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Supply response with mix of stationary and nonstationary data: Case study in pulses, India

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Abstract

Supply response studies in the past were based on traditional econometric techniques (classic linear regression) and the nerlovian framework. Results of traditional econometric techniques are reliable when the time series data are stationary. However, there can be a possibility of some macroeconomic time series data are non-stationary, thereby results and conclusion drawn from using those techniques are having the risk of invalidity. This paper specifically attempted to quantify the relationship between pulses production and price and non price factors viz., land productivity, annual rainfall, irrigated area and revenue difference between cereals and pulses, when the variables in the data expressed in levels are neither stationary [$I(0)$] nor non-stationary [$I(1)$], and do not have the same order of integration.Finding of this study suggests rainfall and revenue difference between the cereals and pulses are major determinants of pulses production.

Keywords: Supply response, production response, pulses

India is an agrarian country, with the advent of green revolution achieved self-sufficiency in the production of major cereal viz., rice and wheat. However, this green revolution achieved unfortunately at the cost of pulses and other coarse cereals (IFPRI, 1991and Banerjee,2011). Since, there has been no major breakthrough in pulses productivity, and due to increased area under intensive irrigated crops like rice and wheat etc., pulses were sidelined to the dry-land and marginal land, as a result it could not take major advantages of development in the Indian agriculture.Farmers also perceived pulses as a inferior crop. These cumulated into stagnation in area and production.

On the other hand, with the rising per capita income of middle income household, consumption pattern has been changing towards their urban household which increased the demand for pulses. As a result, existing gap between the domestic supply and demand has been widening, without leaving the trace of turning down.

These led to the mismatch between the demand and supply of pulses, which in turn led to sharp rise in prices and made pulses an expensive item for vast majority of Indian population (Aggarwal, 2004; Reddy, 2004; IIPR, 2011). It is a great concern, as larger section of population is net buyer of food andpoor. Furthermore, prevalence of malnutrition is highest (HUNGaMAReport). With the stagnant production and being an important source of protein, pulses imports are being often resorted. However, a cost effective option for effectively increasing domestic production and infrastructure development needs to be undertaken as a long terrn solution to the problem as imports cannot be a viable option in the longrun (NABARD, 2010). Also, India is the largest importer but suppliers in the international markets are very few. Therefore, domestic production of pulses has to increase.

So far as bridging the domestic demand and supply concerned how to overcome the stagnation in the pulse acreage and production without reducing the production ofcereals and high value commodities. In this context, the major questions need to be answered are; (i) how to increase the pulse production?, (ii) given that there is a potential to increase pulses production, what kind of interventions are needed in the short as well as long run?. Whether increasing acreage under rice fallow pulses is a right solution?Farmers will increase the area under pulse if there is a breakthrough in the technological change? Empirical estimation of these issues will help the policy makers to design suitable intervention to improve the pulses production.

Reliable estimates of the supply determinants are essential for policy decision making to foster pulse production. Yet, very few studies are availableon pulse supply response in India, though many studies are available on other crops. Many of the past supply response studies are based on traditional econometric techniques (classic linear regression) and the nerlovian framework. Results of traditional econometric techniques are reliable when the time series data are stationary. However, there can be a possibility of some macroeconomic time series data are non-stationary, thereby results and conclusion drawn from using those techniques are having the risk of invalidity, since, it might lead to spurious regression or nonsense regression. Nerlovian frameworkis also not without problemand so most of them fail to take into account the possible non-stationary behavior of time series data used. Perhaps, the problem of non-stationarity of time series can be avoided by taking first differences of the variable in the regression equation. Still, by applying this procedure, firstly, implication for long-run relationship between the variables are nullified or lossed, because, most of the economic theories are expressed in levels and, secondly, differencing greatly attenuates large positive residual autocorrelation false inferences upon the coefficients in the regression equation could be drawn (Bernhard, 2005).

Co-integration analysis would prove to be very useful tool(s) when all the variables are non-stationary and having the same order of integration. But, even any one of the decision variable fails to be stationary; results may be sensitive and unreliable. These problems are particularly common in developing and underdeveloped countries time series data which are characterized by having the property of stationary. This further reduces the scope of using cointegration in subsistence food commodity. The alternative solution to handle the non-stationarity would be transforming the nonstationary variable in meaningful manner and employing any ordinary least square regression. If some variables are non-stationary, deriving results and interpretation based on OLS may be spurious. To circumvent that problem, variable(s) are to be meaningfully transformed.(Kleinand Kosobud,1961)

With this background, this paper examines the supply responsiveness pulses production to changes in price and non-price factors during the study period by taking into account the both stationary [$I(0)$] and non-stationarity[$I(1)$] of time series involved in estimation. Reliable supply response estimates are particularly important when predicting the impact of changes of agricultural marketing and pricing policies.

Supply response in economic literature usually refers to the output production in response to their prices and the supply curves, which are anticipated, and generally derived from the assumption of profit maximization. In agriculture, farmers' decisions play an important role but the transformation process depending on a number of uncontrolled natural inputs, infrastructure facilities with the controlled physical inputs (Bhagat, 1989).

This paper specifically attempts to quantify the relationship between pulse production and price and non-price factors viz., land productivity, annual rainfall, irrigated area and revenue difference between cereals and pulses.

Data and Methodology

To examine the influence of price and non-price factorson pulsesproduction, time series annual data of chick pea and pigeon pea are collected from 1970-71 to 2011-12. These two pulse crops have been selected purposely because of their position as principal pulses contributing 56% to the total pulse production. In India, chickpea is grown in *rabi* or postrainy season. The sowing is done in the month of october or November. While, pigeonpea is a *kharif*crop sown during june-july with onset of monsoon.

Cropas well as state wise data on Farm Harvest Price (FHP) of pulses, and their respective competing crops are obtained from the website of Directorate of Economics and Statistics (DES) and CMIE (Centre for Monitoring Indian Economy) data base. Area, production, yield and areaunder irrigation (net irrigated area) of pulses and their respective competitive crops areobtained from various publications of DES, Government of India (GOI).

Variables Selection

As production is a product of area and yield, acreage response is partofproduction response. Mythili, 2006 and IFPRI 2010). Many regional level studies also witnessed that pulses acreage are not price responsive(Askari and Cummings, 1976; Gulati and Kelly, 1999). Therefore, in this current study production response function ispreferred to know the contribution of pulse productivity as well as the influence of price and non price variable.

Production ***(Y) is a dependent variable expressed in million tonnes.***

Rainfall

As pulses are rainfed crops, production ultimately rest upon the amount of rainfall received, distribution of rain fall and other climatic factors. Therefore to represent the contribution of weather parameter, rainfall received by the individual pulse crop istaken as proxy.

Irrigated area

Pulse crop is being considered as inferior to competing crops, net irrigated area is included to know the impact of irrigation on pulse production

Identification and selection of potential competitive crops

Step I: Competitive crops of pulses are identified based on prevailing competition for seasonal requirements and resources viz., land, labour, irrigation and other resourcesbased on literature review and crop calendar.

Step II: The potential competitive crops are selected from identified competitive crops by computing all the possible combination of regression equation. Based on the criteria of adjusted R^2best fit of the model is judged.

To select the potential competitive crops following specification of the model is used.

$$Area_{mi} = \beta_1 Area_{j1} + \beta_2 Area_{j2} + \ldots\ldots\ldots\ldots\ldots \beta_3 Area_{j3} + e \quad (1)$$

Where

$Area_{mi}$ = area of i^{th} pulse crop

$Area_{j}$ = area of j^{th} competitive crop

m = main crop (pulse crop)

j = competitive crop

Revenue difference

Revenue difference isfound better representative than price ratio of own and substitute FHP. Because, net revenue (revenue is the product of area, land productivity and FHP) or the profitability of agricultural enterprise not only decided by given FHP but also by land productivity (yield). For example, in rice, FHP per quintal is less compared to the FHP of any pulses. However, due to technological change (higher yield), revenue obtained from rice is greater than the pulses.

Revenue difference found to be superior than mere price on following counts.

(a) In reality, not only the price of own and competitive crops, but also the technical efficiency and technological change happening across those crops decide the profitability of those cropping enterprises in the long term.

(b) If own price and respective competitive crops prices and their respective technological change introduced in the supply response equation, with given lesser number of observation and more parameters, estimation will become problematic, since it reduces the degrees of freedom. By taking the revenue difference, prices of own and competitive commodities also the technological change are included. This way it reduces the dimensional problem in a meaningful manner.

Before estimating supply response variables areto be tested for presence of unit root problem.Since, critical‘t’ values based on student t distribution are reported to be inappropriate in small samples

(Granger & Newbold (1974) Augmented Dickey Fuller test is carried out. *Akaike information criterion* (AIC)is employed to select the appropriate lag in the model. Variables which were identified with unit root are transformed into annual growth rate.(Klein and Kosobud,1961 and Bernhard, 2005)

Assuming there are several competing crops, several technologies, and several environmental variables, the hypothesized production response is expressed as follows:

$P_i = \beta_0 + \beta_1 RD + \beta_2 Y + \beta_3 IA^* + \beta_4 RF$

Where

Pi = Production of i^{th} pulse crop (Chick pea and Pigeon pea)

RD =Revenue difference between i^{th} pulse and its competing crops

Y =Yield of i^{th} pulse crop

IA = Irrigated area under i^{th} pulse crop

RF= Rainfall

Variables areexpressed in natural log or annual growth rate. Economic theory suggest that supply response equation, is mainly expressed in terms of price of own commodity and price of substitute/ competitive and complementary commodity and other significant variable. However, in this study prices of own and competitive commodities are expressed implicitly rather than explicitly in the variable called revenue difference.

Results and Discussion

Fit of the model is usually judged by F values. In this current study only those model which best fitted are presented.The variables having significant effect on production are judged by 't' values.

Chick pea

Among pulse crops, chick pea is major one, cultivated in *rabi* season, accounting for 48 and 28% of production and acreage respectively during 2011-12. Based on the literature review and crop calendar, wheat, rapeseed and mustard are identified as competitive crops. But wheat is selected as potential competitive crop.

Table 1. Supply response coefficients–Chick pea

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	-0.27931	1.24728	-0.22	0.8244
RF	0.36242	0.18605	1.95	0.0615
Yield	1.25471	0.18758	6.69	<.0001
IA*	0.20266	0.17239	1.18	0.2497
RD_wheat*	-0.07757	0.02152	-3.60	0.0012

*indicates variable in annual growth rate, other variables expressed in natural log, Rd is revenue difference.

Selected variables are in different units. To interpret the results in percentage variables are log transformed. Variables used in the analysis are logged except annual growth rate of net irrigated area. The co-efficient of determination (R^2) calculated is 73 per cent, that is 73% of variation in the dependent variable explained by chosen independent variables. Significance of each variable in the model is judged by the 't' values. The result of productionresponse presented in the table 1 in all the independent variables viz., rainfall, land productivity and difference between chick pea and wheat revenue have significantly influenced the chick pea production. Yield or land productivity found to be most significant factor, suggesting that every one% change in the yield likely to increase the chick pea production by 1.25% keeping other variables constant. Whereas, rainfall increasesthe chick pea production by 0.36% for every one% change in the rainfall. However, rainfall either is not under the control of farmer or policy maker but it has significant effect on chick pea production. To gain more income and improve the productivity, farmers going for irrigatedchick pea production. But their contribution was not significant as indicated in the table1 nevertheless nearly about 40 % India's' chick pea area is under irrigation. One of the factors contributing negatively for chick pea productionwas revenue difference between wheat and chick pea. The short run possibility to increase the chick pea production is to increase the prices of chick pea to such an extent that chick pea revenue will be greater than the revenue of wheat.If the revenue difference between wheat and chick pea increases by one per cent, chick pea production likely to reduce by 0.08%. This finding supplements the fact that cereals are one of the major factors for displacement of pulse production.

Pigeon pea

Pigeon pea the second most important pulse crop accountingfor 18% area and 15% of total pulse production during 2011-12. Based on classical linear regression,selected potential pigeon pea competitive crops are maize, cotton, rice and ground nut among all identified competitive crops suggested by crop calendar and literature review. These four cropsaltogether explains 82% of variation in the pigeon pea acreage in Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Maharashtra and Gujarat altogether.

As shown in the table2 yield significantly influencing the production of pigeon pea. It suggest that, every one% increase in yield likely to increase the annual growth rate of production by 1.17% implying acreage will increase by 0.17% for every for every one% increase in yield. The effect of yield on production may be attributed to the investment on research and extension. Pigeon pea crop acreage under irrigation negatively associated with the pigeon pea annual production growth rate. However, the cause and effect relationship is not found to be significant that can be verified by trivial coefficient and respective insignificant't' value.

Rainfall influence on pigeon pea production growth rate is significant, this finding also corroborates the fact that more than 70% of pigeon pea production is depend on rainfall. Out of four identified competitive crops maize and rice are significantly impacting the pigeon pea production growth rate. But from the coefficient, it can be inferred that severity of competition given by rice is greater than maize.

If growth rate of gross revenue difference between rice and pigeon pea increasesby 1% that will reduce the growth rate of pigeon pea production by 0.17%. This fact agrees with the statement of cereals are displacing the pulses (Kumar, 1978 and Singh, 1974). This may be attributed to the speeder technological change happening in the rice and ensured FHP that increases the revenue of rice in comparison with pigeon pea. Findings of this study are in conformity with the conclusion of Chopra and Swamy, 1975; CACP report, 2009. In case of maize, the annual growth rate of revenue difference between maize and pigeon pea was negative. But the effect of completion on pigeon pea production was trivial. However, this impact is lesser even than statistically significant.

From the results of pigeon pea supply response it can be inferred in the short-run to augment the production is to increase the pigeon pea revenue more attractively than rice, whereas in the long run production can be increased by raising the yield potential.

Conclusion

The important pulses grown India are chick pea, pigeon pea, black gram and green gram. This study, mainly focus on the production response of the twomajor pulses viz., chick pea and pigeon pea. In chick pea production, wheat and rapeseed

Table 2. Coefficient of supply response-*Pigeon pea*

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	-3.20685	1.44763	-2.22	0.0350
yield	1.17098	0.15796	4.53	<.0001
irrigation	-0.00492	0.01429	-0.34	0.7331
Rfall	0.52725	0.21414	2.46	0.0202
Rd_cotton and Pigeon pea*	0.00009	0.00030716	0.31	0.7601
Rd_gnut_ and Pigeon pea*	0.00139	0.00480	0.29	0.7751
Rd_maize and Pigeon pea*	0.00229	0.00056277	4.08	0.0003
Rd_rice and Pigeon pea*	-0.16813	0.06425	2.62	0.0142

*Variables in annual growth rate and other variables in natural log, Rd is revenue difference.

and mustard were the potential competitive crops, however, the revenue of wheat crop found to significantly reducing the chick pea production. In the case of pigeon pea, rice revenue growth negatively influenced the production. Findings suggest that, yield is a significant variable in the selected pulse crops, implying in the long run the stagnation can be overcome by varietal development and method of cultivation. There is an argument regarding consistent price rise in pulses did not attract the farmers. This phenomenon can be explained as follows. Revenue difference per ha is a function of 'technological change and price of pulse crop' and 'technological change and price of competing crop'. As farmer is a net income maximiser, he cultivates crop which is more remunerative. As revenue obtained from pulse crop is less than competing crops it fails to attract the farmers' attention.

To increase the pulse production, either technological change or price of pulse has to be increased to an extent pulse revenue is greater than its competing crops. Hence three policy options are available with policy maker a). Increase in price of pulse; harms the consumer in India who is already facing the food inflation and majority of the population is poor b). Increase in technological change it is suitable in long run as it takes time to develop suitable varieties c). Increase in both technological change and price.

References

Askari, A and Cummings JT 1976. Agricultural Supply Responses: A Survey of the Econometric Evidence, Paralgar publishers, New York.

Bernhard P. 2008. Analysis of Integrated and Cointegrated Time Series with R. 2nd Ed. Springer.

Bhagat, L.N. 1989. Supply Responses in Backward Agriculture: An Econometric Study of Chotanagpur Region, Concept Publishing Company, accessed at www.books.google.co.in accessed on 26/12/2011.

Chand, R. 1999. Trade Liberalization, Agricultural Prices and Net Social Welfare in India: Key Note Paper on Third Asian Conference of Agricultural Economists, October 18-20, Jaipur.

Chopra, K and Swamy, G 1975. Pulses: an analysis of demand and supply in India 1951-1971, Sterling Publishers, New Delhi.

GOI 2009. Reports of the Commission for Agricultural Costs and Prices (CACP) for the crops sown during 2009-10 season. New Delhi: Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India.

Granger, C.W.J. and P. Newbold 1974. "Spurious Regressions in Econometrics", *Journal of Econometrics* **2:**111-120.

Gulati, Ashok, and Tim Kelley 1999. Trade Liberalization and Indian Agriculture, Oxford University Press, United Kingdom.

HUNGaMA (Hunger and Malnutrition) Report, 2011. Accessed at http://pmindia.nic.in/ accessed on 25/07/2012.

IFPRI 1991. Production and consumption of food grains in India: Implications of accelerated economic growth and poverty alleviation, Research report No.**81**.Washington, DC.

IIPR 2011.Vision 2030 www.iipr.res.in accessed on 01/03/2012.

ISEC 2011. Analysis of Trends in India's Agricultural Growth, working paper 276. Institute of Social and Economic change (ISEC), Bangalore.

Jha, R.; K. Murthy H. Nagarajan and A. Seth 1999. "Components of the Wholesale Bid-ask Spread and the Structure of Grain Markets: The Case of Rice in India". *Agricultural Economics* **21**: 173-189.

Joshi, P.K. and R. Saxena 2002. "A profile of Pulses Production in India: Facts Trends and Opportunities", *Indian Journal of Agricultural Economics* **57**(3): 326-339.

Klein and Kosobud's Great Ratios 2009. *Quantitative and Qualitative Analysis in Social Sciences* **3(3):**12-42.

Kumar, B.L. 1978. Declining Trend in Production of Pulses and Factors Affecting It *Economic and Political Weekly* **13**(27): 1112-1114.

Mallory and Baylis 2012. The Food Corporation of India and the Public Distribution System: Impacts on Market Integration in Wheat, Rice, Pearl Millet, and Corn. http://www.farmdoc

Mythili G. 2006. Acreage and Yield Response for Major Crops in the Pre- and Post-Reform Periods in India: A Dynamic Panel Data Approach. http://www.igidr.ac.in/pdf.

NABARD 2010. Economics of Pulses Production and Processing of India, Department of Economic analysis and Research, Occasional paper **51:** 1-59.

Reddy AA. 2004. Consumption Pattern, Trade and Production Potential of Pulses, *Economic and Political Weekly* **39**(44)**:** 4854-4860.

Singh KB 1974. Problems of Constraining Pulse Yield in Rainfed Areas of Tropical India. Paper presented at FAO/UNDP, International Expert Consultation on the use of improved technology for food production in rainfed areas of Tropical Asia, Hyderabad.