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PUBLIC INVESTMENT IN FARM SECTOR OF PUNJAB- AN IMPACT ANALYSIS

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Abstract

The present study was conducted to assess the impact of public investment in agricultural research on productivity of crops and enterprises in Punjab. In order to achieve the stipulated objectives of the study the data on research expenditure and productivity of crops and enterprises were compiled from Center for Monitoring Indian Economy Reports, Statistical Abstract of Punjab, and from various departments of Punjab Agricultural University for the period 1985-86 to 2009-10. The tabular and functional analyses were used to analyse the data. Overview of growth analysis of research expenditure and productivity shows that for all the crops except oilseed, pulses and maize the research expenditure and productivity shows positive relationship. This calls for promotion in the investment to augment the production for realizing benefits of increased output. The impact of public sector investment on productivity of crops/enterprises was positive but with lapse of time. Lag effect of research investment on productivity implies reduction in food grain productivity. The study pointed out the need for sustained public investment as a means to raise the productivity of crops and allied enterprises such as mushroom farming, beekeeping, etc. The findings suggested that the government should increase the allocation of funds to farm sector research in order to improve research efficiency.

Introduction

The public investment in agriculture is a pre-requisite for the growth of agriculture and is vital for sustained growth of the sector in order to meet the increasing demand of food Grains. The productive base of the farm sector needs to be enlarged through direct public investment in irrigation schemes, soil and water conservation works, land reclamation, etc. Additional boost in agricultural production

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to the levels needed to feed an ever expanding world population will require sharp increase in public investment in research and development and widespread adoption of new technologies, farming techniques and crop varieties. In this view, agriculture research is the most powerful instrument for the development of improved production technology. In India, public research dominates the agricultural research system.

Thus, it is imperative for Government of India to step up its research activities to help and solve agricultural production problems of the country in general and food production in particular. The public investments need to be stepped up in regions which although relatively backward but have a high potential for agricultural growth as productivity levels in the Green Revolution areas have already reached the plateau (Nath, 1998). The attention should be focused toward developing a system that would give research thrust to bring a balance between the food security, management of natural resources, etc. Importance should be given to the identified priority areas of short duration varieties, quality seed and developing crops with more protein and micronutrient content. Moreover, sufficient resources should be allocated to agriculture research and education to facilitate a rapid increase in agricultural productivity.

In this view, public investment is the most important single factor in the growth process especially in the case of Punjab agriculture where average size of farm is small and large numbers of small farmers depend upon public investment for infrastructure development and other requirements such as credit and subsidies (Pal, 2008). Thus, it is important for the policy makers and planners to analyse public sector investment in agricultural research and various type and levels of investments contributing to the productivity in Punjab agriculture. The knowledge of distribution will help to judge the rationality of the investment made. In the backdrop of this, the present study is an attempt to examine the impact of public sector investment on growth and productivity of the crops and enterprises in the Punjab state.

Methodology

In order to achieve the stipulated objectives of the study, the secondary data were used and compiled from Centre for Monitoring Indian Economy Reports, Statistical Abstract of Punjab, and publications of various departments of Punjab Agricultural University for the period 1985-86 to 2009-10. In order to fulfill the objectives of the study, data on crops like wheat, rice, maize, cotton, sugarcane, oilseeds and pulses were collected. The cereals including wheat, rice and maize were included for detailed study. Similarly, mushroom farming and bee-keeping were the

enterprises considered for detailed analysis only due to non-availability of data on other enterprises.

Optimum Sub-periods

For the purpose of growth analysis the entire study period 1985-86 to 2009-10 was divided into sub- periods by construction of strata by following Cumulative Cube Root Rule (Singh, 1975) to obtain approximately optimum strata boundaries. To obtained frequencies, percentage of expenditure to total was obtained. Then cube root of frequencies for each 'K' classes was obtained. Further cumulative total of the cube root of frequencies of each 'K' was obtained. Let T denote the cumulative total for the K^{th} class. For construction of three strata, value of $X=X_1$ was obtained, which corresponds to the value T/3 in the cumulative cube root frequency column. This process was repeated to obtained $X=X_I$ (I= 1, 2). The value (X_1, X_2) so obtained defined three strata with boundaries (< X_1), (X_1 to X_2) and (X_2 to X_2<).By following the above procedure cut-off year was found for different expenditure.

The time horizon of the study was divided in the three periods, Period I: 1985-86 to 1993-94, Period II: 1994-95 to 2000-01 and Period III: 2001-02 to 2009-10 to examine the public sector investment in agricultural research and education. In order to examine the crop-wise research expenditure by Punjab Agricultural University (PAU) the time horizon was divided into periods, Period I (1985-86 to 1992-93), Period II (1993-94 to 2002-03) and Period III (2003-04 to 2009-10).
These three sub-periods reflect distinct patterns in agriculture investment.

Compound Growth Rate

The growth rate in research investment was computed for the entire study period and three sub-periods separately using equation (1):

$$\log Y_t = \log \alpha + X \log \beta + u_t \quad \ldots\ldots\ldots\ldots (1)$$

where, Y_t = Expenditure on agriculture in the year t,

α = Constant-term,

β = Regression parameter,

u_t = Residual term, and

X = Relevant year.

Compound Growth Rate (CGR) = [Antilog (log β)-1] ×100 …… (2)

Significance of co-efficient was tested by t-Statistic and significance of the model was tested in term of goodness of fit.

Functional Analysis

To study the effect of public sector investment on productivity and growth of different crops and enterprises, the time horizon was divided into two sub-periods,

Period I: 1985-86 to 1994-95 and Period II: 1995-96 to 2009-2010. Distributed Lag Model was employed for the analysis. In this approach productivity was regressed on research investment. The productivity of food grains given in of Statistical Abstract of Punjab for period (1985-86 to 2009-10) was considered. The time issues were addressed by forming lag of research investments by PAU using Almon's Lag Scheme. The functions with different lag periods were tried and one with highest R^2 was considered to be the most appropriate. The following investment model was applied for the analysis.

$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + u_t$ …… (3)

Where, Y_t = Productivity of crop/enterprises,

α = Constant-term,

β_i = Regression parameter, where i=1, 2, …n.

u_t = Residual-term, and

X_t = Research expenditure by PAU.

Further, β_i were approximated by a second degree polynomial as shown by equation (5):

We express the β_i in terms of the a's

$\beta_i = a_0 + a_{1i} + a_{2i}^2$ ……(4)

Substituting (4) into (3), we obtain

$Y_t = \alpha + a_0 Z_{0t} + a_1 Z_{1t} + a_2 Z_{2t} + u_t$ ……(5)

Defining, $Z_{0t} = \sum_{i=0}^{2} X_t = X_t + X_{t-1} + X_{t-2}$

$$Z_{1t} = \sum_{i=0}^{2} iX_t = X_{t-1} + 2X_{t-2}$$

$$Z_{2t} = \sum_{i=0}^{2} i^2 X_t = X_{t-1} + 4X_{t-2}$$

From the estimated a's, we easily obtained the original β_i

$$\hat{\beta}_0 = \hat{a}_0$$

$$\hat{\beta}_1 = (\hat{a}_0 + \hat{a}_1 + \hat{a}_2)$$

$$\hat{\beta}_2 = (\hat{a}_0 + 2\hat{a}_1 + 4\hat{a}_2)$$

This model was fitted for each period. Significance of co-efficient was tested by t-Statistic and significance of the model was tested by F-Statistic. Independent variables were tested for their stochastic independence.

Results and Discussion

Impact of Public Sector Investment on Growth and Productivity

The investment requirement of the economy rises when it follows a high growth trajectory, as large investment are needed to sustain the existing levels of growth. The investments being pivotal for accelerating growth by raising the productive capacity, investment and productivity have been considered simultaneously in this section.

Growth Analysis

Research expenditure by the Punjab Government and productivity of crops

The perusal of Table 1 reveals that research expenditure grew at 3.29 per cent per annum and productivity of crops grew by 3.26 per cent per annum during Period I and CGRs were statistically significant. The research expenditure showed highest significant growth at 8.03 per cent per annum during Period II, when crop productivity was estimated to be 2.49 per cent per annum. In Punjab, the productivity of major crops has already reached the plateau, thus, to sustain the level of productivity and to develop cost efficient technologies the pace of research expenditure was increased to more than twice in Period II. During Period III, CGRs of research expenditure and productivity were statistically significant, but growth rate declined to 2.04 per cent per annum in the case of research expenditure and 1.49 per cent per annum in crop productivity. Thus, it could be concluded that there is a need to increase research funding by the state government to enhance crop productivity for meeting the increased demand of food grains.

Table 1: Growth rate of research expenditure by the Punjab Government and crop productivity: 1985-86 to 2009-10

Period	Research expenditure	Crop productivity
Period-I	3.29**	3.26**
(1985-86 to 1993-94)	(2.99)	(0.46)
Period-II	8.03**	2.49**
(1994-95 to 2000-01)	(2.70)	(0.77)
Period-III	2.04**	1.49**
(2001-02 to 2009-10)	(2.08)	(0.72)

Figures in parentheses are standard errors
***** Significant at 5 per cent level***

Research expenditure by PAU vis-à-vis productivity of crops

The results presented in Table 2 revealed that during Period-I the growth of

research expenditure on maize had highest (4.15 per cent per annum) which was followed by wheat, cotton, and pulses, whereas productivity of oilseeds showed highest significant growth of 10.71 per cent per annum, followed by maize and, wheat. In the case of rice, research expenditure showed a significant but negative growth whereas its productivity depicted the growth by 0.98 per cent per annum, which was statistically significant. Similarly, oilseeds research expenditure show significant negative growth and productivity show significant growth. In the case of sugarcane, both research expenditure and productivity showed significant negative growths during Period I.

Table 2: Growth rate of research expenditure by PAU and productivity of crops

Crops	Research expenditure			Crop productivity		
	Period I	Period II	Period III	Period I	Period II	Period III
Wheat	3.29**	17.00NS	2.79**	2.39**	1.77**	1.36**
	(3.08)	(4.83)	(3.19)	(0.62)	(0.19)	(0.85)
Rice	-7.76**	8.18**	39.63**	0.98**	1.34**	1.51**
	(3.25)	(5.41)	(14.19)	(0.73)	(0.61)	(0.77)
Maize	4.15**	20.58**	-13.80**	2.59**	3.79**	4.05**
	(2.12)	(7.47)	(3.09)	(1.97)	(2.19)	(2.64)
Pulses	1.89**	16.21**	-4.55**	-0.28**	-4.59**	-0.37**
	(3.44)	(6.62)	(8.17)	(1.25)	(1.06)	(0.80)
Sugarcane	-18.41**	34.65**	0.33**	-0.05**	0.03**	2.59**
	(4.38)	(8.17)	(15.74)	(0.54)	(0.81)	(1.22)
Oilseeds	-0.03**	23.37*	-8.25**	10.71*	-1.01**	0.58**
	(4.01)	(3.35)	(2.19)	(1.95)	(0.98)	(1.36)
Cotton	2.11**	16.51**	2.15**	0.98**	1.39**	4.34**
	(1.79)	(6.81)	(9.92)	(1.31)	(5.8)	(3.73)

Figure in parentheses are standard errors.
*****and*Significance at 5 and 10 per cent respectively***
NS: Non-significant

During the Period II, research expenditure on all crops showed significant growth rates. Sugarcane had the highest significant growth (34.65 % per annum), followed by oilseeds, maize, wheat, cotton, pulses and cotton. In terms of crop productivity, maize depicted highest significant growth (3.79 % per annum), followed by wheat, cotton and rice. During this period research expenditure on pulses and oilseeds shows a significant growth whereas their productivity declined significantly.

During Period III, growth analysis of research expenditure reveals that rice

had the highest significant growth rate (39.63 % per annum), followed by wheat, cotton, and sugarcane. The growth analysis of crop productivity pointed out that cotton showed highest significant growth of 4.34 per cent per annum followed closely by maize, sugarcane, rice and wheat. Further, the results indicated that the research expenditure on maize and oilseed showed significant but negative growth whereas productivity exhibit significant growths. In the case of pulses, CGR of research expenditure and productivity shows significant but negative growth (Appendix-I).

An overview of growth analysis showed that research expenditure and productivity on wheat had declined overtime, whereas in the case of rice research expenditure and productivity had increased. In the case of maize, research expenditure had a significant growth during Period II, but it show negative growth in Period III, whereas productivity had increased over time. The research expenditure on pulses had a significant growth in Period II but this growth could not be maintained which slumped in Period III, on the other hand productivity on pulses exhibited negative growth in all the three periods. The research expenditure on sugarcane depicted a significant positive growth in last two periods, with a very high growth during Period II, which drastically dropped in Period III, whereas growth rate of productivity had shown improvement overtime and same was observed in the case of cotton. Further, in the case of oilseed, the research expenditure and productivity moved in an opposite direction in all the three periods. Thus, from the above discussion it can be concluded that for crops like oilseeds, maize and pulses the research expenditure and productivity moved in almost in the opposite direction. The possible causes for negative relationship between research expenditure and productivity was an inadequate amount of research expenditure incurred by Punjab Agricultural University on oilseeds, pluses and maize. This calls for the augmentation of investment for increased productivity and this in turn ensures better returns to the farm operators.

Functional analysis

In this section distributed lag model was employed to delineate the impact of research investment on productivity of crops/enterprises and impact of investment on agricultural GDP.

Research investment by the Punjab Government: 1985-86 to 2009-10

The results presented in the Table 3 reveal that research expenditure by Punjab Government during Period-I had a positive impact on crops productivity and its impact was highest in second year. Impact of research expenditure was positive on

productivity but decline gradually in Period-II. As productivity of food grain has reached its peak, to achieve the sustainability in productivity the research expenditure has been incurred by state government. The value of R^2 during Period-I and II came out to be 0.60 and 0.72 respectively and were significant statistically.

The perusal of Table 3 pointed out that during Period I research expenditure by Punjab Government exhibits positive impact on enterprise productivity, which gradually improved and showed its highest impact in second year. During Period II, research expenditure by Punjab Government had a negative impact in current year, thereafter showed a positive impact, indicating productivity response to research expenditure but with the lapse of one year. The value of R^2 during Period I and II comes out to be 0.60 and 0.58 respectively. The results reveal that research expenditure by Punjab Government has positive impact on agricultural GDP with highest impact with lag of two year. The value of R^2 comes out to be 0.67 which was statistically significant.

Table 3: Regression analysis of research investment by Punjab State Government

Particulars	Crops		Enterprises		Agricultural GDP
	Period I	Period II	Period I	Period II	Total period
Intercept	144.96**	163.36**	364.02**	140.65**	166.04**
	(59.63)	(30.92)	(87.35)	(37.06)	(249.51)
X_t	1.05**	2.23**	6.67**	-10.55^{NS}	29.84**
	(2.11)	(1.62)	(3.69)	(2.05)	(3.12)
X_{t-1}	1.97**	1.65**	12.36**	5.40**	23.79**
	(4.62)	(3.44)	(2.94)	(1.92)	(5.61)
X_{t-2}	3.83**	0.59**	23.13**	8.49**	32.00**
	(2.22)	(1.66)	(1.34)	(3.49)	(7.09)
R^2	0.60	0.72	0.60	0.58	0.67

Figure in parentheses are standard errors.
***** Significant at 5 per cent level***
NS: Non-significant

Research investment by the Punjab Agricultural University: 1985-86 to 1994-95

The results presented in Table 4 reveals that in the case of wheat, the value of R^2 comes out to be 0.60 and coefficients of research expenditure were significant at five per cent level. Further, the results pointed out that research expenditure on wheat had positive impact on its productivity with lag of one year and it improves gradually. The value of R^2 for rice was 0.49 and coefficient of research expenditure was significant at five percent level indicating that research expenditure on rice has

positive impact on productivity which had become stronger with time and which was highest in second year.

Table 4: Regression analysis of research investment by Punjab Agricultural University in respect of crops and enterprises (1985-86 to 1994-95)

Particular	Intercept	X_t	X_{t-1}	X_{t-2}	R^2
Wheat	3502.86**	-0.08 NS	0.03**	0.17**	0.60
	(263.15)	(0.65)	(0.29)	(0.13)	
Rice	4393.18**	0.11**	0.20*	0.71*	0.49
	(511.73)	(0.24)	(0.72)	(0.35)	
Maize	314.52**	1.33**	-0.79*	-1.66*	0.72
	(156.87)	(2.34)	(1.32)	(.402)	
Pulses	1015.66**	-0.13NS	-0.05NS	0.02*	0.56
	(166.89)	(0.07)	(0.17)	(0.08)	
Sugarcane	60605.12**	-0.48NS	-0.41NS	0.87*	0.30
	(3578.50)	(1.83)	(7.92)	(3.97)	
Oilseeds	3312.50**	-0.35**	0.52**	0.01**	0.66
	(185.06)	(0.17)	(0.63)	(0.31)	
Cotton	215.68**	0.19*	0.01*	1.58*	0.57
	(194.05)	(0.07)	(0.19)	(0.09)	
Cereals	5992.68**	0.11*	0.14*	0.41*	0.48
	(1654.27)	(0.24)	(0.77)	(0.38)	
Enterprises	934.47**	2.86**	2.80*	3.42*	0.83
	(455.09)	(1.48)	(1.48)	(1.84)	

Figure in parentheses are standard errors.
*****and* Significance at 5 and 10 per cent respectively***
NS: Non-significant

The results depicted that value of R^2 in the case of maize was 0.72 and coefficient of research expenditure were statistically significant. In current year't', productivity respond to research expenditure, thereafter, research expenditure on maize had no positive impact on productivity. Though, the research expenditure did not have positive impact on productivity but this expenditure was expanded to sustain the level of productivity and to develop cost effective technology. In the case of pulses and sugarcane it was observed that the values of coefficient of research expenditure were statistically significant in second year only, indicating that research expenditure had an impact on productivity with lag of two years and the R^2 came out to be 0.56 and 0.30 in the case of pulses and sugarcane, respectively. The research expenditure on cotton and cereals had positive impact on productivity and its impact was highest in the second year. The value of R^2 came out to be 0.57 and 0.48 for

oilseeds and cereals respectively. Same was true in the case of enterprises and the value of R^2 in the case of enterprises was 0.83. In the case of oilseeds, productivity responded to research expenditure with time lag and its response was highest in Period-I and value of R^2 was 0.66.

Research investment by the Punjab Agricultural University: 1995-96 to 2009-10

The result presented in the Table 5 indicates that research expenditure had a positive impact on wheat productivity in current year and was statistically significant. The value of R^2 came out to be 0.63. Further, it was observed that in the case of rice, productivity responds to research expenditure but with a time gap of two years and same trend was observed for sugarcane and enterprises.

Table 5: Regression analysis of research investment by Punjab Agricultural University in respect of crops and enterprises (1995-96 to 2009-10)

Particular	Intercept	X_t	X_{t-1}	X_{t-2}	R^2
Wheat	4150**	0.15**	-	-	0.63
	(192.63)	(0.09)			
Rice	3199.02**	0.19^{NS}	0.02^{NS}	0.19**	0.58
	(286.63)	(0.16)	(0.73)	(0.38)	
Sugarcane	62092.77**	-0.29^{NS}	$-0.1.23^{NS}$	0.38**	0.30
	(1719.89)	(0.86)	(3.24)	(1.59)	
Oilseeds	3312.50**	-0.35**	0.52**	0.01**	0.66
	(185.06)	(0.17)	(0.63)	(0.31)	
Cereals	8711.21**	0.37**	-	-	0.65
	(574.99)	(0.16)			
Enterprises	1840.84**	-0.59^{NS}	-0.37^{NS}	1.32*	0.65
	(301.56)	(1.06)	(3.68)	(1.80)	

Figure within parentheses are standard errors
*****and* Significance at 5 and 10 per cent respectively***
NS: Non-significant

The value of R^2 was 0.58, 0.30 and 0.65 in the case of rice, sugarcane and enterprises respectively. The value of R^2 for oilseeds was 0.66 and the coefficient of research expenditure was significant at five per cent level for all the year. The statistically significant negative coefficient of research expenditure during current year indicated that, level of productivity remained almost constant in year‘t’ without responding to research expenditure. The research expenditure impact on oilseeds was highest with lag of year one. The value of R^2 in the case of cereals came out to be 0.65 and the coefficient of research expenditure were significant at five per cent level

in current year, indicating that impact of research expenditure on productivity was realized in the year in which expenditure was incurred.

From the above discussion it was observed that public investment in agriculture research has positive but lagged impact on productivity of crops and enterprises. Further, the length of lag varies across the crops. The productivities of major crops (wheat, rice and sugarcane) in the state had already reached the plateau this was the main reason for the lag relationship between research investment and productivity.

Conclusions

Overview of growth analysis of research expenditure and productivity revealed in the case of crops like oilseeds, maize and pulses the research expenditure and productivity moves in almost opposite direction but in the case of other crops the research expenditure and productivity showed positive relationship. This calls for more investment to augment production for sustained development of farm sector. The impact of public sector investment on productivity of crops/enterprises was positive but with lapse of time. The study pointed out that there is a need of sustained public investment so as to raise the productivity of crops and allied enterprises such as mushroom farming, beekeeping, etc.

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Appendix

Productivities of different crops in Punjab

(Kg ha^{-1})

Year	Wheat	Rice	Maize	Sugarcane	Cotton	Oilseeds	Pulses
1985-86	3531	3200	1585	64744	426	1976	750
1986-87	2966	3331	2023	62990	507	1856	805
1987-88	3540	3164	1566	54906	510	1754	827
1988-89	3667	2769	1177	61856	475	2000	705
1989-90	3593	3510	1900	63107	570	3339	562
1990-91	3715	3229	1787	59406	463	3407	697
1991-92	3803	3257	1960	63486	607	3741	721
1992-93	3777	3392	2296	61416	570	3661	766
1993-94	4011	3508	1855	60779	446	3563	729
1994-95	4089	3384	1861	61875	499	4122	778
1995-96	3884	3128	1795	64800	447	3540	833
1996-97	4234	3397	2120	63815	441	3811	790
1997-98	3853	3465	2091	56746	220	3319	794
1998-99	4330	3153	2286	59515	180	3151	639
1999-00	4696	3347	2577	62685	340	3482	628
2000-01	4563	3506	2794	64215	430	3363	628
2001-02	4532	3545	2721	65141	370	3619	677
2002-03	4200	3510	2039	60325	410	3186	586
2003-04	4207	3694	2980	53821	556	3801	776
2004-05	4221	3943	2740	60116	697	3696	766
5002-06	4179	3858	2723	57857	731	3596	784
2006-07	4210	3868	3123	60808	750	3627	794
2007-08	4507	4019	3405	60818	663	3950	748
2008-09	4462	4022	3403	57660	737	3725*	775*

Source: CMIE

****Anticipated.***