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Exploring the relationship between farm size and productivity: evidence from Indian farms

Radha R. Ashrit*

Department of Biotechnology, New Delhi 110 003, Delhi, India

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Abstract
The relationship between farm size and productivity is intensely debated in India. The present study aims to understand the association between farm size and productivity using Cost of cultivation Survey plot level data for 2013-14, covering 70% of the total cultivation area. State and crop-specific analyses are carried out to give more disaggregated insights using socio-economic variables and technological changes captured by the crop varieties and soil quality. Descriptive statistics and regression analysis are used to assess the relationship between farm size and productivity in terms of yield and net returns. For crops such as wheat, paddy, maize, rapeseed & mustard, and sugarcane, the large farmers are reaping the profits at par with small farmers. Large farmers have more opportunities to make a profit because they have access to several inputs and infrastructure. However, this scenario puts small farmers disadvantaged due to higher input costs. This weakness can be turned into opportunity by facilitating the formation of more farmers groups. For crops like pulses, coarse cereals, and oilseeds, there is an overwhelming scope for small and marginal farmers to get more yield/returns compared to large farmers due to the inverse relationship observed for arhar, soybean, and bajra. Mixed results are obtained for other crops.

Keywords: Agriculture, Farm size, India, Productivity, Yield.

Introduction

Agriculture and allied activities are the most vital sector providing livelihood, food, and nutritional security to millions in the developing world. According to Chakravorty et al. (2016), more than half of the rapidly increasing population in India is engaged in farming. It was also mentioned that: (a) income inequality in India's agricultural sector is very high, and (b) about half of the income inequality is explained by the variance in household-level income from cultivation, which sturdily depends on m productivity and land tenure.

The small size of land parcels and their scattered nature continue to increase due to the existing quadrupled inheritance systems, which seem incompatible with the new technologies available (Yucer et al., 2016). There is substantial evidence thatsupports the negative influence of land fragmentation on agricultural productivity due to the increased cost of production (Deininger et al., 2017). However, it is a common practice in India that agricultural land area is split into small scattered units.

The relationship between farm size and productivity iswidely debated in India. Numerous studies provided evidence that crop productivity declined with an increase in farm size during the1960s and 1970s (Sen 1962, 1964; Bardhan 1973; Deolalikar 1981; Barrett et al., 2010; Sial et al., 2012). These observations further provided strong support for land reforms, land ceilings, and various other policies to enhance the efficiency and growth of smallholders. Subsequently, various researchers

*Author for Correspondence: Phone: 011-24363656, Email: radha.ashrit@nic.in

started exploring reasons for the higher productivity of smallholders (Binswanger & Rosenzweig 1986; Frisvold 1994; Jha et al., 2000), and a few even questioned the inverse relationship between farm size and productivity. However, another school of thought questions the basis of the hypothesis as the Inverse Relationship (IR) vanishes when applied to the disaggregated data and accounting for possible reasons for IR (Deolalikar, 1981; Binswanger & Rosenzweig, 1986; Jha et al., 2000). These studies have found that the inverse relationship could not be generalized unless and until the same relationship was present even in individual farm-level data. Other researchers argue that no systematic relationship can be established between land size and productivity (Rao, 1967; Helfand & Levine et al., 2004).

In the literature, studies have also postulated different plausible reasons for IR. Studies have identified that credit market imperfections, labour market imperfections (as more persons are engaged in farming activities), weather/price risks, and the omission of soil quality variablesattribute to IR. Measurement errors, aggregation of data, etc., are also considered possible reasons for the presence of IR (Newell et al., 1997; Lamb, 2003; Foster & Rosenzweig, 2010; Barret et al., 2010; Desiere & Jolliffe, 2018).

Most of the previous studies with respect to farm size and productivity primarily focuses of the previous studies with respect to farm size and productivity primarily focus on physical measures of productivity, i.e., quantity per unit area. An approach involving prices rather than quantity addresses issues related to the biased nature of over-reporting of yield and underreporting of the area by small and large farmers, respectively if any (Carletto et al., 2016; Desiere & Jolliffe, 2018). Research has mostly been conducted on aggregate data, and the conclusions have only been applied to a select number of crops like wheat, paddy, and maize. Against this background, the present study revisits the debates on farm size and agriculture productivity to suggest policy measures to address the double burden of raising productivity and income enhancement of smallholders in agriculture. These issues are collectively more relevant and vital in the current scenario as the average size holding is decreasing systematically (drastically) from 2.28 in the year 1970-71 to 1.08 in 2015- 16 (GoI, 2019a). Further, it may be noted that 87% of Indian farmers are small and marginal farmers, and 63% of them are entirely dependent on only cultivation for their livelihood (GoI, 2005, 2014). The analysis is carried out for selected crops (and in the major crop-producing to give more disaggregated insights using socio-economic variables and technological changes captured by the crop varieties and soil quality. Other measures, such as the value of output per unit area and net returns per unit area, are also analysed for the present study.

Materials and Methods

A "Comprehensive Scheme for Studying the Cost of Cultivation of Principal Crops in India" known as the Cost of Cultivation Survey, is being implemented by the Ministry of Agriculture, Govt.

Source: Based of cost of cultivation survey

Figure1: Study area

of India through 16 Universities/ Institutions in 20 States to work out the estimates of the cost of cultivation/production in respect of selected 25 crops. This vital information is utilized for fixing the Minimum Support Prices (MSP) for various crops by the Govt. of India.Various agencies are collecting field data from 8100 sample holdings spread over 20 Indian states. Data on the farmers' socio-economic details such as age, sex, level of education, size class, village and zone was collected. Apart from this, information on the net sown area, irrigation type, soil type, seasonality of crops, the quantity of the produced crops, and inputs (labour, fertilizers, seed, machinery utilized etc) are also collected (GoI, 2008a & 2008b; https://eands.dacnet.nic.in/). Fig. 1 represents the study area.

Theoretical Approach and Empirical specifications

The hypothesis under consideration in this study is to understand the relationship between farm size and productivity. The output Y_i for any crop cultivated from the i[th] plot shall be affected by various inputs used as well as the household characteristics of the farmer. *Ai* represents the area under cultivation, and *X*'s include a vector of inputs such as labour, fertilizer, seeds, soil quality, irrigation facility, household characteristics, etc.

The resultant production function can be specified as $Y_i = \alpha+\beta X+\gamma_1 Ai + u_i$ - where α is the intercept of the term, β is the vector of coefficients of various inputs and γ_i defines the relationship between yield and farm size. u_i is the error term, following a normal distribution byequating mean to zero and variance to a finite number. The u_i s are assumed to be distributed independently of all the other variables. The empirical method is to reject the null hypothesis $H_0 : \gamma_1 = 0$ in favour of the alternative $H_a : \gamma_1 < 0$which wouldindicate the inverse relationship.

The bivariate relationship between farm size and productivity for each crop is represented by the model

$$\text{In } Y_{ij} = \alpha_{ij} + \gamma_{ij} \text{ In } A_{ij} + u_{ij}$$

where, Y_{ij} = productivity; i= 1,2, 3; j=1, 2…n (number of observations)

Y_{1j} = quantity in kg per hectare

Y_{2j} =value of output in Rs per hectare

Y_{2j} = net returns in Rs per hectare

A_{ij} = the area under cultivation in hectare for i[th] productivity and j[th] observation

and

u_{ij} = the error term (are independently and identically distributed under normal distribution with 0 mean and constant variance).

The log transformation allows one to interpret the coefficient as an elasticity. represents the percentage change in the productivity when the area under cultivation increases by one unit. Significant negative coefficient would indicate the existence of IR for the crop under consideration.

The bivariate regression can give inference only based on the relationship between two variables considering that other variables will not impact the relationship. But in reality, the output may be impacted by many other significant exogenous variables. The influence of farm size on output is expected to vary as additional key variables are considered in the production function. To overcome the omitted variable bias, multivariate regression analysis is carried out. The functional form among farm size, and other related variables with productivity is formulated for each crop by the model as follows:

$$\text{In } Y_{ij} = \alpha_{ij} + \gamma_{ij} \text{ In } A_{ij} + \beta_{ij} \text{ In } P^*_{L} + \beta_{2ij} \text{ In } P^*_{HLR} + \beta_{3ij} \text{ In } P^*_{s} + \beta_{4ij} \text{ In } P^*_{F} + \beta_{5ij}\, soil\_quality + \beta_{6ij}\, plot\_count + \beta_{7ij}\, type\_irrigation + \beta_{5ij}\, seed\_variety + \beta_{9ij}\, edun + u_{ij}$$

i = 1,2, 3

j = 1, 2,……(number of observations in each crop)

where, = yield or value of output per hectare or net profits per hectare yield is defined as quantity in kg per hectare for each crop and j[th] observation value of output per hectare is defined as the value of output (both main and by-product) per hectare net profits per hectare is defined as total input costs (labour, seeds, fertilizer, machinery) deducted from the value of output normalized by area under cultivation.

A_{ij} = area under cultivation in ha for the i^{th} productivity and j^{th} observation

P^*_L= total labour (includes the cost of imputed family labour, attached labour and hired labour) cost per hectare

P^*_{HLR}= ratio of hired to total labour cost

P^*_s= cost of seeds per hectare

P^*_F= total fertilizer cost per hectare

soil_quality = takes value one if the soil type is clay, loamy or both, zero otherwise

plot_count = number of plots a farmer has

type_irrigation = takes value one of type of irrigation is through well, canal, *etc*. zero other wise

edun = takes value one of education level of the farmer is secondary and above, zero otherwise takes value one for HYV, zero otherwise

u_{ij} = error term associated with i^{th}productivity and j^{th} observation.

Before discussing the results, it may be pertinent to mention that agriculture production is best characterized as a sequential decision-making process (Antle, 1983). The first decision a farmer makes, at the beginning, is about how much land to cultivate and its distribution across crops. Subsequently, decisions on other inputsare made.

Once allocated, the farmer cannot change farm-size based on the resultant yield or output and their prices. In other words, yield or value of output (price) or net returns is not influencing the initial farm-size. The same argument holds good for other inputs such as fertilizer application and seeds applied. Hence, in the current study, the production function is considered as a conditional production function i.e., conditional on the acquisition and allocation of land at the beginning of the cultivation process. Therefore, the farm size of the cultivation activity process has already been decided and thus is exogenous[1] to the physical production function.

Results and Discussion

Description analysis

In the current study, from the descriptive statistics of productivity and key variables impacting the productivity for each 12 crops (along with major crop producing states) for the year 2013-14, it can be seen that there exists yield variation across the crops in various states. Average net returns per ha are higher for sugarcane and cotton and least for bajra and soybean. Further,the average yield is higher for paddy, and the mean net return per ha is higher for wheat.

Likewise, the average labour cost per ha is higher for sugarcane (Rs.10.67) and cotton (Rs.10.08) and least for gram (Rs.8.85) and soybean (Rs.8.97). It was observed that farmers tend to hire labour which is thrice the amount of family labour for cultivation. The hired labours are mostly utilizedin sugarcane cultivation, which indicates that theoverall cost of production possibly increases due to the wages of the labourers.

The average fertilizer cost per ha is observed to be highest for sugarcane (Rs. 14721.28) followed by cotton (Rs. 7585.16). Crops such as arhar, gram, bajra and jowar have lower fertilizer costs per ha. The cost of seeds per ha is higher for groundnut and sugarcane than rapeseed & mustard, bajra, jowar, and arhar. It can be inferred from the present results that input costs for some crops like cotton and sugarcane higher than those like arhar, bajra and jowar due to higher labour, fertilizers and seed costs.

At all India level, as shown in the Fig. 2, the average area under cultivation ranges from 1.22 ha for cotton to 0.64 ha for arhar. For paddy and sugarcane, the average crop area stands at 0.73 ha. Crops grown with an average area ofmore than 1 ha were gram (1.11 ha), soybean (1.17 ha), groundnut (1.03 ha), and cotton (1.22 ha). Arhar and rapeseed & mustard are grown in smaller areas compared to the other crops. The average area under cultivation shows a

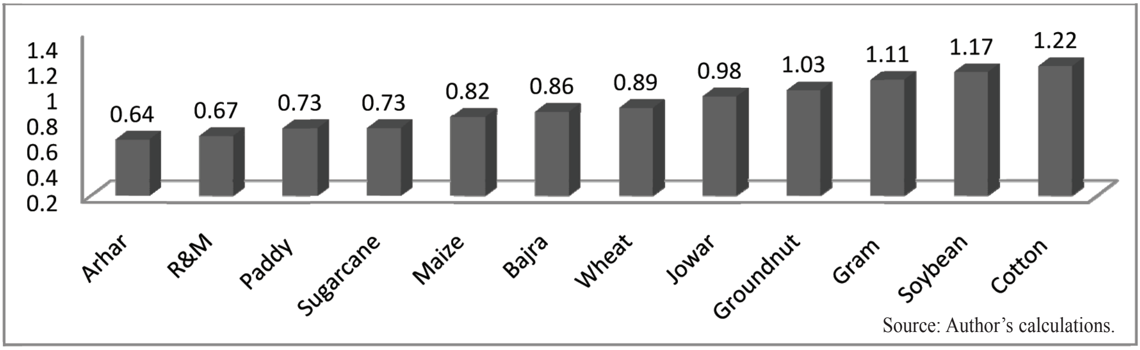


Figure 2: Crop wise average area under cultivation(ha)

considerable variation for all the crops within the states. West Bengal, Uttar Pradesh, and Maharashtra are the states with a lower average area under cultivation especially for crops such as paddy, arhar and rapeseed & mustard.

Fig. 3 represents net returns (Rs/ha). It is observed that net returns are highest for the crop of sugarcane followed by cotton and wheat in general. Arhar and rapeseed & mustard are grown in a smaller areathan the other crops. The average area under cultivation shows a considerable variation for all the crops within the states. West Bengal, Uttar Pradesh, and Maharashtra are the states with lower average area under cultivation, especially for crops such as paddy, arhar and rapeseed & mustard.

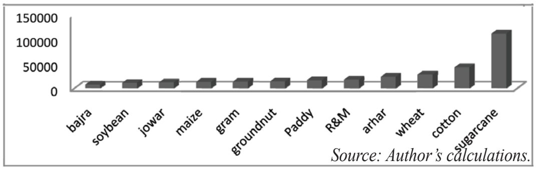


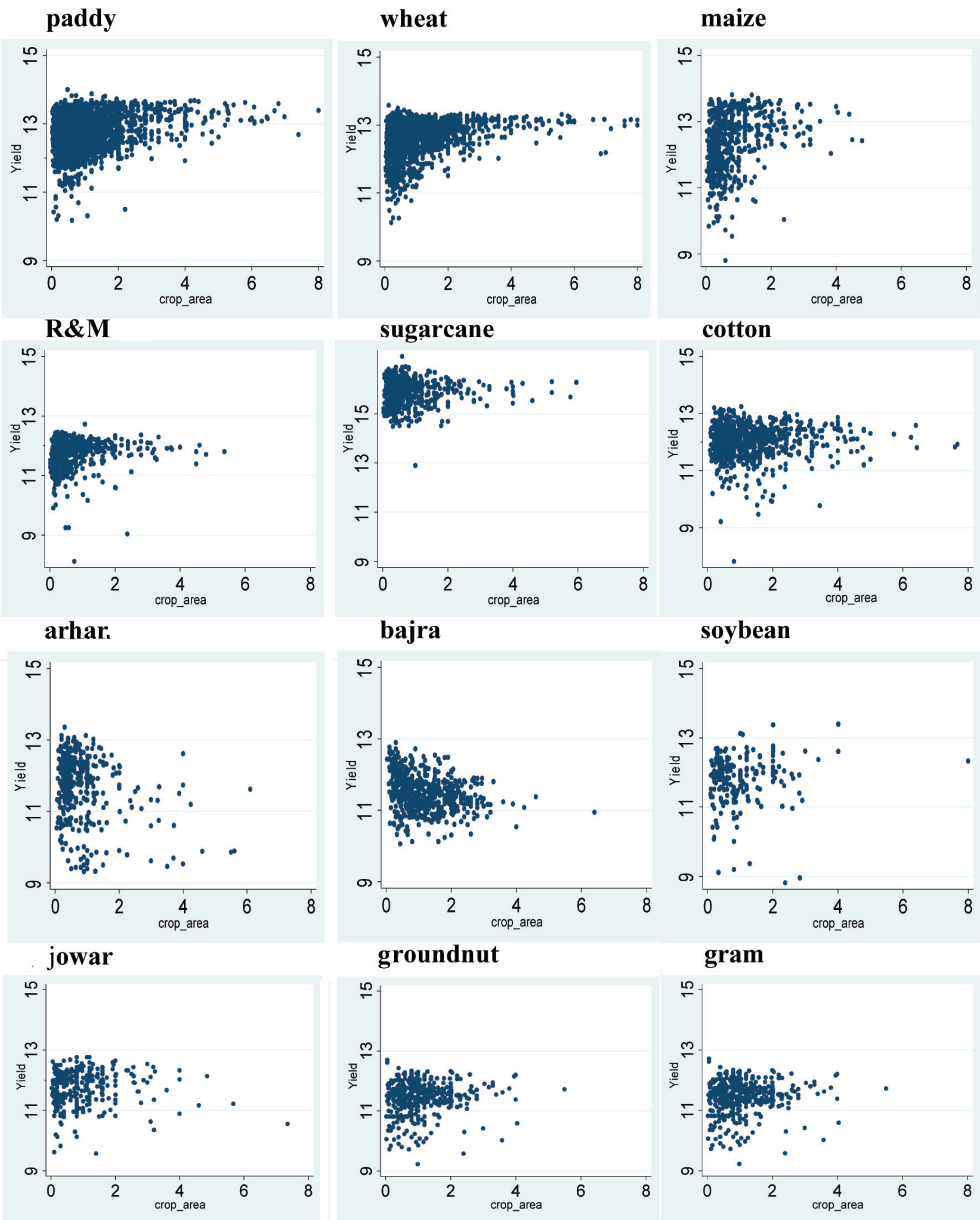
Figure 3: Crop wise net returns (Rs/ha)

Fig. 4 represents the relationship between the area under cultivation and productivity (yield) for all 12 crops at all India level[2] for the year 2013-14. From the Fig. 4, it can be observed that for paddy, wheat, sugarcane, maize, rapeseed & mustard, jowar and cotton the relationship between yield vis-à-vis areas under cultivation appears to be positive. There is an inverse relationship for crops such as arhar, bajra, gram, groundnut and soybean. For the robustness of the results, we have plotted other productivities, such as the value of output/ha and net returns/ha with the area under cultivation (not reported). Results appear to follow the same relationship pattern as yield and area under cultivation.

The relationship between farm size and productivity is analysed in two ways. They are (i) bivariate and (ii) multivariate analyses. Three proxies are used for productivity, i.e., quantity per hectare, value of output per hectare, and net returns per hectare. In the multivariate analysis, many important variables that may impact the relationship are also considered, such as costs of seeds, labour, fertilizer, plot count, soil quality, type of irrigation, variety of seeds, and education level of the farmer. The results presented here relate to 2013-14 (a normal monsoon year).

Bi-variate regression analysis

It was observed by bivariate regression analysis that a statistically significant positive relation exists for paddy and wheat both at all India level and major crop producing states as shown in the Table1. This indicates that paddy and wheat cultivation is profitable for both large and small farmers. This may be due to consistent price support provided by the successive governments. Asimilar positive relation can also be observed for crops such as gram, rapeseed & mustard, cotton, and sugarcane. Further, crops such as arhar, soybean, jowar and bajra showed consistent IR for all three measures of productivity with area under cultivation. These crops are rain-fed crops, and as the yields of these crops are less than wheat and paddy,larger farmers



Source: Author's calculations

Figure 4: Scatter plots of yield(Kg/ha) and area (ha) under cultivation: 2013-14

tend to grow wheat and paddy in place of these crops due to assured returns (GoI, 2019a).

Multivariate regression analysis

Table 3. represents multivariate regression analysis results of productivity and area under cultivation with additional variables such as total labour cost per ha (Rs.), ratio of hired labour to the total labour, total seed cost per ha, total fertilizer cost per ha (Rs.), plot count and education of the farmer. Additionally, dummy variables, namely soil type, irrigation type, and variety of seeds are included in the regression

Table 1. Bivariate relation between productivity and area under cultivation (2013-14)

Crops	Yield (kg/ha)	Value of Output/ha (in Rs.)	Net returns/ha (in Rs.)
Paddy	0.04***	0.04***	0.14***
Wheat	0.09***	0.07***	0.24***
Arhar	-0.16***	-0.14***	-0.15***
Gram	0.01	-0.03	-0.07
Groundnut	0.04	0.01	0.07
R & M	0.10***	0.10***	0.25***
Soybean	-0.19***	-0.20***	-0.26***
Jowar	0.07	0.02	0.29***
Bajra	-0.23***	-0.18***	-0.22**
Maize	0.34***	0.26***	0.42***
Cotton	-0.02	-0.01	0.14***
Sugarcane	0.01	0.01	0.07***

Source: Author's calculations.
*Note: *** sign indicates statistical significance at 1% and ** sign indicates statistical significance at 5%.*

analysis. Here two variables, namely total labour cost per ha (Rs.) and the ratio of hired to the total labour are included to examine the labour market imperfections on the observance of IR. Soil type is included to understand the impact of soil quality and education of the farmer taken as the proxy for skill for best practices adopted by the farmer. The multivariate regression results shown in Table 3 represent a similar pattern to that of bivariate results for most crops. The pattern holds true across all three productivities with area under cultivation.

It may be noted that the results of the analysis are grouped into three, (i) with positive relation, (ii) negative relation (IR), and (iii) mixed relation.

The crops such as paddy, wheat, gram, maize, cotton, rapeseed & mustard, and sugarcane show positive relationships with all proxies of productivity and area under cultivation. The crop-wise results indicate that, for paddy and wheat, positive relation holds true even across the major paddy producing states[3] such as Assam, Odisha and West Bengal.

It has been signified that multiple cultivations on the same land would be beneficial for the farmers as the land available is limited. Higher usage of labour, fertilizers, and irrigation facilities was found to impact productivity positively. Soil quality is also playing an essential determinant in enhancing productivity. In addition to this, local varieties of the seeds were found to be beneficial for paddy and gram, However, high yielding varieties raise better productivity for wheat. For other crops, the variety of seeds was found to be insignificant.

Further, among crops such as arhar, soybean, and bajra, all the proxies of productivity (quantity per hectare/ value of output per hectare/net returns per hectare) show significant IR. The higher usage of labour and seeds are found to positively impactproductivity. Soil quality is an essential determinant in enhancing the productivity of soybean. For crops like groundnut and jowar, all the proxies of productivity (quantity per hectare/ value of output per hectare/net returns per hectare) show either positive or negative (but not statistically significant) relationship with crop area, denoting that reversal or reduction in the magnitude of IR. Higher usage of labour and fertilizer isfound to impact productivity positively. Soil quality is also playing an essential determinant in enhancing productivity. The state-level analysis for the above twelve crops is also indicating similar results (results are not reported).

Further, to sum up, from the above analysis, if we consider all the states together for the year 2013-14, sugarcane is the highest profitable crop, followed by cotton and wheat. Also; these crops have shown a positive relationship between farm size and productivity. The same pattern is reflected in the major crop-producing states too. Also, the mean area under cultivation is highest for cotton, i.e., 1.22 ha, and lowest for arhar, i.e., 0.64 ha. Itcanalso beinferred that for crops like wheat, paddy, maize, rapeseed & mustard, and sugarcane, the large farmers are reaping the profits at par with small farmers. Also, the apparent positive relation points towards the augmentation of the land under cultivation.

Table 2. Crop wise multivariate regression results: 2013-14

	Paddy			Wheat			Arhar			Gram		
	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
X1	0.09***	0.1***	-0.17	0.08***	0.09***	0.19***	-0.05	-0.04	-0.17	0.05*	0	-0.09
X2	0.21***	0.29***	-0.08	0.07***	0.15***	-0.12***	0.27***	0.24***	-0.08	0.3***	0.24***	-0.09
X3	-0.01	0.04***	0.28**	-0.07***	-0.06***	-0.09***	0.18***	0.17***	0.28**	0.04	0.04	0.06
X4	0.14***	0.2***	0.66***	-0.1***	-0.07***	-0.27***	0.33***	0.37***	0.66***	0.1	0.28***	0.59
X5	0.16***	0.2***	-0.01	0.3	0.25***	0.31***	0.13**	0.11*	-0.01	0.17***	0.15***	0.1
soil_type	0.05***	0.06***	-0.04	0.01	0	0.06**	0.22**	0.19*	-0.04	0.21***	0.17***	0.08
plot_count	-0.01***	-0.02***	-0.02	-0.03***	-0.03***	-0.05***	-0.02	-0.01	-0.02	0.04**	0.04***	0.09***
irr_type	0.15***	0.2***	0.25	0.06***	0.04***	0.11***	0	0.07	0.25	-0.02	-0.07	-0.23**
seed_variety	0.01	-0.02	0.13	-0.08***	-0.08***	-0.06	0	0.04	0.13	-0.02	0.02	0.07
edun	-0.01	-0.01	0.06	-0.03**	-0.02	0	0.07	0.05	0.06	0.1**	0.08**	0.11
_cons	8.35***	4.75***	4.84**	10.71***	8.47***	11.31***	4.89**	4.14***	4.84**	6.35***	4.36***	4.18***
N	6646	6646	6646	2630	2630	2545	188	188	158	375	375	319
R^2	0.3028	0.4	0.17	0.23	0.22	0.18	0.4	0.34	0.17	0.25	0.25	0.16

	Soybean			R&M			Bajra			Cotton		
	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
X1	-0.05*	-0.05*	-0.13	0.15***	0.14***	0.2***	-0.13***	-0.07*	-0.12	0.17***	0.18***	0.34***
X2	0.42***	0.42	0.18	0.26***	0.24***	-0.15	0.12	0.26***	-0.35**	0.81***	0.86***	0.99***
X3	0.06***	0.06**	0.05	-0.05***	-0.05***	-0.08**	0.06***	0.03	0.08**	0.05***	0.04***	0.02
X4	-0.08	-0.06	-0.53*	0.1***	0.11***	0.08	0.3***	0.3***	0.55***	0.05*	0.09***	0.17**
X5	0.11***	0.11***	0.22**	0.11***	0.13***	-0.1**	-0.03	0	0.13**	0	-0.03*	-0.22***
soil_type	0.06	0.07*	0.08	-0.11***	-0.13***	-0.17**	0.1	0.01	-0.11	0.08***	0.08***	0.13**
plot_count	0.03***	0.03**	0.04	0.01	0.01*	0.05**	0.05**	0.04**	0.12***	0	0	0.05**
irr_type	0.09**	0.09**	0.2*	0.03	0.03	0.26**	0.04	0.11	0.34***	0.1***	0.13***	0.21***
seed_variety	-0.14	-0.06	-0.04	-0.2***	-0.25***	-0.47***	-0.02	0.27**	0.14	0	0	0
edun	-0.09	-0.08**	-0.1	0.01	0.02	0	-0.01	0.02	0.16	-0.02	-0.01	-0.06
_cons	7.21***	5.77***	9.78***	8.19***	6.91***	11.75***	8.75**	5.66***	6.97***	3.16***	1.93***	0.65
N	548	548	446	630	630	558	323	323	261	997	997	916
R^2	0.32	0.32	0.07	0.21	0.23	0.12	0.28	0.23	0.28	0.48	0.4888	0.2014

	Groundnut			Jowar			Maize			Sugarcane		
	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
X1	0.03	0	-0.07	0.27***	0.24***	0.43***	0.01	-0.03	0.12*	0.04**	0	0.03
X2	0.24***	0.24***	-0.21	0.67***	0.74	0.76***	0.08	0.09**	-0.01	0.41***	0.43***	0.34***
X3	0.02	0.03	0.23**	0.02	0.01	-0.02	0.07***	0.05**	0.2***	0.05*	0.04	0.04
X4	0.17**	0.22***	-0.11	0.24***	0.09	0.02	0.28***	0.28***	0.43***	-0.14***	-0.13***	-0.34***
X5	0.1***	0.11***	0.03	0.18***	0.12**	0.12	0.33***	0.28***	0.15**	0.21***	0.16***	0.1
soil_type	0.1*	0.07	0.37***	-0.03	0.09	0.35**	-0.11	-0.06	0.02	-0.07**	-0.12***	-0.19**
plot_count	-0.02	-0.02	-0.09**	0.02	0.01	-0.03	-0.05***	-0.03**	0.02	0.01	0	-0.03
irr_type	0.37***	0.39***	0.37***	0.13	0.17**	0.22	-0.03	0.08	0.05	0.1***	0.01	-0.05
seed_variety	-0.22***	-0.27***	-0.62***	-0.2**	-0.15**	-0.27	-0.56***	-0.43***	0.44*	0	0	0
edun	-0.05	-0.01	0.08	-0.13	-0.1	-0.03	0.06	0.07	0.04	0.02	0.03	0.07
_cons	6.84***	5.36***	11.64***	2.71***	1.95**	1.15	6.9***	5.24***	4.29***	10.82***	7.3***	10.25***
N	288	288	214	179	179	150	557	557	427	323	323	313
R^2	0.43	0.45	0.2	0.41	0.47	0.19	0.68	0.65	0.27	0.65	0.53	0.19

Source: Author's calculations.

Note Y1: yield in kg per ha; Y2:value of output per ha (Rs.); Y3: net returns per ha (Rs.) X1: crop area; X2: total labour cost per ha (Rs.) X3;: ratio of hired to the total labour cost per ha ; X4: total seed cost per ha (Rs.);X5: total fertilizer cost per ha (Rs.). N : number of observations; R2 = Coefficient of determination; c : value of coefficient ; t: t-statistic

The spatial scale of agriculture varies immensely across countries and even among farms within countries. It was estimated that the world's largest farms occupy more than 1 million hectares which are commercial cattle farms rather than crop farms. However, in many parts of the developing world median farm size is less than 1 hectare (Gollin, 2019). A common description established that increasing farm size inevitably accompanies agricultural development and economic growth.

In Indian agriculture, the overall productivity of a farm depends on the use of yield-enhancing inputs like fertilizer, access to irrigation, technology, crop intensity, and choice of crops (crop pattern) grown at the farm. Therefore, it is pertinent to examine variations in these factors to understand the variation in productivity across farm size categories.

The relationship between farm size and productivity in developing countries remains one of the longest-standing debates in the agricultural development literature. It was intensified in 1962 when Sen (1962) detected an inverse relationship betweenfarm size and output per hectare in the Indian context, signifying that small farms are more productive, as observed for various crops current study also. Nevertheless, the study observed positive, negative, and mixed relationships to the crops in the various locations and other farmer-specific inputs.

Utilizing new technologies and infrastructure is an important means of enhancing productivity. So far, large farms, due to their size-related budgetary capacity and ability to purchase and own the most advanced equipment have usually been the major beneficiaries of this technology and related productivity gains. Further, large farms can better capture the profits of technological advancements and increase returns to size (Sheng et al., 2015, 2016). In contrast to this, there is always a financial inability to invest in advanced and expensive equipment among small farms. Further more, this scenario limits small farms from gaining the potential benefits of increasing returns to size by adopting newly invented technology. To some extent, it was also expected that the disparities in the productivity between small and large farms could be partially explained by the limited access to technological progress embodied in capital investment for various advanced equipment (Lipton 2010).

The results of the current study are also in confirmation with observance of IR but are limited to arhar, soybean, and bajra (Sen 1962, 1964; Bardhan 1973; Chand et al., 2011; Sial et al., 2012; Binswanger and Singh 2018). The possible reason may be attributed to the technical backwardness of the farmers (Ghose, 1979; Collier and Dercon 2014).

The present study also observed a positive relationship between farm size and paddy, wheat and sugarcane productivity. Enhanced application of fertilizer and other cash-intensive inputs may contribute to the same (Rao,1975).

Considering the prevalence of small farmers in India, initiatives that support their farming methods are likely to boost farmers' incomes. It is important for policy makers to assess whether or not existing strategies offer a valuable approach to produce agricultural development, especially when millions of people will continue in smallholder agriculture for decades to come (Latruffe et al., 2012; GoI, 2019).

To conclude, the current study examines the relationship between farm size and farm productivity over a broader range of farm holdings across various states to the various crops in India. The results demonstrate that for crops such as wheat, paddy, maize, rapeseed & mustard, and sugarcane, the large farmers are reaping the profits at par with small farmers. Also, the apparent positive relation points towards the augmentation of the land under cultivation. These results open up wider possibilities for large farmers through an increase in cropping intensity for which necessary infrastructure such as machines & implements, irrigation facilities, etc. are available with them. However, this scenario put small farmers at a disadvantage due to higher input

(Footnotes)

1 It may also be noted that correlation matrix of all the independent variables with dependent variable show very weak correlation and hence production function may not be suffering from major endogeneity problem. For further analysis the reader can refer to Gautam and Ahmed (2019)

2 The state-wise results are also show similar pattern. However, results are not reported.

3 State-wise results are not reported.

costs. This also points towards enabling crop-specific policy formulation of farmer groups by the small farmers to reap the benefits and enhance their bargaining ability. Nevertheless, for crops like pulse (arhar, gram),coarse cereals (bajra, jowar), and oilseeds (soybean, groundnut), there is an overwhelming scope for small and marginal farmers to get more output/ returns compared to large farmers. The above-mentioned results are indicating a need for shift in cropping pattern from existing input intensive (irrigation facilities, high yield variety seeds, costly machineries such as tractor, etc.) crops such as wheat, sugarcane towards arhar, soybean, bajra, jowar, etc., to make farming profitable for small and marginal farmers. As mentioned above, states should make necessary enabling ecosystems such as marketing facilities, higher support prices, and steady income support to farmers for realizing better returns.

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