Impact of Agricultural Extension on Productivity:
Econometric Analysis Using Household Data in India

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Abstract

This study estimates the effect of participating in extension programs on agricultural productivity in India. Using data from India's National Sample Survey 59th Round, farm-level productivity is estimated by a stochastic frontier analysis, and the effect of participation is estimated econometrically by the control function approach. Technical efficiency as measured by total factor productivity was approximately five times higher among farmers participating in private extension programs than among farmers participating in government programs. Among other extension programs, Krishi Vigyan Kendra programs demonstrate greater contributions to productivity than programs by primary cooperative societies and credit agencies.

Keywords：agricultural extension, household agricultural productivity, treatment effects model

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1. Introduction

World agriculture, particularly Asian agriculture, experienced a giant technological change during the Green Revolution of 1965–1985. Increased crop yields and enhanced employment brought a rapid decline in poverty during the 20th century, but these effects have slowed, renewing the imperative to increase productivity. Agricultural extension programs increase farm productivity by exchanging information and improving market access, and extension systems have long been grounded in a diffusion model—the research-extension-farmer linkage in which technologies and information are transferred from research systems to farmers and vice versa (Swanson et al., 1998). In general, government extension programs have emphasized increasing production, and extension is a policy tool for promoting the safety and quality of agricultural products. Thus, by promoting agricultural innovation and information, extension services can improve the livelihoods of the poor.

Approximately 1.4 billion of the world's people are poor. India contains one-third of them, approximately 455.8 million persons as measured by a poverty threshold of $1.25 per day (Table 1) (Chen and Ravallion, 2008). Three-quarters of the world's poor live in rural areas and rely mainly on agriculture for their livelihoods (IFAD, 2001). More than 70% of India's rural population subsists on farming (Hegde, 2000) and about 58.4% of India's labour force is employed in the agricultural sector (Haque, 2003). Thus, welfare of the world's rural populations, of the rural poor and of the poor in general depends on advancements in agriculture, and Indian agriculture is at the centre stage in the global challenge of alleviating poverty.

However, food production faces the ever-increasing and increasingly severe challenges of low productivity and diminishing reserves of potentially cultivable land. Farmers respond to these circumstances by seeking interaction with extension services. Agricultural extension programs are the Indian government's primary means for assisting farmers by providing information and technology to expand their abilities and improve production (Sharma, 2003). The significant questions are whether India's programs improve productivity and, if so, to what extent.

Table 1: Regional distribution of the poor (millions) under international poverty standards of $1.00–2.50 a day in 2005

Region	Living <$1.00	Living <$1.25	Living <$2.00	Living <$2.50
East Asia and Pacific	179.8	336.9	748.3	987.2
Eastern Europe and Central Asia	16.0	23.9	50.1	69.5
Latin America and Caribbean	27.6	45.1	98.7	132.9
Middle East and North Africa	6.2	14.0	58.0	94.3
South Asia	350.3	595.5	1091.6	1246.4
Of which India	266.5	455.8	827.7	938.0
Sub-Saharan Africa	299.1	384.2	551.0	609.9
Total	879.0	1399.6	2597.8	3140.2

Source: Chen and Ravallion, 2008

This study addresses the question of to what extent government, private and other extension services influence agricultural productivity for the individual farm. The study's objectives are as follows: 1) to estimate the productivity of farm-level agricultural production and 2) to assess the benefits of participating in government, private and other extension programs on household agricultural productivity. Understanding the importance of productivity and exploring ways to increase it are essential in identifying effective agricultural policies. By measuring the effectiveness of extension programs, this study will assist in shaping policies that increase agricultural productivity.

2. Empirical methodologies

This study employs a two-step procedure to estimate the effectiveness of extension programs on productivity. In the first step, a stochastic frontier analysis (SFA) is estimated to identify productivity in terms of technical efficiency of each farm household. In the second step, a treatment effects model is applied by using a control function approach to examine how participation in extension programs affects farm-level productivity.

2.1 Productivity estimation

We select total factor productivity (TFP) per farm household as the measure of performance because increases in TFP unambiguously raise farm income when other production inputs and product prices are held constant (Otsuki, 2010). We use a stochastic frontier model to measure TFP because it allows for partitioning the stochastic error term into two components: systematic random error to account for statistical noise and an inefficiency component (Battese and Coelli, 1992). In addition, it provides the basis for conducting statistical tests of hypothesis regarding production structure and degrees of inefficiency. Moreover, in cross-sectional frameworks involving a single time period, technical efficiency is customarily interpreted as TFP.

Aigner et al. (1977) and Meeusen and Broeck (1977) pioneered the development of stochastic frontier production functions. The model estimates technical efficiency/inefficiency of individual farmers, and the technical efficiency/inefficiency measure is equally valid for single outputs or for multiple outputs that need to be aggregated into a single-output index. We have aggregated multiple outputs in this analysis. The entire shortfall of observed output y_i from maximum feasible output $f(x_i;\beta)$ is attributed to technical inefficiency in stochastic frontier model. The model is given as

$$y_i = f(x_i;\beta)\exp\{v_i\}TE_i, \tag{1}$$

where $f(x_i;\beta)\exp\{v_i\}$ is the stochastic production frontier, and the technical efficiency is given as

$$TE_i = yi / f(x_i;\beta)\exp\{v_i\}. \tag{2}$$

Here, y_i achieves its maximum value of $f(x_i;\beta)\exp\{v_i\}$ if and only if $TE_i=1$. Otherwise, $TE_i<1$ provides a measure of the shortfall between the observed output and the maximum feasible output in an environment characterized by stochastic elements that vary across producers. The general form of production function for the ith production unit of this model is given as

$$y_i=f(x_i,\beta)+v_i-u_i=f(x_i,\beta)+\varepsilon_i \ , \qquad (3)$$

where v_i is assumed to be an identically symmetric and independently distributed error that represents random variations in output that are assumed to be normally distributed with a mean of 0 and variance σ_v^2. Following Battese and Coelli (1995), the u_i is assumed non-negative random variables that represent technical inefficiency, i.e. the stochastic shortfall of output from the most efficient production. Stochastic disturbance term v_i is assumed to be distributed independently of u_i. Thus, error term $\varepsilon_i=v_i-u_i$ is not symmetric because $u_i\geq 0$. Assuming that v_i and u_i are distributed independently of x_i, estimation of (3) by OLS will provide consistent estimates of all parameters except the intercept term because $E(\varepsilon_i)=-E(u_i)\leq 0$. Moreover, OLS cannot isolate technical efficiency from the residual term. A different estimation technique with additional assumptions is required for a consistent estimate of the intercept and technical efficiency of each producer. The maximum likelihood estimation is appropriate under the assumption that v_i is normally distributed, while u_i is the positive half-normal distribution which assures that technical efficiency estimates fall between 0 and 1. The half-normal distribution works best and is most often used because the standard deviation of the normal (truncated at zero) is able to concentrate efficiencies near zero or spread them out (Greene, 1990). Other empirical studies using different distributional assumptions for comparison showed that both rankings and efficiency scores are generally similar across distributions (Fujii, 2001; Street, 2003). In this study, we considered the half-normal distributional assumption of the inefficiency component.

2.2 Estimation of participation effect

The examination of the effect of participation in extension programs on productivity is difficult due to the lack of a counterfactual and participation is self-selective. Unobserved factors such as farmers' motivation, management and production skills can increase the likelihood of participation and productivity, worsening the counterfactual problem. Another problem in the estimation of treatment effects—selection bias—arises because treated and non-treated individuals can differ for reasons other than the treatment status per se. The consequence is a failure to meet the randomization assumption, and the counterfactual may provide inconsistent estimates of causal effects by simple comparisons or regression-adjusted comparisons, even after adjusting for observed differences (Otsuki, 2010).

In practice, models of treatment effects permit the comparison of real outcomes with the counterfactual case, thus overcoming the self-selection problem (Otsuki, 2010). They have been used widely in program evaluation literature but seldom for studying extension programs. A standard treatment effects model is given as

$$Y_i = \delta T_i + \beta X_i^{'} + \nu_i \ , \tag{4}$$

where Y_i, $i=1,2,...,N$ is the outcome variable, T_i is the binary treatment assignment ($T=1$ if participation occurs, otherwise $T=0$), δ a coefficient estimator for T_i that is interpreted as a treatment effect, X_i is a vector of exogenous variables, β a vector of coefficient parameters for X_i and ν_i is an error term that follows normal distribution with mean 0 and variance σ_ν^2 . The participation of individuals based on a set of determinants Z_i is specified as

$$T_i^* = \gamma Z_i^{'} + \upsilon_i \ , \tag{5}$$

where T_i^* is a latent variable, γ is a vector of coefficient parameters and υ_i is an error term. The latent variable is unobservable and its relationship with T_i is specified by

$$T_i=1 \text{ if } T_i^*>0, \text{ otherwise } T_i=0 \cdot \tag{6}$$

If unobserved factors in (5) are correlated with ν_i , the correlation coefficient between υ_i and ν_i (denoted by ρ) is non-zero, and thus, the OLS estimate is inconsistent (Greene, 2008). Then, the expected outcome assuming normal distribution for T becomes

$$E[Y_i | T_i, X_i, Z_i] = X_i^{'}\beta + \delta T_i + E[\nu_i | T_i, X_i, Z_i]$$
$$= X_i^{'}\beta + \delta T_i + \left[\rho_1 \sigma_{\nu_1} \{\phi(Z_i^{'}\gamma)/\Phi(Z_i^{'}\gamma)\}\right] P(T_i = 1 | X) + \left[\rho_0 \sigma_{\nu_0} \{-\phi(Z_i^{'}\gamma)/1-\Phi(Z_i^{'}\gamma)\}\right][1 - P(T_i = 1 | X)], \tag{7}$$

where the expected outcome for the participants is

$$E[Y_i | T_i, X_i, Z_i] = X_i^{'}\beta + \delta T_i + \left[\rho_1 \sigma_{\nu_1} \{\phi(Z_i^{'}\gamma)/\Phi(Z_i^{'}\gamma)\}\right], \tag{8}$$

and the expected outcome for the non-participants is

$$E[Y_i | T_i, X_i, Z_i] = X_i^{'}\beta + \left[\rho_0 \sigma_{\nu_0} \{-\phi(Z_i^{'}\gamma)/1-\Phi(Z_i^{'}\gamma)\}\right]. \tag{9}$$

Here, $\rho_1 \sigma_{\nu_1}$ equals the covariance between ν_i and υ_i for participants, $\rho_0 \sigma_{\nu_0}$ equals the covariance between ν_0 and υ_0 for non-participants, $\phi(Z_i^{'}\gamma)$ is the marginal probability of standard normal distribution at $Z_i^{'}\gamma$ and $\Phi(Z_i^{'}\gamma)$ is the cumulative probability of standard normal distribution at $Z_i^{'}\gamma$. The third term of (8) and second term of (9) include the inverse Mill's ratio to control for possible sample selection bias. The difference in expected outcome between participants and non-participants then becomes

$$E[Y_i | T_i=1, X_i, Z_i] - E[Y_i | T_i=0, X_i, Z_i] = \delta + \text{ selection term.} \tag{10}$$

The positive (negative) sign of the selection term implies that OLS overestimates (underestimates) δ and the sign of the selection term depends on that of ρ. The maximum likelihood estimation is utilized because it produces consistent estimators (Maddala, 1983; Greene, 2008). It also jointly estimates the participation and productivity equations and allows the testing of the significance of cross-equation correlation ρ.

2.3 Empirical model

2.3.1 Stochastic frontier model

The agricultural production function is

$$\ln(Output_i) = \beta_0 + \beta_1(lnLand_i) + \beta_2(ln\ Labor_i) + \beta_3(ln\ NonLabor_i) + \upsilon_i - u_i, \quad (11)$$

where ln(*Output*) is the natural log of total receipts obtained from output and byproducts, *lnLand* is the natural log of the total number of hectares under cultivation, *lnLabor* is the natural log of wage expenditures for both regular and casual agricultural labour, *lnNonLabor* is the natural log of expenditures for non-labour inputs (seed, fertilizer, pesticides, water) and *i* is the individual farm.

The technical efficiency of production for the i^{th} farm can be computed as

$$TE_i = \exp(-u_i) = Y_i / Y_i^*, \quad (12)$$

where Y_i is its observed output and Y_i^* is its maximum possible output given the available inputs.

2.3.2 Treatment effects model

The outcome equation is

$$TE_i = \alpha + \beta(Ext_i) + \phi_1(Age_i) + \phi_2(Age_i^2) + \phi_3(Edu_i) + \phi_4(Sex_i) + \phi_5(Hsize_i) + \phi_5(Hland_i) + \varepsilon_i, \quad (13)$$

and the equation for participation in government extension programs is

$$Ext_i = \eta + \delta_1(Regis_i) + \delta_2(AgTrain_i) + \gamma_3(Edu_i) + \omega_i. \quad (14)$$

The participation equations for private and other extension programs differ from that for government programs. Variables for all participation equations are selected from actual criteria for participating in specific extension programs. The variables included in (13), (14) and for participation in other types of extension programs are as follows: *TE* is technical efficiency obtained from SFA, *Ext* is a binary variable for actual participation in an extension program (1 if a participant and 0 if not), *Age* is the age of the respondent, Age^2 is the square of respondents' ages, *Edu* is the respondent's educational level, *Sex* is the respondent's gender (1 if male and 0 if female), *Hsize* is number of persons in each farm household, *Hland* is homestead land size, *Regis* is a binary variable for a registered group membership (1 for membership and 0 for non-membership), *AgTrain* is a binary variable for receipt of agricultural training (1 if training received and 0 if not), *Offincome* is the off-farm income and *i* is the individual farm household.

3. Study area and data

This study uses data from the National Sample Survey 59th Round (NSS-R59) conducted by the National Sample Survey Organization of India in 2003. The survey covered the entire Indian Union except for some inaccessible areas. The survey adopted a stratified multi-stage design in which first-stage units were villages covered by the census and the ultimate stage units were households. First-stage units comprising a total of 10,736 rural villages were allocated to Indian states in proportion to their provisional population in the 2001 census. The ultimate stage units consisted of 51,700 households drawn from the first stage.

The situation assessment survey was designed to collect information about farming and socio-economic characteristics of farm households following five decades of planned economic development. The survey defined a farmer as the one who owned, leased or otherwise possessed land and was engaged in agriculture. This study considers a sample of 16,644 self-employed farmers whose principal source of income was cultivation.

4. Empirical results

4.1 Productivity estimation

The results of SFA for both unconstrained and constant returns to scale (CRS) models are estimated using the maximum likelihood method (Table 2). All variables and the intercept are statistically significant at 1% with the expected signs in both models. The largest elasticity is observed for land in both models, indicating that land is indispensible to agricultural output and independent of other factors that, ceteris paribus, aid productivity. The non-labour input variable has the second-largest elasticity in both models, confirming the importance of other customary agricultural inputs. Labour also has considerable elasticity, indicating its importance.

Table 2: Results of stochastic frontier analysis

Variable	Unconstrained model		CRS model	
	Coefficient	Std. error	Coefficient	Std. error
Constant	3.7412 ***	0.0450	2.9037 ***	0.0136
lnLand	0.3497 ***	0.0080	0.4400 ***	0.0066
lnLabor	0.2313 ***	0.0063	0.2575 ***	0.0063
lnNonLabor	0.2997 ***	0.0069	0.3025 ***	0.0070
σ_u	0.9272	0.0135	0.9170	0.0139
σ_v	0.5682	0.0068	0.5853	0.0069
σ^2	1.1825	0.0210	1.1834	0.0212
λ	1.6319	0.0187	1.5668	0.0191
γ	0.7270		0.7106	
Wald χ^2	23744.84 ***		7281.93 ***	
No. of observation	16,664		16,664	
LR statistics	8.1e+02 ***			

Source: Author's estimation based on NSS-R59 (2003) data for India
Note: The symbol *** indicates 1% significance level. Stata version 11's command 'frontier' is used for the estimation.

Results presented in Table 2 indicate that parameter λ is 1.6319 for the unconstrained model and 1.5668 for the CRS model, which estimates the ratio of the standard deviation of the inefficiency component to the standard deviation of the idiosyncratic component. The likelihood ratio (LR) of the unconstrained model is significant at 1%, indicating the effects of technical inefficiency. Technical efficiency is calculated for each sample once inefficiency term u_i is adjusted so that technical efficiency scores do not exceed the range $[0, 1]$. Parameter γ measures the variability of the two sources of error (white noise disturbance and unilateral error). It reached 0.7270 (72.70%) for the unconstrained model and 0.7106 (71.06%) for the constrained model. The total composed error variance of the production function is explained by the variance of the technical inefficiency term. These terms represent the importance of incorporating technical inefficiency in production functions.

Descriptive statistics for the technical efficiency measure of both models indicate that the mean is slightly higher than half of the highest (Table 3). These statistics imply substantial potential to improve efficiency among sampled farmers and hence improve production output and/or reduce production costs.

Table 3: Descriptive statistics of technical efficiency

Model	Mean	Std. deviation	Median	Minimum	Maximum
Unconstraint	0.5500	0.1548	0.5679	0.0109	0.9343
CRS	0.5528	0.1510	0.5696	0.0101	0.9298

Source: Author's estimation based on NSS-R59 (2003) data for India

4.2 The effect of participation in extension programs

Our econometric model that examines the productivity improvement from participating in extension programs is denoted in the productivity equation. The model is specified by setting a productivity index as Y_i, exogenous factors to influence Y_i as X_i, and a dummy for participation in extension programs as T_i in (4). The participation equation is specified by setting the exogenous determinants of program participation as Z_i in (5). We use the participation equation to derive controls, but we believe there are many other possible equations which also contain information on unobserved determinants of participation. We applied the control function approach to address this problem. The approach uses observed variables and the economic theory to drive controls for the part of the unobserved determinants that is not independent of the participation in extension programs. For the participation equation, we consider alternative extension programs—government, private, Krishi Vigyan Kendra (KVK), primary cooperative societies and credit agencies.

Technical efficiency from the unconstrained model is the productivity measure for estimating effectiveness. We consider the unconstrained model for this purpose for its flexibility, whereas the CRS assumption is sometimes too restrictive and unrealistic. The next sub-section compares results and discusses consequences of participating in government and private extension programs. A later sub-section discusses results of participating in other extension programs, which cannot be clearly distinguished as government or private programs.

4.2.1 Government and private extension

Table 4 presents results of the productivity and participation equations for government and private extension programs. It shows the coefficient estimate and the standard error of each variable and inverse Mill's ratio λ. Table 4 also shows the estimate of coefficient parameter ρ for the productivity and participation equations as well as the chi-squared statistics for the Wald test of model predictability. The p-values for the Wald test suggest that the joint significance of the coefficient parameters attains 1% confidence for both government and private extension organization models.

Results of the participation equation indicate that registered group membership, training and education are personal characteristics that determine participation in government extension programs. Registered group membership and off-farm income are important characteristics determining participation in private extension programs. Significant coefficient parameters are largely different across the treatment types, but as Rogers (2003) indicated, farmers' participation in extension programs is influenced by their degree of innovation.

Table 4: Effect of government and private extension programs on productivity (dependent variable=technical efficiency)

Variable	Government extension		Private extension	
	Coefficient	Std. error	Coefficient	Std. error
Constant	0.4505 ***	0.0243	0.5057 ***	0.0994
Extension service	0.0296 *	0.0161	0.1512 *	0.0798
Age	0.0016 ***	0.0006	-0.0014	0.0033
Age^2	-0.00001 ***	5.63e-06	0.00002	0.00004
Education	0.0010 ***	0.0002	0.0030 ***	0.0009
Sex	0.0113 **	0.0054	0.0261	0.0288
Household size	0.0035 ***	0.0004	0.0023	0.0023
Homestead land	0.0128	0.0182	-0.0200	0.0574
λ	-0.0231	0.0078	-0.0652	0.0286
Contact equation				
Constant	0.8143 ***	0.2852	-8.0704	3417.13
Regis. group member	-0.6713 ***	0.0699	3.9678 ***	1512.63
Training	-0.4993 ***	0.0712		
Off-farm income			0.4018 ***	0.1438
Education	0.0132 ***	0.0022	-0.0164	0.0190
Homestead land	-0.0213	0.2154	-4.0966	1588.88
ρ (P value)	-0.1468 (0.01) **	0.0468	-0.4053 (0.09) *	0.1738
Model χ^2 (P value)	133.44 (0) ***		21.06 (0) ***	
N	14,291		14,291	

Source: Author's estimation based on NSS-R59 (2003) data for India
Note: The symbols *, ** and *** indicate 10%, 5% and 1% significance levels, respectively. Stata version 11's 'treatreg' command is used for the estimation.

Membership in a social group provides opportunities to discuss and observe practices of other members at no cost or time intensity, whereas education and income influence actual participation, confirming previous studies (e.g. Egziabher et al., 2011).

Results of the productivity estimation indicate that participation in government or private extension programs increases productivity. The difference in productivity between participants and non-participants is given by the coefficient estimate for the participation dummy: it is greater for participants in private extension programs, indicating their superior effectiveness. Controlling for other factors, our results indicate that marginal productivity improvement for participants is 15.12% for respondents who participated in private extension programs and 2.96% for those who participated in government programs compared to their respective non-participants. Thus the productivity of private extension program participants is about five times higher compared to productivity of government extension program participants. Similar findings are reported by Dinar et al. (2007). This result may be explained by private extension programs being more up to date and better oriented towards farmers' needs than government extension programs. In addition, results of the participation equation earlier suggested that farmers who are members of registered groups are more likely to participate in private extension. This characteristic may also have an impact on the higher productivity observed among participants in private groups, because a group approach is the salient feature of private extension programs in India, whereas individual farmers are focused on by government programs. Private extension programs also hold their field staffs to stricter levels of responsibility and accountability. Therefore the scopes of the private extension programs need to explore with relaxed operational rules whereas the government extension programs should be made more efficient for productivity improvement.

The independence of the productivity and the participation equations is rejected by the chi-squared test at 5% and 10% levels of confidence for government and private extension programs, respectively. This implies sample selection bias in program participation. The negative selection bias implies a negative correlation (ρ) between unobserved determinants of participation and productivity. This may arise from unobserved adverse factors that discourage farmers' participation in extension programs, such as lack of motivation (Rogers, 2003). These negative factors may have dominated positive factors such as farming skill.

4.2.2 Other extension programs

Table 5 shows results of the productivity and the participation equations for KVK, primary cooperative societies and credit agencies. Wald tests suggest that the joint significance of the coefficient parameters attains 1% confidence in all three models. Results of the participation equation indicate that off-farm income is an important determinant of participation in all three types of extension programs. Generally, income is an indicator of social status in rural India; hence, extension organizations seek higher-income farmers as participants to establish rapport with the community.

Results of the productivity estimation indicate that participation in all three types of extension programs increases productivity, but the coefficient estimate for the participation dummy is greatest for KVK, indicating its singular effectiveness. The coefficient estimate is also the greatest compared to government and private extension programs (Table 4). Controlling for other factors, our results indicate that marginal productivity improvement for participants is 20.49% for respondents who participated in KVK programs, 16.36% for those who participated in primary cooperative society programs and 12.33% for those who participated in credit agency programs compared to their respective non-participants. KVKs are operated by educational, research and training institutes investigating specific farm problems and/or recent technologies. They arrange training to address urgent problems, provide applied solutions and transfer recent technologies that may help participants increase their productivity. Members of primary cooperative societies share their knowledge and problems and are easily approached as a group; thus they may receive more extension services than non-members, increasing their productivity (Githaiga, 2007; Evenson and Mwabu, 1998). According to Rogers (2003), members of societies or groups may be more receptive to innovation than non-members. These groups' innovativeness may improve the productivity of their members. Credit agencies also aid productivity significantly and are regarded as important contributors to Indian agriculture.

The chi-squared test rejects the independence of the productivity and the participation equations at the 5% confidence level for KVK and at 1% for primary cooperative societies. The independence hypothesis was not rejected for the credit agency model, although this does not detract from its significance as an agricultural program. Thus, sample selection bias is implied for participation in extension programs other than those by credit agencies. The negative selection bias implies a negative correlation (ρ) between the unobserved determinants of participation and productivity.

Our overall results suggest that participation in all extension programs maintains or improves agricultural productivity through technology transfer. KVK, primary cooperative societies, credit agencies and private extension programs are more prominent in this regard. These programs can be improved by easing terms and conditions for farmers' participation as well as relaxing the rules and regulations for their operation. To achieve full potential, the government extension service needs to strengthen exploration and better supervise the performance of field personnel. Although sequential improvement in productivity is not investigated in our analysis, participating in extension programs probably maintains higher long-term productivity because transferred technology improves farmers' skills.

5. Conclusion

By employing national survey data in a treatment effects model, this study has investigated whether participating in extension programs improves farm-level agricultural productivity in India. The treatment effects model is estimated by using control function approach for controlling the unobservable determinants of participation. We found that participation in all types of extension programs significantly increases agricultural productivity and India's farms operate at slightly more than half of their full potential, suggesting prospects for further productivity improvements. The marginal productivity of survey respondents who participated in private extension programs was five times higher than that of participants in government extension programs considering their respective non-participants. Among other extension programs, participants in KVKs showed greater improvement than participants in programs sponsored by credit agencies and primary cooperative societies. Extension programs enhance productivity mainly through technology transfer, and expanding their range of services to include solving farming problems could increase their value to Indian farmers. Services by extension programs are expected to have significant economic influence on Indian agriculture. This influence could spread if extension services are more successful at motivating farmers to participate. Future research needs to investigate methods and incentives to induce marginalized farmers to join and remain members of private sector extension programs, credit agencies, primary cooperative societies and KVKs.

Table 5: Effects of other extension services on productivity (dependent variable=technical efficiency)

Variable	Krishi Vigyan Kendra (KVK)		Primary cooperative society		Credit agency	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Constant	0.5122 ***	0.0991	0.5009 ***	0.0999	0.5161 ***	0.0999
Extension service	0.2049 **	0.0807	0.1636 ***	0.0430	0.1233 *	0.0672
Age	-0.0015	0.0033	-0.0016	0.0033	-0.0013	0.0033
Age^2	0.00002	0.00004	0.00002	0.00004	0.00002	0.00004
Education	0.0027 **	0.0009	0.0027 ***	0.0009	0.0029 ***	0.0009
Sex	0.0289	0.0289	0.0254	0.0289	0.0288	0.0289
Household size	0.0020	0.0023	0.0016	0.0023	0.0021	0.0023
Homestead land	-0.0237	0.0567	-0.0125	0.0584	-0.0340	0.0578
λ	-0.0833	0.0288	-0.0125	0.0584	-0.0568	0.0266
Contact equation						
Constant	-4.7098 ***	1.4373	0.7842	1538.69	-12.3058	913.69
Regis. group member	-0.5394	0.5358	-0.1518	0.4570	4.0182	456.85
Off farm income	0.5575 ***	0.1591	0.4574 ***	0.0919	0.2818 ***	0.1083
Education	0.0250	0.0269	-0.0045	0.0117		
Homestead land			-4.5416	1538.691	0.8753	0.5755
ρ (P value)	-0.5177 (0.03) **	0.1752	-0.4744 (0) ***	0.1056	-0.3521 (0.11)	0.1611
Model χ^2 (P value)	23.84 (0) ***		31.78 (0) ***		21.47 (0) ***	
N	744		744		744	

Source: Author's estimation based on NSS-R59 (2003) data for India

Note: The symbols *, ** and *** indicate 10%, 5% and 1% significance levels, respectively. Stata version 11's command 'treatreg' is used for the estimation.

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