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‘FARM SIZE – PRODUCTIVITY’ RELATIONSHIP
Recent Evidence from Central Punjab

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Abstract. The main goal of this study is to test and evaluate the existence of ‘inverse farm size – productivity’ hypothesis based on a random sample of 302 farmers from six districts of central Punjab of Pakistan. The study is designed to evaluate the productivity status of small and large farm categories based on their output and resources allocation. In this regard, econometric analysis is performed on small and large farms for four major cash crops. This study confirms the inverse farm size and productivity relationship in the sample area, though relative use of inputs and resulting output differ along farm size.

Keywords: Farm size, Productivity, Inverse relationship, Small and large farms

JEL classification: Q12, Q15, Q16

I. INTRODUCTION

In development economics, an ongoing debate on farm size and productivity inverse relationship (IR) exists. It is argued that small farms are more efficient as these can use more efficiently resources like family labour with enhanced capability to closely monitor their production activities. Sen (1962) is the first to discover that productivity per acre decreased with increase in size of holding in India. He found empirical evidence regarding small farmers’ relative superiority with regard to per unit land productivity over large farmers largely based on aggregated data. Subsequently, he gave

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technique-based, labour-based, and fertility-based three alternative lines of explanation for this phenomenon. However, the statistical validity of the 'inverse relation' has been challenged in early 1970s by his contemporaries in the region, who based on analysis of dis-aggregated data relating to individual holdings, came up with results contradicting the hypothesis that yield per acre falls as farm size increases (Fan, 2003; Sridhar, 2007). It resulted in commencement of debate among researchers of various regions in the world. In the next two decades, rapid movement of industrialization in Asian countries resulted in urbanization led to demand for labour from rural areas; small labour intensive farms are reckoned as a major obstacle in this process as. In addition, the availability of cheaper modern inputs like fertilizer, pesticides, farm machinery etc. that reduced the labour demand rapidly in the peak seasons, small size farms became less productive when accounted for the opportunity cost of labour. Hence, with the advent of the Green Revolution, researchers showed that the inverse relationship between farm size and land productivity is diminished or even reversed, as agriculture becomes more capital intensive. Therefore, there is an appeal for larger size of farm in the 1970s and 1980s started in these countries (Helfand, 2003; Rios and Shively 2005).

In the last decade of twentieth century, "the small is beautiful" view once again started to gain importance. In 1980s, agricultural production had become more diversified into high value commodities. Old cropping patterns had improved, for example, from cereals to cash crop, from crop to horticultural and livestock products, in which small farms again started to gain comparative advantages over the large farms. Furthermore, big farms are input (fertilizer, pesticides, weedcide, etc.) intensive that led to the degradation of their natural resource. Considering these externalities, large farms are no longer in lead in productivity and efficiency as compared to small farms.

An analysis of cost structure, production practices and output may help in identifying the constraints faced by the farming community in increasing their farm incomes. In face of the scarcity of farmland and constraints of extensive farming, the significance of increasing productivity may not be taken too lightly. Higher agricultural productivity will lead to quicker growth, rural jobs and resources for industrial progress along with food supply to ever-increasing population. This study aims to evaluate an economic relationship between farm size and productivity and to identify structural and technological differences between small and large farmers based on resource endowments, productivity and profitability. The results of this study would be quite beneficial in shedding some light on various policies relating to agrarian structure, access to credit, prices and subsidies. While the results of study would mainly be applicable for the farming community of the central area of the Punjab province, the generalization of the results could be relaxed, perhaps, to the overall farming community of Punjab.

SCOPE OF THE RESEARCH

According to 1990 World Agricultural Census (FAO, 2001), average farm size was 1.6 hectares in both Africa and Asia, which showed the dominance of small forms in the region. In Africa, the average size of land holdings decreased from 1.5 hectares in 1970 to 0.5 hectares in 1990. In China, the average size of land holdings decreased from 0.56 hectares in 1980 to 0.4 hectares in 1999 (Fan and Chan-Kang, 2003); in Pakistan, it steadily declined from 5.3 hectares in 1971-73 to 3.1 hectares in 2000, consequently, the number of small farms rose to more than triple during the period.

Pakistan's agriculture has many features among which the magnitude of the farm size is the most important. Over the past few decades, the farm size has decreased mainly due to inheritance and transfer. The growing increase in the number farms might be due to combine effect of institutional, technological and demographic factors.

About 94.47 percent of the total 5.07 million farms have an area of less than 12.5 acres while only 5.53 percent of the total farms have an area of more than or equal to 12.5 acres in Pakistan. While in case of Punjab, out of the total 3.86 million farms with total farm area of 27.83 million acres, small farms constitute about 85 percent of the total farms accounting for 47 percent of total farm area. Whereas, only 0.58 million farms have an area greater than or equal to 12.5 acres accounting for about 53 percent of total farm area. Above 50 present rural populations in Pakistan is landless while 2.5 percent big farmers have one third of agricultural farms exceed 50 acres (Gop, 2004). The area covered in this survey consists six districts situated a little above the center of Pakistan' Punjab, which is thickly populated area. The results of the study can easily be applied to situation of whole Punjab.

SAMPLE

The data are collected from 302 farmers of six districts Sialkot, Gujranwala, Sheikhupura, Faisalabad, Jhang and Toba Tek Singh using random sampling technique on a pretested questionnaire; 184 small and 118 large farmers for the 2005-06 cropping year. Farmers with land holdings < 12.5 acres are treated as small farmers while those with land holdings ≥ 12.5 acres as large farmers.

II. LITERATURE REVIEW

Over the last few decades, the policy debate on the choice of agrarian structure and performance of small versus large farms led to creation of vast literature based on data from South Asia, Latin America and Africa. In most of these countries, the agrarian structures are such that the distribution of land is highly skewed toward large farms. Although the inverse relationship between farm size and land productivity had been found in various countries, the literature has focused mainly in India. We present an appraisal of empirical evidence on the farm size-productivity relationship and try to evaluate the causes that may clarify the lack of consensus on this debate.

Sen (1975) proposed a theory of agricultural dualism, where the ‘traditional’ small-scale peasant sector is supposed to be gifted with abundant family labour with almost zero opportunity cost, while confronting an acute shortage of capital. Whereas large-scale ‘modern’ or ‘capitalist’ sector depends on more costly hired labour and has good access to credit which amounts to former relatively labour-intensive and the later relatively capital-intensive. Hence, inverse relationship established a basic argument for redistribution of land, which tended to alleviate inequality in the agricultural holdings across farmers, which might improve efficiency and rural growth (Lipton, 1993). The same argument can explain the determinants of rural-urban migration called push factors that are poverty, landlessness and joblessness in the rural areas.

The opinion that large farms benefited unduly from the green revolution might be triggered initially by quicker adoption of the technology by the large farmers due to their better capacity and access to capital inputs. However, once the paybacks of the new techniques had been established, the small farmers equally utilized them (Goldman and Smith, 1995). Empirically, it has been demonstrated that the inverse relationship cannot exist not due to factors like labour market imperfections, diminishing returns to scale etc., which are generally considered less vulnerable but due to intertemporal price risk. The alternative explanation is based on three empirical facts that are common characteristics of low-income agriculture. First, farmers could not fully evade uncertain staple crop prices through futures contracts or by forward sales before the commencement of the crop at the time, they make decision about inputs allocation. Such decisions are made as they are risk averse with regard to both income and consumer prices. Second, land distribution among agricultural population is uneven and thus also the land endowments. Third, households’ net agricultural purchases are also inversely related to farm size as small farmers are net produce purchasers while large farmers are net sellers (Barrett, 1993). The well-established inverse farm size and productivity relationship is generally expounded in terms of decreasing returns and the existence of frictions in the land, capital, labour or insurance markets that inhibit the efficient allocation of land across farms. The analytics do not consider the potential significance of overlooked heterogeneity in farmers' expertise quality and self-selection through job-related choice. There is dire need to demonstrate a discrete choice consumption function that may decide, at a given level of endowment assuming constant returns, skillful peasants are expected more to become farmers than unskillful peasants. Even in the nonexistence of decreasing returns, a differential explanation for the inverse relationship using endogenous work-related choice and disparities of farming skills can be provided empirically (Ghatak and Assunc, 2003). Thus, the opportunity cost of a skillful peasant to turn into a wage worker is reckoned as very high.

Farm size is usually considered the physical size of land held in operation. It has been proved that a regression equation leads to biased estimates and mistakenly leads to an inference that there had been diseconomies of scale in land use, when conventional definition of size of a farm is used as measure of form size (Sampath, 1992). It happens, when the total operational area is dichotomized in the analysis into irrigated and no irrigated land, because of implicit assumption that a unit of irrigated piece of land had the identical cropping intensity potential than a unit of no irrigated piece of land. Using the similar type of dataset, Fan (2003) demonstrated that there were no diseconomies of scale in use of land when the operational holding is dichotomized into irrigated and no irrigated land in the econometric model. Therefore, this led to further examining the relationship between various structure of land size and various variables on the soybean productivity among owner-operated and share cropper-operated farms. Primary data for Madhya Pradesh for the 1999 rainy season crop was used and productivity of owner-operated and trial farms was found higher than sharecropped farms. The celebrated inverse-relationship was found again for both owner-operated (r = 0.27) and share cropper-operated (r = 0.30) farms (Wani *et al.*, 2006).

In the recent past, the evidence was found again in models that allow and do not allow for village dummies (as cluster controls), the fraction of irrigated land (as proxy for land worth) and socio-economic characteristics — households caste, education, size of family etc., as proxy for access to capital. The socio-economic variables were unable to support the evidence (*i.e.* whether the relationship was due to variation in regions or access to capital). The overall result supported, in the household data drawn from a survey from Nepalese mid hills, perhaps due to more use of other inputs by small farms rather than diseconomies of scale[1] (Sridhar, 2007).

With the help of more sophisticated, less restrictive, more informative, more powerful than alternative methods and newly developed Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) techniques came into practice for technical and cost efficiency and productivity measurement with advent of new century. These efficiency techniques adopted by researchers, started to demonstrate differentiated results according to different condition and assumptions imposed on the parameters of production function. Contrastingly, while surveying the farms in two districts of Dak Lak Province to study the technical and cost efficiency of small coffee farms in Vietnam, Rios and Shively (2005) found that small farmers were less efficient than big farmers. In a two-step analysis, measuring technical and cost efficiency by DEA and then running Tobit regressions to find factors correlated with technical and cost inefficiencies, they observed that small farms emerge partly inefficient to investments in irrigation infrastructure. For a group of Honduran farms, diminishing returns to scale renders smaller farms more economically efficient overall, despite the relative technical efficiency of larger farms using DEA (Gilligan, 1998). Helfand (2003) demonstrated a pioneering result, while studying determinants of relationship between technical efficiency and farm sizes using DEA, that the relationship between farm size and efficiency was not linear but a quadratic parabola — with productivity first dropping and then increasing with size. He also found that access to institutions, credit, and modern inputs etc. were key factors responsible for the differences in efficiency across farms and concluded that improvement in these factors could reinforce the efficiency improvement of small and medium size farms.

As, mentioned earlier, some of the previous studies have shown that small farmers are more efficient and productive than large ones. Using 'inverse farm size – productivity relationship' as the basis, it has been argued that land reforms that would pave the way for more equitable distribution ought to be adopted to help agriculture utilize its full potential in terms of higher output, larger income and wider employment. Yet, there are others studies arguing that the 'inverse farm size – productivity relationship' does not exist anymore or has reversed over time, primarily due to the adoption of perched inputs and labour replacing farm machinery. Differences in productivity and structure of agriculture under heterogeneous conditions are

[1]As the application of Cobb-Douglas (CD) technology found constant returns to scale.

quite evident. However, production variability within narrow limits on farms under homogeneous conditions may also be there due to variation in resource endowment, technology and structure. Nevertheless, how much large should be the range of variation, is a matter of concern. The factors responsible for variation in productivity on small and large farms thus need to be investigated in a comprehensive manner. In any case, whether an inverse relationship still prevails or absent is an empirical question that can be settled only with recent data sets.

III. RESEARCH HYPOTHESES

For studying the superiority of comprehensive income to net income for firm performance, we test the following hypotheses:

H_1: The relationship between Gross farm income per farm per acre in Rs. and Value of family labour, Cost of hired labour, land, Capital inputs, per farm in Rs. is significant.

H_2: There are no structural and technological differences between small and large farms.

H_3: The relationship between the value of production per acre and the acres of operational holding was significantly negative.

H_4: The relationship between the value of production per acre and the acres of canal irrigated operational land holding is significantly negative.

H_5: The relationship between the value of production per acre and the acres of tubewell irrigated operational land holding is significantly negative.

IV. RESEARCH METHOD

LABOUR COSTS

Data regarding labour and payments to casual hired labour allocated to each crop are collected. For family labour, opportunity cost of family labour was taken equal to the earnings of a permanent hired labour according to the prevailing rates. The cost of permanent hired labour was estimated by adding the amount paid in cash, value of wages paid in kind, value of food provided, and value of clothes, tobacco and fodder as well as the value of other miscellaneous payments paid by the landlord.

CAPITAL INPUT COSTS

Capital inputs include the charge for relatively fixed inputs like draught animals, hand tools, farm machinery and equipment: For draught animals, the interest and depreciation on the capital value of draught animals is used to estimate their cost. The cost of farm machinery and implements, in case of ownership, includes the capital cost and depreciation on investment plus fuel cost, labour cost and repair and maintenance.

CASH INPUT COSTS

Cash inputs include the relatively variable inputs with respect to crop and season. These include seed, manure, fertilizer, payments to artisans, land revenue, water rates, and hired farm machinery. For home produced seed and manures, the prevailing price at the time of sowing and actual amount spent on purchased seed and manure are used. For fertilizers, the market price plus transportation and application cost for each crop are used. For land revenue and water rates, the actual amount paid to the Government of concerned crop is taken into account. The cost of hired farm machinery and implements is the value paid for hiring them.

LAND INPUT COST (LAND RENT)

Land rent based on duration of the crop (market basis) is calculated by the formula used by Manan (2001) as under:

$$RPA_i = \frac{AR}{TCM} \times NMC_i$$

Where

RPA_i = Rent per acre for the i^{th} crop.

AR = Average rent prevailing in the village of one acre for a year.

NMC_i = Number of months the i^{th} crop is in the field.

TCM = Total crop month on the farm, calculated as under.

$$TCM = \sum_{i=1}^{n} A_i DCM_i$$

Where

A_i = Area under the i^{th} crop.

DCM_i = Duration of the i^{th} crop in months.

MODEL SPECIFICATION AND H_1 TESTING

To evaluate the variability between small and large farm categories, following function is developed for the pooled data:

$$\ln Y = \alpha_0 + \beta_1 \ln(\text{FAM}) + \beta_2 \mu \ln(\text{RVL}) + \beta_3 \ln(\text{CASH}) + \beta_4 \ln(\text{CAP}) + \beta_5 \ln(\text{HIRL}) + \mu \quad (1)$$

Where

ln = Natural logarithm

Y = Gross farm income per farm per acre in Rs.

FAM = Value of family labour per farm in Rs.

RVL = Rental value of land per farm in Rs.

CASH = Cash inputs per farm in Rs.

CAP = Capital inputs per farm in Rs

HIRL = Cost of hired labour per farm in Rs.

μ = Error term

α, βs = Parameters of the model

For comparison and testing of structural and technological differences, separate functions for small and large farm groups are also estimated using Chow's F-test and its value is computed by the following formula:

$$F^* = \frac{\dfrac{S_p^2 - \left(S_S^2 + S_i^2\right)}{K}}{\dfrac{\left(S_S^2 + S_i^2\right)}{\left(N_S + N_1 - K\right)}}$$

Where

F^* = Calculated value of Chow's F.

S_p^2 = Pooled residual sum of square.

S_S^2 = Residual sum of square for small farms.

S_i^2 = Residual sum of square for large farms.

N_S = Number of small farms.

N_1 = Number of large farms.

K = Number of parameters.

The hypothesis tested is H_2:

H_0: Regressions for small and large farmers are statistically same. Against.

H_2: Regressions for small and large farmers are not same, *i.e.* there are no structural and technological differences between small and large farms statistically.

H_3 TESTING RELATING FARM SIZE AND PRODUCTIVITY

To test farm size productivity relationship following simple regression is applied as used by Heltberg (1996):

$$Y = \gamma_1 \log (\text{OPHOLD}) + e_i \qquad (2)$$

Where Y is the value of production per acre and OPHOLD is the acres of operational holding.

TESTING H_4 AND H_5 RELATING FARM SIZE AND PRODUCTIVITY WITH MODE OF IRRIGATION

To facilitate the results of the analysis equation (2) is also relaxed to account for the canal irrigated and tubewell-irrigated area as well, *i.e.*

$$Y = \delta_2 \log (\text{OPCANIR}_i) + \delta_2 \log (\text{OPTWIRR}_i) + \varepsilon_i \qquad (3)$$

Where OPCANIR and OPTWIRR are the acres of canal irrigated and tubewell-irrigated land operated respectively while ε_i is the error term.

THE OTHER TESTS: ESTIMATION OF GROSS MARGIN, PRIVATE PROFITABILITY MARGIN AND COEFFICIENT OF PRIVATE PROFITABILITY

To know the variability between the two farm categories, in terms of profitability for each group, gross margin, private profitability margin (PPM) and coefficient of private profitability (CPP) are estimated. Gross margin is helpful in comparing the efficiency of farms in the short run and it is calculated by deducting the variable cost from gross income. Private profitability margin shows the profit or loss in absolute terms and it is calculated by subtracting the total cost from gross income. Similarly, the co-efficient of private profitability shows the profit or loss in relative terms. It is obtained by dividing the gross income by the total cost. Its value above 1.00 shows the product is profitable for the farmer to produce while the value below 1.00 indicates lack of profitability.

SOURCE OF DATA

The data are collected from 302 farmers of six districts Sialkot, Gujranwala, Sheikhupura, Faisalabad, Jhang and Toba Tek Singh using random sample on a pretested questionnaire. Information about socio-economic characteristics, cultural practices, input use and various outputs is collected and various cost items involved in the farm enterprise are estimated as under.

V. RESULTS AND DISCUSSIONS

SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

Table 1 portrays the socio-economic and general characteristics of the respondents of the study area. It is evident that there is significant variability in most of the characteristics between the two 'farm categories except for the age, land use intensity, and percentage of the farmers using only Canal water for irrigation purpose.

TABLE 1

Socio-economic Characteristics of the Respondents of the Study Area

General Characteristics	Small	Large	All
Age (years)	45.10	43.53	44.48
Education (Schooling years)	5.63	7.64	6.41
Family labour units/cultivated acre	0.39	0.13	0.29
Permanent hired labour (No./acre)	0.02	0.02	0.02
Farm Characteristics			
Operational land holdings (acres)	6.48	30.13	15.72
Land use intensity (%)	96.34	87.60	92.92
C,'opping intensity (%)	181.58	176.99	179.79
Livestock inventory (AA U/CA*)	0.84	0.51	0.71
Tenancy status (percent Farmers)			
Owner (%)	47.68	21.85	69.54
Owner-cum-tenant (%)	10.26	13.91	24.17
Tenant (%)	2.98	3.31	6.29
Power source (percent Farms)			
Own tractor	9.60	20.20	29.80
Hired tractor	35.43	13.25	48.68
Hired tractor + bullocks	4.97	5.96	10.93
Irrigation source (percent Farms)			
Canal	4.03	3.36	7.38
Canal + Tubewell	25.50	18.21	43.71
Tubewell	22.52	13.25	35.76

*Adult Animal Units/Cultivated acre.

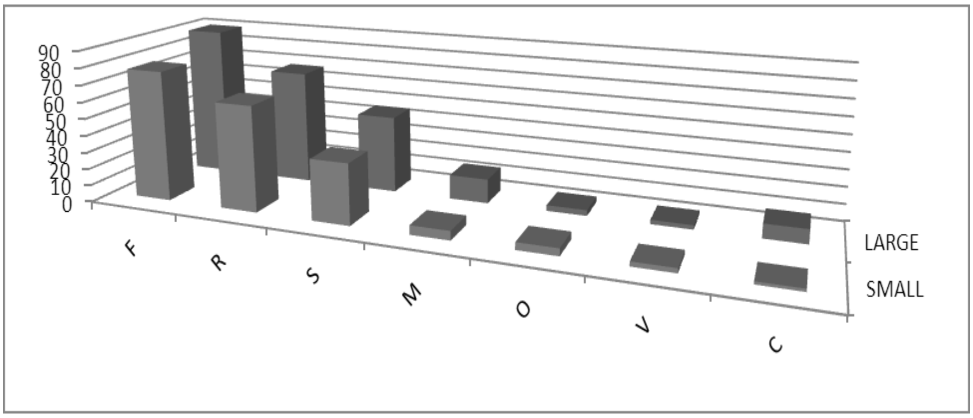
CROPPING PATTERN AND LAND ALLOCATION

1. Kharif Cropping Pattern

Kharif crops sown are cotton, sugarcane, rice, maize, vegetables, fodder, and kharif others like til (sesame) etc. About 4.3 percent of the total farmers are growing cotton, allocating an average area of 4.71 acres, which is 0.77 percent of the culturable area. About 40 percent farmers are growing sugarcane on an average area of 5.32 acres, which is 15 percent of the culturable area while about 65 percent farmers are growing rice on an average area of 11.50 acres, which is 42 percent of the culturable area. About 4 percent farmers are growing vegetables on an average area of 2.31. Similarly about 9 percent of the total farmers are growing maize on an average area of 6.20 acres of operational land. Others like til (sesame) etc. is grown by 4 percent of the farmers on an average area of 2.58 acres. About 82 percent farmers grew kharif fodder on an average area of 2.64 acres, which is 18 percent of the culturable area. There is a significant variation in the frequency of the farmers and their allocation of land to various crops by small and large farmers (Figures 1 and 2). In all cases, the number of small farmers growing kharif crops is less than that of large farmers, as is the case with land allocation to various crops, however, the percentage of the cropped area to the total operational area is relatively less for large farmers except for cotton.

FIGURE 1

Percentage of the Farmers Growing Kharif[2] Crops According to Farm Size Groups



[2]Where C = cotton, F = fodder, M = maize, O = other, R = rice, S = sugarcane, V = vegetables.

FIGURE 2

Percent Operational Area under Kharif Crops
According to Farm size groups

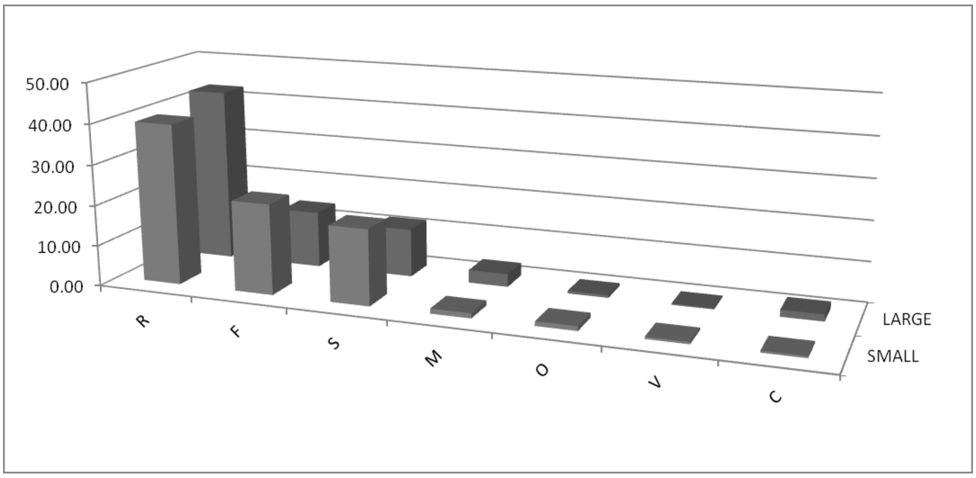
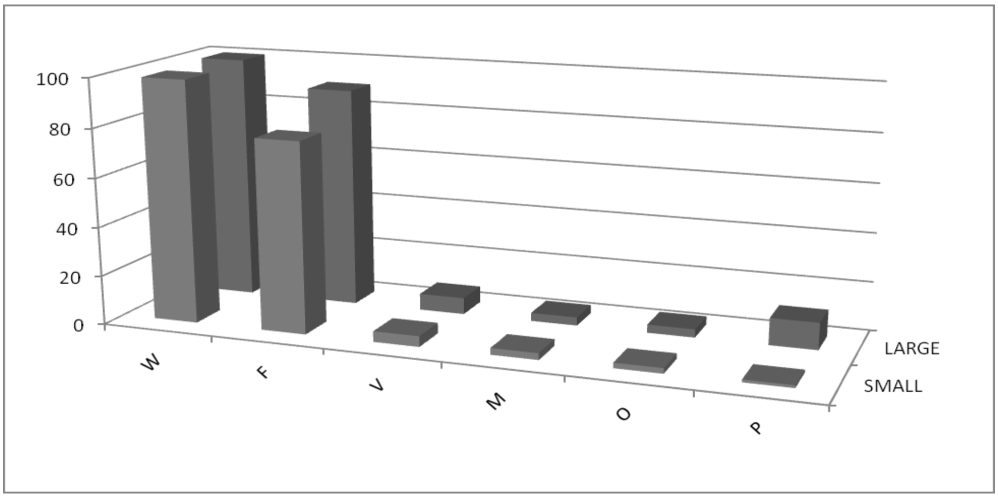


FIGURE 3

Percentage of the Farmers Growing Rabi[3] Crops
According to Farm Size Groups



2. Rabi Cropping Pattern

About all the farmers are growing wheat on their farms and they allocated a larger proportion of cultivated area to wheat crop. Small farmers allocated

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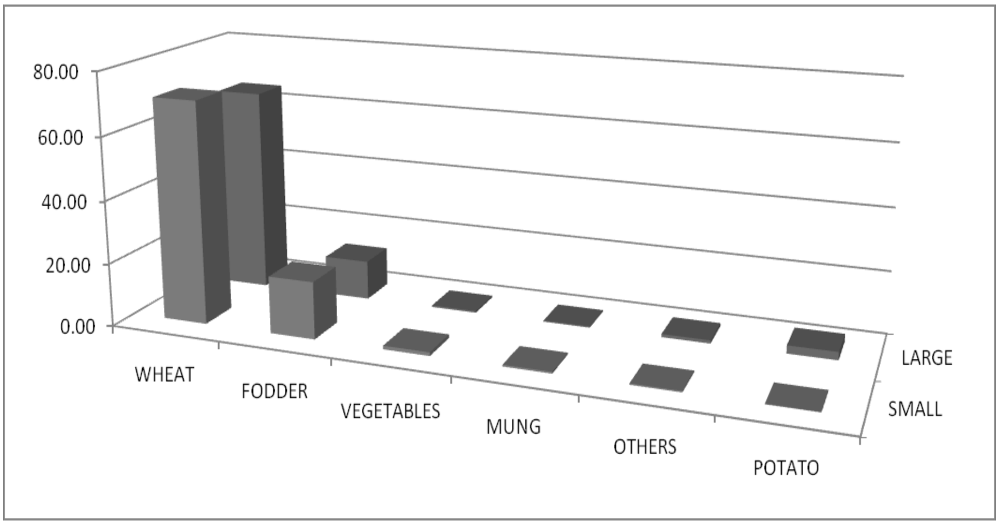
[3]Where F = fodder, M = mung, O = other, P = potato, V = vegetables, W = Wheat

about 71 percent of their operational area to wheat crop while all of the large farmers are growing wheat and they allocated about 65 percent of their operational area to this crop. A minor percentage of the large farmers also grew others like grams etc. Similar trend is found in case of some Rabi vegetables and potato. Nearly 83 percent of the total farmers grew berseem or other Rabi fodders on about 15 percent of their land holdings; large farmers allocating more land than the smaller ones. The percentage of the large farmers is more as compared to small farmers, as is the case for area under Rabi fodders (Figures 3 and 4).

FIGURE 4

Percent Operational Area under Rabi Crops
Relative to Farm Size Groups



3. Value of Output per acre and Farm Size Productivity Relationship

Value of output per cultivated acre differed along the farm size categories. There is an appreciable variation in the value of output on per acre basis between small and large farmers for the whole sample as well as on district basis during a cropping year (Table 2). It is clear that small farmers are not getting more per acre due indivisibilities of capital inputs. Taking the overall sample results, large farmers are getting about 1.3 percent higher put-put per operated acre. Table 3 provides an ample insight to develop a relationship between farm size and output per unit area, *i.e.* productivity. Similarly, the results depicted in Table 3 show an inverse relationship between farm size and productivity as value of output declined with increase in farm size. These results quite conform to the findings of Heltberg (1996).

TABLE 2

Value of Output per Acre in the Study Area

Districts and Type	Value of output per cultivated acre (Rs.)		
	Small	Large	All
Sialkot	33958.88	38163.30	35575.96
Gujranwala	35382.40	43998.87	37967.32
Shaikhupura	29877.27	33492.25	31612.48
Faisalabad	60224.16	57934.42	59674.62
Jhang	25194.68	30027.96	27374.37
Toba Tek Singh	32691.72	36647.54	34629.29
The Whole Sample (All 6 Districts)	37571.41	38071.69	37781.46

FIGURE 5

Value of Output per Acre in the Study Area

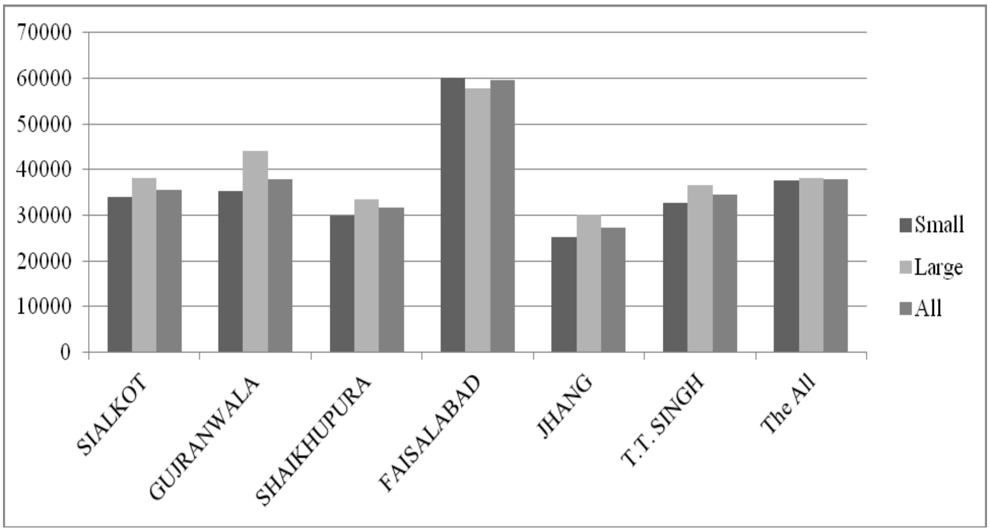


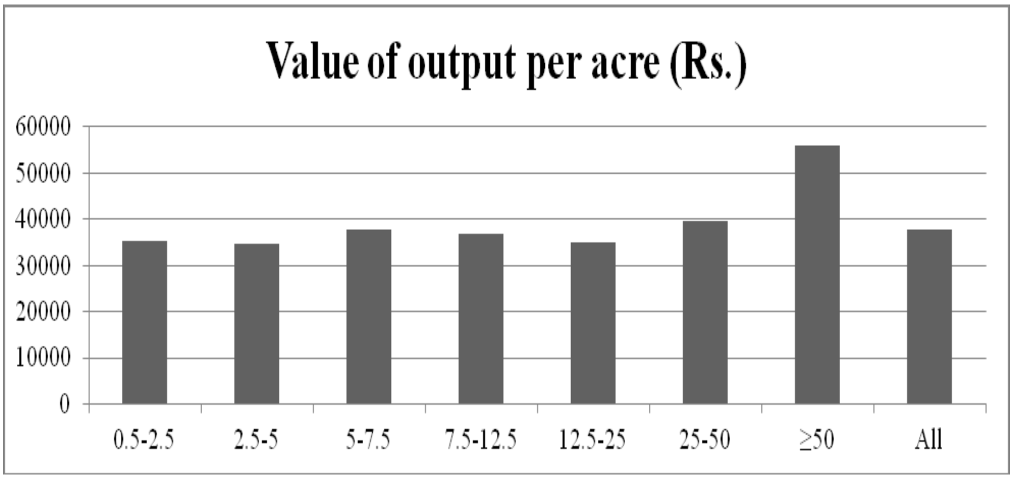
TABLE 3

Value of Output for Various Farm Groups in the Study Area

Total = 37781.5							
Farm groups (acres)	0.5-2.5	2.5-5	5-7.5	7.5-12.5	12.5-25	25-50	≥ 50
Value of output per acre (Rs.)	35242.8	34625.4	37749.0	36863.0	35099.2	39535.6	55914.7

FIGURE 6

Value of Output for Various Farm Groups in the Study Area



THE RESULTS OF HYPOTHESES (1) TESTING

Using pooled data for both small and large farmers, the function in equation (1) is estimated using OLS estimation procedure. Coefficient for family labour is positively related to total output but its contribution is minimal. The coefficients of family labour, hired labour and cash inputs are significant at 95 percent level of confidence and are positively related to output per farm per acre. The results are summarized in Table 4.

TABLE 4

Results of the Pooled Regression Analysis

Model	Coefficients	Std. Error	t-Statistic	P-Value
Constant	12.471	0.642	19.422	0.000
ln (FAM)	0.202	0.025	8.168	0.000
ln (RVL)	0.000	0.023	–0.013	0.990
ln (CASH)	0.089	0.024	3.697	0.000
ln (CAP)	–0.712	0.030	–24.006	0.000
ln (HlRL)	0.247	0.049	5.003	0.000
R^2 =	0.92	$\overline{R}^2$ =		0.91
Durbin-Watson Stat =	1.61	RSS =		8.19
F-Stat =	647.8			

The coefficient land value and capital inputs have negative relation with output. The capital inputs are strongly significant whereas land value is not significantly affecting the output. The coefficients of capital inputs and cash inputs are highly significant at even 99 percent level of significance but they have negative signs. Results of regressions for small and large farmers are appended in Tables 5 and 6.

TABLE 5

Regression Results for Small Farms

Model	Coefficients	Std. Error	t-Statistic	P-Value
Constant	11.324	0.858	13.201	0.000
ln (F AM)	0.271	0.027	10.141	0.000
ln (RVL)	–0.020	0.023	–0.879	0.381
ln (CASH)	–0.002	0.025	–0.073	0.942
ln (CAP)	–0.698	0.030	–23.110	0.000
ln (HIRL)	0.363	0.070	5.171	0.000
R^2 =	0.94	$\overline{R}^2$ =		0.94
Durbin-Watson Stat =	1.42	RSS =		2.73
F-Stat =	539.7			

TABLE 6

Regression Results for Large Farms

Model	Coefficients	Std. Error	t-Statistic	P-Value
Constant	11.502	0.806	14.273	0.000
ln (FAM)	0.178	0.033	5.433	0.000
ln (RVL)	0.017	0.033	0.503	0.616
ln (CASH)	0.126	0.033	3.774	0.000
ln (CAP)	–0.540	0.049	–11.019	0.000
ln (HIRL)	0.127	0.055	2.325	0.022
R^2 =	0.67	$\overline{R}^2$ =		0.66
Durbin-Watson Stat =	1.66	RSS =		2.68
F-Stat =	46.08			

THE RESULTS OF HYPOTHESES (2) TESTING, *i.e.* TESTING FOR STRUCTURAL AND TECHNOLOGICAL VARIABILITY, CHOW'S F-TEST APPROACH

To test the presence of structural and technological variability, equation 1 is estimated using pooled data for full sample. Then separate functions for small and large farms are estimated to test the variability using Chow's F-test approach. Regressions results for pooled data, small farms and large farms data are utilized in the Chow's F-test. The calculated value of F* is as under:

$$F^* = \frac{\dfrac{8.19-(2.73+2.68)}{6}}{\dfrac{2.73+2.68}{290}}$$

$$= \frac{[8.19-(2.73+2.68)](290)}{6(2.73+2.68)}$$

$$= 24.83^{**}$$

If α is fixed at the 5% level, the critical *F** (6,290) = 1 with p-value *F** dist (24.83, 6,290) = 000. Moreover, since the observed value of *F** is 24.83, null hypothesis can be rejected implying that the regressions for small and large farms are statistically not the same. Therefore, it can be concluded that the two farm groups are structurally and technologically different. This result is similar to some earlier results of Sharif *et al.* (1990) implying those small farmers are different in structure and technology to that of larger farmers.

THE RESULTS HYPOTHESES (3) TESTING RELATING FARM SIZE AND PRODUCTIVITY

Regressing value of output per unit of cultivated area against the log of operational holding confirmed a negative relationship between farm size and productivity. Further, this regression analysis is also relaxed to account for canal and tubewell irrigated area to know exact mechanism for both categories of land. The results of these regressions are provided in Tables 7 and 8.

It is evident from the results of the simple regression in Table 4 that there is an inverse relationship between farm size and productivity for full sample and it is significant at 95 percent confidence level. The negative coefficient suggests that productivity decreases with per unit increase in the operational area.

TABLE 7

Simple Regression of Output per Acre

For Variable LNOPHOLD	Sample	Cons-tant	Coeffi-cient	SE	P-Value	R^2
Sialkot	52	11.61	-0.55	0.03	0.00	0.87
Gujranwala	50	11.53	-0.52	0.04	0.00	0.78
Shaikhupura	50	11.60	-0.54	0.04	0.00	0.80
Faisalabad	50	11.60	-0.52	0.04	0.00	0.82
Jhang	51	11.61	-0.51	0.05	0.00	0.68
Toba Tek Singh	49	11.79	-0.50	0.05	0.00	0.69
Full Sample	302	11.62	-0.52	0.02	0.00	0.75

TABLE 8

Multiple Regression of Output per Acre for Full Sample

Variable	Constant	Coeffi-cient	SE	t-stat	P-Value
log (OPCANIR) $n = 108, R^2 = 0.79$	11.52	–0.51	0.03	–20.06	0.00
log (OPTWIRR) $n = 18, R^2 = 0.82$	11.75	–0.51	0.06	–8.57	0.00

THE RESULTS HYPOTHESES (4 AND 5) TESTING, *i.e.* RELATING FARM SIZE AND PRODUCTIVITY WITH MODE OF IRRIGATION

About similar sort of relationship is observed when accounting for canal and tubewell irrigated area. The coefficient for tubewell-irrigated area is stronger than that of canal-irrigated area (Table 5). It may be due to the fact that the underground water may be brackish or salty in nature. Moreover, the canal water is more benefiting in most of the cases than the tubewell water. Similarly, canal water is cheap and hence it reduces per acre cost of irrigation.

FARM SIZE AND PROFITABILITY

Gross margin, private profitability margin and coefficient of private profitability are estimated for major crops, mainly grown for commercial purpose, such as cotton, wheat, rice and sugarcane in order to determine and identify the most beneficial crops (Table 9).

TABLE 9

Gross Margins, Private Margins and Coefficient of Private Profitability

Crop	Farm Category		
	Small	Large	All
Gross Margin (Rs.)			
Wheat	3931.99	5083.93	4385.09
Cotton	4958.37	2478.00	3050.39
Rice	7292.80	9547.54	8217.82
Sugarcane	19832.33	17038.17	18574.96
Private Profitability Margin (Rs.)			
Wheat	2119.77	4694.27	3132.40
Cotton	-2802.73	613.725	-174.69
Rice	3467.77	8295.00	5448.17
Sugarcane	12616.20	14375.22	13407.75
Coefficient of Private Profitability			
Wheat	1.22	1.49	1.33
Cotton	1.66	1.40	1.46
Rice	1.37	1.75	1.53
Sugarcane	1.80	1.80	1.80

Coefficient of private profitability shows that cotton is not profitable to grow for both farm groups while sugarcane had greater profitability values for both farm categories. Wheat and rice had greater values of gross margin, private profitability margin and coefficient of private profitability for small farms whereas sugarcane and cotton had greater values in case of large farms.

VI. SUMMARY AND CONCLUDING REMARKS

Mean farm size of the overall sample of farmers is about 13.14 with small farmer having mean around 6.18 acres and large farmers having mean farm size about 23.85 acres with large farmers having about 386 percent more operational holdings than the small farmers. About 80 percent farmers used canal and tubewell water for irrigation while there are about 17 to 18 percent farmers who used only tubewell water for irrigation purposes. Family labour use is more on small farms than the large farms as the small farmers have surplus family labour and they employ relatively less hired labour. The land use and cropping intensities are higher for small farms. About all the farmers did grow wheat, Rabi and Kharif fodders. There is some variation in the yields of major crops for the two categories of farms. Value of output of all products per acre during a year varied significantly among the farm size groups. Small farmers are getting about 18.6 percent higher output than large farmers from one acre indicating an inverse relationship between farm size and productivity. Using a log linear function, the presence of inverse relationship is confirmed when using value of output per acre as dependent variable and log of operational holding as independent variable. Gross Margin, Private Profitability Margin and Coefficient of Private Profitability for major crops indicated the absolute and relative profitability of maize, sugarcane, rice, wheat and cotton in the descending order. When tested for structural and technological variability using Chow's F-test, it is confirmed statistically that the two farm groups are not same and these have varying nature of size, structure, input use, output, technology, resources and profitability.

VII. RECOMMENDATIONS

Findings of this study leads to the following suggestions to minimize the structural, technological and profitability gaps between small and large farms and to improve the productivity of both farm categories:

1. Although a number of land reforms have been done in the last 60 years in area without any significant changes occurred because those affecting by the reforms immediately transferred land to their near ones to avoid land transfer to the poor. Furthermore, the reforms are not done in the province where the mostly large former existed in number. The distribution of farm size remains skewed even after the reforms. The core conclusion of the inverse relationship is redistribution of land by taking from inefficient large farmers and giving to efficient small former such that the overall welfare of population of the area is increased through overall increase in productivity.
2. In addition, large farms get easier access to credit and capital inputs relative to small farms. Therefore, the majority of small farmers should be facilitated with easy access of to the essential agriculture inputs and be able to avail agricultural credit and other benefits without any restriction and heavy paper work from one window so that they are able to meet their capital requirements in time.

3. As small farmers are more efficient in their farming activities and are resource poor and capital deficient, which imply that these farmers must be provided special subsidized capital inputs like fertilizers, farm machinery, pests, seeds etc. on priority basis.
4. The big farmers must also be trained by especial research/extension programmes in order to use their inputs more sensibly and become more economically efficient.
5. As cotton crop is found less profitable to grow, mainly due to heavy infestation of insect pests, the farmers of the study area are advised to grow disease and pest resistant varieties of cotton while there is also an option of growing some alternative crops like mungbean and maize.
6. Simple education of small and large farmer is necessary so that they may be able understand and benefit from agricultural training/extension programmes initiated by government/private agencies. Raising the literacy level is an essential for the success in productivity and farming efficiency.
7. The productivity of tubewell-irrigated area is found less than that of canal-irrigated area, indicating tube well irrigation costly and less fertile than canal water that contains mud. The underground water may be unfit for irrigation due to the presence of salts and a hardpan underneath the topsoil, therefore, laboratory test water and must be facilitated by authorities.
8. Exchange of international knowhow in farming technologies (*i.e.* efficient international farmer face to face meetings) especially with neighbouring (with less language problems) countries is necessary whose farmers' productivity/yield is significantly high, even if large farmers start first due to expenses reasons, tickle down effect will ultimately reach the small farmers.
9. Inappropriate fertilizer and pesticide use, inadequate availability of quality seed, inadequate markets infrastructure and non-availability of adequate and costly farm power may be addressed through integrated efforts of agri-business private firms, government agencies, research organizations and the cooperative farming itself.

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