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# FARM-SIZE AND PRODUCTIVITY RELATIONSHIP: A STUDY OF AGRICULTURALLY ADVANCED REGIONS IN INDIA

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## ABSTRACT

**The present study was conducted to examine the farm-size productivity relationship in agriculturally advanced states in India namely; Punjab and Haryana. The study is based on the data of 70th round of National Sample Survey Organization. The wheat and paddy are two main crops of rabi and kharif seasons, respectively in both the states with some differences across different farm-size categories. In the present study, the farm-size and productivity relationship is analysed at two levels i.e., crop-wise analysis of physical productivity for wheat crop and farm level analysis for value productivity of all crops. Farm-size and input-use relationship is also examined. There is a positive and significant correlation between area under the wheat crop and productivity in both states. Relationship between the annual value productivity and cropped area is also significant and positive in both states. Relationship between farm-size and input-use is positive for fertilizers, plant protection chemicals, hired labour, diesel while negative for hired machinery in Punjab. In Haryana, farm-size and input-use relationship is size neutral for fertilizers and plant protection chemicals; positive for hired labour and diesel; negative for hiring machinery and electricity. It is recommended that government should support the adoption of cooperative farming by the farm households belonging to marginal and small farm-size categories. Other support measures include developing farming systems & crops important for marginal and small farmers like potato, sugarcane, cotton; addressing input-use constraints faced by the smaller farms through government policies like increasing their RCC limit and providing higher DBT.**

**Keywords:** Farm-size and productivity, Input-use, Inverse relation hypothesis, Punjab and Haryana, Small and marginal farmers



Punjab and Haryana have been frontline states in the adoption of the state- sponsored capitalistic mode of production in agriculture to ensure India's self-reliance in food grain production (Alavi, 1975). As early as the 1960s, the farmers of these states have started adopting High Yielding Varieties (HYVs), chemical fertilizers and plant protection chemicals for wheat cultivation and in 1970s for rice cultivation, which is commonly known as the green revolution (Bhalla *et al.,* 1990; Singh and Kohli, 1997; Hazell, 2009). They have enthusiastically invested in tube-wells, tractors, tractor-operated implements, combines and other machinery which facilitated timely and faster completion of agricultural operations (Bhalla *et al.,* 1990; Singh and Kohli, 1997; Grover *et al.,* 2017). The efforts have been parallelly facilitated by the government through various policies and schemes like assured procurement system, subsidized power availability (both electricity as well as diesel), easy tube-well connections, land development schemes, etc. Other provisions include timely availability of various inputs like high yielding seeds and chemical fertilizers on subsidized prices (Bhalla *et al.,* 1990; Singh and Kohli, 1997; Arora, 2013). The efforts were so fruitful that India became food surplus as well as net exporter of food grains in the coming years (Chand, 2003; Saini and Kozicka, 2014). Despite so many achievements, the green revolution introduced some problems in the economy. After few years of boom, the agricultural growth in Punjab declined consistently. The agricultural growth rate in Punjab was 5.7 per cent between 1971-72 to 1985-86 which decreased to 3 per cent between 1986-87 to 2004-05 and 1.61 per cent between 2005-06 to 2014-15 (Singh and Singh, 2002; Gulati *et al.,* 2017). Studies highlighted that even among cultivators, small farmers gained little from the green revolution. Small farms were resource constrained to make long term investments and to use high productivity inputs extensively (Dasgupta, 1977; Dhanagare, 1988; Gahukar, 1992). On the contrary, the big farmers who invested and managed farms themselves were way more productive than small farms (Pisani, 2006).

In parallel time, a debate on farm-size and productivity relationship was going on among the researchers of the country. The Inverse Relationship (IR) hypothesis between farm-size and productivity states that small farmers are more productive than large farmers. The acceptance of IR hypothesis advocates

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the promotion of small farms. In India, the debate was initiated by Sen (1962), citing inverse relation between farm-size and productivity in Indian agriculture. Further discussion on the topic concluded that inverse relation may exist in certain regions but it cannot be generalized for whole India (Rao, 1967; Bhattacharya and Saini, 1972; Bharadwaj, 1974; Chattopadhyay and Rudra, 1976; Rudra and Sen, 1980). It was also asserted that inverse relation between farm-size and productivity is a phenomenon of an underdeveloped agriculture which changes with the advancement of technology (Ghose, 1979). It was obvious to expect that IR hypothesis would have been rejected for Punjab, Haryana and western Uttar Pradesh once the adoption process for green revolution technologies completes. Fortunately, we have a plethora of empirical evidence for farm-size and productivity relationship for this region between 1950s to 1980s (Rao, 1967; Rudra, 1968a; Bhattacharya and Saini, 1972; Bardhan, 1973; Chattopadhyay and Rudra, 1976; Ghose, 1979; Bhalla and Chadha, 1982). For the pre-green revolution period, there was ambiguity about relationship among the researchers as few observed positive or neutral correlation between farm-size and productivity (Rao, 1967; Bhattacharya and Saini, 1972; Bardhan, 1973; Chattopadhyay and Rudra, 1976) while others have reported negative correlation between farm-size and productivity (Rudra, 1968b; Ghose, 1979). Whereas, all the studies conducted for the post-green revolution period suggested either positive (Chattopadhyay and Rudra, 1976; Ghose, 1979; Bhalla and Chadha, 1982) or neutral relation (Bhattacharya and Saini, 1972; Bardhan, 1973) while negative correlation was completely absent in this period. Further, if there is neutral relationship, then it would have been deduced that all farms are equally efficient and the resources are being optimally utilised. On the contrary, if there is positive relationship, then it highlights serious concerns raised by various scholars from time to time that marginal and small farmers faced difficulty in adoption of green revolution technologies.

Farm-size and productivity debate is core policy issue at every stage of agricultural development. Historically, the primary aim of the debate was to decrease drudgery for people engaged in agriculture and promote better living conditions for the peasant-farmers. In England, the development and adoption of certain agricultural practices like crop rotation, machinery, etc. facilitated the industrial revolution (Overton, 1996). The development of the secondary sector opened up the way to engage population out of agriculture. Simultaneously, the use of capital in agriculture reduced the dependency of agricultural sector on human labour. These peculiar conditions created demand and supply of labour outside the agriculture into the industrial sector. In nineteenth century, the agriculture of England was model for the rest of the Europe which was still developing (Kautsky, 1988). The debate on farm-size and productivity was initiated to inquire whether to promote small farmers or large farmers in these under-developed regions of Europe. In India, the scope of the farm-size and productivity debate should not be restricted to finding optimum farm-size as it was the case for other less populated resource-rich countries.

India and rest of the world have notable differences in the pattern of the economic growth. In India, the services sector has been the main driver of economic growth, contrary to the rest of the world where industrialization was the major force (Amirapu and Subramanian, 2015). The growth rate of employment between the years 2000 to 2012 was 2.93 per cent, 2.89 per cent and -0.52 (negative) per cent for services sector, manufacturing sector and agriculture sector, respectively (Majid, 2019). Hence, there is little structural shift in employment structure. The average size of operational holdings in India has been already very small (1.08 ha) leaving no scope for further fragmentation of land holdings and engaging more population in agriculture (Anonymous, 2020b). Thus, there seems little scope to move workforce out of agriculture or absorb workforce into agriculture. But, if we can address the shortcomings that cause lesser productivity on small farms and frame suitable policies, it may decrease poverty and food insecurity as Pingali (2012) found that “One per cent increase in agricultural value added per hectare leads to a 0.4 per cent reduction in poverty in the short run and 1.9 per cent in the long run”. Hence, the farm-size productivity analysis in Indian conditions must be conducted keeping in mind, which farms are more efficient? What are the shortcomings of inefficient farms? and how to overcome these shortcomings to obtain optimum levels of productivity? And the present study addresses the same issue in detail.

## MATERIALS AND METHODS

Farm productivity depends on many factors which can be broadly classified into three groups i) land quality (intrinsic properties) ii) price received (marketing) iii) farm management practices. Fortunately, the two important crops of Punjab and Haryana i.e., paddy and wheat have homogeneous prices in form of minimum support price. There are two levels at which farm-size and productivity relationship can be measured 1) crop-wise analysis and 2) value productivity analysis at farm-level. Crop-level analysis facilitates comparison between physical productivity of individual crops. In present study, wheat crop is selected for crop level analysis as paddy has many inter-regional differences within states in terms of varieties sown and price received. The difference between the productivity and

price of *basmati* and *parmal* paddy is a major concern. Other concerns include the varieties like PUSA 44 which has significantly higher productivity than other prevalent varieties in the region which makes the comparison difficult. In farm-level analysis, more holistic picture of the farm productivity status can be observed as it includes all factors affecting crop productivity like crops choice, cropping intensity, price received, farm management practices, input-use, etc.

## Terminology and data source

### *Productivity*

#### *Physical productivity*

The physical yield obtained by different farm households was analyzed using the formula given below:

$$Yi = \frac{Qi}{ai}$$

Where, $Y_i$ = Physical productivity of wheat of $i^{th}$ household (kg/ha)

$Q_i$ = Production of wheat crop under consideration for $i^{th}$ farm household (Kg)

$a_i$ = Area under wheat crop $i^{th}$ farm household (ha)

#### *Value productivity*

The overall annual productivity of farm in value terms is calculated at unit level. All the crops grown during the survey year was enlisted for each farm household. The monetary value of each crop was worked out by multiplying the output of the crop with per unit price of the crop. Annual productivity per ha was computed in value terms (Rs/ha)

### *Paid-out costs ($C_i$)*

The expenses incurred in cash or kind on crop production by the agricultural households for out-of-pocket expenses were collected. The inputs costs included the cost of seeds, fertilizers, manures, plant protection chemicals, hired human labour, electricity, irrigation, diesel, repairs and maintenance of machinery, cost of hiring machinery, rent for leased-in land, interest on crop loans and other expenses.

The data for the present study is obtained from National Sample Survey Organization (NSSO) $70^{th}$ round 'Situation Assessment Survey of Agricultural Households'. The households that have at least one person engaged part-time or full time in agricultural activity and earns minimum income of Rs 3000 per annum from agriculture was considered as agricultural household. The households which are engaged in crop production amongst the agricultural household are identified as farm households. The sample size for the Punjab is 558 farm households and for Haryana is 467 farm households.

## Statistical analysis

Analysis of Variance (ANOVA), correlation, regression techniques are applied to analyse the farm-size and productivity relationship. Each sub-section includes outlier detection followed by the preliminary testing of the data. Firstly, the outliers are detected in the sampled farm households using Inter Quartile Range (IQR) approach (Vinutha *et al.,* 2018). Given the nature of farm level data, the range of $Q_1$ - 3*(IQR) and $Q_3$ + 3*(IQR) was used to detect most probable outliers. The final sample obtained after outlier detection is 539 farm households in Punjab with 102 (18.92%) marginal households, 133 (24.68%) small households, 163 (30.24%) semi-medium households, 120 (22.26%) medium households and 21 (3.90%) large households. The final sample size for Haryana is 467 farm households with 107 (22.91%), 128 (27.41%), 148 (31.69%), 72 (15.42%) and 12 (2.57%) farm households in marginal, small, semi-medium, medium and large farm-size category, respectively. The relationship between farm-size and productivity is established using correlation coefficient. Rudra (1977) found that the high or low productivity tendencies may operate for certain range of farm-size categories. Hence, ANOVA analysis is used to determine if there is significant productivity difference across different farm-size categories. Further, post-hoc test is used to identify the significantly different groups. Finally, regression analysis is applied to measure the magnitude of the farm-size and productivity relationship and to determine the goodness of fit. Log linear model is used to study farm-size and productivity relationship in the present study as under:

$$\log Y = \beta_o + \beta_1 \log X$$

Where, Y = dependent variable
X = independent variable
$\beta_o$ = intercept
$\beta_1$ = slope

The dependent variable is the log value of productivity of wheat (Kg/ha) and annual value productivity (Rs/ha), for different sections of analysis and independent variable is the log of area under wheat and operational holdings, respectively for wheat and annual value productivity, respectively.

## RESULTS AND DISCUSSION

Punjab and Haryana are two states in the northern region of India having 2.95 and 2.51 per cent of net sown area of the country. These states are commonly termed as agriculturally advanced states (see appendix). The per hectare fertilizer consumption is the highest for these states along with the highest irrigation cover of 98.98 and 92.96 per cent for Punjab

and Haryana, respectively. The number of tractors per 1000 hectare are 126 and 86 for Punjab and Haryana, respectively. Both states extensively grow wheat and paddy. Around 75 per cent of the net sown area is under paddy and 85 per cent of the net sown area is under wheat in Punjab. In Haryana, around 40 per cent of the net sown area is under paddy and around 70 per cent of the net sown area is under wheat crop. Most of this area is under high yielding varieties. Average yield of wheat crop is 5188 and 4847 kg per hectare for Punjab and Haryana, respectively against all India average of 3096 kg per hectare and average yield of paddy crop is 4132 and 3422 kg per hectare for Punjab and Haryana, respectively against all India average of 2455 kg per hectare.

## Composition of operational holdings

The average size of operational holding for different farm-size categories in Punjab is 0.48, 1.40, 2.76, 6.00 and 14.81 hectares for marginal, small, semi-medium,

**Appendix**

**General profile of agriculture in Punjab and Haryana**

| Sr no. | Particulars | Punjab | Haryana | India |
|---|---|---|---|---|
| 1. | Net Sown Area (lakh hectare) | 41.18<br>(2.95) | 35.08<br>(2.51) | 1395.10<br>(100.00) |
| 2. | Gross Cropped Area (lakh hectare) | 78.39 | 65.49 | 1970.50 |
| 3. | Irrigation (lakh hectare) (percentage out of NSA) | 40.76<br>(98.98) | 32.61<br>(92.96) | 673<br>(48.24) |
| 4. | Fertilizer consumption (000 tonnes) | 1884 | 1477 | 27375.2 |
| 5. | Per hectare fertilizer use (kg) | 457.50 | 421.04 | 196.22 |
| 6. | Tractors (2018-19) (numbers) | 520000 | 300792 | N.A. |
| 7. | Tractors per 1000 hectare of NSA | 126 | 86 | N.A. |
| 8. | Custom hiring centres (number) | 22800 | 5960 | 78117 |
| 9. | Operational holdings (2015-16) (number in lakh) | | | |
| a) | Marginal | 1.54<br>(14.13) | 8.02<br>(49.29) | 1002.51<br>(68.45) |
| b) | Small | 2.07<br>(18.98) | 3.14<br>(19.28) | 258.09<br>(17.62) |
| c) | Semi-medium | 3.68<br>(33.67) | 2.78<br>(17.07) | 139.93<br>(9.55) |
| d) | Medium | 3.05<br>(27.93) | 1.92<br>(11.81) | 55.61<br>(3.80) |
| e) | Large | 0.58<br>(5.28) | 0.41<br>(2.54) | 8.38<br>(0.57) |
| f) | Overall | 10.93<br>(100.00) | 16.28<br>(100.00) | 1464.54<br>(100.00) |
| 9. | Paddy | | | |
| a) | Area (lakh hectare)<br>(percentage out of NSA) | 31.03<br>(75.35) | 14.47<br>(41.25) | 439.03<br>(22.28*) |
| b) | Yield (Kg/ha) | 4132 | 3422 | 2455 |
| c) | Area under HYVs (lakh hectare) (percentage out of area under paddy) | 31.03<br>(100.00) | 12.34<br>(85.30) | N.A. |
| 10. | Wheat | | | |
| a) | Area (lakh hectare)<br>(percentage out of NSA) | 35.20<br>(85.48) | 25.53<br>(72.78) | 305.53<br>(21.90) |
| b) | Yield (Kg/ha) | 5188 | 4847 | 3096 |
| c) | Area under HYVs (lakh hectare) (percentage out of area under wheat) | 35.20<br>(100.00) | 25.53<br>(100.0) | N.A. |

Source: Anonymous 2019; Anonymous 2020c; Anonymous 2020a; Mechanisation and technology division, Department of agricultural co-operation and farmers' welfare, Government of India.

medium and large farms, respectively while the average size of operational holdings for Haryana is 0.56, 1.40, 2.61, 5.57 and 15.15 per cent for marginal, small, semi-medium, medium and large farms, respectively (Table 1).

## Cropping pattern

Cropping pattern is dominated by wheat and paddy crop occupying about 76 per cent Gross Cropped Area (GCA) in Punjab which varies between 53 per cent and 81 per cent across different farm-size categories (Table 2). Next to wheat and paddy, fodder is cultivated on about 10 per cent of the area. Among other crops, cotton has major share (4.93%), followed maize (2.35%), potato (2.19%) and sugarcane (1.25%). The share of different crops across farm-size categories has significant variation. In marginal farm-size category, the fodder crop has the highest share in GCA (34.7%) which is followed by wheat (30.98%) and paddy (22.08%). For other farm-size categories, wheat and paddy dominated the area under cultivation. It is observed that the cropping intensity increased with increase in farm-size. Correlation coefficient between cropping intensity and farm-size is positive and significant but low. During eighties and nineties, studies have reported negative correlation between cropping intensity and farm-size categories for Punjab agriculture i.e., small farmers were cultivating the land more intensively (Rudra and Chattopadhyay, 1976; Bhalla and Chadda, 1982).

In Haryana also, wheat is the main crop of the farmers with 36.77 per cent share in gross cropped area (Table 3). It is followed by area under paddy crop (23.88%), cotton (7.76%), rapeseed & mustard (7.51%), bajra (4.62%) and guar (4.44%). Although, wheat and paddy are the most important crops for all farms in Haryana, the cropping pattern across different farm-size categories is quite diversified. On large farms, more than 95 per cent of GCA is under wheat, paddy and cotton crops. While all other farm categories had significant area under other crops like cotton, rapeseed & mustard, guar, bajra, jowar along with wheat and paddy crops. Correlation between the farm-size and the cropping intensity is absent in Haryana. A lot of difference can be observed in cropping pattern of the states under consideration. Smaller farmers in Punjab are dependent on wheat and paddy whereas large farmers in Punjab are diversified toward cash crops like cotton, potato, sugarcane, etc. On the contrary, small farmers in Haryana have lesser area under paddy and more area under crops like cotton, rapeseed & mustard, guar, bajra and jowar which have less water requirement whereas large farmers are mainly growing paddy and wheat crop.

## Wheat productivity

Wheat is the most important crop of Punjab and Haryana with around 3.6 million-hectare and 2.6 million hectare area under cultivation of wheat, respectively (Anonymous, 2019; Anonymous 2020c). In Punjab, per hectare productivity of wheat is 4.4 tonnes. Across different farm-size categories, the productivity per hectare is 4.1, 4.3, 4.3, 4.5 and 4.6 tonnes for marginal, small, semi-medium, medium and large, respectively indicating increase in wheat productivity with increase in farm size. The correlation coefficient for farm-size and productivity of wheat is positive (r=0.17) and

**Table 1. Average size of operational holdings across farm-size categories, Punjab and Haryana** **(ha)**

| Particulars | Marginal | Small | Semi-medium | Medium | Large | Overall |
|---|---|---|---|---|---|---|
| Punjab | | | | | | |
| a) Owned and managed | 0.44 (90.98) | 1.21 (86.97) | 2.19 (79.37) | 4.30 (71.67) | 9.19 (62.07) | 2.36 (74.16) |
| b) Leased-in | 0.04 (9.02) | 0.18 (13.03) | 0.57 (20.63) | 1.70 (28.33) | 5.62 (37.93) | 0.82 (25.84) |
| c) Operational holdings (a+b) | 0.48 (100.00) | 1.40 (100.00) | 2.76 (100.00) | 6.00 (100.00) | 14.81 (100.00) | 3.18 (100.00) |
| Haryana | | | | | | |
| a) Owned and managed | 0.51 (90.97) | 1.22 (86.85) | 2.25 (86.14) | 4.20 (75.47) | 11.30 (74.63) | 2.10 (81.21) |
| b) Leased-in | 0.05 (9.03) | 0.18 (13.15) | 0.36 (13.86) | 1.37 (24.53) | 3.84 (25.37) | 0.49 (18.79) |
| c) Operational holdings (a+b) | 0.56 (100.00) | 1.40 (100.00) | 2.61 (100.00) | 5.57 (100.00) | 15.15 (100.00) | 2.59 (100.00) |

Note: Figures in the parentheses are percentage to their respective Operational Holdings
*OH= Operational Holdings

Table 2. Cropping pattern of farmers across different farm-size categories, Punjab (ha)

| Particulars | Marginal | Small | Semi-medium | Medium | Large | Overall |
|---|---|---|---|---|---|---|
| Wheat | 0.27 (30.98) | 1.04 (41.53) | 2.20 (42.91) | 4.84 (42.76) | 10.56 (36.25) | 2.46 (41.12) |
| Paddy | 0.19 (22.08) | 0.83 (33.10) | 1.82 (35.47) | 4.33 (38.28) | 9.25 (31.77) | 2.12 (35.34) |
| Cotton | 0.04 (4.45) | 0.17 (6.67) | 0.18 (3.53) | 0.51 (4.50) | 2.02 (6.93) | 0.30 (4.93) |
| Maize | 0.02 (2.00) | 0.05 (1.87) | 0.15 (2.90) | 0.22 (1.95) | 0.81 (2.78) | 0.14 (2.35) |
| Potato | - | - | - | 0.16 (1.37) | 2.47 (8.49) | 0.13 (2.19) |
| Sugarcane | - | 0.01 (0.07) | 0.03 (0.61) | 0.10 (0.92) | 1.07 (3.67) | 0.07 (1.25) |
| Fodder | 0.3 (34.71) | 0.32 (12.96) | 0.56 (11.00) | 0.89 (7.82) | 1.79 (6.14) | 0.57 (9.59) |
| Miscellaneous crops | 0.05 (5.78) | 0.09 (3.79) | 0.18 (3.59) | 0.27 (2.39) | 1.15 (3.95) | 0.19 (3.23) |
| GCA | 0.87 (100.00) | 2.51 (100.00) | 5.12 (100.00) | 11.32 (100.00) | 29.12 (100.00) | 5.99 (100.00) |
| CI (%) | 179.46 | 179.71 | 185.75 | 188.73 | 196.65 | 188.14 |
| Correlation coefficient | 0.15*** | | | | | |

***significant at 1% level of significance
Note: Figures in the parentheses are percentage to their respective GCA



significant but weak (Fig. 1). The difference observed in wheat productivity across different farm-size categories is found statistically insignificant in ANOVA analysis in case of Punjab. Hence, despite overall positive correlation the difference is not statistically high enough to categorize them into different productivity groups. In Haryana, per hectare productivity of wheat among the farm households is 4.05 tonnes. In different farm-size categories, the productivity per hectare is 3.84, 4.16, 4.00, 4.15 and 3.92 tonnes for marginal, small, semi-medium, medium and large farm-size categories, respectively. Correlation coefficient for farm-size and productivity is positive but non-significant. Even, ANOVA analysis revealed no significant productivity difference across different farm-size categories in case of Haryana.

Regression equation is fitted using log of area under wheat cultivation (ha) as independent variable and log of productivity of wheat crop (kg/ha) as dependent variable where coefficients are found significant and positive for both Punjab and Haryana (Table 4). Although, the regression coefficients are significant but the value of R-square is very low which signifies that farm-size is a significant factor explaining wheat productivity but there exist more important factors other than farm-size which determines wheat productivity. Bhalla and Chadha (1982) in their study have reported neutral relationship between farm-size and productivity for wheat crop in Punjab. Singh *et al.* (2000) have reported positive and non-significant relationship for wheat for the year 1988-89 while positive and significant relationship for the year 1998-99. Hence, the findings of our study are in conformity with the earlier studies and refute the existence of inverse relationship between farm-size and wheat productivity for twentieth century onwards and reports positive, significant and weak relationship between farm-size and wheat production.

## Farm-size and productivity relationship-All crops

Further, annual value productivity per hectare is worked for different farms across the region to analyse the relationship between farm-size and annual value productivity. The data for crops grown in a crop year are considered for the analysis. For Punjab farms, there is clear upward trend in productivity with increase in farm size as the value productivity of the large farms is the highest (Rs 1.56 lakh), followed by medium farms (Rs 1.44 lakh), semi-medium farms (Rs 1.35 lakh), small farms (Rs 1.29 lakh) and the lowest (Rs 1.22 lakh) for marginal farms (Fig. 2). The value of correlation coefficient between farm-size and productivity is positive and significant (r=0.21). The results of ANOVA followed by post-hoc test revealed that there are broadly two

**Table 3. Cropping pattern of farmers across different farm-size categories, Haryana** **(ha)**

| Particulars | Marginal | Small | Semi-medium | Medium | Large | Overall |
|---|---|---|---|---|---|---|
| Wheat | 0.33 (34.05) | 0.89 (37.56) | 1.48 (35.65) | 3.41 (37.54) | 11.64 (45.14) | 1.56 (36.77) |
| Paddy | 0.12 (12.82) | 0.58 (24.43) | 0.87 (21.07) | 2.29 (25.26) | 8.96 (34.76) | 1.01 (23.88) |
| Cotton | 0.07 (6.88) | 0.08 (3.27) | 0.38 (9.17) | 0.89 (9.85) | 1.64 (6.36) | 0.33 (7.76) |
| Rapeseed & Mustard | 0.07 (7.27) | 0.17 (7.30) | 0.42 (10.06) | 0.74 (8.20) | 0.44 (1.70) | 0.32 (7.51) |
| Guar | 0.04 (3.69) | 0.10 (4.35) | 0.17 (4.18) | 0.64 (7.07) | 0.47 (1.83) | 0.19 (4.44) |
| Bajra | 0.08 (8.19) | 0.19 (8.10) | 0.21 (5.07) | 0.38 (4.18) | 0.10 (0.39) | 0.20 (4.62) |
| Jowar | 0.09 (8.82) | 0.08 (3.37) | 0.11 (2.55) | 0.12 (1.35) | 0.22 (0.84) | 0.10 (2.32) |
| Sugarcane | - | 0.01 (0.53) | 0.11 (2.59) | 0.16 (1.79) | 0.32 (1.24) | 0.07 (1.58) |
| Fodder | 0.09 (9.47) | 0.19 (7.91) | 0.25 (6.10) | 0.37 (4.05) | 0.51 (1.98) | 0.22 (5.14) |
| Miscellaneous crops | 0.08 (8.80) | 0.07 (3.16) | 0.15 (3.55) | 0.07 (0.72) | 1.48 (5.75) | 0.13 (3.18) |
| Total crops | 0.96 (100.00) | 2.36 (100.00) | 4.14 (100.00) | 9.08 (100.00) | 25.79 (100.00) | 4.24 (100.00) |
| CI (%) | 173 | 168 | 159 | 163 | 170 | 164 |
| Correlation coefficient | -0.04$^{NS}$ | | | | | |

$^{NS}$ : non-significant results
Note: Figures in the parentheses are percentage to their respective GCA



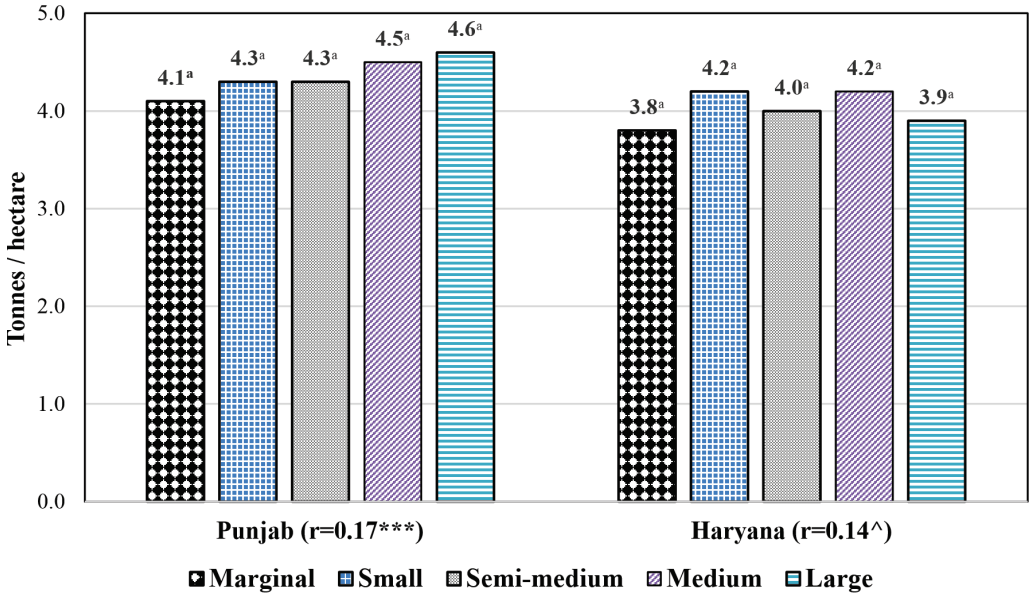


**Fig.1. Productivity of wheat across different farm-size categories, Punjab and Haryana**
Note: Same alphabet for different farm-size categories signifies no statistical difference among categories with same alphabets.
Note1: r signifies value of correlation coefficient between farm size and wheat productivity.
Note2: *** and ^ denotes that the coefficient is significant at 1% level of significance and non-significant, respectively.

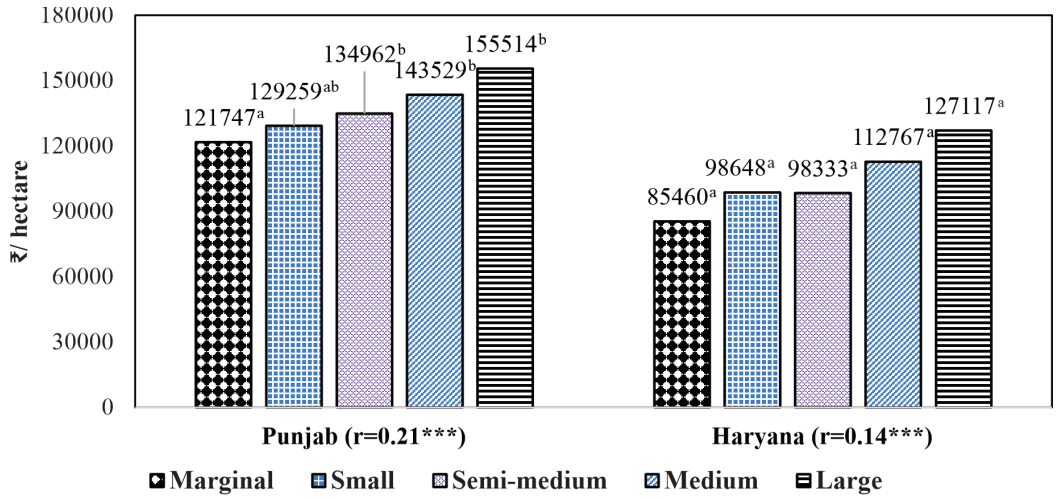


**Fig. 2. Annual productivity across different farm-size categories, Punjab and Haryana**

Note: same alphabet signifies no statistically significant difference among categories with same alphabet and different alphabet signifies significant difference among categories with different alphabet.

Note 1: r signifies value of correlation coefficient between farm size and value productivity.

Note 2: ***depicts the coefficient is significant at 1% level of significance.



**Table 4. Regression coefficients for farm-size (ha) and wheat productivity (Kg/ha), Punjab and Haryana**

| Regression | Punjab | Haryana |
|---|---|---|
| Coefficient ($b_1$) | 3.61+0.04 $b_1$ (0.001) | 3.56+0.07 $b_1$ (0.005) |
| $R^2$ | 0.03 | 0.02 |

Note: Figures in the parentheses are the p-values

productivity groups in Punjab agriculture. First group consists of marginal farmers (<1 ha) for whom the productivity is comparatively lower while the other group comprises of farmers with operational holdings greater than two hectares have higher value productivity. The productivity on small farm-size category (1-2 ha) is somewhat similar to both the productivity groups. For Haryana farms, the value productivity of the large farms is the highest (Rs 1.27 lakh), followed by medium farms (Rs 1.13 lakh), semi-medium farms (Rs 0.98 lakh), small farms (Rs 0.99 lakh) and the lowest (Rs 0.85 lakh) for marginal farms. The value of correlation coefficient between farm-size and productivity is positive and significant (r=0.14). The results of ANOVA and post-hoc test reveals that the difference in productivity is non-significant across different farm-size categories. It indicates positive and significant but weak relationship and refute the existence of inverse relationship between farm-size and productivity in Punjab and Haryana with productivity differential lesser in Haryana than in Punjab.

In regression equation model, log of operational holding (ha) is treated as independent variable and log of annual value productivity of the farm (Rs/ha) as dependent variable (Table 5). The regression coefficient is significant and positive for both Punjab and Haryana farms. Despite significant regression model, the R-square is very low (5.0 & 1.0%) highlighting there are important factors other than farm-size which affect the productivity. Even earlier studies have reported land quality and irrigation as more important variables than farm-size (Barbier, 1984). Thus, the existence of inverse relationship of farm-size and productivity is refuted in Punjab and Haryana which is opposite to findings of Singh *et al.* (2011) for the country as a whole. However, the findings are not the first reporting on the prevailing trend as farm-size and productivity relationship for Punjab agriculture was found to be positive in earlier studies also (Rudra and Chattopadhyay, 1976; Bhalla and Chadha, 1982; Singh *et al.,* 2000). Hence, the inverse relationship hypothesis between farm-size and productivity can be rejected for Punjab and Haryana state. Instead, there is positive and weak relationship between farm-size and productivity depicting production inefficiency on smaller farms.

**Table 5. Regression coefficients for farm-size (ha) and annual productivity (Kg/ha), Punjab and Haryana**

| Regression | Punjab | Haryana |
|---|---|---|
| Coefficient ($b_1$) | 5.06+0.09 $b_1$ (0.001) | 4.90+0.08 $b_1$ (0.02) |
| $R^2$ | 0.05 | 0.01 |

Note: Figure in the parentheses is the p-value for the model

## Relationship between input-use and farm-size

The productivity of a farm can vary due to various factors such as intensified cultivation, more area under high-risk high-value crops and more use of family labour and farm-size itself is not an important factor affecting productivity. Hence, the relationship between annual

per hectare input-use and annual value productivity is analysed. Various inputs considered are cost of fertilizers & manures, plant protection chemicals, hired labour, diesel, electricity, repair & maintenance and cost of hiring machinery. The relationship between farm-size and input-use for different farm-size categories in Punjab and Haryana has been presented in Table 6. In Punjab, the use of fertilizers & manure and PPC increased with increase in the farm-size as the correlation coefficient is positive. The findings are in conformity with study by Bhalla and Chadha (1982) where per unit fertilizers & manure and plant protection chemicals use is positively related to farm-size. In case of human labour input, the use of hired human labour is more extensive on larger farms as the correlation coefficient between hired human labour and farm-size is positive (0.25) (Chattopadhyay and Rudra, 1976). The use of diesel also showed positive relationship with the farm-size (0.17). Small farmers incurred more cost on hiring machinery as the per hectare cost of hired machinery is negatively correlated to farm-size (-0.099). Previously, the studies conducted by Rudra and Chattopadhyay (1976) and Bhalla and Chadha (1982) have found negative correlation between farm-size and total input-use per hectare which is contrary to findings of current study. The correlation between per hectare paid-out cost and farm-size is positive and significant in the present study. It is interesting to note that various previous studies have reported the input use is inversely related to farm-size in both the pre-green revolution as well as post-green revolution periods in Punjab (Rudra, 1968b; Chattopadhyay and Rudra, 1976; Ghose, 1979; Bhalla and Chadha, 1982) but present study reports positive relationship between the farm-size and per hectare paid-out cost for Punjab agriculture. In Haryana, the situation is contrary to Punjab. Out of all the inputs under consideration, the correlation coefficient for per hectare cost on the use of fertilizers & manure, plant protection chemicals and repairs & maintenance with farm-size is non-significant i.e., their use is size neutral. The relationship between per hectare cost of hired labour, diesel is positive and significant with respect to farm-size whereas the relationship between per hectare cost of electricity, hiring machinery with farm-size is found to be negatively correlated to farm-size and significant. The correlation coefficient between overall paid-out cost per hectare and farm-size is non-significant.

The cropping intensity has positive relationship with farm-size in Punjab while the relationship is neutral in Haryana. Wheat and paddy are the main crop grown by small, semi-medium and medium farmers of Punjab whereas the marginal farmers grow fodder and the large farmers are inclined toward cash crops like potato, sugarcane, cotton, etc. In Haryana, wheat is the main crop of rabi season while in kharif season, large farmers grow paddy and other farm-size categories have significant proportion of area under cotton, rapeseed-mustard, guar, bajra and jowar along with paddy. The productivity of wheat crop has positive relationship with farm-size in both Punjab and Haryana but the difference in productivity is not high enough between different farm-size categories to distinguish them into different productivity groups. Even the overall annual productivity of farms in Haryana, although have positive relationship between farm-size and productivity, do not have clearly distinguishing productivity groups across different farm-size categories. But, In Punjab, there are clearly distinguishing two productivity groups in which marginal farmers belong to low productivity group and small farmers also resembles somewhat to marginal farmers but not completely lies in low productivity group. Hence, the existence of inverse relation hypothesis can be rejected in these agriculturally advanced regions. At the same time, positive relationship between farm-size and productivity can be confirmed.

**Table 6. Correlation coefficients between farm-size and important input-use, Punjab and Haryana**

| Inputs (Rs/ha) | Correlation coefficient | |
|---|---|---|
| | Punjab | Haryana |
| Fertilizers & manures | 0.16 (0.001) | -0.03 (0.573) |
| Plant protection chemicals | 0.19 (0.001) | 0.06 (0.191) |
| Hired labour | 0.26 (0.001) | 0.10 (0.021) |
| Diesel | 0.17 (0.001) | 0.15 (0.001) |
| Electricity | - | -0.09 (0.052) |
| Repairs & maintenance | -0.02 (0.57) | 0.08 (0.101) |
| Cost of hiring machinery | -0.10 (0.022) | -0.14 (0.002) |
| Total paid-out cost | 0.33 (0.001) | 0.04 (0.347) |

Note: Figures in the parentheses are the p-values

Low value of r-square for the fitted model revealed that farm-size is not an important factor affecting productivity i.e., there are factors other than farm-size which explain productivity. The difference in input-use can be traced as primary factors affecting productivity. Cropping intensity, risk capacity and high-input use are the important factors affecting productivity. The analysis between farm-size and per hectare input revealed the overall per hectare paid-out cost is positively related to farm size in Punjab and size neutral in Haryana. There is high use of fertilizers and plant protection

chemicals on large farms in Punjab while it is size neutral in Haryana. Further, higher use of hired labour on larger farms for both states is reconfirmed in the present study. Moreover, per hectare cost of hired machinery is found to be inversely related to farm-size in Punjab and Haryana while the per hectare cost of diesel is higher on large farms for both states. There is cost of electricity in Haryana and the per hectare cost on electricity is slightly higher on marginal farms. The earlier finding of inverse relationship between input-use per hectare and farm-size is refuted in light of new evidence. It is suggested that the government should support and promote cooperative farming among the marginal and small farm households as suggested by Rudra and Sen (1980) and Singh and Singh (2002). Further, the recommendations aimed at developing farming systems and crops beneficial for marginal and small farmers like potato, sugarcane, cotton, etc should be promoted among these farmers. State government should provide solutions to the constraints faced by the smaller farms in adoption of input-use and address them through suitable government policies. Revolving cash credit limit for marginal and small farmers should be increased along with provision of interest free credit to facilitate timely input-use. Similarly, DBT for marginal and small farmers can be increased in Punjab. The working of Custom Hiring Centres should be regulated and monitored to ensure timely availability of machinery & implements to the farmers of both the states and to decrease cost on hired machinery.



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## Authors' contribution

Conceptualization of research work and designing of experiments (MK); Execution of field/lab experiments and data collection (RS); Analysis of data and interpretation (RS, MK); Preparation of manuscript (RS, MK)

## LITERATURE CITED

Alavi H 1975. India and the Colonial Mode of Production. *Econ Polit Wkly* **10**(33/35): 1235–62.

Amirapu A and Subramanian A 2015. Manufacturing or Services? An Indian Illustration of a Development Dilemma. *CGD Work Paper no. 409*. Washington DC.

Anonymous (2020a) *Agricultural Statistics at a Glance 2019*. Department of Agriculture, Cooperation and Farmers Welfare, Government of India, New Delhi, pp.51.

Anonymous (2020b) *All India Report on Agricultural Census 2015-16*. Department of Agriculture, Cooperation and Farmers Welfare, Government of India, New Delhi, pp. 17.

Anonymous (2020c) *Statistical Abstract of Haryana 2018-19*. Economic Advisor to Government of Haryana, Chandigarh, pp. 391-99.

Anonymous (2019) *Statistical Abstract of Punjab*. Economic Advisor to Government of Punjab, Chandigarh: Chandigarh, pp. 92.

Arora V 2013. Agricultural Policies in India: Retrospect and Prospect §. *Agric Econ Res Rev* **26**(2): 135–57.

Bardhan P K 1973. Size, productivity, and returns to scale: An analysis of farm-level data in Indian agriculture. *J Polit Econ* **81**(6): 1370–86.

Bhalla G S and Chadha G K 1982. Green revolution and the small peasant: A study of income distribution in Punjab agriculture:I. *Econ Polit Wkly* **17**(20): 826–33.

Bhalla G S, Chadha G K, Kashyap S P and Sharma R K 1990. Agricultural growth and structural changes in the Punjab economy: an input-output analysis. *International Food Policy Research Institute,* Washington DC.

Bharadwaj K 1974. Notes on farm size and productivity. *Econ Polit Wkly* **9**(13): A11–24.

Bhattacharya N, and Saini G R 1972. Farm size and productivity: A fresh look. *Econ Polit Wkly* **7***(26):* A63-A72.

Chand R 2003. Government Intervention in Foodgrain Markets in the New Context. *Policy paper 19, National Institute of Agricultural Economics and Policy Research*, New Delhi.

*Chattopadhyay* M and Rudra A 1976. Size-productivity revisited. *Econ Pol Wkly 11*(39): A104-A116.

Dasgupta B 1977. India's green revolution. *Econ Polit Wkly* **12**(6/8): 241–60.

Dhanagare D N 1988. The green revolution and social inequalities in rural India. *Bull Concern Asian Sch* **20**(2): 2–13.

Gahukar R T 1992. Green revolution in food crops: An Indian experience. *Outlook Agric* **21**(2): 129–36.

Ghose A K 1979. Farm size and land productivity in Indian agriculture: A eappraisal. *J Dev Stud* **16**(1): 27–49.

Grover D K, Singh J M, Kaur A and Kumar S 2017. *State Agricultural Profile-Punjab*. Agro-Economic Research Centre, Punjab Agricultural University, Ludhiana: Ludhiana.

Gulati A, Roy R and Hussain S 2017. Getting Punjab Agriculture Back on High Growth Path: Sources, Drivers and Policy Lessons.

Hazell P B R 2009. The Asian Green Revolution. *International Food Policy Research Institute*, Discussion Paper 00911, Washinton DC.

Kautsky K 1988. *The Agrarian Question*. 1988th edn Edited by BurgessP. Zwan Publications: London and Winchester, pp 132.

Majid N 2019. Structural change and employment in India. ILO/SIDA Partnership on Employment Working papers, *International Labour Organization*, Geneva.

Overton M 1996. *Agricultural Revolution in England: The Transformation Of The Agrarian Economy 1500-1850*. Cambridge University Press: Cambridge, pp 217.

Pingali P L 2012. Green revolution: Impacts, limits, and the path ahead. *Proc Natl Acad Sci, **109**(31):* 12302–08.

Pisani E 2006. Some socio-economic consequences of the green revolution. *Land Reform, Land Settlements and Cooperatives* **2**: 97–107.

Rao A P 1967. Size of holding and productivity. *Econ Wkly* **2**(44): 1981–91.

Rudra A 1968a. Farm Size and Yield Per Acre. *Econ Polit Wkly* **3**(26/28): 1041–4.

Rudra A 1968b. More on Returns to Scale in Indian Agriculture. *Econ Polit Wkly* **3**(43): 33–8.

Rudra A and Sen A 1980. Farm size and labour use: Analysis and policy. *Econ Polit Wkly* **15**(5/7): 391–4.

Saini S, and Kozicka M 2014. Evolution and critique of buffer stocking policy of India *Working paper 283,* Indian Council for Research on International Economic Relations (ICRIER), New Delhi.

Singh L and Singh S 2002. Deceleration of economic growth in Punjab: Evidence, explanation and a way-out. *Econ Polit Wkly **37**(6): 579-86*.

Singh N and Kohli D S 1997. The green revolution in Punjab, India: The economics of technological change. *J Punjab Studies* **12**(2): 285–306.

Vinutha H P, Poornima B and Sagar B M 2018. Detection of outliers using interquartile range technique from intrusion dataset. In*: Inf Decis Sci* Satapathy S CTavares J M R SVikrant Band Mohanty J R (eds.) Springer Singapore, pp 1052–92.