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Sources of technological knowledge and farm output: evidences from a large-scale farmers' survey

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Abstract The paper examines sources of technological knowledge and their effect on farm output in India. We find farmers accessing information on technologies from several sources involving information and communication technologies (ICT). The use of ICT however is limited to 21.8% of households and has increased over time. Further, from the econometric analysis we find that both use of ICT and non-ICTs differentiates farm output, but it is only the large farmers who realize more if they use ICTs. However, small farmers get higher return if they have access to ICT as well as non-ICT sources of information.

Keywords Technological knowledge, Institutional policies, Agricultural extension, Farm output

JEL classification Q2, Q16, Q18

1 Introduction

In the age of information technology and artificial intelligence, agriculture can't and should not remain primordial. There are enough evidences on what roles technological information play in boosting the agricultural output as well as income (Das 2013; Vaidyanathan 2010; Deokar & Shetty 2014; Birthal et al. 2015). The application of modern agricultural technologies will boost farmers' income and thus help alleviate rural poverty. Like any other sector, technologies in the field of agriculture are witnessing rapid changes. Dissemination of information on modern technologies among farmers is as important as the development of technologies in research centres and incubation centres. Farmers need information not only on farming (e.g., new seeds, fertilizers, pesticides, equipments) but also for selling output at right place and remunerative price, demand patterns, government schemes, weather information, and so on. Information and communication technologies (ICTs), both traditional (radio, television, newspaper) and modern (mobile phone and internet), can be of great help to the farmers for obtaining all beneficial information needed for farming. But the question remains: what percentage of farmers is able to use ICTs to obtain modern farm technologies? What percentage of farmers is still using the traditional sources like extension agents, krishi vigyan kendra, agricultural university, private commercial agents, progressive farmer to obtain the information on modern agricultural technologies? Do all these sources of technological knowledge differentiate the farm output? In this paper, we try to answer these questions using data from nationally representative surveys.

The remainder of this paper is organised as follows. Section 2 discusses the conceptual framework of the study. Section 3 discusses the data sources used and the methodology employed in analysing the research issues. Section 4 presents the results on the role of agricultural research and extension services and impact of technological knowledge on farm output. Section 5 summarises with a recapitulation of the main findings and concluding remarks.

2 Conceptual framework

The development of agriculture rests on three pillars: agricultural research and extension services, policies,

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and capabilities of farming communities. The interaction and learning among these components leads to an agricultural innovation system (Raina et al. 2010). Innovation system, in general, comprises of '*all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion and use of innovations*' (Edquist 1997; Edquist 2005). The historical roots of this concept could be traced to Friedrich List (1841); its modern version was introduced by Lundvall (1985). Freeman (1987), while analysing economic performance of Japan, brought the concept to an international level. Since then, there has been a proliferation in literature innovation system (Lundvall 1995; Nelson 1993; Freeman 1995; Edquist 1997). The system deviates from conventional linear approach to technological process and places innovations as the driving forces behind growth. The approach emphasizes interaction among different actors in the system[1] leading to interactive learning and capacity building which contribute to the development and diffusion of new technologies. It considers knowledge as the most fundamental resource in an economy and institutions play an important role in acquisition of knowledge through interactive learning. Further, the National System of Innovation (NSI) framework emphasises that for effective operation of the national systems, state plays a vital role, inter alia, facilitating the creation of appropriate institutional architecture and the formulation and implementation of policies (Freeman 1987; Freeman 1995).

The agricultural innovation system framework tells us that how the interaction between farming communities and agricultural research and extension services leads to development of agriculture. In this system, first comes the role of state in developing agricultural technology. In India, since independence an extensive research and extension system has been put in place with Indian Council of Agricultural Research as the leading research institution, and state departments of agriculture for dissemination of technological knowledge. In recent years, private sector, non-governmental oranizations and information and communication netwroks have emerged as important sources of technological knowledge.

Second comes, how the farming community translates this technological knowledge into the economic benefits. Existing studies have shown concerns over inefficiency of small and marginal farmers in accessing as well as applying the modern technologies (Bowonder & Yadav 2005; Ghosh & Ganguly 2008). To the extent, the information on technologies required for improving the cultivation practices, the dissemination of information becomes more challenging as the range of information depends on various other aspects of farming. It is argued that the information requirement varies widely across farmers and agro-climatic regions depending on size of holdings, crops grown, market preferences, weather conditions, etc. (Shalendra et al. 2011). The challenge of disseminating information becomes more daunting owing to lack of education, low income and dearth of basic infrastructure among the farming community. Availability of timely and appropriate information is as critical as to find out the appropriate agricultural technology (Shalendra et al. 2011). Hence availability of information plays a vital role in their decision making regarding farming (Gandhi 2011). As information at different level is the key to transforming traditional agriculture, the role of different sources in disseminating technological knowledge has received considerable attention in academia. These sources could be extension workers, NGO, krishi vigyan kendra, agricultural university, progressive farmers, radio, television, newspaper, internet and others (NSSO 2003; NSSO 2013).

Third component of agricultural system is institutional policies. Government of India has taken different policy initiatives to facilitate adoption of technologies. These include investment in infrastructure and markets, price support, input susbsidies and increased flow of institutional credit.

3 Data and empirical strategy

3.1 Data

This study makes use of data from two nationally representative farmers' surveys conducted by the National Sample Survey Office (NSSO) in 2002-03 and 2012-13. Both these rounds contain information on various institutional and organization aspects of agriculture besides the usual information on farm and farmer characteristics. The first round of farmers'

[1] System could be national, regional or sectoral

survey had a sample of 51,770 farm households while second round covered 35200 farm households. Both the round provides information on different aspects of agricultural households like types of crop produced, input expenditure for crop production, total output and its value, awareness about minimum support price (MSP), use of different sources like extension agents, krishi vigyan kendra, agricultural university, private commercial agents, progressive farmer, radio, television, newspaper, internet, vetenary department and NGO for accessing technical knowledge and many more. The study has clubbed different sources into two broad categories; ICTs and non-ICTs sources. ICTs could be those products '*that are able to store, retrieve, manipulate, transmit or receive information in digital form*' (Das 2014). On the basis of this, the radio, television, newspaper and internet are included as ICT source. Others are included as non-ICTs source. If the households are accessing any one ICT[2] indicator for receiving the information on agricultural technology, then we have taken that household as ICT user. Similarly if the household is using any one non-ICT source[3], then we have taken that household as non-ICT user. If the household is accessing both ICT and non-ICT sources, then the household is considered as the user of both the sources.

3.2 Empirical strategy

The ordinal least square method is employed to assess the effect of technical knowledge on farm output. It is hypothesised that technical knowledge has significant positive impact on farm output. Mathematically, the rletaion can be experessed as:

$$logY_i = \beta_1 + \beta_2 SFICT + \beta_3\, MFICT + \beta_4 SFNonICT + \beta_5 MFNonICT + \beta_6 SFICT\&NonICT + \beta_7 MFICT\&NonICT + \beta_8 log\ Expenses + \beta_9\, Insurance + \beta_{10}\, MSP + \beta_{11}\, Basic\ Edu + \beta_{12}\, Above\ Basic\ Edu + \beta_{13}\, OBC + \beta_{14}\, SC\&ST + \beta_{15}\, Age + \beta_{16}\, HHSSize + \beta_{17}\, HHS^2_{Size} + \beta_{18}\, Age^2 + \beta_{19}\, Region + U_i$$

Here, Y_i represents the farm output in acre. The variable is taken in logarithm form. The variables 'SFICT', 'MFICT', 'SF Non-ICT', 'MF Non-ICT', 'SF ICT & Non-ICT', 'MFICT & Non-ICT' indicate use of different sources by small and medium farmers. The variable 'Expenses' implies the expenditure on agricultural inputs for crop production. This variable is also entered in logarithm form. Insurance and 'MSP' refer to crop insurance and minimum support price. The variable basic education and above basic education imply the education level of household head. Basic education includes education level of households whose education level is up to primary level whereas above basic education level includes households whose education level is secondary, higher secondary, certificate, graduate, postgraduate and above. Our data source has given different sources available for accessing technical knowledge and these sources are divided into ICT, Non ICT and ICT & Non ICT sources. As discussed earlier, ICT source includes if the households use either radio or television or newspaper or internet and non-ICT includes when the households use sources like extension agent, Krishi Vigyan Kendra, agricultural university, private commercial agents, progressive farmer, veterinary department and NGO. ICT and Non-ICT sources include when the households use both ICT and Non-ICT source. We have taken interactive dummy variables of these two sources with the land holding size. We have also included certain control variables like regions and household characteristics. We have taken six regions in our study — east, west, north, south, central and north eastern regions. Household characteristics include age of the household head (age), social group of the farm household (OBC and SC & ST), household size (HHS_{Size}). Other than that, the household size and age of the head of the household is also entered in quadratic form in the equation. The model is run for five different crop categories, namely cereal and pulses, fruits and vegetables, plantation, spices and non-food crop.

2 The definition of ICTs has changed between 2003 and 2013. The 2003 definition included Radio, TV and newspaper; but the 2013 definition added internet to the three existing sources.

3 The definition of Non-ICTs has also changed between 2003 and 2013. The 2003 definition included participation in training programmes, Krishi Vigyan Kendra, extension workers, village fairs, government demonstrations, input dealers, other progressive farmers, farmers' study tour, private agencies or NGOs, primary cooperative societies, output buyers, credit agencies and others.

The 2013 definition include extension agent, Krishi Vigyan Kendra, agricultural university, private commercial agents (including drilling contractor), progressive farmer, and veterinary department.

3.2.1 Hypothesis and variable construction

Based on agricultural innovation system, the variables are chosen under agricultural research and extension services, institutional policies and farming communities.

Agricultural research and extension services: Under agricultural research and extension services, the study attempts to analyse all those sources that are involved in dissemination technological knowledge to farm households. These actors are divided into two groups: ICT and Non ICT sources. We have created interactive variables of access to different sources with the land holding size. ICT use by holding size explains the holding size and the use of ICT sources for technological knowledge. The holding size has been categorised into three groups – small (where holding size varies from 0.002 hectare to 2 hectares), medium (2 hectares to 10 hectares) and large (more than 10 hectares). For these we have created two dummies – small and medium farmers, keeping large farmers as base category. Then, two final variables are created. One is by taking the household that belongs to small farmer group and uses ICT as the source of technical advice and second is the household that belongs to medium farmer group and uses ICT as the source of technical advice. Similarly, interactive dummies for non-ICT user and both ICT & non-ICT user are created.

Institutional policies: Under institutional policies, only two variables the minimum support price (MSP) and crop insurance are included. MSP is a form of market intervention by the government to insure agricultural producers against any volatile in farm prices. The market price for agricultural produce many times tends to be unstable. Hence, assurance of remunerative and stable price environment for farm households is indeed important for increasing agricultural production and productivity. The data-set provides information on awareness about MSP of particular crop. From this information we have created another variable that is state wise percentage of farmers awareness about MSP. The study hypothesises that awareness of MSP for the crop incentivises farmers to cultivate more and increase their productivity. Crop insurance provides financial support to farmers in case of loss of their crops due to natural disasters or the loss of revenue due to declines in the prices of agricultural commodities. The study hypothesises that crop insurance encourages farmers in using modern agricultural practices and that lead to increase in farm productivity.

Farmers' component: Under farmers' component, the study includes expenses on agricultural technology, household size, age, education and social group. The data-set provides total expenditure of farm households for cultivation and we have taken total expenditure in rupees on agricultural inputs per hectare as one of the independent variables. The variable is entered in logarithm form. It is hypothesized that age of the household-head is negatively related to the farm output. Other than these two variables, the education level of the household-head has been considered and, for the purpose, twelve categories of education have been regrouped into three –illiterate, basic education and above basic education. From these three groups, two dummy variables have been created – household-head with basic education and household-head with above basic education. Illiterate farm households are reference category. Under social category, the study hypothesises that households that belong to higher social category have returns from cultivation. Social groups have been classified into three categories: OBC, SC/ST and others. The variable has entered the model as dummy and two dummies have been considered– SC/ST and OBC. Others are reference category.

Other than these variables, region dummy is also included in the study. We have included six regions in the study east, west, north, south, central and north-eastern. North-eastern region has been taken as base category in the study.

The summary table of all these variables and their expected signs are presented in the table 1.

4 Farmers' access to different sources of technical knowledge

We categorised different information sources as ICT and Non-ICT, and accordingly the section seeks to analyse the use of ICTs and Non-ICT sources.

In table 2 we have presented the percentage of farmers obtaining agriculture-related technical information from different sources. In order to assess the change in access to alternative sources over time period we have compared the access to information in 2003 and 2013. At national level, the use of ICTs to obtain farm related technical information has gone up marginally. Use of ICTs by farmers has increased from 19.9% in 2003 to

Table 1. Hypothesis and variables

Variables	Notation	Description	Expected sign
Expenses on agricultural technology (in rupees)	Log expenses	The expenditure on agricultural inputs for crop production. The variable is a continuous variable and entered in logarithm form	+
Crop insurance	Insurance	Dummy variable with households having crop insurance (one) and not having (zero)	+
Minimum support price	MSP	The variable is entered as continuous variable with state wise percentage of households aware about minimum support price	+
Education	Basic Education Above basic education	Dummy variable with household head having basic education (one), above basic education (two) and illiterate (zero)	+
Social group	OBC SC & ST	The variable has entered the model as dummy and two dummies have been considered– SC/ST and OBC. Others are reference category.	+
ICT use and land holding	SFICT MF ICT	The variable is entered as an interactive dummy with category of households according to their land holding and households using ICT as source of information	+
Non-ICT use and land holding	SFNon-ICT MFNon-ICT	The variable is entered as an interactive dummy with category of households according to their land holding and households using non-ICT as source of information	-
ICT & Non-ICT and land holding	SFICT & Non-ICT MFICT & Non-ICT	The variable is entered as an interactive dummy with category of households according to their land holding and households using ICT and Non-ICT as source of information	+
Age	Age	The variable is entered as continuous variable and household head's age has been taken into consideration	+
HHS Size	HHS_{Size}	The variable is entered as continuous variable and number of members in the household is taken into consideration	+

21.8% in 2013. There is also wide disparity in access to ICTs by farmers across states. In 2013, Kerala ranked first in the use of ICTs; around 59% of farmers availed information from ICT sources. In the same year, Rajasthan ranked at bottom with only 8.2% famers using ICTs. The states that have recorded higher percentage of farmers using ICTs than the national average are Andhra Pradesh, Assam, Haryana, Jammu and Kashmir, Karnataka and Kerala. Between 2003 and 2013 when some states witnessed a rise in the use of ICTs, at the same time, some others have witnessed a fall in the use of ICTs. Kerala has recorded the highest percentage increase in use of ICTs from 45% in 2003 to 59% in 2013.

Compared to ICTs sources, a relatively large percentage of farmers still rely on non-ICT sources for availing farm-related technical information. At all India level, farmers who used non-ICTs sources has gone up from 28% in 2003 to 31.4% in 2013. However, at state level, some states have witnessed a rise in the use of ICTs and some others have witnessed a fall. States like Chhattisgarh, Karnataka and Kerala have recorded a rise of more than 20% in the use of non-ICTs sources. In 2013, Chhattisgarh had the highest percentage (55%) of farmers using non-ICTs sources and Jharkhand had the lowest (15%).

There are also some households that use both ICTs and non ICTs sources combined. At all Indian level, the proportion of such famers has gone up from 10.2% in 2003 to 14% in 2013. Most states have witnessed a rise in the percentage of such farmers who used both

Table 2. Use of different ICT and non-ICT sources

States	ICTs		Non-ICTs		ICTs & Non-ICTs	
	2003	2013	2003	2013	2003	2013
Andhra Pradesh	13.6	22.9	50.4	43.9	10.0	17.6
Assam	29.5	33.2	24.0	29.5	13.9	17.0
Bihar	15.9	16.9	20.6	27.8	7.2	10.2
Chhattisgarh	7.2	15.0	23.7	55.1	3.7	13.8
Gujarat	13.7	19.7	48.1	41.8	12.8	17.5
Haryana	16.8	26.2	21.7	33.5	6.7	17.8
Jammu & Kashmir	53.3	52.1	4.14	40.2	3.7	29.2
Jharkhand	18.8	13.1	15.5	14.8	8.1	3.4
Karnataka	19.8	41.5	30.2	52.1	9.9	32.8
Kerala	44.5	58.6	24.7	47.4	18.6	35.5
Madhya Pradesh	13.5	15.3	36.5	27.7	8.8	7.0
Maharashtra	27.9	20.6	34.1	31.7	18.2	14.9
Orissa	11.5	15.9	19.2	34.6	4.8	12.2
Punjab	15.8	19.5	14.2	34.9	6.7	14.7
Rajasthan	5.8	8.2	12.9	20.1	2.9	4.2
Tamil Nadu	23.5	20.3	27.9	25.5	12.5	14.4
Uttaranchal	5.8	16.7	24.2	15.7	2.7	6.7
Uttar Pradesh	18.0	15.4	20.9	21.5	9.5	8.2
West Bengal	22.6	19.4	45.9	34.5	13.9	12.0
All India	19.9	21.8	28.0	31.4	10.2	13.9

Source: Author's calculations based on NSSO 59th and 70th RoundNote: Figures are in percentages

ICTs and non ICTs sources. In 2013, Kerala stood top in the use of both ICTs and non-ICTs with 35.5% and Jharkhand at bottom with only 3.4% using both the sources.

From this, it can be said that though there is increase in access of all the three categories of information sources, but the access has gone up marginally. Still, a large proportion of farmers are not using any source for receiving information on agricultural technology.

5.1 Effect of technological knowledge on farm output

This section discusses the impact of information on farm output. The farm output is categorised into five crop groups: cereals and pulses, fruits and vegetables, plantation, spices and non-food crops. Table 3 presents the results.

To assess the impact of technological knowledge on farm output, we have added two interactive dummies, the holding size and use of different sources for technological knowledge. The result shows that small farmers who use ICT as the source of technological knowledge have less output than the large farmers for cereals and pulses, plantation and non-food crops. However, the medium farmers with land holding size between 2 to 10 hectare, the use of ICT for technical knowledge realize more agricultural output than do the large farmers for all crops. Almost similar results are observed in case of non-ICT sources. Small farmers who use non-ICT as the source of technological knowledge, realize lesser farm output than do the large farmers for cereals & pulses and plantation. Medium farmers, however, get higher returns than the large farmers for all crop categories. However, if small farmers use both ICTs and non-ICTs sources, then for cereals & pulses and fruits & vegetables they get higher output than do the large farmers. For medium farmers, the estimated coefficient is negative that implies that by using both ICT and non-ICT sources large farmers have higher output than the medium farmers.

Table 3. OLS Regression results

Outcome variable: Log output

Explanatory variables	Cereals & pulses		Fruits & vegetables		Plantation		Spices		NFC	
	Coefficient	SE@	Coefficient	SE	Coefficient	SE@	Coefficient	SE	Coefficient	SE@
Constant	1.46***	0.109	0.326	0.224	3.734***	0.477	1.584***	0.508	1.804***	0.250
	(0.000)		(0.145)		(0.000)		(0.002)		(0.000)	
SF ICT	-0.061**	0.028	0.046	0.068	-0.211**	0.087	-0.065	0.127	0.103	0.077
	(0.028)		(0.498)		(0.015)		(0.609)		(0.179)	
MF ICT	0.340***	0.054	0.441***	0.092	0.474***	0.146	0.708***	0.215	0.180**	0.085
	(0.000)		(0.000)		(0.001)		(0.001)		(0.035)	
SF Non-ICT	-0.090***	0.019	-0.082	0.051	-0.181*	0.095	0.282**	0.123	0.074	0.048
	(0.000)		(0.111)		(0.058)		(0.022)		(0.126)	
MF Non-ICT	0.283***	0.032	0.125*	0.064	0.573***	0.143	0.541***	0.164	0.271***	0.049
	(0.000)		(0.052)		(0.000)		(0.001)		(0.000)	
SF ICT & Non-ICT	0.141***	0.040	0.318***	0.097	0.277**	0.136	-0.206	0.185	-0.167*	0.101
	(0.001)		(0.001)		(0.042)		(0.265)		(0.099)	
MF ICT & Non-ICT	-0.253***	0.071	-0.073	0.124	-0.590***	0.215	-0.826**	0.288	-0.206*	0.105
	(0.000)		(0.555)		(0.006)		(0.004)		(0.051)	
Expenditure	0.650***	0.007	0.779***	0.012	0.494***	0.020	0.540***	0.023	0.649***	0.015
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
Crop insurance	0.007	0.032	-0.481***	0.058	0.153	0.200	0.074	0.188	-0.407***	0.048
	(0.824)		(0.000)		(0.444)		(0.694)		(0.000)	
MSP	0.016***	0.000	0.028***	0.002	-0.015***	0.003	-0.007*	0.004	0.034***	0.001
	(.000)		(0.000)		(0.000)		(0.080)		(0.000)	
Basic education	0.065***	0.019	0.040	0.041	-0.026	0.102	0.284***	0.094	0.173***	0.039
	(0.000)		(0.335)		(0.795)		(0.003)		(0.000)	
Above basic education	0.053***	0.017	0.158***	0.040	-0.089	0.098	0.113	0.093	0.497***	0.039
	(0.002)		(0.000)		(0.362)		(0.223)		(0.000)	
OBC	0.002	0.017	-0.158***	0.040	0.347***	-0.130	-0.130	0.096	0.002	0.037
	(0.877)		(0.000)		(0.000)	(0.179)	(0.179)		(0.957)	
SC/ST	0.011	0.019	-0.094**	0.045	0.434***	0.095	-0.091	0.100	-0.211***	0.044
	(0.531)		(0.036)		(0.000)		(0.364)		(0.000)	
Age	0.008**	0.003	0.014*	0.007	0.004	0.016	0.037**	0.017	0.007	0.007
	(0.013)		(0.052)		(0.753)		(0.030)		(0.273)	

contd...

Explanatory variables	Cereals & pulses		Fruits & vegetables		Plantation		Spices		NFC	
	Coefficient	SE@	Coefficient	SE	Coefficient	SE@	Coefficient	SE	Coefficient	SE@
HHS Size	0.046***	0.006	0.082***	0.012	0.057*	0.030	0.083**	0.033	0.056***	0.011
	(0.000)		(0.000)		(0.060)		(0.012)		(0.000)	
Age^2	-0.000	0.000	-0.000*	0.000	-0.000	0.000	0.000**	0.000	0.000	0.000
	(0.134)		(0.089)		(0.716)		(0.044)		(0.955)	
HHS $Size^2$	-0.001***	0.000	-0.001*	0.000	-0.002	0.001	-0.001	0.002	-0.000	0.000
	(0.002)		(0.068)		(0.114)		(0.597)		(0.284)	
East	-0.921	0.029	-1.003***	0.076	-0.624	0.165	0.082	0.163	-2.223***	0.119
	(0.000)		(0.000)		(0.000)		(0.615)		(0.000)	
West	-0.906	0.031	-1.080***	0.063	-0.652	0.200	-0.605**	0.240	-2.210***	0.111
	(0.000)		(0.000)		(0.001)		(0.012)		(0.000)	
North	-0.985	0.028	-0.887***	0.057	-2.019	0.130	-.721***	0.116	-1.345***	0.116
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
South	-1.11	0.032	-1.213***	0.064	-1.207	0.105	-1.05***	0.145	-2.086***	0.120
	(0.000)		(0.000)		(0.000)		(0.000)		(0.000)	
Central	-0.695	0.039	-1.509***	0.065	-1.033	0.179	0.301	0.282	-1.864***	0.122
	(0.000)		(0.000)		(0.000)		(0.287)		(0.000)	
R^2	0.58	0.49	0.50	0.43	0.54					
No. of observations	14535	6141	1674	1293	5118					

Note: Figures in parentheses are P value. ***, ** and * indicate the significance level at 1, 5 and 10 respectively. SE@ indicates robust standard error

From our analysis, we observe that farm households who spend more on agricultural inputs like on fertilisers, manures, plant protection chemicals, irrigation, labour and many more, report more output. The result shows that a one percent increase in agricultural input leads to 0.65 per cent increase in cereals & pulses' output. Similarly, the increase in output for fruits & vegetables will be 0.77%; for plantation it will be 0.49%; for spices, the increase in output will be 0.54% and for non-food crops it will be 0.64%. We did not get any significant impact of crop insurance in case of cereals & pulses, spices and plantation. The crop insurance for fruits and vegetables and non-food crop shows a negative and significant relation with farm output, which implies if the crop is insured then the output of that crop is low in comparison to uninsured crop. This could be explained by the moral hazard problem of the crop insurers. However, another variable under institutional factors that is MSP has positive and significant impact on farm output for most crop categories.

We don't not find any significant impact of social groups. However, in case of plantation crops farm output is more on farms of SC/ST households. This could be due to the fact that plantation crops are grown in hilly region where most of the population belong to SC/ST category.

As hypothesised the educated farm households have higher output than the illiterate households for most crop categories except plantation crop. For all crop categories we have included region dummy as a control variable and we found that after controlling with region dummy, we got significant result for agricultural input, different sources of technological knowledge and institutional factors.

6 Conclusions

It is indeed imperative to discuss the result of our analysis against the theoretical literature discussed in the paper. The literature says that the interaction and learning among the three major components of agricultural system- agricultural research and extension services, farming communities and institutional factors lead to overall development of agricultural sector. The regression analysis has taken into consideration all those factors into consideration.

From the descriptive analysis, the study finds that from the year 2003 to 2013, use of ICT as well as non ICT sources has increased marginally. A large proportion of farm households are still not using any source for accessing agricultural technology. We also observe wide disparity across the states in order to access to different sources for agricultural technology.

From the analysis, we find that the use of information from both the sources is definitely a decisive factor in farm output. For small holding farmers, if they are using any one source for technical knowledge, then their output is less than large farmers. But if farmers are using both ICT and non-ICT sources, then they are having higher return in terms of output than large farmers. For cereals & pulses and fruits & vegetables, small farm households using both the sources, report higher output that the large farmers. As a major proportion of farmers cultivate cereals and pulses, this result draws immense significance with respect to policy decision. We also find that institutional factors like MSP have positive relation towards farm productivity for many crop categories. Other than technological and institutional factors, education has also significant contribution towards farm output.

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