SUPPLY RESPONSE ANALYSIS OF PULSES IN INDIA

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Abstract: *The present work analysed the agricultural supply response of an important pulse crop namely Chickpea crop in India based on the time series data covering the period 1975-76 to 2015-16 with the help of area response relation and production response relation. The variables incorporated in the model were tested for stationarity based on the ADF test and found that the time series for the selected variables are stationary at levels hence, using Nerlove's price expectation cum area adjustment model as the basic framework both acreage and production equations were estimated with the help of least squares method. The results indicated that area allocation decision of the framers for chickpea is influenced by the lagged area under the crop and lagged yield and farmers do respond to risk factors. Irrigational facilities significantly (positively) impact the production of Chickpea in the country. The results revealed the need for reducing the risk factor especially price risk and to enhance the irrigational facilities for the crop so as to reduce the weather risk so that the farmers will be motivated to increase the land under the Chickpea crop and in turn enhance the production to meet the increasing demand.*

Key Words: *Nerlove, Area , Production, Stationarity, recursive model.*
Field: *Agriculture Economics, Econometrics.*
JEL Classification*: C22, C32*

1. INTRODUCTION:

Pulse crops are of integral part of the Indian Agriculture due their contribution to soil conservation by fixing nitrogen into the soil being legume crops and secondly, for their nutritional value as an important source of vegetable protein. Millions of people in India depend on pulses for their protein requirement. Apart from this pulse crops are grown in rain fed areas and survive with limited water. With all these qualities pulse crops occupied a unique place in the Indian Economy. Due to rich agro-climatic regions varieties of pulses are grown in India like Chickpea (Gram), Pigeon Pea (Tur), Green gram, Red gram, Black gram, etc. India is the major producer of pulses in the world. Chickpea and Pigeon Pea are the important pulses grown in the country. In terms of area and production of Chickpea India ranks first in the world. Chickpea also known as gram is consumed by the millions of the people in India in their daily diet as an important source of protein. The demand for pulses is increasing continuously due to increasing population and income of the people but at the same time supply is unable to catch up with the increasing demand. But despite its importance pulse crops have been neglected by the farmers and these crops have been grown mainly on the marginal and less fertile land on non-irrigated areas. This is evident from the magnitude of area under pulse crops which is stagnant over the years. Government of India recognising the importance of the pulse crops initiated various programmes in order to encourage the farmers to enhance land under pulse cultivation also encouraged the scientists to take up research activities to enhance the yield of pulse crops. Despite all these efforts yet we have not been successful in bridging the gap between per capita demand and supply of pulses in India. In view of this the present study aims at understanding the factors that influence the area allocation under the pulse crops and pulse production. The analysis will throw light on the factors which require attention by the farmers, government and policy makers in enhancing the pulse area and production which is the need of the hour. The present study focuses on the important pulse crop grown in the country i.e., Chickpea (gram).

2. LIETERATURE REVIEW:

The rich literature is available on supply response analysis of agriculture commodities in India and other countries of the world. These studies adopted various econometric modelling to understand the acreage and production behaviour of agriculture commodities. Nerlove's work with the incorporation of price expectations formulations and area adjustment-lags, started a new era in Agricultural Supply Response Analysis (Nerlove, 1958). Since then, several studies had used and also using Nerlove's model either in the original form or with some modifications. But in Nrelove's framework model is estimated at level form of the variables which posed serious problem if time series variables are non-stationary. This resulted into development of Co-integration and Error Correction Model (Engle & Granger, 1987) and Johansen (1988) mechanism of multivariate Co-integration analysis in the form of Vector Error

Correction Mechanism (VECM). Number of studies are found in literature using these techniques to analyse the agriculture supply response. VECM model was used to assess the cassava supply response in Nigeria based on the time series data from 1996-2010 and results indicated that prices and land cultivated had positive impact on the cassava supply in the short run (Obayelu & Ebute, 2016). Supply response for wheat in Turkey was analysed with the help of VECM based on the time series data and findings suggested that farmers were not price responsive in case of wheat crop (Ozkan, Ceylan & Kizilay, 2011). Supply response of Potato in Bangladesh was studied with the VECM approach and based on the results it was concluded that the price policies were effective in obtaining the desired output level for potato in the country (Huq & Fatimah, 2010). Modified Nerlove's model of agriculture supply response was used to study the supply response of gram, tur and other pulses in different states and for all India and risk and price factors were found to be insignificant in influencing the pulse supply response (Satyapriya, 1986). Supply response of pulses had been done using Nerlove's model for different pulse growing regions of the country and results revealed that the farm harvest prices and good rainfall positively impact the area allocation decision of the farmers (Savadatti, 1997,2007). There are number of other studies which worked on the agriculture supply response of various commodities (Muchapondwa, 2009; Gulam, Latif & Egwuma, 2016; Huq, Arshad & Islam, 2013). The literature review provided the required theoretical framework for the present study of agricultural supply response of Chickpea at the macro level.

3. MEHTODOLOGY:

3.1 Data

The present study aims at analysing the supply response of pulses mainly Chickpea (Gram) at macro level and the required data on number of variables like, area under the crop concerned, production, yield, gross irrigated area under all crops, irrigated area under the chickpea crop were collected from data sources like Centre for Monitoring Indian Economy (CMIE) and India Stat.Com. Data required on minimum support prices of Chickpea and the competing crop especially wheat were collected from Reserve Bank of India data source namely Data Base of Indian Economy (DBIE), Government of India, data on monthly actual rainfall were collected from the Indian Meteorological data base available on the net and India Stat.com. The investigation is based on the annual time series data pertaining to the period 1975-76 to 2015-16. All the series were transformed into natural logarithms. E-Views 9 statistical package was used for the data analysis.

3.2 Theoretical Framework

The supply aspect of the Chickpea (Gram) has been explained with the help of two relationships. The first equation is an area response relation described by the price and non-price factors while the second one represents the production of Chickpea explained by the acreage and non-acreage factors. Majority of studies conducted on supply response of agricultural commodities used Nerlovian model as the underlying framework for their analysis. According to Nerlove (1958), it is difficult for the farmers to make complete adjustment while responding to different economic variables or farmers may find it difficult to adjust instantaneously. In such cases distributed lag model may be suitable for measuring the farmer's response behaviour. In the Nerlovian framework the long-run equilibrium supply Y_t^* is assumed to be a linear function of the expected price P_t^*

$Y_t^* = a + bP_t^* + U_t$ --------------------- (1)

The expected price P_t^* is adjusted in each time period by a proportion 'β' of the difference between the previous period's actual price P_{t-1} and its expected price which is described as

$P_t^* - P_{t-1}^* = \beta\,(P_t^* - P_{t-1}^*)\ ;\ 0 < \beta < 1$ ---------------------- (2)

Where β is the rate of adjustment associated with price uncertainty and is termed by Nerlove as the "Coefficient of Expectations".

In similar manner, the supply is adjusted towards the long run equilibrium supply as follows

$Y_t - Y_{t-1} = \delta\,(Y_t^* - Y_{t-1})\ ;\ 0 < \delta < 1$ --------------------------- (3)

Where δ is the coefficient of adjustment representing the proportion of the adjustment towards equilibrium which occurs in one time period. If there is no uncertainty, which means β=1, then farmers' expected price will be equal to previous year's price P_{t-1}, i.e., $P_t^* = P_{t-1}$ through further substitution the reduced form of the equation can be obtained as

$Y_t = A + BP_{t-1} + C\,Y_{t-1} + V_t$ ---------------------------- (4)

Where $A = a\delta\ ;\ B = b\delta\ ;\ C = (1-\delta);\ V_t = \delta U_t$

The equation (4) is the computational equation, which allows for inclusion of more independent variables. This model helps in the estimation of both the short run elasticity (B) and long run elasticity $\left(B/_{1-C}\right)$.

But here variables are used in level form, there is a possibility of getting spurious regression in case of non-stationarity. Hence, there is need for checking the stationarity of the time series before proceeding to estimate the equation in the level form. The equation for ADF test may be expressed as below (Gujarati & Sangeeta, 2007).

$\Delta Y_t = \beta_1 + \beta_2 t + \emptyset Y_{t-i} + \Sigma\alpha\Delta Y_{t-i+1} + U_t$: ---------------------------------- (5)

In this case H_0: Ø = 0 , series are non- stationary as against H_1 = Ø < 0, series are stationary. Akaike Information Criteria (AIC) and Schwartz Information Criteria(SIC) criteria have been used to decide the lag length. If the series are stationary then the regression equation incorporating variables in level form may be run otherwise one has to resort to co-integration and Error Correction Mechanism which necessitates that the series have be integrated of the same order I(1). But in the present analysis the variables under consideration are stationary hence, adopting the Nerlove's adjustment lag model as the basic framework regression equation is run using variables at levels. Various model adequacy checks have been used to test the goodness of fit of the estimated model. Tests like Variance Inflating Factor for multicollinearity, stationarity of the residuals, serial correlation test, model stability diagnostics have been used for evaluation of the fitted models.

3.3 Model Specification

Acreage Response Function

The acreage response function for the Chickpea (Gram) is specified as follows

$Y_{1t} = \alpha_{10} + \alpha_{11}Y_{t-1} + \alpha_{12}X_{1t-1} + \alpha_{13}X_{2t} + \alpha_{14}X_{3t-1} + \alpha_{15}X_{4t-1} + \alpha_{16}X_{5t-1} + \alpha_{17} X_{6t} + \mu_t$ ---------------------(6)

Where

$\alpha_{11}, \alpha_{12}, \alpha_{13}, \alpha_{14}, \alpha_{17} > 0 \;\; and \;\; \alpha_{15}, \alpha_{16} < 0$

and

Y_{1t} = *Area under the Chickpea in '000' hectares in the year 't'*
Y_{t-1} = *lagged raea under the Chikpea in '000' hectares*
X_{1t-1} = *lagged relative minimum support price (MSP) of Chickpea in Rs./ Quintal*
X_{2t} = *Actual average rain fall in mms during sowing months of Chickpea*
X_{3t-1} = *Lagged yield in Kgs per hectare of the Chikpea*
X_{4t-1} = *Lagged relative price risk measured by the standard deviation of the relative MSP measrued over the three preceding years*
X_{5t-1} = *Weather risk measured by the standard deviation of average rain fall during sowing months of Chickpea measured over three preceding years*
X_{6t} = *Gross area irrigated under all crops in '000' hectares in the year 't'*
μ_{1t} = Random disturbance term

3.4 Production Response Function

The production response relation is expressed as below

$Y_{2t} = \alpha_{20} + \alpha_{21}Y_{1t} + \alpha_{22}X_{8t} + \alpha_{23}X_{9t} + \mu_{2t}$ ---------------------------------- (7)

Where

$\alpha_{20}, \alpha_{21}, \alpha_{22}\, \alpha_{23} > 0$

and

Y_{2t} = *Production of Chickpea in '000' tonnes in the year 't'*
Y_{1t} = *Area under the Chikpea in '000' hectares in the year 't'*
X_{8t} = *Area irrigated under the chickpea crop in the year 't'*
X_{9t} = *Growing period rainfall in mms in the year 't'*
μ_{2t} = Random disturbance term

3.5 Model Estimation

The above model is of recursive type therefore identification problem does not arise. The Ordinary Least Squares (OLS) method can be applied to the relations of the model sequentially, to get unbiased and consistent estimators in general. But there is need to find appropriate estimation procedure to Area Response Relation as the lagged dependent variable (Y_{t-1}) is appearing on the right hand side of the equation as an exogenous variable. Area response relation is the reduced form equation of the area adjustment equation where lagged dependent variable appears on the right side of the equation. This poses a problem for estimation of the parameters by OLS method. One of the important assumptions of the OLS is the existence of zero covariance between the explanatory variables and the disturbance term. If this assumption is violated, then coefficients of the area response equation may be biased and inconsistent. Thus in order to obtain statistically consistent and unbiased estimators of the parameters of the area response equation, the residual μ_{1t} values are not to be serially correlated. It is this problem that resulted into the following set assumptions about the reduced form disturbance term μ_t in the Nerlove's model

i. μ_1 is distributed with mean zero
ii. Diagonal variance covariance matrix with a constant own variance and
iii. The disturbance term and the contemporaneous elements of Y_{1t} matrix are distributed independently.

In view of the above serial correlation in the disturbance terms of the area response equation are tested and results revealed the absence of the problem. Hence, use of OLS yielded satisfactory results. Log linear form of the relations of the model have been tried with the help of annual time series data covering the period 1975-75 to 2015-16. The study analyses one of the important pulse grown in India namely, Chickpea (Gram) (Savadatti, 1997,2007).

4. RESULTS AND DISCUSSION:

Area Response Relation

Any time series analysis begins with the testing of the series for stationarity. The Augmented Dickey Fuller (ADF) test is used for testing the stationarity of the series under consideration and the results of the analysis are presented in Table 1. It is revealed from the results that the series for all the variables are stationary (crop yield series is trend stationary) except series on gross area irrigated under all crops (X_{6t}) which is non-stationary. Hence, gross area irrigated variable is not included in the final fitted model.

Table 1. ADF unit root test results for Chickpea (Gram) Area Equation Variables

Variable	ADF Statistic	ADF Critical Values			p-value*	Inference
		1%	5%	10%		
**Area under the crop(Y_{1t})	-3.3631	-3.6056	-2.9369	-2.6068	0.0184	I(0) (Stationary)
Lagged Relative Minimum Support Price (X_{1t-1})	-2.8792	-3.6156	-2.9411	-2.6091	0.0572	I(0) (Stationary)
Sowing Period Rainfall (X_{2t})	-4.4364	-3.6329	-2.9484	-2.6129	0.0012	I(0) (Stationary)
Lagged Crop Yield (X_{3t-1})	-7.3919	-4.2119	-3.5298	-3.1964	0.0000	I(0) (Stationary)#
Relative Price Risk (X_{4t-1})	-4.4364	-3.6329	-2.9484	-2.6129	0.0012	I(0) (Stationary)
Sowing Period Weather Risk (X_{5t-1})	-4.3485	-3.6210	-2.9434	-2.6103	0.0014	I(0) (Stationary)
Gross Area Irrigated under all crops (X_{6t})	-1.1194	-3.6056	-2.9369	-2.6069	0.6988	I(1) (Non - Stationary)

*MacKinnon (1996) one sided p-values ; # with intercept and trend
**values are in natural log form for all the variables under study ; Source: Data Analysis

Table 2: Regression Results of the Acreage Response Relation for Chickpea (Gram)

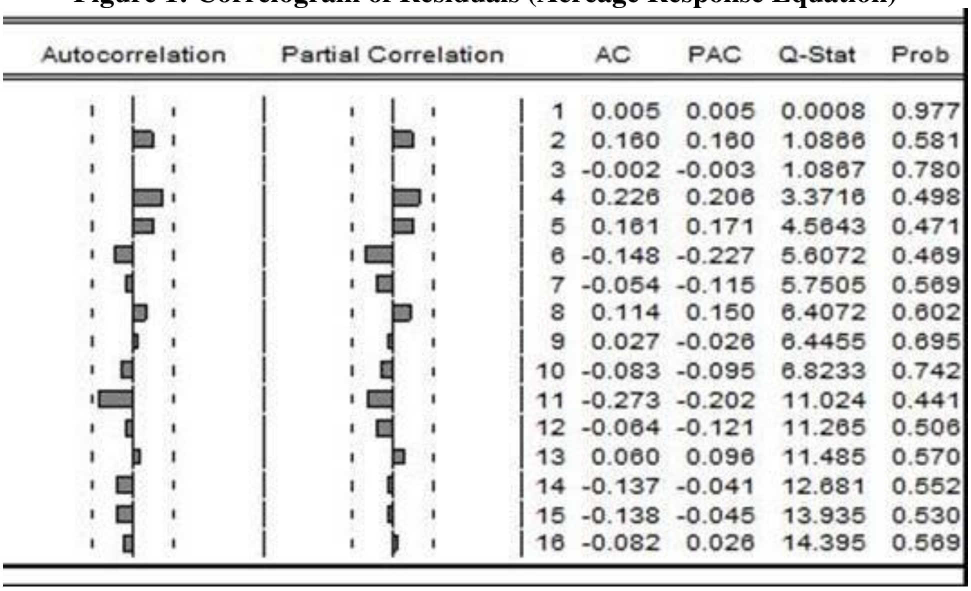
Variable	Coefficient	Standard Error	t-statistic	Probability
C	2.807012**	1.348735	2.081217	0.0458
Lagged Area under the crop(Y_{1t-1})	0.337582**	0.168175	2.007332	0.0535
Lagged Relative Minimum Support Price (X_{1t-1})	-0.166346	0.112853	-1.474014	0.1506
Sowing Period Rainfall (X_{2t})	0.119556			
Lagged Crop Yield (X_{3t-1})	0.414073**	0.188701	2.194337	0.0358
Relative Price Risk (X_{4t-1})	-0.001143	0.017167	-0.066556	0.9474
Sowing Period Weather Risk (X_{5t-1})	-0.011683	0.030191	-0.386974	0.7014
R-squared	0.413389***			
Adjusted R-squared	0.299852			
S.E. of regression	0.116202		Akaike info criterion	-1.302158
Sum squared residuals	0.418587		Schwarz criterion	-1.000498
Log likelihood	31.74101		Hannan-	-1.194830

			Quinn criter.	
F-statistic	3.640990		Durbin-Watson stat	1.977874
Prob(F-statistic)	0.007511			

*** & ** indicate significant at 1% and 5% level ; Source: Data Analysis

Since all the series are stationary at levels the OLS is applied to estimate the model and the results of the fitted model are presented in Table 2. The regression results presented in Table 2 indicate that all the coefficients have expected signs except price variable which is also insignificant. Area allocated for Chickpea during previous period along with the previous period's yield play significant role in the farmers' decision making with respect to land allocation for Chickpea crop in the present period as the coefficients of these variables have expected sign and are significant at 5 per cent level. So, higher the area and yield of the crop in the previous years impact positively the farmers' decision making regarding area allocation for Chickpea in the current period. Farmers do take into account the risk factors while allocating land for the crop. The coefficients of sowing period weather risk and price risk though insignificant but having expected sign thus impacting negatively the farmer's decision. Higher these risks lower will be the area allocation for chickpea crop by the farmer. The estimated model explains 41 per cent of the variation in the area under the crop. The estimated R^2 is significant at 1 per cent level.
The model adequacy has been tested with various residual diagnostic tests and results of the same are presented below. Firstly, the presence of the serial correlation among the residuals of the estimated model are checked with the help of correlogram presented in the Figure 1.

Figure 1: Correlogram of Residuals (Acreage Response Equation)



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.005	0.005	0.0008	0.977
		2	0.160	0.160	1.0866	0.581
		3	-0.002	-0.003	1.0867	0.780
		4	0.226	0.208	3.3716	0.498
		5	0.161	0.171	4.5643	0.471
		6	-0.148	-0.227	5.6072	0.469
		7	-0.054	-0.115	5.7505	0.569
		8	0.114	0.150	6.4072	0.602
		9	0.027	-0.026	6.4455	0.695
		10	-0.083	-0.095	6.8233	0.742
		11	-0.273	-0.202	11.024	0.441
		12	-0.064	-0.121	11.265	0.506
		13	0.060	0.096	11.485	0.570
		14	-0.137	-0.041	12.681	0.552
		15	-0.138	-0.045	13.935	0.530
		16	-0.082	0.026	14.395	0.569

None of the autocorrelation and partial correlations are significant indicating the absence of correlation among the residual values this is further validated by the high probability values presented in the Figure 1. Secondly ADF test has been adopted to test the presence of unit root in the estimated residual series and the results of the same are presented in Table 3.

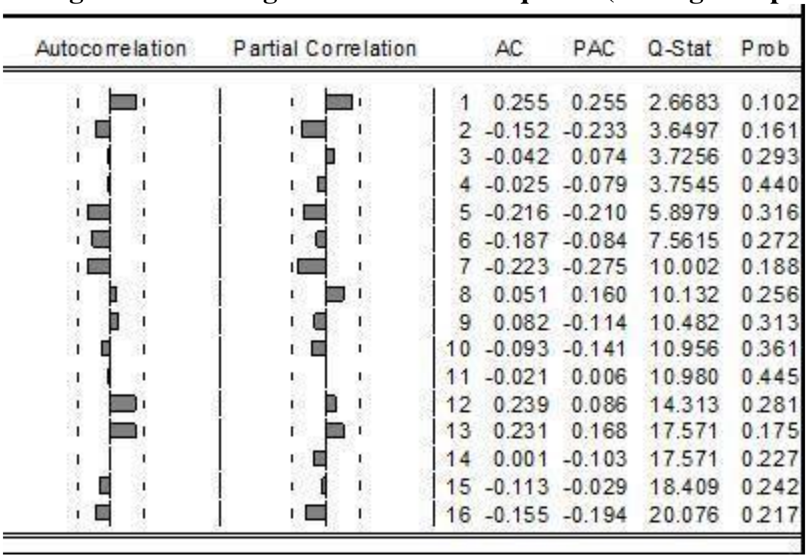
Table 3: ADF unit root test for the Residuals from the Regression of Acreage Response Equation

Variable	ADF Statistic	ADF Critical Values			p-value*	Inference
		1%	5%	10%		
Residuals	-5.854232	-3.621023	-2.943427	-2.610263	0.0000	I(0) (Stationary)

*MacKinnon (1996) one sided p-value ;Source: Data Analysis
Source: Data Analysis

It is amply clear from the ADF test results that the residual series are stationary. Thirdly, the correlogram of the residual squares have been checked for presence of any significant terms and none of the terms are significant as it is evident from the probablility of Q statistics shown in graph 2 below.

Figure 2: Correlogram of Residuals Squares (Acreage Response Equation)



Source: Data Analysis

Fourthly presence of serial correlation among the residuals is checked with the help of Breusch -Godfrey Serial Correlation LM Test and the results of the same are detailed in Table 4 below.

From the results presented in Table 5 it may be concluded that the absence of serial correlation in residuals as the probability of Chi-square value is high hence, fail to reject the null hypothesis. Fifthly presence of multicollinearity problem among explanatory variables has been diagnosed with the help of Variance Inflating Factor (VIL) the results of the same are presented in Table 5. The VIL is used as an indicator of multi-collinearity. The larger the value

of VIF, the higher will be the collinear the explanatory variables. If the VIF of the variable exceeds 10, then that variable is said to be highly collinear (Gujarati & Sangeetha, 2007). From Table 5 it is evident that for all the variables the VIF is less than or around 2 indicating that

Table4 : Breusch _Godfrey Serial Correlation LM Test (Acreage Response Relation)

F-statistic	0.735588	Prob. F(2,29)	0.4880	
Obs*R-squared	1.834675	Prob. Chi-Square(2)	0.3996	
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	2.000705	2.596509	0.770537	0.4472
Y1t-1	-0.243619	0.306451	-0.794969	0.4331
X3t-1	0.038777	0.193214	0.200692	0.8423
X2t	-0.025124	0.079949	-0.314256	0.7556
X1t-1	-0.019159	0.115036	-0.166544	0.8689
X4t-1	-0.002806	0.017782	-0.157784	0.8757
X5t-1	0.000468	0.030651	0.015271	0.9879
RESID(-1)	0.229432	0.340020	0.674758	0.5052
RESID(-2)	0.294638	0.243046	1.212275	0.2352
R-squared	0.048281		Akaike info criterion	-1.246380
Adjusted R-squared	-0.214262		Schwarz criterion	-0.858531
F-statistic	0.183897		Hannan-Quinn criter.	-1.108387
Prob(F-statistic)	0.991316		Durbin-Watson stat	2.026220

H_0: there is no Serial correlation of any order in residuals ; Source: Data Analysis

Table 5: Multi-collinearity test for the Explanatory Variables of Area Equation

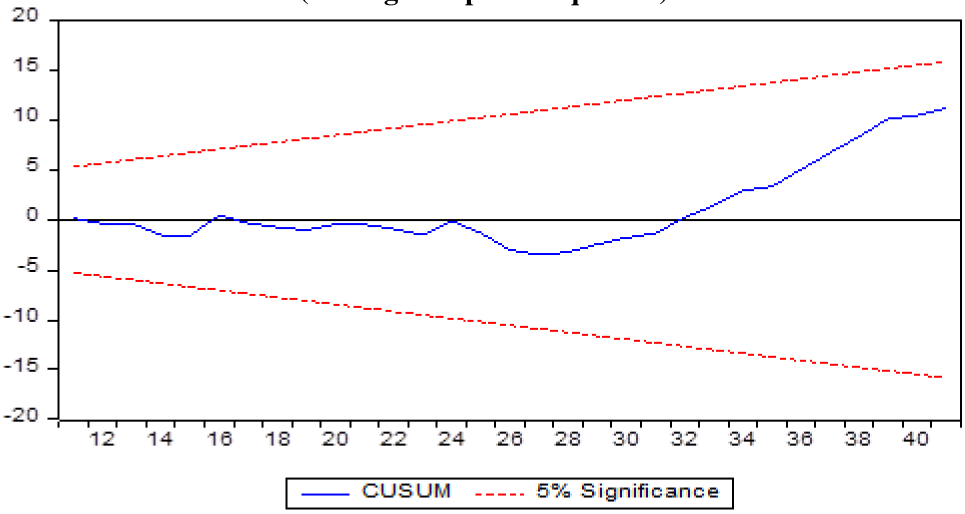
Variable	Coefficient Variance	Variance Inflating Factor (VIF)

C	1.819087	---
Y_{1t-1}	0.028283	1.466274
X_{1t-1}	0.012736	1.817324
X_{2t}	0.005837	1.033783
X_{3t-1}	0.035608	2.174190
X_{4t-1}	0.000295	1.143089
X_{5t-1}	0.000912	1.099032

Source: Data Analysis

There is no problem of multi-collinearity in this case. Next the adequacy of the model is further tested with the help of model stability diagnostic test – Cusum test and the results are given in the plot below. The plot indicates that the blue trend line is within the boundary of 5% level of significance signalling that model is dynamically stable. All the tests of model adequacy confirm that model is adequate and the assumptions of the leas square methods are satisfied and hence, results are satisfactory in case of area response relation.

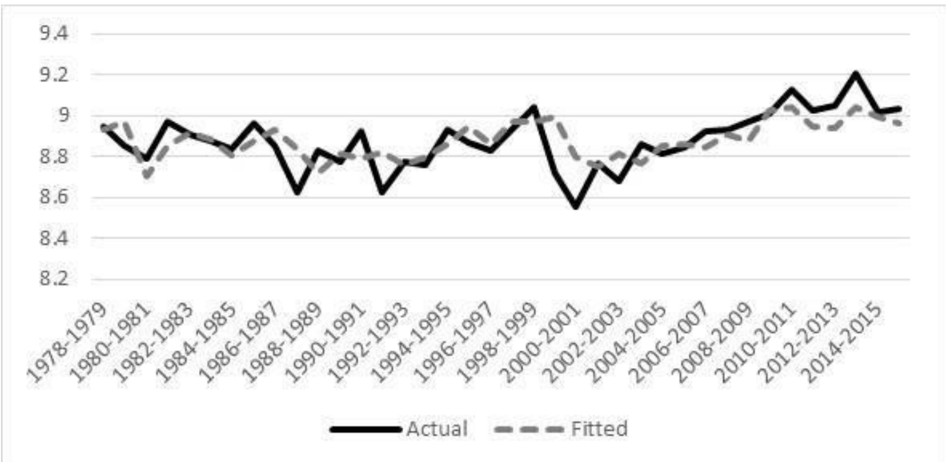
Figure 3 : Model Stability Diagnostic Test – Cusum Test
(Acreage Response Equation)



Source: Data Analysis

The observed and estimated values for the fitted area model are presented in Figure 4. It can be seen from the figure that the fitted values follow the actual values and most of the directions are captured by the estimated area response relation.

Figure 4 : Graph of Actual and Fitted Values for the Acreage Response Relation



Source: Data Analysis

Production Response Relation

The analysis of the Production Response Relation started with the testing of stationarity of the time series data related to variables under consideration, as this result will determine the further analysis to be adopted for data analysis. The results of the unit root tests based on the Augmented Dickey Fuller (ADF) test for the variables included in the Production Response Relation are presented in Table 6.

Table 6. ADF unit root test results for Chickpea (Gram) Production Equation Variables

Variable	ADF Statistic	ADF Critical Values			p-value*	Inference
		1%	5%	10%		
**Production of Gram (Y_{2t})	-4.4651	-4.2050	-3.5266	-3.1946	0.0051	I(0) (Stationary)#
Area under the crop(Y_{1t})	-3.3631	-3.6056	-2.9369	-2.6068	0.0184	I(0) (Stationary)
Area Irrigated under Gram crop (X_{8t})	-3.7739	-4.2050	-3.5266	-3.1946	0.0286	I(1) (Stationary)#
Growing Period Rainfall (X_{9t})	-4.4221	-3.6056	-2.9369	-2.6069	0.0012	I(0) (Stationary)

with constant and trend ; *MacKinnon (1996) one sided p-values
**values are in natural log form for all ; Source: Data Analysis

The results revealed that all the series are stationary at levels and production of gram(Y_{2t}) and area irrigated under gram crop(X_{8t}) are trend stationary. Since all the series are stationary at levels linear regression incorporating the variables at levels is run with the help of OLS and the results of the same are given in Table 7 below.

Table 7: Regression Results of the Production Response Relation

Dependent Variable: Production of Gram (Y_{2t})

Variable	Coefficient	Standard Error	t-statistic	Probability
C	-3.484258***	0.961273	-3.624628	0.0009
Area under the crop(Y_{1t})	1.120528***	0.130372	8.594818	0.0000
Area Irrigated under Gram crop (X_{8t})	0.312820***	0.053980	5.795143	0.0000
Growing Period Rainfall (X_{9t})	-0.063241	0.052010	-1.215944	0.2317
R-squared	0.860727***			
Adjusted R-squared	0.849434			
S.E. of regression	0.091894		Akaike info criterion	-1.843901
Sum squared residuals	0.312445		Schwarz criterion	-1.676723
Log likelihood	41.79997		Hannan-Quinn criter.	-1.783024
F-statistic	76.22158		Durbin-Watson stat	2.196471
Prob(F-statistic)	0.000000			

***:indicate significant at 1% level
Source: Data Analysis

The regression results of the Production Response Relation indicate that production of the Chickpea is significantly influenced by the area under the crop and irrigation facilities available for the crop. Area under the crop (Y_{1t}) and area irrigated under the Chickpea crop (X_{8t}) are significant at 1% level and having expected positive sign but that of growing period rainfall (X_{9t}) has unexpected sign and also insignificant indicating that rainfall during growing season of the Chickpea crop does not influence the production as the 33 per cent of the Chickpea area is irrigated which plays a significant role in determining the production of the crop. The R^2 is high explaining 86 per cent of the variation in the dependent variable which is significant at 1 per cent level. To test whether fitted model is good various model adequacy tests are adopted which have been discussed below. The first and foremost important is to check whether the estimated residuals of the model are stationary or not. This has been done by observing autocorrelations (ac) and partial autocorrelations (pac) of the residuals presented in Figure 5.

Figure 5: Correlogram of Residuals (Production Equation)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.105	-0.105	0.4888	0.484
		2	0.112	0.102	1.0518	0.591
		3	-0.061	-0.041	1.2264	0.747
		4	-0.053	-0.075	1.3587	0.851
		5	0.005	0.005	1.3602	0.929
		6	0.010	0.022	1.3651	0.968
		7	-0.019	-0.025	1.3844	0.986
		8	-0.041	-0.053	1.4726	0.993
		9	-0.046	-0.049	1.5897	0.996
		10	-0.022	-0.022	1.6162	0.999
		11	0.055	0.054	1.7916	0.999
		12	-0.056	-0.055	1.9837	0.999
		13	0.011	-0.020	1.9909	1.000
		14	-0.074	-0.060	2.3449	1.000
		15	-0.014	-0.026	2.3592	1.000
		16	0.075	0.076	2.7533	1.000
		17	-0.148	-0.151	4.3516	0.999
		18	-0.110	-0.178	5.2819	0.998
		19	-0.014	-0.003	5.2982	0.999
		20	-0.145	-0.133	7.0591	0.996

Source: Data Analysis

It is clear from the Correlogram that none of the ac and pac are significant as evident from the high value of the probability of Q-statistics indicating that residuals are stationary. This decision is reinforced by the unit root test results based on the ADF test presented in Table 8. Residuals are stationary at 1 per cent level.

Table 8: ADF unit root test results for the Residuals from the Regression of Production Equation

Variable	ADF Statistic	ADF Critical Values			p-value*	Inference
		1%	5%	10%		
Residuals	-6.866004	-3.605593	-2.936942	-2.606857	0.0000	I(0) (Stationary)

*MacKinnon (1996) one sided p-value ; Source: Data Analysis

Correlogram of the squared residuals presented in the Figure 6 revealed that none of the ac and pac are significant indicating absence of heteroscedasticity among residuals.

Figure 6 : Correlogram of Residuals Squares (Production Equation)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.008	-0.008	0.0025	0.960
		2	0.192	0.192	1.6621	0.436
		3	-0.064	-0.064	1.8547	0.603
		4	-0.098	-0.140	2.3098	0.679
		5	-0.031	-0.007	2.3578	0.798
		6	-0.020	0.025	2.3783	0.882
		7	-0.019	-0.028	2.3976	0.935
		8	-0.028	-0.048	2.4383	0.965
		9	-0.004	0.001	2.4390	0.982
		10	0.022	0.037	2.4676	0.991
		11	-0.059	-0.072	2.6692	0.994
		12	0.002	-0.022	2.6693	0.997
		13	-0.031	-0.001	2.7281	0.999
		14	0.031	0.036	2.7897	0.999
		15	0.022	0.012	2.8239	1.000
		16	0.047	0.026	2.9791	1.000
		17	-0.040	-0.050	3.0972	1.000
		18	0.053	0.050	3.3139	1.000
		19	-0.051	-0.028	3.5217	1.000
		20	-0.019	-0.042	3.5515	1.000

Source: Data Analysis

To test the presence of serial correlation among residuals Breusch – Godfrey LM Test is used and the results of the same are presented in Table 9. The Chi-square probability is 0.6335 > 0.05 hence, fail to reject H_0 hence conclude that there is no serial correlation among the residuals which satisfies the one of the assumption of the OLS. The presence of the problem of multicollinearity is examined with the help of Variance Inflating Factor (VIF) and the VIFs of the variables included in the Production Response relations are shown in the Table 10. It may be observed from the Table that all the estimated VIF for the variables are having very small value less than 2 indicating that there is no problem of multicollinearity among the explanatory variables of the equation.

Table 9 : Breusch - Godfrey Serial Correlation LM Test (Production Response Equation)

F-statistic	**0.398620**	**Prob. F(2,35)**	**0.6743**	
Obs*R-squared	**0.913111**	**Prob. Chi-Square(2)**	**0.6335**	
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.154771	0.993112	-0.155845	0.8771
LNGA	0.022345	0.135113	0.165379	0.8696
LNGAIRR	-0.005602	0.055763	-0.100466	0.9205
LNGGPRF	-0.000716	0.053327	-0.013430	0.9894
RESID(-1)	-0.095751	0.170759	-0.560739	0.5785
RESID(-2)	0.109210	0.175173	0.623443	0.5370
R-squared	0.022271		Akaike info criterion	-1.768863
Adjusted R-squared	-0.117405		Schwarz criterion	-1.518096
F-statistic	0.159448		Hannan-Quinn criter.	-1.677547
Prob(F-statistic)	0.975643		Durbin-Watson stat	1.974543

H_0: there is no Serial correlation of any order in residuals
Source: Data Analysis

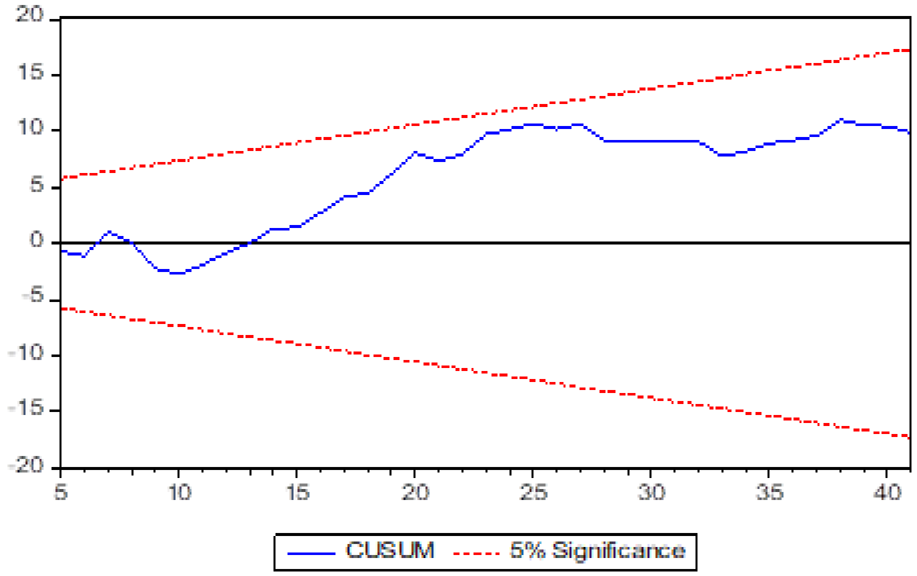
Table 10: Multi-collinearity test for the Explanatory Variables of Production Equation

Variable	**Coefficient Variance**	**Variance Inflating Factor (VIF)**
C	0.924046	NA
Y_{1t}	0.016997	1.516473
X_{8t}	0.002914	1.489700
X_{9t}	0.002705	1.267376

Source: Data Analysis

The dynamic stability of the estimated model is checked with the Cusum Test and the results are presented in Figure 7.

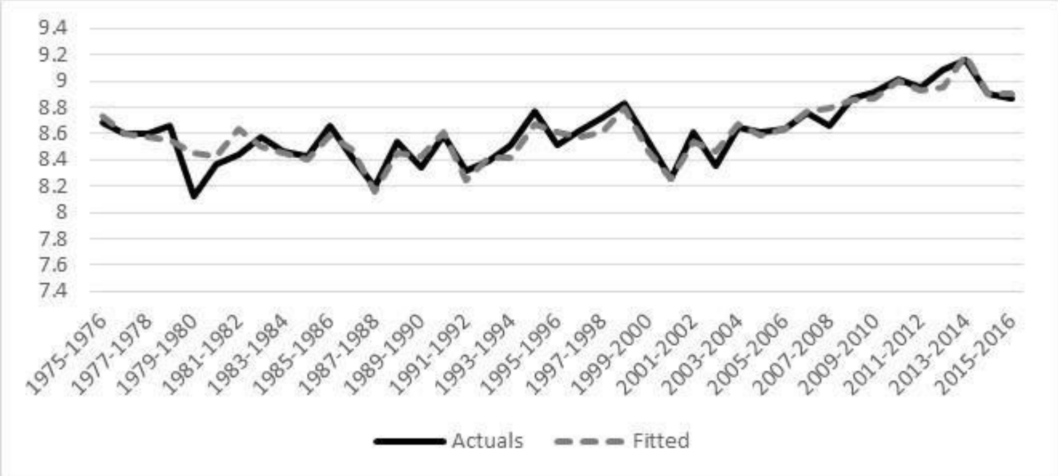
Figure 7 : Model Stability Diagnostic Test – Cusum Test (Production Equation)



Source: Data Analysis

The blue trend line is within the 5% significance level bound indicating that the model is stable. All the tests revealed that the estimated equation is reasonably good and explains the production behaviour of the Chickpea crop. The observed and fitted values of the Chickpea production are presented in Figure 8. The Graph clearly showed that fitted model captured the movements in the dependent variable i.e., production of the Chickpea well.

Figure 8: Graph of Actual and Fitted Values for the Production Response Relation



Source: Data Analysis

5. CONCLUSION AND RECOMMENDATIONS:

The present analysis tried to understand how price and non-price variables influence the area allocation decision and production of Chickpea at all India level. The estimated equations turned out be satisfactory based on the various tests conducted to test the adequacy of the results. Area response relation results indicated that farmer's decision to area allocation to Chickpea crop in the current period is highly influenced by the area allocated in the previous period and the lagged yield of the crop. Farmers do take into account the risk factors especially price risk and weather risk before allocating the land to Chickpea crop. Risk factors influence negatively the farmer's area allocation decision. Sowing period rain fall impact positively the farmer's decision. The present analysis showed that price variable turned out to be insignificant having unexpected sign though the relative price risk is having the expected sign. This indicates that price variable weakly influences the farmer's area allocation decision this could be mainly due to relative price risk which affects adversely farmer's decision. This calls for efforts on the part of the government to ensure price stability for the product so that this will act as an incentive for the farmers to allocate more land for Chickpea crop. Production response relation results showed that the area under the crop and irrigation play important role in deciding the production once the land is allocated to the concerned crop. The growing period rainfall though has positive impact but insignificant. It is revealed from the results that removing instability in prices the farmers receive for the Chickpea crop and enhancing irrigation facilities will help to increase the area under the crop and in turn production of Chikcpea. Recognising the nutritional importance of the pulse crop Chickpea it is required to ensure better and stable prices for the Chickpea crop growers along with more irrigational facilities so that the area under the crop will be enhanced and production so that the nutritional requirements of the increasing population will be met domestically and burden on the exchequer will be reduced by reducing imports of the pulse crops. It also necessary to ensure effective and efficient marketing facilities for the famers to sell their marketable surplus at profitable prices. With these measures it may be possible to enhance the area under the crop which has been almost stagnant for decades.

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