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Recent Evidence on Farm Size and Land Productivity: Implications for Public Policy

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1. INTRODUCTION

Agricultural productivity is low in most of the developing countries including Pakistan. Moreover, slow and meandering agricultural growth is unable to keep pace with the fast and persistently growing population pressure in these countries. That in turn, has, continued to result in malnutrition and recurrent famines [Cornia (1985)]. Worse than this are the results of an ILO (1977) study, which has shown that food consumption inequalities have actually increased overtime not only in the food deficit countries but also in countries experiencing rapid agricultural growth. This points to the ever-hanging shadows of food deficiency and resulting malnutrition over the countries characterised by slow or negative growth in per capita food production and perverted income distribution [Cornia (1985)]. The only choice with these countries is to enhance food production and provide better access to food consumption for the poor masses.

In order to achieve this objective policy-makers consider various options including increased use of modern inputs—mechanical and biological technologies, and removal or reform of the prevalent socio-economic power structure in agriculture that is considered to be an impediment to growth. It may not be desirable to apply these options separately in order to achieve the objective of reducing rural poverty [Cornia (1985)]. Growth in agriculture—that is sustainable and appropriate, is possible when all factors of production are accessible to all strata of the farming community. This is particularly so in the case of access to land. In this regard, land redistribution accompanied by increased input supply is the preferred policy option. The supporters of this policy package cite the argument that small sized farms are

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not only beautiful but efficient as against large farms. However, the empirical literature on determination of the optimal size of farms that ensure maximum productivity, efficiency and equity has remained inconclusive both in developed as well as less developed countries [Mendis (1992)].

In the present study, an attempt has been made to address the following questions: Does the managerial efficiency (Technical Efficiency) differ across farm size categories and different regions in Punjab? Does the inverse relationship between farm size and productivity per acre found in the past prevails in recent years? Does the use of inputs differ across farm sizes and regions in Punjab?

The paper is organised as follows. The survey of the previous literature is given in Section 2. Section 3 provides a detailed discussion of the data and analytical procedures. The results are given in Section 4. The concluding section provides a survey of the main conclusions and draws some important policy implications.

2. SURVEY OF LITERATURE

The debate on the subject of farm size and productivity relationship started with Sen's (1962) seminal work using India's Farm Management Survey Data. Afterwards, a significant number of studies have been completed proving or rejecting the claim of the inverse relationship between farm size and land productivity in South Asian and some other developing countries. The studies using Indian data, which found inverse relationship are Sen (1962); Mazumdar (1965); Rao (1966); Saini (1971); Bharadwaj (1974); Chaddha (1978); Ghose (1979); Bhalla (1979); among others. The studies which did not find inverse relationship or had inconclusive results are Rao (1967); Bhattacharya and Saini (1972); Khan and Tripathy (1972); Rao (1975); Dasgupta (1977); Chattopadhyay and Rudra (1976); Saini (1980); Bagi (1981); Deolalikar (1981); Rao and Chotigeat (1981); Roy (1981); among others.

Studies of the type done in India are relatively scarce in other developing countries. The few studies conducted in other countries have also come up with mixed results. In the case of Egypt, Radwan and Lee (1986) support the inverse relationship, while Commander (1987) finds no consistent association. Dyer (1991) states that the relation may hold in a relatively backward agriculture but it breaks down with the advancements in technology. Hossain (1977); Berry and Cline (1979) and Herdt and Mandac (1981) found that the inverse relationship holds in the case of Indonesia, the Philippines and Bangladesh, respectively.

Studies using efficiency analysis in developing countries also show mixed results of the kind found in studies discussed above that have used the size-productivity relationship to resolve the debates. In case of Indian agriculture, Khusro (1964); Sahota (1968); Sidhu (1974); Ray (1985); Huang and Bagi (1984) and Kalirajan (1991) concluded that productive efficiency did not differ across different farm size categories. While Yotopoulos, Lau and Sonel (1970); Lau and

Yotopoulos (1971); Yotopoulos and Lau (1973) and Bagi (1987) found negative relationship between farm size and efficiency. Squire and Tabor (1991); Bravo-Ureta and Evenson (1994) and Pinheiro (1992) found no relationship between farm size and efficiency in agriculture sectors of Indonesia, Paraguay and the Dominican Republic, respectively.

In spite of the pertinent nature of the policy debates the analysis of farm size and productivity relationship did not attract much attention of the researchers in Pakistan. However, a few studies have been conducted in the past dealing with this issue. The first is that of Khan (1979) using 732 irrigated farms in the Indus basin for the year 1974 and a production function technique incorporating a farm size dummy variable concluded that the large farmers get higher output per acre. The study further indicates that per acre use of non-traditional inputs—fertiliser, hired labour and farm machinery—is higher on large farms than on small farms: The observed difference is a result of market distortions induced by public policy. The second study by Khan and Maki (1980) uses the same 1974 data set. It conducts analyses for wheat and rice crops only. It found no significant farm size-based difference in efficiency. However, they reported the existence of increasing returns to scale.

Mahmood and Haque (1981) using two sets of data—Agricultural Census and the Rural Credit Survey data for the year 1972—concluded that the smallest (<5 acres) and the largest farm size categories were the most efficient and equally productive. While the middle farmers were relatively inefficient as they used inefficient combination of inputs, which resulted in lower marginal productivity.

The study by Chaudhry *et al*. (1985) finds the inverse relationship between size of farm and productivity for Pakistan. It is interesting to note that studies on this issue are old and pertain to data set, which are at least 15 years old. It is therefore important to have a fresh look into the subject.

A number of studies relating to productive efficiency in Pakistan have also been conducted as of Khan and Maki (1979) discussed in the foregoing.

Ali and Flinn (1989) using the profit frontier approach found an average economic efficiency of 69 percent for the Basmati rice farmers in Punjab using data from Gujranwala district. Farmers' education, lack of credit facility, late application of fertilisers, and irrigation constraints were considered to be the factors for low efficiency. Ali and Choudhry (1990) found average technical efficiency of about 84 percent with some regional level variations. Battese *et al.* (1993) using wheat data from Faisalabad, Attock, Badin and Dir found that technical inefficiencies exist in three of these districts that are Faisalabad, Badin and Dir. The study suggests that the adoption of new technology and a good agricultural extension system are required to enhance the efficiency of the wheat farmers. Parikh and Shah (1994) found average technical efficiency of about 96 percent in NWFP. The farm level technical efficiency was found dependent upon farmers' education, credit, age and the extent of land fragmentation. Parikh, Ali and Shah (1995) using cost function found an average inefficiency of about 12 percent. The study also concluded that the small farmers were more efficient than the large farmers in the study area. The authors suggested that providing rural education, extension service and credit could reduce inefficiency.

It was the evidence of inverse relationship (between farm size and per acre productivity) that provided an empirical support to the policy-makers for reforming the agricultural sector in various countries. Pakistan faces tremendous problems on various fronts including social, cultural, institutional and economic. These problems continued to affect the achievable potential growth of the agriculture sector keeping it down to its minimum through their depressing effects on land productivity and economic efficiency.

The solution considered for increasing land productivity was to reform the feudal land tenure system inherited by Pakistan. Consequently, two land reforms, 1959 and 1972, took place. The land reforms have to serve three purposes; increased production, efficiency and equity through redistribution of land and security of tenure. However, these reforms did not succeed in changing the status quo in Pakistan and thus had almost no impact on production [Naqvi *et al.* (1989)].

3. DATA AND METHODOLOGY

In this study, the farm level input and output data comes from the 'Rural Finance Survey of Punjab (RFS)' conducted by Punjab Economic Research Institute, Lahore. The data pertains to crop year 1997-98. There were 1229 farm families in this survey excluding Cholistan, which was not included in the analysis. For the purpose of analysis, the province of Punjab is divided into five crop ecological regions namely Rawalpindi, Gujranwala, as Faisalabad, Multan and Thal.[1] Each of these zones represents more or less homogeneous conditions such as sources of irrigation, cropping pattern, physiography, climate and soils, etc. [Chaudhry and Ahmad (1980)]. Given these regions and the RFS data, 117, 125, 261, 556 and 170 observations lie in Rawalpindi, Gujranwala, Faisalabad, Multan and Thal, respectively.

To achieve the objectives of the paper, we proceed as follows. Firstly, a stochastic frontier production function developed independently by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) is used. The key feature of this model is that the error term has two components: one is symmetric

[1]Rawalpindi includes Rawalpindi, Gujar Khan, Pindi Gheb, Serai Alamgir, Sohawa, Talagang, Jehlum and Chakwal tehsils of various districts. Gujranwala includes Gujranwala, Kamoke, Wazirabad, Pindi Bhatian, Hafizabad, Gujrat, Pasrur, Daska, Sialkot, Shakargarh, Narowal, Kharian and Malikwal. Faisalabad comprises Faisalabad, Chak Jhumra, Jaranwala, Tandlianwala, Gojra, Jhang, Chiniot, Sargodha, Silanwal, Sahiwal, Patoki, Okara and Depalpur. Multan consists of Multan, Lodhran, Dunyapur, Karor Paca, Vehari, Burewala, Mailsi, Arifwala, Pakpatan, Kabirwala, Khanewal and Mian Channnu. Thal includes D.G. Khan, Rajanpur, Layyah, Chobara, Khushab, Isa Khel, Bhakkar, Mankera, Kalurkot, Mianwali, and Muzaffar Garh.

representing statistical noise and exogenous shocks, and the other is one sided that captures technical inefficiency such as mistakes related to management. For the purpose of analysis for this study, the following Cobb-Douglas production frontier is used:

$$Ln\,(Y_i) = \alpha + \beta_1 D_f + \beta_2 ln(Fert_i)^* D_f + \beta_3 (Lprep_i) + \beta_4 D_I + \beta_5 ln(Irri_i)^* D_I + \beta_6 ln(Seed_i) + \beta_7 D_c + \beta_8\, ln(Chem_i)^* D_{c} + \beta_9 D_m + \beta_{10}\, ln(Fym_i)^* D_m + \beta_{11} ln(Fsize_i) + \beta_{12}\, ln(CI_i) + \beta_{13}\, Ts_2 + \beta_{14}\, \mathrm{Ts}_3 + \mathrm{v}_\mathrm{i} - \mathrm{u}_\mathrm{i} \quad \ldots \quad \ldots \quad (1)$$

where,

- Y is the value of aggregate output per cultivated acre at village level prices,
- D_f is a dummy variable showing value of one if Fertiliser (NPK) use is greater than zero; otherwise 0,[2]
- *Fert* represents the fertilizer nutrients (NPK in kg) per cultivated acre,
- *Lprep* is the land preparation cost per cultivated acre,
- D_I is a dummy variable showing value of one if Irrigation >0; otherwise 0,
- *Irri* represents the average number of irrigations per acre,
- *Seed* is seed cost per acre,
- D_c is a dummy variable showing value of one when Chemical use > 0; otherwise 0,
- *Chem* represents cost of chemicals, i.e., insecticides and weedicides per acre,
- D_m is a dummy variable showing value of one if Farm-Yard-Manure > 0; otherwise 0,
- *Fym* is cost of Farm-Yard-Manure per acre,
- *Fsize* represents cultivated land in acres,
- *CI* is cropping intensity,
- Ts_2 represents owner-cum-tenants' farms,
- Ts_3 represents tenants' farms,
- v is a usual random error term accounting for random variation in output due to factors outside the farmer's control which is assumed to be independently and identically distributed as $N(0, \sigma_v)$,
- u is a non-negative unobservable random variable associated with the technical inefficiency of production assuming half normal distribution with mean zero and σ_u,
- i represents *i*th farm observation,
- *ln* represents the natural log, and
- βs are unknown parameters to be estimated.[3]

[2]Dummy variables like D_f, D_I, D_c and D_m are used in the production function 'to account for different production regimes for farmers' who use certain inputs, relative to those who do not [Battese *et al.* (1993) and Battese (1996)].

Farm level technical efficiency is measured by taking exponent of the predicted values of the non-negative unobservable random variable that can be expressed as $TE_i = \exp(-u_i)$.

Secondly, to compare results from the present study with that of the results of previous studies on farm size and productivity relationship as well as the results obtained from Equation 1, we also estimated the following models:

$$\text{Ln}\,(YC_i) = \alpha + \beta_1 ln(\text{Fsize}) + v_i \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

$$\text{Ln}\,(Y_i) = \alpha + \beta_1 ln(\text{Fsize}) + v_i \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

YC_i represents value of output per cropped acre. Comparison of Equations 1 to 3 and footnote 3 indicates that the parameter estimates β_1's of Equations 2 and 3 do not provide any extra information regarding farm size and productivity relationship except that of biased 'returns to scale' measure.

To resolve the issue, we computed rank correlation coefficients for cultivated area (Fsize) with those of income, farm inputs used, livestock numbers and family members per acre. We also computed the correlation coefficients of technical efficiency and value-cost ratios with the farm size to determine the existence of any association.

4. RESULTS AND DISCUSSION

Keeping in view the objectives of the paper and the subsequent analysis, this section is further divided into two subsections. The first gives the detailed results and discussion regarding the stochastic production frontier and technical efficiency measures. The second section is devoted to estimation of farm size and land productivity relationship.

[3]We believe that there is not much difference between an aggregate farm level Cobb-Douglas production function and the function used on per acre input and output values (as is in our study) and the proof is shown below. Preference of using the function on per acre basis is only to compare the parameter estimate of Fsize variable with that of the estimates obtained in Equations 2 and 3, which have usually been applied in empirical analysis in farm size productivity studies. In Equation 1, the coefficient of Fsize variable represents returns to scale. Assuming the following multiplicative farm level aggregate production function

$$Y = AX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5}$$

Where X_1 to X_3 are farm inputs, X_4 is the cultivated area and X_5 is cropping intensity. Multiplying the left-hand side of this equation with X_4 / X_4, and the right-hand side with $(X_4/X_4)^{b1}$, $(X_4/X_4)^{b2}$ and $(X_4/X_4)^{b3}$ will yield :

$$(Y / X_4) = A(X_1 / X_4)^{b1} (X_2 / X_4)^{b2} (X_3 / X_4)^{b3} (X_5)^{b5} X_4^{b1+b2+b3+b4-1=\theta}$$

It is evident from the above formulation that the production function based on per acre basis yields the same parameter estimates as that of in aggregate. However, in the present form the coefficient (now θ) of X_4 represents the returns to scale, ranging from –ive to +ive values: it exhibits decreasing, constant, or increasing returns to scales if θ is –ive, 0, or +ive, respectively.

(i) Stochastic Production Frontier and Technical Efficiency Measures

The maximum likelihood estimates of the production frontier, given in Equation 1, are estimated separately for each of the five regions in Punjab using LIMDEP Version 7. The results are presented in Table 1. The value of adjusted R^2's of 0.70, 0.39, 0.77, 0.53 and 0.85 for the models of the various regions show that the model variables explain 39 percent to 85 percent of the variation in output per acre. Given the cross-sectional nature of the data, the values of these statistics are reasonably high. The ratios of the standard errors of u_i and v_i, i.e., λ, are 6.72, 1.13, 2.37 and 1.21 in case of Rawalpindi, Faisalabad, Multan and Thal, respectively. These magnitudes show that the one sided error term u_i dominates the sources of random variation in the models implying that the discrepancies between the observed output and the frontier output are due primarily to technical inefficiencies in four of the five regions. However, in Gujranwala the λ is equal to 0.92 indicating that the symmetric error term v_i dominates the sources of random variation in the model.

Table 1

Parameter Estimates of Stochastic Frontier Production Functions

Variable	Rawalpindi	Gujranwala	Faisalabad	Multan	Thal
Constant	4.2520***	7.6155	6.4815***	9.5345***	6.6490***
D_f	–0.3681	–0.3104	–0.4748	–0.4512**	0.1680
Ln(Fert)*Df	0.1243	0.1474**	0.1790***	0.1054***	0.0228
Ln(Lprep)	0.1705**	0.0075	0.0645**	0.0669**	0.0528
D_I	0.2156	–0.0248	0.2288	–0.8175***	–0.1616
Ln(Irr)*D_I	–	0.1270**	0.2632***	0.0645	0.3594***
Ln(Seed)	0.5314***	0.0756	0.1129***	–0.0179	0.2081***
D_c	0.1859	–0.0597	–0.3965**	–0.5304***	–0.2875
Ln(Chem)	–	0.0087	0.1092***	0.1007***	0.1160***
D_m	0.0549	0.0103	–0.0308	–0.0434	–0.0225
Ln(FYM)*D_m	–0.0552*	0.0094	0.0038	–0.0136	0.0175
Ln(Fsiz)	–0.0018	0.0207	0.0241	0.0184	–0.0725**
Ln(CI)	0.4261***	0.4866***	0.2366***	0.7600***	0.5548***
TS2	0.1274	0.0278	–0.0361	0.0058	–0.0740
TS3	–	0.0495	0.0496	–0.0264	0.0596
$\lambda=\sigma_u/\sigma_v$	6.7152*	0.9164[a]	1.1307***	2.3689***	1.2140**
$\sqrt{\sigma_u^2+\sigma_v^2}$	0.6777***	0.2758***	0.3596***	0.5789***	0.4037***
Adj. R^2	0.70	0.39	0.77	0.53	0.85
Mean T. Efficiency	0.62	0.86	0.81	0.68	0.79

***, ** and * are significant at the 1 percent, 5 percent and 10 percent levels, respectively.
[a] Significant at the 15 percent probability level.

The last row of Table 1 shows that Rawalpindi is the least efficient region having technical efficiency of 0.62. This implies that the farmers of this region are only able to realise 62 percent of the potentially achievable level of output from the given bundle of inputs. Lower technical efficiency of this region is due mainly to lack of irrigation water, which increases the risk and uncertainty in crop production. The second least efficient region is Multan. One of the potential reasons of this lower efficiency measure is probably the prevalence of Cotton Leaf Curl Virus in the cotton region of Punjab. The other cause could be that this region faces the most dynamic situation in terms of introduction and adoption of new technologies—the farming community usually takes time to adjust and reap higher production potential from the changing technologies. Gujranwala, the rice region, is found to be the technically most efficient. This is due mainly to the fact that wheat and rice are more stable crops in this region. It has a relatively traditional set up in term of crop choices and crop establishment [Ali and Choudhry (1990)].

The coefficient of land (Fsize) variable is also of great interest representing the returns to scale measure.[4] In all regions except Thal, the land parameter estimates are highly statistically non-significant meaning that these coefficients are not different from zero. This implies that the constant returns to scale prevails in Rawalpindi, Gujranwala, Faisalabad and Multan regions. In Thal region, the land coefficient is statistically significant at the 5 percent level and is negative in sign. This implies that there are decreasing returns to scale in the region.

The results further show that cropping intensity is the most important variable contributing to output per unit of land. The corresponding parameter estimates in Table 1 show an increase in output per unit of land from a low of 2.3 percent in Faisalabad to a high of 7.6 percent in Multan region in response to increase in cropping intensity by one percent. Low response in the former region could be due mainly to prevalence of water logging and salinity. In the latter region, cotton is the most popular crop, which is more remunerative.

The system of land tenure is generally considered to be one of the factors that affects farm productivity through managerial ability and investment potential of the farmers. The insecurity and the financial stringency in case of tenants are the major restraining factors that inhibit more productive enterprising activities such as land improvement and other investment strategies as well as improvement in managerial capabilities. However, the tenants generally operate on small land holdings and thus are under lot of economic pressure like paying rent/share, meeting production costs and saving something for the families' survival. Consequently, the tenants put more effort to achieve higher output levels. The results given in Table 1 support this argument as all farm categories are equally productive. It should be noted that the

[4]If all the inputs are changed by the same proportion the consequent change in output could be less than, equal to or greater than the change in inputs, which in turn could be termed as decreasing, constant or increasing returns to scale, respectively.

parameter estimates of owner-cum-tenants and tenants are not statistically different than the control group, i.e., owner-operator.

The average technical efficiency measures by farm size and tenurial status are given in Table 2. In the Rawalpindi region, the farmers operating greater than or equal to 25 acres of land are the least efficient and the size category of >5 to 12.5 acres appears to be the most efficient. The correlation coefficient of –0.02 shows however no overall association between farm size and technical efficiency in this region.

Technical efficiencies for all farm size categories in Gujranwala region are almost the same. The correlation coefficients convey the same message. The results of Faisalabad region show that the largest farm size category is the most technically efficient, while the other four categories realise the same output potential from the given level of inputs. The correlation coefficient is though positive and statistically non-significant.

The results shown in Table 2 further reveal that the farmers of all farm size categories are equally technically efficient in the Multan region. In the Thal region, average technical efficiency measures show somewhat increasing trend over the last four farm size categories. The correlation coefficient shows positive and significant association of technical efficiency with farm size. The overall technical efficiency measures, using the whole sample, exhibits slightly increasing trend ranging from 0.73 for farms ≤ 5 acres and 0.79 for the largest farm size category. The correlation coefficient implies not only positive (though small) but statistically significant association.

The results in Table 2 further show that the farmers belonging to different tenurial status groups, i.e., owners, owner-cum-tenants and tenants, on average are equally technically efficient in almost all the regions. This result implies that the farmers, irrespective of their tenurial status, not only produce equal level of output per unit of land—as it has also been shown in regression results discussed before, but

Table 2

Farm Size, Tenurial Status and Technical Efficiency (TE)

Region	≤5 Acres	>5 – 12.5 Acres	>12.5–25 Acres	25–50 Acres	>50	Correl. TE vs Fsize	Owners	Owner-cum-Tenants	Tenants
Rawalpindi	0.60	0.69	0.61	0.46	–	-0.02	0.62	0.62	–
Gujranwala	0.86	0.87	0.86	0.87	–	0.06	0.86	0.86	0.85
Faisalabad	0.81	0.81	0.81	0.80	0.85	0.05	0.81	0.81	0.81
Multan	0.68	0.68	0.67	0.69	0.70	0.04	0.68	0.68	0.69
Thal	0.79	0.76	0.79	0.81	0.82	0.11**	0.78	0.78	0.79
Average	0.73	0.74	0.75	0.76	0.79	0.08**	0.73	0.74	0.76

** Significant at the 5 percent level.

also use the given technology equally efficiently. The overall Punjab averages of different farm size categories show that the tenants are a little more efficient (i.e., 0.76) than the owner operators (i.e., 0.73); however, the difference appears to be negligible. This result is consistent with that of Kalirajan (1981, 1984, 1990), who found that the technical efficiency is probably not affected by the tenurial status of the farmers.

(ii) Farm Size and Land Productivity

The parameter estimates of models 2 and 3 are presented in Table 3. The first part of the table, where the dependent variable is the value of crops per cropped acre, shows that the overall regression as well as the parameter estimates are only significant in Rawalpindi and Multan regions: While, all the parameter estimates of farm size are, however, negative.

The second part of the table—where the dependent variable is the value of crops per cultivated acre, shows that all regressions and the negative coefficients of farm size except that of Gujranwala region are statistically significant. These results indicate—as it has been the usual practice in interpreting such results in studies relating to farm size and productivity, that the inverse relationship exists in Rawalpindi, Faisalabad, Multan and Thal regions; while, Gujranwala shows no relationship. As mentioned in Section 2, such an approach to evaluate the farm size

Table 3

Parameter Estimates of Models 2 and 3

Region	Farm Size	Adj. R^2	F-Value
Dependent Variable—Productivity per Cropped Acre (Model 2)			
Rawalpindi	–0.144**	0.070	15.63**
Gujranwala	–0.021	0.000	1.03
Faisalabad	–0.030	0.000	1.06
Multan	–0.066**	0.059	7.49**
Thal	–0.036	0.000	0.55
Dependent Variable—Productivity per Cultivated Acre (Model 3)			
Rawalpindi	–0.385**	0.20	29.11**
Gujranwala	–0.020	0.00	0.00
Faisalabad	–0.144**	0.04	13.45**
Multan	–0.046*	0.003	2.81*
Thal	–0.306**	0.148	30.26**
Overall Sample: (1)	–0.138**	0.402	166.05**
(2)	–0.133**	0.025	32.01**

(1) Regional effects were incorporated in the model and (2) is without regional effects.
**, * Significant at the 5 percent and 10 percent levels, respectively.

and productivity relationship is not very fruitful. This becomes evident when we compare R^2 values of models results given in the second part of Table 3 and the corresponding values in Table 1. This comparison shows that the exclusion of all variables from the regional models and keeping only cultivated land (Fsize) reduces the explanatory power of the models from 82 percent in case of Thal to 100 percent in Gujranwala. Therefore, it can be concluded that the interpretation of inverse relationship and its intensity using the parameter estimates given in Table 3 does not convey the true message. This is possible only when the excluded variables have no correlation with that of the farm size, which is not true in our case. Consequently, the land parameter estimates given in Table 3 are biased—because of the reason that violation of one of the random error term assumption, i.e., v_i is identically independently distributed from the other included model variables. Nonetheless, the last row of Table 3 gives the results of the overall sample and implies significant inverse relationship between farm size and output per acre.

To resolve the above issue as well as to identify any prevalent association of farm size with those of other variables, we calculate the average gross income per cultivated acre for various farm size categories (Table 4). To see the trends, the rank correlation coefficients are also calculated. The results in Table 4 show that the gross income per cultivated acre declines from smaller to larger farm size categories in Rawalpindi, Faisalabad and Thal regions as well as in overall Punjab. However, in Gujranwala no consistent trend is observed as the largest farm size category turns out to be the most productive category. Multan region shows a somewhat U-shaped relationship. The smallest farm size category is the most productive category. The overall figures of the Punjab reveal a significant declining trend as farm size increases. The correlation coefficients given in last column of Table 4 support our conclusion that negative and statistically significant association exists in Rawalpindi, Faisalabad, Thal and Punjab as a whole. No association is observed in Gujranwala region, while in Multan the relationship is negative but statistically non-significant.

Table 4

Average Gross Income (AI) per Acre in Rupees by Farm Size Categories

	≤5 Acres	N	>5 – 12.5 Acres	N	>12.5-25 Acres	N	>25 Acres	N	Correl. GI vs. Fsize
Rawalpindi	3931.69	(81)	2862.43	(28)	1560.56	(5)	717.81	(3)	–0.45**
Gujranwala	7164.36	(74)	7348.58	(33)	6725.33	(12)	8238.15	(6)	–0.00
Faisalabad	9376.55	(135)	7969.01	(75)	7608.56	(45)	7453.17	(6)	–0.21**
Multan	13846.42	(308)	12912.91	(171)	12623.19	(57)	13098.20	(20)	–0.06
Thal	8041.85	(63)	5115.12	(45)	3493.74	(38)	4833.14	(24)	–0.42**
Punjab	10417.24	(661)	9541.52	(352)	8173.09	(157)	8038.62	(59)	–0.14**

**Significant at the 5 percent probability level.

To find out the relationships between farm size and the inputs used per cultivated acre, correlation coefficients are computed and are reported in Table 5. These coefficients show that the large farmers in Rawalpindi region spend significantly less on land preparation and seed and use less fertiliser but the association is not statistically significant. Large farms spend more on weedicides and pesticides though only a few farmers use these chemicals. The Gujranwala region shows that fertiliser and land preparations have negative association with the farm size, while irrigation and chemicals' use per acre are positively associated with that of size. In Faisalabad, use of all inputs, except chemicals, per acre declines as farm size increases. In Multan region, use of all inputs per acre has negative relationship with that of farm size, except chemicals—where the sign is positive but the magnitude and its statistical non-significance show no relationship. In Thal, all inputs have negative relationship with farm size. Use of inputs per cultivated acre on average in the entire Punjab shows significant declining trend. These results provide a clear explanation as to why the large farmers get less output per unit of land when a comparison is made with small farmers.

There is a general argument that, although, there exists an inverse relationship between farm size and productivity this in no way means that small farms have a necessarily lower per unit cost of output. As the data set did not have detailed information on labour costs we could not include a comprehensive measure of cost in our computation: However, fertiliser, chemicals and land preparation costs also include labour costs. The correlation of VCR with that of farm size shows strong positive association in Rawalpindi and Faisalabad regions. This relationship is weak in Gujranwala, Multan and Thal regions; however, the coefficient is statistically significant in the former region. This result leads us to conclude that while the small farmers produce more per unit of cultivated land, they do not necessarily do so at lower per unit of output cost. This result is consistent with our earlier finding that the larger farmers are more efficient than that of the smaller ones.

Table 5

Correlation Coefficients—Farm Size vs. Variables are per Cultivated Acre

Region	Fertiliser	Land Prep.	Irrigation	Seed	Chemical	VCR[a]
Rawalpindi	–0.10	–0.55**	–0.01	–0.46**	0.14**	0.53**
Gujranwala	–0.23**	–0.35**	0.29**	–0.03	0.38**	0.12**
Faisalabad	–0.40**	–0.36**	–0.15**	–0.13**	0.12**	0.32**
Multan	–0.15**	–0.17**	–0.16**	–0.18**	0.04	0.04
Thal	–0.35**	–0.43**	–0.40**	–0.33**	–0.02	0.08
Overall	–0.16**	–0.31**	–0.08**	–0.15**	0.08**	0.17**

** Coefficients are significant at the 5 percent level. [a] Value Cost Ratio = (Gross income per cultivated acre)/(cost per cultivated acre including fertiliser, chemicals, seed, land preparation, farm yard manure only).

Correlation coefficients between farm size and output value per cropped acre are presented in Table 6. These coefficients show a somewhat different picture, as there is no relationship between farm size and gross income per cropped acre in the three regions of Rawalpindi, Faisalabad and Multan. The relationship is positive in Gujranwala and negative in Thal region. One of the main reasons for the positive relationship in Gujranwala is that the large farmers use more irrigation water and spend more on seed and chemicals on a per cropped acre basis. In the case of Thal the negative relationship is due to the fact that larger farm categories not only use less inputs per cultivated acre but they also do so on per cropped acre (see Correlation coefficients in Table 6).

As regards production per acre of major crops, Table 7 shows no statistically significant association of production per acre of crops with farm size in most of the cases. The only exceptions are Thal in case of wheat—negative relationship, and Faisalabad in case of rice—a positive association. In case of overall analysis on Punjab basis, the coefficients suggest that there exists a positive association between rice yield per acre and farm size, while cotton productivity per cropped acre is negatively associated with the size of farm. The other coefficients do not characterise any significant association.

Table 6

Correlation Coefficients—Farm Size vs. Variables per Cropped Acre

Region	Gross Income	Fertiliser	Land Preparation	Irrigation	Seed	Chemicals
Rawalpindi	–0.08	–0.09	–0.13**	–0.01	–0.05	0.14**
Gujranwala	0.26**	–0.07	–0.08	0.41**	0.16**	0.39**
Faisalabad	–0.02	–0.30**	–0.23**	0.04	0.07	0.13**
Multan	–0.13**	–0.15**	–0.05	–0.03	–0.05	0.11**
Thal	–0.00	–0.35**	–0.24**	–0.25**	0.01	–0.01

** Coefficients are significant at the 5 percent level.

Table 7

Correlation Coefficients—Farm Size vs. Production per Acre of Major Crops

Region	Wheat	Rice	Cotton	Sugarcane	Maize
Rawalpindi	–0.01	–	0.24	0.08	0.10
Gujranwala	0.12	0.14	–	0.33	–
Faisalabad	–0.06	0.36**	–0.14	0.06	–0.18
Multan	0.004	0.04	–0.07	0.25	–0.34
Thal	–0.23**	–0.14	–0.02	0.12	–0.57
Average	–0.05	0.22**	–0.09**	0.08	–0.14

** Significant at the 5 percent level.

Small farmers stuck with their limited holdings try to fetch greater output per unit of cultivated land by intensive cultivation and thus generally have higher cropping intensities—the ratio of total cropped to cultivated land (Table 8). This is achieved through irrigating high proportion of their total cropped area and generally by intensive use of other inputs (Table 6) especially human labour at their disposal. The latter is evident from the high and negative correlation coefficients between farm size and the number of family members per cultivated acre given in the last column of Table 8. The small farmers are thus in a better position to tackle different chores in the production process in time. Small farmers also keep a larger number of animals per acre of cultivated area as is shown by high negative correlation coefficients in Table 8. A large stock of animals acts as a hedge against financial hardships for poor small farmers. It also provides animal waste, which is an important source of organic manure that helps in conserving long-term soil fertility, improving soil structure and restoring the micro nutrient balance to the soil on intensively cultivated small farms.

Table 8

Average Cropping Intensities over Various Farm Size Categories and Regions

Region	≤5 Acres	>5 to 12.5 Acres	>12.5 to 25 Acres	>25 to 50 Acres	>50 Acres	Aver-age	Correlation Coefficients—Fsize vs.: Crop Intensity	Livestock/Acre	Family Memb./Acre
Rawalpindi	123	90	66	22	–	110	–0.49**	–0.50**	–0.90**
Gujranwala	182	156	157	178	–	173	–0.36**	–0.35**	–0.91**
Faisalabad	159	145	129	111	125	149	–0.34**	–0.41**	–0.86**
Multan	180	166	161	164	138	173	–0.25**	–0.42**	–0.85**
Thal	150	124	100	102	166	126	–0.39**	–0.34**	–0.89**
Average	166	149	134	128	140	155	–0.30**	–0.44**	–0.87**

** Significant at the 5 percent level.

5. SUMMARY AND POLICY IMPLICATIONS

The existence of inverse relationship between farm size and total value of output per cultivated acre is established for the overall Punjab province but not for all of its regions. In fact, Gujranwala and Multan regions show no significant association. The causal factors for the inverse relationship are a more intensive use of inputs per cultivated acre as well as a high level of cropping intensity on small farms. The inverse relationship between output per acre of crops with the farm size was not found for all crops. In fact, rice and sugarcane have exhibited the opposite relationship, i.e., a strong positive association between the farm size and productivity. Technical efficiency is positively related with the farm size implying that the larger farmers realise greater potential output from the given level of inputs and technology.

Given the results of our analysis, one cannot make a case for redistributive land reforms on the grounds of farm size and land productivity inverse relationship. Consequently, pursuing a distributive land reform policy based on only this lineage would not help in attaining the objectives of poverty alleviation and increasing agricultural production. On the contrary it would lead to worsen the situation in the era of modern technologies [Dyer (1991)]. On account of the results of this study and some of the other related work on Pakistan agriculture reviewed in this paper, it is imperative to increase the managerial skills of the farming community. There is a special need to focus on small farms to enable them to adopt the new production technologies. This would help the small holders to produce the same output by using less inputs and therefore at lower costs. For the farm sector, overall output per unit of land can be increased by 14 percent in Gujranwala and by 38 percent in Rawalpindi from the same resources by improving the farmers' managerial skills.

The factors responsible for low technical efficiency have not been analysed in the present study due to lack of relevant data. However, the literature suggests that various measures could be considered to achieve higher efficiency levels and greater productivity. Farmers' education is one of the most important factors to achieve this objective. An educated farmer is always in a better position to have access to new information and thus, to new technologies. He is also likely to be more receptive to new innovations.

The agricultural extension system needs to be reformed to ensure that it provides equal access for all segments of population as far as information on agricultural technologies is concerned to achieve higher output potential. The literature further suggests that consolidation of land holdings and timely provision of agricultural credit help in increasing the technical efficiency of the farmers.

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Comments

The paper provides a recent empirical evidence of inverse relationship between farm size and total value of out put per cultivated acre. The results of the study revealed that inverse relationship between farm size and productivity have been established for the overall Punjab province and for all regions except Gujranwala and Multan. The authors have highlighted that this relationship holds due to intensive use of inputs per cultivated acre as well as high level of cropping intensity for small size farms. The results further revealed that inverse relationship between farms size and productivity is not found for all crops rather rice and sugarcane depicted the opposite relationship. The authors further found that technical efficiency is positively associated with farm size as the larger farmers realise greater potential output from the given level of resource use and technology.

The hypothesis tested by the authors is not new. In the early 50s, the case for land reform was advocated on the basis of negative relationship between farm size and productivity. However, the land reforms enacted in 50s and 70s were based on political considerations rather than economic consideration and on farm size productivity relationship. The empirical evidence has become inconclusive regarding the hypothesis tested by the authors both in India and Pakistan. The literature fully demonstrates this view. The empirical evidence further revealed that farmers are technically efficient and allocatively inefficient thus economically inefficient. But the authors have provided evidence on the contrary that only large farm size are technically efficient. The authors have used dummies along with quantitative variables making the analysis straight-jacketed with inconclusive evidence on the widely held hypothesis i.e. inverse relationship of farm size with productivity. The other constraining factor in the analysis is that the authors have used individual crops whereas the existing farming system comprises livestock, fisheries, poultry etc. Had the dependent variable been total farm productivity the results may have been different.

The authors have rightly concluded that a case for land reforms on the basis of inverse relationship between farm size and productivity alone cannot be made. The evidence is well in place to support this conclusion. I would therefore suggest that Pakistan should introduce agrarian reforms rather than land reforms that the law of inheritance is taking care of in a natural process.

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