Caste, Informal Social Networks and Varietal Turnover

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Abstract:

The potential gain from the agricultural technologies can be realized only if it is adopted and disseminated in a short period of time. There are many factors which affect the rate of adoption and diffusion of technologies, both at macro and micro level. Social learning and social networks play a critical role in adoption of technologies as the adoption decisions of a farmer may be influenced by the others in his social network. Caste is a key factor which influences the decisions of people in Indian society. This study focuses on such caste based social networks and examines the role of caste based social networks and other farm level determinants on the varietal turnover of rice. Within caste social networks found to act as a barrier for faster replacement of varieties. Identifying and programming with caste based local leadership as nodes of varietal dissemination may be an effective extension strategy.

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Key words: *Caste, informal networks, varietal preferences, varietal turnover, India*

JEL codes:

Introduction

The adoption of superior varieties of crops is imperative to ensure the food security of the growing population and to reduce the vulnerability of the marginal farmers to various kinds of biotic as well as abiotic stresses. Availability and use of good quality seed is also an important factor which determines the yield and quality of the output, as the response of the crop to other inputs depends on the quality of the seed. Estimates show that quality seed alone contributes 15-20% to the total production directly, which can be further increased to 45% with the efficient management of other inputs (www.seednet.gov.in; Poonia, 2013 and Ali, 2016). Hence it is important to develop a seed production and delivery system that continuously develops new varieties suited to the changing environment and disseminate it faster replacing obsolete varieties. Frequent seed and cultivar replacement not only helps in achieving yield potential but also prevents cultivar depreciation, reduces the potential damage due to newly evolved pest and diseases (Krishna et al, 2014) and climate change. Unfortunately farmers tend to cultivate older varieties, rather than recent ones which are superior to the former with respect to several hidden traits such as pest and disease resistance, stress tolerance, grain quality etc. This is evident from the change in average age of rice varieties cultivated in India i.e., from 11.5 years in 90's (Witcombe et al, 1998) to 28 years in 2014 (Atlin et al, 2017). One of the reasons for low adoption rate of new varieties is due to the lack of clear yield and profitability advantages over older ones (Pandey et al, 2012 and Witcombe et al, 1998). Other factors such as technical, institutional and socio-economic factors at the farm level which includes technological information about the variety, access to credit, price of the seed and complimentary inputs also have a role in lowering the adoption rates (Krishna et al, 2014).

The Indian seed system is well organised with institutions at national, state and regional level involved in the production, certification and distribution of seeds of crops and varieties. There are both formal (include both public and private players) as well as informal channels which mainly includes the exchange of seeds between members in a community (either organized or unorganized structures exist). This system is dominated by the public sector which is inefficient (Krishna et al, 2014) whereas a significant proportion of exchange of farm saved seeds, knowledge and technology happens through unorganised or informal channels (Singh et al, 2008). Only 30-35 per cent of the total seeds distributed in the country are through the organized sector and the rest is through unorganized sector, comprising mainly of farm-saved seeds (State of Indian Agriculture, 2015). Hence, we point out that the adoption decisions of the famers are influenced heavily by these informal channels/social network based on various social interactions. Understanding of such interactions provides for the effective targeting and development of appropriate extension strategies for effective dissemination of technologies or varieties.

Recent studies have shown that social learning is an important factor determining the adoption and diffusion of an innovation and individuals rely on small social networks which do not necessarily coincide with geographical boundaries for gathering information (Matuschke and Qaim, 2009; Meartens and Barrett, 2012). Social networks may be of limited reach, i.e., farmers may have strong networks within their own village but the connections are limited with farmers in similar villages nearby (Magnan, 2014). These social networks can be concentrated via informal social gatherings based on caste, religion, political orientation etc., The existence of caste based social stratifications in rural India may have a role in affecting village dynamics and adoption decisions (Matuschke and Qaim, 2009; Gupta et. al., 2017). The caste system in India manifests in social, political and economic decisions of the society and the adoption and diffusion of technology is not an exception. Hence in this study it is hypothesized that caste influences varietal adoption and consequently on varietal turn over and seed replenishment rate.

This study examines the effect of caste and informal social networks on the adoption of new rice varieties. The age of a variety is taken as the proxy for varietal turnover, which measures the newness of the varieties cultivated by the farmer. On the other hand, varietal replacement is used for measuring the speed with which a variety is replaced by the farmer.

Literature

a. Social networks

The adoption of new technologies, given the limited availability of resources, is a prerequisite for increasing agricultural productivity for meeting the demand of a rising population. The decision of a farmer to adopt a technology is the outcome of an interaction of various factors at the household level which includes technological factors, economic factors, institutional factors and household specific factors (Mwangi and Kariuki, 2015; Krishna et al, 2014). There are a vast number of studies available which discuss the factors affecting the adoption of technologies. Earlier, focus was given to adoption behaviour in relation to personal characteristics and endowments, imperfect information, risk, uncertainty, institutional constraints, input availability and infrastructure. Recent studies have started paying attention to social networks and learning and the role they play in determining adoption of technologies (Mwangi and Kariuki, 2015).

Social networks and social learning affects the adoption decisions of individuals (Bandeira and Rasul, 2002; Foster and Rosenzweig, 2010; Meartens and Barrett, 2012; Conely and Udry, 2001). Meartens and Barrett (2012) in their study, defined social networks as the individual members (nodes) and the links among them through which information, money, goods or services flow, and the importance of a link is not reflected by the frequency of exchange over the link. Matuschke (2008) mentioned that social networks are essentially informal communication channels, which farmers employ to receive and share information on new technologies or natural resource management practices and one of the keys to the success in the design of novel extension schemes is more intensive leveraging of farmers' social networks. The response of farmers in various network settings can be different. The adoption by an individual farmer is positively correlated with the extent of prior adoption by his neighbours (Foster and Rosenzweig, 2010) and learning spillovers significantly augment the profitability (Foster and Rosenzweig, 1995), while Bandeira and Rasul (2002) reported that farmers who know many adopters might strategically delay adoption to free-ride on the information gathered by others. Todo *et al* (2015) reported from their study of effects of social network structure on the diffusion and adoption of agricultural technology in Ethiopia, that the effect of social networks varies depending on the network structure and characteristics of the technologies considered. According to them the diffusion of information on a simple technology is determined by whether farmers know an agricultural extension agent, whereas diffusion of information on a more complex technology is not promoted by simply knowing an extension agent but by knowing an agent that a particular household can rely on and by clustered networks in which most friends of the household are friends of each other.

The strength and the nature of social networks are determined by various socio economic factors such as caste, gender (Magnan *et al*, 2014), economic status (Magnan *et al*, 2013), age, religion, literacy etc., In a study conducted by Magnan *et al* (2013) reported that social network are strongest among poor farmers and the underlying factors that shape the network linkages among male and female farmers of the same household are different. Birol et al (2008) found that the close-knit networks and religious organizations that are restrictive in nature have been effective for determining technology choice of farmers whereas large-scale adoption programs such as media and non-religious organizations along with the public sector managed agricultural extension services have no significant association with farmer's decision toward adopting a modern variety.

So in general, the adoption and diffusion of a technology is affected by the existence of social networks and the response of farmers toward the adoption is determined by the strength and nature of networks and technological characteristics.

b. Caste

Caste is the one of the deeply rooted structural features of the social system in India, which affects the decisions of individuals in the society, thus shapes the linkages in a social network. The caste system is considered a closed system of stratification which determines access to wealth, power, and privilege (Deshpande, 2010). Caste credo determines not only everyday practices, calendrical and life cycle rituals of an individual but also community structures and political power as well (De, 2009). Also it determines the possession of land and socio-economic status of the village community (Punia and Sharma, 1982). The influence of caste varies across different communities (Arora and Sanditov, 2015). In India, the caste system is a classification of people into four hierarchically ranked castes called *varnas,* which are then divided into specialized sub-castes called *jatis* which is composed of a group deriving its livelihood primarily from a specific occupation (Deshpande, 2010). In a study conducted by Vanneman *et al* (2006) reported that the social distance between various *jatis* are preserved through endogamous marriage and close knit kinship patterns, residential segregation in village life and caste associations are set up as mutual aid societies. The result of their study confirms that social capital does indeed vary as expected across caste, tribal, and religious boundaries which is reflected in the significant caste and religious differences in social networks and they follow the traditional hierarchies (Vanneman *et al*, 2006). An empirical study conducted by Munshi and Rosenzweig (2009) concluded that local risk-sharing networks restrict mobility, is that among households with the same (permanent) income, those in higher-income caste networks are more likely to participate in caste-based insurance arrangements and are less likely to both out-marry and out-migrate. Since caste networks are enrooted in the social system of Indian society, affecting various socio-economic outcomes, adoption decisions of farmers also may be affected by it.

c. Varietal turn over

Farmers can harness the potential gain from plant breeding (which can be in terms of yield gain, resistance to pest and diseases, tolerance to abiotic stresses etc.) only if they replace old varieties with newer varieties as and when it is released. Varietal age can be used as a measure of adoption of new varieties as it is used in earlier studies. Brennan and Byerlee (1991) measured the rate of wheat varietal replacement on farms by using weighted average age of varieties and found that there was a decline the weighted average age of wheat varieties so also the rate of varietal turnover in most of the developing countries. The rate of varietal turn over measured by the age of cultivars can be different across regions. By reviewing earlier studies Witcombe *et al* (2016) concluded that in developed countries, high varietal replacement rates result in low average ages while in developing countries the cultivars were older and throughout the developing world farmers are forgoing the substantial benefit they could get from growing modern varieties. Smale *et al* (2008) also used area weighted average age of varieties as a proxy for variety change and found that older variety ages on farms (slower variety change) dampen productivity, and also offset the positive impact of diversifying the genetic base through plant breeding. A study conducted in Sub Saharan Africa under Diffusion and Impacts of Improved Varieties in Africa (DIIVA) project measured varietal turnover using area weighted grand mean of 21 crops across 117 countries and found that the average age is 14 years (Walker and Alwang, 2015). Varieties should turn over at an optimal rate, at which it becomes profitable for the farmers to change varieties and optimum replacement rate of crop varieties depends on the cost and benefits of releasing new varieties (Byerlee and Helseiy, 1990). In the case of India the weighted average age in years of various crop cultivars were estimated, as rice-11.5, pearl millet-5.8, maize-16.6, sorghum-15.9, ground nut-15.3, chick pea-19.7 and wheat-9.3 (Witcombe *et al*, 1998). In a recent study done by Krishna *et al* (2014) found that the rate of varietal turnover for wheat has slowed in India from an average of 9–10 years a decade ago to 13–14 years in 2010. Most of the previous studies used area weighted average age of cultivars but as Witcombe *et al* (2016) point out that weighted average ages underestimate the true ages of varieties that are defined by the year of their release. Hence the present study uses the actual age of cultivars cultivated by the farmers and the number of years that a farmer takes to replace a variety for analysing the varietal turnover of rice varieties.

As we discussed earlier, social network affects the adoption decisions of farmers so is the case with adoption of varieties, which in turn determines the varietal turn over. In their study on impact of social networks on hybrid seed adoption in India, Matuschke and Qaim (2009) reported that social networks matter in adoption decisions, especially with respect to newly released technologies. Birol *et al* (2015) found that existence of endogenous social effects in adoption, largely from exclusionary channels like close-knit networks that, with social fragmentation, limit benefits to few and affect adoption significantly, while studying the effect of networks on the adoption of modern technology of pearl millet. Krishna *et al* (2014) reported that the average age of wheat cultivars in the fields of other farmers in the village was found to be positively associated with the average age of household varieties, that suggested the possibility of strong social networks which are closely associated with older varietal portfolios, thus repress the varietal turnover.

Methodology

a. Social network

Data for measuring social network effect was collected using random matching within sample technique, wherein each respondent was randomly matched with another farmer from the sample and then obtained the details of the relationship between farmer and the match by asking questions (Maertens and Barrett, 2012). For this study, three types of social networks were estimated, across caste groups, within caste groups and average social networks. 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, whereas average social network was obtained by matching individual interactions within and across caste networks in the village. Looking at these three 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.

The successful diffusion of an information or technology needs clear understanding of nodes and links in a social network. Banerjee and Duflo (2014) in their study to identify central people in a social network reported that, the respondents accurately nominated those who are diffusion central (not just those with many friends) and these nominees are more central in the network than traditional village leaders and geographically central individuals. Their estimate shows that, if a household is both a nominee and a leader, it has a 47% likelihood of being in the top 10% of the centrality distribution. Banerjee *et al* (2013) while studying the diffusion of microfinance found that the centrality of the injection points constitutes a strong and significant predictor of eventual village-level participation.

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.

$$SN_i = \Sigma_{j=1}^{J} \frac{\left[\mathrm{w}_1\mathrm{K}_{ij} + \mathrm{w}_2\left(\mathrm{C}_{ij} \middle| \mathrm{K}_{ij} = 1\right) + (\mathrm{w}_3 \sum_{m=1}^{M} \mathrm{Q}_{mij} | \mathrm{K}_{ij}=1, \mathrm{C}_{ij}=1)/\mathrm{M}\right]}{J} \quad (1)$$

The value of M is eight and the value of J varies with type of SN estimation (across caste, within caste and average network): J = 6 for average social network and $J \leq 6$ for across and within caste network. That is, within caste network estimation, J takes the value of the number of people belonging to the same caste as that of respondent and for across caste it takes the value of the number of people belonging to caste categories different from the respondent. J can be zero in those cases where no individual in the network belongs to the same caste category as the respondent in the case of within caste. In the case of across caste networks, J can be zero if all individuals belong to same caste as that of respondent

b. Econometric model – varietal turn over

Multivariate probit regression is used to analyze the factors affecting the varietal replacement which indicates the speed with which a variety has been replaced by the farmer. Some of the famers cultivate more than one variety in different plots which might have adopted at various points in time. Hence a single farmer may have different varietal replacement corresponding to each variety that he cultivates. We classified the adoption of varieties by the farmer into four categories, Varieties that was replaced < 6 years ago, between 6-12 years, > 12 years and traditional.

Following Chib and Greenberg 1998, let Y_{ij} denotes the binary response $0/1$ representing whether the farmer i $(i = 1,2 \dots, n)$, belongs to the j^{th} category, and let $Y_i = (Y_{i1}, Y_{i2}, Y_{i3})'$ $(1 \le i \le n)$ denote the collection of responses on all four types of varietal replacement ($j = 4$). The multivariate probit model is specified as below:

$$Y_{ij}^{*} = \mathrm{SN}_i\alpha_j + \mathrm{Caste}_i\beta_j + \mathrm{VarAge}_i\gamma_j + \mathrm{VarPref}_i\mu_j + \mathrm{SeedSource}_i\pi_j + \mathrm{X}_i\delta_j$$

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

Here SN_i is the social network; Caste_i denotes the caste group the individual i belong (General, OBC, SC, ST or minority); VarAge_i is the age of the variety in years that the farmer cultivates; $\mathrm{VarPref}_i$ denotes varietal preference characteristics such as duration, height, stress tolerance, milling, marketability etc.; $\mathrm{SeedSource}_i$ denotes the source of seed of the variety that the farmer obtained or purchased; $\boldsymbol{X}_i$ denotes the k -vector exogenous covariates such as farm characteristics, household characteristics, location etc.; ϵ_i are assumed to be iid independent across i but correlated across j for any i and MVN denotes the multivariate normal distribution.

c. Study site and sampling

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 regions (classification by National Bureau of Soil Survey and Land Use Planning)[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,

[1] The following districts were selected:
Bihar- Rohtas,Gaya (AE 9);Madhubani, PurbaChamparan 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 regions identified were (refer https://nbsslup.in/content_folder/Agro_Ecological/agro/ for more details of NBSS&LUP classification of agroecology regions)-
AE 9 – Northern plains, hot sub humid, AE 12 – Eastern (Chottanagpur) Plateau and Eastern Ghats hot sub humid, AE 13 – Eastern Plain hot sub humid (moist), AE 15 - Assam and Bengal Plains hot sub humid to humid, AE 18 – Eastern coastal plain hot sub humid to semi-arid

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. 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.

d. Data and descriptive

The varieties cultivated by the rice farmers were identified as improved, traditional and hybrid and, those varieties which were not identified are categorised into 'unidentified'. About 76% of the varieties cultivated were improved, which is followed by traditional (6.04%) and hybrid (1.82%) during kharif 2015. The caste composition of the farmers in the sample consists of, OBC -34.15 %, General - 28.79%, SC-21.71%, ST-9.19% and Minority-6.16%. Over 70 % of the famers in the sample were literate, and 43.43% of them had education up to secondary level (grades 11 and 12). But 27.33 % of the farmers were non-literate. The primary source of income for majority of the farmers (45.08%) was agriculture followed by non-agricultural labour (21.17%), self-employment (14.06%) and so on. Similarly, agriculture forms the primary occupation for 65.60 % of the households followed by non-agricultural labour (11.15%), self-employment (8.36%) and so on.

The household were grouped into marginal (<1 ha), small (1-2 ha), semi medium (2-4 ha), medium (4-10 ha) and large (>10 ha) as per the classification of operational land holdings done by Government of India. The classification was done based on the size of landholdings under rice cultivation. The proportion of landholdings belonged to marginal, small, semi medium, medium and large categories were respectively, 61.29%, 24.36%, 10.71%, 3.39% and 0.25%. Improved varieties were preferred by the farmers irrespective of education, occupation and land class, to traditional and hybrid varieties.

Table 1 shows popular rice cultivars cultivated by the farmers in the study area. Swarna was the most popular variety which accounts 29.30% of the total varieties cultivated followed by Puja (9.39%), Mahsuri (9.31%), Lalat(5.03%)() and MTU 1001 (4.16 %). These five varieties together account 57.19% of the total varieties cultivated by the farmers in the study area. Swarna which is considered as old mega variety which was released in the year 1979 is still popular among the famers. With few exceptions, irrespective of land class, caste and state, Swarna was the most widely cultivated variety. In Bihar, Mahsuri was the popular variety.

Table 1: Popular rice cultivars grown in the study area across land classes and caste groups

Characteristics	Swarna % (n)	Puja % (n)	Mahsuri % (n)	Lalat % (n)	MTU 1001 % (n)	Others % (n)	Total % (n)	Varietal age (in years)
Land Class								
Marginal	33.2 (489)	8.01(118)	9.23 (136)	6.65 (98)	2.65 (39)	40.26 (593)	61.22 (1473)	31.14
Small	23.77 (140)	11.21(66)	10.36 (61)	2.72 (16)	4.92 (29)	47.03 (277)	24.48 (589)	27.98
Semi medium	22.66 (58)	13.28 (34)	8.59 (22)	2.34 (6)	8.59 (22)	44.53 (114)	10.64 (256)	27.02
Medium & Large	20.45 (18)	9.09 (8)	5.68 (5)	1.14 (1)	11.36 (10)	52.27 (46)	3.66 (88)	25.02
Caste								
General	29.05 (201)	11.85 (82)	6.5 (45)	4.34 (30)	4.05 (28)	44.22 (306)	28.76 (692)	27.87
Minority	50.68 (75)	7.43 (11)	4.73 (7)	3.38 (5)	0.68 (1)	33.11(49)	6.15 (148)	32.62
OBC	21.87 (180)	7.41(61)	15.43 (127)	2.79 (23)	4.98 (41)	47.51(391)	34.21(823)	31.22
SC	28.21(147)	11.13 (58)	7.49 (39)	6.33 (33)	3.26 (17)	43.57 (227)	21.65 (521)	29.26
ST	45.95 (102)	6.31(14)	2.7 (6)	13.51(30)	5.86 (13)	25.68 (57)	9.23 (222)	29.65
State								
Bihar	15.28 (110)	0 (0)	27.36 (197)	0 (0)	3.75 (27)	53.61(386)	29.93 (720)	38.37
Odisha	27.63 (255)	23.73 (219)	0.87 (8)	1.95 (18)	7.37 (68)	38.46 (355)	38.36 (923)	23.66
West Bengal	44.56 (340)	0.92 (7)	2.49 (19)	13.5 (103)	0.66 (5)	37.88 (289)	31.71 (763)	32.28
Total	29.3 (705)	9.39 (226)	9.31 (224)	5.03 (121)	4.16 (100)	42.81(1,030)	100 (2406)	29.72

Results

a. Varietal turn over

In this section, we describe the varietal turnover considering two dimensions – first, the age of variety and second varietal replacement. Our hypothesis here is that the farmers are replacing variety, not with newly released ones but significantly with the older varieties leading to 'aged varietal turnover'. That is, though the varietal turnover is fast but varietal age remains high.

The varietal age is measured as the difference between the year of survey and the year of release of the variety. The large farmers are negligible in the sample; hence we have taken medium and large farmers together in one category. The average varietal age was found lowest for medium and large category farmers (25.02 years) who were cultivating newer varieties. Marginal, Small and Semi medium farmers cultivated varieties of age 31.14, 27.98 and 27.02 years respectively. There can be several factors influencing farmers to continue to cultivate older varieties – lack of clear profitability advantage for newer varieties, market acceptability, lack of awareness about new varieties, poor seed supply system, etc. Nevertheless, we observed that as land size increases the age of variety decreases. Larger farmers usually are more risk bearing and market oriented, having greater access to extension and information systems are likely to adopt newer varieties. Unfortunately, there is no systematic and desirable change is observed. If we consider across caste, farmers in general category cultivate newer varieties (27.87 years) and farmers in minority category cultivates older varieties (32.62 years) when compared to OBC (31.22 years), SC (29.26years) and ST (29.65 years) category famers. Across states, the average age of varieties is lower in case of Odisha (23.66years) which can be explained by the existence of well-established public system in disseminating seeds of improved varieties. It is also evident that Bihar cultivates older varieties (38.37 years) when compared to the other two states while the average age was found to be 32.28 years for West Bengal.

Table 2 summarises the average years since the varieties were replaced and the average years since the seeds were replaced for different types of rice varieties across land class, caste and state. On an average, the varieties were replaced in every 7.30 years and the seeds were replaced in every 2.75 years. It is evident from the table that the average number of years for replacing a variety increases as the size of land holding increases. Although the farmers having larger land sizes cultivate newer varieties they replace varieties slowly, wherein farmers with smaller land sizes replace varieties faster but the varietal age is found to be high. Farmers with smaller size landholding replace the traditional variety or old improved variety that they were cultivating with older varieties about which they already have clear knowledge. Similar conclusion was made in the study of Krishna et al, (2014) that farmers with larger area under wheat cultivation may be more willing or able to experiment with, and eventually adopt, more recent varieties. On the other hand the

Table 2: Varietal replacement and seed replacement across land class and caste

Category	Varietal replacement (years)				Total	Seed replenishment (years)				Total
	Improved	Traditional	Hybrid	Unidentified		Improved	Traditional	Hybrid	Unidentified	
Land Class										
Marginal	7.63	7.37	2.13	4.69	7.14	3.07	1.24	1.75	1.64	2.72
Small	7.76	8.92	4.33	5.04	7.22	2.96	1.80	4.20	2.92	2.96
Semi medium	9.09	4.20	3.50	4.15	8.03	2.73	1.00		3.00	2.69
Medium & Large	9.22	5.67	5.67	5.17	8.18	2.38	1.00	1.00	1.00	1.73
Caste										
General	8.29	6.14	3.71	5.76	7.77	3.19	1.30	2.00	2.70	3.02
Minority	8.87	4.50	10.00	5.86	8.15	3.13	1.00		1.33	2.93
OBC	7.78	8.10	3.29	3.82	6.92	3.01	1.13	1.75	1.68	2.52
SC	7.50	7.60	2.40	4.76	7.06	2.83	1.71	2.00	1.88	2.63
ST	7.32		2.75	4.86	7.07	2.83		3.00	2.00	2.80
State										
Bihar	5.48	5.31	4.64	4.94	5.31	1.73	1.00	4.00	1.42	1.57
Odisha	8.03	9.64	2.56	4.15	7.45	3.24	2.17	2.67	2.33	3.09
West Bengal	8.87	7.71	3.60	5.53	8.35	3.15	1.27	1.00	2.72	3.02
Overall	7.88	7.10	3.38	4.76	7.30	3.01	1.29	2.90	1.96	2.75

number of years for replacing seeds was lowest (1.73 years) for land holdings having size more than 4 ha, while it was high (2.96 years) in the case of small holdings, which may be due the fact that it is affordable for the large farmers to purchase new seeds every year while it is not the case with small farmers. On average farmers replace the seeds within two to three years. Based on caste, OBC category is observed to replace varieties and seeds faster (6.92 and 2.52 years respectively) and Minority category replaces the varieties at a lowest pace (8.15 years). SC & ST caste categories take almost same number of years to replace a variety. Among the three states, Bihar was faster in replacing varieties and seeds (5.31 &1.57 years respectively) and West Bengal was slower (8.35 years) in case of varieties and Odisha in case of seeds (3.09 years). In the sample the average number of years for replacing a variety varies from 0 to 40 years while for seeds it varies from 0 to 35 years. The varieties and seeds of improved types are taking longer time to replace when compared to the rest of the types.

One would expect a lower varietal age given the fact that varietal and seed replacements are done at much faster rate (8 years for varietal replacement and 3 years for seed replacement). But we observed very high varietal age (29.72 years), pointing to the inefficient and stagnant seed production and supply system in the region. In India, public sector dominates the seed production system of low value high volume crops like cereals, oil seeds and pulses, even though both public and private sectors play a significant role in the production and distribution of seeds. But rice hybrids are getting momentum in some states where rice yields are low relative to the national average and private hybrids account for more than 95% of area under hybrid rice cultivation in those states (Spielman *et al*, 2014). Seed production system in India follows three generations system namely breeder, foundation and certified seeds for seed multiplication in a phased manner, that involves Indian Council of Agricultural Research (ICAR) at centre, and is supported by ICAR Research Institutions, National Research Centres and All India Coordinated Research Projects, State Agricultural Universities (SAUs), Sponsored breeders recognized by selected State Seed Corporations and Non-Governmental Organizations. Breeder seed is produced based on the indents submitted by various seeds producing agencies to the Department of Agriculture and Cooperation (DAC), Government of India, through respective State Departments of Agriculture, which in turn sends the whole information to the Project Coordinator/Project Director of the respective crops in ICAR for final allocation of production responsibility to different SAUs/ICAR institutions. Indents are prepared on the basis of current market conditions and information on how the existing and new cultivars perform in terms of actual or potential yield in relevant districts and agro-climatic zones and under specific management recommendations (Krishna *et al*, 2014). The breeder seed is then supplied to indenting organizations by the National Agricultural Research System (NARS) on the basis of allocation by DAC for further multiplication to foundation and certified seeds (Chauhan *et al*, 2016). Further, the responsibility of multiplication of breeder seed into foundation and certified seeds is entrusted with NSC, SFCI, State Seeds Corporation, State Departments of Agriculture and private seed producers, who have the necessary infrastructure facilities. The distribution of seeds is undertaken through a number of channels i.e. departmental outlets at block and village level, cooperatives, outlets of seed corporations, private dealers etc.,(www.seednet.gov.in).

Thus, public seed system follows well defined and systematic procedures of seed production and distribution. However, Krishna et al (2014) in their study argued that the demand forecasts and supply responses are determined only partly by local market intelligence on farmers' varietal preferences and expected quantities demanded, it also depend on the government's seed policy and priorities for the introduction of new cultivars, for instance, cultivars that are resistant to various stresses. An analysis done by Chauhan *et al* (2016) showed that 860 rice varieties has been notified as of 2015, since 1960. Out of that only 241 varieties were indented for production in 2014-15, in that top five varieties (Cottondora Sannalu (MTU-1010), MTU-7029, Vijetha (MTU-1001), Sahbhagi Dhan and IR-64) constitute 30.4% of the indent, and these were released prior to 2000 except Sahbhagi Dhan, which was released in 2011. Therefore, the varietal turn over can be improved only through concerted effort from the Government by introducing seeds of new superior varieties in the seed production system.

Varietal preferences

Table 3 shows that the varietal preferences of farmers for different varieties. The main characteristics farmers took into consideration during the selection of variety are yield, cooking quality, resistance to biotic as well as abiotic stresses, duration, height of the plant, vigour, input requirement, marketability, price premium, water consumption and milling quality. More than sixty per cent of the famers considered yield (94 %), cooking quality (86%), vigour (71%), marketability (64%), water consumption (61%) and milling (62%) while selecting a variety.

Table 3: Varietal Preferences of respondents

Name of variety	Varietal Preferences (Average)												
	Yield	Cooking Quality	Biotic stress	Abiotic stress	Duration	Height	Vigour	Input	Marketability	Price	Establishment	Water reqmt	Milling
Popular varieties													
Swarna	0.93	0.84	0.49	0.50	0.54	0.51	0.67	0.51	0.58	0.51	0.43	0.58	0.49
Puja	0.90	0.84	0.21	0.13	0.10	0.30	0.40	0.14	0.46	0.23	0.05	0.14	0.35
Mahsuri	0.97	0.93	0.87	0.88	0.96	0.93	0.96	0.97	0.91	0.90	0.85	0.95	0.96
Lalat	0.90	0.86	0.48	0.47	0.61	0.61	0.69	0.54	0.56	0.55	0.37	0.63	0.44
MTU 1001	0.95	0.80	0.48	0.24	0.51	0.59	0.64	0.48	0.71	0.66	0.47	0.45	0.72
Recent Varieties (<10 Years)													
CSR36	1.00	0.50	0.75	1.00	0.50	0.75	1.00	1.00	0.75	1.00	0.00	1.00	1.00
Pratikshya	0.97	0.68	0.30	0.38	0.49	0.51	0.78	0.41	0.65	0.68	0.24	0.46	0.57
Swarna Sub1	0.91	0.79	0.41	0.35	0.38	0.59	0.94	0.50	0.74	0.41	0.47	0.65	0.65
Hybrids													
Arize 6444	0.93	0.93	0.57	0.29	0.50	0.64	0.50	0.50	0.71	0.43	0.43	0.50	0.64
Other Varieties	0.95	0.86	0.56	0.52	0.68	0.66	0.76	0.63	0.67	0.67	0.45	0.69	0.69
Grand Total	**0.94**	**0.86**	**0.54**	**0.51**	**0.58**	**0.56**	**0.71**	**0.56**	**0.64**	**0.56**	**0.42**	**0.61**	**0.62**

b. Social network

The social network was calculated using random matching within random sample approach discussed in the methodology section. Majority of the farmers were cultivating varieties aged more than 20 years across all caste categories and land classes. Social networks within caste is stronger than the across caste network. Farmers belonged to minority category are observed to have the weakest social network across caste and strongest social network within caste, indicating that their interactions are primarily limited within the minority category. Across caste social network was stronger for the ST category and within caste social network was weaker in the case of SC category. Among the land class, marginal holdings observed to have weakest social networks - lowest scores for both across and within caste networks, and it indicates their poor interaction with other individuals in a social network. Across caste social network is stronger in the case of small as well as large farmers, while within caste network is higher for semi medium farmers. On average, social network is stronger in the case of general category and weaker in the case of SC category. Across land class, social network for small farmers is observed to be weaker and semi medium farmers have stronger network effects. ST has stronger social network across caste which is unexpected. Probably, STs and SCs are involved primarily as agricultural wage laborers and work for fields in other caste communities, and most of them if cultivate are either share croppers or tenant farmers, resulting in more interactions with other caste communities. Our data shows that more than 50 per cent of the STs and 44 per cent of SCs were primarily working as agricultural as well as non-agricultural labours followed by other castes (General-22.15 %, OBC-18.41 % and Minority-28.57 %). It also forms the secondary source of income for 23.31 per cent of STs and 18.34 per cent of SCs followed by other castes (General- 11.64 %, OBC- 12.90 % and Minority- 14.29 %).

Social networks across different age categories of varieties provide interesting insights. The varieties having age between 10 to 20 years have stronger networks than younger or older varieties. Older varieties (>15 years) have stronger within caste social network whereas the varieties of age between 10 to 20 years have both across as well as within caste networks. This implies that strong social networks significantly explain why farmers continue to cultivate older varieties, the result is further validated in the regression model. Table 4 shows variety wise social network-across and within caste categories and average social network. Let us consider the social networks of popular old varieties – swarna is the most popular, but recently showed declining trend in area of cultivation; Mahsuri is very popular in Bihar and reached the peak of adoption; MTU1001 was popular, now in declining trend; puja is increasingly popular in Odisha and West Bengal and recent area estimates showed an increasing adoption rate of this variety (*quote RMS report*). As inferred from the table, puja got exceptionally better social networks both within and across caste indicating that this variety will spread further and faster and may replace swarna or Lalat but not Mahsuri/MTU 1001 which have stronger within and across caste social networks. Among recent varieties Swarna sub1 and CSR36 has the desirable social network characteristics and are promising, fewer chances that the variety pratikshya will gain momentum in adoption. The old hybrid variety Arize 6444 is performing better in Bihar and West Bengal.

Table 4: Variety wise social network across and within caste categories (Averages)

Variety Name	Social Network		
	Across Caste	Within Caste	Average
Popular Varieties			
Swarna	0.3792 (0.1971)	0.4428 (0.2074)	0.4067 (0.1684)
Puja	0.4254 (0.1826)	0.4960 (0.2221)	0.4515 (0.1612)
Mahsuri	0.4283 (0.2034)	0.4473 (0.2122)	0.4331 (0.1922)
Lalat	0.3206 (0.1868)	0.3840 (0.2109)	0.3644 (0.1663)
MTU 1001	0.4187 (0.1505)	0.5062 (0.2130)	0.4444 (0.1250)
Recent Varieties (<10 Years)			
CSR36	0.3824 (0.1526)	0.4755 (0.1072)	0.4354 (0.0817)
Pratikshya	0.3212 (0.2453)	0.3256 (0.2499)	0.3260 (0.2199)
Swarna Sub1	0.3227 (0.2180)	0.3606 (0.2547)	0.3681 (0.1745)
Hybrids			
Arize 6444	0.4209 (0.1756)	0.4002 (0.1860)	0.3763 (0.1514)
Other Hybrids	0.3947 (0.1565)	0.4061 (0.1694)	0.3798 (0.1383)

d. Caste and Varietal replacement - MV probit model

Multivariate probit model was used to test the hypothesis that the social network influences the varietal replacement. The dependent variable used for the study is varietal replacement which is the average number of years since a variety was replaced. It was then categorised into three groups – first, varietal replacement happens within 6 years, second, from 6 to 12 years and third, more than 12 years. One more category was included namely, 'traditional'- these are farmers who cultivate traditional varieties for which year of release are unknown. Four binary dependent variables were used for estimating the model, which take value of 1 if the responses belong to a particular category of varietal replacement and zero otherwise. A single farmer may cultivate more than one variety in different plots which have been adopted in different years. Consequently, the choice to replace one variety with another is correlated. Four models were estimated by changing the social network variable such as social network across caste, social network within caste, average social network and by including both across caste and within caste simultaneously, while keeping all other variables same. The independent variables used for fitting the model were age of the variety, level of education of household head, age of the household head, caste, total land area owned which indicates asset ownership of a farmer, total area under rice cultivation in Kharif-2015, information access, membership in organization (SHG, farmer club, farmer cooperative and other), seed source, varietal characteristics that farmer consider while selecting a variety and location dummies for state. For redundancy only social network effect on varietal replacement is presented in table 5.

The results indicate that social network across caste does not influence varietal replacement (model 1 and 5 in table 5). Model 2 and 3 showed that social network within caste negatively and significantly affects the speed of replacement of a variety. Social network within caste reduces the chance of a variety being replaced in 6 years. One of the reasons may be the stronger within caste informal social networks acts as a barrier for the adoption of new technologies vis-a-vis varieties. At the same time, stronger within caste social network among farmers tend to continue cultivating traditional varieties. In the fourth model, both across and within caste social network variables were included in the estimation, but results showed similar trend.

Varietal age indicates the age of the variety which replaces the old one. It showed that faster replacement happens with younger variety and often the slower varietal replacement is observed with older variety. That is, an increase in varietal age tends to reduce the chance of a variety being replaced within 6 years, but increases the chance of a variety being replaced between 6 and 12 years, and more than double the chance after 12 years. Famers replace varieties at a slower pace and replacement is done with older varieties.

The results also showed that varietal preference characteristics such as biotic stress resistance, abiotic stress resistance, duration of the variety and water consumption also slower the replacement rate or we can say that all these varietal considerations do not result in faster replacement. It may be due to the lack of awareness/availability of varieties which provide economic gains as compared to older varieties. The increase in land owned as well as area under cultivation of rice tends to increase the cultivation of traditional varieties, because large farmers may diversify their cultivation which is consistent with the finding of Tiongco and Hossain (2015) that farmers with larger landholdings are more likely to have higher levels of on-farm varietal diversity.

Table 5. Social Network and varietal replacement - Multivariate probit estimates

	Varietal Replacement							
Variables	**<6 years**		**6-12 years**		**>12 years**		**Traditional**	
	Co efficient	Std Error	**Co efficient**	Std Error	**Co efficient**	Std Error	**Co efficient**	Std Error
Model 1								
SN across caste	-0.422	0.287	0.295	0.278	-0.015	0.282	-0.805	0.519
Varietal age	-0.036***	0.006	0.011**	0.005	0.022***	0.006	0.006	0.010
Model 2								
SN Within Caste	-0.503*	0.266	0.289	0.254	0.406	0.273	-1.121**	0.511
Varietal age	-0.035***	0.006	0.011**	0.006	0.025***	0.006	0.005	0.010
Model 3								
SN Average	-0.5367*	0.312	0.2631	0.2973	0.2631	0.2973	-1.3634***	0.5503
Varietal age	-0.0368***	0.006	0.0127***	0.0052	0.0127***	0.0052	0.0042	0.0089
Model 4								
SN-across caste	-0.252	0.326	0.070	0.321	-0.014	0.321	-0.487	0.723
SN-within caste	-0.492*	0.295	0.342	0.286	0.544*	0.295	-0.962	0.632
Varietal age	-0.035***	0.006	0.010*	0.006	0.024***	0.006	0.005	0.011

Conclusion

The adoption and dissemination of technologies in a short interval is critical for raising agricultural productivity given the limited resources available. Therefore, focus should be given to effective targeting and transfering of technologies so that they can spread faster. Many recent studies have emphasized the role of social networks and social learning in influencing the adoption decisions of farmer. There are many socio economic factors that shape social networks. We hypothesize that the caste system in India affects the socio economic decisions of people may have a role in orienting the social networks between farmers and affect their decisions. The social network scores show that within caste social network is stronger than the across caste networks. The speed with which a technology is adopted by a farmer is critical as it affects the potential gain. Study of the adoption of rice varieties shows that, social networks within caste categories act as a barrier in the faster adoption of improved varieties, while it favours the conservation of traditional varieties. But social network favours the adoption of old improved varieties which are already established when compared to recent varieties which were released less than 10 years ago and hybrids. Thus the extension system must identify such informal social networks such as caste based local leadership for the effective dissemination of technology rather focusing on its traditional approach of approaching a few progressive farmers in the village. In addition, the varietal replacement is done with older varieties instead of new varieties leading to a very high average age of rice varieties. Hence breeding for new varieties which are superior to existing ones is important along with effective targeting for the faster adoption and dissemination of rice varieties.

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