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DETERMINANTS OF FARM EARNINGS: A STUDY OF FIVE DISTRICTS IN RURAL PAKISTAN

(BACKGROUND PAPER FOR FOOD SECURITY STUDY IN RURAL PAKISTAN)

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INTRODUCTION

The analysis of rural household food security is invariably linked to agriculture as it remains the major source of income for most of the population. In a semisubsistence economy, households produce partly for their own consumption and partly for sales in the market. They purchase inputs such as fertilizer and seeds but they also use their own resources, such as land and labor. Hence, any changes in government policies affecting these household activities have consequences for farm production, farm earnings, as well as on labor supply and food consumption. It is on this premise that "agricultural household models" are formulated to predict the consequences of alternative sets of policies (Singh et al. 1986). While it is recognized that production-consumption decisions in semisubsistence households are linked, an integrated model of behavior for the agricultural household is not attempted at this stage. Instead, we shall use this first phase in the analysis to map out determinants of farm production and farm earnings, assuming for the meantime that production is separable from consumption decisions. At a later stage, when data for a complete cycle combining three agricultural years are available, an integrated agricultural household model for a multicrop environment will be tested.

The first part of this paper provides a brief description of the cropping pattern and yields of selected villages in five districts--

Faisalabad, Attock in Punjab, Dir in NWFP, Badin in the Sind, and Mastung/Kalat in Baluchistan--followed by discussions of crop profitability, the determinants of farm output in a multicrop environment, and finally, some policy implications.

FARMING SYSTEM APPROACH

The unit of analysis used in this study is the total farm households' output for the whole agricultural year covering rabi and kharif seasons. It is quite essential to treat multiple crop outputs in the production analysis since the farms in our sample are seldom specialized single-crop farms. Farmers are, therefore, treated as if they maximize profitability for the entire crop year while addressing other objectives for subsistence food, fodder needs, and cash incomes. In a multi-crop environment, interactions between various farm objectives are critical because of competition and complementarity of inputs. Production practices in one crop may depend on competing labor and draught power in other crops. Biological interactions over time between planting of rabi crop in relation to the harvest of a previous kharif crop is one type of interaction that has been pointed out in several farming system studies. For instance, in a study of the cotton-wheat zones in Punjab, Akhtar et al. (1986) found the conflicts of the dates of the planting of wheat in relation to the previous cotton crop. The delay in the harvest of cotton pushed the time of planting of wheat in large number of fields into December and January

--with a consequent decline in wheat yields by 50 percent of the normally planted wheat. However, the farmers were quite rationally choosing to plant wheat late to maximize productivity of the total cropping pattern: the returns to one additional cotton picking was substantially more than the value of wheat yield lost to planting.

CROPPING PATTERNS

The proportion of land planted to the main crops in the 1986/87 crop year are given by village in Tables 1 to 4. The dominant crops in Dir are wheat, barley, maize, and fruit (orchard). The proportion of wheat area to farmed ranged from a low of 27 percent in village Munjai to 94 percent in Malakand. Dir had the highest concentration of orchard, where 6 out of the 12 villages had about a third of the land cultivated with fruit. Faisalabad had higher proportions planted to wheat and sugar. In some villages, the cotton-wheat rotation was observed. Maize was also grown as fodder and as grain. Barseem plots in these areas were also common.

Badin is dominantly irrigated IRRI rice, while around 10 percent are devoted to wheat in the rabi. Sugarcane was grown in 13 of the 23 "dehs" in the sample. The villages in Mastung/Kalat region are growing mainly wheat and fruit, with onion, spices, and fodder as minor crops.

Table 2--Villages from NWFP (Dir) in sample

Name	Land Area[a]	Population	Wheat Area/ Farmed Area (Rabi 1986/7)	Wheat Yield (md/acre)	Barley Area/ Farmed Area (Rabi 1986/7)	Barley Yield (md/acre)	Percent Area to Fruit (Rabi 1986/7)	Maize Area/ Farmed Area (Kharif 1987)	Maize Yield (md/acre)
Katigram	5,050 (01)	7,000	61.7	8.1	24.1	6.5	0.6	86.0	2.9
Batan	1,000 (00)	1,104	40.2	7.8	26.9	5.9	0.0	89.6	3.3
Shah Alim Baba	900 (46)	1,365	49.7	10.3	30.1	9.3	0.0	90.9	2.8
Bakandi	500 (06)	1,000	71.2	11.2	10.3	11.5	0.0	83.3	3.4
Kamangara	2,500 (00)	200	87.2	14.7	11.7	5.9	0.0	97.2	1.3
Malakand	2,000 (50)	1,000	93.9	6.3	1.2	4.0	4.4	96.8	3.9
Khema	230 (35)	800	61.8	9.6	0.0	..	33.3	54.4	2.4
Khazana	1,200 (03)	700	50.0	4.2	16.7	6.0	33.3	0.0	..
Shahzadi	1,500 (33)	400	53.6	3.2	0.0	..	32.0	34.1	2.8
Munjai	150 (100)	1,732	26.6	9.2	1.3	4.0	50.7	16.8	3.5
Gasan	1,250 (48)	680	43.1	10.3	21.9	6.1	6.1	69.5	3.4
Khan Pur	1,000 (30)	1,975	73.8	12.9	2.3	16.7	8.0	67.1	5.2

[a] Number in parenthesis indicates percent of land irrigated.

Table 3--Villages from Punjab in sample (Attock and Faisalabad)

Name	Land Area	Population	Percent Wheat Area (Rabi 1986/7)	Wheat Yield (Maunds/Acre)	Sugar Area	Sugar Yield (Maunds/Acre)
Siniwala	2,250	3,447	81.6	23.8	13.1	2,884
Singhpura	1,825	9,797	100.0	18.5	0.0	0
Chakku	3,756	4,750	96.0	19.6	4.0	4,481
Subadarwala	1,500	3,945	72.4	23.0	12.2	5,416
Khahi abad	1,300	2,253	73.5	22.5	5.4	5,402
Kohali[a]	1,325	2,367	73.9	24.5	22.8	6,210
Khairala Kalan	2,250	1,661	75.1	5.0	0.0	0
Phatti Gujran[a]	4,000	1,249	68.4	6.0	0.0	0
Kareaman[a]	2,250	1,326	84.3	16.3	0.0	0
Hattawar[a]	22,135	4,467	67.3	6.1	0.0	0
Makyal[a]	2,000	1,712	61.1	7.3	0.0	0
Dhak Guyar[a]	2,500	642	93.2	5.8	0.0	0
Gulyal[a]	3,750	2,231	36.0	3.0	0.0	0
Dhak Kazi[a]	2,000	327	97.9	9.3	0.0	0

[a] Village in Attock.

Table 4--Villages from Baluchistan (Mastung/Kalat) in the sample

Name of Village	Total Land Area[a]		Village Population	Percent Cultivated Wheat (Rabi 1986/87)	Average Wheat Yield	Percent Cultivated Area in Orchards (1986/87)	Value of Fruit Per Acre Planted (July 1986-June 1987)
Surgaz	1,449	(17)	1,200	50.4	4.6	17.4	6,316
Noar Mud	302	(05)	500	41.0	9.0	45.1	3,441
Hazar Khan	566	(15)	430	35.7	9.0	26.8	24,800
Bibri	1,774	(02)	1,650	65.5	8.2	3.3	1,333
Abad	1,628	(27)	1,700	84.1	3.5	1.6	5,357
Kherdawn	1,834	(60)	1,100	72.5	10.3	11.1	3,321

CROP YIELDS FOR THE 1986/87 SEASON

Different irrigated wheat zones in Pakistan have been noted to have different yields which are mainly explained not only by productivity of the soil but also by the different cropping rotations in these areas. Wheat yields, for instance, have been noted to be nearly 25 percent higher in the cotton-wheat zones than in the rice-wheat zones in Punjab (Akhtar et al. 1986).

Two villages in Faisalabad have farming systems dominated by the cotton-wheat rotation and the yield of 21 maunds per acre in the 1986/87 season and is about the level noted in other irrigated areas in Faisalabad. Farmers in these villages have kept pace with the rest of the canal-irrigated wheat farms in Pakistan in the application of chemical fertilizer and the widespread adoption of new and recommended, semi-dwarf wheat varieties.

The barani farms in the Attock district, however, had yields of only 10 maunds per acre, much lower than expected at the start of sowing. Farmers in these areas sustained severe crop damage from hailstorms during the harvesting period.

Wheat yield in Dir is likewise quite low at 10.7 maunds per acre, a level which is achieved by nonirrigated farms, and is less than one-half the yields from the irrigated areas in NWFP's maize-wheat zones. The same yields are also found in Mastung/Kalat area in Baluchistan.

Wheat farmers in the Sind had the lowest yields in the sample. Despite the irrigation, yields are 40 percent lower than a comparable, rice-wheat rotation in the Punjab.

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Yield of IRRI rice in Badin was observed at about 20 maunds per acre and did not vary substantially across the "dehs".

VALUE OF FARM PRODUCTION

All crops cultivated by the sample farmers in the 1986/87 season are included in the analysis. The 1986/87 rabi crops consisted of wheat, barley, gram, masoor, mustard, sunflower, potato, onion, vegetables, spices, tobacco, and fodder crops (berseem and lucern). The kharif (1987) crops were rice, maize, jawar, bajra, cotton, mung and other pulses, groundnuts, tomato and other vegetables, melon, and kharif fodders, including guara. Orchards were likewise accounted as well as sugarcane, which is an annual crop. Greater variety of crops and intercropping were noted in the irrigated areas in Faisalabad and Dir and less in the barani areas in Attock. Minor crops, such as oil seeds, vegetables, pulses, and groundnuts, usually take small part of the total cultivated area. A big percentage of the land is devoted to the major crops like wheat, rice, sugar, cotton, maize, and fodder.

Detailed questions on area cultivated, production, and prices even for the less important crops provided a complete estimate of the value of production of each farmer. As the surveys were conducted every two months, reliance on farmer's memory of the quantities of outputs, prices received, and the inputs used are deemed satisfactory.

In valuing production, prices received by the farmer for crops sold were used in the analysis. For crops not sold, mean village prices were used. Agricultural by-products were included in the value

Table 5--Crop prices, 1986/87 season

	Punjab (Attock/Faisalabad)	Sind (Badin)	NWFP (Dir)	Baluchistan (Mastung/Kalat)
		(in rupees per maund)		
Wheat	73	71	93	77
Basmati rice	125	112	130	-
Irri rice	48	52	48	-
Barley	60	57	64	-
Gram	110	115	110	-
Masoor	199	234	218	-
Mustard/rape	163	-	230	-
Onion	75	67	70	45
Sugarcane	12	12	-	-
Maize	76	76	77	-
Jawar	50	60	80	60
Bajra	70	-	70	-
Cotton	186	150	-	-
Mung	175	-	270	-
Groundnut	215	-	-	

Table 6--Value of crop production by land size (in rupees)

Farm Size (Acres)	Faisalabad			Attock			Sind			NWFP			Baluchistan		
	Cases	Total Value	Value Per Acre	Cases	Total Value	Value Per Acre	Cases	Total Value	Value Per Acre	Cases	Total Value	Value Per Acre	Cases	Total Value	Value Per Acre
Below 2.5	17	4,039	2,992	20	1,445	1,361	7	4,008	2,474	49	3,987	3,991	7	7,209	5,144
2.6 to 5.0	24	10,280	2,580	23	4,512	1,232	43	8,409	2,018	48	8,691	2,487			
5.1 to 7.5	11	16,806	2,552	27	6,352	969	36	12,386	1,955	14	12,510	2,028	16[a]	7,940	1,432
7.6 to 12.0	26	23,103	2,404	27	6,581	710	64	16,129	1,671	24	14,773	1,656	9	31,316	1,684
12.1 to 25.0	17	54,392	2,217	31	11,691	772	49	34,311	1,652	13	32,432	1,633	17	36,721	1,765
Above 25.0	2	74,808	2,291	6	28,865	524	15	68,975	1,622	6	45,437	1,142	14	36,490	871
All samples	97	27,991	2,886	134	7,593	955	214	21,437	1,869	154	14,027	2,789	63	24,754	2,218

of gross production. Straw from wheat, rice, barley, and maize were calculated using village prices. In some villages, in Dir and Faisalabad, farmers harvested maize as fodder used not as grain--in which case, the fodder was green fodder and was priced in per acre terms. The value of stalks from cotton which are used as firewood have also been calculated, as are trees cut and sold for firewood. The value of gur produced in the crop year has also been included.

Table 5 presents the average prices prevailing in the 1986/87 crop year in the five districts under study. There are inter-village variations within the districts, generally reflecting distance to the nearest market.

VALUE OF FARM PRODUCTION AND FARM SIZE

A comparison of the total value of production by farm size (Table 6) examines on an aggregate level the relationship between farm productivity and farm size in the five districts. The main results indicate an inverse relationship for all of the five study districts. Smaller farms derive more output per acre than larger farms. It is evident that productivity-size differences across districts are varied. It appears to be more pronounced in the barani areas in Attock and less in the irrigated farms in Faisalabad, Dir, and Badin. The variations in farm size productivity are determined by variations in factor input application, and discussions in later sections will examine these in the context of a complete production function. For this analysis, farm production does not cover livestock, thus, to a

certain degree, estimates are not the full farm production. The correlates of livestock productivity will be treated elsewhere.

Evidence on the size-productivity relationship elsewhere in Pakistan has been mixed. Using three land size categories, Nabi et al. (1986) found inverse relationships between total farm output per acre and cultivated area aggregated for eight crops in the villages of Khunda, Jatli, Mehdiabad, and Chak on the north part of Punjab province. Khan (1975) concludes that due to easier access to modern inputs by larger farmers, the relationship between productivity and landholding is positive in the irrigated farm samples in Sind and Punjab. In his study of 192 farmers in Gujranwala and Sahiwal, Salam (1978) also concluded that there is no difference in productivity in between small and large farmers.

FARM PROFIT

In this section, we shall examine net returns to agricultural production in the agricultural year, which mainly consist of three groups of crops: rabi crops, kharif crops, and the annual crops. We take the agricultural year as the unit of farmer decisions following the argument that farmers maximize output to meet multiple objectives of cash incomes, subsistence food, and fodder needs. For example, wheat farmers may deliberately sacrifice yields on that crop to take an extra picking of cotton before planting wheat. Thus decisions on cropping patterns and intensities over a crop year have built-in interactions due to complementarity as well as competition for resour-

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ces. For this analysis, we will treat livestock incomes separately, although it is clear that fodder and straw obtained from wheat are inputs to livestock production.

Methods used in valuing output have already been discussed in the previous section. In the calculation of farm crop profits, we will attempt to measure inputs of each factor in farm production. The first major input is rental payment for land cultivated. Several forms of rental arrangements were noted in the sample: fixed rental and the share rentals. Fixed rentals per acre observed ranged from 225 rupees in Sind to 700 rupees in Punjab. In Baluchistan, rental was mostly on fixed arrangement. Alternative forms of sharing arrangements were also found. In Faisalabad, the 50-50 share cropping arrangement was dominant. Under this arrangement, the tenant was responsible for all the inputs, and outputs are invariably split into two. In the 75-25 arrangement, some inputs were normally supplied by landlord. This included tractor, fertilizer, and sometimes seeds. This arrangement was observed for majority of the Sind sample. For farmers cultivating their own land, the rental rate per acre net of inputs provided by a landlord prevailing in the village is deducted from the estimate of profits. This, therefore, imputes for the opportunity cost of land used in his farming.

The next major input is farm labor. There are two main sources: family labor and hired labor. A full account of the family members' input into field preparation and weeding, construction and repairs, planting, harvesting, and threshing was done in the survey. The first four of these activities listed were in a majority of cases performed

by family labor while hired labor normally performed the tasks of planting, harvesting, and threshing. In valuing family labor, wage rates prevailing in the villages were used. Wage rates were observed to differ among the activities. For instance, harvesting wage rate was about 35 rupees per day in Faisalabad, compared to 25 per day for planting. Labor provided on obligation or exchange was treated as own family labor because family members also supplied corresponding labor days to other farmers.

Expenditures for fertilizer, pesticides, and farm yard manure were also deducted as inputs. Seeds bought from the market, as well as seeds from own stock, were also valued as inputs using village prices. For land preparation, tractor and bullocks were used. Hiring of tractor was observed at 60 rupees per hour, a rate which already includes labor (driver) and fuel. Thus, for farmers who own tractor, the tractor hiring rate, net of fuel and driver cost, was used. This rate already allows for the depreciation of the tractor. Own bullocks used in cultivation was valued at the village rate. In most villages there were no bullock hiring; therefore, rates used was that prevailing at the district.

Expenditures for tubewell water used was also deducted. Where farmers own their tubewell, the value of water used was priced at the village rate. Electricity expense and fuel expense were also deducted as farm cost. However, for farmers who owned tubewells, electricity expenses were mostly accounted by tubewells. The cost of threshing was also deducted. In most cases, payments of threshing was in-kind. These were valued at village prices for the grain payments.

Table 7--Crop profit by land size (Sind)

Farm Size (Acres)	Cases	Crop Gross Profit[a] Per Acre	Crop Profit Net of Family Labor[b] Per Acre	Crop Profit Net of Family Labor and Value of Own Land Per Acre[c]
		(in rupees per acre)		
Below 2.5	8	1,181	616	463
2.6 to 5.0	43	1,071	680	447
5.1 to 7.5	39	1,048	346	157
7.6 to 12.0	72	1,015	490	265
12.1 to 25.0	61	1,035	649	404
Above 25.0	16	917	514	484
All samples	239	1,021	457	235

[a] Value of production less cash and noncash inputs, except family labor.

[b] Gross crop profit less value of family labor, valued at village wage rates.

[c] Gross crop profit less family labor, less rental of own land.

Table 8--Crop profit by land size (NWFP)

Farm Size (Acres)	Cases	Crop Gross Profit[a] Per Acre	Crop Profit Net of Family Labor[b] Per Acre	Crop Profit Net of Family Labor and Value of Own Land Per Acre[c]
		(in rupees per acre)		
Below 2.5	49	3,987	3,122	2,408
2.6 to 5.0	48	2,401	1,834	1,258
5.1 to 7.5	14	1,817	1,399	803
7.6 to 12.0	24	1,546	1,188	675
12.1 to 25.0	13	1,609	1,424	1,089
Above 25.0	6	1,117	933	1,152
All samples	177	2,602	2,034	1,507

[a] Value of production less cash and noncash inputs, except family labor.

[b] Gross crop profit less value of family labor, valued at village wage rates.

[c] Gross crop profit less family labor, less rental of own land.

Table 9--Crop profit by land size (Attock, Punjab)

Farm Size (Acres)	Cases	Crop Gross Profit[a] Per Acre	Crop Profit Net of Family Labor[b] Per Acre	Crop Profit Net of Family Labor and Value of Own Land Per Acre[c]
		(in rupees per acre)		
Below 2.5	22	394	-1,912	-2,214
2.6 to 5.0	29	380	-49	-229
5.1 to 7.5	29	339	-19	-245
7.6 to 12.0	31	290	-9	-178
12.1 to 25.0	35	285	90	-83
Above 25.0	6	275	191	-87
All samples	152	292	-263	-470

[a] Value of production less cash and noncash inputs, except family labor.

[b] Gross crop profit less value of family labor, valued at village wage rates.

[c] Gross crop profit less family labor, less rental of own land.

Table 10--Crop profit by land size (Faisalabad, Punjab)

Farm Size (Acres)	Cases	Crop Gross Profit[a] Per Acre	Crop Profit Net of Family Labor[b] Per Acre	Crop Profit Net of Family Labor and Value of Own Land Per Acre[c]
		(in rupees per acre)		
Below 2.5	17	887	-100	-631
2.6 to 5.0	24	810	51	-521
5.1 to 7.5	11	578	120	-605
7.6 to 12.0	26	722	165	-201
12.1 to 25.0	17	1,342	766	436
Above 25.0	2	1,411	691	344
All samples	104	889	234	-235

[a] Value of production less cash and noncash inputs, except family labor.

[b] Gross crop profit less value of family labor, valued at village wage rates.

[c] Gross crop profit less family labor, less rental of own land.

Table 11--Crop profit by land size (Baluchistan)

Farm Size (Acres)	Cases	Crop Gross Profit[a] Per Acre	Crop Profit Net of Family Labor[b] Per Acre	Crop Profit Net of Family Labor and Value of Own Land Per Acre[c]
		(in rupees per acre)		
Below 2.5	7	870	611	395
2.6 to 7.5	16	839	691	248
7.6 to 12.0	9	1,540	1,401	993
12.1 to 25.0	17	1,347	1,178	607
Above 25.0	14	286	231	224
All samples	63	969	811	484

[a] Value of production less cash and noncash inputs, except family labor.

[b] Gross crop profit less value of family labor, valued at village wage rates.

[c] Gross crop profit less family labor, less rental of own land.

In calculating crop profit, we attempt to measure net returns to the main assets owned by the household, such as land and family labor. Three measures of crop profit are therefore made to account for these adjustments. The first definition is gross profit per acre where all cash and noncash inputs are netted out, except for family labor. The second crop profit measure subtracts family labor from the gross profit, while the third deducts the imputed values of family labor and own land used in the production process.

Results are presented for each of the five districts in Tables 7 to 11. The results give wide variation in profitability across districts. In Dir, the relatively larger proportions of orchard have driven crop profitability higher than the rest of the districts. The barani areas in Attock, which were affected by the hailstorms at harvest time, had the lowest profitability. In fact, negative average profits are observed when family labor and value of own land are deducted.

Trends in profitability in crop production by size of cultivated area follow different patterns across districts. In Badin, crop profit does not appear to vary by land size while profitability in Dir appears to decline in higher size category of land. It does not appear to vary in Attock, although it is clear that the higher labor use in the smaller farms results in a large negative profit, under our second crop profit measure. In Faisalabad, slightly higher crop profits are realized per acre in larger farms.

DETERMINANTS OF FARM OUTPUT

The sharp variations in value of output and profitability of farming across districts may reflect differences in environments and farmer decisions about technology at given price environments. In this section, we shall examine these factors through the use of production functions. The production relationships will be approached at the total farm level where crops produced by each farm are aggregated. The production function is treated not simply as technological relations but also contains important some behavioral elements. In contrast the traditional single crop production function concentrates only on a particular crop where physical measures of production and its technical relationships to physical inputs are studied.

The production function of a Cobb-Douglas form was specified and used in the analysis. The estimating equation is as follows:

$$\text{LTVAL} = f(\text{LogArea, LogFL, LogHL, PIRRIG, DISTMAR, LTRACT, LFERT, EDUCS, EDUCP}) \quad (1)$$

where

LTVAL	=	log of total value per acre of farm output from all crops,
LogArea	=	log of area cultivated,
LogFL	=	log of family labor (days x wage rate) per acre,
LogHL	=	log of hired labor (days x wage rate) per acre,
PIRRIG	=	percent cultivated area irrigated,
DISTMAR	=	distance to the nearest mandi,
LTRACT	=	log of tractor and bullocks (days or hours x rate) per acre,

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LFERT = log of fertilizer, pesticides, and manure expense per acre,

EDUCP = dummy = 1 if maximum educational attainment of household head is primary or higher, 0 = otherwise,

EDUCS = dummy = 1 if maximum educational attainment of household head is secondary or higher, 0 = otherwise,

PORCH = percent area devoted to orchard,

PSUGAR = percent area devoted to sugar.

The dependent variable in the first equation is the sum of all outputs from crops produced over the agricultural year valued at farmgate prices, expressed on a per-acre basis. All crops produced, whether sold or used for own household consumption or for fodder, are included in the analysis.

The first important variable considered in explaining agricultural output is land, which is measured in this study as the total cultivated area or operational holding given in acres. In majority of the farms, land cultivated in the rabi and kharif seasons, including fallow land, were nearly always identical. In instances where they are not equal, land area cultivated in the rabi was chosen in Attock, Faisalabad,a Dir, and Mastung because of the dominance of wheat in these areas. In Badin the operational holding in the kharif season was chosen because their main crop was rice which is grown in the kharif. The variable land was treated as a continuous variable and not in the context of size categories.

Bhalla (1988) argued strongly that where land quality is correlated with any of the farmers' choice variables, its exclusion in the

production function results in misspecification and bias; and therefore proposes the use of land quality indices in farm production analysis. Land quality was not measured in the survey. Ideally, the quality of soil and its locational characteristics should influence the productivity of land. Land is heterogeneous and therefore it is expected that different qualities of land represent different productive earning power and rental values. Land where salinity intrusion is high is, for example, perceived to have low rents. However, it was feasible from the survey to determine the percentage of the operational landholding that had access to irrigation. This brings us to the second explanatory variable used in the analysis--percent of land irrigated. For purposes of present estimates, we do not distinguish the quality of irrigation (e.g., canals, tubewells). It is well recognized that the effectiveness of irrigation is a function of the reliability of water supply. Distance from the canal head, for example, is an important indicator.

Farm labor as an explanatory variable is measured in terms of person days utilized in the farm over the agricultural year multiplied by the village level wage rate. Farm labor is broadly divided into casual and permanent workers. Included in the latter are family workers (men, women, and children) and annual hired workers, including farm servants. Casual workers are mainly hired labor. For the present analysis, we shall distinguish between family labor and hired labor as separate variables. It is important to understand that quite a number of factors lie behind the hiring of labor. Part of the reason may be technological--that in periods of harvest, it is neces-

sary for operations to be conducted in a very short period in order that yield is not adversely affected. This requires the hiring of labor even on small farms to supplement family labor. This distinction between hired and family labor has given rise to the issue of labor market dualism in agriculture (Sen 1966).

In the economy of crop production, bullock labor provides a substantial part of the draught power. The market for bullock in the study areas is almost nonexistent, but where such services are offered, the rate of hiring almost invariably cover also labor. In Faisalabad, Attock, and Dir, exchange arrangements for bullock services were observed. The value of bullock labor per acre is quantified in terms of days multiplied by the hiring rate per day.

The other source of draught power is tractor, which has gained wide acceptance for most of the sample villages. The value of tractor used per acre is measured by the time utilization in the farm, in hours, valued at the hourly rate at the village. Own tractor use in own farms was likewise recalled and is priced at the hiring rate, net of family labor (in cases where the tractor driver is a family member).

For this analysis, the value of tractor and bullock power used per acre was combined as one draught power variable.

The largest cash inputs into farm production are accounted for by fertilizer and pesticides. The application of such modern inputs has made considerable inroads in the study villages and farmers did gain knowledge of the various doses to gain increments in yields. The

total value of fertilizer, pesticides, and farm yard manure per acre spent on the farm is used as the measure.

In the separate estimates for Punjab, Baluchistan, and NWFP, an additional variable--percent area devoted to orchard--was included an an explanatory variable to test production effects from growing high-valued fruits, such as mango, grapes, and apples. In the Sind estimates, percent devoted to sugar was also tested as an explanatory variable to determine how sugar as an annual crop affects total farm output.

The next group of explanatory variables are features of the household which are not direct inputs but which may affect output through their influence on farming practice. Two education variables are included in the analysis: one dummy for primary education, and another for secondary education. Higher education is posited to affect the application of modern inputs and thus productivity. Ali and Flinn (1987), for instance, found in their study of basmati rice farmers in Gujranwala and Lahore, that the per hectare profit-loss was least among farm households with higher education. Better educated farmers had better access to extension services and agricultural information.

The other explanatory variable which may have indirect effect on production is distance to market. In this context, the availability of infrastructure necessary to bring output into the market and inputs into the farm has been proven in several studies to have consequences on production. Ahmed (1988), for instance, showed that gross agricultural production in 129 villages in Bangladesh increased by 35 percent

due to infrastructure development, and the diffusion of technology was found to be one of the most important factors influencing this result.

ESTIMATION AND RESULTS

Separate estimates of the production function were done for 232 farmers in Attock/Faisalabad, 214 farmer in Badin, 154 in Dir, and 62 in Kalat/Mastung areas. The functional form adopted in the analysis is translog as we expect to find diminishing returns to the direct inputs in production. The variables logged include the output and the direct inputs: land cultivated, fertilizer, tractor/bullock, hired labor, and family labor.

Results are presented in Table 12. The one proposition that has attracted much attention and which has continued to recur over the years is the alleged inverse relationship between yield per acre and size of landholding. Results for Punjab and NWFP support the inverse relationships observed in a number of other studies, but not for Sind and Baluchistan. Various hypotheses have been offered in the literature explaining this inverse relationship. One argument is the higher intensive use of land in smaller farm operators in the form of double cropping and intercropping. This may be a plausible explanation for the smaller Faisalabad and Dir farmers who have considerably more types of crops planted in the rabi and kharif seasons.

Another hypothesis is given in terms of the qualitative difference in labor inputs. It is argued that small farmers working in their own farms take greater care in performing their tasks and are

Table 12--Farm production function

Dependent variable: value of production per acre, in log

Independent Variables (Per Acre Value)	Punjab (Faisalabad/Attock)		Sind (Badin)		NWFP (Dir)		Baluchistan (Mastung/Kalat)	
Constant	5.164	(14.78)*	6.699	(18.37)*	7.774	(18.02)*	1.038	(0.48)
Log fertilizer[a]	0.178	(6.71)*	0.049	(2.30)*	0.144	(2.65)*	0.011	(0.99)
Log tractor/bullock[b]	0.199	(3.81)*	0.021	(1.78)*	0.143	(2.75)*	0.037	(0.97)
Log family labor	0.034	(0.85)	0.037	(0.83)	0.037	(0.52)	0.092	(0.62)
Log hired labor	-0.017	(-0.64)	0.082	(2.21)*	-0.026	(-0.83)	0.162	(1.44)
Log area	-0.074	(-1.79)*	-0.037	(-0.69)	-0.149	(-2.47)*	-0.149	(-0.95)
Percent irrigated	0.570	(6.21)*	[e]		0.052	(1.86)*	0.749	(1.91)*
Primary education, head[c]	-0.108	(-1.25)	0.135	(1.35)	0.028	(0.18)	-0.168	(-0.41)
Secondary education, head[d]	0.141	(1.28)	0.606	(2.51)*	0.313	(1.89)*	0.755	(1.59)*
Percent orchard area	2.476	(5.60)*			0.310	(2.59)*	2.422	(3.61)*
Percent sugar area			0.869	(4.32)*				
Log distance to market	-0.115	(-2.85)*	-0.153	(-1.65)*	-0.222	(-2.05)*	-1.239	(-2.19)
R^2	0.66		0.25		0.25		0.48	
F-Statistic	38.43		6.84		4.35		4.79	
Number of cases	232		214		154		62	

Notes: Numbers in parentheses are t-values. Asterisks indicate significance at 0.10 or better.

[a] Includes expenditures per acre for chemical fertilizer and farm yard manure.

[b] Own tractor and bullock used are valued at prevailing village hiring rates net of labor and fuel.

[c] Dummy = 1 if maximum educational attainment of household head is primary level or higher, and zero otherwise.

[d] Dummy = 1 if maximum educational attainment of household head is secondary level or better.

[e] All Sind samples have irrigated farms.

better managers. An examination of the family labor input per acre by farm size in Table 13 indicate that smaller farms in Punjab and NWFP use more family labor compared to larger farms. This trend seem less apparent in Sind and Baluchistan.

In this study of Indian agriculture, Bhalla (1988) found that the correlation between the index of quality of soil and farm size is generally negative. This lends support to Sen's (1964) argument that smaller holdings are characterized by a superior quality of soil. Starting notionally with a situation where there are lands of equal size but of different qualities, operated by families of uniform size, Sen visualized a process by which higher per capita income on more fertile lands would induce the size of family on such land to expand. This, he argues, leads to more fragmentation of such lands so that eventually better quality land would form the smaller size holdings. This hypothesis cannot be tested in the present analysis because data on soil quality in the subject farms are not available.

One striking result is the insignificant effects of family and hired labor on output per acre, except in one case on hired labor in Badin. Applying the principles of efficient resource allocation in which market wage rate reflects the opportunity cost of resources, does the result imply that the marginal product of labor is zero? Is there in fact, surplus labor in the study villages? It is quite interesting to note that Nabi et al. (1986) found similar conclusions among farms in Punjab, although their labor variable was measured in terms of the number of adult males working in the farm.

Table 13--Family labor by farm size

Land Size (Acres)	Punjab	Sind	NWFP	Baluchistan
		(mandays per acre)		
Below 2.5	55	21	29	18
2.6 to 5.0	23	28	19	12
5.1 to 7.5	17	25	13	..
7.6 to 12.0	12	19	11	9
12.1 to 25.0	9	17	8	7
Above 25.0	3	14	8	7

Irrigation appears to have a clear positive effect on per acre value productivity, which is observed to be stronger in Punjab and Baluchistan farmers. The variations with the Punjab farmers are, of course, largely accounted for by the differences between the barani farmers of Attock and the canal-irrigated farms in Faisalabad, which are combined in the same regression. It is difficult to assess relative efficiency of irrigation in the estimates since our variable used "percentage area irrigated" cannot adequately reflect the nature and extent of the facility.

The combined effect on output of tractor/bullock power is seen to be statistically significant in all areas, except Baluchistan. In the total crop production, there may be some complementarity between bullock and human labor and may partly account for the insignificant effects observed for family labor.

The proportion of land devoted to orchard is observed to significantly increase value of output per acre in Punjab, NWFP, and Baluchistan. This implies that high-valued crops provide higher returns to farmers compared to the traditional crops.

Two dummies on education were used as factors in the production function, representing different levels of educational attainment of the household head. Results indicate quite strongly that no effect could be detected for primary education but significant and positive effects for secondary education. The impact of education on farm output generally proxies for farm management abilities of farmers. The second generation inputs used in the green revolution era offered opportunities to substantially increase productivity, although at the

same time has increased the complexity of crop management. In wheat production, for instance, the increasing use of fertilizer, tractor power, tubewell, and threshers require additional technical information. Added to this array are methods of pest control management, soil amendments, farm water management methods, precise methods of planting and spacing, all requiring capacity to understand the efficient use of such inputs to fully exploit the potential from the high-yielding varieties. These are also particularly relevant in the multiple-cropping sequences of two or three crops that are common in the farmers in the study area. Of particular interest in the results is that the threshold to achieve higher value of output per acre is determined in part by the contribution of secondary but not primary education.

A final important result from the analysis is the significant positive impact of distance to market on value of output per acre. The relationship is unambiguously negative--farmers situated far from the markets produce less per acre. The variable "distance" connotes in general the effect of accessibility and availability of inputs, including technology, as well as the market for the farm produce. A key element here is therefore infrastructure. Good roads and adequate communications affect input prices, as well as the efficiency in the use of such inputs.

POLICY IMPLICATIONS

The following conclusions could be gleaned from this study:

1. Evidence presented in this paper strongly supports the need to increase the quantity as well as the quality of education by farmers in an era where opportunities for increasing productivity from the use of modern inputs are available. It has been observed that rapid growth of agricultural productivity associated with the introduction of semi-dwarf varieties of wheat and rice of the so-called green revolution has now been slowing as a result of skill constraints mainly from the low level of formal schooling among farmers (Byerlee 1986). Technical knowledge of farmers regarding new technological components is often very poor. Thus, a large payoff would be achieved by improving rural institutions and rural schooling.

2. The role of rural infrastructure in improving farm output is seen as critical as indicated by the unambiguous negative effect of distance to market on output. Gross agricultural production undoubtedly will be affected by infrastructure development not only through its effect on prices but also on the efficiency of the use of modern inputs.

3. The inverse relationship between yield per acre and size holding was found to be significant in Punjab and NWFP but not in Sind and Baluchistan. The result provides additional ambivalence to the evidence on size productivity relationships. Nabi et al. (1986) and Salam (1978) found proof of the inverse relationship in their study of Punjab and NWFP farmers. Others argue that this may no longer hold because of the opportunities offered by modern inputs, in which larger farmers have invariably more access. Clearly, these results have wide implications for the land reform argument which purports to redistrib-

ute land into smaller units,and as argument against pooling of land into larger units.

4. Modern inputs, such as fertilizer and pesticides, significantly contribute to output and its interaction, particularly with farmers' technical skills, are important determinants. Returns to the use of tractor power are significant. The use of irrigation increases land productivity mainly through its effect in making possible the production of lucrative crops. This is clearly shown in Dir and Faisalabad where intercropping and multicropping results largely from access to water.

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