Impact of non-farm work and land tenancy contracts on soil conservation measures

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Abstract

This paper examines the impacts of non-farm work and land tenancy arrangements on the intensity of investment in soil-improving measures and farm productivity. A multivariate tobit model that accounts for potential endogeneity between the intensity of investment and the non-farm work and tenancy arrangement variables is estimated for 341 rural households in Punjab province of Pakistan. Instrumental variable approach is also used to analyze the impact of tenancy arrangement and non-farm work on farm productivity. The empirical results show that participation in non-farm work and tenure security tend to increase the intensity of investment in long-term soil-improving measures, but decrease chemical fertilizer use intensity. We also find that increases in non-farm work and tenure security exert significant and positive effects on agricultural productivity. Investment in soil conservation measures is also found to significantly increase agricultural productivity.

Keywords: farm productivity, land tenure, non-farm work, soil conservation.

1-Introduction

One of the most enduring challenges in developing countries is to increase investment in order to enhance productivity in small-scale farming. There is a need to focus on the intensification of agriculture practices by sustainable management of natural resources. Investment measures are the key component of sustainable management of resources which ultimately enhance productivity of farm sector. The poor households are not able to undertake investments because of the two major limiting factors. First one is the irregular income and high covariate risk in agriculture sector. Second one is the lack of secure property rights of land. This situation has pushed the resource poor and land constraint households away from agriculture and urged to find employment opportunities in non-farm sector. Non-farm income may enhance investments in agriculture sector by providing capital in the context of imperfect credit and insurance markets. Rural economies depend heavily on non-farm earnings in order to diversify risk, income security, smooth consumption, and financing productivity-enhancing investments. The important share of household income in developing countries is derived from non-farm activities. Haggblade et al. (2010), for instance, reported that non-farm income contributed 35-50 percent of rural household income across the developing world.

The empirical evidence on the effects of non-farm income on agricultural production is mix. For instance, increased participation of household members in non-farm work leads to decrease on-farm efficiency (Goodwin and Mishra, 2004) and reduces the availability of family labor for farming (McNally, 2002; Goodwin and Mishra, 2004). On the other hand, its positive aspects include achieving food security (Owusu et al., 2011); higher agricultural growth (Haggblade et al., 2002); overcoming working capital constraint and purchase of inputs for farming (Chang et al., 2011).

Similarly, secured property rights provide incentives for farmers to stimulate long-term investments in many ways. First, the ownership rights of land seem to stimulate long-term agricultural investment and ultimately higher productivity through security effect. On the other hand insecure land right, which is the characteristic of many farmers in less developed countries, create disincentive for the users to spend resources on land improving inputs so the demand for investment declines which ultimately leads to low productivity. This is in line with the Marshallian theory, which states that sharecropping tenancy agreement is inferior contract as the sharecropper receives a fixed fraction of output regardless of the extent of efforts he makes. This may have a negative effect on production. Second, the secure tenancy improves the credit availability of household to finance agricultural investments by using land title as collateral. Thirdly, secure tenancy increases the possibilities for trade in recovering full value of the land by making it easier for farmers to liquidate their land in the case of exogenous shocks (Deininger and Jin, 2006).

Most of the studies mentioned above have either examined the role of non-farm work on agricultural investments, or the impact of tenancy arrangement on investment in conservation measures. However, very few have analyzed the link between tenancy arrangements and farm investment through enhanced income possibilities from non-farm work (Feng et al., 2010). The recent study by Feng et al. (2010) examined the impact of land rental market and participation in off-farm employment on land investment, input use, and rice productivity in China, and found that tenure status of plots did not affect the level of land investments. They also found that off-farm employment does not significantly affect crop yields. A shortcoming of the study is the consideration of the household's decision to participate in non-farm work as exogenous, without accounting for potential endogeneity of the variable. This study seeks to contribute to the literature by considering participation in non-farm work and land tenure arrangement as endogenous to investment decisions.

The main objective of this study is to examine how participation in non-farm work and tenancy arrangements affect investment in soil conservation and productivity-enhancing measures in Pakistan. The study utilizes cross-sectional rural household level data collected in 2010 from a randomly selected sample of 341 households in Punjab province of Pakistan.

Land ownership in Pakistan remains highly concentrated in rural areas due to class stratification, where 67 percent of households are landless and just 0.1 percent households possessed 1 hectare and above landholdings (Anwar et al., 2004). Land lease markets are therefore very active in the country, with large land owners employing hired labor or leasing their land to tenants in order to release themselves and their families from manual labor (Rehman, 1987). The main types of tenancy arrangements are ownership, fixed-rent and sharecropping contracts. The most common type of tenancy is ownership where private individuals have rights to use, rent or sell land. The fixed-rent arrangement involves land owners renting out parcels to tenants, while sharecropping contracts involve arrangements between the landlords and the operators, such that part of the output is given to the landlord as compensation for using the land. As a result of unequal access to land and population growth, non-farm sector has expanded significantly over the last decades. Almost 45-50 percent of the rural population in Pakistan is directly dependent on non-farm income for their livelihood (GOP, 2011).

The rest of the paper is organized as follows: In the next section, the conceptual framework is presented. Section 3 outlines the empirical specification. The data used in the analysis is described in section 4. In section 5, the empirical results are discussed. The final section presents the conclusion.

2-Conceptual Framework

In the presence of credit market imperfection, households face liquidity constraint in farm investment. Earnings from non-farm can help households to overcome credit and insurance market constraints by providing liquidity that can be used for investment in soil conservation measures and productivity-enhancing inputs (Upton and Haworth, 1987). Similarly, ownership security provides incentive for farmers to engage in investment in soil-quality, yield-enhancing and resource management practices. However, these investments depend upon the nature of users rights, that is, whether the farmers have permanent rights to use land (e.g., owners) or have temporary rights (e.g., fixed-renters or sharecroppers). Hence, farmers consider these tenancy arrangements when making agricultural investment decisions.

To illustrate the relationship between non-farm work participation, tenancy arrangements and investment in soil-improving and productivity-enhancing activities, we start by specifying a simplified allocation model. To fix things, consider a household that maximizes utility over consumption of goods C and leisure, N, i.e., $U = U(C, N)$. Utility is maximized subject to time, budget, production, liquidity, and non-negativity constraints. The time constraint is $T = L_1 + L_2 + N$, where T is total time endowment, L_1 and L_2 are respectively time allocated to farm work and non-farm work, and N is leisure as defined above. The farm technology is specified as $Q = Q(L_f, A, X; Z)$, where Q represents quantity of agricultural production, X captures inputs such as investment in organic manure, farm manure and chemical fertilizer, A is fixed capital like land etc., and Z is the individual, household and location characteristics. In the case of liquidity constraints, expenditures on purchased inputs ($P_x X$) cannot exceed household income from farm (Y_f), non-farm (Y_{nf}), and un-earned (Y_u) sources, given as: $P_x X \le Y_f + Y_{nf} + Y_u$. The full household budget constraint can be specified as

$$P_C C \le P_Q Q - P_X X - w_f L_f - K_A(\lambda, \gamma) + w_{nf} L_{nf} + Y_u, \tag{1}$$

where P_C is the price for the consumption good purchased in the market, P_X is the vector of costs associated with the nonconventional inputs, P_Q, represent vectors of prices of farm output, K_A is cost of land; w_f w_{nf} are the farm and non-farm wages.

The first order conditions associated with maximizing utility subject to these constraints, yield the following optimal choices of the household

$$P\frac{\partial Q}{\partial X} - P_x = (\eta / \rho) P_x \qquad (2)$$

$$P\frac{\partial Q}{\partial L_f} = \alpha / \rho = \frac{\partial U / \partial N}{\partial U / \partial C} = w(1 + \eta / \rho) \qquad (3)$$

where α is the multiplier for the labor market constraint, which is equal to the marginal utility of leisure, η is the multiplier for liquidity constraint and is equal to the marginal utility of liquidity, and ρ is the marginal utility of full income.

Equation (2) shows that when the liquidity constraint is binding, rather than being equal to zero at the optimum, the marginal profit from purchased inputs is equal to the shadow value of liquidity (η / ρ). Intuitively, increasing demand for the purchased input carries with it an additional cost above and beyond the input price, in terms of the exhaustion of scarce liquidity. Therefore, liquidity-constrained households cannot purchase productivity-enhancing inputs and pursue longer term investment in agriculture. Equation (3) indicates that households will equate the marginal rate of substitution between consumption and leisure of family labor and the shadow wage rate. When the liquidity constraint is binding, the shadow wage will be less than the market wage by a factor of the shadow price of the constraint (η / ρ), with additional labor being allocated to non-farm activities in order to relax the liquidity constraint. If the liquidity constraint is not binding (η=0), the shadow wage would be equal to the market wage, and inputs are used up to the point where their marginal effect on profit vanishes, which is the case of a separable agricultural household model.

The first order condition for optimal time allocation for farm work, non-farm work and leisure is given as

$$\partial U / \partial L_i = W_i \partial U / \partial C - \partial U / \partial L = 0 . \qquad (4)$$

Equation (4) can be rearranged to obtain the returns to labor from farm work and non-farm work: $w_i = (\partial U / \partial L)/(\partial U /(\partial Q)$. As shown in Huffman (1991), a positive number of non-farm hours will be observed for an individual i, if the potential market wage (w_i^m) is greater than the reservation wage (w_i^r).The labor supply functions can then be derived as $L_i = L_i(w_i, P_i; Z)$ for cases where farm households allocate their time to the three activities.

The above derivation of non-farm work can be employed to relate non-farm work to farm input use through duality theory. As shown in Bazaraa (1993) and Phimister and Roberts (2006), by Lagrangean duality theory, at the optimal solution the farm household production problem can be specified as the outcome of a profit-maximization problem given as

$$\pi(P_Q, P_X, \lambda, \gamma, w_f, w_{nf}, Z) = \max_{L,A,X} \lfloor P_Q Q - w_f L_f - P_X X - K_A(\lambda, \gamma) \rfloor \qquad (5)$$

subject to the technology constraint, $Q = Q(L_f, A, X; Z)$; where $K(\cdot)$ represents the cost of land, reflecting the three different land tenancy arrangements, namely, ownership, fixed-rent contract and sharecropping contract. With these three types of arrangements, the cost of land can be specified as

$$K_A(\lambda, \gamma) = (1-\lambda)\overline{K}_A + \lambda\gamma P_Q Q \qquad (6)$$

where the parameter γ represents an output-sharing rule, with λ equal to zero for fixed-rent tenants and one for sharecroppers. Given this specification, the cost of land for sharecroppers will be $\gamma P_Q Q$. In the case of no sharecropping (owner and fixed-rent tenant), $\lambda = 0$, the cost of the land is given by the constant $\overline{K}_A$.

From equation (5), we can specify the maximized profits as a function of prices, household characteristics, and tenancy arrangements as

$$\pi = \pi(P_Q, P_X, \lambda, \gamma, w_{f,}, w_{nf}, Z) \qquad (7)$$

Beginning with any well-specified normalized profit function, direct application of Hotelling's lemma to equation (7), then yields the reduced-form specifications for input demand (land, labor and non-conventional inputs) and farm output functions

$$L = L(P_Q, w_{f,}, w_{nf}, P_x, \lambda, \gamma, Z) \qquad (8)$$

$$A = A(P_Q, w_{f,}, w_{nf}, P_x, \lambda, \gamma, Z) \qquad (9)$$

$$X = X(P_Q, w_{f,}, w_{nf}, P_x, \lambda, \gamma, Z) \tag{10}$$

$$Q = Q(P_Q, w_{f,}, w_{nf}, P_x, \lambda, \gamma, Z) \tag{11}$$

The specifications (8)-(10) show that input and output prices, tenancy arrangements, and non-farm work tend to influence farm profits, demand for inputs, while equation (11) shows how these factors affect farm output. On the basis of above theoretical concepts, we formulate two hypotheses. The first hypothesis is that participation in non-farm work exerts a positive effect on investment in longer term soil-improving measures. The second hypothesis is that secure tenancy arrangements lead to higher investment in soil-improving measures.[1]

3-Empirical Specification

The main goal of the empirical analysis is to analyze the impact of non-farm work and tenancy arrangements on investment in three soil-improving and productivity-enhancing activities. A direct way to examine the effects of farm household participation in non-farm work and tenure security on input use would involve estimating a structural farm household model, which can directly capture the optimal production decisions and how they interact with non-farm labor supply (Phimister and Roberts, 2006). However, as shown in Lopez (1984), this requires detailed information on both production and consumption decisions, as well as complex econometric modeling techniques. We therefore employ a reduced-form approach that is less data-intensive, but still includes the production relationships indicated in the discussions outlined previously. Specifically, we employ the specifications in (8)-(11) for the empirical analysis.

The investment measures we address in the analysis include organic manure (m) and green manure (g), which are soil conservation measures, as well as chemical fertilizer (f), which is a productivity-enhancing measure, since its productivity effects are limited to the season of application (Jacoby and Mansuri, 2008). In the absence of information on non-farm wages, we can approximate the investment function by using the input demand function in equation (10), and substituting non-farm labor supply for non-farm wages in the following reduced-form specification

$$Y_{in} = \alpha L_{in} + \beta T_{iAn} + \psi Z_{in} + \varepsilon_{in} \qquad n = m, g, f, \tag{12}$$

[1] Tenure security refers to the assurance that an individual can use or hold land for an agreed period of time and cannot be deprived of rights and benefits of using that land.

where Y_{in} represents investment by household i in soil conservation and productivity-enhancing measure n, and L_i captures the household's participation in non-farm work. The vector T_{in} represents tenancy arrangements and includes the variables λ and γ, indicating whether the farm is owner-cultivated, or on sharecropping or fixed-rent contract. The vector Z_{in} is as defined earlier, capturing household and farm-level characteristics. Because of the censored nature of the investment in the soil-improving and productivity-enhancing measures, we employ a tobit specification in the analysis. Suppressing subscripts, this can be expressed as

$$Y_i^* = \alpha L_i + \beta T_{iA} + \psi Z_i + \varepsilon_i \qquad (13)$$

$$Y_i = Y_i^* \quad if \;\; Y_i^* > 0 \qquad (14)$$

$$Y_i = 0 \quad if \;\; Y_i^* \leq 0$$

where Y_i^* is a latent variable capturing the expected profits for household i from investing in an activity, while Y_i is observable variable and indicates the level of investment in soil-improving and productivity-enhancing measures, and ε_i is the error tem, α is a constant, β and ψ are parameters to be estimated. Given that the errors of the individual specification may have nonzero correlation, a multivariate tobit estimation can be employed. In particular, because of the substitutability or complementarity between these investment options, and the fact that the farm lands in the sample are similar across equations, it is most likely that the error terms of these equations will be correlated.

The specification above in equation (12) assumes that the non-farm work and tenancy arrangement variable are exogenous. However, many studies on non-farm work and investment in farm inputs could be jointly determined (Pfeiffer et al., 2009; Kilic et al., 2009). Similarly, studies on the relationship between tenancy arrangements and investment in soil conservation measures suggest that the two variables may be jointly determined (Braselles, 2002). Given that the dependent variable is censored, the usual two-stage approach will not be able to address the endogeneity problem. We therefore employ the approach suggested by Smith and Blundell (1989), by modeling both non-farm work and tenancy arrangement explicitly and then allowing for interactions between these decisions and the investment variables specified in equation (12).

$$L_i = Y_i\delta + X_i\xi + \mu_i \quad (15)$$

$$T_i = Y_i\phi + X_i\theta + \varepsilon_i \quad (16)$$

where δ , ξ , θ are parameters to be estimated and μ_i and ε_i are error terms. Both the observed values and the residuals from the regressions are then used in the investment specification as follows

$$Y_i^* = L_i\,\omega_1 + T_{iA}\omega_2 + Z_i\omega_3 + U_i\omega_4 + \eta_i\omega_5 + \nu_{iA} \quad (17)$$

where L_i and T_i are vectors of the observed variables for non-farm work and tenancy arrangement, respectively; U_i and η_i are the residual terms of non-farm work and tenancy arrangement from equations (12) and (13), and ν_{iA} is the error term. As noted by Smith and Blundell (1989), the tobit estimates of ω_1 and ω_2 in equation (17) are consistent. An interesting feature of the approach is the fact that the usual tobit t-statistics on ω_4 and ω_5 are valid tests of the null hypotheses that the variables are exogenous.

A linear probability model that yield consistent estimates of the parameters is used in the first-stage estimation. Proper identification of the investment specification requires that some of the variables included in the first-stage estimation of non-farm and tenancy arrangement regressions are excluded from the multivariate tobit estimation. In the tenancy arrangement equation, we use the distance of the farm from the farmer’s residence and a dummy variable indicating whether cultivator resides in the village where the farm is located or not as instruments. In the non-farm equation, we employ migration status of the farmer as an instrument. As pointed out by Pfeiffer et al. (2009) and Kilic et al. (2009), migrant network is correlated with national and international migration and thus with participation in non-farm work, but not directly with agricultural investment decisions.

To examine the impacts of non-farm work and tenancy arrangements on farm output, we use an instrumental variable approach to estimate specification (11). This accounts for the potential endogeneity of intensity of investment with the non-farm work and tenancy arrangement variables. To avoid confounding a potential increase in productivity from increased output with returns to storage, we value output at producer prices at the time of harvest.

4-Data Description

Data was collected from a farm household's survey conducted in 2010 in Punjab province of Pakistan. Punjab is the second largest and most populous province of Pakistan, and contributes about 68 percent to annual food grain production. A stratified random sampling approach was employed in collecting information from 341 households from six districts in the province.

The survey asked farmers whether they used any soil conservation and productivity-enhancing inputs such as organic manure, green manure, terraces, strip cropping, and chemical fertilizer in the past few years. The land investments considered in the present study are organic manure and green manure, while the productivity-enhancing input is chemical fertilizer.[2] As noted by Jacoby and Mansuri (2008), organic manure supply nutrients to soil which remain available over a longer period of time than the nutrients supplied by mineral fertilizer. Thus, intensive use of fertilizer, considered as a static input, may cause soil degradation and hence lead to low crop productivity.[3] Farmers were also asked to indicate the applicable acreage in each case, and the costs of inputs such as organic manure and chemical fertilizer. The data from the survey also contain information about the farm topography, farm operation, non-farm activities, farm finance, and human capital of the household head. Non-farm work includes wage (on and off-farm) and self-employment.

In addition, farmers were requested to provide information on the type of tenancy arrangement under which they operated their farms. The sample of interviewed households consisted of 200 owner-cultivated, 91 sharecropping and 50 fixed-rental households, without any recorded cases of households with multiple tenancy arrangements. Information was also collected on other farm and non-farm activities, socio-demographic and location characteristics.[4] The households were asked about their perceptions of soil fertility. The variable is captured as a dummy, where one represents good soil fertility and zero poor soil

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[2] In our sample, very few farmers engaged in terraces and strip cropping. We therefore did not consider them in the empirical analysis.

[3] Increased application of mineral fertilizer leads to boost the productivity of crops in the short run but with time crop yield decrease if there is no usage of organic or green manure. Manures are long-term soil investments which increase the fertility of the soil by adding organic matter and nutrients.

[4] Non-farm activities include non-farm self-employment, wage-labor, migration, non-labor work, renting of household and farm assets and all other activities other than agriculture.

fertility. Farm size is captured by the number of acres under cultivation. The distance of the farm from the home of the cultivator and from the home of the landlord in case it is a rented land was also included in the questionnaire. Information on output and input prices was also collected. The definitions of the variables used in the analysis are presented in Table 1.

Table 1: Descriptive statistics of variables used in the regression models.

Variable	Definition of variables	Mean	S.d
Investment variables			
Organic Manure	Organic manure used per acre (kgs)	280.86	373.67
Green Manure	Leguminous crops grown per acre	0.73	2.37
Fertilizers	Chemical fertilizer applied per acre (Kgs)	324.87	256.09
Non-farm Participation variable			
Parti in Nfarm	1 if HH members participate in non-farm work	0.63	0.48
MigNet	1 if HH member migrated, 0 otherwise	0.29	0.45
DisMarkt	Distance of market from house (km)	14.02	20.01
Tenancy variables			
Owner	1 if land is under owner-cultivated, 0 otherwise	0.59	0.50
Fix-renter	1 if land is under fixed-rent contract, 0 otherwise	0.26	0.44
Sharecropper	1 if land is under sharecropping contract, 0 otherwise	0.15	0.23
Household-level characteristics			
AgeHead	Age of HH head (years)	45.87	13.30
Head	1 if female is the head of HH, 0 otherwise	0.74	0.43
HeadEdu	Years of education of HH head	6.04	5.43
HHSizOvr14	No.of HH members < 14 years	4.32	3.02
Livstk	1 if HH has livestock, 0 otherwise	0.83	0.38
TTwell	Number of tube well	0.66	0.97
NONLAB	Unearned income (Rs)	5.55	15.74
Credit	1 if HH has access to credit, 0 otherwise	0.36	0.48
Exte0ff	1 if HH has contact to extension agent, 0 otherwise	0.21	0.41
Farm-level characteristics			
CultiLand	Total cultivated land in acres	22.83	38.71
SoiFert	1 if land is fertile, 0 otherwise	0.13	0.36
ADisField	Distance of farm from owner’s residence (km)	1.99	4.12
Residence	1 if landlord reside in village where farm is located,0 otherwise	0.54	0.43
Family labor	Total hrs of family labor worked on farm last year	140.61	184.37
Hired labor	Total hrs of hired labor worked on farm last year	221.26	270.71
Location dummies			
Location1	1 if HH resides in Lahore district, 0 otherwise	0.15	0.36
Location2	1 if Hh resides in Sahiwal district, 0 otherwise	0.20	0.39
Location3	1 if HH resides in M.Garh district, 0 otherwise	0.30	0.46
Location4	1 if HH resides in Layyah district, 0 otherwise	0.02	0.13
Location5	1 if HH resides in Sialkot district, 0 otherwise	0.25	0.43
Location6	1 if HH resides in Khushab district,0 otherwise	0.08	0.27

5-Regression Results

The analysis was conducted by using the STATA statistical package. The investment specification was estimated by using a multivariate tobit model, controlling for endogeneity of the non-farm work and tenancy arrangement variables, while the productivity analysis was conducted with an instrumental variable approach. The first-stage estimates of the determinants of non-farm work and tenancy arrangements are first presented, followed by the second-stage investment estimates.

Table 2 reports the first-stage estimates of the determinants of participation in non-farm work. The signs of the estimated parameters are consistent with previous studies. A household head with more schooling had a significantly higher probability of engaging in non-farm activities, suggesting that additional schooling raises an individual's non-farm wage by more than it raises his or her reservation wage for farm or home activities. Age increases the probability of participation in non-farm work which represents general experience that increases the marginal value of time in each activity. Non-labor income tends to increase the probability of participating in non-farm work. Migrant household heads are more likely to participate in non-farm work, compared to non-migrants. Lack of credit access serves as a constraint to non-farm participation.

Table 2: Linear probability estimates of determinants of non-farm participation

Variable	non-farm work	Standard errors
AgeHead	0.026***	0.01
Head	0.299	0.23
HeadEdu	0.088***	0.02
HHSizOvr14	0.051	0.03
Livstk	-0.652**	0.31
TCultiLand	0.012***	0.00
Credit	0.444**	0.18
TTwell	0.295**	0.13
NONLAB	0.019***	0.01
SoiFert	0.011***	0.00
DisMarkt	0.009*	0.00
Location1	0.142	0.39
Location2	1.20***	0.37
Location3	0.684**	0.33
Location4	0.930	0.92
Location5	0.644**	0.30
MigNet	0.627**	0.26
Intercept	-1.384**	0.49

Note: Significance of t-statistics of mean difference is at the *10%, **5% and ***1% levels.

The first-stage estimates of the determinants of tenancy arrangement are presented in Table 3. The omitted category used as a reference group is the sharecropping variable in the case of tenancy arrangement. Owner-cultivators are more likely to be males, while fixed-rent tenants are more likely to be females. Landlords living in the same village where plots are located are more likely to be owner-cultivated. Similarly, plots located at further distances from the cultivator’s residence are more likely to be on fixed-rent contracts, but less likely to be owner-cultivated. This is probably because landlords prefer to cultivate plots closer to their homes, and to rent out those that are far away because of transportation and monitoring cost. The estimations generally provide robust first-stage results that can be employed in the second-stage multivariate tobit analysis. The variables employed as identifying instruments in the analysis are all statistically significant in the first-stage regressions. The value of the *F*-statistics on the joint significance of instruments in the tenancy arrangement regression given in Table 3 suggests that the instruments can be considered exogenous in the estimation.

Table 3: Linear probability estimates of determinants of land tenure arrangements

Variable	Own-cultivated	Standard errors	Fix-rented	Standard errors
AgeHead	0.024***	0.01	-0.031***	0.01
Head	-0.707**	0.26	0.793***	0.30
HeadEdu	0.343***	0.08	-0.399***	0.09
HHSizOvr14	0.009	0.03	0.008	0.04
Livstk	0.026*	0.01	-0.018*	(0.01
TCultiLand	0.009**	0.01	-0.008**	0.00
Credit	0.492**	0.19	0.437**	0.20
TTwell	0.645***	0.16	0.685***	0.16
Exte0ff	0.250*	0.14	0.563**	0.27
SoiFert	0.031***	0.00	0.007*	0.00
Location1	-0.284	0.43	-0.330	0.54
Location2	-0.485	0.41	0.020	0.45
Location3	-0.335	0.37	0.396	0.40
Location4	-0.875	0.69	0.039	0.81
Location5	-0.123	0.36	-0.057	0.41
ADisField	-0.187**	0.08	0.078***	0.02
Residence	0.077***	0.02	-0.839***	0.23
Intercept	-0.257	0.54	-0.015	0.60
F-Statistics (P-values)	18.13[0.00]		10.79[0.00]	

Note: *p*-values in squared brackets. Significance of *t*-statistics of mean difference is at the *10%, **5% and ***1% levels.

Table 4 presents the results of the second-stage regression on investment. The estimated coefficients and their associated t-statistics are presented in the first panel of the Table, while a number of test statistics are reported in the second panel. Considering the test statistics, the estimated correlation coefficients are all positive and significantly different from zero at the 5% level of significance, suggesting that unobserved variables involved in each investment option are significantly positively related. The likelihood ratio test of the joint significance of the correlation coefficients (ρ_i) rejects the null hypothesis that there is no correlation between the investment specifications, indicating that it is more efficient to use the multivariate tobit model than the separate tobit models. The estimates of residuals ResNF, ResOwn, and ResFix, derived from the first stage regressions of non-farm work and tenancy arrangement are not significantly different from zero, indicating that there is no simultaneity bias and that the coefficients are consistently estimated (Wooldridge, 2002). The value of χ^2 statistics for the joint significance of these residuals for each equation could not reject the null hypothesis that the residuals are jointly equal to zero, confirming the value of the individual t-statistics. These findings confirm the exogeneity of non-farm participation and tenancy arrangement variables.

On the estimated coefficients and their t-statistics, the positive and statistically significant coefficients for the non-farm work variable in the organic manure and green manure specifications show that participation in non-farm work increases the intensity in the application of these inputs. This result is in line with the findings reported by Savadogo et al. (2004) and by Oseni and Winters (2009). As argued by Marenya and Barrett (2007), non-farm income helps in easing liquidity constraints needed to invest in soil-improving inputs. In contrasts, the negative and significant coefficient in the chemical fertilizer specification suggests that fertility intensity declines with participation in non-farm work, a finding that is consistent with the results reported by Phimister and Roberts (2006) and by Kilic et al. (2009).

The results for the tenancy arrangement variables reveal positive and significant coefficients for the owner-cultivators variable in the organic manure and green manure specifications, suggesting that the intensity of investments in these farm inputs are higher for owner-cultivators, compared to sharecroppers. This finding is consistent with the results reported by Deininger and Ali (2008) for Uganda, but contrasts with the findings by Quisumbing et al. (2001), who found in their study that investment in sustainable management practices are unaffected by land tenure regimes in Ghana. The results also show that sharecroppers tend to apply higher levels of chemical fertilizers, relative to owner-cultivators. The intensity of investment in organic manure and green manure is lower for fixed-rent tenants, compared to sharecroppers. Consistent with expectations, fixed-rent tenants tend to apply higher levels of chemical fertilizers than sharecroppers.

A few interesting results also emerge for the farm and household-level variables used in the regressions. Age exerts a negative effect on soil conservation measures but positive effect on the application of mineral fertilizers, indicating that younger farmers are more likely to invest in soil conservation measures than older ones. This may be attributed to the fact that younger farmers cultivate land for longer periods of time, and as such expect to reap the long-term benefits from soil-improving investments. In particular, the coefficient of education is positive for all three types of investments, a finding that is in line with the human capital theory.

The coefficient representing the effect of farm size is positive and statistically significant in the case of organic and green manure but negative and significant for chemical fertilizer. This is probably due to the fact that with increasing plot size, farmers are more likely to adopt soil investment measures because of the higher establishment cost in these types of longer term measures, as compared to investment in fertilizer. This finding is consistent with the results reported by of Shively (1997), who found a positive relationship between farm size and investment in soil conservation in Philippines. Livestock ownership is found to have positive and significant effect on investment in organic and green manure, but negative and significant effect on the application of chemical fertilizer. Livestock ownership may be a necessary, but not sufficient condition for investment in organic manure. This is because the manure market functions quite well in the study area, with farmers buying and selling manure in the market. With regard to plot characteristics, we found that investments in all three types of measures are higher on fertile soils, where the marginal returns to such investments are likely to be much higher. Access to extension services and education also appear to increase the intensity of investments. Non-labor income, which also relaxes household liquidity constraints, also tends to increase the intensity of investment.

Table 4: Multivariate tobit estimates of extent of investment in soil conservation and productivity-enhancing measures

Variable	Organic Manure	Green Manure	Fertilizer
Participation in non-farm work	762.609*	356.986*	-444.531**
	(451.52)	(202.59)	(198.39)
Own-cultivated	658.964***	417.658***	-307.909*
	(233.66)	(125.41)	(168.03)
Fix-rented	-8.942***	-4.360***	1.772*
	(2.96)	(1.58)	(1.04)
AgeHead	-2.442	-0.028	0.277
	(3.99)	(0.02)	(1.73)
Head	5.184	0.201	37.112
	(91.68)	(0.46)	(39.21)
HeadEdu	9.801***	1.007**	16.752***
	(3.36)	(0.50)	(5.72)
HHSizOvr14	1.334	0.126*	6.029
	(13.87)	(0.07)	(47.13)
livstk	7.291***	1.496**	-0.452*
	(1.56)	(0.63)	(0.26)
TCultiLand	1.885*	0.019*	-3.927**
	(1.13)	(0.01)	(1.82)
Credit	-57.149	-0.573	40.429
	(71.39)	(0.36)	(32.16)
TTwell	8.435	0.496*	1.709
	(5.38)	(0.28)	(24.74)
NONLAB	0.993*	0.031*	1.971*
	(0.571)	(0.02)	(1.13)
SoiFert	4.588*	0.037*	0.929
	(2.61)	(0.01)	(1.059)
Exte0ff	217.135***	0.251	52.480
	(83.66)	(0.41)	(36.80)
ResNF	-0.155	-0.345	0.117
	(0.19)	(0.970)	(0.84)
ResOwn	-0.273	-0.779	-0.104
	(0.33)	(0.66)	(0.16)
ResFix	-0.338	-0.237	-0.709
	(0.43)	(0.66)	(0.56)
Intercept	1633.371***	-0.9160	426.146***
	(319.60)	(1.51)	(120.74)
Number of observations	341	341	341
Cross-equation correlations			
ρ_{12}		0.218***	
		(0.06)	
ρ_{13}		0.137**	
		(0.07)	
ρ_{23}		0.724***	
		(0.06)	
Likelihood ratio test of ρ		12.70	
		(0.00)	
χ^2 -statistics for joint significance of residues	0.68[0.34]	1.29[0.68]	0.83[0.58]
χ^2 - statistics for overidentification	0.57[0.39]	0.62[0.42]	0.91[0.63]

Note: standard errors are in parentheses and p-values in squared brackets. Significance of t-statistics of mean difference is at the *10%, **5% and ***1% levels. District fixed effects included in the estimation, but not reported here.

The results of the instrumental variable analysis are presented in Table 5. We employed value of crop output per acre as dependent variable, given the significant diversity of crops on the farms. Given the potential endogeneity of the non-farm work and tenancy arrangement variables, they were instrumented by first estimating probit regression and then using the predicted values of these variables in the farm productivity estimation. The estimates in Table 5 show a positive and significant effect of non-farm work on farm productivity, suggesting that income from non-farm work provides much needed capital for investment in soil-improving measures that eventually increases productivity.

The coefficients for the both own-cultivated and fixed-rent variables are positive and significant, suggesting that productivity is higher on farm under these tenancy arrangements, compared to sharecropping contracts, even after adjusting for other factors. These results further support the Marshallian inefficiency hypothesis These results are consistent with the findings by Banerjee et al. (2002) for India and Abdulai et al. (2011) for Ghana, who found positive and significant impacts of tenure security on productivity in their studies. The results also show that physical assets like land, labor, farm equipments and human capital like education tend to increase farm productivity.

Table 5: Instrumental variable estimates of determinants of land productivity

Variable	Coefficient	t-value
Participation in non-farm work	0.135**	2.24
Own-cultivated	1.309***	7.61
Fix-rented	1.067***	5.32
Organic Manure	0.050***	4.16
Fertilizers	0.011*	1.72
TCultiLand	0.329*	1.68
Equipments	0.688**	2.30
Family labor	0.164*	1.85
Hired labor	0.422***	3.50
Head	0.840*	1.76
HeadEdu	0.275*	1.70
AgeHead	-0.016	-1.06
HHsizOvr14	0.164	1.49
livstk	3.593***	7.47
location1	-0.0112	-0.02
location2	-1.274*	-1.86
location3	-0.602	-0.96
location4	-1.29	-1.82
location5	0.649	1.10
Constant	6.656***	6.18
R^2	0.2984	
Adjusted R^2	0.2637	
Wald-statistics $\chi^2(19)$	36.61	
F-value	121.29	
Prob>F	0.00	
Number of obsevations	341	

Note: Significance of t-statistics of mean difference is at the *10%, **5% and ***1% levels.
Predicted values of non-farm participation and tenancy arrangement variables are used.
Wald test for the joint significance of the non-intercept exogenous variables against a critical value of $\chi^2_{(19,0.05)} = 30.14$
The instrument used in the non-farm equation is migration status. In tenancy arrangement equations, distance and location are used as instruments.

Although our results show that tenure security have positive impacts on investment and agricultural productivity, it is also significant to examine the direct relationship between investment and productivity. We therefore, employed a propensity score matching approach to examine the direct effects of investment in organic manure, green manure, and chemical fertilizer on farm productivity. Table 6 presents the average treatment effects (ATT) estimated by nearest neighbor (NNM) and kernel-based methods (KBM). The matching results from both approaches generally indicate that investment in organic manure, green manure, and mineral fertilizer exert a positive impact on farm productivity, indicating that may partly account for the productivity impacts of tenure security.

Table 6: Average treatment effect for organic manure, green manure and fertilizer

	Matching	Outcome	ATT	Nr of treated	Nr of controls	Common support imposed	Balancing property satisfied
Organic Manure	NNM	Output value per acre	254002.08**(2.31)	192	147	Yes	Yes
	KBM		230887.26*(1.97)	192	147	Yes	Yes
Green Manure	NNM	Output value per acre	34130.03**(2.03)	271	68	Yes	Yes
	KBM		27542.06***(2.96)	271	68	Yes	Yes
Fertilizer	NNM	Output value per acre	266991.271**(2.33)	306	29	Yes	Yes
	KBM		234394.563**(2.21)	306	29	Yes	Yes

Note: Numbers in parentheses are t-values.
Significance of t-statistics of mean difference is at the *10%, **5% and ***1% levels.
ATT is the Average Treatment effect for the Treated.
NNM stands for Nearest Neighbor Matching and KBM stands for Kernel Based Matching.

6-Conclusion

Land tenure arrangements in developing countries tend to have significant implications for allocative and farm productivity. The imperfect financial markets in these countries also make non-farm work a source of liquidity to overcome credit and insurance market constraints, and increase investment in soil-improving and productivity-enhancing measures in farming. This study utilized cross-sectional data of 341 rural household of Pakistan to examine the effects of non-farm work and tenancy arrangements on the intensity of investment in soil-improving and productivity-enhancing measures, as well as farm productivity. The empirical results show the significance of controlling for potential endogeneity of investment intensity and variables such as tenancy arrangement and participation in non-farm work when examining the effects of these variables.

The evidence from our analysis suggests that participation in non-farm work increases the intensity of investment in soil-improving measures but decreases the use of chemical fertilizer. Thus, household participation in non-farm work induces investment in soil-improving measures with long-term benefits, and away from static inputs such as chemical fertilizer with short-term benefits. The findings are consistent with the evidence reported by Oseni and Winters, (2009). We also find evidence that participation in non-farm work exerts positive and significant impact on farm productivity, suggesting that non-farm work can contribute to higher household incomes and poverty reduction in rural areas.

The analysis also reveals that land tenancy arrangements influence investment measures. In particular, owner-cultivators invested more in soil-improving measures, but less in chemical fertilizer. On the other hand, fixed-rent tenants invested less in soil-improving measures, but more in chemical fertilizer. These findings confirm the notion that farmers on short-term fixed-rent contracts normally aim for short-term benefits and therefore tend to invest more in static inputs such as chemical fertilizer. However, owner-cultivators, with secured property rights, mostly target longer term benefits from their agricultural investments.

Overall, our findings suggest that the strengthening of tenure security, either through land reforms to improve ownership or improving tenancy contracts through longer tenure durations can have positive impacts on investment. Moreover, improving the access of rural households to non-farm opportunities can have significant investment and productivity effects. In particular, in rural areas with imperfect credit markets, where farm households find it difficult to obtain credit, improving non-farm work opportunities could provide a substitute for credit as a mechanism to facilitate investment in longer term soil-improving measures and increasing agricultural productivity.

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