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Supply Response of Horticultural Crops: The Case of Apple and Pear in Jammu & Kashmir[§]

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Abstract

The apple and pear have a significant place in the horticulture sector of Jammu & Kashmir. The planted areas have been expanding quiet significantly since 1990s. Advanced technologies for these crops have been rationalized and adopted by the growers; however, seasonal and annual variations of the fruit supplies continue to characterize prices at both wholesale and consumption levels. In this study, Nerlovian model has been used to estimate supply response, Engle- Granger test and Vector Error Correction Model have been used to estimate the long-run and short-run dynamics. The study has revealed that the price of apple has more variation compared to price of pear. The existence of correlation between the prices of apple and pear suggests that there exist both long-run and short-run relationships between the prices of these commodities. The results have exhibited a high value of R^2 (95%) and estimated own price elasticities of 0.32 and 0.33 in apple and 0.03 and 0.28 in pear, respectively in short- and long-run. The results have further revealed that the price of pear has a positive and significant impact on price of apple, as demonstrated by their respective coefficients. The study has concluded that if price of apple increases, people can opt for pear which has turned out to be an alternative crop.

Key words: Apple, pear, co-integration, supply elasticities, Jammu & Kashmir

JEL Classification: Q13, Q11

Introduction

Horticulture is the mainstay of agricultural economy of India's hill state of Jammu & Kashmir. In 2012-13, it generated ₹ 4300 cores, which is equivalent to 7 per cent of the state Gross Domestic Product (Anonymous, 2013). Apple and pear account for more than 70 per cent of the total value of output of horticultural crops in Jammu & Kashmir (Anonymous, 2014). The changes in the planted areas and production of these two crops reflect their growing domestic and export demand. The area under apple increased from 73.10 thousand ha to 161.37 thousand ha and in pear from 12.23 thousand ha to 14.83 thousand ha between 1993-94 and 2013-14. During the same period, apple production increased from 7.93 lakh tonnes to 16.62 lakh tonnes and of pear from 0.16 lakh tonnes to 0.73 lakh tonnes (Anonymous, 2014).

Inspite of having niches in production, the state does not have specialised markets, and these fruits are traded in distant markets such as the Delhi, Ahmedabad, Bangluru, Mumbai and Kolkata markets. This leads to a rise in post-harvest costs, including marketing cost, forcing the growers to opt for pre-harvest disposal to

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meet their financial obligations and avoid climatic risks. Apple and pear are both produced and marketed during the same season and are characterised by strong seasonality and perishability. This induces competition and affects their prices and quantities supplied.

While lot of work has been done on the production aspects of these crops, no study seems to have been undertaken on the assessment of their supply response. The present study is focussed on the supply side of these crops to understand the producer's behaviour in the production of these crops. Given the fact that the investment decisions in perennial crops like apple and pear are very critical, owing to their long gestation period and irreversible nature of the area in the short-run. The study, therefore, aims to estimate the short-run and long-run supply elasticities of these crops that could help in addressing the sensitivity of the supply response.

Materials and Methods

Data Sources

The study is based on the time series data on area, production, maximum/minimum temperature, rainfall and wholesale prices of apples and pear for the period from 1981 to 2013 collected from the secondary sources like Department of Horticulture, Department of Horticulture Planning and Marketing, Department of Planning and Development, Directorate of Economics and Statistics, Government of Jammu and Kashmir, Fruit and Vegetable Mandi, Srinagar, and various other agencies involved in the marketing of fresh and dry fruits in Jammu and Kashmir in addition to the published sources of information including those from the meteorological department of the state.

Method of Estimation

The role of supply response in understanding the price mechanism in horticultural crops gains importance in view of the latest trade policies affecting horticulture globally under the new economic order (Nerlove and Bachman, 1960, cited in Mushtaq and Dawson, 2003), supply response would, therefore, indicate the changes in output with changes in prices and the supply shifter would approximate the long-run equilibrium in the sector (Tripathi, 2008).

Nerlovian Model

The supply response has been estimated directly by including partial adjustment and restricted adaptive expectations (Nerlove, 1958). The Nerlovian model describes the dynamics of supply by incorporating price expectations and partial area adjustment. Since the desired output in this model is a function of price expectation, the supply function can be written as:

$$Q_t^d = \beta_1 + \beta_2 P_t^e + \beta_3 Z_t + u_t$$

where,

Q^d_t = Desired output of the fruits in period *t*,

P_t^e = Expected price of fruits,

Z_t = Set of exogenous shifters (e.g., temperature, rainfall),

u_t = Unobserved random effects affecting the output and has expected value zero and constant variance,

$\beta_i s$ = Parameters, and

β_2 = Long-run elasticity coefficient of output with respect to price.

The response in output by orchardists may be constrained by different risk factors like credit constraint, lack of availability of inputs, etc. To account for this, in the Nerlovian tradition, it was assumed that the actual output could differ from the desired ones due to the adjustment lags of variable factors. Since the full adjustment to the desired level of output is only possible in the long-run, it was assumed that the actual output would only be a fraction, 'δ' of the desired output, i.e.

$$Q_t - Q_{t-1} = \delta\,(Q_t^d - Q_{t-1}) + v_t$$

$$Q_t = Q_{t-1} + \delta\,(Q_t^d - Q_{t-1}) + v_t$$

where,

Q_t is the actual output in period *t*, Q_{t-1} is the actual output in period *t*-1, and δ is the partial adjustment coefficient and its value lies between 0 and 1.

Most of the previous studies have used Nerlove (1958) restrictive adaptive expectations and partial adjustment model. However, most of the economic time-series data are trended over time and the regressions between trended series may produce significant results with high R^2 value that may be spurious (Granger and Newbold, 1974). To overcome this problem, Engle-Granger co-integration with Error Correction approach is widely used as the co-integration analysis with non-stationary time series data that can avoid spurious regressions (Banerjee *et al.*, 1993). In the present study, Engle-Granger co-integration approach along with Vector Error Correction Model was used. However, prior to this, Augmented Dickey-Fuller (ADF) test was performed to examine each of the variables for the presence of unit root, since it follows the first order auto-regressive processes and includes the first order difference in lags in the test in such a way that the error-term is distributed as a white noise process. The equation for the ADF test is:

$$\Delta Y_t = bY_{t-1} + \sum_{i=1}^{j} \alpha_i \Delta Y_{t-1} + u_t$$

where, Y is the processes to be tested, b is the test coefficient, and j is the lag length chosen for the ADF such that u_t is a white noise process.

Here, the significance of b is tested against the null hypothesis to find that the process is not weak (non-stationary). Thus, if the null hypothesis of not weak stationary cannot be rejected, the variables are differenced until they become stationary (until the existence of unit root is rejected).

Engle-Granger Co-integration Approach

Given a set of I (1) variables $\{x_{1t}, \ldots, x_{kt}\}$, if there exists a linear combination consisting of all variables with a vector β so that,

$$\beta_1 x_{1t} + \ldots + \beta_k x_{kt} = \beta' x_t$$

is trend-stationary and

$$\beta_j \neq 0, j = 1, \ldots, k.$$

Then, the x's are cointegrated of the order CI (1,1); and $\beta' x_t$ is a (trend) stationary variable. If $\beta' x_t$ is trend-stationary, then also $c(\beta' x_t)$ with $c \neq 0$. Moreover, any linear combination of cointegrated variables is stationary. Generally, we could consider $x \sim I(d)$ and $\beta' x \sim I(d-b)$ with $b > 0$. Then the x's are C I(d, b).

Vector Error Correction Model

In this paper, only the standard case of CI (1,1) has been dealt with. Under Engle-Granger representation theorem, if a set of variables is cointegrated in an order of I (0), there exists an ECM describing the relationship. The theorem explains that cointegration and an ECM can be used as a unified theoretical and empirical framework to analyze both short-run and long-run behaviour. If the series Y_t and X_{it} are I (1) and cointegrated, then the ECM is represented in the following form:

$$\Delta X_{it} = \alpha_0 + \beta_i \Delta X_{(t-1),i} + \beta_j \Delta X_{(t-1),j} + \delta ECT_{t-1} + u_t$$

$$\Delta X_{it} = \varphi_0 + \sigma_j XP_{(t-1),j} + \sigma_i X_{(t-1),i} + \lambda ECT_{t-1} + u_t$$

where, Δ is the difference operator, X_{it} is the price of fruits (i =1), and X_{jt} represent the independent variables mentioned earlier (i = 2, ... ,5); u_t and ε_t are white noise error-terms, ECT_{t-1} is the error correction-term (adjustment vector) derived from the long-run co-integrating relationship, and n represents the optimal lag length orders of the variables that are determined using the general-to-specific modelling procedure (Hendry and Ericsson, 1991).

Result and Discussion

Stepwise analysis of the data was done which included descriptive analysis, estimation of short-run and long-run elasticities, Engle-Granger cointegration test and finally, the Vector Error Correction Model to estimate long-run and short-run dynamics in apple and pear. Price and production series of apple and pear along with the maximum temperature, minimum temperature and the rainfall in Jammu & Kashmir for the period 1981 to 2013 have been considered for the present investigation.

Descriptive Statistics

A perusal of the summary statistics for the different series in Table 1 indicates that the production of apple and pear and the price of apple were positively skewed and leptokurtic, whereas, four series, viz., pear price, maximum and minimum temperatures and average rainfall showed negative skewness. The pear price and average rainfall have exhibited platykurtic behaviour, while maximum and minimum temperatures have shown leptokurtic phenomena. Though variation in the price was more of apple than of pear, the volatility in production was much higher in pear than in apple.

Table 1. Descriptive statistics of apple and pear variables in Jammu & Kashmir

Variables	Minimum	Maximum	Mean	Standard error of mean	Standard deviation	Skewness	Kurtosis
Apple price (₹/box of 18 kg)	61.3	565.4	202.6	23.4	134.6	1.01	0.58
Apple production (Mt)	427063	1852412	930271	64948	373103	0.96	0.24
Pear production (Mt)	21239	32568	27263	1274	3822.4	-0.21	-0.75
Pear price (₹/box of 18 kg)	72.8	454.0	297.2	20.0	114.7	-0.59	-0.94
Maximum temperature (^{0}C)	20.0	33.5	29.3	0.5	3.0	-1.85	4.25
Minimum temperature (^{0}C)	10.2	18.9	17.3	0.3	1.7	-2.72	10.21
Average rainfall (mm)	556.0	1872.7	1196.2	65.6	376.6	-0.06	-0.93

Short-run and Long-run Elasticities

The short-run and long-run elasticities for two major fruits, apple and pear, in Jammu & Kashmir, were computed and are documented in Table 2.The estimation of supply elasticity helps in prediction of short-run and long-run impacts of price variation on production and hence allows for the appropriate price policies. All explanatory variable estimates had the expected signs and were mostly significant with an R^2 value of more than 95 per cent. The estimated own price elasticities for apple were 0.32 and 0.33, whereas for pear were 0.03 and 0.28, in short-run and long-run, respectively and all were found highly significant. The results revealed that one degree decrease in minimum temperature could decrease price of apple by 0.56 per cent and 0.57 per cent, respectively in short-run and long-run. It is because any further decrease in minimum temperature could have a negative influence on the production of apples, which would directly influence the price. An increase in fruit production by one per

Table 2. Estimated elasticities of apple and pear in Jammu & Kashmir

Variable	Apple		Pear	
	Short-run	Long-run	Short-run	Long-run
Intercept	-8.04***	-8.19***	-2.32	-2.68
	(-3.15)	(-3.21)	(2.96)	(2.48)
Lagged price	0.32***	0.33***	0.03***	0.28***
	(0.12)	(0.19)	(0.01)	(0.09)
Maximum temperature	0.14	0.14	0.21	0.23
	(0.74)	(0.62)	(0.60)	(0.82)
Minimum temperature	-0.56	-0.57	0.06	0.07
	(0.72)	(0.65)	(0.10)	(0.09)
Average rainfall	0.05	0.05	0.89**	0.99***
	(0.37)	(0.32)	(0.21)	(0.25)
Production	0.15***	0.15***	0.10***	0.11***
	(0.01)	(0.01)	(0.01)	(0.01)
Lagged production	0.02**	0.02**	0.05***	0.06***
	(0.005)	(0.001)	(0.00)	(0.00)
Price of competing fruit	0.30***	0.31**	0.20***	0.20***
	(0.10)	(0.13)	(0.01)	(0.01)
R square	0.96	0.98	0.95	0.96
Adjusted R square	0.93	0.92	0.90	0.91

Note: The figures within parentheses indicate standard deviation
* ,** and *** denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively

Table 3. ADF test for unit root

Variable	Apple		Pear	
	Levels	With differencing	Levels	With differencing
Lagged price	0.637	-4.825	-1.809	-4.365
Production	-0.458	-6.888	-0.037	-0.377
Lagged production	-0.917	-5.473	-2.210	-3.723
Maximum temperature	-3.989	—	-3.989	—
Minimum temperature	-4.583	—	-4.583	—
Average rainfall	-1.716	-4.123	-1.716	-4.123
Price of competing crop	-1.853	-4.467	1.059	-4.569

Note: The critical value at 5 per cent level of significance was -2.9627

cent would yield a higher price to the tune of 15 per cent for apple in both short-run and long-run, respectively and by 10 per cent and 11 per cent, for pear. The coefficient of the price of competing crop has exhibited a positive and significant impact on the price of apple having the value of 0.30 and 0.31 in short-run and long-run, respectively. The respective coefficients for pear were 0.20 in both short-run and long-run, which demonstrates that if the price of apple increases, people may opt for a substitute fruit crop.

Co-integration Analysis

Subsequent to supply response, the ADF test was carried out to find whether the data was stationary or not by testing the hypothesis that all the variables contained a unit root. Both the price series were tested for the presence of unit root by Augmented Dickey Fuller (ADF) test and the results are presented in Table 3. While the production and prices of both the fruits as well as the average rainfall became stationary after differencing, the maximum and minimum temperature series were found to be stationary at the levels. The production and lagged production of apple and pear at levels were found stationary for series with trend and without trend, whereas all other variables were non-stationary at levels even with deterministic trend. At first differencing, all the series became stationary at 5 per cent level of significance and after knowing the order of integration, the model was specified.

The long-run equilibrium and results of the co-integration analysis for the above series are reported in Table 4. The Engle-Granger co-integration approach was followed to test the existence of long-run equilibrium relationship among the variables. However, for co-integration, two conditions had to be met, first each variable should be integrated of the same order and second, a linear combination of these variables must be integrated of an order one less than the original order of the variable (Engle and Granger, 1987). In other words, if the variables are integrated of order one, i.e., I (1), then the residual from the co-integrating relationship should be integrated of order zero or I(0).

The results revealed that the lagged price of apple, with a co-integration coefficient of 0.137, had a positive influence on the production (Table 4). This indicated that the orchardists responded positively to the previous year's price to determine the future drift in price. The coefficient of production was found to be negative for apple (-2.449), and positive for pear (0.066). However, the coefficient for lagged production was positive for both apple and pear (4.162 and 0.028, respectively). The exogenous factors were positive for apple and negative in pear. The price of competing crop was negatively significant for apple (-0.078) and positively significant for pear (0.833). The Durbin-Watson coefficient was approximately two for both the fruits, which showed the absence of autocorrelation among the residuals.

The short-run dynamics of the variables worked out by Vector Error Correction Model (VECM) revealed a negative price elasticity (lagged price) for apple and pear with a coefficient of -1.0 and -0.98, respectively, compared to the price of competing fruit which turned out to be positively significant with the coefficients of 1.71 and 0.001 for apple and pear, respectively (Table 5). The Error Correction factor was found 0.03 for apple and -0.01 for pear. The value for pear indicated slow adjustment towards the long-run

Table 4. Estimates of long-run equilibrium and co integration for apple and pear in Jammu & Kashmir

Variable	Coefficients	
	Apple	Pear
Constant	-8.043***	0.940**
	(2.681)	(0.41)
Lagged price of main fruit	0.137**	-0.083***
	(0.052)	(0.037)
Production of main fruit	-2.449	0.066***
	(2.320)	(0.029)
Lagged production of main fruit	4.162*	0.028
	(2.250)	(0.091)
Maximum temperature	0.146	-0.233
	(0.331)	(.194)
Minimum temperature	0.018	0.254
	(0.342)	(0.610)
Average rainfall	0.070	-0.051
	(0.205)	(0.621)
Price of competing fruit	-0.078***	0.833***
	(0.019)	(0.230)
R-square	0.962	0.947
Adjusted R-square	0.931	0.898
log-likelihood	46.725	53.856
Schwarz criterion	-41.464	-52.261
Rho	0.037	-0.286
Durbin-Watson	1.893	2.014
Hannan-Quinn	-56.163	-67.939
Akaike information criterion	-63.450	-75.713

Note: Figures within the parentheses indicate standard deviation, *,** and *** denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively

Table 5. Short-run dynamics and estimates of Vector Error Correction Model for apple and pear in Jammu & Kashmir

Variable	Coefficients	
	Apple	Pear
Constant	0.98***	0.99***
	(0.00)	(0.00)
Lagged price	-1.00***	-0.98* **
	(0.00)	(0.00)
Production of main fruit	-1.17* **	0.001
	(0.00)	(0.00)
Price of competing fruit	1.71***	0.001***
		(0.00)
EC1	0.03	-0.01
R-square	0.96	0.93
Adjusted R-square	0.91	0.95
Durbin-Watson	2.04	1.92
Rho	-0.19	-0.21

Notes: The figures within parentheses indicate standard deviation; *,** and *** denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively

equilibrium level in the current period. The high value of R^2 and the value of Durbin-Watson test statistic too indicated no autocorrelation among the residuals.

Conclusions and Policy Implications

The supply response model for the perennial crops, such as apple and pear, is required owing to their implications for production, profitability, government policy impacts and input storage effects. The perennial crops are more complicated to model than annual crops due to the time lag between initial planting and first output, then an extended period of production, followed by a substantial drop in production. A clear understanding of the short-run and long-run production decisions and the life-cycle of perennials crops is necessary to accurately model the supply response. The study has concluded that the lagged price of apple had a positive influence on production, indicating that the growers responded to the previous year's price to determine future drift in price. The price of pear had a positive and significant impact on the price of apple, as demonstrated by their respective coefficients. It indicated that if price of apple increases, people can opt for pear which is an alternative crop. Based on the results, following policy implications have emerged:

- Proper infrastructure in terms of cold storages, etc. and communication for market intelligence need to be created on priority being a pre-requisite for increasing production of fruit crops.
- The fruit development in Jammu & Kashmir needs to be viewed from the point of competitiveness from other markets/states. Therefore, dissemination of technologies for increasing the quality production of these fruits needs prioritization to regulate supplies.

- Pragmatic policies for reducing transportation cost, post-harvest losses, storage costs, etc. need to be framed to help farmers for rational area allocation under various fruits.
- Market intervention schemes for regulation of supplies and stabilization of prices need to be evolved.

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