Psychological Constructs toward Agricultural Technology Adoption: Evidence from Eastern India

T. Yamano, S. Rajendran, and M. Malabayabas

Contributed Paper prepared for presentation at the 87th Annual Conference of the Agricultural Economics Society, University of Warwick, United Kingdom
8 - 10 April 2013

Psychological Constructs toward Agricultural Technology Adoption: Evidence from Eastern India

May 2013

T. Yamano, S. Rajendran, and M. Malabayabas,

Abstract

We apply the theory of planned behavior (TPB) to identify farmers' psychological constructs toward agricultural technology in three dimensions: attitude, subjective norm, and perceived behavioral control. We use data from 731 farmers in Eastern India. The sample farmers come from two groups: 157 farmers who have received seed mini-kits of a new stress-tolerant rice variety, called Swarna Sub 1, from NGOs; and 574 farmers who were randomly selected in the villages where the mini-kits were distributed. In this paper, we find that the mini-kit recipient farmers have higher scores on psychological constructs toward new technologies than the representative farmers. We also find that scheduled caste, female, and less educated farmers have lower scores on the psychological constructs. Among representative farmers, we estimate an adoption model of Swarna Sub 1 and find that psychological constructs are positively associated with the adoption of Swarna Sub 1. Although the causality between the psychological constructs and the adoption of Swarna Sub 1 is indecisive in this paper, the result indicates the importance of investigating farmers' psychological constructs in technology adoption in developing countries.

Keywords: Psychological Constructs, Behavioral Economics, Technology Adoption, Stress-tolerant Crop, Rice, India

Psychological Constructs toward Agricultural Technology Adoption: Evidence from Eastern India

1. Introduction

It is well recognize that psychological factors are correlated with economic decisions (Ajzen, 1991; Cramerer and Loewerstein, 2004). To analyze psychological factors toward adoption behaviors, Ajzen (1991) has proposed Theory of Planned Behavior (TPB), and some recent studies have applied it to examine psychological factors in farm decision making in developed countries (Beedell and Rehman, 2000; Hansson et al., 2012; Lapple and Kelley, 2013). Although a few studies have attempted to examine how psychological constructs among farmers in developing countries (Burton, 2004; Azman et al, 2013), to our knowledge, no study has examined the determinants of psychological constructs toward agricultural technology adoption in a systematic way in developing countries by using a large scale survey data.

In this paper, we focus on adoption of a submergence-tolerant rice variety, which is called Swarna Sub 1, in Eastern India. Approximately 80% of the rice-growing area in Eastern India is rainfed and exposed to floods. Because farmers in rainfed areas are mostly poor, crop losses due to floods can have a devastating impact, potentially exacerbating poverty in the region. Swarna Sub 1 is a product of molecular breeding techniques developed by International Rice Research Institute (IRRI) and its collaborators, as we describe later. Since 2008, Swarna Sub 1 has been distributed by non-governmental organizations (NGOs) and the National Food Security Mission (NFSM) of the Indian government. The number of farmers reached by NGOs and the NFSM program is estimated to be more than 3 million farmers in 2012 alone. The

diffusion of Swarna Sub 1, however, will not sustain unless the seeds are transferred from progressive farmers who are involved in seed distribution programs to neighboring farmers. Because Swarna Sub 1 requires same levels of inputs and practices as other local rice varieties, we expect farmers financial resources matter less that they do for other agricultural technologies that require financial resources such as hybrid seeds or agricultural machines. Thus, we conjecture that farmers' psychological factors matter relatively more in the adoption of Swarna Sub 1 than the adoption of other technologies that require financial resources and provide us a good opportunity to investigate the role of psychological constructs in technology adoption. Rural areas in Eastern India also provide an opportunity to identify socio-economic factors in psychological constructs because villages in the areas tend to be heterogeneous due to caste, religion, and other social factors.

We use data from 731 farmers who live in submergence-prone areas in Uttar Pradesh and Odisha in Eastern India. Some NGOs and government agencies have been distributing Swarna Sub 1 since 2008 in both states. For this study, we have sampled two farmer groups: (1) farmers who have received a seed mini-kit of Swarna Sub 1 directly from NGOs and (2) farmers who have been randomly selected in villages where the farmers in the first group reside. We obtained lists of farmers who received Swarna Sub 1 seeds from four NGOs and selected up to four recipient farmers in a sample village. In total, 157 farmers were selected from the recipient lists of 50 villages. In addition, from the same 50 villages, we randomly selected around 12 farmers per village, making the total number of randomly selected farmers to 574. In general, farmers in the first group are considered as progressive farmers, and we expect that they have significantly different psychological constructs toward agricultural technology than the representative farmers. By using the data, we identify determinants of psychological constructs toward agricultural

technologies and examine associations between the psychological constructs and the adoption of Swarna Sub 1.

The paper is organized as follow: we provide a conceptual framework of psychological constructs toward technology adoption in Section 2. The data used in this paper are described in Section 3, followed by Section 4 in which we explain our estimation strategies and variables. The results are discussed in Section 5, before we conclude the paper in Section 6.

2. Conceptual Framework and Background Information

2.1 Psychological Constructs toward Technology Adoption

There are numerous adoption studies on agricultural technology in developing countries (Feder et al., 1985; Doss, 2008; Foster and Rosenzweig, 2010). The majority of the studies focuses on profitability or productivities of the new technology and discusses constraints to adopting new technologies. By conducting profitability analyses, researchers assume that farmers possess full or adequate information about the new technologies to make decisions. However, this may not be a good assumption for the adoption of new technologies, such as Swarna Sub 1. For instance, first, because Swarna Sub 1 is new in many areas and farmers rely on information provided from change agents such as NGOs, extension officers, local opinion leaders, and neighboring farmers. Second, because Swarna Sub 1 is a submergence-tolerant rice variety, the benefits of the variety become visible only after floods occur; this may happen once in a few years in our study areas. Therefore, it may take several years before adopting farmers realize the benefits of Swarna Sub 1.

In the diffusion process, factors other than attributes of an innovation also matter. Even innovations with high attributes may be adopted by few if the innovations appear unacceptable to social norms or demand strict self-control. Individuals need to hold a perception that others in their social network support the innovation, and they also need to think they can control their behaviors to adopt the innovation. This view has been summarized in Theory of Planned Behavior (Ajzen, 1991). The TPB model consists of three components: *Attitude*, *Subjective Norm*, and *Perceived Behavioral Control*. *Attitude* includes individuals' evaluations of a given innovation, such as an expected profit of adopting a technology. *Subjective Norm* measures people's perception of what important others, such as community leaders or opinion leaders, think of the innovation (Feder and Savastano, 2006). For instance, an innovation may not be adopted if it is against cultural norm or has negative externality to neighbors. *Perceived Behavioral Control* measures people's perceptions of their voluntary control of the adoption process. Even if a given innovation appears attractive and acceptable to others, individuals may not adopt the innovation if the adoption process requires behaviors that are difficult to control such as saving cash until the next season, remembering commitments, and obtaining information across social classes or gender. A growing literature on behavioral economics focuses on this issue, as summarized by Datta and Mullainathan (2013). For instance, two randomized control trials in Malawi and the Philippines have found that people can increase savings when they are offered and use a bank account which locks up funds in their own accounts until a self-specified goal has been reached (Ashraf et al., 2006; Brune et al., 2011). The Malawi study finds an increased expenditure on agricultural inputs when farmers use such a restrictive bank account. Farmers may be facing more social issues: female farmers may hesitate contacting male extension workers or buying agricultural inputs or equipment from male dealers. Farmers in low

social classes may find it difficult to contact extension workers or dealers who belong to upper classes.

In recent years, several studies have applied Theory of Planned Behavior on agricultural decisions. For example, Poppenborg and Koellner (2013) studies farmers' decision making process through their attitude towards ecosystem services with respect to land use in a South Korean watershed. Bergevoet et al. (2004) applies TPB on the expansion of dairy production among Dutch dairy farmers under milk quota system. Sutherland (2010) applied it on farmers' responses to agri-environment program in Scotland, while Beedell and Rehman (2000) studies farmers' conservation-related behavior from the responses of 100 farmers in Bedfordshire, United Kingdom. Hansson et al. (2012) is one of the most recent studies. They constructed psychological indexes of attitude, subjective norm, and perceived behavioral control, and investigated if these indexes are associated with farmers' decisions regarding farm diversification by using data from Sweden. Their results indicate that the attitude and subjective norm indexes have positive associations with the farm diversification in Sweden.

No studies, however, have applied TPB on agricultural technology adoption in developing countries. In this paper, we apply concepts developed in TPB on adoption of Swarna Sub 1, which has been developed in recently.

2.2 Development and Distribution of Swarna Sub 1

Nearly 25 percent of the world's rice is cultivated in rainfed lowland ecosystem, and India has the largest area, i.e., 17.2 million, in the world. Widawsky and O'Toole (1995) shows

that out of 42 biotic and abiotic stresses, which prevail in rainfed lowland rice areas in Eastern India, submergence stress is the third most important limitation to rice production, following drought and weeds. Flush-floods are highly unpredictable and may occur at any growth stage of rice and the yield loss may be anywhere between less than 10 percent and 100 percent, depending on factors such as water depth, duration of submergence, temperature, turbidity of water, rate of nitrogen fertilizer, light intensity, and age of the crop.

Rice plants respond to flooding stress through two mechanisms: (a) elongation ability by which rice varieties avoid complete submergence through elongation of the plant above the rising flood water levels and (b) submergence tolerance by which certain rice varieties survive submergence of 10 days or more particularly in shallow water through metabolic adjustment (Mohanty, Malik, and Grover, 2000). As late as the 1980s, rice scientists identified some flood tolerant rice varieties that rely on the latter mechanism and tried to combine both desirable levels of flooding tolerance and high grain yield (Mohanty, Malik, and Grover, 2000). They could not, however, succeed it through conventional breeding.

In the 1990s, rice scientists have found that the submergence tolerance in certain rice varieties is controlled by a single major quantitative trait locus (QLT), which is name *Sub1* (Xu and Mackill, 1996; Xu et al., 2006). The *Sub 1* QTL provides tolerance to complete submergence up to 14 days. An Indian rice variety, called FR 13A, is found to possess *Sub 1* and has become a popular parental variety to provide *Sub 1* to rice breeders to combine it with popular rice varieties in India. *Swarna* is one of such popular Indian rice varieties. It is a modern rice variety developed in India in 1980s and has since become one of the most popular rice varieties in East India. Adding submergence tolerance to already popular *Swarna* makes it easy for farmers to

adopt the new variety because they can cultivate the new variety as they cultivate *Swarna*. Finally, in the early 2000s, rice scientists successfully introgressed *Sub 1* QTL into *Swarna* through marker-assisted backcrossing (MAB) (Neeraja et al., 2007; Septiningsih et al., 2009).

Under normal conditions, studies find no significant differences in agronomic performance, grain yield, and grain quality between Swarna and Swarna Sub 1, indicating complete restoration of the Swarna background in Swarna Sub 1 (Sankar et al., 2006; Neeraja et al., 2007). Swarna Sub 1, however, shows a two-fold or higher yield advantage over Swarna after submergence for 10 days or more during the vegetative stage (quoted in Septiningsih et al., 2009, p 152). Although *Sub 1* has been successfully introgressed into other mega rice varieties recent years, *Swarna Sub 1* remains the most successful *Sub 1* variety (Septiningsih et al., 2009).

In 2008, a project called Stress-tolerant Rice for Africa and South Asia (STRASA) has started distributing Swarna Sub 1 seeds to farmers. The STRASA project coordinates the seed multiplication with local counterparts, such as universities and national agricultural research centers, and distributes the Swarna Sub 1 seeds through NGOs and governmental agencies. In 2008, the project distributed the seeds to only 117 farmers but has expanded the coverage exponentially to 3 million farmers in 2012. The expansion occurred when the National Food Security Mission (NFSM) started distributed Swarna Sub 1 seeds in 2010.

The distribution of Swarna Sub 1 is expected to grow in 2013 and beyond in submergence prone areas. However, the numbers underestimate total number of farmers who have cultivated Swarna Sub 1 because farmers can multiple Swarna Sub 1 seeds from their own rice production. When farmers start exchanging seeds among themselves, the diffusion of Swarna Sub 1 seeds increases exponentially because one Swarna Sub 1 adopter can transfers the

seeds to multiple farmers and then the new adopters can transfer to multiple farmers next year. Previous diffusion studies describe the diffusion of a technology with a S-shaped cumulative adoption curve.

3. Sampling, Data, and Descriptive Analyses

3.1 Sampling Procedure

The data used in this paper come from two-visit surveys conducted in April-June and October-December in 2012. The surveys were conducted in six districts in Uttar Pradesh (UP) and two districts in Odisha.[1] The eight districts were chosen from a list of districts where four local NGOs[2] have distributed Swarna Sub 1 seeds in mini-kits, which consist of only seeds, not other inputs. The distribution started from 2008 but was scaled-up in 2011. From the four NGOs, we received lists of villages and farmers who received the mini-kits. From the village list, we randomly selected 6 villages per district in Uttar Pradesh and 8 to 9 villages per district in Odisha. In total, we selected 52 villages. From the recipient lists, we randomly selected up to four Swarna Sub 1 recipients per village. If the number of the recipient farmers is equal to or less than four in a village, we selected all recipient farmers. In this paper, we call the selected recipient farmers as *Original Users*. In total, we interviewed 174 *Original Users* from the eight districts in Uttar Pradesha and Odisha. In addition to *Original Users*, we also selected 12 households who resided in the same villages as *Original Users*. Because a census list of households was not available for us, we used voting registrations of sample villages. About two

[1] The six districts are Gorakpur, Maharajganj, Sidhartnagar, Sant Kabir Nagar, Basti, and Mau districts in UP, whereas Puri and Khurda in Odisha

[2] These are NEFORD, GDS, and GEAG.

prior to our first survey, state elections took place in Uttar Pradesh and Odisha. Thus, voting registrations were updated and easily available for us. From the voting registrations, we randomly selected 12 registered voters. If more than one person is chosen from one household, we selected a replacement voter so that the total number of distinct sample households becomes 12 per village. As a result, we interviewed 624 representative households in 50 villages across eight districts in Uttar Pradesh and Odisha. To distinguish the randomly selected households from *Original Users*, we call them as *Neighbors* because they reside in the same villages as *Original Users*.

When NGOs look for farmers who would agree to receive Swarna Sub 1 seeds and plant them, they tend to contact farmers who are more progressive than other farmers. Thus, *Original Users* are mostly more progressive than other villagers. On the other hand, because *Neighbors* were chosen randomly from voting registrations, we consider them as representative households of the sample villages, assuming that the voting registration does not systematically exclude certain types of households in the villages.

Adoption of Swarna Sub 1 in Uttar Pradesh and Odisha

Among 363 neighbor households, we find that 126 households have cultivated Swarna Sub 1 in Karif[3] 2011. Thus, the adoption rate of Swarna Sub 1 is about 34.7 percent among the households. The adoption rate is high in two districts: Maharajganj and Sant Kabir Nagar. In these districts, NGOs as well as government agencies have actively distributed Swarna Sub 1 especially in 2011. As a result, many households have received Swarna Sub 1 from NGOs and

[3] Kharif is the main agricultural season in Eastern India. Kharif is followed by Rabi and then Summer season.

government agencies in 2011, and active distributions of Swarna Sub 1 by NGOs and government agencies explain the high adoption rates in the two districts. Even in the remaining districts, the adoption rate is higher than 12 percent.

3.2 Farmers' Perception about Themselves

According to DeVellis (2003) psychological constructs are considered to be non-observable latent constructs. However, measureable indicators of constructs are observable and can be used to tap the latent constructs. Hansson et al. (2012) argue that if indicators are assumed to cause the latent construct, a formative model should be used, otherwise reflective or choice of formative model should be used. In this paper, we assume that latent constructs such as attitudes, norms and behavioral control are causing the measurement indicators and hence reflective model is considered. Thus, from Hansson et al. (2012), we have adopted their 10 statements, with slight modifications, to measure *Attitude*, *Subjective Norm*, and *Perceived Behavioral Control*. On each statement, we asked respondents to evaluate the statement on a 5 point Likert scale to ask to what extent they agreed with the statement. Scale 1 indicates a strong disagreement; whereas Scale 5 indicates a strong agreement.

Of the 10 statements, the first four statements are about farmers' attitude toward new agricultural technology: (1) I consider myself as a progressive farmer, (2) I like to try new agricultural technologies or practices, (3) I actively seek new information from others, and (4) I like new ideas in general. We expect that progressive farmers would agree with these four statements more strongly than other farmers. Indeed, in Table 2, we find that *Original Users*

have higher scores on these statements than Neighbors. The average score for *Original Users* on these four attitude statements is 4.0, while it is only 3.3 for *Neighbors*.

Original Users, however, do not feel that other farmers consider them as progressive as they consider of themselves. We have three statements about *Subjective Norm*: (5) other farmers think I am a progressive farmer, (6) other farmers ask my opinions about agricultural technologies and (7) other farmers will object how I produce rice on my fields. The average score for *Subjective Norm* is 3.2. This score is close to 3.0 which indicates neither agree nor disagree with the statement and suggest that *Original Users* do not expect others share the same opinion as they do about themselves. Among *Neighbors*, the average score for *Subjective Norm* is even lower at 2.7.

Regarding *Perceived Behavioral Control*, we find similar scores for *Original Users* and *Neighbors* to *Attitude*. The average score for *Perceived Behavioral Control* is 3.8 among *Original Users*, while it is 3.2 for *Neighbors*. Thus, farmers who think they are progressive farmers think they are also capable of controlling their behaviors in (8) acquiring information about new technologies, (9) contacting extension workers, and (10) adopting new agricultural technologies which are profitable.

The results in Table 2 are informative, but analyzing scores on 10 statements in 5-point Likert scale makes it difficult for us to identify determinants of these psychological constructs. Thus, we construct an index for each of the three psychological construct components.

3.3 Constructing Indexes for *Attitude*, *Subjective Norm*, and *Perceived Behavioral Control*

We construct psychological constructs through factor analysis. Based on the factor analysis, data reduction was performed by means of factor analysis with oblique rotation. Hair et al (2010) suggested that if the constructs or factors are likely to be correlated with each other, it is necessary to use oblique rotation for the factor solution and interpretation of the factors and also create indexes. Factor loading highlights the dimensionality, it indicates that higher the load the more relevant in the defining the factor's dimensionality. The factor load has been estimated for the various indicators in each constructs. We have followed Kaiser Criterion to retain those factors with eigenvalues equal or higher than 1 and also measured total variance accounted by each factor. Indexes for farmers' psychological constructs have been predicted by estimating the individual scores through the regression coefficients from the factor model. The mean value for the constructed indexes is set to be zero.

The results are presented in Table 3. First, we compare the average scores of the three indexes between *Original Users* and *Neighbors*. The t-tests indicate that *Original Users* have higher scores than *Neighbors* on all three indexes. The results are consistent with our expectations since Original Users received Swarna Sub 1 seeds from NGOs, and NGOs are likely to choose farmers who tend to think themselves as progressive farmers, be considered as progressive farmers by others, and be capable of obtaining new information and in good contact with information sources.

Next, we compare the average scores of the three indexes across different groups. When we compare male and female household heads, we find that female household heads have lower scores on all three indexes. More educated household heads have higher scores, and especially so when they have completed secondary level or higher degrees. Scheduled Caste (SC) and Other

Backward Class (OBC) farmers have lower scores on the three indexes than other caste groups. The results on Castes have large regional differences and need further investigations by disaggregating samples by areas. When we classify samples into three groups based on land size and wealth, which is measured by the total value of assets and livestock holdings, we also find that better off farmers have higher scores than farmers in the bottom third.

Finally, in Table 4, we compare the average scores across Swarna Sub 1 users and non-users. When we include *Original Users*, we find that Swarna Sub 1 users have higher scores than non-users. However, when we exclude Original Users and compare users and non-users among *Neighbors*, we find significant difference in three behavioural component (i.e attitude, norms and control) across the two groups. The difference is significant at 1 percent level.

The results in Table 4 are interesting and informative, but not conclusive because groups are not mutually exclusive. For instance, educated farmers tend to be larger and less poor. Education and wealth are correlated with caste categories also. Thus, it is not clear if it is education that is associated with psychological constructs or other factors. To isolate associations between these factors and psychological constructs, we estimate regression models that control observed variables. We describe our estimation models next.

4. Estimation Models and Variables

First, to identify determinants of farmers' psychological constructs toward technology adoption, we estimate the following model on *Attitude*, *Subjective Norm*, and *Perceived Behavioral Control*:

$Psy_{ji} = f$ (individual characteristics, household characteristics, village fixed effects)

Psy_{ji} is psychological construct of j of household i, where $j = A$ is for Attitude, $j = N$ is for Subjective Norm, and $j = C$ is for *Perceived Behavioral Control*. Individual characteristics include household head's characteristics on education, age, a dummy variable for female heads, a dummy variable for Scheduled Caste (SC) and Other Backward Class (OBC), and dummy for Original users, Household characteristics include number of male adults, number of female adults, total land size, and total value of owned assets and livestock. We estimate these models for both Original users and Neighbor households and identified that Original users differs significantly from Neighbors on psychological constructs. We have also estimated these models for only neighbor households without including original users because they were not randomly selected and hence regression results could contain selection bias. We estimate these models with Village Fixed Effects.

Second, we estimate the following Swarna Sub 1 adoption model. In the adoption model, we include three psychological constructs to investigate association between the adoption Swarna Sub 1 adoption and the three psychological constructs.

$Sub\ 1_i = g$ ($Psy_{A\,i}$, $Psy_{N\,i}$, $Psy_{C\,i}$, individual characteristics, household characteristics, village fixed effects)

$Sub\ 1_i$ is a dummy variable for Swarna Sub 1 adoption. If household i cultivated Swarna Sub 1 in 2011 Karif season, $Sub\ 1_i$ takes one; otherwise, it takes zero. Again, we estimate this model among Neighbor households only.

Regarding the associations, we make an assumption that the psychological constructs are fixed over time because the 10 statements that we use to create the three psychological constructs are general statements. Thus, we think it is reasonable to assume that farmers' responses to these statements can be considered fixed over time. The three psychological constructs are not endogenous variables, which are correlated with unobserved characteristics of household *i*. Instead, they represent part of unobserved farmer characteristics. However, we cannot rule out the possibility of the three psychological constructs being endogenous variables. Thus, we need to note that estimated coefficients on the three psychological constructs do not suggest any causality between the psychological constructs and the adoption because the causality between the psychological constructs and the adoption could affect each other in both ways. For instance, a positive coefficient of *Attitude* could suggest that a household with high attitude toward technology adoption is more likely to adopt a new technology, i.e., Swarna Sub 1. On the other hand, it could also suggest that a household has high attitude toward technology adoption because of the experience of adopting Swarna Sub 1. Without a proper identification strategy, such as randomized control trials, we cannot determine the direction of the causality in this paper.

Nonetheless, any findings on associations between psychological constructs and technology adoption would suggest importance of psychological factors in technology adoption. The results will provide important indications how new agricultural technologies should be promoted among farmers. We will discuss implications to extension at the end of the paper after discussing the results.

5. Regression Analysis Results

5.1 Determinants of Psychological Constructs

We present the regression results on the determinants of psychological constructs for two groups: full samples and neighbors in Table 5. In this table, we find that Original Users have significantly higher scores on all three constructs than Neighbors. Note that we control for observable individual and household characteristics, in addition to village fixed effects, in the regression models. Thus, the results clearly show that Original Users are psychologically different from Neighbors. Either NGOs can successfully identify farmers who have high scores in psychological constructs and distributed Swarna Sub 1 seeds or farmers who have high scores approached to the NGOs who were distributing the seeds, or both. As we discussed earlier, Original Users could be considered as progressive farmers, and the results in this paper quantifies (for the first time in the literature according to our knowledge) the psychological difference between progressive and ordinary farmers.

Specifically relevant in India, we find that social classes affect the psychological constructs of farmers. Farmers who belong to SC have lower scores in the psychological constructs than farmers who are unclassified. Specifically, farmers who belong to SC have lower scores on *Perceived Behavioral Control* and *Attitude*, and the results remain the same even when we estimate the same model among Neighbors only, excluding Original Users. Thus, the results indicate that farmers in SC have lower attitudes toward new agricultural technologies and are less confident about their ability to adopt new technologies than unclassified farmers. This suggests that farmers in SC may be facing psychological constraints to adopt new technologies in addition to other constraints. Interestingly, we do not have that farmers who belong to OBC have

significantly lower scores in the three psychological constructs than unclassified farmers (except one coefficient on *Control*).

To investigate if education or wealth reduces the gaps in psychological constructs between farmers who belong to SC and unclassified farmers, we have estimated models with various interaction terms between the caste dummies with other variables, such as education, land size, and the log of the total asset value. However, we find none of the interaction terms significant. (The estimation results are not presented in this paper.) Thus, the results on interaction terms suggest that it would be difficult to reduce the psychological gaps between farmers who belong to SC and unclassified farmers via education or welfare programs. Further research is necessary to investigate how to reduce the psychological gaps.

Education itself is positively associated with psychological constructs. In addition, we also find positive associations between wealth indicators, such as land size and the total asset value, and psychological constructs. Perhaps, the results are hardly surprising because previous studies have found farmers who are well educated, wealthy, and have large land are more likely to adopt new agricultural technologies than other farmers (Feder et al., 1985; Doss, 2006). However, the results in Table 5 suggest that farmers who are well educated, wealthy, and have large land have also higher psychological constructs than other farmers. They have a higher attitude toward new technologies, considered highly by others, and are confident in controlling their behaviors necessary to adopt new technologies. Next, we investigate if the psychological constructs have association with the adoption of Swarna Sub 1.

5.2 Swarna Sub 1 Adoption Model with Psychological Constructs

We estimate the Swarna Sub 1 adoption model among Neighbors, who were randomly selected for our study, because Original Users are purposely selected by NGOs or self-selected to adopt Swarna Sub 1. The causality between the independent and dependent variables could go either way. Thus, in Table 6, we present the estimation results among neighbors. As we discussed earlier, the causality between the psychological constructs and the adoption of Swarna Sub 1 is unclear also. If we assume that farmers' psychological constructs are fixed over time, then we can interpret the results as the impacts of the psychological constructs on the adoption. However, if farmers' psychological constructs are not fixed but could be influenced by other factors, such as successful adoption of new technologies, such as Swarna Sub 1, it is possible for the causality to go the opposite direction. Without well designed randomized control trials, it is impossible to identify the causality. Thus, in this paper, we only claim that the coefficients found in this paper represent present associations between the psychological constructs and the adoption of Swarna Sub 1.

In Table 6, we find positive coefficients on *Attitude* and *Control* on the adoption of Swarna Sub 1 but not on the other variables. As we explain in Section 2, Swarna Sub 1 can be grown just as one of its parental varieties, Swarna. Thus, farmers face few constraints to produce Swarna Sub 1. Thus, we do not expect to find other variables such as education and wealth variables to be significant determinants to the adoption of Swarna Sub1, and the results are consistent with the expectations. Nonetheless, it is a new variety and yet to be widely spread. Farmers need to seed for the seeds in their communities. This is probably why we find *Attitude* and *Control* to be significant determinants of the Swarna Sub 1 adoption but not *Norm*. Those

farmers who have a strong attitude toward to new technologies and are confident in obtaining seeds seek for new seeds. At the same time, Swarna Sub 1 is not a controversial innovation. It is simply an improvement of an existing popular rice variety. Therefore it is understandable for us to find that *Norm* is not an important factor.

In Table 6, the estimated coefficient of *Attitude* is 0.09. This suggests that if the score in *Attitude* is higher by 1 point, the probability of adopting Swarna Sub 1 is also higher by 9 percentage points. In the previous table, we find that farmers in SC have about a 0.3 point lower score in *Attitude* than unclassified farmers. The results indicate, therefore, that the probability of adopting Swarna Sub 1 is 2.7 percentage points lower for farmers in SC than unclassified farmers because of their low score in *Attitude*. Similarly, we find that the probability of adopting Swarna Sub 1 is 2.1 percentage points lower for farmers in SC than unclassified farmers because of their low score in *Control*. Because the average adoption rate of Swarna Sub 1 is about 22 percent in the study areas, the estimated changes are substantial.

6. Conclusion

In this paper, we apply the theory of planned behavior (TPB) to identify farmers' psychological constructs toward agricultural technology, i.e., *Attitude*, *Subjective Norm*, and *Perceived Behavioral Control*, and identify determinants of the psychological constructs in Eastern India. We also estimate an adoption model of a new rice variety called Swarna Sub 1, which is submergence tolerant. Regarding the determinants of the psychological constructs, we find that farmers who have received Swarna Sub 1 from NGOs have higher scores on

psychological constructs toward new technologies. The results clearly indicate that progressive farmers are psychologically different from other farmers and suggest either that NGOs can somehow identify those farmers who have high scores in psychological constructs or that those farmers who have high scores seek NGOs to obtain new seeds, or both. Although it is well known that change agents, such as NGOs and extension workers, work more with progressive farmers than other farmers, for the first time in the literature to our knowledge, we empirically demonstrate that change agents work with farmers who have high scores in psychological constructs toward new technologies.

Regarding the determinants of the psychological constructs, we find that socio-economic factors such as caste, gender, and asset holdings affect the psychological constructs toward adoption of new agricultural technologies. Farmers who belong to Scheduled Castes (SC) have significantly lower scores in the three psychological constructs. This result suggests the importance of helping farmers in a deprived social class to obtain better perceptions about themselves.

Finally, we find that that farmers' psychological constructs toward new technologies matter in the adoption of Swarna Sub 1. Intuitively the result is hardly a surprise. However, this paper makes an important contribution to the literature by quantifying the associations between the psychological constructs and the adoption of a new technology in a developing country. Because this is still a new research area, there remain basic questions: Are people's psychological constructs toward new technologies fixed? Or do people change their psychological constructs toward technologies? If they do, how do they change? And, are there any roles for public interventions? It is difficult to answer these questions without well designed

randomized experiments, and this is beyond the scope of the present paper. However, the results in this paper suggest that this is an important research area that deserves future studies.

References

Ashraf, N., Karlan, D., and Yin, W. (2006). "Tying Odysseus to the Mast: Evidence from a Commitment Savings Product in the Philippines." *Quarterly Journal of Economics*, 121(2): 635-672.

Ajzen, I. (1991). "The Theory of Planned Behavior," Organizational Behavior and Human Decision Process, 50; 179-211.

Azman, Azmariana,, Jeffrey Lawrence D Silva, Bahaman Abu Samah, Norsida Man, Hayrol Azril Mohamed Shaffril (2013). "Relationship between Attitude, Knowledge, and Support towards the Acceptance of Sustainable Agriculture among Contract Farmers in Malaysia", *Asian Social Science,* 9(2): 99-105.

Beedell, J., and T. Rehman (2000). "Using Social-Psychology Models to Understand Farmers' Conservation Behavior,' *Journal of Rural Studies*, 16: 117-127.

Bergevoet, R.H.M., C.J.M. Ondersteijin, H.W. Saatkamp, C.M.J. van Woerkum, and R.B.M. Huirne (2004). "Entrepreneurial Behavior of Dutch Dairy Farmers under a Milk Quota System: Goals, Objectives, and Attitude," *Agricultural Systems*, 80: 1-21.

Brune, Lasse; Giné, Xavier; Goldberg, Jessica; Yang, Dean (2011). "Commitments to Save: A Field Experiment in Rural Malawi," *Policy Research Working Paper*, 5748, World Bank: Washington DC.

Burton, Rob J.F. (2004). "Reconceptualising the 'behavioural approach' in agricultural studies: a socio-psychological perspective", *Journal of Rural Studies,* 20(2): 359-371

Cramerer, C.F., and G. Loewenstein (2004). "Behavioral Economics: Past, Present, and Future," in C.F. Cramerer, G. Loewenstein, and M. Rabin (eds.), *Advances in Behavioral Economics*, Princeton University Press, 3-51.

Datta, S., and S. Mullainathan (2013). "Behavioral Design: A New Approach to Development Policy," Center for Global Center, *CDG Policy Paper*, 16 (November).

Doss, C.R. (2008). "Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement," *Agricultural Economics*, 34 (3): 207-219.

Dearing (2008). "Evolution of Diffusion and Dissemination Theory," *Journal of Public Health Management and Practice*, 14 (2): 99-108.

Feder, G., R.E. Just, and D. Zilberman (1985). "Adoption of Agricultural Innovations in Developing Countries: A Survey," Economic Development and Cultural Change, 33 (2): 255-298.

Feder, G., and S. Savastano (2006). "The role of opinion leaders in the diffusion of new knowledge: The case of integrated pest management," *World Development*, 34 (7): 1287-1300.

Foster, A., and M. Rosenzweig (2010). "Microeconomics of Technology Adoption," *Annual Review of Economics*, 2: 395-424.

Hansson, H., R. Ferguson, and C. Olofsson (2012). "Psychological Constructs Underlying Farmers' Decisions to Diversify or Specialize Their Business – an Application of Theory of Planned Behavior," *Journal of Agricultural Economics*, 63 (2): 465-482

Lapple, Doris and Hugh Kelley (2013). "Understanding the Uptake of Organic Farming: Accounting for Heterogeneities among Irish Farmers", *Ecological Economics,* 88:11-19

Mohanty, H.K., S. Malik, and A. Grover (2000). "Prospects of Improving Flooding Tolerance in Lowland Rice Varieties by Conventional Breeding and Genetic Engineering," *Current Science*, 78 (2): 132-137.

Neeraja, C., R. Maghirang-Rodriguez, A. Pamplona, S. Heuer, B. Collard, E. Septiningsih, et al. 2007. "A Marker-assisted Backcross Approach for Developing Submergence-Tolerant rice Cultivars," *Theoretical and Applied Genetics*, 115: 767-776.

Poppenborg, Patrick and Thomas, Koellner (2013). "Do Attitudes toward Ecosystem Services Determine Agricultural Land Use Practice? An Analysis of Farmers' Decision-making in a South Korean Watershed", *Land Use Policy,* 31(Themed Issue): 422-429.

Roger (2003). *Diffusion of Innovations*, Fifth Edition, Free Press.

Sankar, R.K., J.N. Reddy, S.G. Sharma, and A.M. Ismail (2006). "Physiological Basis of Submergence Tolerance in Rice and Implications for Crop Improvement," Current Science, 91: 899-906.

Septiningsih, E. M., A. M. Pamplona, D. L. Sanchez, C. N. Neeraja, G. V. Vergara, S. Heuer, A. M. Ismail, and D. J. Mackill (2009). "Development of Submergence-Tolerant Rice Cultivar: the Sub 1 Locus and Beyond," *Annals of Botany*, 103: 151-160.

Sutherland, L.A. (2010). "Environmental Grants and Regulations in Strategic Farm Business Decision-making: A Case Study of Attitudinal Behavior in Scotland," Land Use Policy, 27: 415-423.

Widawsky and O'Toole (1996). "Prioritizing the Rice Research Agenda in Eastern India," in Evenson, R.E., R.W. Herd, and M. Hossain (eds.) *Rice Research in Asia: Progress and Priorities*, CABI International.

Xu, K., and D.J. Mackill (1996). "A Major Locus for Submergence Tolerant Mapped on Rice Chromosome," *Molecular Breeding*, 2: 219-224.

Xu, K., X. Xia, T. Fukao, P. Canlas, R. Maghirang-Rodriguez, S. Heuer, et al. (2006). "Sub 1A is an Ethylene Response Factor-like Gene that Confers Submergence Tolerant to Rice," *Nature*, 442: 705-708.

Table 1. Sampled Villages and Households in Uttar Pradesh and Odisha, 2012

	Number of Sample villages	Number of Sample Households	By household Type		Swarna Sub1 users among Neighbors
			Original Users [(a)]	Neighbors [(b)]	
	(A)	(B)	(C)	(D)	(E)
State	Number	Number	Number	Number	% of D
Uttar Pradesh	34	501	117	384	27.3
Odisha	16	230	40	190	10.0
Total	50	731	157	574	21.6

Note: (a) *Original Users* are households who received Swarna Sub 1 seeds, as mini-kits, from four NGOs who have been distributing Swarna Sub 1 in Uttar Pradesh and Odisha. Up to four *Original Users* were randomly selected in each village from the lists of Swarna Sub 1 recipients. The lists were provided by the four NGOs. (b) Twelve households were randomly selected in each village where *Original Users* resided. Most recent voter registrations were used to randomly select the twelve households in each village. In this paper, the randomly selected 12 households were called *Neighbors*.

Table 2. Psychological Constructs in Eastern India (Odisha and Uttar Pradesh)

	Original Users[(a)]	Neighbors[(a)]
	(A)	(B)
	Average[(b)]	Average[(b)]
Attitude toward new technology (Attitude)		
1. I consider myself as a progressive farmer	3.8	2.9
2. I like to try new agricultural technologies or practices	4.1	3.3
3. I actively seek new information from others	3.8	3.2
4. I like new ideas in general	4.1	3.6
Average	*4.0*	*3.3*
Social Norm (Norm)		
5. Other farmers think I am a progressive farmer	3.3	2.5
6. Other farmers ask my opinions about agricultural technologies	3.3	2.7
7. Other farmers will object how I produce rice on my fields	3.0	2.9
Average	*3.2*	*2.7*
Perceived Behavioral Control (Control)		
8. It is easy for me to collect information about new technologies	3.4	2.7
9. I have good contacts with extension workers	3.5	2.7
10. I can adopt new agricultural technologies which are profitable	4.6	4.1
Average	*3.8*	*3.2*
Number of observations	157	574

Notes: (a) See Notes at the bottom of Table 1. (b) Average of 1-5 scale: 1 = Strongly Disagree, 2 = Disagree, 3 = Neither, 4 = Agree, and 5 = Strongly Agree.

Table 3. Perception Indexes on *Attitude*, *Norm*, and *Control*
(Samples include both Original Users and Neighbors)

	Attitude	*Norm*	*Control*
	(A)	(B)	(C)
Original Users and Neighbors			
Original Users	0.48	0.45	0.44
Neighbors	-0.13**	-0.12**	-0.12**
By Gender of Household Head			
Male	0.08	0.06	0.05
Female	-0.70**	-0.57**	-0.48**
By Education level			
Illiterate (baseline group for t-tests)	-0.46	-0.51	-0.26
Primary level education	0.09**	0.14**	-0.14
Secondary level education	0.15**	0.15**	0.08**
Higher Secondary level and more	0.29**	0.29**	0.36**
By Caste Groups			
Unclassified (baseline group for t-tests)	0.26	0.32	0.09
Other Backward Class (OBC)	-0.03**	-0.10**	-0.06
Scheduled Castes (SC)	-0.52**	0.42**	-0.43**
By Land size			
Small (0-2ha) (baseline group for t-tests)	-0.05	-0.06	-0.04
Medium (2ha-4ha)	0.67**	0.76**	0.57**
Large (4ha and above)	1.00**	0.93**	0.88**
By Wealth (classified by tercile)			
Poorest group (baseline group for t-tests)	-0.40	-0.36	-0.31
Middle	0.05**	-0.01*	-0.04
Least Poor	0.36**	0.37**	0.34**

*Note: * indicates 5 % level significance. ** indicates 1 % level significance.*

Table 4. Swarna Sub 1 Adoption and Perception Indexes

	Attitude	*Norm*	*Control*
	(A)	(B)	(C)
Users vs. Non-users all samples			
Users	0.48	0.45	-0.44
Non-Users	-0.13**	-0.12**	0.12**
Users vs. Non-users among Neighbors			
Users	0.10	0.07	0.10
Non-Users	-0.19**	-0.17**	-0.18**

*Note: * indicates 5 % level significance. ** indicates 1 % level significance.*

Table 5. Regression results on Perception Indexes among Users and Neighbors: *Attitude*, *Norm*, and *Control*

	Full Sample			*Neighbors Only*		
	Attitude	*Norm*	*Control*	*Attitude*	*Norm*	*Control*
	(A)	(B)	(C)	(D)	(E)	(F)
Original User Dummy	0.361***	0.311***	0.286***			
	(5.55)	(4.50)	(4.67)			
Other Backward Class (OBC)	0.057	-0.033	-0.120*	0.109	-0.003	-0.113
	(0.77)	(-0.43)	(-1.73)	(1.24)	(-0.03)	(-1.42)
Scheduled Caste (SC)	-0.294***	-0.210**	-0.383***	-0.274***	-0.163	-0.347***
	(-3.16)	(-2.12)	(-4.37)	(-2.68)	(-1.53)	(-3.73)
Education	0.028***	0.026***	0.013**	0.031***	0.033***	0.021***
	(4.27)	(3.71)	(2.16)	(4.20)	(4.22)	(3.16)
Age	0.003	0.002	0.0002	0.005**	0.004*	0.004*
	(1.63)	(0.71)	(0.084)	(2.02)	(1.69)	(1.81)
Female dummy	-0.180*	-0.159	-0.169*	-0.114	-0.132	-0.110
	(-1.88)	(-1.56)	(-1.87)	(-1.11)	(-1.22)	(-1.17)
Household Characteristics						
Number of male adults	-0.014	0.005	0.008	0.012	0.014	0.017
	(-0.58)	(0.21)	(0.35)	(0.40)	(0.46)	(0.64)
Number of female adults	0.0005	0.018	0.024	-0.041	-0.013	-0.014
	(0.018)	(0.68)	(0.98)	(-1.31)	(-0.41)	(-0.52)
Land size (ha)	0.166***	0.175***	0.183***	0.197***	0.278***	0.258***
	(3.61)	(3.57)	(4.21)	(3.22)	(4.33)	(4.63)
Log (Asset value)	0.069***	0.090***	0.062***	0.062**	0.056**	0.045*
	(3.17)	(3.86)	(3.01)	(2.45)	(2.10)	(1.93)
Log (Livestock value)	0.046**	0.019	0.011	0.038	0.011	-0.016
	(2.14)	(0.86)	(0.58)	(1.52)	(0.42)	(-0.70)
Constant	-1.553***	-1.459***	-0.926***	-1.522***	-1.272***	-0.752***
	(-6.18)	(-5.47)	(-3.91)	(-5.13)	(-4.09)	(-2.78)
Number of households		728			571	
Number of village1		50			50	
R-squared	0.301	0.263	0.262	0.186	0.172	0.177

Note: numbers in parentheses are t-statistics. *** p<0.01, ** p<0.05, * p<0.1

Table 6. Regression results on Adoption of Swarna Sub 1 among Neighbors (Probit)

	Among Neighbors
	(A)
Psychological Constructs	
Attitude toward New Technologies	0.093***
	(2.82)
Subjective Norm	0.041
	(1.31)
Perceived Behavioural Control	0.071**
	(2.16)
Household Characteristics	
Education	-0.0046
	(-1.13)
Age	-0.0012
	(-0.92)
Female dummy	-0.0088
	(-0.15)
Other Backward Class (OBC)	0.0019
	(0.041)
Scheduled Caste (SC)	-0.049
	(-0.88)
Number of male adults	-0.010
	(-0.66)
Number of female adults	-0.0056
	(-0.33)
Land size (ha)	0.037
	(1.09)
Log (Asset value)	-0.0089
	(-0.64)
Log (Livestock value)	-0.032**
	(-2.31)
Constant	0.711***
	(4.32)
Observations	571
R-squared	0.127
Number of village1	50

Note: Coefficients are marginal effects. Numbers in parentheses are t-statistics.
*** p<0.01, ** p<0.05, * p<0.1