_1^{b_1} W_4^{b_2} W_5^{b_3} (P_1^e)^{b_4} N^{b_5} I^{b_6} e^{b_6} \cdot U$$

where Q - Index of aggregate production;

W_1, W_4, W_5 are rainfall variables representing rainfall during June-July, August and September-October respectively;

N is the index of fertilizers;

I is the index of irrigated area.

The R^2 was 0.91 and the rainfall turned out to be the most important impact on output. The elasticity with respect to price was positive and low at 0.24 so the first hypothesis was accepted, although 'low' is a very relative term. The equation shows that weather has been a major cause of variations in production followed by technology and price.

In order to test the second hypothesis that the supply elasticity of aggregate production in technologically changing agriculture is more than in traditional agriculture, two equations were fitted for the traditional (1956-57 to 1965-66) and changing (1966-67 to 1976-77) agriculture using dummy variables, D_1 and D_2 . D_1 assumes unit value for the first set of years and zero for the second set while D_2 assumes values in the reverse order. The results show that although the elasticity of technologically changing agriculture was (0.22) more than that for the traditional phase (0.19) it was

not significantly more. This could however have been due to the fact that the spread of technology in the sample district was limited. Secondly, this estimate is highly questionable due to the problem of multicollinearity between the price and technology variables. The third and last hypothesis: The supply elasticities of both aggregate area and yield were positive, but the supply elasticity of area (0.6) was more than that of yield (0.22). So the third hypothesis that area elasticity is greater than that of yield is rejected.

Thus the study provides strong evidence in favour of the hypothesis that the aggregate elasticity of (yield and area) total production was positive. But the results are doubtful due to the existence of problems of autocorrelation and multicollinearity.

The research area of aggregate supply response is a relatively neglected field due to the kind of problems it poses. But this formidable task was taken up by Shashikala Sawant.

Shashikala Sawant (1978): Sawant said that any aggregate supply analysis should consider demand and supply and price interactions, the acreage and yield changes during the period under study. It should also try to make theoretical formulations for capturing the process of price expectations. The time lags involved in both expectation formation and actual implementation should be properly studied.

It was noted earlier that there are two alternative methods of arriving at the aggregate supply function.

(1) Estimation of the aggregate supply function directly from time series data, like the one adopted by Dr. Herdt.

(2) The indirect approach which involves the construction of total production index of prices received and the weather index. This approach involves problems like the choice of the base year, choice of the weights to be used in aggregation of suitable formula for construction indices.

In order to avoid the problem of aggregation of the total output she chooses a virtual mono-crop region. Her sample consists of 16 districts divided into 2 groups with 4 districts each from West Bengal, Assam and Madras forming the first group, which has 70 to 90 per cent of its gross sown area under paddy.

The second group of four districts belong to Maharashtra and here paddy accounts for around 70 per cent of the gross sown area.

The choice of the districts was made in such a way as to keep the intercrop substitution at the minimum level.

The period chosen for the analysis was 1920-21 to 1941-42 - the period of traditional agriculture and 1950-51 to 1966-67 representing the period of progressive agriculture.

The Price: The price of paddy was deflated by the wholesale price index for all commodities at the all India level.

The relationship between prices and aggregate supply is usually affected by the existence of certain supply shifters. Sawant took some of these into account. Of these, irrigation was represented by the irrigated area; rainfall by (1) the absolute deviation of the actual rainfall from the normal rainfall and (2) the absolute deviations of monthly rainfall [both (1) and (2) were worked out for most districts]; the time Trend (T) was accepted as a satisfactory variable to approximate technological changes of minor degree (It was, however, not expected to capture the great change like a green revolution; therefore, the period of analysis was restricted to 1966-67).

The author formulated three alternative models, the first incorporating output adjustment lag, the second representing a price expectation lag and the third incorporating both adjustment and expectation lags.

Model I

$$Y_t = Ar + (1 - r) Y_{t-1} + arP_{t-1} + bI_t + (W_t + rU_t + V_t)$$

This is a typical adjustment lag model of the Nerlovian type, with a naive price expectation of $P_t^* = P_{t-1}$.

Model II

$$Y_t = A + \sum_{i=1} B_i P_{t-1} + bI_t + (W_t + V_t + U_t)$$

which has a reduced form:

$$Y_t = A(1 -) + P_{t-1} + bI_t - b I_{t-1} + C W_{t-1} - C W_{t-1} + Y_{t-1} + V_t - V_{t-1} + U_t - U_{t-1}$$

This model incorporates adaptive price expectations but ignores time lags involved in carrying out output plans.

Model III

$$Y_t = Ar + (1 - r)Y_{t-1} + arP_t^* + bI_t + CW_t + rU_t + V_t$$

This model tries to incorporate both the lags in carrying out output plans - adjustment lags and lags in formation of price expectations.

P_t^* - expected price of paddy

P_t - actual price of paddy deflated by the 'All Commodity Wholesale Price Index'

I_t - irrigated area under paddy

W_t - rainfall in different months of periods. W_{it} represents either actual rainfall or deviation of the actual rainfall in specified months or periods.

Results: Model I conserves the degrees of freedom, and does not require a large sample.

Model III could be solved with an iterative procedure and had a decisive advantage when the sample was large but not when it was small.

The results show that during the pre-war period, the elasticity of aggregate supply was very low (almost zero) for majority of the districts. This could be attributed to the stagnant technology during the period. The long run elasticities during this period could have been positive. But her model did not allow for a positive long run elasticity in face of a zero short-run elasticity.

The pattern of supply elasticities for the plan period revealed a large variation over the districts, and thus indicates that the analysis of supply response at a higher level of aggregation is not meaningful. The elasticities of adjustment for yield were distinctly higher than those for acreage.

The estimates of supply elasticities for the pre-war period are almost zero. But there was "greater evidence in favour of positive elasticities for the plan period than obtained for the pre-war period. This may be attributed to the change in the agricultural technology between the two periods under study." This improvement in the aggregate supply elasticity was attributed to substantial investment in irrigation, production of chemical fertilizers and better seeds.

Table 4.1 : The State Level Elasticities

Run	States			
	Madras	West Bengal	Maharashtra	Assam
Average short-run elasticity	-0.34	0.43	0.19	0.12
Long run elasticity	-0.34	0.91	0.30	0.12

The author explains the lower magnitude of the short run elasticities by pointing out that the technology of agricultural production underwent a slow change in most districts covered in the study.

Sawant concludes by saying that supply response

increases with increase in irrigation, literacy rate and proximity to metropolitan centres. The influence of weather was found to be pervasive for both the periods.

She concluded by saying that increased supply response obtained during 50s and early 60s seems to be due to the gradual expansion of the resource base of agriculture, "It may be inferred therefore that in future agricultural supply in India will become increasingly more responsive positively to changes in prices" (Sawant, 1978, p. 167).

S. Sawant's work is commendable, especially because it is in an area where very little research was done prior to their work. Besides it has sailed clear of most problems visualized at its onset. For example, she has circumvented the problems (faced by Herdt) of aggregation of different crops by choosing virtual mono-crop regions for her analysis.

But, the question remains in regard to multi-crop areas, where the problems cannot be avoided.

The Aggregate Supply Elasticities may not be meaningfully approximated for the multiple crop areas, where inter-crop substitutability is substantial, *from the monocrop regions.*

Moreover, most mono-culture regions in the country are characterized by lack of alternate employment for both land and labour. In such a situation the farmer will cultivate the single crop so long as the cost of his purchased inputs and even a part of the labour cost is covered. The land will be kept uncultivated failing this, thus acreage response in

this area is likely to be very unresponsive to price changes.

This is not to belittle Sawant's achievement but only a reminder of how complicated the problem is. It is actually disturbing to conclude this section with a statement made by Nerlove and Bachman (1960) around thirty years ago. "If we knew perfectly the way in which each of the many hundreds of products produced in the agricultural sector was determined, the interrelation among these supplies, and the way in which to aggregate this knowledge the problem of total supply would be solved. Until the day we know so much has come, however the problem of total supply will continue to be qualitatively different in many ways from the problem of supply of any particular commodity." (Nerlove and Bachman, 1960).

CHAPTER V

CONCLUSIONS

The attempts of understanding the phenomena of supply response of farmers to agricultural prices through its visible manifestations in form of changes in acreage allocations, marketed surplus, have yielded good results. Economic research in this area has come a long way since Dharam Narain's pioneering study that used graphs and charts. The Nerlovian distributed lag model has however dominated the research in this area. This model and its modified versions constitute the major chunk of literature in this area.

The modifications¹ to the original Nerlovian adjustment lag model has been mostly made in order to develop plausible expected price models that explain the acreage variation at least as well without the serious statistical problem of serial correlation. But these have been limited to a few studies. In spite of this the systematic study of price expectations has been limited to a few of studies.² The proper identification of the price stimulus is absolutely essential in order to gauge the supply response of the farmers to agricultural prices.

1 Modification regarding the perennial and perishable crops not discussed here.

2 M.S. Rao, Jai Krishna and D.S. Tyagi.

The Nerlovian expectation lag model allows for price expectations involving a specific format of dependence on previous prices. The idea that 'the expected prices are a weighted average of the previous prices such that these weights proportionately decrease as we go into the past', is peculiar. If the farmers have some definite notion of what the 'normal' price is, they would not include in their expectation function prices which fluctuate due to abnormal circumstances like floods or droughts.³

Secondly, this price does not incorporate any information or prediction regarding the policy changes which have in reality far reaching impacts on the level of prices, and their expectations.

Nerlove (1979) admits that, unlike his earlier presumption, 'visible' prices do not convey all the information to which farmers find it necessary to respond. Thus, supply response is not an isolated phenomenon of only prices but also involves response to "change in the agricultural sector, the complex forces set in motion by technological improvement, public investment in infrastructure and public health, the development of markets, and differential abilities of economic agents to deal with disequilibria".

There have been some attempts at modifying the Nerlovian

³ Even inclusion of such prices into the expectation function is not very problematic if (the expectation lag coefficient) is relatively small; then the impact of such prices would be reduced considerably.

model to incorporate risk aversion⁴ into the model. Here risk was represented by standard deviation in some cases while some other studies used coefficient of variation for the purpose. In spite of their low significance level in these models, their right signs created hope in the direction of the incorporation of risk-aversion into the model.⁵ The amount of research in this area has not even touched the tip of the problem of ascertaining the risk and uncertainty involved in decisions on supply response in Indian agriculture.

Nerlove faced difficulty in separating out the impact of the price expectational lag and the output (acreage) adjustment lag. His efforts at introducing a variable ' Z_t ', in order to make the structural parameters enter the estimating equation asymmetrically, failed due to lack of an appropriate variable (Z_t). Later efforts in this direction have met similar fate.⁶ Thus the lack of a suitable candidate for ' Z_t ', kept the problem of identifying ' r ' and ' β ' separately, unsolved.

A proper specification and identification of the impact of the non-price factors on supply is absolutely essential for the isolation of the supply response to price.

4 Behrman (1968), Maji-Jha-Venkatraman (1971).

5 Refer discussion in Section 2.3 about inappropriateness of use of standard deviation as an independent variable in O.L.S. estimate.

6 S. Sawant (1978).

The problems relating to the proper specification of such other variables is a hurdle in the measurement of supply response. The problems encountered in incorporating the non-price variables have remained almost as untackled now as in the early 50s.

In spite of the few efforts at measuring the weather index, or using proxy variables to represent it, the unpredictable weather variable has continued to be elusive. Thus its inadequate representation in the face of its sizable impact on yield, reduces the predictability of the models estimating supply response.

The technological changes are often represented by the trend variable. This is contrary to the reality that technological inventions/innovations do not follow any trend. These changes in production functions would introduce fresh shocks every time they occur. The movement would be, no doubt, unidirectional and irreversible, but not secular, monotonic or time related, as the trend variable would suggest. The trend does somewhat approximate the adaption of a new technology which is gradual over time.

The trend variable is also often expected to be a 'catch all' variable meant to capture the impact of advances in infrastructural and other improvements over time as the data regarding the latter is usually not available.

Data availability has constrained micro-level studies of the supply response of farmers. Most studies of supply

response to prices in India are conducted at the macro level. Hence these studies reveal the individual decision making process of the farmers inadequately.

The research in supply response to price is directed towards understanding the mechanism of supply response adequately, to be able to forecast supply changes effectively and to be able to be of some practical use to the policy makers in seeking solutions to problems related to agricultural supply. A disturbing fact about models in general is that models which show good explanatory powers for certain periods of time may not hold for the same regions some years hence. Due to this, the model loses most of its utility, as its potential predictability is in doubt. The above phenomenon was observed by Rath and Patvardhan when they fitted the Raj Krishna model to the post-Independence period data for the (Indian) Punjab State.

Econometric Problems

There have been various econometric problems which have always plagued the process of estimation of the Nerlovian distributed lag model by the ordinary least squares.

The problem of serial correlation arises due to inclusion of lagged-dependent variable as an independent variable in the estimating equation. This problem of serial correlation assumes greater seriousness under the distributed lag model than under ordinary multiple regression. In case of

distributed lag models, the existence of serial correlation gives not only inefficient but also inconsistent estimates. Using simple least squares instead of OLS also does not solve the problem.

The use of the Durbin-Watson statistics for testing serial correlation in a model distributed lags is useless as it always gives values close to two. Durbin, therefore, introduced the 'Durbin-h' statistics; however this has been largely ignored, except by a few authors.

Multicollinearity has often played havoc with the results of the estimating equations, the magnitudes of R^2 s and standard errors. However, most authors have shown adequate knowledge of this phenomenon.

The heteroskedasticity problem has, however, often passed unnoticed in many studies.

In spite of these econometric problems with some studies, the evidence is no doubt in support of a positive supply response to price. The acreage response was observed to be positive but small in the short run and substantial in the long-run. The marketed surplus response is likely to be negative in the stock period, although there is a greater evidence of positive supply response in the short run as well as the long run. There is inadequate evidence in regard to the Aggregate Supply Response. While Herdt's study shows poor supply response in the post-Independence period, Sawant's exercise as well as Bapna's give positive results. However,

Sawant's results are restricted to a monoculture area, and cannot be easily generalized.

Our brief study here is too modest an effort to draw any policy implications, but we would like to note a couple of points. The magnitudes of the price elasticities obtained for foodgrains were positive, significant but small. For all practical purposes, a smaller elasticity of supply response to price indicates that the role of a price policy as an instrument of economic growth can be very limited. Thus, the results obtained by scholars in this area caution the proponents of price policy against what Raj Krishna has called 'price fundamentalism'.

"Like agricultural and Industrial growth fundamentalism, there is price fundamentalism. The rational escape from the former is provided by the notion of balanced sectoral growth; likewise a rational answer to price fundamentalism would be a balanced view of the role of price policy and non-price (technology) policy in promoting growth. The need for balance is clearly suggested by the present state of research in farm supply response."⁷

7 Raj Krishna. "Some Aspects of Agricultural Growth Price Policy and Equity," reprinted in Ed. Echer

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