Caste, Technology and Social Network

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Abstract

This paper analyzes the role of informal social networks in the technology diffusion in a caste based society where social hierarchical structure is prevalent. Often information and technology diffusion get constrained within the social and economic boundaries. In a complex and hierarchical social system where caste plays a very decisive role in everyday life as well as the political and policy fabric of the regional, state and national system; proper targeting and dissemination of technology to the marginalized sections of the society is very important for their development. Taking diffusion of improved rice varieties as an example, we analyse whether technology diffusion is confined within caste based social network or technology can break the caste boundaries and spreads across the social network.

Keywords: Technology adoption, Varietal diffusion, Social Network, Caste.

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Introduction

Improved agricultural technologies increase agricultural productivity or farm income and help improve the livelihoods of the poor. However, the challenge lies in the effective targeting and dissemination of these technologies. In this paper, the adoption of improved rice varieties is taken as an example of technology diffusion. Seed is the most critical inputs in agricultural production; the responses of all other inputs depend on quality and genetic make of the seeds. Sustained increase in agricultural production and productivity requires continuous development of new seeds suited to various agro-climatic regions and efficient production and supply of those improved varieties to users so as to achieve higher seed replacement and faster varietal turn-over. However, inherently, the Indian seed system is very complex and unique, having responsibilities and roles intertwined between different levels of (formal and informal) institutions at national, state and regional levels involving both public, private and developmental partners. Different institutions and organization such as research institutes (variety development and nucleus/breeder seed generations), certification agencies and national and state seed policies play vital role in this system. But these are only the organized or formal channels of seed dissemination. One should note that the unorganized or the informal channels are the ones dominating the system and where the challenge lies. By unorganized channels, here, we refer to informal social networks amongst farmers through which they exchange farm saved seeds, technology and information. These networks are what make the effective targeting and dissemination of technologies, or in this case seeds of improved rice varieties, difficult at times. This holds true, particularly in a developing country such as India where land holdings are small and fragmented and farmers are heterogeneous in terms of their social and economic status and political orientation in the society.

Adoption of improved technologies by farmers is not immediate. To understand the diffusion of any technology it is important to understand the dynamics involved in the process of varietal adoption. In this regard social networks among farmers is one of the dynamics which has been relatively less explored (Maertens and Barrett, 2012), but very crucial in a complex and hierarchical society. Farmers depend on their connections for information regarding the feasibility and profitability of new technologies. Often new technologies are introduced to progressive or model farmers in a village with the hope that other farmers would observe its benefits and adopt it. Extension services often rely on this assumption while targeting the dissemination of any technology to the farmers. (Magnan et al 2013). While this approach assumes that all farmers in a village would get influenced by one individual's decisions and follow suit, the reality might be otherwise. Adoption decisions are often not dependent on the whole village, rather, famers rely on individual networks. This holds particularly true in the context of rural India where, social structures, such as caste often plays a role in influencing village dynamics (Matuschke and Qaim, 2009). Hence, understanding these networks is crucial for targeting technologies in a better and effective manner.

India has a complex and hierarchical social system where caste plays a very decisive role in everyday life as well as the policy fabric of the regional, state and national system. The Indian caste system is a system of closed social stratification wherein a person's status in the society is often restricted to the caste he or she is born into. It is an endogamous and rigid system which ranks people right from their birth. Developments that have taken place in India both pre and post-independence have shaped much of how caste in India exists today. Caste in India is made up of the concepts of *varna* and *jati*. *Varna* refers to the class a person is born into and within each class are occupation based stratifications called *jati*. Historically there have been dominant castes who by the virtue of their birth have enjoyed certain privileges and positions of power, which have been denied to the marginalized castes (Deshpande 2010).The Indian Constitution seeks to safeguard the interests of these marginalized groups who have historically been discriminated against. Part III, Article 15, 16 and 17 of the Constitution[1] prohibits discrimination on grounds of religion, race, caste, sex or place of birth. For administrative purposes these marginalised groups have been classified into three categories, the Schedules Castes (SCs), Scheduled Tribes (STs) and Other Backward Classes (OBCs). To provide a level playing field, the government provides reservations to groups in state educational institutions, legislatures and government jobs. The fourth category is the General category, these includes those groups which have historically been the privileged and dominant castes. In this study we have classified the farmers into these four groups. Additionally a fifth category, called Minority[2], has been used which consists of all those who belong to a religious minority and not the dominant religious group of *Hindus* in India. Indian villages bear testimony to this rigid structure where caste plays a crucial role in terms or people's access to resources. Customarily, higher caste dominates agriculture sector in their role as landlords and lower castes perform the farming activities as tenants or laborers. Villages in India are often divided into hamlets which are inhabited by people belonging to a particular caste category and exchange of resources and information across these hamlets is often restricted by their caste compositions. Caste or religious segregated informal gatherings are very frequent in villages where they often share information and hence the chances of networks concentrate within the caste is high. Given the history, the targeting of any technology to the marginalized sections is very important for their development. Thus keeping in mind the complexity of informal networks and the role caste plays in various aspects of an individual's life, we hypothesize that caste acts as a barrier to technology diffusion since informal social networks concentrate within a caste group and varietal diffusion depends on these informal networks.

The rest of the paper is organized as follows: Section 2 describes the methodology which is used to estimate social networks across and within caste and also the econometric model used. In Section 3, the sampling procedure, data and variables of our survey are discussed. Sections four, contains the main results from the estimation. Section 5 checks for robustness of the results and Section 6 concludes.

[1]http://lawmin.nic.in/coi/coiason29July08.pdf

[2] This refers to individuals belonging to religious minorities, like Muslims and Christians.

Method

Social Network – Caste

To get social network data the approach of random matching within sample was used, wherein each respondent was randomly matched with another farmer from the sample and then they were asked questions about the farmers that they were matched with (Maertens and Barrett 2012). For this study, two types of social networks were estimated, one across caste groups and the other within caste groups. Networks across caste refer to groups where individuals belonging to different caste categories interact with one another. On the other hand in networks within caste, the interaction is limited to members belonging only to one particular caste category. Looking at these two types of networks would help us ascertain if informal networks are concentrated within caste based groups or they break these boundaries and spill over across caste.

Equation (1) depicts how informal social networks were estimated. Here, K_{ij} refers to the respondent i knowing who person j is. It takes the value of one if the respondent knows person j and zero otherwise. C_{ij}takes the value of one if the respondent i know that person j cultivated rice, given that she knows j, and zero otherwise. Q_{mij}refers to the question asked to the respondent i about j's cultivation habits where $m = 1, \dots, 8$. Q_{1ij} to Q_{8ij}take the value of 1 if the respondent i knows the answer to the questions asked about person j, otherwise it is zero. The value of the social network variable thus estimated lies between 0 and 1. w_1, w_2 and w_3 are the weights assigned.

$$SN_i = \frac{\left[w_1 K_{ij} + w_2\left(C_{ij} \middle| K_{ij} = 1\right) + w_3 \sum_{m=1}^{M} Q_{mij} \middle| K_{ij}=1, C_{ij}=1\right]}{M\ N} \qquad (1)$$

The value of M is eight and the value of N varies with type of SN estimation (across or within caste network): N=6 for social network across caste and $N \leq 6$ for within caste network. That is, within caste network estimation, N takes the value of the number of people belonging to the same caste as that of respondent i. N can be zero in those cases where no individual in the network belongs to the same caste category as the respondent.

Econometric Model – Varietal Selection

Multivariate probit regression is used to analyze the factors affecting the varietal selection. There are three types of varietal selection possible in rice cultivation: traditional, improved or high yielding (HYV) and hybrid varieties. Following Chib and Greenberg 1998, let Y_{ij} denotes the binary response $0/1$ representing whether the farmer i $(i = 1,2 \dots, n)$, was adopted the type of variety j, and let $Y_i = (Y_{i1}, Y_{i2}, Y_{i3})'$ $(1 \leq i \leq n)$ denote the collection of responses on all three types of varietal adoption $(j = 3)$. The multivariate probit model is specified as below:

$$Y_{ij}^* = \boldsymbol{X}_i \delta_j + \epsilon_{ij}\ ; \quad \text{where} \quad Y_{ij} = \begin{cases} 1 & \text{if} Y_{ij}^* > 0 \\ 0 & otherwise \end{cases} \text{ and } \quad \epsilon_i \sim \text{MVN}(\mathbf{0}, \boldsymbol{\Sigma})$$

Here $\boldsymbol{X}_i$ denotes the k-vector exogenous covariates, ϵ_i are assumed to be iid independent across i but correlated across j for any$i$ and MVN denotes the multivariate normal distribution.

Data

Sampling Procedure

The survey was conducted in 2015 in three major rice growing states in eastern Indian, namely Bihar, Odisha and West Bengal. Five districts[1] were chosen in each state based on three criteria. First, rice intensity of 50 per cent or more, second agro ecological zone[2] and third, irrigation status. In each district, top two rice growing blocks were chosen making a total of 30 blocks. In each block, five villages were selected randomly. In total, 150 villages were selected to implement the current research work. In each village, rice farming households were identified using the complete census of the village. In the village census the names of every household head in the village, their caste, religion and rice farming status was recorded. Finally from each village list, 10 households were selected for the household survey, in proportion to the caste composition in the village. Thus 1500 households were sampled for the survey. The households were categorized into five caste categories – General, Minority, Scheduled Caste, Scheduled Tribes and Other Backward Classes.

Variables and Summary Statistics

A total of 1490 households were surveyed in this study. One village could not be covered in Bihar due to logistical issues. Hence, the total sample in Bihar was 490 and in Odisha and West Bengal it was 500. An average household consisted of five members and the average age of both men and women was around 31 years, in the households surveyed. Average years of experience of men and women in agriculture was close to 18 and 15 years respectively. In terms of caste composition, majority of the respondents belonged to the OBC category (33.7%), followed by the general category (25.5%). Figure 1, depicts the caste composition across the three states. Bihar is highly dominated by OBC category respondents (61 per cent) and a very small ST (1 per cent) population. In contrast, in Odisha and West Bengal no single caste group is dominating, but at least two caste groups have a large population share (General and OBC for Odisha and General and SC for West Bengal).

[1] The following districts were selected:
Bihar- Rohtas,Gaya (AE 9); Madhubani, Purba Champaran and Munger (AE 13); Odisha - Puri, Kendrapara (AE 18), Bargarh, Mayurbhanj and Rayagada (AE 12); West Bengal- Bankura(western), Puruliya (AE 12) ; Bardhhaman (eastern), South 24 Parganas and SouthDinajpur (AE 15)

[2] The agroecology zones identified were -
AE 9 - Northernplains hot sub humid, AE 12 - EasternPlateau Chottanagpur and Eastern Ghats hot sub humid, AE 13 - EasternPlain hot sub humid (moist), AE 15 - Assam and Bengal Plains hot sub humid to humid, AE 18 - Easterncoastal plain hot sub humid to semi-arid

	General	Minority	OBC	SC	ST
Total	380	111	502	338	159
West Bengal (%)	32.0	12.6	10.4	30.4	14.6
Odisha (%)	30.0	2.4	30.2	21.2	16.2
Bihar (%)	14.3	7.4	61.0	16.3	1.0

Figure 1: Caste Composition across States

Education levels were defined in terms of years of education completed and they were categorized into, non-literate, literate with no formal education, primary (grades 1 to 4), secondary (grades 5 to 10), senior secondary (grades 11 and 12) and graduate and above (under-graduate degree and above). 39.8% of female and 47.8% of male members had completed secondary education. The proportion of female members were found to be more non-literate than their male counterparts. Within each caste category, around 44% (or more) of the household members had attained secondary education, except those belonging to the minority category. Out of all the members belonging to the general category, 71.3% of them got formal schooling whereas it was 63.3% for minorities and around 65% for OBC, SC and ST category households respectively. 31.2% of the members who belonged to the minority category were non-literate, which was more than those in the other caste categories.

Agriculture was the primary occupation of household heads belonging to the general, minority and OBC categories, with 62.7%, 70.3% and 67.4% being involved in the same respectively. However, this proportion was less when it came to SC (54.5%) and ST (55.4%) headed households, even though agriculture was their main occupation. Compared to others a greater proportion of SC and ST headed households were involved in manual labour. Agriculture was also the main source of income for respondents belonging to the general, minority and OBC category. Whereas, for SC and ST categories the main source of income was non-agricultural labour. Remittances were also a popular source of income for the respondents; especially those belonging to the minority and OBC category derived around 10% of their income from it.

The households were also categorized as marginal (0-1 hectare), small (1-2 hectare), semi medium (2-4 hectare), medium (4-10 hectare) and large farmers (greater than 10 hectare) based on the area under cultivation. This classification has been done following the Government of India's classification of land holdings. Data on area under rice cultivation was collected for two cropping seasons, Kharif 2015 (June/ July to October/ November) and Rabi 2014-15 (November/ December to March/ April). Majority of the farmers within each caste category who cultivated rice were marginal, that is, their landholdings under rice were between 0 to 1 hectares. This was followed by farmers with small landholdings between 1 and 2 hectares. Households with large landholdings (more than 10 hectares) were very few, only 1%

in general category and negligible when it came to the SC, ST and OBC households. Table 1 summarises the educational attainment of household members, their primary source of income, the head's primary occupation and landholdings within each caste category.

Table 1: Sample Household Characteristics

Characteristics	***General***	***Minority***	***OBC***	***SC***	***ST***
Education*** †	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*
Non-literate	18.9	31.2	26.7	26.2	24.6
Literate with no formal education	2.9	1.6	1.7	2.5	4.5
Primary	11.9	17.6	11.7	13.6	12.3
Secondary	47.5	38.7	43.3	43.7	44.1
Senior secondary	11.9	7.0	10.5	8.6	9.0
Graduate and above	7.0	3.9	6.0	5.3	5.6
Primary Occupation of Household Head* †	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*
Farmer	62.7	70.3	67.4	54.5	55.4
Labour	19.2	11	12.9	23.1	24.3
Self employed	7.3	7.6	7.9	8.3	14.1
Housemaker/ Housewife	2.8	4.2	4.2	3.7	0.6
Salaried employment	3.4	3.4	2.4	4.6	1.1
No Occupation	1.1	1.7	2.8	2.8	3.4
Livestock/ poultry/ Fishery	2.3	0.9	1.8	0.9	1.1
Other (specify)	1.1	0.9	0.8	2.2	0
Primary Income Source of Household** †	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*
Agriculture/ Cultivator	44.9	43.2	48.0	31.1	26.4
Labour	22.2	22.5	19.1	43.8	49.7
Self employed	17.7	16.2	14.1	11	11.3
Remittance	4.0	9.9	10.8	5.3	1.3
Salaried employment	7.1	5.4	5.8	6.5	8.8
Livestock/ Poultry Rearing	2.4	0.9	1.2	1.2	1.9
Pension	0.8	0.9	0.2	0.6	0.6
Other (specify)	1.1	0.9	0.8	0.6	0.0
Land holdings under rice cultivation** †	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*
MarginalFarmers (0 -1 ha)	57.9	61.3	58.4	75.7	72.3
SmallFarmers (1 - 2 ha)	23.2	26.1	26.7	15.1	14.5
Semi-mediumFarmers (2 - 4 ha)	11.3	8.1	9.6	7.4	10.1
MediumFarmers (4 - 10 ha)	6.6	3.6	5.2	1.5	3.1
LargeFarmers (10 ha and above)	1.0	0.9	0.2	0.3	0.0

†Comparisons were made between household members belonging to different caste groups and their level of educational attainment, their income source, their head's primary occupation and land holdings using chi-square test.

*, **, *** indicates the corresponding differences are significant at the 10%, 5%, and 1% levels, respectively between different caste groups

Table 2 shows the percentage of farmers belonging to different land classes as per the total agricultural land they own and the area under rice cultivation in both Kharif 2015 and Rabi 2014-15. As is evident from the table below, within each state marginal farmers made up the greatest proportion with respect to both own agricultural land and area under rice cultivation. Overall the proportion of marginal farmers was 63.8% for area under rice cultivation and 78.2% for own agricultural land. Next was small farmers, overall 21.8% of the area under rice and 14% of own agricultural lands were between 1 and 2 hectares. The proportion of farmers having access to land sizes greater than 10 hectares is almost negligible.

Table 2: Farmers (%) belonging to land classes as per area under rice cultivation and own agricultural land

Land Class	Landholdings under Rice***				Own agricultural landholdings***			
	Bihar	Odisha	West Bengal	Total	Bihar	Odisha	West Bengal	Total
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Marginal Farmers (0 -1 ha)	66.3	48.6	76.6	63.8	78.8	69.0	86.8	78.2
Small Farmers (1 - 2 ha)	22.9	26.6	16.0	21.8	13.7	19.2	9.2	14.0
Semi-medium Farmers (2 - 4 ha)	7.6	16.4	4.6	9.5	4.9	9.2	3.6	5.9
Medium Farmers (4 - 10 ha)	3.3	7.4	2.4	4.4	2.2	2.4	0.4	1.7
Large Farmers (10 ha and above)	0.0	1.0	0.4	0.5	0.4	0.2	0.0	0.2

†Comparisons were made between landholdings in different states using chi-square test.
*, **, *** indicates the corresponding differences are significant at the 10%, 5%, and 1% levels, respectively.

Results

Caste and Varieties

During the survey the farmers were asked which varieties they cultivated during the two cropping seasons of Kharif and Rabi, tables 3 and 4 summarize the some of the observations. For our analysis these varieties that were cultivated by the farmers have been categorized as improved, hybrid and traditional. Many varieties are referred to by their local names, by farmers across Eastern India, this makes categorizing them difficult. For example Swarna which is an improved variety and was released in the 1979, is one of the most popular varieties in Eastern India. But Swarna may be identified by multiple names across these regions by farmers. Hence, those varieties which could not be categorized or identified by the farmers themselves, have been put under “Unidentified”. As per table 4, close to 75% of the varieties cultivated by farmers in the sample were improved, followed by traditional (6%) and hybrid (2%). In India Kharif is the season when most of the rice is cultivated, hence it isn’t surprising to see that very little rice was cultivated in Bihar during Rabi. However farmers in the state of

Odisha and West Bengal do cultivate some rice during Rabi which is reflected in the sample as well. Across both season and within each state majority of the varieties that were cultivated were improved. Within all the caste categories, improved varieties were cultivated the most. The second most popular variety were the traditional varieties for all households except those farmers who were scheduled tribes; they cultivated hybrids. In Bihar and West Bengal none of the farmers belonging to the ST category cultivated hybrid and traditional varieties. The same can be said about farmers belonging to the minority category in Odisha.

Table 3: Varieties cultivated

	Improved	Traditional	Hybrid	Unidentified	Total
Overall	75.6	6.0	1.7	16.8	2,773
	(%)	(%)	(%)	(%)	(%)
Bihar* **					
Kharif 2015	61.0	10.4	2.7	25.8	729
Rabi 2014-15	0.0	0.0	0.0	100.0	7
Odisha					
Kharif 2015	82.6	1.8	1.9	13.6	927
Rabi 2014-15	86.7	0.6	1.1	11.7	180
West Bengal* **					
Kharif 2015	82.2	6.9	0.8	10.1	765
Rabi 2014-15	60.5	10.8	0.0	28.7	167
Caste* **					
General	77.5	7.2	1.1	14.1	788
Minority	72.8	4.6	1.0	21.5	195
OBC	69.2	7.1	2.8	20.9	907
SC	76.6	5.6	1.0	16.8	608
ST	90.6	0.4	1.5	7.6	275

†Comparisons were made between varieties cultivated in each season, in each state using Fisher's exact test.

*, **, *** indicates the corresponding differences are significant at the 10%, 5%, and 1% levels, respectively.

This study also explored farmers' preferences when it came to selecting varieties and seeds of a variety. Tables 9 and 10 summarize some of the important traits farmers took into account. While choosing a variety, yield was considered for 92.9% of the varieties. Out of the varieties for which yield was considered, 76% were improved, 5.7% were traditional and 1.7% were hybrid. Similarly, for 85.6% of the seeds, purity was considered and out of them, 75% were of improved varieties, 6.5% were traditional and 1.6% were hybrid. Cooking quality, vigor and marketability were other main considerations farmers took into account while choosing the variety. For seed selection colour of the seed, size and certification were some of the major traits considered. Other traits which the farmers considered while selecting the variety were water requirement, price premium from selling the variety in the market, duration of the variety and its ability to resist stress. While selecting the seed the source of acquiring the seed, labelling and moisture content were also taken into account.

Table 4: Varietal and Seed preference

Variety	Did you consider the following while selecting the Variety? (% yes)				Did you consider the following while selecting the Seed? (% yes)			
	Yield	Cooking quality***	Vigor***	Marketability**	Purity**	Colour**	Size*	Certification status***
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Improved	75.9	76.3	73.7	75.3	74.9	74.1	72.5	73.3
Traditional	5.7	6.5	7.3	7.0	6.5	6.6	7.5	7.9
Hybrid	1.7	1.4	1.7	1.6	1.6	1.5	1.6	1.8
Unidentified	16.6	15.8	17.3	16.2	17.0	17.9	18.4	17.0
Total	92.9	81.8	69.8	64.1	85.6	73.5	71.6	59.6

†Comparisons were made between varieties used and preferences using Fisher's exact test. *, **, *** indicates the corresponding differences are significant at the 10%, 5%, and 1% levels, respectively.

Agri-input shops are the most popular source of acquiring seeds with around 47% of the seeds being acquired from there. This was followed by farmer to farmer transfers which accounted for 19% of the sources through which farmers acquired seeds. If we look at the sources by varieties that the farmers cultivated, as illustrated in Figure 2, then in Bihar and West Bengal, the most popular source was agri-input shops for all the varieties. In Odisha the public system was the most popular source of acquiring seeds for improved varieties and for the rest of the varieties it was agri-input shops. In Odisha farmer to farmer exchanges were also a popular source.

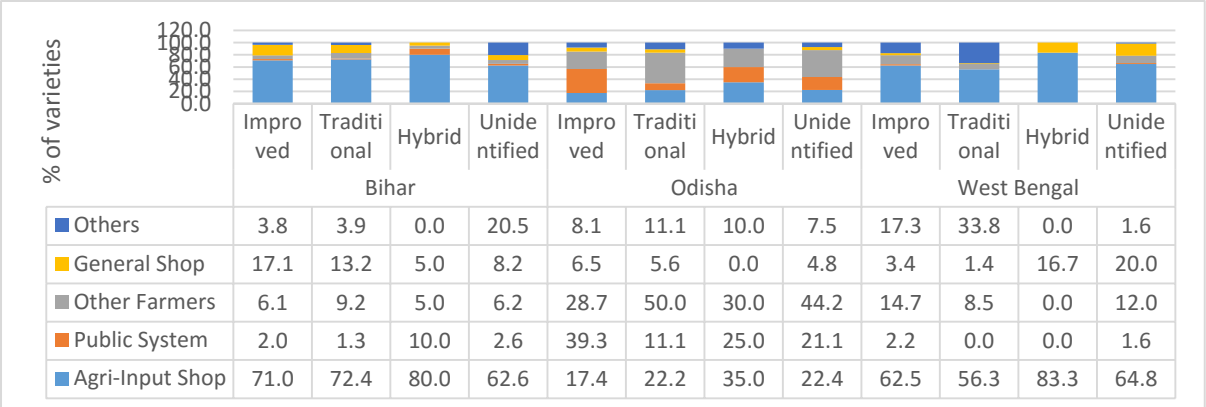

Figure 2: Source of acquiring seeds of different varieties in each State

Table 5 summarises the average number of years since seeds were replaced by famers in our sample and also the number of years since varieties were replaced. Overall, seeds are replaced every alternate year for almost all varieties on an average. Average years since an improved variety was replaced was eight years, for traditional it was six years and for hybrid three years. Seeds are replaced faster in Bihar as compared to West Bengal and Odisha. In contrast varieties are replaced faster in Bihar, every 5 years, in Odisha and West Bengal it is

replaced every eight years. Within caste categories, farmers replace seeds mostly within a year in each state. Farmers in Bihar belonging to the general category farmers replace the varieties every four years, whereas in Odisha it is seven years and West Bengal eight years. Minorities use the same variety for a longer period of time in West Bengal and Bihar, but in Odisha they replace it around every six years. For farmers belonging to the OBC, SC and ST category, years since replacement of variety is longer in Odisha and West Bengal as compared to Bihar. Overall the range for varietal replacement among the surveyed farmers varies between zero to 40 years and the same for seed replenishment is zero to 35 years.

Table 5: Seed replenishment and varietal replacement (average years)

Variety cultivated	Bihar					Odisha					West Bengal				
	General	Minority	OBC	SC	ST	General	Minority	OBC	SC	ST	General	Minority	OBC	SC	ST
Seed replenishment															
Improved	0.3	0.2	0.3	0.1	0.5	1.3	1.4	0.9	1.1	0.6	1.2	0.9	0.9	0.9	1.7
Traditional	0.1	0.0	0.3	0.2	0.0	1.2	-	-	0.0	0.5	0.3	0.0	0.4	0.1	-
Hybrid	-	0.0	0.7	0.5	1.0	0.2	-	0.0	1.0	2.0	0.5	-	0.0	-	0.0
Others	0.1	0.2	0.3	1.2	0.0	1.1	2.0	0.3	0.9	0.6	0.9	0.7	0.5	0.4	0.4
Total	0.3	0.2	0.3	0.5	0.4	1.3	1.4	0.8	1.0	0.6	1.0	0.8	0.8	0.7	1.6
Varietal replacement															
Improved	3.5	12.3	6.1	4.8	0.0	8.8	6.5	8.8	8.8	6.8	8.0	10.8	9.6	8.1	9.5
Traditional	4.3	7.0	4.7	7.3	-	12.0	-	6.7	10.0	17.0	6.1	7.0	7.7	3.4	10.7
Hybrid	5.0	6.0	4.0	5.0	-	3.6	0.0	1.8	3.3	2.0	12.0	-	1.5	0.0	3.0
Others	5.9	5.8	4.7	5.4	2.0	4.8	2.7	1.6	4.5	6.1	6.4	5.8	6.5	5.5	2.2
Total	4.0	8.7	5.5	5.3	1.0	8.2	5.9	7.8	8.1	6.8	7.5	9.5	9.0	7.3	9.0

Social Network

The social network variable across and within caste is estimated using the methodology discussed in section 3.a. In our study 10 rice farming households were surveyed in each village. Out of these 10, six farmers were randomly picked and each respondent was matched with different combinations of these randomly selected farmers. The respondents were asked if they knew any of those six farmers and were further probed to see the extent of knowledge they had about the selected farmers in their village. Table 6 summarises the values this variable takes within and across each caste category and landholdings that farmers have in each state. The weights w1, w2 and w3 take the values 0.1, 0.3 and 0.6 respectively. Quality of knowledge about a person's cultivations habits in the respondent's network is given a greater weight. In-depth knowledge about the variety that an individual cultivates, the source they get their seeds from etc., reflects how close knit a network is and can help guide policy and dissemination strategies. Networks within caste appear to be stronger within in all the three states. Across caste categories and farmer landholdings the same holds true, the social network variable within caste has either higher or same values. For instance in Bihar, farmers who belong to the OBC category have stronger networks within their caste. The same can be said about semi-medium farmers in Odisha. In West Bengal if we look a farmers disaggregated by the size of their landholding then social network across and within caste takes the same value. However if we look at West Bengal farmers based on their respective caste categories then the networks appear to be stronger within them. Thus it seems that informal networks tend to concentrate within caste based groups. Section 4.c. will further explore if varietal diffusion depends on these informal social networks.

Table 6: Social Network across and within caste categories (averages)

Type of Network	Bihar		Odisha		West Bengal		Overall	
	Across Caste	Within Caste	Across Caste	Within Caste	Across Caste	Within Caste	Across Caste	Within Caste
General	0.4766	0.4873	0.4463	0.4802	0.3355	0.3650	0.4051	0.4300
Minority	0.4162	0.5838	0.4625	0.4633	0.3157	0.3666	0.3641	0.4406
OBC	0.3778	0.3880	0.4326	0.5011	0.2955	0.3732	0.3859	0.4186
SC	0.3920	0.4158	0.4373	0.4961	0.2879	0.3042	0.3594	0.3843
ST	0.4467	-	0.4415	0.4757	0.3750	0.3829	0.4111	0.4321
Marginal Farmers (0 -1 ha)	0.4020	0.4211	0.4386	0.4764	0.3172	0.3457	0.3813	0.4083
Small Farmers (1 - 2 ha)	0.3826	0.4325	0.4306	0.5068	0.3775	0.4058	0.4035	0.4592
Semi-medium Farmers (2 - 4 ha)	0.3736	0.3665	0.4856	0.5532	0.2653	0.3331	0.4104	0.4500
Medium Farmers (4 - 10 ha)	0.3898	0.3400	0.3705	0.4086	0.1250	0.1667	0.3593	0.3496
Large Farmers (10 ha and above)	0.3750	0.3250	0.5000	0.7000	-	-	0.4167	0.4500
Overall	0.3976	0.4174	0.4399	0.4885	0.3201	0.3498	0.3859	0.4172

Caste and Technology Adoption – MV Probit Model

In order to test our hypothesis we use a multivariate probit model. The dependent variable here is the adoption of rice varieties, which as mentioned earlier has been categorized as traditional, improved and hybrid. It is important to note that a farmer may cultivate different varieties at one point of time. For example, it might be the case that during the same cropping season a farmer cultivates a traditional and an improved rice variety, in different plots. Thus we have three categories of dependent variables, traditional, improved and hybrid all of which take the value of one if they have been cultivated by the farmer across the two cropping seasons and zero otherwise. Two models are estimated to see whether varietal diffusion depends on informal social networks and caste acts as a barrier in this diffusion. The first model looks at the impact of informal social networks across caste based groups on the adoption of varieties and the second one looks at the impact of informal social networks within caste. Other independent variables used in both the models are rice area as a percentage of total cultivated area, amount of land rented in and rented out, primary income earned by the households, overall households' average monthly expenditure, average monthly expenditure on food, preferences about varietal characteristics taken into account by the respondents while selecting a variety and dummies for state, caste, source of seed, area under rice and primary source of income. The variables used in the regression analysis have been explained in detail in Table 7.

First, we look at the results of the model which captures the impact of informal social networks across caste based groups on varietal diffusion, the results of which are summarized in Table 8. Informal social networks among farmers across caste categories significantly affects the adoption of traditional varieties negatively and that of improved varieties positively. However when it comes to hybrids there is no significant impact. Thus, social networks across caste, among farmers have a positive impact on the adoption of new and improved technologies and discourages the adoption of older traditional technologies. Other factors which significantly affect the adoption of traditional and improved varieties are percentage of area under rice and the amount of land that is rented out by the farmer. As area under rice increases farmers tend to dis-adopt traditional varieties and adopt more improved varieties. This can be explained by the fact that as area under cultivation expands farmers tend to diversify the type of varieties they grow and experiment with different varieties and crops.

Table 7: Variable names, definitions and descriptive statistics

Variables	Description	Mean (SD)	Range	
			Maximum	Minimum
Dependent Variables				
Improved	Takes the value of 1 if improved variety was cultivated, 0 otherwise.	0.96 (0.19)	0	1
Traditional	Takes the value of 1 if traditional variety cultivated, 0 otherwise.	0.11 (0.31)	0	1
Hybrid	Takes the value of 1 if hybrid variety cultivated, 0 otherwise.	0.03 (0.18)	0	1
Independent Variables				
Social Network Across Caste (Model I)	Social network variable estimated across caste based groups.	0.39 (0.18)	0	1
Social Network Within Caste (Model II)	Social network variable estimated within caste based groups.	0.43 (0.22)	0	1
Other Independent Variables (used in both models)				
Rice area (% cultivated area)	Total rice area cultivated as a percentage of total cultivated area, in both seasons.	73.1 (37.24)	1.3	100
Primary income	Income earned from primary source ('000 Rupees), in last 12 months from date of survey	72.45 (93.05)	0	1200
Average monthly expenditure	In '000 Rupees.	6.10 (5.22)	0	100
Average expenditure on food	In '000 Rupees.	3.79 (5.89)	0.4	150
Rented in land	Total land rented in (area in ha), in Kharif 2015.	0.35 (0.75)	0	9.45
Rented out land	Total land rented out (area in ha), in Kharif 2015.	0.05 (0.40)	0	7.17
Yield	Varietal preferences: Characteristics that the respondent took into consideration about a variety before deciding which one to cultivate - yield, cooking quality, vigour and marketability of the variety (yes/ no).	0.98 (0.14)	0	1
Cooking quality		0.95 (0.22)	0	1
Vigour		0.75 (0.43)	0	1
Marketability		0.72 (0.45)	0	1
Dummy variables				
Landholding under rice (small 1-2 ha)	Dummy for total area under rice, aggregated for both seasons. Reference category is Marginal (0-1 ha).	0.23 (0.42)	0	1
Landholding under rice (Medium to large >2 ha)		0.15 (0.36)	0	1
Seed Source (agri input shop)	Dummy for source of acquiring seeds of the varieties cultivated in both seasons. Reference category is other farmers.	0.46 (0.50)	0	1
Seed Source (public system)		0.14 (0.35)	0	1
Seed Source (general shop)		0.14 (0.35)	0	1
Seed Source (others)		0.61 (0.24)	0	1
Caste (Minority)	Dummy for caste category of the households. Reference category is general category	0.75 (0.26)	0	1
Caste (OBC)		0.31 (0.46)	0	1
Caste (SC)		0.27 (0.42)	0	1
Caste (ST)		0.11 (0.32)	0	1
Primary Income Source (Self Employed)	Dummy for primary source of income of the household. Reference category is agriculture.	0.15 (0.35)	0	1
Primary Income Source (Salaried employment)		0.06 (0.24)	0	1
Primary Income Source (Labour)		0.28 (0.45)	0	1
Primary Income Source (Others)		0.08 (0.26)	0	1
State (Odisha)	Dummy for the states in which the survey was conducted. Reference category is Bihar.	0.36 (0.48)	0	1
State (West Bengal)		0.35 (0.48)	0	1

We also find that increases in the amount of land that is rented out increases the adoption of traditional varieties and decreases the same for improved varieties. One possible reason could be the behavioral aspect behind renting out land for cultivation. Usually income generation from agriculture is not a major objective for thepeople who choose to rent out land

as opposed to those who own very little land and depend on agriculture for subsistence. Such individuals might thus choose to cultivate some traditional varieties meant for special purposes. The amount of income earned by the household has a negative and significant impact on the adoption of improve varieties. Compared to marginal rice farmers, medium to large rice farmers cultivate more traditional varieties, as is evident from the significant and positive dummy used for medium to large landholdings under rice. Marginal farmers mostly cultivate a crop for generating income and in such a scenario they tend to go for improved varieties as they guarantee a higher yield. In our sample we find that out of the total number of marginal farmers who cultivated rice, 96% of them cultivated improved varieties. Compared to this medium and large farmers tend to diversify the varieties they cultivate.Other dummies that significantly influence the adoption either three categories of our dependent variable are seed source dummies for public system and general shops, all the caste dummies, primary income source dummies for self-employment and salaried employment and state dummy for Odisha. Compared to other farmers when farmers acquire seeds from the public system their adoption of traditional varieties fall and when farmers acquire the same from general shops the adoption of improved varieties increases. This result can be supported by the fact that the public system in India has extensive programs on dissemination of new and improved seeds, whereas amongst one another, farmers exchange farm saved seeds which are often belong to old and traditional varieties. The general shops store seeds manufactured by the private sector which are again improved. Farmers belonging to the minority, SC and ST categories compared to those who belong to the general category cultivate less traditional varieties. As compared to the general category farmers belonging to the ST and OBC categories cultivate more improved and hybrid varieties. This result can we confusing since we see the marginalized communities adopting improved technologies more as compared to the general community. However if one looks at the social network estimates both across caste and within caste amongst STs, in Table 6; it is clear that compared to all other caste categories they have the strongest networks. In such a concentrated and tight network we would expect technology to spread much faster through informal channels and hence we see these communities adopting more improved varieties. Respondents whose primary income source was self-employment and salaried employment cultivated less traditional varieties as compared to those whose primary source was agriculture. Generally people who are earn a salary, or especially, have their own businesses, are profit oriented, and so such individuals would invest in varieties which would give them higher returns and not in traditional varieties whose cost of cultivation often exceeds itsbenefits. Compared to Bihar, farmers in Odisha cultivate less traditional and more improved varieties. This result can be explained by the fact that, as compared to Bihar, in Odisha the public system is well established in terms of its initiatives in disseminating new and improved varieties. The results from this survey also corroborate this fact as 46% of the traditional varieties cultivated in our sample were from Bihar and only 10% from Odisha and further 92% of the seeds acquired from the public system were from Odisha. Finally, when yield was considered as an important characteristic while choosing a variety, the adoption of improved varieties went up and that of traditional varieties fell. Hence, higher yield is an important consideration for farmers, which is a driving force for them to go for improve technologies. In this model we do

not see many variables significantly affecting the impact of hybrid varieties. This can be because in our sample we do not find many hybrids.

Table 8: Model I - Across Caste Groups

Variables	traditional		improved		hybrid	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Social Network Across Caste	-1.732***	0.307	2.125***	0.490	-0.381	0.427
Rice area (% cultivated area)	-0.003*	0.001	-0.001	0.002	-0.002	0.002
Primary Income ('000 Rupees)	0.0002	0.001	-0.002**	0.0007	0.012	0.011
Average monthly expenditure ('000 Rupees)	0.006	0.009	0.065	0.045	-0.006	0.015
Average expenditure on food ('000 Rupees)	0.0001	0.010	0.047	0.061	-0.183	0.054
Rented in land (area in ha)	-0.112	0.076	0.250	0.157	0.015	0.081
Rented out land (area in ha)	0.242**	0.106	-0.238**	0.106	0.129	0.112
Landholding under rice Dummy (small 1-2 ha)	0.177	0.136	-0.072	0.214	0.150	0.177
Landholding under rice Dummy (Medium to large >2 ha)	0.409**	0.177	-0.326	0.282	0.259	0.222
Seed Source Dummy (agri input shop)	0.054	0.163	0.106	0.226	-0.038	0.214
Seed Source Dummy (public system)	-0.682**	0.283	0.951	0.686	-0.006	0.224
Seed Source Dummy (general shop)	0.016	0.19	0.463*	0.282	-0.280	0.294
Seed Source Dummy (others)	-0.322	0.269	0.124	0.363	-0.625	0.419
Caste Dummy (Minority)	-0.659***	0.235	3.947	101.349	0.032	0.352
Caste Dummy (OBC)	-0.216	0.137	0.157	0.203	0.352*	0.192
Caste Dummy (SC)	-0.305**	0.146	0.270	0.210	0.007	0.236
Caste Dummy (ST)	-1.245***	0.350	0.966*	0.496	0.148	0.281
Primary Income Source (Self Employed)	-0.483**	0.211	0.188	0.307	-0.056	0.211
Primary Income Source (Salaried employment)	-0.490*	0.272	0.038	0.356	-0.248	0.342
Primary Income Source (Labour)	0.192	0.146	-0.254	0.214	-0.174	0.21
Primary Income Source (Others)	0.137	0.183	-0.070	0.264	-0.626	0.381
State Dummy (Odisha)	-0.379*	0.221	0.955**	0.388	0.067	0.289
State Dummy (West Bengal)	-0.230	0.173	0.725	0.280	-0.241	0.253
Preferences : Varietal characteristics						
Yield	-0.872**	0.369	1.597***	0.442	-0.183	0.544
Cooking quality	0.325	0.307	-0.490	0.398	0.323	0.433
Vigour	0.300	0.186	-0.232	0.333	-0.107	0.198
Marketability	-0.009	0.141	-0.242	0.227	0.046	0.193
Constant	0.229	0.432	-0.728	0.573	-1.723**	0.681

* p<0.1, ** p<0.05, *** p<0.01

In the second model we regress the social network variable within caste categories on our dependent variable. Like model 1, this variable has a positive and significant impact on adoption of improved varieties and a negative and significant impact on traditional varieties. What is different here is that, the social network variable affects the adoption of hybrids

negatively and is significant. Thus networks within caste tend to discourage the adoption of hybrids. From table 6 it is clear that networks are deeper and more concentrated within caste, and in such a situation we expect a greater dependency on informal channels of seed dissemination, or farm saved seeds. Hence, hybrids do not qualify, as their seeds have to be replaced every year. Additionally one can also argue that hybrids are a relatively newer technology as compared to improved varieties and any new technology takes time to get absorbed.It becomes difficult for technologies to break these caste based networks as farmers tend to stick to practices that are already established and tested. Other independent variables used have the same impact as in the first model, but with some exceptions. Here, rented in land significantly affects the adoption of improved and traditional varieties. But it has a negative effect on the cultivation of traditional varieties and a positive one on the cultivation of improved varieties. This result is further strengthened by the impact of rented out land on the dependent variable, which is similar to the first model. Individuals who rent in land do so mainly with the objective of income/ profit generation and would tend to adopt improved technologies in the hope of higher returns. The dummy for medium to large rice farmers has a significant and positive impact on the adoption of hybrid varieties in comparison to marginal rice farmers in this model. Hybrids are expensive to cultivate, given the high prices of their seeds and input requirements and so it is not surprising to find larger farmers adopting it. Farmers belonging to the OBC categories also tend to cultivate lesser traditional varieties as compared to the farmers belonging to the general category. Finally the state dummy for West Bengal is significant for both traditional and improved varieties in this model but has a negative impact on the adoption of traditional and a positive one on the adoption of improved varieties. This result is also supported by the fact that West Bengal has a strong private sector, which is a major player in the dissemination of improved varieties. In our survey as well, we find that out of all the seeds acquired from the private sector, 46% of them are from West Bengal. Thus social networks within caste, as compared to across caste has an impact on the adoption of all the three categories of varieties. In both the cases we can see that technology diffusion does depend on informal networks amongst farmers and moreover, caste acts as a barrier in this diffusion since networks are concentrated within caste based groups.

Conclusion and Policy Implications

Agricultural productivity depends on the effective targeting and dissemination of new and improved technologies. At the policy level, these dissemination efforts mostly concentrate on formal channels like the extension services, the national and state systems and the private sector. However informal channels of dissemination, or farmer to farmer exchange of information and technology makes up a substantial portion of how technologies spread and are adopted. These exchanges are made up of individual networks amongst farmers which are further characterized by social, political and economic factors. In this paper we look at caste based informal social networks amongst farmers and find that the networks that farmers have with one another tend to be deeply concentrated within caste based groups as opposed to networks across caste. Further, we look at the adoption of rice varieties as an example of

technology diffusion and find that both networks across caste and within caste causes farmers to adopt more improved varieties. When we consider networks within caste we see that the adoption of hybrid varieties fall which again tells us that farmer to farmer exchanges within castes influences adoption decisions, since hybrid seeds cannot be re-used. Moreover, in our sample, respondents who belong to the marginalized communities adopt more of improved varieties which shows that the more concentrated a network is in terms of its caste composition, faster will be the spread of any new technology. Therefore, in order to ensure better targeting of technologies informal networks amongst farmers need to be identified, keeping in mind the caste composition of the members of such networks, among other things. If a new technology is introduced to farmers who belong to a common social network and have similar characteristics, in terms of their caste, we can expect faster uptake and diffusion of that technology. Further as interactions across caste based networks happen over time, technology diffusion would be accelerated.

Table 9: Model II - Within Caste Groups

Variables	**traditional**		**improved**		**hybrid**	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Social Network Within Caste	-1.910**	0.292***	1.613***	0.424	-0.621*	0.369
Rice area (% cultivated area)	-0.002	0.001	-0.002	0.003	-0.003	0.002
Primary Income ('000 Rupees)	-0.002	0.010	-0.002***	0.0008	-0.0004	0.001
Average monthly expenditure ('000 Rupees)	-0.003	0.012	0.055	0.043	0.009	0.011
Average expenditure on food ('000 Rupees)	-0.965	0.399	0.056	0.058	-0.004	0.015
Rented in land (area in ha)	-0.265**	0.108	0.261*	0.158	-0.098	0.113
Rented out land (area in ha)	0.266**	0.114	-0.255**	0.109	0.071	0.118
Landholding under rice (small 1-2 ha)	0.155	0.153	-0.032	0.227	0.334*	0.182
Landholding under rice (Medium to large >2 ha)	0.576***	0.197	-0.432	0.279	0.533**	0.239
Seed Source Dummy (agri input shop)	0.014	0.182	0.174	0.238	-0.114	0.223
Seed Source Dummy (public system)	-0.938***	0.355	1.074	0.711	-0.051	0.246
Seed Source Dummy (general shop)	0.046	0.210	0.472	0.294	-0.214	0.288
Seed Source Dummy (others)	-0.502	0.313	0.189	0.390	-0.442	0.388
Caste Dummy (Minority)	-0.969***	0.305	3.369	63.622	-0.108	0.349
Caste Dummy (OBC)	-0.364**	0.154	0.177	0.218	0.153	0.194
Caste Dummy (SC)	-0.362**	0.162	0.309	0.224	-0.177	0.252
Caste Dummy (ST)	-1.281***	0.366	1.042**	0.516	0.165	0.291
Primary Income Source (Self Employed)	-0.684**	0.270	0.522	0.384	0.108	0.214
Primary Income Source (Salaried employment)	-0.689**	0.309	0.164	0.388	-0.418	0.411
Primary Income Source (Labour)	0.231	0.157	-0.214	0.219	-0.086	0.216
Primary Income Source (Others)	0.149	0.203	-0.172	0.270	-0.611	0.388
State Dummy (Odisha)	-0.528**	0.256	1.079**	0.428	-0.072	0.308
State Dummy (West Bengal)	-0.438**	0.198	0.643**	0.310	-0.385	0.261
Preferences : Varietal characteristics						
Yield	-0.965**	0.398	1.796***	0.501	-0.317	0.556
Cooking quality	0.373	0.330	-0.671	0.428	0.436	0.435
Vigour	0.225	0.212	-0.145	0.354	-0.037	0.216
Marketability	0.018	0.156	-0.311	0.248	0.044	0.201
Constant	0.588	0.448	-0.641	0.571	-1.407**	0.687

* p<0.1, ** p<0.05, *** p<0.01

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