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SUPPLY RESPONSE OF PERENNIAL CROPS—A STUDY OF HIMACHAL APPLES*

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Extensive studies have hitherto been carried out in the field of agricultural supply response without complementing substantially with the studies on the acreage response for horticultural perennial crops. Fruit crops in the past few years have assumed greater importance in the process of agricultural development. It is because of the high increase in income derived from the cultivation of fruit crops as compared to annual crops. In addition, fruit crops being the sources of protective foods, brought awareness among the consumers. The developing countries also depend heavily on perennial crops to earn foreign exchange. It is in this context that the acreage supply response studies have become important so as to help formulate proper policies for horticultural development. According to Sargent, "In primitive stages of agricultural development, agriculture remains the main occupation of the people. In the transitional stage of economic development, agriculture carried immense burden in the drive for economic growth. However, during maturing phase the main emphasis still remains on the maintenance of balanced role for agriculture, but horticulture became more important."[1] In this process of transformation, the prices of agricultural commodities have a pivotal role to play. The price system, no doubt, has its own limitations, still it is a powerful tool to elicit and transmit the economic informations for stimulating proper decisions by producers and consumers.[2] The present study is a modest attempt in this direction which primarily undertakes to estimate acreage response behaviour of apple growers in Himachal Pradesh. Precisely, the study has been designed in such a manner as to probe into the validity of the hypothesis that "the apple growers in Himachal Pradesh are responsive to prices/economic incentives" and that "the price elasticity is positive and differs significantly from zero."

SELECTION AND SPECIFICATION OF VARIABLES

The supply response of perennial crops requires special attention due to their typical characteristics like long gestation and extended periods of out-

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1. M. J. Sargent: Economics in Horticulture, English Language Book Society and Macmillan, London, 1973.

2. Robert Dorfman: Prices and Markets, Foundations of Modern Economics Series, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1967.

put from the initial investment, replanting and new plantings, etc. The behaviour of new plantings is governed by expectations concerning the behaviour of the other growers and their probable impact on output. Therefore, the model should explain the important expectations influencing the decision-making process and must consider the most appropriate lag between the initial investment and the output realised. Apple being a perennial fruit crop, requires long-term commitments of land, labour and capital and inflows are expected only to be accruing from the sixth year of the plantation of the crop. In case the crop remained relatively/absolutely more remunerative, the farmers may expand the acreage under the crop rationally. In taking such long-term decisions, the farmers, no doubt, take into account the preceding years' experiences as an indicator for formulating their expectations. The present study, therefore, hypothesises various factors as the possible expectations which enter into the decision-making process of the apple growers such as prices, profitability, parity prices, developmental indicator, etc. The specification of each of them is given below:

Price Expectation

The prices which the farmers take into account for making production decision are called the expected prices. Traditionally, last year's prices used to be regarded as the basis; however, Nerlove[3] has argued that estimates of supply response obtained by using last year's price is an under-estimation; he, therefore, proposed that the farmers take many years into account and the weightage declines as we move into the past. Nerlove's price expectation model has been the basis for many supply response studies which previously have gone into various dimensions of price expectation formulations. However, in the case of perennial crops, the literature on price expectations is negligibly limited. These few studies are also not intensively devoted to varied formulations of price expectation.

A study by Ady[4] implicitly assumes that cocoa available for harvesting in 't' years is the function of prices in 't—9', because the crop of cocoa requires full nine years to mature. Another study by Bateman[5] formulates acreage planted in any one year as the function of mean values of discounted future price of cocoa and coffee. The price of coffee has been incorporated into the model because of its being considered as an alternative crop to cocoa in some of the Ghanaian regions. Baritelle and Price[6] have hypothesised average price received by growers for their apple and assumed that the growers' behaviour is based on several past years' prices. In view of the

3. Marc Nerlove: Dynamics of Supply: Estimation of Farmers' Response to Price, Johns Hopkins University Press, Baltimore, U.S.A., 1958.

4. Peter Ady, "Trends in Cocoa Production", *Oxford University Institute Statistical Bulletin*, Vol. 2, 1949.

5. M. J. Bateman, "Aggregate and Regional Supply Functions for Ghanaian Cocoa—1946-63", *Journal of Farm Economics*, Vol. 47, No. 2, May 1965.

6. J. L., Baritelle and D. W. Price, "Supply Response and Marketing Strategies for Deciduous Crops", *American Journal of Agricultural Economics*, Vol. 56, No. 2, May 1974.

longevity of investment, the length of lag was, however, left to statistical estimation. French and Matthews[7] have tried several combinations of prices and argued that two years' average price is statistically superior for estimating the supply response of asparagus in the United States. The studies discussed above have considered prices as one of the important variables in the estimation of supply response. However, in each study a different type of formulation has been tried and as such nothing specific can be derived from them concerning price expectation behaviour pattern followed by the growers.

Though in the studies relating to agricultural supply response, farm harvest or farmer's prices have been the basis, the situation with regard to perennial crops is altogether different due to non-existence of time-series data on farm harvest prices. However, time-series data on wholesale prices of apples are recorded and maintained in big cities like Delhi and an attempt has been made to utilise these data which are collected by the Directorate of Economics and Statistics, New Delhi for the period 1961-82. Based on these wholesale prices, another series of prices were generated by deducting the marketing costs. The idea of generating two price series was to help in identifying the most suitable series influencing the expectation behaviour of growers. The former series does not take into account the marketing cost and the farmers cannot ignore the cost aspect indefinitely. Therefore, it has been considered essential to generate another series which takes into account the marketing costs as well.

To begin with, it has been considered appropriate to examine which of the price series carries more weight in the decision-making process, *i.e.*, wholesale price of Delhi apple market termed as raw price (P_r) or net price, *i.e.*, wholesale price minus marketing cost, termed as prices (P).

The degree of association of each price series with apple acreage was examined with the help of correlation coefficient. The result so obtained clearly signified that the raw price series provided better relationship with the acreage as compared to the prices, hence price series was dropped.

Besides, the relationship of the dependent variable was examined with varied lag length of raw prices with a view to selecting the appropriate lag. Various formulations of raw prices, such as P_{rt-1} ..... P_{rt-4} and their simple averages were tried. The result so obtained provided conclusive evidence in support of the fact that as we moved backward the explanatory power of the independent variable, *i.e.*, the raw prices, declined. The fact revealed that current prices (last year's raw price) carried more weight in the decision-making process than its higher lags; may be so due to their short memory. The length of lag, therefore, was restricted to the preceding two years only which helps in conserving the degree of freedom. On the basis of 'r' and 'r^2' values, last year's prices (P_{rt-1}) and simple average of last two

7. B. C. French and J. L. Matthews, "A Supply Response Model for Perennial Crops", *American Journal of Agricultural Economics*, Vol. 53, No. 3, August 1971.

years ($P_{rt-1} + P_{rt-2}/2$) were found to be more strongly associated with the dependent variable, and as such were selected for the final analysis.

Expected Profitability

While estimating the aggregate and regional supply function for Ghanaian cocoa, Bateman ignored the cost expectations and argued that it is not a major factor in determining the acreage planted and the fluctuation in the cost have been directly related to changes in cocoa prices.[8] The above contention of the author is not based on any empirical investigation, because the farmers cannot ignore the cost component indefinitely which has a direct bearing on profitability. Subsequently, improvements were noticed and researchers tried to accommodate profitability as one of the explanatory variables in the supply response models. In a study of United States apples, future profitability was hypothesised as a function of recent past prices and costs were duly accounted for by deflating the price series with the index of prices paid by the farmers. However, in the absence of time-series data pertaining to cost of production of asparagus, alternative means were used to approximate the profitability variable.[9]

In the case of apple it is assumed that profitability is also an important factor governing the expectation behaviour of the growers. Since it is not an observable variable, it is therefore approximated as the function of past prices. A look at the time-series data on apple prices depict an erratic behaviour. In a year of good crop, prices are observed to be lower and vice versa. Therefore, per hectare profitability is considered to be a better indicator, rather than price per box. Though the productive capacity of the plants goes on increasing with the age reaching at its maximum and declining thereafter, it could not be possible to incorporate this factor in the model due to the limitation of time-series statistics on the agewise distribution of plants and their production. Hence, the average yield was calculated by dividing the total production by the total area.

In order to approximate the profitability variable, it is a pre-requisite to have time-series data on cost of production, but till date no systematic/scientific study has been conducted in respect of the estimation of cost structure as well as the cost of production of apples in this State. In the absence of such a study, it is rather difficult to select suitable cost deflators. However, the State Department of Horticulture has estimated the recurring cost for one hectare modal orchard. According to these estimates, labour and ferti-

8. Bateman, *op. cit.*

9. French and Matthews, *op. cit.*, wherein the authors have approximated the profitability variable in the absence of time-series data on cost of production for asparagus in U.S.A. as follows:

$$\pi_t^e = C_o + C_1 \left(\frac{P_t}{W_t}\right)^e + V_{gt}$$

where 'P' is the grower's price, 'W' is the index of farm wage rates expressed as a proportion and the subscript 'e' denotes expected value. The value of (P/W) was approximated as a two-year's average of actual value of (P_t/W_t), alternatively they were expressed as geometrically weighted average of past prices. This formulation has been derived from the adaptive expectation model.

lisers together account for 70 per cent of the total recurring cost (40 per cent on labour and 30 per cent on fertilisers). These estimates indicate that the profitability of the crop was, by and large, governed by the movement in wage rates and fertiliser prices. Thus, a composite price index was prepared and weights were assigned to each component in proportion to their share in the total cost. Finally, prices per box received by the growers were deflated by the composite price index to arrive at the profitability per box.

Since apple production is a biological phenomenon and very much sensitive to the vagaries of weather, the profitability per box may not be an efficient indicator in measuring the profitability of the crop. Therefore, as discussed earlier, the profitability per hectare was taken into account and the same was arrived at by multiplying the profitability per box with the yield per hectare.

The long run expected profitability per unit area associated with the incremental change in acreage might be the actual profits realised in year t—1. However, the apple crop is typically subject to fairly large year-to-year variation in prices, production and yield. It is, therefore, likely that the producers might consider experience over several previous years to form a better indicator of expected profitability. This indicator might be summarised in the form of a simple average or it could follow some more complex form such as the Nerlovian type of adaptive expectation model. However, simple averages of past years were considered as better indicators than a more complex weighting structure. Various formulations of profitability which can possibly influence the decision-making process of the growers may be π_{t-1}, π_{t-2}, $\pi_{t-1} + \pi_{t-2}/2$, etc. Each formulation has been tried with the dependent variable and the two formulations adjudged on the basis of 'r' and 'r^2' value were considered for further analysis.

Parity Prices

Another important factor that can enter into a set of independent variables which determine the farmers' expectation behaviour could be the parity between the prices received for apple and the price paid for the consumables. Apple, a cash/commercial crop is also a major source of income of the orchardists and therefore, if the terms of trade remain in favour of the apple industry, the growers can invest more for extending the area under apple. Therefore, prices received by the growers were deflated by the consumer price index to arrive at parity prices. The decision to effect change in area under apple could be the function of previous year's parity prices or simple average of previous year parity prices, etc. The various formulations of lagged parity prices, which can influence the decision-making process could be P_{qt-1}, P_{qt-2}, $P_{qt-1} + P_{qt-2}/2$, etc., and the two associated more closely with the dependent variable were selected for further analysis.

Infrastructure development plays a role of catalyst in the overall development in general and for horticulture in particular. Apple being a commercial crop, is entirely marketed at distant places which are located all

over the country, hence improvement of roads is imperative. It is, therefore, hypothesised that if the transportation facilities like construction of roads are extended to difficult hilly terrains, more and more people will be encouraged to take up apple cultivation. The incremental change in apple acreage in this case assumes a function of lagged road length. Various formulations have been tried and the two of them giving best results have been selected for final analysis.

SPECIFICATION OF MODELS

Two types of multiple regression models, *i.e.*, linear and double-log were specified with different combinations of independent variables. As explained above, the lag length was restricted to past two years only with a view to conserve the degree of freedom to meet the statistical requirements. Also the existing reporting system of apple acreage does not take into account the removal aspect and the incremental area put under the crop is reported under bearing acreage after six years. Therefore, to measure the acreage response it does not make any difference if we take acreage under bearing category or total acreage under apple. The latter was preferred in order to conserve the degree of freedom as incorporation of the former would require minimum lag equivalent to its gestation period which in the case of apples is six years. Several alternative specifications, as discussed above, were tried both in linear and double-log formats and the one giving efficient results on the basis of coefficient of multiple determination, proper sign and significance of parameters together with the absence of auto-correlation problem, were selected. Though the simple least square estimates would be biased due to the presence of lagged variables in the model, if the disturbance term follows a normal distribution, they would tend to have the desirable asymptotic properties of consistency and efficiency. As the number of observations increases, the maximum likelihood estimates would tend stochastically to the least square estimates.[10] Since the number of observations in this case is 19, which is possibly a long time-series for such kind of studies, therefore it satisfied the properties of large sample estimates.[11] The two specifications of each variable already selected were further tested for multicollinearity by zero order correlation matrix. The 'd' statistic was also computed to examine the incidence of auto-correlation. Finally, the specifications of the variables included in the model were $P_{rt-1} + P_{rt-2}/2$, Pq_{t-1}, π_{t-2} and R_{t-1}. These specifications were selected so as to minimise the incidence of multicollinearity. Following models have been specified with different formulations of independent variables (Table I).

10. J. Johnston: Econometric Methods, McGraw Hill, Kogakusha Ltd., Tokyo, 1972.

11. In support of this, see, S. L. Shah and V. K. Pandey, Technical Report—Study of Marketable Surplus of Wheat in Critical Areas of India, G. B. Pant University of Agriculture and Technology, Pantnagar, 1976.

TABLE I. SPECIFICATION OF MODELS

Linear

1.1 $A_t = a + b_2 P_r^e + b_3 P_q^e + U$

1.2 $A_t = a + b_2 P_r^e + b_4 \pi^e + U$

1.3 $A_t = a + b_2 P_r^e + b_3 P_q^e + b_4 \pi^e + U$

1.4 $A_t = a + b_2 P_r^e + b_4 \pi^e + b_5 R + U$

1.5 $A_t = a + b_2 P_r^e + b_3 P_q^e + b_4 \pi^e + b_6 T + U$

1.6 $A_t = a + b_2 P_r^e + b_3 P_q^e + b_4 \pi^e + b_5 R + U$

1.7 $A_t = a + b_2 P_r^e + b_3 P_q^e + b_4 \pi^e + b_5 R + b_6 T + U$

Double-log

2.1 $\log A_t = \log a + b_2 \log P_r^e + b_3 \log P_q^e + \log U$

2.2 $\log A_t = \log a + b_2 \log P_r^e + b_4 \log \pi^e + \log U$

2.3 $\log A_t = \log a + b_2 \log P_r^e + b_3 \log P_q^e + b_4 \log \pi^e + \log U$

2.4 $\log A_t = \log a + b_2 \log P_r^e + b_4 \log \pi^e + b_5 \log R + \log U$

2.5 $\log A_t = \log a + b_2 \log P_r^e + b_3 \log P_q^e + b_4 \log \pi^e + b_6 \log T + \log U$

2.6 $\log A_t = \log a + b_2 \log P_r^e + b_3 \log P_q^e + b_4 \log \pi^e + b_5 \log R + \log U$

2.7 $\log A_t = \log a + b_2 \log P_r^e + b_3 \log P_q^e + b_4 \log \pi^e + b_5 \log R + b_6 \log T + \log U$

where

A_t = total acreage under apple in year 't',

P_r^e = expected raw prices of apples = $P_{t-1} + P_{t-2}/2$,

P_q^e = expected parity prices of apples = P_{t-1},

π^e = expected long run profitability = π_{t-2},

R = road length = R_{t-1}

T = trend,

log a = intercept,

$b_1, b_2, \ldots\ldots b_6$, are the regression coefficients of the respective variables,

U = random variable.

In the linear format the regression coefficients of equation Nos. 1.4, 1.5 and 1.7 gave spurious signs to some of the variables included in these equations and hence were dropped. The coefficient of multiple determination in the case of equation No. 1.2 was observed to be comparatively low and hence it was also dropped. The regression coefficients of the remaining equations (1.1, 1.3, 1.6) bore consistent structural sign and had appreciably high value of R^2, and were considered suitable for discussion.

The results obtained from the double-log model revealed that the regression coefficients as well as their level of significance were consistently superior over the linear one. However, equation No. 2.2 was dropped in view of the severe incidence of auto-correlation. Equation Nos. 2.4 and 2.7 were rejected in view of the spurious structural sign of the regression coefficients. Hence, the remaining equations 2.1, 2.3, 2.5 and 2.6 were found statistically superior for estimating the acreage supply response.

RESULTS AND DISCUSSIONS

The results obtained from the selected models, both in the case of linear and double-log formats, are presented in Tables II and III. It emerged from the results that the value of the coefficient of multiple determination was substantially high and ranged between 86 and 99 per cent, which indicated that the models selected were well specified, therefore, commands strong explanatory power.

Among the set of various explanatory variables, raw prices emerged as the most crucial factor influencing the expectation behaviour of the apple growers. The regression coefficient of expected raw prices is found positive in all the specified models and significantly different from zero at one per cent level of probability in most of the cases both in linear and double-log functions. The above findings supported the hypothesis that the farmers in hilly areas respond to prices while taking long-term investment decisions. These decisions are not merely based on the prices of single year but in view of the longevity of investment and to avoid risk, the farmers consider simple average of last two years as a good indicator to form their opinion about the expectation. The price elasticity of acreage lies between 0.68 and 0.80 which indicates that the acreage response to prices is inelastic. The foregoing discussion confirms the hypothesis that the price elasticity of apple acreage is positive and significantly differs from zero.

The findings of various studies conducted in different parts of the country under diverse agro-climatic conditions revealed that individual crops generally have much higher supply (area) elasticity than the aggregate (area) elasticity. Among the individual crops, foodgrains occupy a dominant place in the cropping pattern, and have lower elasticities than cash crops[12] depending upon the agro-climatic conditions. The supply (area) elasticity for foodgrains in a majority of cases generally varied between 0.10 and 0.40 and for

12. For details, see S. L. Bapna: Acreage Supply Response of Crops in a Developing Region, Sultan Chand & Sons, New Delhi, 1980.

TABLE II. REGRESSION COEFFICIENTS OF ACREAGE SUPPLY RESPONSE: LINEAR FUNCTION

Model specification	a	b_2	b_3	b_4	b_5	TAE	d	R^2	$\bar{R}^2$
Equation No. 1·1 $A_t = f(P^e_r P^e_q)$	29652·95	469·51* (82·901) [0·7994]	—136280·17* (16888·788) [—0·7362]	—	—	0·06 (0·48)	2·25	0·92	0·91
Equation No. 1·3 $A_t = f(P^e_r P^e_q \pi^e)$	28179·52	463·38* (82·456) [0·7889]	—140142·37* (17115·696) [—0·7571]	86·40 (77·78) [0·0778]	—	0·032 (0·48)	2·28	0·93	0·91
Equation No. 1·6 $A_t = f(P^e_r P^e_q \pi^{eR})$	15093·79	44·72 (69·25) [0·0761]	—46303·80* (15186·15) [—0·2501]	65·73*** (36.09) [0·0592]	2·49* (0.34) [0·6379]	0·45 (0.45)	1·43	0·99	0·98

TABLE III. REGRESSION COEFFICIENTS OF ACREAGE SUPPLY RESPONSE: DOUBLE-LOG FUNCTION

Model specification	Log a	b_2	b_3	b_4	b_5	b_6	TAE	d	R^2	$\bar{R}^2$
Equation No. 2·1 $A_t = f(P^e_r P^e_q)$	2·3965	0·759* (0·235)	—0·978* (0·153)	—	—	—	—0·219 (0·280)	2·39	0·87	0·85
Equation No. 2·3 $A_t = f(P^e_r P^e_q \pi^e)$	2·1961	0·683* (0·219)	—1·091* (0·151)	0·170*** (0·086)	—	—	—0·238 (0·289)	2·43	0·89	0·87
Equation No. 2·5 $A_t = f(P^e_r P^e_q \pi^{eT})$	3·7651	0·0797 (0·985)	—0·207** (0·089)	0·033 (0·028)	—	0·411* (0·036)	0·204** (0·096)	2·06	0·99	0·99
Equation No. 2·6 $A_t = f(P^e_r P^e_q \pi^{eR})$	1·4401	0·046 (0·173)	—0·304*** (0·170)	0·0797† (0·052)	0·672* (0·125)	—	0·448** (0·217)	1·16	0·97	0·96

Note:— TAE=Total area elasticity is the sum of all the significant elasticities.

Figures in parentheses are the standard errors of the respective coefficients.

Figures in square brackets are the elasticities of the regression coefficients. Elasticities $\left(E_p\right) = \frac{dy}{dx_2} \times \frac{x_2}{y}$ where x=1,2,3,4.

*Significant at 1 per cent level.

**Significant at 5 per cent level.

***Significant at 10 per cent level.

† Significant at 20 per cent level.

cash crops it varied between 0.20 and 0.70.[13] The findings of this study are comparable with those of cash crops and from the foregoing discussion it can be inferred that the apple growers in Himachal Pradesh are as responsive to prices as has been noticed in the case of cash crops grown in other parts of the country.

Another important variable included in the model was parity ratios. The magnitude of the coefficients exhibited negative sign and was significantly different from zero in all the selected models. The type of behaviour exhibited by the parity ratios clearly indicated that the apple prices have not increased at the same pace as the consumer price index, which may be ascribed to the fact that the demand for apples has not shown a commensurate increase with supplies resulting in a steady rise in raw apple prices. Notwithstanding the above, there has been a continuous increase in the area under apples, despite adverse terms of trade, and the orchardists have tried to maintain the same level of parity by producing more through intensive and extensive cultivation practices, which is confirmed from the fact that there has been an increase in both area and productivity during the period under reference.

Though the expected profitability of apple crop was observed to be associated positively in all the models of linear and double-log formats, it did not emerge as strong as price. The study revealed that the profitability of the crop is also an important factor inducing the growers to take up apple plantation. Another factor, namely, linking of difficult terrains in the interior with roads, was also found associated positively with dependent variable and emerged significant at one per cent level of probability in all types of models. Apart from these factors, trend was also introduced as one of the independent variables and the value of coefficient of multiple determination was found to be maximum with the introduction of this variable. The regression coefficient of trend emerged positive and significant at one per cent level of probability, which clearly indicated that the acreage response has trend and this may be due to exogenous factors like development of infrastructural facilities, government policies, etc. Owning an apple orchard is considered a status symbol which seems to have motivated more people to take to apple cultivation in this hilly State.

CONCLUSION

The most significant finding of the study is the conclusive evidence in regard to the acreage response of perennial crops, which establishes that the apple growers in Himachal Pradesh are as responsive to raw prices as has been noticed in the case of cash crops grown in other parts of the country. Apart from prices, the profitability of the crop, development of infrastructural facilities, trend, etc., also exhibited positive impact while taking long-term apple plantation decisions. The parity ratio, on the other hand, showed inverse relationship. The study provides a clue to policy makers that price policy can be an effective instrument in bringing about the desired change in acreage under perennial horticultural crops.

13. Bapna: *op. cit.*