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Gender in agriculture: Determinants of female labor supply decisions among rural households in the context of market imperfections in Pakistan

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Abstract

Welfare of the household depends on the better understanding of time allocation among different sectors in response to changes in economic conditions. This article estimates labor supply of male and female of rural households regarding activities for own-farm, agricultural-wage, and nonfarm sector. The study utilizes the cross-sectional data of 341 rural households of the Punjab, Pakistan through random sampling technique. In Pakistan, like other developing countries, gender-based wage data are almost nonexistent, and functioning of labor market is imperfect. Therefore, reservation wages are calculated through production function analysis. Our results reveal that literacy rate, social status, and rural infrastructure are key determinants in the rural labor market. Hypothesis of separability in agricultural household models is tested by applying three tests. Separability hypothesis is rejected on the bases of results indicating the presence of imperfect labor market in rural settings of Pakistan. The findings suggest that policy makers should focus on educational opportunities, infrastructure development, and minimizing entry barriers in labor market, especially for females, regarded as socially backward class in order to raise economic conditions of rural dwellers in Pakistan.

KEYWORDS
gender, imperfect labor market, labor supply, Pakistan, social class system

JEL CLASSIFICATION
J16, J22, J43, D53

1 | INTRODUCTION

Labor activities play significant role in rural households' welfare in developing countries. Women are mainstay of the communities in low-income countries as they perform wide spectrum tasks, ranging from household domestic duties to income generating activities. They contribute an integral portion of the labor force in developing countries, like 66% in Somalia, 55.3% in Morocco, 53.2% in Egypt, and 50.7% in Lebanon. Although they play a significant role in income generation and household activities, yet their efforts are not acknowledged in economic term (Radoviťc-Markoviťc, 2013). This condition is aggravated by the negligence of policy makers in recognizing and promoting their contribution. Therefore, society is deprived of in taking the full benefits from the productive role of women in household welfare (Begum & Yasmeen, 2011).

Pakistani society is preliminarily a male dominant society, where gender segregation is prominent especially in the rural areas. Overall, women contribute 14.5% to the total labor force whereas their contribution in agricultural labor is 67% (GOP, 2019). Despite their active participation in agriculture, women lack land ownership and access to resources (Lastarria-Cornhiel, 2006; Shahzad & Abdulai, 2020). Low crop production and resulting poverty and inability to provide sufficient food to the family forces women to get engaged in labor activities (World bank, 2008). Additionally, women are discriminated on the basis of wages as well (Hertz et al., 2008). Participation of women in the labor force is seen as an indicator of sustainable human development indicator (World Economic Forum, 2014) and also an important catalyst for their economic uplift (Verick, 2014). Hence, appraisal of women participation in labor market is imperative for researchers and policy makers for the formulation of suitable policies.

Most of the empirical estimation of the labor demand and supply decisions of farm households extensively uses the empirical advantage of separability assumption (Abdulai & Delgado, 1999; Singh et al., 1986). This assumption states that there is independence between the production and consumption decisions of the farm households. This is the case when the rural labor markets are well functioning. When labor markets are imperfect, which is a common feature of developing countries, including Pakistan, empirical results based on such an approach are likely to mislead policy conclusions. So, the emphasis of development economics has shifted to the separability assumption (Abdulai & Regmi, 2000; Benjamin, 1992) in which rural households are the producers as well as consumers of farm produce simultaneously.

Previous literature has focused on share of female labor in agriculture (Palacios-Lopez et al., 2017), fulfilling household's food requirements (ESCAP, 1997), role in decision making in agriculture (Rasheed, 2004), discrimination in resource ownership (Chaudhry and Rahman, 2009), linkages between human capital, productivity, and labor allocation (Fafchamps & Quisumbing, 1999), gender differences in food insecurity (Broussard, 2019), and the role of market imperfections in female labor supply (Abdulai & Regmi, 2000). Empirical literature on the labor supply of male and female members of farm-households in Pakistan under the assumption of nonseparability is very limited. The purpose of this study is to fill this gap and to make contribution to scarce empirical literature by investigating the effects of education, family status, and infrastructure on the allocation of labor between own-farm, nonfarm, and farm-wage earning activities of rural households based on gender using the shadow wages.

2 | BACKGROUND AND CONCEPTUAL FRAMEWORK

To investigate the gender-based labor supply of farm households, the study presents the basic household model of labor allocation based on the work of Singh et al. (1986) and Abdulai and Delgado (1999). This model assumes that a typical rural household consists of the head of household and his/her spouse, which jointly choose the consumption of market goods (C), home produced goods(Q), and allocation of their respective time (L_i) between agricultural (L_{iA}), nonfarm (L_{iNF}), home production (L_{iD}), and leisure (N_i). Given this, the household utility function is given as

$$U_{\text{Max}} = U(C, N_i; Z)\ i = 1, \text{Male}, i = 2, \text{Female}, \tag{1}$$

where U is the household utility function which is assumed to be strictly concave and possesses continuous second partial derivatives. N_i is the leisure hours, and Z is the individual and household characteristics. Household faces constraints like time $L_i = L_{iA} + L_{iNF} + L_{iD} + N_i$, nonnegative $L_{iA} \geq 0$, $L_{iNF} \geq 0$, $L_{iD} \geq 0$, production $Q = Q\,(L_{iA}, H_i, X, Z, \theta, A, S, V)$, and budget $Y_{iA} + Y_{iNF} + Y_{iD} + Y_{iO} - P_X X = P_C\ C$. So, full budget constraint is written as:

$$\begin{aligned} P_C C &= PQ(L_{iA}, H_i, X, Z, \theta, A, S, V) - P_X X - W_H H_i \\ &\quad + W L_{iNF} + W_D L_{iD} + Y_{iO}, \end{aligned} \tag{2}$$

where $Y_{iA}/Y_{iNF}/Y_{iD}/Y_{iO}$ represents income from agriculture, nonfarm, home production, and other sources respectively for male and female members of household. P_x, P_c, and P represent vector of prices of variable inputs, purchased goods and farm output, respectively. H_i represents amount of hired male and female labor. W_H, W and W_D denote wage paid to hired labor, nonfarm work and home production respectively. θ embodies production shocks (climatic risks, economic fluctuations), A represents fixed assets of the household (land etc.), S represents vector of social/cultural constraints, V represents village level characteristics such as distance, infrastructure etc., X represents vector of purchased inputs and Q characterizes quantity of agricultural production. The Lagrangian of the household's maximization problem is:

$$\begin{aligned} \int &= U(C, N_i; Z) + \lambda\,(L - L_{iA} - L_{iNF} - L_{iD} - N_i) \\ &\quad + \phi \begin{bmatrix} PQ\ (L_{iA}, H_i, X, Z, \theta, A, S, V) - P_X X \\ -W_H H_i + W L_{iNF} + W_D L_{iD} + Y_{i0} - P_C C \end{bmatrix}, \end{aligned} \tag{3}$$

where λ is the Lagrangian multiplier associated with the inequality constraints on each type of labor participation,

ϕ is the Lagrangian multiplier associated with income inequality constraint. The Lagrangian function ($\int$) is maximized with respect to L_{iA},L_{iNF},$L_{iD}H_i$,X, λ, ϕ for maximizing the utility (U) is shown in Appendix A1.

The above model assumes that the markets are complete where production and consumption decisions of the household are separable. In low-income countries where markets for key factors and products are weak or absent, usually separability does not exist and mostly farm households are both producers and consumers of agricultural goods simultaneously. Under nonseparability, labor is allocated in such a way that the marginal product of labor is equal to an endogenously determined shadow wage (w^*). Thus, we introduce market failure in the model as a market labor constraint: $L_{iNF} \leq M$, where M is the maximum number of hours a farmer can work in the labor market. This type of failure is important particularly for the existing situations of Pakistan. First order conditions for the optimal choices of household are given in Appendix A2.

By using the shadow wage, the nonlinear budget constraint can be replaced by an artificial linear constraint. The household maximization problem $U_{\text{Max}} = U(C, N_i; Z)$ is subject to $P_C C + w_i^* \ N_i = Y_i{}^*$. Where shadow income (Y^*) is written as:

$$Y_i{}^* = PQ(L_{iA}, H_i, X, Z, \theta, A, S, V) - P_X X - W_H H_i + w_i^* L_i(Z) + Y_{io}. \quad (4)$$

Structural demand function for leisure and corresponding structural labor supply functions are given as:

$$N_i^* = N_i(w_i^*, Y^*; Z), \quad (5)$$

$$T_i^* = T_i(w_i^*, Y^*; Z), \quad (6)$$

where T_i^* is the total hours of work of family members of gender i in agricultural, nonfarm and other activities.

$$T_i^* = L_i - N_i^* = L_{iD}^* + L_{iA}^* + L_{iNF}^* \quad \text{if } L_{iNF}^* > 0, \quad (7)$$

$$T_i^* = L_i - N_i^* = L_{iD}^* + L_{iA}^* \quad \text{if } L_{iNF}^* = 0. \quad (8)$$

3 | METHODOLOGY

3.1 | Data description

Household-level data were collected between September 2010 and January 2011 through a cross-sectional survey of rural households in the Punjab province of Pakistan. Punjab province is the country's most populous region, constituting largest pool of professionals and highly skilled manpower. It has three broad agro-climatic zones named as South, North, and Central. Two districts from each zone were selected for the survey. A stratified random sample of a total of 341 households was selected in six districts to ensure representation of all categories of households, which potentially influence the extent and nature of livelihood diversification.

Table 1 includes the definitions and sample statistics of variables used in the analysis for male and female respondents. Total value of output is computed as the sum of value of all crops grown, income from the sale of animal byproducts and 20% of the value of the household's herd, using an approach similar to work of Jacoby (1993); Abdulai and Regmi (2000); Kousar et al. (2018). The value of each crop is estimated by using village level median price of the prices that farmers indicate their crops would currently fetch on the market. This avoids the problem of using the same set of prices for all farms.[1] The farming community of Pakistan consists of mostly subsistence farmers, so many households do not sell much of their output and a significant portion of agricultural produce is self-consumed. Furthermore, the quality of produce may vary across villages and because the price may vary accordingly, and prices data are not available. We therefore used the product-level median price for all the product of all households. Median prices were the reported prices of their crops that the farmers would currently fetch on the market (Abdulai & Regmi, 2000; Jacoby, 1993; Todo & Takahashi, 2013). The land variable is the total cropped area in acres during survey year, whether owned, rented, or sharecropped. In the case of variable physical inputs such as fertilizer, seed, and pesticide, only the information on the level of expenditures was collected. Although literature suggests that the use of values in place of quantities in the production function can lead to biased estimates if input price variation is substantial. Yet, taking this approach seems preferable by ignoring these inputs altogether and suffering an omitted variables problem (Abdulai & Regmi, 2000; Jacoby, 1993).

Data were collected from the most influential and informed persons being responsible for the production and labor allocation decisions of the household. So, both adult males and females were interviewed for the preset study.

[1] As argued by Bardhan (1979), if farmers face the same prices and the true production possibility frontier is concave, rather than linear, crop composition cannot be allowed to vary across farms, since farmers are assumed to have the same technology. However, if crop composition is variable in the sample, movements along a given production possibility frontier will be construed as shifts in the value of output.

TABLE 1 Definition and descriptive statistics of the variables used in production

Variable	Definition of variables	Mean	SD
Dependent variable			
Value of output	Total output value in Rupees	1654011	6598264
Explanatory variables			
Land	Total cultivated land in acres	19.93	41.35
Fertilizer cost	Expenditures on fertilizer (Rs.)	6584.33	8288.42
Seed cost	Expenditures on seed (Rs.)	7202.84	9626.00
Pesticides cost	Expenditures on pesticide (Rs.)	3901.95	4325.17
Equipment	Number of farm equipment	4.34	4.56
Family male farm labor	Total hours of family male labor worked on farm	97.25	135.94
Family male nonfarm labor	Total hours of family male labor worked on nonfarm	166.91	732.11
Family male agri-wages labor	Total hours of family male labor worked for agri- wages	248.34	104.68
Family female farm labor	Total hours of family female labor worked on farm	43.36	95.79
Family female nonfarm labor	Total hours of family female labor worked on nonfarm	218.74	198.67
Family female agri-wages Labor	Total hours of family female labor worked for agri- wages	292.99	215.46
Hired male farm labor	Total hours of hired male labor worked on farm	139.20	184.20
Hired female farm labor	Total hours of hired female labor worked on farm	82.06	104.77
Child farm labor	Total hours of farm child labor (family and hired)	9.54	24.78
Gender of Head	1 if Head of HH is male, 0 otherwise	.74	.44
Education of Head	Years of education of HH head	2.12	1.18
Age of Head	Age of education of HH head (years)	48.47	11.54
Children >5	No. of children under the age of 5 years	1.01	1.41
Children between 6–14	No. of children between age 6–14 years	6.25	6.46
Livestockḥ	1 if HH has livestock, 0 otherwise	.83	.38
Location1	1 if HH resides in Lahore district, 0 otherwise	.15	.36
Location 2	1 if HH resides in Sahiwal district, 0 otherwise	.20	.40
Location 3	1 if HH resides in M.Garh district, 0 otherwise	.30	.46
Location 4	1 if HH resides in Layyah district, 0 otherwise	.02	.13
Location 5	1 if HH resides in Sialkot district, 0 otherwise	.25	.43
Location 6	1 if HH resides in Khushab district,0 otherwise	0.08	0.27
Instruments			
Male wage rate	Average village daily wage rate of male	272.23	74.21
Female wage rate	Average village daily wage rate of female	156.95	76.64
Distance	Distance of village from city in km	18.05	12.69
Road	1 if village has road, 0 otherwise	.67	.47
Water supply	1 if village has water supply, 0 otherwise	.85	.35
Electricity	1 if village has electricity, 0 otherwise	.99	.09
Adults	No. of adult household members	4.99	2.76
Adults of farm	No. of adults working on farm	1.83	1.62

Data on the socioeconomic characteristics of households such as age, education, family size, and so on were also utilized in the analysis. The farm labor is divided into four categories as evident from Table 1, family male labor, family female labor, hired male labor, and hired female labor. The use of hired labor is high (62%) as compared to family labor (38%) in the sample.

3.2 | Empirical approach

3.2.1 | Testing for separability

In this section, the hypothesis of separability was tested by applying three tests to gain further intuition into the efficient functioning of labor markets in rural Pakistan.

The Jacoby's test for a perfect market assumption
The hypothesis of equality between marginal products of labor and the market wages is tested in this section by regressing the shadow wages on the observed market wages:

$$W_i{}^* = \quad \alpha + \beta W_h + \varepsilon_i, \tag{9}$$

where W_i^* represents the estimated shadow wages of labor type $i = (m, f)$, W_h is the market wages of male and female, ε_i is the random term. Assuming that there are no serious biases involved in the derivation of the marginal productivities of family labor from a Cobb–Douglas production function, the null hypothesis of the absence of any frictions in off-farm employment implies that $\alpha = 0$ and $\beta = 1$. This means that the allocation of time between farm and market is made purely on efficiency grounds. The theory also implies that ε_i is independent of the taste/preference for work.

The Benjamin's test for differing efficiencies
Benjamin (1992) proposed a test that uses the relationship between production decisions and household preferences. The following linear regression is used to explain this test:

$$\mathrm{Log}L \ = \ \beta \mathrm{Log}W^* + \gamma \mathrm{Log}Z + (1-\alpha)\frac{H}{L} + \varepsilon, \tag{10}$$

where L is the total hired and family labor, W^* indicates the shadow wages, Z is household preferences, $\frac{H}{L}$ is the fraction of hired labor. The objective of perfect substitutability of family and hired labor is to test $(1 - \alpha) = 0$.

The Le's generalized test
Both the Benjamin and Jacoby's tests employ only one relationship; either between production decisions and preferences, or between shadow and market wages. It means, both tests imply half of the information to test the separability and results of both tests are contradictory. This shortcoming is covered by Le's generalized test (Le, 2010). He simultaneously studied both relationships in one relation to increase the power of test and to avoid possibility of contradictory results. The present study also applied the approach of Le's generalized test to examine the separability in agricultural households, given as:

$$\mathrm{Log}PQ/L \ = \ \beta \mathrm{Log}W + \gamma \mathrm{Log}Z + \varepsilon, \tag{11}$$

The test for the separability model is whether, $\beta = 1$ and $\gamma = 0$.

3.2.2 | Estimation of shadow wages and shadow income

Marginal productivity of family labor was estimated through production function approach. The marginal productivity of family labor thus estimated (shadow wages) and shadow income are then used in the second stage to estimate the male and female labor supply functions. In this study, Cobb–Douglas production function is used because of its simplicity in estimation and interpretation, consistency with most of the economic data (Abdulai & Regmi, 2000; Kadiyala, 1972) and widespread empirical support from data of various industries, including agriculture and for various countries.

Besides, more flexible functional form, such as the translog production function was initially estimated, which yielded results that were inconclusive. Specifically, most of the coefficients of the inputs were not statistically significant, while some of the coefficients turned out to be negative, contrary to prior expectation. Results of translog production function are given in Appendix B1 (Table B1). Even though the Cobb–Douglas production function describes economic data very well, it has some well-known limitations, such as it assumes unitary elasticity of factor substitution, requires all inputs to be positively employed, and single equation estimates are bound to be inconsistent (Kadiyala, 1972; Ulveling & Fletcher, 1970). Thus, a typical Cobb–Douglas production function is specified as:

$$\ln Y_i = \sum_j \alpha_j \ln X_{ij} + \sum_k \beta k \ D_{ik} + \varepsilon_i, \tag{12}$$

where Y_i represents the total value of agricultural output of farm household i. X_{ij} is the quantity of input j used by farmer i, D_k represents the location dummies indicating some location-specific characteristics such as topography and temperature, which effect output but not observable to an econometrician. α and β are input intensity parameters that represent the elasticities of output with respect to the individual inputs. ε_i is the error term summarizing the effects of omitted variables.

The variable inputs in the vector include cropped area, value of fertilizer, seed, and pesticide, number of farm equipment, hours of family male farm labor, hours of family female farm labor, hours of hired male farm labor, hours of hired female farm labor, hours of total child farm labor (family and hired), dummy variables, representing the presence of livestock, gender of household head, age, and education level of household head as a proxies of management inputs. In the regression, all the explanatory variables are in logarithmic form except dummies for household headship, livestock, and vector of age and education level of household head. The variables measured in monetary terms include values of output, fertilizer, seed, and pesticide and were divided by village-specific price index used as measure of the price of the composite agricultural commodities consumed and produced. There exist zero values in most of the variable inputs, so in order to keep the estimation manageable in the presence of zero values in most of the variable inputs, the logarithmic transformation was carried out by adding one to the inputs (i.e., $\ln X_{ij} = \ln(X_{ij} + 1)$) following the previous empirical studies of Skoufias (1994); and Abdulai and Regmi (2000).

Shadow wage estimation

The shadow wage rate of labor (MPL) from the instrumental variable (IV) estimates of Cobb–Douglas production function, as shown in Table 5, using the expressions:

$$W_m^* = \frac{\hat{Y}}{F_m}\hat{\alpha}_m \, W_f^* = \frac{\hat{Y}}{F_f}\hat{\alpha}_f, \tag{13}$$

Where $\hat{Y}$ is the predicted value of output based on the estimated coefficient α_j. The fitted output $\hat{Y}$ is used instead of real output Y since farmers make decisions when they do not know the random shocks and real output. F_m and F_f are the total hours of adult male and female labor, respectively. We obtained negative marginal product for some observations and have subsequently set these values equal to 1.[2]

Shadow income estimation

The estimates of the shadow income Y_i^* of the household are derived from the following expression:

$$\begin{aligned} Y_i^* &= \hat{Y} + \prod + Y_{io} - W_m^* F_m - W_f^* F_f - W_h H_m \\ &\quad - W_h H_f - W_L Liv - \text{Fert} - \text{Pesti} - \text{Seed}, \end{aligned} \tag{14}$$

where $\prod$ is the net return from sale of livestock products and nonfarm income; Y_{io} is the unearned income, such as rent of land, farm equipment, and transfers received by households; W_m^* and W_f^* are shadow wages of male and female, F_m and F_f are hours of adult male and female, W_h, W_L are the average village wage rates of labor and animal services respectively; $\text{Fert}, \text{Pesti}, \text{Seed}$ indicate expenditures on fertilizer, pesticide, and seed, respectively.

[2] Jacoby (1993) and Skoufias (1994) also found negative marginal product of labor. They then either dropped these observations or set the value to 1 to avoid negative shadow wages.

3.2.3 | Estimation of own-farm, nonfarm, and agri-wage labor supply functions

The estimated shadow wages and income in the first stage of analysis are used to calculate the labor supply of farm household in three major activities: own-farm, nonfarm, and agri-wages. For each household, the male and female labor supply variables are computed as the average annual hours spent by working on their own-farm, nonfarm, and on the farm of others. Time spent on social ceremonies, religious activities, and other pure consumption activities, such as eating or sleeping are considered as leisure. The average daily working hours are found to be 8.1 h for males and 14.1 h for females, indicating that females spend more time in working than males. Particularly, males are more engaged in farm and nonfarm activities and females are more involved in domestic and livestock activities. All the females reported positive hours for domestic work and almost 33.14% male spent no time on domestic work.

The empirical specifications for the labor supplies of male (P_{im}^*) and female (P_{if}^*) in three activities ($i = own - farm, non - farm, agri - wage$) are:

$$\begin{aligned} \ln P_{im}^* &= \alpha_{m0} + \alpha_m \ln W_m^* + \alpha_{mf} \ln W_f^* \\ &\quad + \alpha_{my} \ln Y^* + \alpha_{mz} Z_m + \mu_m, \end{aligned} \tag{15}$$

$$\begin{aligned} \ln P_{if}^* &= \alpha_{f0} + \alpha_{fm} \ln W_m^* + \alpha_f \ln W_f^* \\ &\quad + \alpha_{fy} \ln Y^* + \alpha_{fz} Z_f + \mu_f, \end{aligned} \tag{16}$$

where α's are parameters to be estimated, W_m^*, W_f^*, Y^* are described above, Z_i is the vector of individual and household characteristics and μ_i is the error term summarizing the effects of unobserved factors. The coefficients α_m, α_f provide estimates of own-wage elasticities for male and females, respectively. Since these are reflections of the usual opposing substitution and income effects, no prediction can be made about their sign. This is also the case for the coefficients α_{mf}, α_{fm} that provide estimates of cross wage elasticities. The coefficients, α_{my}, α_{fy} provide estimates of the income elasticities of male and female labor, respectively. If leisure is a normal good, higher levels of income would result in fewer hours of work. Previous studies generally support this hypothesis although estimates have been inelastic (Jacoby, 1993; Skoufias, 1994).

TABLE 2 The Benjamin test (dependent variable: log farm labor) for testing the functioning of labor market

Explanatory Variables	OLS Coefficients	IV Coefficients
Log wage	−.372(28.24)	−.184(3.79)
Log land	.123(3.31)	−.004(.06)
Log fertilizer cost	.083(.62)	−.273(1.11)
Log sowing cost	.164(1.25)	.768(3.21)
Log pesticide cost	−.092(2.04)	−.052(.63)
Log equipment	−.089(1.75)	−.011(.09)
Adult male	.045(2.16)	−.072(1.78)
Adult female	.011(.42)	.076(1.67)
Log fraction of hired labor	−.082(2.84)	−.099(1.82)
Livestock	.703(8.14)	−.151(1.05)
Age of head	−.003(.97)	.001(.22)
Education of head	.008(.36)	−.017(.40)
Location1	.066(.57)	.258(1.22)
Location2	−.223(2.02)	−.141(.66)
Location3	−.006(.06)	−.039(.20)
Location4	−.276(1.22)	−.278(.63)
Location5	.086(.82)	−.032(.16)
Constant	1.721(10.21)	1.302(4.17)

Note: Value of *t*-statistics in parentheses.

TABLE 3 Tests of the equality of estimated marginal products and market wages received by market participants (dependent variable: shadow wage)[a]

	$\hat{\alpha}$	$\hat{\beta}$	R^2	*F*-test [b]
Males ($n = 337$)				
OLS	−2.32(−17.07)	.15(3.44)	.0341	11.84
IV	−1.17(−2.68)	−.41(-1.96)	.0114	3.85
Females ($n = 341$)				
OLS	−1.58(−14.99)	.29(4.39)	.0544	19.28
IV	−1.85(−11.92)	.60(3.83)	.0420	14.68

[a]Value of *t*-statistics in parentheses.
[b]Value of *F*-statistics under null hypothesis H0: $\hat{\alpha} = 0$ and $\hat{\beta} = 1$.The 5% critical value is 3.

4 | RESULTS AND INTERPRETATIONS

4.1 | Estimates of the separability tests

This section provides the results of separability tests by employing estimates of Benjamin, Jacoby, and Le.

4.1.1 | The Benjamin's test estimates

The results of estimation of Benjamin test by Ordinary Least Square (OLS) and instrumental variable estimation are presented in Table 2. Column 1 shows the results of OLS estimation, where coefficients of the number of adult male and fraction of hired labor are significant while the coefficient representing the number of adult females is not statistically significant. Column 2 reports the results of instrumental variable estimation. In this specification, the coefficients of all three labor variables are significant, strongly rejecting the separability hypothesis. Compared with OLS, the results show that the coefficients of the number of adult male, adult female, and fraction of hired labor increase in absolute values.

4.1.2 | The Jacoby's test estimates

The findings of Jacoby's test are presented in Table 3. In order to account for the potential presence of measurement error in the reported individual wage rates, instrumental variable estimation is also reported in Table 3. The value of *F*-statistics for both, the OLS and instrumental variable (IV) approaches reject the assumption of perfect market in this sample of Pakistani farmers. It shows that market imperfections are responsible for the inequality between marginal product and market wages as supported by Jacoby (1993), Skoufias (1994), and Abdulai and Regmi (2000).

4.1.3 | The Le's generalized test estimates

The results of Le (2010) test are presented in Table 4. Column 1 reports the OLS estimates. The coefficient of wage is significantly different from 1 but coefficients of preference shifters are not significant. The results of same instrumental variables, as used in Jacoby's test are given in the second column. The coefficient of wage is significantly different from 1 and coefficients of preference shifters are significant. All tests strongly rejected the separability hypothesis, indicating the dependence of production and consumption decisions of rural households in Pakistan.

4.2 | Shadow wages and shadow income estimates

The first column of the Table 5 represents OLS estimates of the coefficients of the production technology of the sample households. The results indicate that variable inputs have positive coefficients, while cropped area, equipment, and livestock appear to be significantly important inputs in production function. Among the labor inputs, adult male labor contributes most to the output and the contribution of teenagers and children appear to be relatively small.

Moreover, in the estimation of production function, labor hours, fertilizer, seed, and pesticide use are likely

TABLE 4 The Le's generalized test (dependent variable: log (value of output/farm labor)

Explanatory Variables	OLS Coefficients	IV Coefficients
Log wage	.461(5.93)	.276(1.68)
Log land	.266(1.21)	.412(1.79)
Log fertilizer cost	−.165(.21)	.327(.40)
Log sowing cost	.596(.77)	− .189(.23)
Log pesticide cost	.087(.33)	.026(.09)
Log equipment	−.716(2.37)	.690(1.67)
Adult male	.065(.53)	.233(1.70)
Adult female	−.132(.89)	−.201(1.31)
Log fraction of hired labor	−.218(1.28)	.223(1.70)
Livestock	3.378(6.62)	4.482(9.23)
Age of head	−.011(.68)	−.015(.93)
Education of head	.064(.45)	.099(.68)
Location 1	−.487(.71)	−.831(1.15)
Location 2	−1.878(2.87)	−2.033(2.84)
Location 3	−.872(1.41)	−.888(1.31)
Location 4	−.953(.71)	−1.139(.76)
Location 5	.307(.49)	.417(.62)
Constant	1.52(1.52)	2.036(1.93)

Note: Value of *t*-statistics in parentheses.

TABLE 5 Cobb–Douglas production function (dependent variable: log value of output)

Explanatory variables	OLS Coefficients	IV [b] Coefficients
Log land	.46(2.05)	1.13(5.60)
Log fertilizer cost[a]	.05(.06)	1.86(3.34)
Log seed cost[a]	.46(.59)	.49(1.92)
Log pesticide cost[a]	−.08(.37)	1.03(2.20)
Log equipment	.56(1.79)	.18(.60)
Log family male farm labor[a]	.07(.72)	.47(2.00)
Log family female farm labor[a]	−.09(.90)	.28(1.73)
Log hired male farm labor[a]	.26(1.90)	.68(1.88)
Log hired female farm labor[a]	−.13(1.08)	.19(.52)
Log child farm labor[a]	.12(.99)	.14(.35)
Gender of Head	1.18(2.42)	2.31(5.33)
Education of head	.00(.01)	.02(.10)
Age of head	−.02(1.27)	−.02(1.06)
Livestock	4.30(9.09)	4.40(8.87)
Location 1	−.79(1.12)	−.53(.69)
Location 2	−2.27(3.41)	−2.64(3.91)
Location 3	−.91(1.44)	−1.02(1.54)
Location 4	−-1.29(.95)	−1.82(1.32)
Location 5	.40(.63)	.13(.19)
Constant	3.13(3.20)	3.06(2.70)
Adj R^2	.7105	.6928
Male labor marginal product	2.73	.89
Female labor marginal product	6.05	1.20
Number of observations	341	341

Note: [a]Variables considered endogenous in the instrumental variable estimation.
[b]Wu–Hausman statistics for the joint exogeneity test is 1.88 against a critical value of $F(8, 312) = 2.29$ which is significant at 10%.
Value of *t*-statistics in parentheses.

to be endogenous variables so the estimates from OLS could be biased. We address the endogeneity bias in this study by adopting an IV approach to estimate the Cobb–Douglas production function. The variables used as identifying instruments in the estimation are as follows: male and female daily field wages; distance of village from city; dummies for the presence of road, water supply and electricity; adult household size; and number of adults working on farm. The value of the Wu–Hausman statistic as presented in Table 5 suggests that the instruments can be considered exogenous in the estimation.

The results of IV approach, in the second column of the Table 5, indicate that most of the inputs have significant positive effects on agricultural output. Livestock and land appear to be important inputs in the production process. It is also found that inputs like fertilizer, seed, and pesticide lead to higher farm output. All the labor inputs have significant positive impact on the output except the hired female labor and child labor which do not significantly differ from zero. The family male labor has a greater impact on output as compared to family female labor due to the fact that the activities such as ploughing, irrigation, and so on, which are undertaken by men, contribute more at the margin to output than activities such as weeding, picking, and transplanting in which females are mostly engaged. This finding is in line with the results of Abdulai and Regmi (2000) but in contrast to the results reported by Skoufias (1994).

The gender of household head has a positive and significant impact on agricultural output, indicating the existence of gender discrimination in the access to resources. This supports the findings of Thapa (2008) who indicated that male headed households have relatively better access to resources. The coefficient representing age is negative though not significant, indicating that young farmers use new technologies to increase production as compared to the old ones. Education of household head has positive effect on agricultural output, confirming the widely accepted role of human capital towards improving farmer's efficiency (Kousar & Abdulai, 2015).

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TABLE 6 Instrumental variable estimates of labor supply (dependent variable: log average annual hours of male and female in own-farm, nonfarm and agri-wage work)

	Own-farm	Nonfarm	Agri-wage			
Variables	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Log male shadow wage	−1.184(3.24)	.097(.27)	.583(.59)	−1.568(1.93)	−1.404(1.93)	−.345(1.02)
Log female shadow wage	.059(.19)	−1.106(3.57)	.397(.43)	−.769(1.00)	.911(1.41)	.404(1.51)
Log shadow income	−.916(3.77)	−2.072(5.62)	−1.244(1.63)	−.979(1.52)	−1.788(2.81)	−.708(2.50)
Adults	.106(1.67)	.014(1.70)	.500 (2.53)	.314(1.86)	−.009(.05)	−.086(1.12)
Children > 5	.057(.61)	−.013(.10)	.418(1.61)	−.368(1.86)	.581(2.07)	.012(.10)
Children between 6–14	−.020(.94)	.037(1.77)	−.006(.12)	.009(0.17)	−.045(.75)	.010(.45)
Age of head	.007(.63)	.012(.86)	−.028(.82)	−.000(0.00)	.019(.57)	.033(1.59)
Location 1	−.657(1.35)	.589(.59)	5.009(2.72)	6.071(3.44)	3.572(2.47)	.094(.15)
Location 2	−.799(1.67)	−1.202(2.24)	1.802(1.37)	2.236(2.44)	1.018(.93)	−.129(.21)
Location 3	−1.251(2.99)	−1.114(2.25)	1.114(1.04)	2.286(3.27)	−1.632(1.87)	−.437(.80)
Location 4	.524(.71)	1.051(1.41)	−.089(.05)	1.880 (1.32)	−3.131(2.16)	.049(.07)
Location 5	−.156(.34)	.496(.98)	.228(.22)	1.063(1.74)	.232(.25)	.961(1.63)
Education	−.127(1.69)	−.058(1.86)	1.098(3.18)	.099(.69)	−.229(1.82)	−.041(2.62)
Upper class	−.640(2.52)	.648(1.79)	1.255(1.69)	−1.85(1.95)	−.709(1.89)	−.209(1.87)
Lower class	−.718(1.94)	.337(.91)	.425(.44)	−1.569(1.50)	2.939(2.35)	1.809(2.32)
Factory/mill	−.405(1.67)	−.095(.25)	1.763(2.19)	1.386(1.90)	−.268(.48)	−.028(.07)
Constant	13.268(4.80)	25.038(5.97)	13.647(1.58)	−10.190(1.43)	22.175(3.14)	11.034(3.09)
Adj R^2	.2637	.1161	.1776	.1005	.1543	.0770
Wu–Hausman [a]	3.13	2.32	1.86	4.01	1.42	.45
Breusch-Pagan [b]	85.63	562.13	262.10	424.11	291.42	179.85
Wald-Statistics[c]	10.89	4.26	5.69	4.19	4.78	2.84

[a]Wu–Hausman test for exogeneity of the set of instruments against a critical value of (2286) = 4.68 at $\alpha = .01$.
[b]Breusch–Pagan test for homoskedasticity (critical value = 32.00 at 1%).
[c]Wald statistics for the joint significance of the nonintercept exogenous variables against a critical value of $F(16,324) = 2.75$ at 1% significance level. Value of *t*-statistics in parentheses.

4.3 | The labor supply functions estimates

The variables in W_m^*, W_f^*, Y^* are correlated with μ_i so, labor supply functions are estimated by using instrumental variable approach to obtain consistent estimates. In the first-stage, the shadow wage rate and shadow income are regressed on variable of individual and household characteristics such as age of household head, education of household head, number of adults, number of children less than five and between 5 and 16 years, upper class, lower class, presence of factory/mill in the vicinity, locational dummies, nonlabor income, savings, and all IVs that are used in Cobb–Douglas production function. Results of first stage of the IV estimation are given in the Appendix B2 Table B2. In the second stage, the predicted values from these regressions are used to estimate the labor supply function employing OLS. The value of the Wu–Hausman statistics given in Table 6 suggests that the instruments can be considered exogenous in the estimation.

Estimation of the labor supply functions require deleting some variables that are used in the first stage regression to allow for the identification of models and variables left out, therefore serve as identifying instruments. Male and female daily field wages; distance of village from city; dummies for the presence of road, water supply and electricity; adult household size, number of adults working on farm, nonlabor income and savings served as identifying instruments. The Wald test statistics χ^2_{10} for the joint significance of these variables for male and female shadow wage equations are 27.20 and 35.20, respectively, which are significant at 1% level as against a critical value of $\chi^2_{(10,0.01)} = 23.21$. The corresponding figure for the shadow income equation is 235.40, also against a critical value of $\chi^2_{(10,0.01)} = 23.21$. The joint significance of these variables in the first stage regressions suggests that the instruments do enter in the first stage estimation and are therefore regarded as appropriate instruments.

In order to account for any potential heteroskedasticity induced by the two-stage procedure of using estimated shadow wages and income as well as for heteroskedasticity possibly present across households, the Breusch–Pagan test was employed. The computed Breusch–Pagan test values χ^2_{16} 85.63, 262.10, 291.42 for males and 562.12, 424.11, 179.85 for females in own-farm, nonfarm, and agri-wage work respectively, are above the critical value of 32.00 at the 1% level, suggesting the presence of heteroskedasticity. In order to account for the heteroskedasticity, the *t*-statistics as reported are based on the standard errors calculated from White's (White, 1980) formula that accounts for nonparametric forms of heteroskedasticity.

To test the exogeneity of the set of instruments, the value of Wu–Hausman statistics given in the Table 6 suggests that the instruments can be considered exogenous in the labor supply functions. The joint hypothesis that all nonintercept coefficients in the labor supply models are zero, are tested with the Wald statistics. The sample values of the Wald statistics are 10.89, 5.69, 4.78 for male and 4.26, 4.19, 2.84 for female labor supply functions in three sectors, with a critical value $F(16{,}324) = 2.75$, thus rejecting the null hypothesis which is significant at 1 % level.

Table 6 also displays parameter estimates of the male and female labor supply functions. Starting with the estimates for males, the uncompensated own-wage effect is negative in the case of own-farm and agri-wage work, suggesting a backward sloping labor supply. It means that the income effect dominates the substitution effect. In the case of nonfarm work, own wage effect is positive, suggesting upward sloping labor supply. The negative own-wage elasticity for female confirms the findings of Skoufias (1994) and are in contrast to Jacoby (1993); and Abdulai and Regmi (2000).

The cross-male wage effect on the nonfarm and agri-wage labor supply of females is negative and significant in the case of nonfarm, indicating that female labor supply is quite sensitive to any change in the male wage. This is presumably due in part to the reallocation of time by females from income generating to nonincome generating personal matters such as funerals and weddings. It suggests that male and female leisure are gross substitutes in terms of utility and indicates that studies that restrict such cross-wage effects to be zero may result in specification errors. The cross-female wage effect on the labor supply of male is positive, but not significant, indicating that males are not much sensitive to reduce their labor supply even when females earn more from income generating activities.

The coefficient of shadow income is significant and negative for both males and females in all three sectors, indicating that both male and female leisure are normal goods. This finding is in line with the results obtained by Jacoby (1993) for Peru; Skoufias (1994) for India; and Abdulai and Regmi (2000) for Nepal.

Household composition and characteristics seem to matter as well on the labor supply. The presence of working age men and women, which is an indicator of nonnuclearity of household, tends to increase the labor supply of both male and female in own-farm and nonfarm. These results are in line with the study of Abdulai and Regmi (2000). The presence of young children (>5 years) in the household impedes the labor supply of female in own-farm and nonfarm sector, particularly significant effect in the case of nonfarm work. It indicates that child-caring appears to be a competing activity with farm and nonfarm work in the study area. This result is in contrast with the findings of Skoufias (1994); and Abdulai and Delgado (1999) who reported that market labor supply and child-rearing are not competing activities in the developing countries.

Turning to the variables of interest in this article viz. the education level of household members; social class; village infrastructure, we found that investment in human capital significantly decreases the labor supply of household on own-farm and agri-wage activities. This reflects the lack of response of agricultural wages to human capital in South Asia as noted by Kurosaki and Khan (2006); Ito and Kurosaki (2009) and disgrace of working as an agricultural laborer in rural areas (Ito & Kurosaki, 2009). Once villagers are educated, they are reluctant to perform manual agricultural work for themselves and especially for others. The positive coefficient of education in nonfarm work indicates that individuals who having more years of schooling, spend a great proportion of their working hours in nonfarm work. Thus, education is found to be an important factor to mobilize human capital through high returning nonfarm work. High return work often requires a specific level of schooling and therefore individuals who have attained less than that are excluded from particular better-paid activities (Abdulai & Delgado, 1999). Most activities in nonfarm work like service sector or running a small business require a certain level of education or skill and serve as important criteria regarding the allocation of scarce nonfarm employment. In other words, illiteracy serves as an entry barrier into high returning activities. Thus, education serves as a powerful source that leads labor out of agriculture and shifts it into high returning nonfarm sector.

Looking at the role of family status or social status of the family (with the middle class as the reference group), we found that male labor supply from upper class decreases in the case of own-farm and agri-wage activities and increases in the case of nonfarm sector. Social status based on income has a traditional role in social grouping, having great influence in Pakistan. This class stratification is closely related to income inequalities and distribution of land ownership. Indeed, the class system has a clear constraining effect on members' effort to improve living conditions. Males from upper class are more resourceful persons so they employ hired labor or lease their land to tenants in order to release themselves from manual agricultural work. It is also found that female labor supply decreases in nonfarm and agri-wage work as we move up to the class category. There are cultural and social barriers that prevent women from entering and remaining in the labor force. They are not allowed to go outside for work and are confined to only household duties which are considered honorable for them. These findings show that family class plays a pivotal role in minimizing the liberty of females. Labor supply increases for agri-wage work for lower class males and females. This is due to the fact that lower class families do face difficulties in nonfarm employment in the sense they face high transaction costs associated with entry into the labor market. These results are consistent with the findings of Ito and Kurosaki (2009).

Presence of small-scale industry (factory or mill) as indicator of village infrastructure is associated with higher amount of nonfarm labor, indicating that good state of infrastructure tends to increase employment opportunities of farm-based people. This reduces transaction cost and increases efficiency with which rural labor and financial markets channelize inputs into high yielding activities by declining cost of information and transport.

5 | CONCLUDING REMARKS

In developing counties where mostly factor markets are imperfect or weak and wage data have limited access, shadow wages and shadow income are used for estimating the labor supply of farm households. Our estimation approach tested the market imperfections by applying three tests (Benjamin, 1992; Jacoby, 1993; Le, 2010). The analysis provides strong evidence against the perfect labor market hypothesis in Pakistan. After testing the assumption of separability, this article estimated labor supply of rural households on own-farm, nonfarm and agri-wage employment. We analyzed how households adjust their labor supply decisions in response to changes in economic conditions/incentives, such as agricultural labor returns (shadow wages, shadow income), which matters for labor allocation decision. This is crucial for designing policy for the welfare of individuals.

Results reveal that education can be a powerful source for rural households that leads labor out of agriculture and shifts into high returning nonfarm sector. Social status based on income level plays an important role in overthrowing the autonomy of female. Socially backward families have higher constraints to enter in nonfarm sector in the sense they face higher transaction costs. The proximity of physical infrastructure, like factory or small-scale industry in village enables households to engage in high returning activities.

Our study goes beyond the previous studies in several ways. First, unlike the previous literature, this study takes into account the household-level actual time spent by different members, disaggregated by gender and age. Secondly, existing literature on labor supply of farm households used aggregated or homogenous approach (Benjamin, 1992; Jacoby, 1993; Skoufias, 1994), making it difficult to distinguish whether and to what extent, labor is spent on-farm and/or off-farm and on which household members and age categories the analysis is focusing. If women's participation is not categorized into different types of activities, it will limit the impact on policy formulation.

Based on the findings, the study suggests that the aim of public policy should be to improve regional job opportunities through development of small-scale industry. This would encourage them to work off the farm and to enter labor market especially for women and socially backward families. Furthermore, policy measures should promote the education of the rural households. Research is needed to employ panel data as the use of cross-section data prevents the detection of the association of women's participation over time.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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APPENDIX A1

The Lagrangian function ($\int$) is maximized with respect to L_{iA}, $L_{iNF,}$ L_{iD} H_i, X, λ, φ for maximizing the utility (U) across gender of household members as shown below:

$$\partial \int / \partial L_{iA} = -\lambda + \phi p \frac{\partial Q}{\partial L_{iA}} = 0, \tag{7.1}$$

$$\partial \int / \partial L_{iNF} = -\lambda + \phi W = 0, \tag{7.2}$$

$$\partial \int / \partial L_{iD} = -\lambda + \phi p \frac{\partial Q}{\partial L_{iD}} = 0, \tag{7.3}$$

$$\partial \int / \partial H_i = \phi p \frac{\partial Q}{\partial H_i} - \phi W_H = 0, \tag{7.4}$$

$$\partial \int / \partial X = \phi p \frac{\partial Q}{\partial X} - \phi p_X = 0, \tag{7.5}$$

$$\partial \int / \partial \lambda = L - L_{iA} - L_{iNF} - L_{iD} - N_i = 0, \tag{7.6}$$

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$$\partial \int / \partial \phi = PQ(L_{iA}, H_i, X, Z, \theta, A, S, V) - P_X X - W_H H_i - WL_{iNF} + W_D L_{iD} + Y_{i0} - P_C C = 0. \quad (7.7)$$

APPENDIX A2

Given this development, maximization of Langrangian with respect to N_i, H_i, L_{iA}, L_{iNF}, L_{iD}, yields the following first order conditions for the optimal choices of the household:

$$\frac{\partial U/\partial N_i}{\partial U/\partial C} = w_i^* \quad (7.8)$$

$$\frac{\partial Y_{iA}}{\partial H_i} = W_H \quad (7.9)$$

$$W_i = \frac{\partial Q}{\partial L_{iA}} = \frac{\partial Q}{\partial L_{iNF}} = \frac{\partial Q}{\partial L_{iD}} = w_i^* \text{ if} L_{iNF} < M, \quad (7.10)$$

$$W_i > \frac{\partial Q}{\partial L_{iA}} = \frac{\partial Q}{\partial L_{iNF}} = \frac{\partial Q}{\partial L_{iD}} = w_i^* \text{ if } L_{iNF} = M. \quad (7.11)$$

The equilibrium condition (7.8) for household utility maximization implies that household will equate the marginal rate of substitution between consumption and leisure of family labor of type "*i*" and the "shadow wage rate" $w_i^*$of labor type "*i*." Condition (7.9) states that hired labor will be utilized up to the point where the marginal product of hired labor of each gender is equal to the wage paid to hired labor. Also shadow wage is same as market wage (7.10), if labor market is complete and nonfarm labor constraint is not binding. Shadow wage will be less than the nonfarm wage (7.11), if labor market is incomplete and nonfarm labor constraint is binding.

APPENDIX B1

TABLE B1 Translog production function (dependent variable: log value of output)

	OLS
Explanatory variables	Coefficients
Log land	−.30(1.21)
Log fertilizer cost	.58(.52)
Log seed cost	.48(.55)
Log pesticide cost	−1.21(1.94)
Log equipment	.45(1.39)
Log family male farm labor	1.84(1.61)
Log family female farm labor	−1.89(2.39)
Log hired male farm labor	−.21(.45)
Log hired female farm labor	.35(.89)
Log child farm labor	.07(.60)
Gender of head	1.24(2.49)
Education of head	.02(.15)
Age of head	−.02(.50)
Livestock	4.33(9.04)
Location 1	−1.16(1.60)
Location 2	−2.83(4.07)
Location 3	−1.27(1.94)
Location 4	−1.18(.87)
Location 5	.24(.37)
Log fertilizer cost^2	−.02(.37)
Log pesticide cost^2	.09(1.77)
Log family male farm labor^2	−.06(1.07)
Log family female farm labor^2	.22(3.19)
Log hired male farm labor^2	.02(.31)
Log hired female farm labor^2	−.11(1.46)
Log fertilizer log family male	−.16(1.35)
Log pesticide log family female	.04(.44)
Log family female log land^2	.14(1.51)
Constant	3.58(2.68)
Adj R^2	.7177
Number of observations	341

APPENDIX B2

TABLE B2 First stage estimates of labor supply

	Coefficients		
Variables	Log shadow wage male	Log shadow wage female	Log shadow income
Male wage rate	.00(2.09)	.01(1.67)	−.00(3.32)
Female wage rate	−.00(2.37)	−.02(1.92)	.00(1.91)
Distance	.01(2.30)	−.01(2.27)	.02(7.72)
Road	−.08(1.88)	−.21(1.95)	.22(5.56)
Water supply	−.06(1.77)	.13(1.87)	.16(2.48)
Electricity	−.13(1.92)	.62(2.58)	.52(2.63)
Adults	−.09(2.18)	.00(2.02)	.05(7.41)
Adults of farm	−.39(5.09)	−.42(5.58)	.03(1.95)
Children >5	−.06(.80)	−.03(.46)	.02(1.13)
Children between 6–14	.03(1.72)	.039(2.54)	.00(1.41)

(Continues)

TABLE B2 (Continued)

Variables	Coefficients: Log shadow wage male	Log shadow wage female	Log shadow income
Education of head	−.07(.83)	−.04(.48)	.31(2.36)
Age of head	−.05(2.26)	−.06(2.66)	.03(6.15)
Gender of head	.04(1.55)	.05(2.27)	−.01(1.99)
Nonlabor income	3.11(3.73)	−3.70(2.52)	4.72(3.60)
savings	1.69(2.46)	−2.03(1.98)	1.09(1.70)
Upper class	.09(.98)	.00(.78)	.05(1.03)
Lower class	−.02(1.24)	.00(1.01)	.00(.24)
Factory/mill	.06(1.80)	.26(.39)	.08(1.04)
Location 1	−.00(1.10)	.25(.53)	−.04(.54)
Location 2	.36(.88)	.79(1.97)	−.37(5.01)
Location 3	.21(.44)	.41(.89)	−.01(1.21)
Location 4	.81(.91)	1.36(1.59)	−.04(.24)
Location 5	0.26(0.46)	.57(1.02)	0.71(6.81)
Constant	3.083(1.99)	.177(.12)	9.169(3.84)

Note: Value of *t*-statistics in parentheses.