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Off-farm work, land tenancy contracts and investment in soil conservation measures in rural Pakistan*

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This study examines the impacts of participation in off-farm work and land tenancy contracts 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 off-farm work and tenancy contract variables is estimated for 341 rural households in Punjab province of Pakistan. An instrumental variable approach is also used to analyse the impact of tenancy contract and off-farm work on farm productivity. The empirical results show that participation in off-farm work and tenure security tends to increase the intensity of investment in long-term soil-improving measures. We also find that increases in off-farm work and tenure security exert significant and positive effects on farm productivity.

Key words: farm productivity, land tenancy, off-farm work, soil conservation.

1. Introduction

Sustainable management of natural resources such as land and water remains a key component of production strategies that aim at encouraging soil conservation. As rightly noted by Pretty *et al.* (2011), soil conservation on its own does not necessarily increase productivity, but conservation methods that capture water and add new system components can result in improved productivity of crops. Thus, sustainable management of natural resources is a possible route to improved agricultural productivity and increased farm income. This has attracted attention to identify and promote sustainable farm management practices in low-income countries. Although soil type, rainfall and slope of the land largely influence rates of soil loss, farmers' management decisions can exacerbate or mitigate their effects (Lee and Stewart 1983).

There is now strong evidence that institutions such as land tenancy arrangements tend to influence farmers' decisions to invest in soil-improving

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and productivity-enhancing practices (Feder and Onchan 1987; Abdulai *et al.* 2011). However, Arcand *et al.* (2007) show that the impact of tenancy arrangement on investment in soil conservation measures is quite weak. The recent literature on tenancy contracts and investment in soil-improving practices suggests three major effects that explain the positive and significant impact of tenure security on investment in soil conservation measures (Brasselle *et al.* 2002).¹ The first is the ‘assurance effect’, which is related to the security involved in undertaking soil conservation measures, without any fear of expropriation. The second effect, which is known as the ‘transaction effect’, operates through the trade effect when land is easily convertible to liquid assets as a result of tenure security. The third effect, tenure security, improves farmer’s access to credit to finance agricultural investments, by using land title as collateral. On the other hand, insecure tenancy arrangements, such as fixed-rent and sharecropping contracts, tend to create disincentives for the users to invest in soil-improving inputs, resulting in productivity declines.

Meanwhile, a growing body of empirical evidence suggests that off-farm participation may be equally important in promoting investments in sustainable management practices and productivity-enhancing inputs (e.g. Barrett *et al.* 2001; Phimister and Roberts 2006; Pfeiffer *et al.* 2009). The underlying intuition is that in the presence of credit market imperfections, off-farm income can be used to relax the budget constraint and therefore raise investment in farming by providing capital (Pfeiffer *et al.* 2009). The available evidence on the impact of off-farm work on investment in soil-improving inputs and farm productivity also appears to be mixed. For instance, Barrett *et al.* (2001) found that off-farm work exerts a positive effect on purchase of farm inputs by relaxing the liquidity constraints. In contrast, Goodwin and Mishra (2004) found that increased participation in off-farm work leads to decrease in family labour and subsequent reduction in farm efficiency.

Most of the studies mentioned above have either examined the role of off-farm work on agricultural investments or the impact of tenancy contracts on investment in conservation measures. However, very few have analysed the link between tenancy contracts and farm investment through enhanced income possibilities from off-farm work (Feng *et al.* 2010). The 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. A more recent study by Ma *et al.* (2013) finds that higher tenure security and participation in off-farm work stimulate investments in irrigation canals construction and maintenance in north-west China but do not affect investments in land quality improvement.

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.

The main objective of this study was to examine how off-farm work and tenancy contracts affect investment in soil conservation and productivity-enhancing measures. The empirical analysis focuses on the impact of explanatory variables that represent participation in off-farm work, tenancy contracts and farm characteristics on agricultural input investment and farm productivity. The study contributes to the literature by considering participation in off-farm work and land tenure contracts as endogenous to investment decisions. The study utilises cross-sectional rural household-level data from Punjab province of Pakistan.

Land ownership in Pakistan remains highly concentrated in rural areas due to class stratification, where 67 per cent of households are landless and just 0.1 per cent households possess landholdings of one or more hectares (Anwar *et al.* 2004). Land lease markets are therefore very active, with large landowners also employing hired labour. The main types of tenancy contracts 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 contract involves landowners 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. Because of unequal access to land and population growth, the off-farm sector has expanded significantly over the last decades (Government of Pakistan 2011).

2. Conceptual framework

In developing countries, where the risks of farming are high and rural credit markets are poorly developed, the off-farm sector provides a vital source of income. Thus, earnings from off-farm work can help to overcome credit and insurance market constraints by providing liquidity that can be used for investment in soil conservation measures and productivity-enhancing inputs (Barrett *et al.* 2001). Similarly, tenure security provides incentive for farmers to engage in investment in soil-improving and yield-enhancing measures. To illustrate the relationship between off-farm work participation, tenancy contracts and investment in soil conservation activities, we start by specifying a simplified time allocation model. Consider a household that maximises utility over consumption of goods C and leisure time, N

$$U = U(C, N; Z). \quad (1)$$

Thus, C and N are assumed to be objects of current choice. U is the household utility function, which is assumed to be strictly concave and to possess second partial derivatives. The vector Z represents individual, household and location characteristics. Utility is maximised subject to time and budget constraints. The time constraint is

$$T = L_1 + L_2 + N, \quad (2)$$

where T is total time endowment, and L_1 and L_2 are time allocated to farm work and off-farm work, respectively. 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 such as land, and Z is the individual, household and location characteristics. The household also faces a budget constraint specified as

$$P_C C = P_Q Q - P_X X - w_f L_f - K_A(A) + w_{nf} L_{nf} + Y_u, \quad (3)$$

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 is a vector of prices of farm output, K_A is cost of land, with w_f and w_{nf} representing farm and off-farm wages, respectively. The decision problem is to choose the quantity of consumption goods to purchase, the hours of farm and off-farm work, and the quantity of purchased farm inputs so as to maximise household welfare. The Lagrangian of the household's maximisation problem is:

$$\begin{aligned} \mathcal{L} = & U(C, N; Z) + \alpha (T - L_1 - L_2 - N) \\ & + \eta [P_Q Q - P_X X - w_f L_f - K_A(A) + w_{nf} L_{nf} + Y_u - P_C C], \end{aligned} \quad (4)$$

where α is the Lagrangian multiplier associated with the labour market constraint, and η is the Lagrangian multiplier for liquidity constraint. The first-order conditions associated with maximising utility subject to these constraints yield the following optimal choices of the household

$$\frac{\partial \mathcal{L}}{\partial X} = P_Q \frac{\partial Q}{\partial X} - P_x = (\eta/\rho) P_x = 0 \quad (5)$$

$$\frac{\partial \mathcal{L}}{\partial L_f} = P_Q \frac{\partial Q}{\partial L_f} = \alpha/\rho = \frac{\partial U/\partial N}{\partial U/\partial C} = w(1 + \eta/\rho) = 0, \quad (6)$$

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

Equation (5) 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). Equation (6) indicates that households will equate the marginal rate of substitution between

consumption and leisure of family labour 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 labour being allocated to off-farm activities in order to relax the liquidity constraint. If the liquidity constraint is not binding ($\eta = 0$), 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. The first-order condition for optimal time allocation for farm work, off-farm work and leisure is given as

$$\partial U/\partial L_i = w_i \partial U/\partial C - \partial U/\partial L = 0. \quad (7)$$

As shown in Khalan and Mishra (2014), a positive number of off-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 labour 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 off-farm work can be employed to relate off-farm work to farm input use through duality theory. As shown in Bazaraa *et al.* (1993) and Phimister and Roberts (2006), by Lagrangian duality theory, at the optimal solution, the farm household production problem can be specified as the outcome of a profit-maximisation problem given as

$$\pi(P_Q, P_X, \lambda, \gamma, w_f, w_{nf}, Z) = \max_{L, A, X} [P_Q Q - w_f L_f - P_X X - K_A(A)] \quad (8)$$

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. The cost of land can be specified as

$$K_A(A) = (1 - \lambda)\bar{K}_A + \lambda\gamma P_Q Q \quad (9)$$

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 \bar{K}_A .

From Equation (8), we can specify the maximised profits as a function of prices, household characteristics and tenancy contracts as

$$\pi = \pi(P_Q, P_X, \lambda, \gamma, w_f, w_{nf}, Z). \quad (10)$$

Beginning with any well-specified normalised profit function, direct application of Hotelling's lemma to Equation (10) then yields the reduced-

form specifications for input demand (land, labour and nonconventional inputs) and farm output functions

$$L = L(P_Q, w_f, w_{nf}, P_x, \lambda, \gamma, Z) \quad (11)$$

$$A = A(P_Q, w_f, w_{nf}, P_x, \lambda, \gamma, Z) \quad (12)$$

$$X = X(P_Q, w_f, w_{nf}, P_x, \lambda, \gamma, Z) \quad (13)$$

$$Q = Q(P_Q, w_f, w_{nf}, P_x, \lambda, \gamma, Z) \quad (14)$$

The specifications (10)–(13) show that input and output prices, tenancy contracts and off-farm work tend to influence farm profits and demand for inputs, while Equation (14) shows how these factors affect farm output.

Based on the above theoretical concepts, we argue that participation in off-farm work exerts a positive effect on investment in soil conservation measures and farm productivity. Secondly, we hypothesise that tenure security in terms of ownership leads to higher investment in soil conservation measures and farm productivity. Furthermore, in line with the Marshallian inefficiency hypothesis, we expect farmers on fixed-rent contracts to be more productive than their counterparts on sharecropping contracts.

3. Empirical specification

A direct way to examine the effects of participation in off-farm work and tenancy contracts on input use would involve estimating a structural farm household model, which can directly capture the optimal production decisions and how they interact with off-farm labour 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 modelling 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 (11)–(14) for the empirical analysis.

The investment measures include organic manure (m) and green manure from leguminous crops (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 off-farm wages, we can approximate the investment function by using the input demand function in Equation (13) and substituting off-farm labour supply for off-farm wages in the following reduced-form specification

$$Y_{in} = \alpha L_i + \beta T_{iA} + \psi Z_i + \varepsilon_i, \quad (15)$$

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 off-farm work. The vector T_{iA} represents tenancy contracts, with the subscript A indicating whether the farm is owner-cultivated, or on sharecropping or fixed-rent contract. Because of the censored nature of the investment, we employ a Tobit specification in the analysis. Suppressing subscripts, this can be expressed as

$$Y_i^* = \alpha L_i + \beta T_{iA} + \psi Z_i + \varepsilon_i \quad (16)$$

$$Y_i = Y_i^* \quad \text{if } Y_i^* > 0 \quad (17)$$

$$Y_i = 0 \quad \text{if } Y_i^* \leq 0 \quad Y_i = 0 \quad \text{if } Y_i^* \leq 0,$$

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 measures, and ε_i is the error term, which is assumed to be independently and identically distributed, 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, it is most likely that the error terms of these equations will be correlated.

The specification in Equation (15) assumes that the off-farm work and tenancy contract variables are exogenous. However, off-farm work and investment in farm inputs may be jointly determined through the income effect and so-called lost-labour effect, as emphasised in the new economics of labour migration literature (Taylor *et al.* 2003). Through the income effect, off-farm earnings may help households overcome credit and insurance market constraints by providing liquidity that can be used to purchase productivity-enhancing inputs and long-term investment in agriculture (Taylor *et al.* 2003; Shi *et al.* 2011). However, off-farm work and investment options can compete for household labour and capital that could be used for crop technology improvements and land improvements, resulting in the lost-labour effect (Shi *et al.* 2011).

Similarly, studies on the relationship between tenancy contracts and investment in soil conservation measures suggest that the two variables may be jointly determined (Brasselles *et al.* 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 modelling both off-farm work and tenancy

arrangements explicitly and then allowing for interactions between these decisions and the investment variables specified in Equation (15). The approach involves specifying the first-stage equations for off-farm work and tenancy arrangements as functions of explanatory variables as follows:

$$L_i = Y_i\delta + X_i\xi + \mu_i \quad (18)$$

$$T_i = Y_i\varphi + X_i\theta + \varepsilon_i, \quad (19)$$

where δ , ξ and 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

$$Y_i^* = L_i\omega_1 + T_{iA}\omega_2 + Z_i\omega_3 + R_i\omega_4 + \eta_i\omega_5 + v_{iA}, \quad (20)$$

where L_i and T_i are vectors of the observed variables for off-farm work and tenancy contract, respectively; R_i and η_i are the residual terms of off-farm work and tenancy contract from Equations (18) and (19), and v_{iA} is the error term. As noted by Smith and Blundell (1989), the Tobit estimates of ω_1 and ω_2 in Equation (20) are consistent.

Given that the first stage of the two-stage estimation procedure involves a linear form, we employed a linear probability model that yields consistent estimates (Wooldridge 2002). Proper identification of the investment specification requires that some of the variables included in the first-stage estimation of off-farm and tenancy contract regressions are excluded from the multivariate Tobit estimation. In the tenancy contract equation, we use the distance of the farm from the farmer's residence and a dummy variable indicating whether or not the cultivator resides in the village where the farm is located as identifying instruments. In the off-farm equation, we employ the migration status of the farmer as the identifying instrument. As pointed out by Pfeiffer *et al.* (2009) and Kilic *et al.* (2009), the migrant network is correlated with national and international migration and thus with participation in off-farm work, but not directly with agricultural investment decisions.

To examine the impacts of off-farm work and tenancy arrangements on farm output, we use an instrumental variable approach to estimate specification (14). This accounts for the potential endogeneity of intensity of investment with the off-farm work and tenancy contract 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

This study utilises farm-level data collected between September 2010 and January 2011 in the Punjab province of Pakistan. Given that the Punjab

province has three broad agro-climatic zones, we selected two districts each from these zones and then employed a stratified random sampling approach to select 341 households for the survey. The six selected districts are Sahiwal, Layyah, Sialkot, Khushab, Muzaffargarh and Lahore.

The survey asked farmers whether they had 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. Very few farmers engaged in terraces and strip cropping. We therefore did not consider them in the empirical analysis. As noted by Jacoby and Mansuri (2008), organic manure supplies nutrients to soil, which remain available over a longer period than the nutrients supplied by mineral fertilizer.

Table 1 displays the definitions of the variables used in the analysis. As indicated previously, the dependent variable in the study is investment in soil-improving and productivity-enhancing measures. The three tenancy arrangement variables used are owner-cultivated, fixed-rent and sharecropping contracts. Off-farm work is represented with a dummy variable taking the value of one if the household participated in the off-farm labour market, and zero otherwise. The sample consisted of 200 owner-cultivated, 91 sharecropping and 50 fixed-rental households, without any recorded cases of households with multiple tenancy arrangements. The proportions of farmers who used organic manure, green manure and mineral fertilizers are given in Table 1.

The approach that is mostly used to examine the Marshallian inefficiency hypothesis under a sharecropping contract is a comparison of output per hectare between land cultivated under sharecropping contracts and those cultivated under ownership and/or fixed-rent contracts. We therefore present some differences in output and input use between these tenancy arrangements in Table 2. Given that farmers cultivated various crops, we use the value of crop output per acre as is commonly done in the empirical literature (e.g. Deininger and Ali 2008; Abdulai *et al.* 2011). The value of crop output per acre is about 155 percentage points higher on owner-cultivated land compared to land under sharecropping contract. Value of crop output per acre on fixed-rent plots is also much higher than land under sharecropping contract by about 89 percentage points. Also presented in the table are differences in physical output between the three tenancy contracts for three crops. It is again evident that output is highest for owner-cultivators and lowest for sharecroppers for wheat, rice and cotton. There are also marked differences in application of inputs between the tenancy regimes. In particular, the average quantity of fertilizer used on owner-cultivated land was about 10 percentage points higher than that on land under sharecropping contract. Fixed-rent tenants appear to apply more fertilizer than both owner-cultivators and sharecroppers.

Table 1 Descriptive statistics of variables used in the regression models

Variable	Definition of variables	Mean	SD
Investment variables			
Organic Manure	Organic manure used per acre (kgs)	280.86	373.67
Green Manure	Leguminous crops grown per acre	0.53	0.49
Fertilizers	Chemical fertilizer applied per acre (kgs)	324.87	256.09
FuseOrganic	1 if farmer applies organic manure, 0 otherwise	0.56	0.43
FuseGreen	1 if farmer applies green manure, 0 otherwise	0.79	0.38
FuseFerti	1 if farmer applies chemical fertilizer, 0 otherwise	0.91	0.25
Off-farm participation variable			
Parti in Nfarm	1 if HH members participate in off-farm work	0.63	0.48
MigNet	1 if HH is a migrant household, 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	0.58	0.50
Fix renter	1 if land is under fixed-rent contract, 0 otherwise	0.27	0.28
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
Gender	1 if HH head is female, 0 otherwise	0.20	0.23
Education	Years of education of HH head	8.22	6.28
HHSizOvr14	Number of HH members <14 years	4.02	2.89
Livstk	1 if HH has livestock, 0 otherwise	0.86	0.57
TTwell	Number of tube well	0.66	0.97
NONLAB	Unearned income (rupees)	3.25	4.80
Credit	1 if HH has access to credit, 0 otherwise	0.58	0.47
ExteOff	1 if HH has contact to extension agent, 0 otherwise	0.21	0.41
Farm-level characteristics			
Farm size	Total cultivated land in acres	22.83	38.71
SoiFert	1 if land is fertile, 0 otherwise	0.73	0.36
ADisField	Distance of farm from owner's residence (km)	1.99	4.12
Residence	1 if landlord resides in village where farm is located, 0 otherwise	0.54	0.43
Family labour	Total hours of family labour worked on farm last year	140.61	184.37
Hired labour	Total hours of hired labour 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 empirical results of the impact of off-farm work and tenancy contracts on investments in soil-improving and productivity-enhancing inputs, as well as agricultural productivity, are presented in this section. The investment specification was estimated by using a multivariate Tobit model, controlling for endogeneity of the off-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 off-farm work and

Table 2 Difference in investment and other key characteristics by owners and fix renters and sharecropper status

Variable	Description	Owner	Fix renter	Sharecropper
Organic	Organic manure used per acre (kgs)	338.05	257.69	286.48
Green	Leguminous crops grown per acre	0.72	0.44	0.25
Fertilizer	Chemical fertilizer applied (kg/acre)	343.24	387.76	311.60
Out Value	Value of crop output per acre in rupees	391135.2	289372	153266
Wheat yield	Output in kg/acre	1640	1480	1280
Cotton yield	Output in kg/acre	1300	875	750
Rice yield	Output in kg/acre	2400	1600	1440
Gender	1 if HH is female, 0 otherwise	0.27	0.18	0.11
Education	Years of education of HH head	9.95	6.06	5.63
AgeHead	Age of HH head (years)	49.09	40.00	45.00
HHSizOvr14	No. of HH members <14 years	4.03	4.07	3.9
Livstk	1 if HH has livestock, 0 otherwise	0.89	0.97	0.8
Farm size	Total cultivated land in acres	21.46	33.43	14.71
Credit	1 if HH has access to credit, 0 otherwise	0.86	0.45	0.25
NONLAB	Unearned income in rupees	5.49	0.95	1.78
TTwell	Number of tube well	1.21	0.60	0.35
SoiFert	1 if land is fertile, 0 otherwise	0.95	0.65	0.76
ExteOff	1 if HH has contact to extension agent, 0 otherwise	0.25	0.16	0.05

tenancy arrangements are first presented, followed by the second-stage investment estimates.

Table 3 reports the first-stage estimates of the determinants of participation in off-farm work. The signs of the estimated parameters are consistent with previous studies. Educated household heads had a significantly higher probability of engaging in off-farm activities, suggesting that additional schooling raises the off-farm wage more than the reservation wage for farm or home activities. Age increases the probability of participation in off-farm work, which reflects the general experience that age increases the marginal value of time in each activity. Nonlabour income tends to increase the probability of participating in off-farm work. Migrant household heads are more likely to participate in off-farm work, compared to nonmigrants. Lack of credit access serves as a constraint to participation in off-farm work. Farmers cultivating fertile land appear to be more likely to participate in off-farm employment, probably because of the higher returns from these lands that contribute to higher house income.

The first-stage estimates of the determinants of tenancy contract are presented in Table 4. The omitted category used as a reference group is the sharecropping variable in the case of tenancy contract. The estimates reveal that owner-cultivators are more likely to be males, while fixed-rent tenants are more likely to be females. 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

Table 3 Linear probability estimates of determinants of participation in off-farm work

Variable	Off-farm work	<i>t</i> -values
AgeHead	0.026***	2.60
Gender	0.299	1.30
Education	0.088***	4.40
HHSizOvr14	0.051	1.70
Livstk	-0.652**	-2.10
Farm size	0.012***	12.00
Credit	0.444**	2.47
TTwell	0.295**	2.27
NONLAB	0.019***	1.90
SoiFert	0.011***	19.00
DisMarkt	0.009***	9.17
Location1	0.142	0.36
Location2	1.200***	3.24
Location3	0.684**	2.07
Location4	0.930	1.01
Location5	0.644**	2.15
MigNet	0.627**	2.41
Intercept	-1.384**	-2.82

Note Significance of coefficients is at the *10%, **5% and ***1% levels.

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 the instruments (distance, residence) in the tenancy contract regression given in Table 4 suggests that the instruments can be considered exogenous in the estimation.

Table 5 presents the results of the second-stage regression on investment in soil-improving and productivity-enhancing measures. The test statistics show that the estimated correlation coefficients are all positive and significantly different from zero at the 5 percent level of significance, suggesting that unobserved variables involved in each investment option are 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, supporting the use of the multivariate Tobit model. The estimates of residuals ResNF, ResOwn and ResFix, derived from the first-stage regressions of off-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

Table 4 Linear probability estimates of determinants of land tenure arrangements

Variable	Own-cultivated	<i>t</i> -values	Fix-rented	<i>t</i> -values
AgeHead	0.024**	2.40	-0.031***	-3.10
Gender	-0.707***	-2.72	0.793***	2.64
Education	0.343***	4.29	-0.399***	-4.43
HHSizOver14	0.009	0.30	0.008	0.20
Livstk	0.026*	2.60	-0.018*	-1.80
Farm size	0.009	0.90	-0.008***	-6.67
Credit	0.492**	2.59	0.437**	2.18
TTwell	0.645***	4.03	0.685***	4.28
Exte0off	0.250*	1.79	0.563**	2.08
SoiFert	0.031***	25.83	0.007***	5.83
Location1	-0.284	-0.66	-0.330	-0.61
Location2	-0.485	-1.18	0.020	0.04
Location3	-0.335	-0.91	0.396	0.99
Location4	-0.875	1.27	0.039	0.05
Location5	-0.123	-0.34	-0.057	-0.14
ADisField	-0.187**	-2.34	0.078***	3.90
Residence	0.077***	3.85	-0.839***	-3.65
Intercept	-0.257	-0.48	-0.015	-0.02
<i>F</i> -Statistics (<i>P</i> -values)	18.13 [0.00]		10.79 [0.00]	

Note *P*-values in squared brackets. Significance of coefficients is at the *10%, **5% and ***1% levels.

findings confirm the exogeneity of off-farm participation and tenancy arrangement variables.

On the estimated coefficients and their *t*-statistics, the positive and statistically significant coefficients for the off-farm work variable in the organic manure and green manure specifications show that participation in off-farm work increases the intensity in the application of these inputs, a finding that is consistent with the income effect. This finding is in line with the results reported by Oseni and Winters (2009). However, they contrast with the findings by Shi *et al.* (2011), who found in their village-level analysis in Jiangxi Province of China that the lost-labour effect dominates the income effect, resulting in a net negative effect of off-farm employment on organic manure use. The negative and significant coefficient in the chemical fertilizer specification suggests that fertilizer intensity declines with participation in off-farm work, supporting the lost-labour effect of off-farm work on input use, a result that is in line with the findings of Shi *et al.* (2011) for China. This result may be because chemical fertilizers need to be applied several times throughout the agricultural season, while organic manure is applied once, and green manure is easily combined with off-farm work (Shi *et al.* 2011).²

The results for the tenancy contract 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 inputs is higher for owner-cultivators, compared to sharecroppers. This

² We are thankful to an anonymous reviewer for suggesting this to us.

Table 5 Multivariate Tobit estimates of extent of investment in soil conservation and productivity-enhancing measures

Variable	Organic manure	Green manure	Fertilizer
Participation in off-farm work	762.609* (1.69)	356.986* (1.76)	−444.531** (−2.24)
Own-cultivated	658.964*** (2.82)	417.658*** (3.33)	−307.909* (−1.83)
Fix-rented	−8.942*** (−3.02)	−4.360*** (−2.76)	1.772* (1.70)
AgeHead	−2.442 (−0.61)	−0.028 (−1.40)	0.277 (0.16)
Gender	5.184 (0.06)	0.201 (0.44)	37.112 (0.95)
Education	9.801*** (2.92)	1.007** (2.01)	16.752*** (2.93)
HHSizOver14	1.334 (0.09)	0.126* (1.80)	6.029 (0.13)
livstk	7.291*** (4.67)	1.496** (2.36)	−0.452* (−1.74)
Farm size	1.885* (1.67)	0.019* (1.90)	−3.927** (−2.16)
Credit	−57.149 (−0.80)	−0.573 (−1.59)	40.429 (1.26)
TTwell	8.435 (1.57)	0.496* (1.77)	1.709 (0.07)
NONLAB	0.993* (1.74)	0.031* (1.66)	1.971* (1.74)
SoiFert	4.588* (1.76)	0.037*** (3.70)	0.929 (0.88)
Exte0off	217.135*** (2.59)	0.251 (0.61)	52.480 (1.43)
ResNF	−0.155 (−0.82)	−0.345 (−0.36)	0.117 (0.14)
ResOwn	−0.273 (−0.83)	−0.779 (−1.18)	−0.104 (−0.65)
ResFix	−0.338 (−0.79)	−0.237 (−0.36)	−0.709 (−1.27)
Intercept	1633.371*** (5.11)	−0.9160 (−0.61)	426.146*** (3.53)
Number of observations	341	341	341
Cross-equation correlations			
ρ_{12}		0.218*** (3.63)	
ρ_{13}		0.137** (1.96)	
ρ_{23}		0.724*** (12.07)	
Likelihood ratio test of ρ		4233.33*** [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 *t*-values are in parentheses and *P*-values in squared brackets. Significance of coefficients is at the *10%, **5% and ***1% levels. District fixed effects included in the estimation, but not reported here.

finding is consistent with the results reported by Deininger and Ali (2008) for Uganda. 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 farmers that are under sharecropping contracts. These results lend support to the notion that farmers on fixed-rent contracts, which in most cases are shorter than sharecropping contracts, tend to be more interested in short-term benefits from chemical fertilizer than the expected long-term gains from organic manure (Jacoby and Mansuri 2008).

The results also show that the coefficient of education is positive for all three types of investments, a finding that is in line with 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 because with increasing plot size, farmers are more likely to adopt soil investment measures because of the higher establishment cost in these types of long-term measures, as compared to investment in fertilizer. Livestock ownership exerts a positive and significant effect on investment in organic and green manure, but negative and significant effect on the application of chemical fertilizer. Access to extension services and education also increase the intensity of investments in soil conservation and productivity-enhancing investments. Nonlabour income, which also relaxes household liquidity constraints, also tends to increase the intensity of investment.

The coefficients presented in Table 5 indicate the impact of explanatory variables on the intensity of each investment measure, but do not indicate the differences in intensity levels of the investments. We therefore compute marginal effects to show the marginal contribution of each explanatory variable on the intensity of investment. The computed marginal effects and their standard errors are presented in Table 6. The estimates show that participation in off-farm work increases the intensity of investment in organic manure and green manure by 60 per cent and 42 per cent, respectively, while it decreases the use of fertilizer by 36 per cent. Looking at the tenancy contract variables, the results show that being an owner-cultivator increases the intensity of investment in organic manure and green manure by 56 per cent and 57 per cent, respectively, but decreases the use of chemical fertilizer by 39 per cent. On the other hand, being a fixed-rent tenant increases, the use of chemical fertilizer by almost 54 per cent. Overall, the positive and statistically significant impact of ownership on investment in soil conservation measures is consistent with the notion that secured rights matters for investment in these activities. Households endowed with valuable physical capital such as farmland or livestock also invest more in organic and green manure, as they capitalise their assets to finance longer-term investment measures.

Table 7 presents the results of the impact of off-farm work and tenancy contract on farm productivity. We employed value of crop output per acre as the dependent variable, given the significant diversity of crops on the farms. Given the potential endogeneity of the off-farm work and tenancy arrangement variables, they were instrumented by first estimating a probit regression and then using the predicted values of these variables in the farm productivity estimation. The estimates show a positive and significant effect of off-farm work on farm productivity, suggesting that income from off-farm work provides needed capital for investment in soil conservation measures that eventually increases farm productivity. This finding offers evidence in support of the income effect of the new economics on labour migration hypotheses that in the absence of credit markets, income from off-farm work may be used by households to expand purchases of inputs that lead to higher on-farm productivity (Taylor *et al.* 2003; Shi *et al.* 2011).

Table 6 Marginal effects on the marginal probability of investment

Variable	Organic manure	Green manure	Fertilizers
Participation in off-farm work	0.603(7.35)	0.418(2.17)	-0.359(-1.84)
Own-cultivated	0.559(5.59)	0.568(2.61)	-0.387(-2.55)
Fix-rented	-0.694(-4.01)	-0.421(-105.25)	0.541(2.39)
AgeHead	-0.912(-1.40)	-0.168(-0.79)	0.856(2.63)
Gender	0.295(0.38)	0.164(0.58)	0.109(0.74)
Education	0.621(4.89)	0.606(2.89)	0.638(1.68)
HHSizOver14	0.158(2.26)	0.129(1.79)	0.256(12.19)
Livstk	0.558(69.75)	0.479(14.97)	0.322(13.42)
Farm size	0.062(2.00)	0.064(64.00)	-0.085(-2.74)
Credit	-0.382 (-1.01)	-0.336(-2.38)	0.351(4.03)
TTwell	0.146(1.60)	0.212(4.93)	0.312 (0.53)
NONLAB	0.103(10.30)	0.194(1.73)	0.504(4.13)
SoiFert	-0.024(-12.00)	-0.087(-7.91)	-0.044(-2.10)
Exte0off	0.423(17.63)	0.291(2.39)	0.563(6.33)

Note *t*-values of the estimated marginal effects are presented in parentheses.

The coefficients for the both owner-cultivated and fixed-rent variables are positive and significant, suggesting that on-farm productivity is higher on farms under these tenancy arrangements, compared to sharecropping contracts, even after adjusting for other factors. These results provide additional evidence in support of the Marshallian inefficiency hypothesis, whereby sharecroppers are less efficient than owner-cultivators and fixed renters, due to the fact that they receive only a share of the marginal output at a given level of input use. The results also reveal that physical assets such as land, labour, farm equipment, as well as human capital such as education, tend to increase on-farm productivity.

6. Conclusion

This study utilised cross-sectional data of 341 rural households of Pakistan to examine the effects of off-farm work and tenancy arrangements on the intensity of investment in soil-improving and productivity-enhancing measures, as well as on 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 off-farm work when examining the effects of these variables.

The evidence from our analysis indicate that participation in off-farm work increases the intensity of investment in soil conservation measures and also results in higher on-farm productivity, a finding that is consistent with the new economics on labour migration. Thus, in the absence of credit markets, off-farm employment provides needed capital for investment in soil-improving measures that eventually increases farm productivity. In particular, the income effect of off-farm work is found to be much stronger than the potential lost-labour effect. The positive effect of off-farm employment on

Table 7 Instrumental variable estimates of determinants of farm productivity

Variable	Coefficient	<i>t</i> -value
Participation in off-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
Farm size	0.329*	1.68
Equipments	0.688**	2.30
Family labour	0.164*	1.85
Hired labour	0.422***	3.50
Gender	0.840*	1.76
Education	0.275*	1.70
AgeHead	-0.016	-1.06
HHsizeOver14	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	
<i>F</i> -value	121.29	
Prob> <i>F</i>	0.00	
Number of observations	341	

Note Significance of coefficients is at the *10%, **5% and ***1% levels. Predicted values of off-farm participation and tenancy arrangement variables are used. Wald test for the joint significance of the nonintercept exogenous variables against a critical value of $\chi^2_{(19,0.05)} = 30.14$.

soil-improving measures and farm productivity indicates that off-farm work can contribute to higher household incomes and poverty reduction in rural areas.

The analysis also reveals that land tenancy contracts influence investment in soil conservation measures. Specifically, the data show that owner-cultivators invested more in soil-improving measures, and also applied more chemical fertilizers, compared to sharecroppers, a finding that is consistent with the Marshallian inefficiency hypothesis. However, the econometric estimates, after accounting for the effects of other variables, such as soil fertility, landholdings and household characteristics, reveal a positive coefficient for investment in soil-improving measures, but a negative coefficient for chemical fertilizers. While the positive coefficient confirms the Marshallian inefficiency hypothesis, the negative sign for fertilizer appears to be in contrast with the hypothesis.

Fixed-rent tenants were found to invest less in soil conservation measures, but more in chemical fertilizer. Given that sharecroppers normally expect to be in more durable relationships with their landlords than fixed-rent tenants, they tend to invest more in long-term soil-improving measures. These findings

confirm the notion that farmers on 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 in soil conservation measures and agricultural productivity. Moreover, improving the access of rural households to off-farm work 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 off-farm work opportunities could provide a substitute for credit as a mechanism to facilitate investment in soil-improving measures and increasing agricultural productivity.

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