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Gender Dimensions on Farmers' Preferences for Direct-Seeded Rice with Drum Seeder in India

Md. Tajuddin Khan

Avinash Kishore

P. K. Joshi

South Asia Office

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHORS

Md. Tajuddin Khan (m.t.khan@cgiar.org) is research analyst in the South Asia Office of the International Food Policy Research Institute (IFPRI), New Delhi.

Avinash Kishore (a.kishore@cgiar.org) is a research fellow in the South Asia Office of IFPRI, New Delhi.

P. K. Joshi (p.joshi@cgiar.org) is director of the South Asia Office of IFPRI, New Delhi.

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ABSTRACT

This study measures the willingness of male and female farmers to pay for climate-smart technology in rice. Rice is the most important crop in India in terms of area, production, and consumption. It is also the biggest source of greenhouse gas emissions among all crops. Direct-seeded rice (DSR) with drum seeder, a climate-smart technology, requires less labor and water and is more climate friendly than transplanted rice; yet, its adoption is slow in India. The authors of this study carried out a discrete choice experiment with 666 farmers from the Palghar and Thane districts of Maharashtra to measure their willingness to pay for drum seeders—a key piece of equipment for adopting DSR. Both male and female farmers were surveyed to capture the heterogeneity in their valuation of the key attributes of drum seeders. Although both male and female farmers prefer cheaper drum seeders, the marginal valuation of different attributes of the drum seeder varies by the farmers' gender. The authors also used the Women Empowerment in Agriculture Index (WEAI), developed by the International Food Policy Research Institute (IFPRI), to collect self-reported data on the role and say of women in agriculture. The respective gender roles in the family and on the farm seem to explain some of this difference. Men have a greater say over how the family spends the cash. Accordingly, men tend to have a higher willingness to pay for attributes that increase income (increase in yield) or reduce cash costs (reduction in the seed rate). Women contribute a large share of the labor for transplanting rice, much of which is unpaid work on family farms. Not surprisingly, therefore, women seem to value labor saving significantly more than their male counterparts. Further, the WEAI data show that although men in the family have more say, women do have an influence on decisions regarding crop production and the adoption of new technologies, to an extent. Therefore, to enhance the adoption of drum seeders, the product designers and extension workers should also target women.

Keywords: direct-seeded rice, choice experiment, gender roles, RPLM, willingness to pay (WTP), India, gender

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1. INTRODUCTION

Rice is the most important crop in India in terms of area, production, and consumption. Transplanting rice seedlings grown in nurseries to puddled soils is the dominant method of rice establishment in India and the rest of Asia (Pandey and Velasco 2002). Growing transplanted rice is more water and labor intensive and emits more greenhouse gases into the environment as compared with direct-seeded rice (DSR) with drum seeders. Rising wage rates, increased water scarcity, and growing environmental concerns make DSR a more attractive option, both economically and environmentally. Because DSR offers higher returns and allows more intensive cropping, both state and central governments in India are promoting adoption of DSR through extension and capital subsidies on essential equipment, such as drum seeders. Still, the adoption of DSR is slow in India.

This paper uses discrete choice experiments to examine farmers' preferences for growing DSR using drum seeders and explores heterogeneity in these preferences. Agricultural decisions are not undertaken by a unitary household (Duflo and Udry 2004). Female farmers may have preferences that differ from those of the men in their families, and adoption of a new technology may affect them differently. This finding is particularly true for rice cultivation, because women contribute significantly more toward rice-based agriculture than men. Studies on the gender division of labor in rice production reveal that women in South Asia contribute 60–80 percent of the required labor (Ricepedia 2016). A shift from transplanting to direct seeding may significantly affect the livelihoods of women, because, in most parts of India, transplanting is their traditional task. If women are unpaid laborers, the shift will reduce the drudgery of transplanting.[1] If they are paid laborers, however, it will deprive them of a source of income. The same reasoning holds for weeding. There is more weed growth in DSR and, therefore, an increased need for manual weeding. Thus, women are major stakeholders in the adoption of new technologies and practices such as DSR.

Few studies measuring willingness to pay (WTP) for new technologies include women in the sample (Kamwamba-Mtethiwa et al. 2012). Even studies that look at the heterogeneity in the preference between male and female farmers often rely on a comparison of male- and female-headed households. But this approach provides only limited information on a small segment of female producers[2] and ignores the majority of female farmers who live in male-headed households. Therefore, this paper aimed to survey a man and a woman from each farming family in the sample to measure their marginal valuations for different attributes of drum seeders.

The study uses a discrete choice experiment with 666 female and male farmers from 395 families in two predominantly rice-growing districts (Thane and Palghar) in Maharashtra to measure their WTP for a drum seeder, which is the main equipment used in DSR. The findings indicate interesting similarities and differences in marginal valuations of different attributes of drum seeders between female and male farmers in the sample. Both women and men prefer cheaper drum seeders and have positive valuations for reductions in labor use and seed rate and for increase in crop yield; however, men value increase in crop yield more than women do. Women, on other hand, have significantly higher valuation for labor savings. Interestingly, although the decision to buy, rent, or use machines is almost entirely in the man's domain, more women than men in the sample showed any interest in adopting drum seeders. The findings show that 42 percent of women and 73 percent of men went with the status quo in the choice experiments.

[1] According to Kanchi (2010), 79 percent of rural women are engaged in agriculture and allied activities, as compared with 63 percent men; more than 50 percent of female agricultural workers are unpaid family workers.

[2] Fewer than 10 percent of all farming households in India are female-headed households (Government of India 2013).

The remainder of this paper is organized as follows: Section 2 presents a brief discussion on the benefits and limitations of DSR in comparison to the more common transplanted rice. Section 3 discusses the empirical methodology used in the paper. A description of the data is provided in Section 4. Section 5 presents the results of the empirical analysis, and Section 6 draws some policy implications from the research.

2. TRANSPLANTED RICE, DIRECT-SEEDED RICE, AND DRUM SEEDERS IN INDIA

Transplanting is the dominant mode of rice establishment in India. Transplanted rice requires more labor and water and emits more greenhouse gases into the environment than DSR. In the past, DSR was mainly practiced in areas with low population density and where low or uncertain water availability prevented intensification of rice systems. However, the area farmed using DSR has been increasing in recent years in response to rising wage rates, increasing labor, and growing water scarcity (Pandey and Velasco 2005). DSR has several advantages over transplanted rice. DSR saves on labor by as much as 50 percent (Pandey and Velasco 2005; Bhushan et al. 2007). When rainfall at planting time is highly variable, as has been the case in many parts of India in recent years (Kishore, Joshi, and Pandey 2015), DSR may help reduce production risk. It is also less vulnerable to terminal drought and facilitates higher cropping intensity by saving the time needed to grow rice nurseries for transplanted rice.

Direct seeding has some disadvantages as well. Because there is higher weed growth with DSR as compared with transplanted rice, farmers have to use weedicides or manual labor to control weeds. Thus, a part of the labor and money saved by direct seeding gets used for weeding. Poor establishment of seeds is another potential problem that affects crop yields. Although using drum seeders for sowing seeds mitigates this problem, drum seeders are not easily available to farmers. In addition, the reduction in labor requirement for rice cultivation under DSR may reduce the wage income of women and men who are engaged in transplanting.

A new drum seeder costs 4,200–5,400 Indian rupees (INR) (Reddy, Sreenivasulu, and Manohar 2016). The average working life of a drum seeder is nearly 7–10 years, and it is easy to maintain. Chavan and Palkar (2010) and Chandrasekhrarao, Jitindranath, and Murthy (2013) assumed the variable cost of a drum seeder to be less than 10 percent of its total fixed cost. The government of India and the state governments in rice-growing regions of India are trying to promote adoption of DSR as an alternative to transplanting in order to save water, reduce vulnerability of rice crop to vagaries of rainfall, mitigate greenhouse gas emissions, and remove drudgery involved in transplanting (Kumar and Ladha 2011; Mahajan, Chauhan, and Gill 2013). Yet, the adoption of DSR has been slow in India despite capital subsidies on equipment like drum seeders and extension support to farmers.

3. EMPIRICAL METHODOLOGY

This paper uses discrete choice experiments (DCEs) to analyze farmers' preferences for drum seeders. DCE is a quantitative technique for eliciting preferences that can be used in the absence of revealed preference data. The method involves asking individuals to state their preference over hypothetical alternative scenarios, goods, or services. Each alternative is described by several attributes, and the responses are used to determine whether preferences are significantly influenced by the attributes. It also allows estimation of marginal values of these attributes (Mangham, Hanson, and McPake 2009) and the extent to which individuals are willing to trade one attribute for another (Drummond et al. 2005). In this study, DCE allows the authors to elicit farmers' marginal values or willingness to pay for increase in yield and reduction in labor requirement for rice cultivation using drum seeders.

In the agricultural and resource economics literature, the DCE methodology has been used to analyze consumer preferences for environmental amenities (Selassie and Kountouris 2010; Bennett and Blamey 2001; Birol and Das 2010, 2012; Bell, Shah, and Ward 2014), ecosystem services (Hurd 2006; Villalobos and Huenchuleo 2010), food quality attributes (Lusk and Schroeder 2004; Ortega et al. 2011), conservation agriculture (Ward et al. 2015), electricity service (Sagebiel 2011), and new or improved production technologies (Ward et al. 2014; Ward and Singh 2015; Arora, Bansal, and Ward 2015).

DCE has its theoretical foundation in Lancaster's model of consumer choice (Lancaster 1966), which regards a good as a bundle of attributes and considers the value of a good as a function of these attributes and their levels. Consumer choices are modeled using the random utility theory, which assumes that the individual will choose the alternative that yields the highest utility. The utility has both a deterministic component and a random, individual-specific component that is unobservable to the researcher.

Because farmers are heterogeneous, their preferences for different attributes of a drum seeder could also be heterogeneous. A common method of evaluating preference heterogeneity is the estimation of random parameters logit models (RPLM), also called mixed logit. This is a highly flexible model that allows for random taste variation, unrestricted substitution pattern, and correlation in unobserved factors (McFadden and Train 2000; Petrin and Train 2003). Further, this model can use any distribution for the random coefficients. In this study, the coefficients corresponding to all attributes, except for price, vary normally; price is restricted to be constant to ensure a negative marginal utility of price and easier computations of WTP.

Respondents are asked to choose among a series of alternative attribute bundles; the net utility of an alternative is a linear function of the individual's observed characteristics plus an additive error term (Greene 2008). The econometrician, however, does not observe this utility. What is observed is the stated preference for different attributes and levels. Given resources and other factor endowments, we assume a randomly selected individual i who chooses repeatedly in t situations between several alternatives $n(j)$. Each alternative accommodates attributes k with levels A_{kn}, which vary over alternatives. This can be represented as follows:

$$U_{in} = \{\ 1 \text{ if } U^{*}{}_{in} = \max\big(\ U^{*}{}_{in}(1), U^{*}{}_{in}(2), \dots, U^{*}{}_{in}(j)\big) \text{ and 0 otherwise}\}. \qquad (1)$$

For simplicity, we assume indirect utility functions U_{in} for each alternative *n* and individual *i* to be linear with respect to attribute levels A_{kn}. For each alternative, there are utility-sensitive elements e_{int} that cannot be observed by the researcher but are known to the individual. This simple formulation of indirect utility function can be written as follows:

$$U_{in} = V_{in} + e_{in} = \beta_1 A_{i1n} + \beta_2 A_{i2n} + \dots + \beta_k A_{ikn} \epsilon_{in} \qquad (2)$$

where A_{ikn} is the level of attribute k for alternative n, β_k is the corresponding utility coefficient, and ϵ_{in} is a stochastic component of utility that is independently and identically distributed across individuals and alternative choices. This function captures the unobserved variation in preferences and errors in an individual's perception and optimization. The WTP for each attribute is thereby distributed in the same way as the attribute's coefficient. In the random parameters logit model, the taste and preference of attributes for each individual is unobserved and varies randomly; this can be interpreted as marginal utilities. The ratio of two such marginal utilities is the marginal rate of substitution of one for the other. The WTP is the marginal rate of substitution between an attribute and the cost attribute (that is, $-\frac{\beta_i}{\beta_{cost}}$); the WTP value gives necessary compensation in monetary terms for a one-unit deterioration of an attribute in order to maintain the same level of utility. The WTP can be estimated as follows:

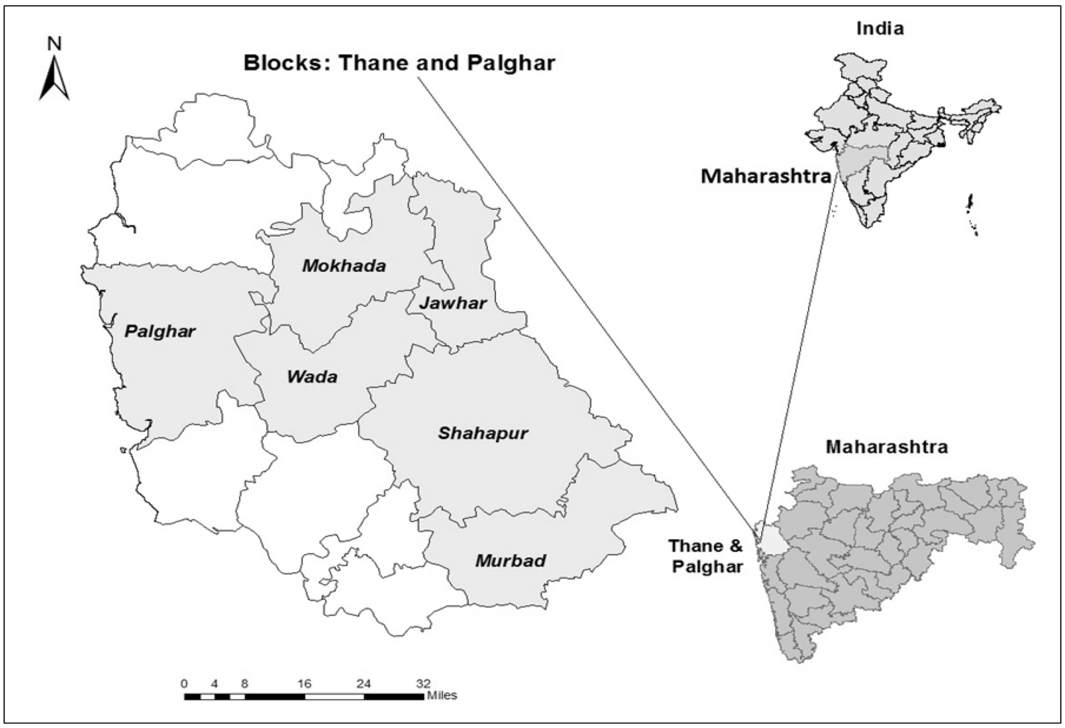
$$WTP_n = -\frac{\beta_n}{\beta_N}, n \in [1, N-1], \quad (3)$$

where β_n is the estimated parameter for the nth attribute. The negative sign is used because the marginal utility of income is negative of the marginal disutility of cost, thus ensuring that the marginal utility of favorable attributes will be positive. A negative of this ratio implies that the WTP for favorable attributes is represented as a positive sum.

4. DATA

The sample for this study consists of 329 men and 337 women farmers from 395 households in tribal areas of Maharashtra. The survey sample was formed using a multistage sampling approach. The first stage consisted of two districts—Thane and Palghar—where a Climate Change, Agriculture and Food Security (CCAFS) project to promote climate-smart agriculture is underway (Figure 4.1). The land in the study area is undulating, receives high rainfall (2,300 mm/yr), and is largely rainfed. Most farmers belong to the socially and economically disadvantaged community of scheduled tribes (STs). With 10.51 million STs, Maharashtra has the second largest tribal population in India, after Madhya Pradesh. The study area is close to Mumbai, one of the largest cities in India. A large number of young men from rural areas of both districts migrate to Mumbai for work, resulting in labor scarcity and feminization of agricultural labor. In the second stage, six rice-growing blocks were selected from the two districts: four from Palghar (Jawhar, Mokhada, Wada, and Palghar) and two from Thane (Shahapur and Murbad).

Figure 4.1 Location of study



Source: Authors' creation.
Note: In June 2014, the Thane district was bifurcated into two districts: Thane and Palghar.

The number of blocks drawn from each district is proportional to the share of rice production in that district. Within each block, five villages were randomly selected from which to draw households. For each of these 30 villages, door-to-door listing was used to prepare a roster of all rice-growing households, with 15 households being randomly selected for the choice experiment. The authors tried to select a man and a woman engaged mainly in agriculture from each household in the sample for choice experiment; however, it was possible to find both a male and a female farmer in only 271 families. In the other 124 families, either a man or a woman was surveyed. Thus, the sample consists of 337 women and 329 men. Of these, 542 men and women belong to the same family. In each family where both the man and the woman were interviewed, they were interviewed separately to elicit their independent WTP for the drum seeder, without influence from their partner or any other family members.

The most relevant attributes of drum seeders and their levels were identified after a careful review of literature and consultations with agronomists and extension experts familiar with the study area. The attributes were then pretested, as were the levels in focus groups with male and female farmers in the study area. The authors conducted 41 focused group discussion (FGD) sessions in 6 villages; 185 men and 70 women attended the sessions. The authors organized FGDs for women and men separately to get their independent inputs on key attributes that may guide their choice of a drum seeder for DSR.

Paddy yield is one of the most important attributes that farmers consider when deciding to adopt a new technology or variety. Studies show that yields could increase by a significant amount per hectare with the adoption of DSR (Ali, Erenstein, and Rahut 2014; Singh et al. 2008). Rice is a labor-intensive crop; farmers in the study area face acute labor scarcity, especially during time-sensitive operations like transplanting and harvesting. Therefore, labor saving is the second most important attribute for respondents. DSR avoids nursery raising and transplantation and thus reduces the labor required for growing rice. As mentioned in Section 2, because more weeds grow in DSR than in transplanted rice, farmers have to apply weedicides in DSR. Weedicide cost is the third consideration for farmers. Finally, DSR requires a drum seeder. The price of a drum seeder was included as an attribute with four distinct levels (4,000, 5,000, 6,000, and 7,000 INR) to allow for the estimation of money metric measures for WTP and welfare comparisons. Table 4.1 summarizes the attribute-level specifications for the choice experiment.

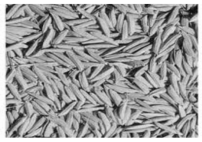
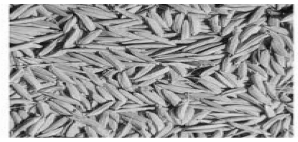
Table 4.1 Selected attributes and the levels used in the choice experiment for direct-seeded rice with drum seeder

Attribute	Definition	Levels
Seed rate (kg)	Amount of seed required for 1 acre of land	5, 10, 15, 20
Labor saved (in person-days)	Number of labor saved in 1 acre of land	8, 10, 12
Yield increment (kg)	Yield increment is considered in DSR	50, 100, 150, 200
Weedicide cost (INR)	Weedicide costs in DSR with drum seeders is considered	400, 600, 800, 1,000
Drum seeder price (INR)	Price of the drum seeder	4,000, 5,000, 6,000, 7,000

Source: Authors.
Note: DSR = direct-seeded rice; INR = Indian rupees.

The authors used the “dcreate” module in Stata to generate a D-optimal design that takes into account all main effects. This module used the modified Fedorov search algorithm (Cook and Nachtsheim 1980; Zwerina, Huber, and Kuhfeld 1996; Carlsson and Martinsson 2003) to create an efficient design. The authors generated 36 unique choice sets that were randomly allocated into 4 blocks of 9 choice sets each to reduce the probability of respondent fatigue. Respondents were then randomly assigned to respond to the choice tasks presented in one of these four groups, with an even number of households allocated to each group. Each choice set consisted of two alternatives and a status quo option. (Figure 4.2 provides an example of a choice set.) Illustrations (as in Figure 4.2) were used to increase respondents’ comprehension of the attributes and levels presented in each choice set.

Figure 4.2 Example of choice set presented to survey respondents (Block1: Set 3)

DSR (drum seeder) characteristics	Option A	Option B	My current practice
Seed rate (kg)	 5 kg/acre	 10 kg/acre	**Status Quo:** **I like neither A nor B. I prefer to cultivate with same traditional method.**
Labor saved (person-days)	 12 person-days/acre	 8 person-days/acre	
Yield increment (kg)	 200 kg/acre	 50 kg/acre	
Cost of equipment (INR)	 5,000 INR	 4,000 INR	
Weedicide cost (INR)	1,000 INR/acre	600 INR/acre	

Source: Authors.
Note: DSR = direct-seeded rice; INR = Indian rupees.

In addition to collecting data for the choice experiment, the authors conducted a survey to collect information on household and individual characteristics (including demographic and socioeconomic characteristics, main and subsidiary occupation, and interest in agriculture) and rice cultivation (production; productivity; and use of various inputs, such as family and hired labor, irrigation, fertilizer, and so on) from each respondent independently. These additional sources of information are relevant for further understanding the determinants of the WTP, especially as it pertains to preference heterogeneity both between and within households. Table 4.2 summarizes the respondents in the sample on some of these important dimensions.

Table 4.2 Summary statistics of the sample households

Variable	Women	Men	t-test of significance difference in means/proportions
Land and personal characteristics			
Average age of respondent (years)	41.5	46.4	-4.7839***
Own land (acres)	3.7	3.9	-0.49615
Family size (number of persons)	6.3	6.6	-1.2454
Farming experience (years)	24.3	26.9	-2.7506***
Education			
Illiterate (%)	48.2	25.6	6.0302***
Primary (%)	19.0	23.5	-1.3949
High school (%)	16.7	24.1	-2.3748**
Above high school (%)	16.1	26.8	-3.3802***
Institutional membership, extension, and awareness			
Member of registered farmer group (%)	1.2	3.1	-1.6845*
Member of self-help group (%)	36.6	48.0	-2.9725***
Like farming as a profession (%)	32.3	33.3	-0.27135
Is soil tested earlier (%)	9.5	8.3	0.57256
Migrate for off-farm employment opportunities (%)	17.6	21.4	-1.2511
Crop insured at any time (%)	6.0	8.9	-1.4359
Markets and institutional variables			
Access to input market (%)	26.8	45.0	-4.8802***
Access to output market (%)	20.8	38.7	-5.0435***
Access to credit facilities (%)	9.2	28.0	-6.2394***
Access to weather advisory (%)	27.2	39.8	-3.4346***

Source: Authors' estimates.
Note: ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively.

Female farmers in the sample are, on average, younger and less educated and have fewer years of experience in farming than the men in their families.[3] The women have poorer access to input and output markets, credit and extension, and weather advisory. Women are also less likely to be members of farmer institutions and other village-level representative bodies, such as the village council (*gram sabha*). Two-thirds of men and women in the sample dislike farming as a profession because of the drudgery, low profits, and high risk.

Respondents were also asked questions from the Women Empowerment in Agriculture Index (WEAI) to measure the roles and extent of women's engagement in the agriculture sector in five domains—agricultural production, resources, income, leadership, and time. WEAI measures the empowerment, agency, and inclusion of women in the agriculture sector in an effort to identify ways to overcome those obstacles and constraints (Alkire et al. 2013). The WEAI module was administered to both male and female respondents in the sample. The module consists of a series of questions; respondents are asked to rate the extent to which they could make decisions, if they wanted to, in different domains in their lives. They were asked to give a rating from 1 to 5, with 1 denoting "no say" and 5 denoting "complete say." Table 4.3 presents the self-reported ratings of women and men in the sample on their say in different decision domains in the family using the WEAI module.

[3] This is because women are almost always younger than their husbands in Indian marriages.

Table 4.3 Summary statistics from the Women's Empowerment in Agriculture Index

Variable	Men	Women	Difference	t-test
To what extent do you feel you can make decisions if you want(ed) to:				
Food crop farming	4.671	3.894	0.778	9.893***
	(0.036)	(0.069)		
Agricultural production	4.434	3.634	0.801	9.381***
	(0.040)	(0.076)		
Inputs to buy	4.521	3.691	0.829	10.224***
	(0.039)	(0.072)		
Crops to grow	4.407	3.732	0.675	8.108***
	(0.046)	(0.069)		
Crops to market	4.451	3.495	0.956	6.951***
	(0.063)	(0.142)		
Own wage salary	4.378	3.904	0.475	5.848***
	(0.044)	(0.069)		
Who, according to you, can decide whether to buy, sell, or rent/mortgage (self)?				
Farm equipment (nonmechanized)	0.379	0.092	0.287	9.262***
	(0.027)	(0.016)		
Farm equipment (mechanized)	0.0703	0.002	0.067	4.713***
	(0.014)	(0.002)		
Leadership: Public speaking				
Do you feel comfortable speaking up in public?	0.406	0.274	0.132	3.545***
	(0.027)	(0.025)		
Time: Workload and leisure				
Did you work more than 10.5 hours in the previous 24 hours?	0.539	0.762	-0.222	-6.142***
	(0.028)	(0.023)		
How would you rate your satisfaction with your available time for leisure activities?	4.5	3.494	1.006	5.705***
	(0.119)	(0.129)		

Source: Authors' estimates.
Note: Figures in parentheses are standard errors. *** denotes significance at the 1 percent level.

Women in the sample worked longer and enjoyed less leisure time than the men; they also had significantly less say in household decision making, including decisions about crop production and the use of crop income. Among different aspects of farming, decisions to purchase, sell, or rent mechanized or nonmechanized farm equipment are almost entirely the men's domain, with women having very little say. Extension and subsidy policies for mechanization should not reinforce this gender asymmetry between contribution to and control over farming. The WEAI module also shows that although the men in the sample households are more privileged than women, the latter do have a considerable say in many different decision domains of farming.

5. RESULTS

Table 5.1 presents the results of the random parameters logit model. The table shows three sets of results: one for the full sample of respondents (pooled) and one each for the male and female farmers in the sample. The top panel shows the posterior mean values of the marginal utility parameter, which explains the relative value associated with each attribute level. The bottom panel shows the posterior mean values of standard deviations for the normally distributed marginal utility parameter, indicating the heterogeneity in farmers' preferences for each attribute. Except for the weedicide cost, the standard deviations of all attributes in both the full sample and the women-only sample are statistically significant, indicating a clear rejection of homogeneous preferences for these attribute levels.

Table 5.1 Estimation of random parameters logit results

Variable	Pooled	Men	Women
Random marginal utility parameters			
Seed rate (kg)	-0.01567**	-0.01906**	-0.01482
	(0.00641)	(0.00803)	(0.0103)
Labor saved (person-days)	0.20763***	0.14591***	0.2896***
	(0.01716)	(0.02251)	(0.02433)
Yield increment (quintals)	0.95118***	1.30505***	0.68066***
	(0.06642)	(0.10559)	(0.08177)
Weedicide cost (INR)	-0.00004	-0.00015	-0.00007
	(0.00012)	(0.00022)	(0.00016)
Nonrandom marginal utility parameter			
Price of DSR (INR)	-0.00088***	-0.00093***	-0.00086***
	(0.00004)	(0.00005)	(0.00005)
Distribution parameters			
Standard deviation (seed rate)	0.04658***	0.027997*	0.07928***
	(0.00838)	(0.01645)	(0.01028)
Standard deviation (labor saved)	0.13533***	0.07062**	0.13779***
	(0.00838)	(0.01208)	(0.01282)
Standard deviation (yield increment)	0.20774*	-0.01035	0.54613***
	(0.10978)	(0.01179)	(0.11268)
Standard deviation (weedicide cost)	0.00018	0.00008	0.00037**
	(0.00018)	(0.00011)	(0.00017)
Log likelihood	-4213.1788	-1788.1942	-2319.042

Source: Authors' estimates.
Note: INR = Indian rupees; DSR = direct-seeded rice. Standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively.

The regression coefficients on the price of the drum seeder are negative in all three cases, indicating that both male and female farmers prefer cheaper drum seeders to the more expensive ones. This coefficient can be used to generate money-metric WTP measures for each attribute level. Table 5.2 shows the estimated WTPs of each attribute for the whole sample and for subsamples of female and male farmers.

Table 5.2 Estimated willingness to pay (RPL Model) for direct-seeded rice drum seeder attributes

Variable	Mean	Lower	Upper
Pooled			
Seed rate (kg)	-17.814	-33.788	-2.920
Labor saved (person-days)	236.038	207.591	264.995
Yield increment (quintals)	1081.309	951.363	1202.904
Weedicide cost (INR)	-0.042	-0.305	0.209
Men			
Seed rate (kg)	-20.561	-38.689	-2.928
Labor saved (person-days)	157.416	120.789	193.560
Yield increment (quintals)	1408.008	1228.597	1577.995
Weedicide cost (INR)	-0.164	-0.595	0.272
Women			
Seed rate (kg)	-17.175	-44.165	7.086
Labor saved (person-days)	335.648	295.986	379.038
Yield increment (quintals)	788.898	611.896	955.412
Weedicide cost (INR)	-0.084	-0.437	0.247

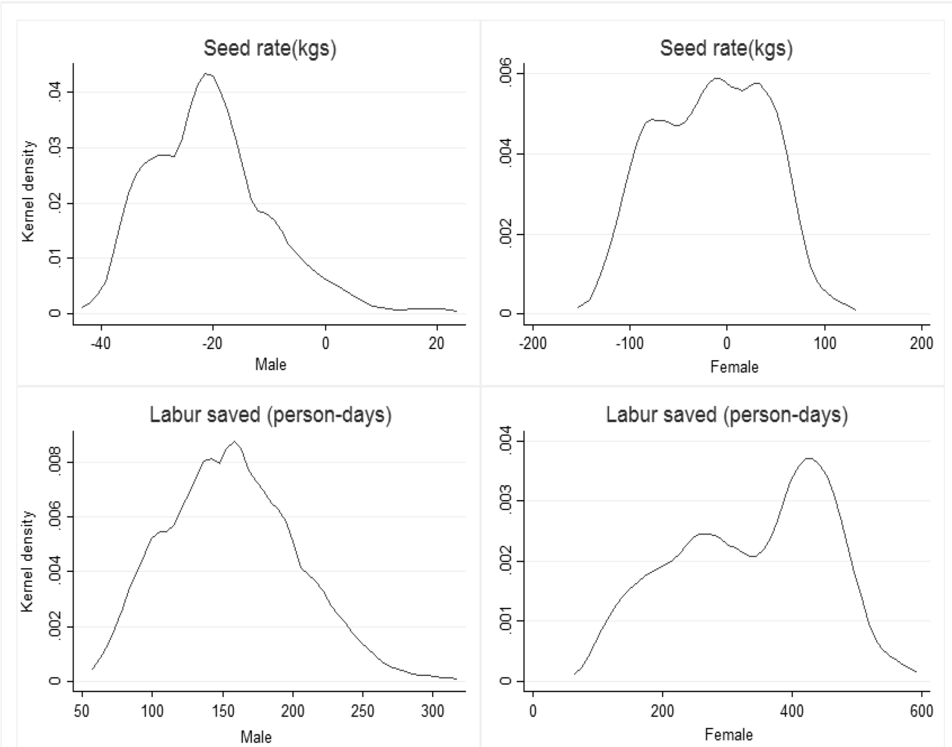
Source: Authors' estimates.
Note: INR = Indian rupees. Confidence interval derived using bootstrap procedure introduced by Krinsky and Robb (1986) based on 1,000 random draws with mean and variance-covariance matrix of the estimated model parameter.

On average, women are willing to accept a marginally smaller amount for an increase in the seed rate than men (17.2 INR/kg for women versus 20.6 INR/kg for men). Values for both men and women are close to the average price of the paddy seed in the region. When it comes to labor saving, women, who contribute the bulk of the labor for rice cultivation, value it significantly more than the men in their families (335.6 INR/person-day versus 157.4 INR/person-day). The average valuation for labor saving by women is slightly more than the agricultural wage rates reported in the study area, while men value it less than the going wage. Unlike labor savings, men seem to value yield enhancements more than women (1,408.0 INR/quintal for men versus 788.9 INR/quintal for women). The value placed on additional yield by men is around the farm-harvest price of paddy in the region. Average marginal valuation of yield enhancement is less than the market rates. Thus, although both men and women care about the price of the drum seeder and the cost savings or yield increases it may bring, the relative valuations of men and women vary in expected ways. Men care more about cost savings and yield enhancement, whereas women have relatively higher valuation for reduction in labor requirement.

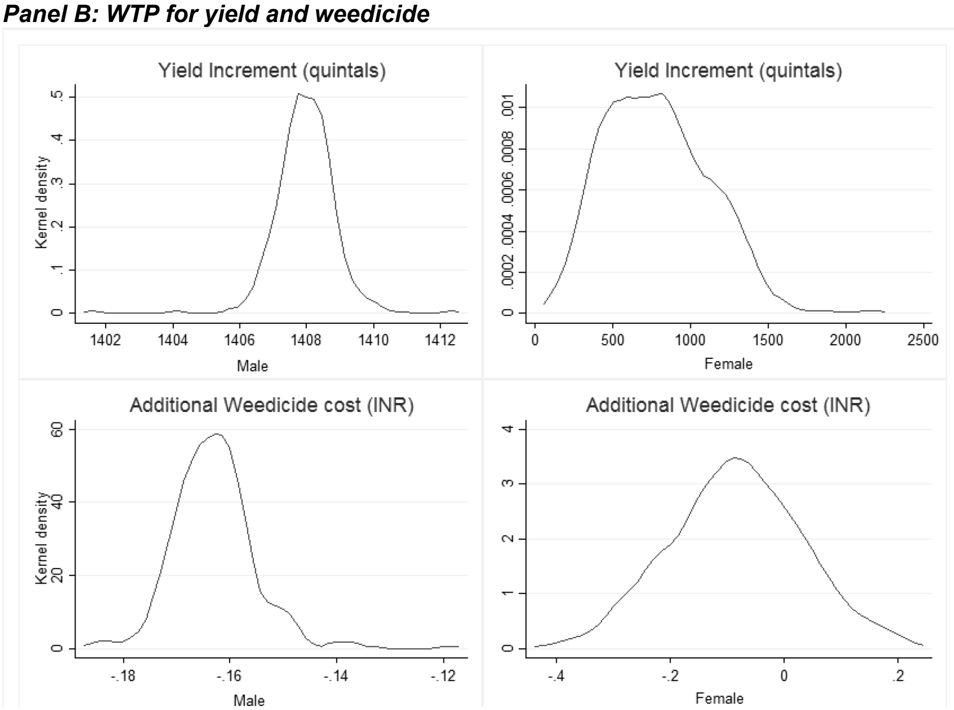
Figure 5.1 plots the kernel density of marginal WTP for different attributes of DSR for both male and female farmers. Table 5.3 presents results of the t-test of differences between mean values of marginal WTP for different attributes of DSR. The mean values of marginal WTP for seed savings is higher for men than for women; men also have a higher marginal WTP for higher yield. Women, however, have a significantly higher marginal WTP for labor saving due to DSR than men. The kernel density plots show wider dispersion in marginal WTP for all attributes for women than for men. Figure 5.2, which plots the kernel density for the total WTP for a typical drum seeder, shows that the total WTP for a typical DSR peaks at a lower value for men than for women. Again, women's WTP is more widely dispersed than the men's. Comparing the average total WTP for a drum seeder with its market price suggests that a capital subsidy is needed to promote its adoption by farmers in the study area.

Figure 5.1 Individual-level marginal willingness to pay for direct-seeded rice attributes

Panel A: WTP for seed and labor



Panel B: WTP for yield and weedicide



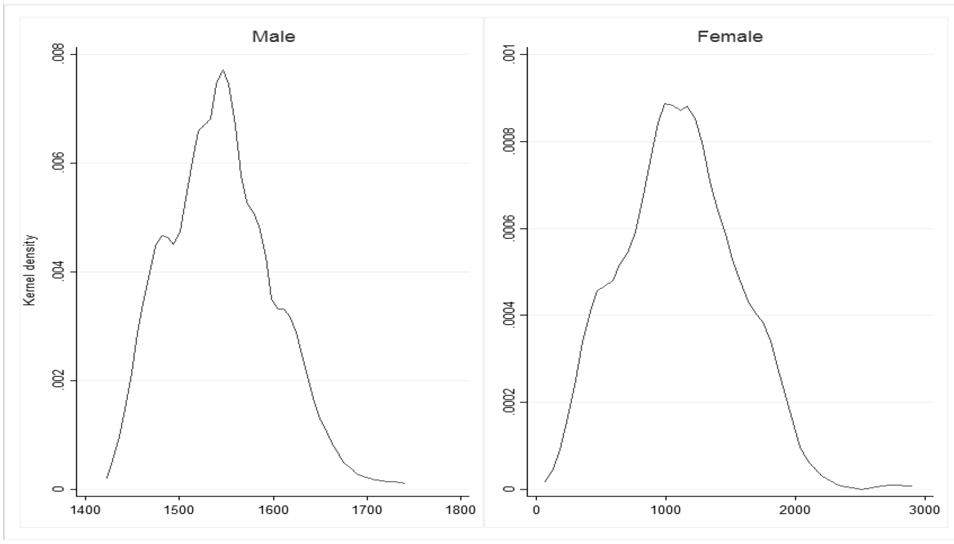
Source: Authors' estimates.
Note: WTP = willingness to pay. Marginal willingness to pay (in Indian rupees) is shown on the horizontal axis.

Table 5.3 T-test results of the difference between men and women marginal WTP for direct-seeded rice with drum seeder attributes

Variable	Men	Women	Diff.	T-test of sig. diff. in means
Seed rate (kg)	-20.45	-16.48	-3.98	-1.27
Labor saved (person-days)	157.04	336.53	-179.49	26.39***
Yield increment (quintals)	1407.96	787.41	620.54	33.83***
Weedicide cost (INR)	-0.16	-0.08	0.08	12.39***

Source: Authors' estimates.
Note: INR = Indian rupees. *** denotes significance at the 1 percent level of significance

Figure 5.2 Individual-level total willingness to pay for direct-seeded rice with drum seeder



Source: Authors' estimates
Note: Total willingness to pay (in Indian rupees) is shown on the horizontal axis.

In this choice experiment, farmers faced 5,940 choice situations in which they had to choose between either of two different combinations of DSR with drum seeder and the status quo option of transplanted rice. One in five times, farmers in the sample chose to stay with the status quo option. Table 5.4 compares the average probability of selecting either one of the two DSR combinations over the status quo between men and women in the family (household fixed effect) for the same choice sets (card fixed effect). Men are 20 percent less likely than the women in their families to choose DSR over the status quo. Thus, the female farmers in the sample seem to show more interest in adopting this new technology than men.

Table 5.4 Linear probability model comparing men's and women's probability of selecting direct-seeded rice with drum seeder over the status quo option in choice situations

Dependent variable: "Choose either of the two DSR with drum seeder combinations"	All households
Male respondent	-0.1950***
	(0.0187)
Constant	0.9952***
	(0.0931)
Card fixed effect	Yes
Household fixed effect	Yes
No. of observations	5867
R^2	0.4025

Source: Authors' estimate.
Note: DSR = direct-seeded rice. *** denotes significance at the 1 percent level. Figures in parentheses are standard errors, which are clustered at the individual level.

Next, the authors ran simple linear regressions, with the mean total WTP for the drum seeder as a dependent variable and a set of respondent and household characteristics as independent variables; these were used to understand factors that determine willingness to adopt (Table 5.5) for the full sample and the subsample of households in which both a man and a woman took part in the choice experiment. Although the dependent variable in Table 5.5 is some measure of WTP, it can be taken as a measure of the probability of adoption (Ward et al. 2015). Men have significantly lower average total WTP for drum seeder than women, which is contrary to the findings of Akter et al. (2016), who found that women's WTP for weather-indexed insurance in Bangladesh was significantly less than men's. WTP is not higher for farmers who own more land. However, educated farmers are more likely to adopt a drum seeder than illiterate ones. Farmers who like farming as a profession and are aware of government policies, such as the minimum support price of rice, have a significantly higher WTP. Farmers who said in the post experiment survey that they were considering adoption of DSR are also likely to pay more for the drum seeder.

Respondents with greater workload (those who worked more than 10.5 hours in a day) are more likely to adopt this labor-saving technology, though the difference is statistically not significant. Working in government workfare program, Mahatma Gandhi National Rural Employment Guarantee Scheme, and having better access to input and output markets, credit facilities, and weather advisory are positively associated with WTP for drum seeder; however, all these coefficients are statistically not significant.

Table 5.5 Determinants of total willingness to pay for the drum seeder

Dependent variable : Mean WTP	Full sample	Households with 2 respondents
Land owned (hectares)	2.8128	2.5410
	(2.0987)	(2.6095)
Average age of the respondent (years)	0.7084	1.0835
	(0.6196)	(0.7579)
Gender (men = 1, else = 0)	-93.1631***	-88.7659***
	(14.1457)	(16.5899)
Scheduled tribe (yes = 1, else = 0)	11.5258	43.3328**
	(18.0883)	(20.0730)
Primary education (%)	51.6877**	54.3138**
	(24.3932)	(25.3882)
High school education (%)	40.5572*	52.1023*
	(22.4817)	(26.6340)
Above high school education (%)	63.4655***	73.9729***
	(19.0683)	(22.7417)
Planning to use DSR drum seeder (%)	98.8973***	111.9289***
	(20.3575)	(23.8922)
Migrate for off-farm employment opportunities? (%)	-18.0504	-2.5952
	(21.3456)	(18.2813)
Member of self-help group? (%)	14.8968	23.6014
	(18.4077)	(19.9791)
Like farming as a profession? (%)	30.7038**	39.1254**
	(13.9497)	(17.6413)
Awareness of minimum support price? (%)	100.0034***	101.6704***
	(26.8772)	(26.9441)
Workload (work for more than 10.5 hours)	25.3472	14.3723
	(18.1257)	(21.7355)
Working in MGNREGS	13.3335	8.9300
	(22.5393)	(27.1465)
Access to input market (%)	9.8028	6.1369
	(24.5999)	(23.7012)
Access to output market (%)	19.4466	34.4348
	(24.3787)	(22.7103)
Access to credit facilities (%)	8.6710	12.7241
	(15.6803)	(18.6563)
Access to weather advisory (%)	17.8597	15.5068
	(14.7894)	(18.7852)
Constant	1095.2106***	998.7731***
	(52.8667)	(53.6846)
Number of observation	650	527
R-squared	0.2052	0.2120

Source: Authors' estimate.

Note: WTP = willingness to pay; DSR = direct-seeded rice; MGNREGS = Mahatma Gandhi National Rural Employment Guarantee Scheme. The dependent variable is individual-level estimated mean total willingness to pay. Village-level clustered standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively.

6. CONCLUSION

This paper examines male and female rice farmers' preference heterogeneity for DSR with drum seeders in Maharashtra, a state in the western part of India where both the farmers and the state government are interested in DSR. In 2011, women constituted 46.2 percent of all agricultural laborers and 32.9 percent of all cultivators in India. Women's contribution in rice-growing areas is even higher. Women perform the bulk of the backbreaking work involved in transplanting rice, weeding fields, and harvesting. Direct seeding of rice with equipment such as drum seeders can reduce the labor required in rice cultivation (as well as offer other benefits, such as yield gain, lower seed requirement, higher profits, and reduced carbon footprint). However, India's extension system is male dominated and tends to ignore female farmers in promoting new technologies and practices. For example, very few women in the study sample reported having received any extension inputs from government or private extension agents. The extension system tends to target only men, perhaps because women in the family traditionally have very little say in the purchase, adoption, or use of farm equipment and less control over decisions to hire farm laborers and spend family income. This may be one reason that much of the research on technology adoption also ignores female farmers.

In recent years, however, there is a growing emphasis in all development programs, including programs to promote climate-smart agriculture, to actively target female farmers, who are more vulnerable to climate change (Arora-Jonsson, 2011) but are often left out due to existing gender inequalities in education, ownership of and access to land and financial resources, ability and freedom to interact with the outer world, and the reach of extension programs. Women may have very different preferences from the men in the family, given their different roles and responsibilities. This is especially true in decisions related to rice farming in South Asia, where women do bulk of the work. Therefore, it is important that studies exploring preference for climate-smart technologies in rice farming include female farmers in their sample.

This study tried to account for heterogeneity in preferences for DSR with drum seeders between women and men by drafting both female and male farmers in the discrete choice experiment. The findings suggest that any strategy to promote the adoption of DSR drum seeders should take heterogeneous preferences of female farmers into account. The findings also indicate that women have different relative valuations for different attributes of drum seeders. Women seem to value reduction in labor requirement (and possibly the accompanying drudgery) significantly more than the men, whereas men value reduction in seed costs more than the women. Women's higher marginal valuation for labor saving is probably due to the fact that they contribute the bulk of the labor for rice cultivation. Both women and men prefer cheaper drum seeders and are likely to adopt them only if they are heavily subsidized from their current market prices. However, a key finding of this experiment is that women are more interested in adopting DSR with drum seeders and are willing to pay more for it than the men in their families.

The study's findings of women having higher WTP for a new technology runs somewhat contrary to the existing literature on technology adoption, which shows that women have slower observed rates of adoption of a wide range of technologies than men (Doss and Morris 2000) and lower WTP for new products, such as weather-indexed insurance (Akter et al. 2016), probably due to greater time and resource constraints, lower human capital endowment (education and exposure to the outer world), and poorer access to complementary inputs (Kamwamba-Mtethiwa et al. 2012). In this sample, women are more interested in and are willing to pay more for a new technology that promises to reduce the backbreaking work.

Women in rural Maharashtra work harder in rice cultivation, but they have a significantly lower say than the men in household decisions related to farming, such as choice of crops, inputs to buy, and the adoption and purchase of new technologies and equipment. This study also found, however, that although women have less say than the men in their families, they are not completely powerless. In fact, women do have a considerable say in many household decisions. Therefore, existing development programs, including agriculture extension, should not ignore women when promoting new climate-smart technologies, products, or practices, as ignoring women may reinforce the existing gender inequalities. Given women's interest in new and better technologies, extension for the promotion of DSR drum seeder is likely to be more successful if it also targets female farmers and highlights the attributes of the technology that are of greater interest to them.

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NASC, DPS Road, Opp Todapur, Pusa
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Tel.: 91 11 2584-6565
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