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Econometric Analysis of Agriculture Productivity in Rajasthan

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Abstract

Rajasthan is the state where agriculture growth is faster than other states of the country even a water deficient state. Irrigation facilities, good quality of seeds, use of fertiliser and other institutional and infrastructure variables are playing significant role for development in agriculture sector in the state. This paper attempts to investigate various inputs in various crops to identify the most input for agriculture productivity. Using panel data approach this paper analyses various factors affecting productivity of sixteen important crops vulnerability over time from 1990 to 2010 covering all districts.

The study concluded that the fertiliser consumption played a key role in all crops for enhancement of productivity except soyabean, cotton, kharif pulses and taramira. Although rainfall is an important factor which affects agriculture production but it had not impact positively on productivity across districts over the years except the crop gram.

The contribution of road length was significant on productivity of wheat, pearl millet, barley, ground nut, maize, rice and kharif pluses in the state. Energized wells and tube wells contributed significant role in all crops productivity except guar, cotton, kharif pulses and taramira.

Keywords: Productivity, Crops, Fixed Effect, Random Effect, Panel

Introduction

Rajasthan is mainly divided into two parts that are desert and non desert. The state has 61% of desert area where 40% of the population are living. More than half of the population depend on agriculture in desert and non desert districts. Since it is water scared state so there is much potential in wheat and bajra crops but not in rice crop because rice is water intensive crop in which one kg of rice requires 3000-5000 litres of water.

So the state focused on the enhancement of production of wheat and there is much potentiality in this respect. Rajasthan is the largest state in terms of area, which has 10.41 per cent of area, 5.67 per cent of population, 10.70 per cent of live stocks and 8.48 per cent of milk production of India.

Further, total forest area 4.24, tree covered area 8.92, gross irrigated area 8.95, net irrigated area 9.88, total cropped area 11.67 and net area sown is 12.42 percent of India[1]GOR (2012). GDP growth rate of Rajasthan in 2012-13 is 5.31 per cent. The sector wise contribution of GSDP at constant price of 2004-05 in agriculture 19.88, in Industry 31.31 and in service sector is 48.81 percent. It is proposed in twelfth five year plan (2012-17) that the outlay on agriculture and allied service is 5.57 per cent. Although the state has 61% desert area but the productivity of major crops in last two decades in desert were growing much faster than in non desert (Jhabar *et al., 2014).*

Sinha and Kulshrestha (2012) analysed panel data of two crops, which are wheat and pearl millet and concluded that gross cropped area and energized wells had significant role in pearl millet production. Rainfall, fertilizer consumption, cropping intensity, gross irrigated area and energized wells played statistically significant role in production of wheat.

The technological changes in agriculture in Rajasthan are also associated with specific institutional developments in banking, co-operative and agricultural extension including the development of infrastructure and communication media (Adams and Bumb, 1979). Nag *et al.* (2009) analyzed the growth rate of cropping intensity and described that growth rates are significant in all districts except a few.

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Methodology

This study is based on data of secondary twent years (1990-2010) collected from directorate of economics and statistics, Govt. of Rajasthan.Sixteen major crops such as wheat, pearl millet, barley, ground nut, gram, jowar, linseed, maize, rapeseeds & mustard, sesamum, soyabean, rice, guar, cotton, kharif pulses and taramira were taken into account for estimation of productivity on the basis of more than 5% cropped area in the state. For the purpose of panel data estimation specification of the model is as follows:

$Y_{it} = \alpha + X'_{it}\beta + u_{it}$ (1)

Or more simplification

$Y_{it} = \alpha_{it} + \beta_1 CI_{it} + \beta_2 \mathrm{Rain}_{it} + \beta_3 CIA_{it} + \beta_4 \mathrm{FC}_{it} + \beta_5 RL_{it} + \beta_6 Wells_{it} + u_{it}$ .... (2)

where i denote cross-sections and t denotes time-periods with i = 1, 2. . . N and t = 1, 2,..N

Y_{it} is the value of dependent variable (productivity) for the ith districts during the t^{th} year.

Where i = (1….30 Districts) t = (1….20 Years)

$X_{k,it}$ represents one independent variables, β's are the coefficient for independent variables

CI = Cropping Intensity (GCA/NCA*100), Rain = Rainfall (CM), CIA = Crop irrigated area (000 Ha), FC = Fertilizer Consumption (kg ha^{-1}), Road = Road Length (KM), Wells = Energised wells and tube wells, u_{it} is the error term

Hausman test is used to identify which effect is more appropriate for estimation of crop productivity, whether it is fixed effect or random effect.

The rationale behind random effect model is different from that of the fixed effect model in which the variation across districts is assumed to be random and uncorrelated with the independent variables included in the model (Cameron and Trivedi 2005).

Analysis

The productivity of sixteen selected crops was estimated by using Error Correction Model. Crop wise results are discussed as follows:

Wheat

Table 1.1 reveals that the productivity of wheat is positively affected across districts over time by crop irrigated area, fertilizer consumption, well and tube wells energized where as road length had negative impact on the productivity. Cropping intensity and rainfall had no significant contribution in enhancement of the productivity of wheat it is evident that wheat is water facilitative crop and is grown in the area of assured irrigated facilities.

Fertiliser consumption coefficient is much higher it shows that this affected wheat productivity in significant manner. The coefficient of determination (R^2) is quite good which reflected that the 57 per cent variation is explained through this model and F-statistics shows that the model is significant at 1% level of significance. Hausman test value is significant which reflects that the fixed effect model is better for this analysis.

Table 1.1
Wheat Estimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t-ratio	p-value
Const	1706.17	240.59	7.09	0.00
CI	2.10	1.99	1.05	0.29
RF	0.56	0.50	1.12	0.26
CIA	1.06	0.21	5.02	0.00
FC	3.64	1.09	3.35	0.00
RL	-0.16	0.03	-4.62	0.00
WE	0.03	0.00	6.82	0.00
R-squared	0.57	Adjusted R-squared		0.54
F-test	21.04***			
Hausman test	Chi-square(6) = 34.4125 with p-value = 5.59937e-006			

Note: * represent significance at 1% level Bajra**

Table 1.2 shows that the productivity of pearl millet (bajra) is significantly affected by cropping intensity, fertilizer consumption, road length and wells and tube wells energized, in which cropping intensity, fertilizer consumption and energized wells and tube wells had positive impact on the productivity where as road length had negative impact, which implies that the pearl millet productivity had no influence of the infrastructure development such as roads.

Rainfall had no significant role in influencing the production of bajra. Crop irrigated area did not play any significant role in enhancing the productivity of this crop. It can be inferred that irrigation facilities has no impact in increasing the productivity of pearl millet.

Coefficient of determination shows that the 55 percent variation of the productivity of pearl millet is explained by given variables and F-statistic shows that the model is significant at 1% level of significance. Hausman test shows that random effect model is better for this analysis.

Table 1.2
Bajra Estimation of Productivity using Random Effect Model Barley

	Coefficient	Std. Error	t - cal	p-value
Const	-55.43	125.61	-0.44	0.66
CI	3.63	0.90	4.02	0.00
RF	0.24	0.28	0.87	0.39
CIA	-2.04	2.28	-0.89	0.37
FC	2.11	0.64	3.27	0.00
RL	-0.04	0.02	-2.15	0.03
WE	0.01	0.00	5.65	0.00
R-squared	0.55	Adjusted R-squared	0.53	0.53
F	20.07***			
'Within' variance	91187	'Between' variance		75704.3
Hausman test	Chi-square(6) = 10.6501 with p-value = 0.0998129			

It is clear from Table 1.3 that the productivity of barley is influenced significantly only by three inputs out of six, which are cropping intensity, fertilizer consumption and energized wells and tube wells.

The significant impact of cropping intensity on productivity shows that as much as it raises the farmer going toward this crop. Farmers did not depend on rainfall because rainfall had no significant contribution on it. Crop irrigated area didn't affect the productivity of this crop. Sixty seven per cent of the total variation in the productivity of barley is explained by the variables included in the study.

Table 1.3
Barley: Estimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t - cal	p-value
Const	1048.42	192.21	5.45	<0.00001
CI	3.43	1.49	2.30	0.02
RF	-0.65	0.32	-2.04	0.04
CIA	6.00	3.03	1.98	0.05
FC	4.33	0.76	5.67	<0.00001
RL	0.05	0.02	2.16	0.03
WE	0.01	0.00	5.21	<0.00001
R-squared	0.67	Adjusted R-squared		0.49
F-test	3.85***			
'Within' variance	129968	'Between' variance		51485.8
Hausman test	Chi-square(6) = 71.6115 with p-value = 1.90929e-013			

Ground Nut

It can be inferred from Table 1.4 that the productivity of ground nut is affected by all the variables except rainfall, therefore cropping intensity, crop irrigated area; fertilizer consumption, road length and energised wells and tube wells had positive impact on it. It can be said that these variables are important for this crop.

Table 1.4
Ground Nut Estimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t - cal	p-value
Const	-138.03	175.52	-0.79	0.43
CI	6.21	1.37	4.53	<0.00001
RF	-0.02	0.28	-0.07	0.94
CIA	11.45	2.66	4.31	0.00
FC	1.32	0.68	1.94	0.05
RL	0.07	0.02	3.34	0.00
WE	0.01	0.00	2.81	0.01
R-squared	0.49	Adjusted R-squared		0.46
F-test	1454***			
'Within' variance	100856	'Between' variance		50236
Hausman test	Chi-square(6) = 68.6616 with p-value = 7.69056e-013			

Gram

The Table 1.5 depicts that the productivity of the gram is affected significantly by three variables out of six, in which cropping intensity had sizable role for enhancement of the productivity of the crop. Rainfall, crop irrigated area and road length had no impact on the productivity of gram. For this crop fixed effect model is better for analysis. Forty seven per cent of variation in the productivity of gram is explained by the variables.

Table 1.5
GramEstimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t - cal	p-value
Const	205.56	76.13	2.70	0.01
CI	3.67	0.58	6.35	0.00
RF	0.31	0.18	1.73	0.08
CIA	0.93	0.81	1.15	0.25
FC	0.84	0.42	1.97	0.05
RL	-0.01	0.01	-0.71	0.48
WE	0.00	0.00	2.82	0.00
R-squared	0.47	Adjusted R-squared		044
F-test	14.29***			
'Within' variance	43546.5	'Between' variance		21779.7
Hausman test	Chi-square(6) = 14.3628 with p-value = 0.0258357			

Jowar

It can be inferred from Table 1.6 that the productivity of jowar is affected across districts by cropping intensity, fertilizer consumption and energized wells and tube wells significantly.

Cropping intensity and fertilizer consumption are significant at 1% level of significance which shows that the fertilisers enhance the productivity of the crop where as cropping intensity shows that the farmers also diverted toward jowar. But infrastructure variable like road length showed no impact on it, which implies that the developed districts are moving toward other crops than jowar. Crop irrigated area and rainfall showed no significant contribution in the productivity of this crop.

Hausman test shows that fix effect model is better for the analysis. Independent variables explained forty nine per cent variation in the productivity of this crop.

Table 1.6
Jowar Estimation of Productivity using Fixed Effect Model

	Coefficient	Std.Error	t - cal	p-value
Const	23.70	106.20	0.22	0.82
CI	2.72	0.79	3.46	0.00
RF	0.26	0.23	1.14	0.25
CIA	89.16	59.41	1.50	0.13
FC	1.87	0.53	3.50	0.00
RL	-0.03	0.02	-1.78	0.07
WE	0.00	0.00	2.42	0.02
R-squared	0.49	AdjustedR-squared		0.45
F-test	15.11***			
'Within' variance	68678.5	'Between' variance		31992.9
Hausman test	Chi-square(6) = 29.734 with p-value = 4.41604e-005			

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Linseed

It is evident from Table 1.7 that the productivity of linseed is much affected by cropping intensity and up to some extent by fertilizer consumption. The variables like crop irrigated area and road length has no significant impact on the productivity of the crop. Farmers are going towards linseed which has shown by the significance of the cropping intensity of this crop. The coefficient of rainfall is found to be significant at 10% level which shows that across districts there is little bit impact of rainfall for this crop. Hausman test value is significant at 5% significance level which reflects that fix effect model is better for this analysis.

Table 1.7
Linseed: Estimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t - cal	p-value
Const	205.56	76.13	2.70	0.01
CI	3.67	0.58	6.35	0.00
RF	0.31	0.18	1.73	0.08
CIA	0.93	0.81	1.15	0.25
FC	0.84	0.42	1.97	0.05
RL	-0.01	0.01	-0.71	0.48
WE	0.00	0.00	2.82	0.00
R-squared	0.47	Adjusted R-squared		0.43
F-test	14.29***			
'Within' variance	43546.5	'Between' variance		21779.7
Hausman test	Chi-square(6) = 14.3628 with p-value = 0.0258357			

Maize

It can be said from the Table 1.8 that the productivity of the maize is affected significantly by cropping intensity, fertilizer consumption and energized wells and tube wells. The variables such as rainfall, road length had no significant contribution in the productivity of the maize. Coefficient of determination shows that 40 per cent change in maize productivity is explained by given variables and model is good at 1% level of significance. Hausman test shows that the random effect model is better for estimation than fixed effect model.

Table 1.8
Maize: Estimation of Productivity using Random Effect Model

	Coefficient	Std. Error	t-ratio	p-value
Const	276.45	150.37	1.84	0.07
CI	3.67	1.15	3.20	0.00
RF	0.06	0.33	0.18	0.86
CIA	-12.22	5.50	-2.22	0.03
FC	2.90	0.80	3.64	0.00
RL	0.02	0.02	0.94	0.35
WE	0.01	0.00	2.85	0.00
R-squared	0.40	AdjustedR-squared		0.37
F	10.89***			
'Within' variance	166622	'Between' variance		59710.8
Hausman test	Chi-square(6) = 9.94245 with p-value = 0.127097			

Rapeseed and Mustard

The Table 1.9 reveals that the productivity of rapeseed and mustard is affected by the crop irrigated area, fertilizer consumption and energized wells and tube wells. Crop irrigated area and productivity are directly related because the districts such as Ganganagar, Hanumangarh, and Bharatpur etc. has done well in this field. Ganganagar, Hanumangarh, Alwar and Bharatpur are well ahead in the productivity of the rapeseed and mustard because of the good irrigation facilities. On the other hand variables such as rainfall and road length did not play any significant role in increasing the productivity of the crop. Hausman test value is significant at 5% level which shows that the fixed effect model is better for estimation than random effect model.

Table 1.9
Rapeseed and Mustard: Estimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t - cal	p-value
Const	633.83	86.36	7.34	0.00
CI	1.13	0.66	1.71	0.09
RF	-0.18	0.16	-1.11	0.27
CIA	0.56	0.20	2.88	0.00
FC	2.45	0.43	5.73	0.00
RL	0.00	0.01	0.29	0.77
WE	0.00	0.00	2.79	0.01
R-squared	0.36	Adjusted R-squared		0.32
F-test	9.12***			
'Within' variance	50724.3	'Between' variance		9365.18
Hausman test	Chi-square(6) = 9.94245 with p-value = 5.06783e-010			

Sesamum

The productivity of sesamum is affected by rainfall, fertilizer consumption, road length and energized wells and tube wells. It is reflected that the productivity of sesamum is much affected by the consumption of fertilizer but the significance of the road length is negative, which shows that the under developed districts had negative impact of it. The variables like cropping intensity and crop irrigated are had no significant contribution in the productivity of the crop as shown in Table 1.10. For this crop fixed effect model is better than the random effect model

Table 1.10
Sesamum: Estimation of Productivity using Fixed Effect Model

	Coefficient	Std.Error	t- cal	p-value
Const	131.08	60.41	2.17	0.03
CI	0.39	0.46	0.84	0.40
RF	0.18	0.09	1.96	0.05
CIA	18.97	17.66	1.07	0.28
FC	0.95	0.27	3.50	0.00
RL	-0.01	0.01	-1.96	0.05
WE	0.00	0.00	2.33	0.02
R-squared	0.54	Adjusted R-squared		0.51
F-test	19.88***			
'Within' variance	29720.1	'Between' variance		2467.29
Hausman test	Chi-square(6) = 19.2372 with p-value = 0.00378127			

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Soyabean

It is evident from Table 1.11 that the productivity of soyabean is positively associated with the cropping intensity where as negatively associated with energized wells and tube wells. The reason behind this is that farmers are diverted to soyabean crop over the last two decades as the cropping intensity shows positive impact on it. But energised wells and tube wells had negative impact on it, the reason behind this might be that the farmers having facility of energised wells and tube wells have diverted to other crops than the soyabean. The coefficient of determination is very low in this model which shows that contribution of independent variables is very low to estimate the variation in productivity in soyabean.

Table 1.11
Soyabean: Estimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t-ratio	p-value
Const	318.20	186.74	1.70	0.09
CI	6.22	1.49	4.15	0.00
RF	0.13	0.14	0.92	0.36
CIA	5.71	3.31	1.72	0.09
FC	-0.99	0.81	-1.22	0.22
RL	0.01	0.01	0.71	0.47
WE	-0.01	0.00	-1.98	0.05
R-squared	0.10	Adjusted R-squared		0.02
F-test	1.16			
Within' variance'	60656.95	'Between' variance		3450.76
Hausman test	Chi-square(6) = 31.0138 with p-value = 2.51962e-005			

Rice

Rice is the area dominant crop therefore it is grown only in some districts of the state where the irrigation facilities are available like Ganganagar, Hanumangarh, Bharatpur etc. and some factors such as fertiliser consumption significantly affected the productivity of it. The energized wells and tube wells also affected it positively where as road length had negative impact on it as shown in Table 1.12. Hausman test suggests that the fixed effect model is better for estimation than random effect model for this crop.

Table 1.12
Rice: Estimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t-ratio	p-value
Const	546.26	330.37	1.65	0.10
CI	3.05	2.32	1.32	0.19
RF	0.92	0.76	1.21	0.23
CIA	4.27	6.14	0.70	0.49
FC	4.08	1.74	2.35	0.02
RL	-0.17	0.05	-3.58	0.00
WE	0.02	0.01	4.73	0.00
R-squared	0.64	Adjusted R-squared		0.61
F-test	20.58***			
'Within' variance	198250	'Between' variance		152784
Hausman test	Chi-square(6) = 29.4324 with p-value = 5.03803e-005			

Guar

Guar is the most important cash crop of the state in recent time, the only variable which affected the productivity of guar significantly is fertiliser consumption. Coefficient of determination of the model is very low which is found to be non significant this shows that variables which are taken in the study did not explain the variation in productivity of guar.

Table 1.13
Guar: Estimation of Productivity using Random Effect Model

	Coefficient	Std. Error	t-ratio	p-value
Const	-439.06	694.85	-0.63	0.53
CI	7.52	5.53	1.36	0.17
RF	0.07	0.69	0.10	0.92
CIA	-4.68	3.42	-1.37	0.17
FC	5.13	2.58	1.99	0.05
RL	-0.06	0.06	-0.96	0.34
WE	0.00	0.00	-0.30	0.76
R-squared	0.08	Adjusted R-squared		0.01
F-test	1.23			
Within' variance	2518630	'Between' variance		127411
Hausman test	Chi-square(6) = 3.65535 with p-value = 0.7232			

Cotton

Cotton is the cash crop and there is no such factor taken in the study which is statistically significant and play either positive or negative role in improvement of the productivity of the crop. The reason behind this may be that there in no such consistent improvement happen in terms of productivity of the crop.

Table 1.14
Cotton: Estimation of Productivity using Random Effect Model

	Coefficient	Std. Error	t-ratio	p-value
Const	79041.65	272353.3	0.29	0.77
CI	152.04	2239.83	0.068	0.94
RF	-269.39	965.23	-0.28	0.78
CIA	-129.49	636.50	-0.21	0.83
FC	499.40	970.28	0.51	0.60
RL	-13.61	26.99	-0.51	0.61
WE	-0.74	2.46	-0.31	0.76
R-squared	0.26	Adjusted R-squared		0.20
F-test	4.93***			
'Within' variance	2.32E+11	'Between' variance		7.20E+10
Hausman test	Chi-square(6) = 5.80855 with p-value = 0.444975			

Kharif Pulses

The Table 1.15 reveals that two variables out of the six, which played a significant role in effecting the productivity of kharif pulses, affected it in positive direction where as road length affected it in negative direction. Cropping intensity is growing up over years due to infrastructural development in the field of agriculture.

Table 1.15
Kharif Pulses: Estimation of Productivity using Fixed Effect Model

	Coefficient	Std. Error	t-ratio	p-value
Const	98.20	81.01	1.21	0.23
CI	1.86	0.62	3.00	0.00
RF	0.06	0.09	0.61	0.54
CIA	0.11	0.10	1.06	0.29
FC	0.46	0.29	1.59	0.11
RL	-0.03	0.01	-3.72	0.00
WE	0.00	0.00	0.22	0.82
R-squared	0.19	Adjusted R-squared		0.14
F-test	3.80***			
'Within' variance	31456.9	'Between' variance		2391.22
Hausman test	Chi-square(6) = 20.7383 with p-value = 0.00204416			

Taramira

It is evident from Table 1.16 that the productivity of taramira is affected positively by crop irrigated area but negatively by fertilizer consumption and road length. This shows that productivity of the taramira is related to the irrigated area of the crop and enrichment of the productivity is due to this area. On the other hand the negative impact of fertilizer consumption and road length had shown that this crop is preferred in the underdeveloped districts. The other variables such as cropping intensity, rainfall, and energized wells and tube wells did not contribute in enhancing productivity.

Table 1.16
Taramira: Estimation of Productivity using Fix Effect Model

	Coefficient	Std. Error	t - cal	p-value
Const	617.39	70.92	8.71	0.00
CI	-0.97	0.55	-1.76	0.08
RF	0.10	0.14	0.75	0.46
CIA	102.04	18.10	5.64	0.00
FC	-1.68	0.35	-4.77	0.00
RL	-0.02	0.01	-2.18	0.03
WE	0.00	0.00	1.88	0.06
R-squared	0.14	Adjusted R-squared		0.11
F-test	3.91***			
'Within' variance	33555	'Between' variance		5476.92
Hausman test	Chi-square(6) = 24.8462 with p-value = 0.000364584			

Conclusion

The panel data of twenty years, of different districts of sixteen major crops sown were used for estimation purpose by using random effect and fixed effect models. On the basis of these estimates the study concluded that cropping intensity and crop irrigated area had significant contributions in enhancing the productivity of few crops. The fertiliser consumption played a key role in all crops for enhancement in productivity except in soyabean, cotton, kharif pulses and taramira. Fertiliser is an important factor since green revolution. Punjab and Haryana have good experience of agriculture growth in earlier period of green revolution. Now Rajasthan state is using fertilisers, so growth of agriculture become more significant in recent period. Although rainfall is an important factor which affects agriculture but it has no impact on productivity across districts over the years except gram. The contribution of road length has significant role in productivity of wheat, pearl millet, barley, ground nut, maize, rice and kharif pluses in the state. Since roads facilitate farmers to use input in time and make them more efficient. Energized wells and tube wells also contributed significantly in all crops productivity except guar, cotton, kharif pulses and taramira. Since energised wells and tube wells make sure for irrigation facility for farmers and this contributed for enhancement in productivity.

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