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Supply elasticity of major crops in Jammu region: An Engle-granger Co-integrating approach

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Abstract

A study was undertaken to analyze the supply response of crop sector and its implications on consumption using co integration approach incorporate with Nerlovian partial adjustment model for the period 1981-82 to 2010-11 based on secondary data. Since the study used yearly time series data, thus the unit root test has been done by ADF test for concluding about the stationary of data and the order of integration. The result of ADF test indicates that all the series are stationary after first order difference. Engle-Granger con-integration test was conducted to test the existence of long-run equilibrium among the variables of the rice output response function. The results showed that the coefficients of lagged production was negative for rice and maize while as positive for wheat, bajra and barley. Coefficient for price was negative for all the crops except maize. Likewise coefficient for lagged production was positive for rice, wheat and bajra and negative for maize and barley.

Keywords: Supply response, Engle-granger and iterative regression

Introduction

Supply response, one of the most important issues of agricultural development economics as the farmers' are responsive to economic incentives and these incentives determines contribution of agriculture to economic development of a country. Also technological revolution is the key instrument for augmenting growth in the agricultural sector. Once an apposite technology is available, then the agricultural pricing policy plays a significant role in increasing both production and income (Mushtaq and Dawson, 2003) [5].

In India, with the introduction of reforms in early nineties accompanied by trade and exchange rate liberalisation, it was expected that Indian farmers would benefit considerably from the increased market incentives (Rao, 2003) [9]. Price plays an important role in the selection of crops and generation of marketed surplus. Generally higher prices are expected to result in a larger output. Prices are therefore, among the most important determinants of the area under different crops. In economic analysis of the farm supply response price is considered to be the critical economic factor that determines farmers production decision also consumers' demand for food is an important component of the structure within which the agriculture sector must operate (Ramalu, 1996; Huq *et al*, 2004) [10, 3].

It is widely believed that the reforms of 1990s helped to remove some of the constraints that Indian farmers had been facing in responding to market incentives, and hence a greater response is expected in the post-reform period. The lack of response may be because the policies are still unable to identify and target the proper constraints. An alternative view is that the farmers' response to liberalization is a lengthy process and hence in the short span of 10 to 15 years, the full effects are yet to be realized (Mythili, 2008) [6].

Agriculture, the main occupation of people in Jammu & Kashmir showed tremendous fluctuations in area, production and yield over the years which may be the result of various technological developments and pricing policies, all these variation result in elasticity of agricultural sector, thus this paper is an attempt in this direction and to estimate supply response and consumption demand of various crops in Jammu region. The crops chosen under the study are important for the food security of the region as rice and wheat are the major sources of food grains supply. These two crops share more than 70 per cent of the total food grains and are the backbone of Jammu's food and household nutritional security, but these are short in domestic supply and significantly depend on imports.

Materials and Methods

Agricultural pricing policy plays a major role in increasing both the farm production and incomes and fundamental to an understanding of this price mechanism in supply response

(Nerlove and Bachman, 1960 cited in Mushtaq and Dawson, 2003) [8, 5]. The responses of elasticities are also important for decision making about policy regarding to agricultural growth and development. Supply response indicates the change in output with the changes in prices as well as supply shifter and, therefore, approximates to the long-run, dynamic concept of supply theory (Tripathi, 2008) [12].

Supply response is estimated directly by including partial adjustment and restricted adaptive expectations (Nerlove, 1958) [7]. This approach is also known as Nerlovian model. Nerlovian's model describes the dynamic of supply by incorporating price expectations and partial area adjustment. In the present study we are using Nerlovian price expectation model, according to which, desired output is the function of price expectation. So, the form of the supply function can be written as:

$$Q_t^d = \beta_1 + \beta_2 P_t^e + \beta_3 Z_t + u_t \quad (1)$$

Where;
Q^d_t= desired output of the period *t*
P^e_t= expected price
Zt= set of exogenous shifters (e.g. weather, irrigation, non-price factors) and
u_t = unobserved random effects affecting the output from cultivation and has expected value zero and variance constant
β_i's = parameters
β_2= long–run elasticity coefficient of output with respect to price.

Response of output by farmers may be constrained by different risk factors, credit constraint, lack of availability of inputs etc. For this, in the Nerlovian tradition it is assumed that the actual output may differ from the desired ones because of the adjustment lags of variable factors. Since the full adjustment to the desired level of output is only possible in the long-run, therefore, it is assumed that the actual output would only be a fraction δ of the desired output.

$$Q_t - Q_{t-1} = \delta(Q^d{}_t - Q_{t-1}) + v_t \quad (2)$$

$$Q_t = Q_{t-1} + \delta(Q_t^d - Q_{t-1} + v_t \quad (3)$$

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

The adjustment coefficient must lie between 0 and 2 for the adjustment to converge over time, but δ>1 implies persistent over adjustment, and does not appear plausible in subsistence peasant agriculture. So, the limit of coefficient δ lies between 0 and 1 (Molua, 2010) [4]. Similarly, the price expectations are adaptive and based on the actual and expected price. So, according to Sadoulet and de Janvry (1995) [11]

$$P^e{}_t - P^e{}_{t-1} = \gamma\left(P_t^e - P^e{}_{t-1} + w_t\right) \quad (4)$$

Where;
P_t = current price
P^e_t = expected price.
Rearranging the equation:

$$P^e{}_t = \gamma P_{t-1} + (1+\gamma)P^e{}_{t-1} + \omega_t \quad (5)$$

Where;
P_{t-1} = price that prevails when the decision making for cultivation occurs in period *t*
γ = adaptive expectation coefficient.
Since Q_t^d and P^e_t are not observable, so we can eliminate them, and after rearranged the reduced form equation is:

$$Q_t = \theta_1 + \theta_2 P_{t-1} + \theta_3 Q_{t-1} + \theta_4 Z_t \quad (6)$$

Where
$\theta_1 = \beta_1 \delta\gamma$
$\theta_2 = \beta_2 \delta\gamma,$ is the short-run elasticity coeffecient of supply response
$\theta_3 = (1-\delta) + (1-\gamma),$ and long-run elasticity coeffecient $\beta_2 = \theta_2 /(1-\theta_3)$

Although, most of the previous studies used Nerlove's (1958) [7] restrictive adaptive expectations and partial adjustment model, however, most 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) [2]. To overcome this problem Engle-Granger co-integration with Error Correction approach are widely used. Co-integration analysis with time series non-stationary data can avoid the spurious regressions (Banerjee *et al*., 1993) [1]. In the present study also Engle-Granger co-integration approach with Error Correction approach was used.

For testing the stationary unit root test carried out, the study used Augmented Dickey -Fuller (ADF) test to examine each of the variables for the presence of a unit roots (indication of non-stationary), since it follows the first order auto-regressive processes and includes the first order difference in lags in the test such a way that the error term is distributed as a white noise processes. The equation of ADF test is as follows:

$$\Delta Y_t = bY_{t-1} + \sum_{i=1}^{j} \alpha_i \Delta Y_{t-1} + u_t \quad (7)$$

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

Here the significance of the b is tested against the null hypothesis that the process is not weak stationary (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). Test for the nature of the equilibrium relationship that exists between variables in the model is then carried out. If established that the data series have a long-run equilibrium relationship but have significant short-run divergences the model is given an error-correction representation, theoretically defined as:

$$\Delta Y_t = \pi_0 + \pi_1 \Delta Y_t^* + \pi_2 \left[q^*{}_{t-i} - q_{t-i}\right] \quad (8)$$

Where

Y^*_t= change in the 'desired' equilibrium level.

The error-correction mechanism captures the short- run dynamics, while making the model consistent with long-run dynamics. In the present research, we have employed Gret software to workout Engle-Granger long run equilibrium and error correction short run dynamics.

To study the effect of supply response on the consumption, the effect of production, import and price on consumption of rice and wheat were studied using Iterative Seemingly Unrelated Regression (ISUR) method as follows:

$C_r = \alpha_r + \beta_{1r}Pd_r + \beta_{2r}I_r + \beta_{3r}Pr_r$

$C_w = \alpha_w + \beta_{1w}Pd_w + \beta_{2w}I_w + \beta_{3w}Pr_w$

Where

C_r and C_w= consumption of rice and wheat

Pd_r and Pd_w = Production of rice and wheat

I_r and I_w = Import of rice and wheat

Pr_r and Pr_w = Price of rice and wheat

Results and Discussion

Short-run and long run elasticities

Information about supply elasticity (Table1) allows for the formulation of appropriate agricultural policies that helps in prediction of short run and long run impacts of input changes on production revealed that estimated own price elasticity for rice were 0.070 in short run and 0.065 in long run. Rice yield is negatively related to price, rainfall and temperature. This may be due to the fact that during kharief season, temperature is high and a slight decrease in temperature could have positive impact on production. A one per cent increase in price of rice will decrease rice yield by 0.009 per cent both in short run as well as long run. Wheat yield observed own price elasticity of 0.311 and 0.846 in short run and long run, respectively. Wheat yield has negative relation with price, one per cent increase in price of wheat decreases wheat yield by 0.261 per cent in short run and 0.709 in long run. Unlike rice production wheat production has positive effect of rainfall and temperature. A one per cent increase in rainfall increases wheat production by 0.023 per cent in short run and 0.062 per cent in long run. This indicated that maximum temperature was observed to be significant contributor to production may be because during rabi season temperature is low and improvement in temperature would have positive effect on production.

Maize production has significant effect of price and rainfall and negative effect of own price elasticity and temperature. Increase in price of maize by one per cent increases maize yield by 0.558 per cent and 0.504 per cent in short run and long run respectively. The estimated own price elasticity of maize is -0.426 in short run and -0.385 in long run. One per cent increase in rainfall increases maize production by 0.057 per cent and 0.051 per cent in short run and long run, respectively. Thus indicated that the results of both the *kharif* crops *viz.* rice and maize had somewhat similar impact of temperature. Estimated bajra own price elasticity in short run was 0.001 and in long run it was 0.003. Price elasticity for bajra was estimated to be -0.001 in short run and -0.002 in long run which means one per cent increase in bajra price decreases bajra yield by 0.001 per cent in short run and 0.002 per cent in long run. Increase in rainfall decreases bajra yield by 0.002 per cent in short run and 0.005 per cent in long run. Increase in barley price decreases barley yield by 0.003 per cent and 0.004 per cent in short run and long run, respectively. The estimated own price elasticity of barley was calculated as 0.002 per cent in short run and 0.003 per cent in long run. Barley production has negative relation with rainfall and temperature. A one per cent increase in rainfall decreases barley yield by 0.001 per cent both in short run as well as long run.

Unit root tests

Foregoing to supply response analysis, a unit root test of each of the time series data were undertaken to find out whether the variables are stationary or not. A well known unit root test, the ADF test was employed to analyse the hypothesis that all the variables contain a unit root cannot be rejected at the 5 per cent level.

The results of the ADF tests with and without deterministic trend are presented in Table 2. The results specify that variables like production and lagged production of rice, maize, and barley were stationary in both trend and non trend level series. Where as all other variables were non-stationary in the level series even in deterministic trend. Thus, the study proceeded to first order differentiated i.e. I (1) of each series and the results showed all time series become stationary at 5 per cent significance level. Therefore, the model was specified after having known the order of integration.

Empirical study on long run equilibrium

Engle-Granger co-integration approach was carried out to test the existence of long-run equilibrium among the variables. However, for co-integration two conditions must be hold, first one is each variable should be integrated of the same order. Secondly, the linear combination of these variables must be integrated of an order one less than the original order of the variable (Engle & Granger, 1987). In other words, if the variables are integrated in order one I (1), then the residual from the co-integrating relationship should be integrated in zero order or I (0). The results in Table3 revealed that both log of lagged production and log of price had negative impact on rice production with co-integration coefficient of -0.17 and -0.24 respectively. The log of lagged price had a positive effect on the production of rice with co-integration coefficient of 0.395 thereby indicating that farmers positively responded to the previous year price in order to determine the future drift of rice production. That means if the farmers got higher price in the previous year then they are motivated to increase production using HYV seeds, other agricultural inputs and technology. In case of wheat and bajra, log of price had negative impact with coefficient of -0.16 and -0.095 respectively, while as lagged price and lagged production had a positive impact on the production of wheat and bajra with coefficients of 0.516 and 0.463 in case of wheat and 0.156 and 0.651 in case of bajra. The lagged production had negative impact on maize with coefficient of -0.113 and positive impact on barley with coefficient of 0.132. However, the price had positive impact on maize production and negative impact on barley production. The lagged price had negative impact on both maize and barley, with coefficients of -0.32 and -0.001 respectively. Indicating that the maize production was not dependent on price of previous year but may be on other variables (HYVs, technologies, policy regimes, etc.). The value of R^2 were 0.35, 0.511, 0.219, 0.526 and 0.209 indicating that independent variables contributed maximum in case of bajra and minimum in case of barley. The lowest value of Schwarz criterion or Bayesian information criterion of -35.494 in barley indicated that this model is better than others for calculating yield response. The lowest values of Akakie criterion and Hannan-Quinn criterion were also observed to be better for barley than others with values of -35.494 and -41.090 respectively. The values of Durbin-Watson were nearly equal to 2 in all models indicating the absence of autocorrelation of the residuals in the models.

The short run dynamics and yield response

The short run dynamics and yield response was worked out by vector error correction model (VECM) and is presented in Table 4. The perusal of data in the Table revealed t that the price elasticity of rice, maize and barley were negative but inelastic with coefficients of -0.045, -0.375 and -0.001 while as that of maize was positive but inelastic with the value of 0.086. Bajra was perfectly inelastic with respect to price. The lagged price was negative and less elastic in maize with coefficient of-0.085 and positive in all other crops with maximum value of coefficient in case wheat (0.335) followed by rice (0.045) and almost inelastic for bajra and barley (0.001). Coefficients of rainfall were -0.021, 0.011, 0.012 and -0.002 for rice, wheat, maize and bajra, respectively. In case of barley the elasticity coefficient was found to be 0.000 indicating perfectly inelastic nature. The coefficients of maximum temperature were -6.234, 11.498, -8.142, -0.634 and -0.036, while as that of minimum temperature were -9.128, -13.014, -23.372, 1.027 and 0.185 for rice, wheat, maize, bajra and barley, respectively. The magnitude of the error correction term indicated that the speed of adjustment of any disequilibrium toward a long run equilibrium state, and its values were -0.499, -0.103, -0.447, -0.239 and -0.413 for rice, wheat, maize, bajra and barley, respectively. The values indicated slow adjustment towards the long run equilibrium level in the current period for all the crops.

Iterative seemingly unrelated regression of consumption

The coefficients of Iterative seemingly unrelated regression of consumption are given in Table 5, which indicated that rice consumption was mostly influenced by own production and price of rice while as import had less impact on the consumption of rice, with values of 1345.65, 1305.04 and 188.91 for price, production and import, respectively. The Table further indicated that besides these three variables, there are other factors which area responsible for the consumption of rice as indicated by the high constant term of 2062.00. In case of wheat, the main factor for the consumption observed was import which had highest value of coefficient of 4166.67 where as the production and price had low value of coefficients. The results also revealed that the production of rice and wheat is not consistent, the reason may be population growth is much larger than production and demand for food would continue to rise and food supply has to keep pace in order to avoid food shortages. This requires production to increase manifold. Since net area under cultivation has almost exhausted, productivity levels have to increase by leaps and bounds. This could be achieved by focusing on several areas simultaneously i.e. easy availability of quality inputs, institutional credit and warehousing/ marketing facilities and concessions for the needy farmers. There is also a need to increase the land under high yielding varieties of seeds, expand the network of irrigation system and rationalize the use of fertilizers and pesticides.

Conclusion and policy implication

It may be concluded that short run elasticities of price was negatively inelastic while that of lagged price was positively inelastic for all the crops except maize, thus indicating that effective price policy is essential to obtain desired level of production of different crops. The inelastic nature of long-run elasticity that indicated the structural constraints facing by the farmers, price policy in the form of incentive is not a sufficient instrument for effecting farmers' response in the state. The speed of the variables towards the long run was very low, indicating the need to overcome it.

The results from this paper suggest following policy implications

a. Producer‘s react to price changes, as a result most of the producers increase their acreage under particular crop on the basis of its price in previous year. Therefore, price stabilization through market intervention can be effective for increasing food grain production.
b. Since the consumers have inelastic responses to price changes, thus not only the government price intervention but also combination of price and income policy may induce more effectiveness in food consumption pattern in Jammu region.

Table 1: Short run and long run supply elasticities of major crops in Jammu region

Regressor	Rice		Wheat		Maize		Bajra		Barley	
	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run
Lagged production	-0.087 (0.195)		0.632* (0.211)		-0.107 (0.203)		0.673* (0.116)		0.155 (0.157)	
Price	-0.009 (0.104)	-0.009	-0.261 (0.364)	-0.709	0.558 (0.354)	0.504	-0.001 (0.001)	-0.002	-0.003 (0.003)	-0.004
Lagged price	0.070 (0.106)	0.065	0.311 (0.366)	0.846	-0.426 (0.352)	-0.385	0.001 (0.001)	0.003	0.002 (0.003)	0.003
Rainfall	-0.001 (0.027)	-0.001	0.023 (0.057)	0.062	0.057 (0.041)	0.051	-0.002** (0.001)	-0.005	-0.001 (0.000)	-0.001
Max temperature	-7.097 (8.213)	-6.532	4.515 (16.263)	12.278	-4.938 (11.287)	-4.459	-0.463** (0.211)	-1.419	-0.127 (0.122)	-0.151
Min temperature	-7.307 (12.995)	-6.724	0.749 (26.383)	2.037	-16.189 (19.425)	-14.618	0.789** (0.362)	2.416	0.213 (0.193)	0.252

Note: * significant at 0.01 los and ** significant at 0.05 los

Table 2: ADF tests results for the variables of supply response analysis

Series	level series		first differences	
	No trend	with trend	No trend	with trend
Log of rice production	-4.527	-6.711	-	-
Log of wheat production	-2.403	-2.594	-6.514	-6.624
Log of maize production	-4.065	-5.068	-	-
Log of bajra production	-2.273	-3.114	-5.446	-5.442
Log of barley production	-3.45	-3.831	-	-
Log of lagged rice production	-4.337	-6.808	-	-
Log of lagged wheat production	-2.452	-3.496	-6.887	-6.797
Log of lagged maize production	-4.271	-5.14	-	-
Log of lagged bajra production	-2.341	-2.862	-5.396	-5.465

Log of lagged barley production	-4.817	-5.041	-	-
Log of price of rice	-1.421	-0.675	-5.137	-5.279
Log of price of wheat	-1.959	0.293	-4.049	-4.442
Log of price of maize	-1.922	-0.63	-4.606	-4.965
Log of price of bajra	-2.423	-1.112	-7.62	-8.621
Log of price of barley	-1.473	-1.038	-4.921	-5.143
Log of lagged price of rice	-1.063	-0.951	-5.281	-5.418
Log of lagged price of wheat	-1.515	0.078	-4.211	-4.611
Log of lagged price of maize	-1.871	-0.698	-4.594	-4.968
Log of lagged price of bajra	-2.087	-1.022	-6.972	-8.407
Log of lagged price of barley	-1.289	-1.21	-4.964	-5.102
5 % level critical values	-2.989	-3.584	-2.992	-3.588

Table 3: Engle-Granger test for long-run equilibrium co-integration of various crop production response models

Regressor	Rice	Wheat	Maize	Bajra	Barley
Constant	4.376 (1.383)	5.789 (7.897)	5.614 (1.192)	0.256 (0.430)	1.765 (0.462)
Log of lagged production	-0.170 (0.194)	0.463 (0.214)	-0.113 (0.248)	0.651 (0.134)	0.132 (0.178)
Log of price	-0.240 (0.434)	-0.160 (0.848)	0.482 (0.567)	-0.095 (0.240)	-0.058 (0.204)
Log of lagged price	0.395 (0.422)	0.516 (0.960)	-0.320 (0.525)	0.156 (0.226)	-0.001 (0.192)
R^2	0.350	0.511	0.219	0.526	0.209
Adjusted R^2	0.246	0.433	0.128	0.471	0.118
Log-likelihood	8.116	-1.343	10.803	12.925	24.549
Schwarz criterion	0.775	19.691	-8.002	-12.245	-35.494
Akaike criterion	-6.231	12.685	-13.607	-17.850	-41.099
Hannan-Quinn	-3.990	14.927	-11.814	-16.057	-39.306
Durbin-Watson	2.062	1.890	1.934	2.013	1.826

Table 4: Short run dynamics and Yield response

Regressor	Rice	Wheat	Maize	bajra	Barley
Constant	380.577 (291.722)	-84.063 (467.065)	640.498 (431.169)	2.718 (6.287)	-2.552 (3.891)
Price	-0.045 (0.141)	-0.375 (0.401)	0.086 (0.477)	0.000 (0.001)	-0.001 (0.003)
Lagged Price	0.045 (0.142)	0.335 (0.401)	-0.085 (0.478)	0.001 (0.001)	0.001 (0.003)
Rainfall	-0.021 (0.038)	0.011 (0.065)	0.012 (0.058)	-0.002 (0.001)	0.000 (0.000)
Max. temperature	-6.234 (11.722)	11.498 (18.968)	-8.142 (16.655)	-0.634 (0.263)	-0.036 (0.144)
Min. temperature	-9.128 (18.441)	-13.014 (30.775)	-23.371 (27.631)	1.027 (0.419)	0.185 (0.227)
EC (1)	-0.499 (0.179)	-0.103 (0.229)	-0.447 (0.186)	-0.239 (0.181)	-0.413 (0.160)
R-squared	0.330	0.096	0.318	0.411	0.262
Adjusted R-squared	0.147	-0.151	0.132	0.251	0.061
Durbin-Watson	2.269	1.898	2.248	1.776	1.855

Table 5: Iterative seemingly unrelated regression of consumption of rice and wheat

Regressor	Rice		Wheat	
	Coefficient	S.E.	coefficient	SE
Production	1305.04	799.476	0.00	0.000219
Import	188.91	44.585	4166.67	0.000368
Price	1345.65	298.984	0.00	0.000453
Constant	2062.00	122.521	-0.10	0.172518

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