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Bi-Modal Preferences for Bt Maize in the Philippines: A Latent Class Model

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The only country in Asia to have approved a biotech food or feed crop is the Philippines, where Bt maize was initially commercialized in 2003. This study uses the choice experiment method and a latent class model to differentiate among maize producers and estimate their willingness to pay for Bt seed and other important attributes. Two segments are identified with markedly different willingness to pay and different preferences with respect to information and seed acquisition. The bi-modality of preferences confirms the importance of marketing and extension strategies that are tailored to the diversity of farm populations and agro-ecologies of the maize sector in the Philippines. The supply of credit for seed acquisition is likely to constitute an important policy instrument for diffusing all improved, yellow maize seed, including both biotech and non-biotech hybrids. The authors consider the choice experiment method as an appropriate technique to investigate the preferences of new seed adopters but caution applied researchers regarding its hypothetical bias, framing, and preparation.

Key words: Bt maize, Philippines, choice experiment, latent class model.

Introduction

Asia is the home of the Green Revolutions in wheat and rice (Hazell, 2010), as well as more than half of the world's poor people, but has been slow to introduce biotech food or feed crops. The only country in Asia to have approved a biotech food or feed crop is the Philippines, where *Bacillus thuringiensis* (Bt) maize was initially commercialized in 2003. Not only is the Philippines unique as an adopter in its own region, but on a global scale it is among the few developing countries to adopt genetically modified (GM) maize. An in-depth study of public understanding and perceptions among a range of stakeholder groups in the Philippines (Torres, Suva, Carpio, & Dagli, 2006) found that a majority did not relate biotechnology to moral values. Most respondents expressed the belief that genetic engineering could lead to more nutritious and cheaper foods, although they remained cautious on matters of food safety and regulatory requirements for biotechnology and biotech-derived products.

In the first year of commercial adoption (2003), Bt maize (including that combined with herbicide tolerance) was grown on only 1% of the total area planted with maize—about 10,769 hectares. In 2007, an estimated 16% of maize planted was Bt. National hectarage increased to about 280,417—or by roughly 22%—in 2009 (Department of Agriculture, 2010). International Service for the Acquisition of Agric-Biotech Applications (ISAAA, 2011) reports that the area planted to biotech maize attained 541,000 ha in 2010. Bt/herbicide-tolerant (HT) maize represented the largest share of the total in that year, followed by HT maize and single-trait Bt maize. Biotech maize in the Philippines is yellow and used as feed. As a percentage of all yellow maize planted, biotech maize has increased by an estimated 5% per year, reaching 42% of area grown in 2010.

Maize is the second most important grain in the Philippines after rice and is the third largest contributor to gross value added in agriculture. Maize consumed directly as human food is white. Yellow maize is especially important for the Filipino economy as an input to the growing livestock sector, where it accounts for almost two-thirds of livestock feed formulation. The demand for yellow maize in the Philippines has been increasing since 1970s, with a large annual supply deficit (Mangabat, 1999; Teh & Yorobe, 1993; Unnevehr & Nelson, 1985). From 1969 until the recent Ginintuang Masaganang Ani (GMA) Maize Program, eight nationwide maize production programs have been launched by the government to promote the adoption of improved yellow maize (Mangabat, 1999; United Nations Development Programme, National Economic and Development Authority [UNDP-NEDA], 2005). Since 1980, Bureau of Agricultural Statistics data show that white maize production has declined, yields of white maize have dropped, and farmers have reallocated crop area toward yellow maize and/or higher-value crops like sugarcane and vegetables (Gerpacio, Labios, Labios, &

Diangkinay, 2004). Yields of yellow maize have persistently risen.

At the same time, throughout much of Asia, and especially Southeast and East Asia, rapid economic growth and accelerating urbanization have caused a pronounced shift away from traditional rice-based diets toward consumption of a broader range of foods, including meat and dairy products. Given growing incomes and high population densities in the region, this change is generating a major, demand-driven impetus for livestock production and a derived demand for feed (Gerpacio & Pingali, 2007). As a region, Asia now produces more than half of the world's pork and poultry; roughly three-quarters of maize production in the Philippines, which is among the fourth in maize production in the region after China, India, and Indonesia, is destined for feed (Erenstein, 2010). In the meantime, integrating livestock into smallholder farming systems also has an impact on the magnitude and stability of income sources.

The broadening of the seed market for yellow maize hybrids provided the impetus for public and private investments in crop improvement to sustain yield growth and address biotic and abiotic constraints in maize farming. During the 1980s, the Asian corn borer (*Ostrinia furnacalis* [Lepidoptera]) became a major maize pest in the Philippines, and its infestation was widespread (Logrono, 1998). The Asian corn borer is considered most destructive pest of maize in the Philippines (Morallo-Rejesus, 2002), and significant efforts have been directed toward managing it through biological means.

In this research, we analyze the preferences of farmers in the maize seed market of two of the major maize-producing provinces in the Philippines—Isabela and South Cotabato. Farmers are grouped into market segments based on their characteristics and willingness to pay (WTP) for the maize seed attributes they consider to be important. The most important maize seed attributes were identified by farmers in focus group discussions (FGDs) conducted in the two study sites. These include: seed price, payment method (whether the option of credit is available in addition to payment in cash), whether the seed is Bt or non-Bt, the source of the information regarding the seed, and the percentage of yield lost because of the seed's susceptibility to Asian corn borer.

We apply the choice experiment method to estimate farmers' WTP for each seed attribute and to rank attributes in terms of their relative importance. Data were collected from 464 maize-producing households. A focus of this analysis is the heterogeneity of preferences among farmers, which has implications for seed-industry development and policy because it implies that farmers will not respond uniformly to economic incentives. In order to examine heterogeneity in the sample, we employ a latent class model (LCM). The advantage of the LCM is that it simultaneously identifies the characteristics that differentiate farm households and the values that these farm households derive from seed attributes (Boxall & Adamowicz, 2002).

The next section describes the theoretical framework of the choice experiment method and the LCM, the choice experiment design, and survey administration. The institutional context of seed supply in farming communities, as well as the characteristics of the study sites and farmers surveyed, are then presented, followed by the econometric results. The final section draws policy implications for adoption of Bt maize in the Philippines and highlights challenges and limitations of the method used.

Choice Experiment Approach

Theoretical Framework

The choice experiment approach is theoretically grounded in Lancaster's model of consumer choice (Lancaster, 1966), which proposed that consumers derive satisfaction not from the goods themselves, but from the attributes they provide. The choice experiment method also has an econometric basis in models of random utility (Luce, 1959; McFadden, 1974), which integrate behavior with economic valuation. In the choice experiment approach, the utility of a choice is comprised of both a deterministic component and an error component that is independent of the deterministic part and follows a predetermined distribution. The error component implies that predictions cannot be made with certainty; choices made among alternatives will be a function of the probability that the utility associated with a particular option is higher than that associated with other alternatives (Hensher, Rose, & Greene, 2005).

When estimating preferences, the heterogeneity of the preferences in the sample should be accounted for through the use of an appropriate model. Accounting for preference heterogeneity reduces the potential for biased estimation of individual preferences, and hence enhances the accuracy and reliability of demand, marginal welfare, and total welfare estimates (Greene, 2008). Furthermore, accounting for heterogeneity leads to policy recommendations that take equity concerns into account. Information about who will be affected by a policy change and the aggregate economic value associated with such change is necessary in order to design targeted, efficient, effective, and equitable policies and interventions (Boxall & Adamowicz, 2002).

A number of alternative models have been developed to address heterogeneity, including the covariance heterogeneity (CovHet) model (Colombo, Hanley, & Louviere, 2009), the random parameter (mixed) logit (RPL) model (Greene & Hensher, 2003; McFadden & Train, 2000; Rigby & Burton, 2005; Train, 1998), and the LCM (Louviere, Hensher, & Swait, & Adamowicz, 2000; Swait, 1994). Colombo et al. (2009) compared the approaches in detail. The LCM has been successfully used to identify the sources of heterogeneity at the segment (or group) level. The CovHet and RPL models capture heterogeneity at the individual level. Investigation of heterogeneity at the segment level is most policy-relevant when assessing the farmers' demand and marketing and promotion strategies for new products. With the purpose of better understanding an emerging seed market, we consider the LCM as the most appropriate model to investigate the preferences of new seed adopters.

The LCM casts heterogeneity as a discrete distribution by using a specification based on the concept of endogenous (or latent) preference segmentation (Wedel & Kamakura, 2000). The approach depicts a population as consisting of a finite and identifiable number of segments or groups of individuals. Preferences are relatively homogeneous within segments but differ substantially across segments. The number of segments is determined endogenously by the data. The allocation of an individual into a specific segment is probabilistic, and depends on the respondent characteristics. Respondent characteristics indirectly affect choices through their impact on segment membership.

A growing number of studies, including some conducted in developing countries, have used this approach to estimate the preferences of farmers and consumers for agricultural technologies and foodstuffs. For example, Scarpa et al. (2003); Ouma et al. (2007); and Ruto, Garrod, and Scarpa (2008) employed this model for the valuation of livestock attributes. Hu, Hünnemeyer, Veeman, Adamowicz, and Srivastava (2004); Kontoleon and Yabe (2006); and Kikulwe, Birol, Wesseler, and Falck-Zepeda (2011) used the LCM to explore consumer preferences for GM food. Birol, Villaba, and Smale (2009) used it to examine farmer preferences for agrobiodiversity conservation and GM maize adoption.

In the LCM applied here, the utility that Farmer i (who belongs to a particular Segment s) derives from choosing maize seed alternative $j \in C$ can be written as

$$U_{ij/s} = \beta_s X_{ij} + \varepsilon_{ij/s}\,, \tag{1}$$

where X_{ij} is a vector of attributes associated with Maize Seed Alternative j and Farmer i, and β_s is a segment-specific vector of taste parameters. The differences in β_s vectors enable this approach to capture the heterogeneity of preferences with respect to maize seed attributes across segments. Assuming that the error terms are identically and independently distributed (IID) and follow a Type I (or Gumbel) distribution, the probability of Alternative j being chosen by the i^{th} individual in Segment s is then given by

$$P_{ij/s} = \frac{\exp(\beta_s X_{ij})}{\sum_{h=1}^{C} \exp(\beta_s X_{ih})}\,. \tag{2}$$

M^* is a segment membership likelihood function that classifies the farmer into one of the S finite number of latent segments with some probability, P_{is}. The membership likelihood function for Farmer i and Segment s is given by $M_{is}{}^* = \lambda_s Z_i + \xi_{is}$, where Z represents the observed characteristics of the farm household, such as their social and economic descriptors, and variables related to maize production. Assuming that the error terms in M^* are IID across consumers and segments—and follow a Gumbel distribution—the probability that Farmer i belongs to Segment s can be expressed as

$$P_{is} = \frac{\exp(\lambda_s Z_i)}{\sum_{k=1}^{S} (\lambda_k Z_i)}\,, \tag{3}$$

where λ_k (k=1,2…,S) are the segment-specific parameters to be estimated. These denote the contributions of the various farmer characteristics to the probability of segment membership. A positive (negative) and significant λ implies that the associated farmer characteristic, Z_i, increases (decreases) the probability that the Farmer i belongs to Segment s. P_{is} sums to 1 across the S latent segments, where $0 \leq P_{is} \leq 1$.

By bringing Equations 2 and 3 together, we can construct a mixed-logit model that simultaneously accounts for maize seed choice and segment membership. The

Table 1. Maize seed attributes and attribute levels used in the choice experiment.

Seed attributes	Definition	Attribute levels
Yield loss	Percent of yield lost due to the pest, Asian corn borer. Farmers were asked to consider all good and bad years for pest infestation and yield loss in their farming experience. They were then told to consider the next five years. In any single season, the yield they will probably lose due to the pest depends on the seed chosen. The percentage of yield that could be lost was specified in four levels.	15% , 20%, 40%, 70%*
Bt maize	Whether the maize seed is Bt variety or non-Bt variety. Farmers were told that for a long time, plant breeders have used male and the female plants to make new maize seed that has characteristics of both the mother and father. They were told that breeders can insert one characteristic into the plant without changing the others. An example is Bt maize. Bt is an organism that organic farmers have sprayed to control pests. Plant breeders insert this organism into the maize plant in order to make it resistant to the pest.	Bt maize vs. non-Bt maize**
Information	Information about the performance of the new seed could be provided either by another farmer or by an input supplier.	Farmer informant vs. input supplier informant**
Payment	The payment for seed can be made by cash. Alternatively, there is an option to pay with credit, which carries a 25% interest rate per cropping season.	Cash or credit vs. cash only**
Seed price	The price of 18 kg of the new seed in Pesos.	600; 1,500; 2,700; or 4,900*

** Attributes with four levels were coded in cardinal-linear form.*

*** Attributes with two levels were effects coded with Bt maize, farmer informant, and cash or credit as 1, and non-Bt maize, input supplier informant and cash only as -1 (Louviere et al., 2000).*

joint unconditional probability of Farmer i belonging to Segment s and choosing Maize Seed Alternative j can be given by

$$P_{ijs} = (P_{ij/s}) * (P_{is}) = \left[\frac{\exp(\beta_s X_{ij})}{\sum_{h=1}^{C} \exp(\beta_s X_{ih})}\right] * \left[\frac{\exp(\lambda_s Z_i)}{\sum_{k=1}^{S} (\lambda_k Z_i)}\right]. \qquad (4)$$

Choice Sets

The most important maize seed attributes and their levels were identified following a thorough inventory of the maize seed varieties that are currently being sold in the Philippines, discussions with Filipino maize breeders and agricultural scientists, and FGDs with farmers in the study sites. The selected attributes and the levels they encompass are reported in Table 1.

Each one of the attributes was explained using the definition reported in Table 1. Caution was taken to emphasize that each one of the attributes is independent of the other. In other words, in this hypothetical experiment, a high price does not imply that the maize seed is Bt. However, it is inevitable that the prior experience of a respondent with Bt maize and/or the farmer's knowledge, attitude, and perceptions regarding Bt maize would have implications for understanding the experiment and choices.

A large number of unique combinations can be constructed from this number of attributes and levels included in the definition. Statistical design methods (see Louviere et al., 2000) were used to structure the presentation of the levels of the five attributes in choice sets. More specifically, an orthogonalization procedure was employed to recover only the main effects, consisting of 32 pair-wise comparisons of maize seed profiles. These were randomly blocked to four different versions with eight choice sets. Each farmer was presented with eight choice sets (the full set of choice sets is presented in the Appendix). Each set contained two maize seed profiles and the choice to "opt out" by selecting neither of the two. This choice can be considered as a status quo or baseline alternative, which is instrumental to achieving welfare measures that are consistent with demand theory (Bateman et al., 2003; Bennett & Blamey, 2001; Louviere et al., 2000). Even though there are concerns over the efficiency of orthogonal designs (Scarpa & Rose, 2008), according to Louviere et al. (2000), these are the most suitable, currently available designs (see Ferrini & Scarpa, 2007, for a discussion on this issue), especially in the absence of prior values (as was the case in this experiment).

Visual representations of the attributes and levels were included in the choice sets to facilitate farmers'

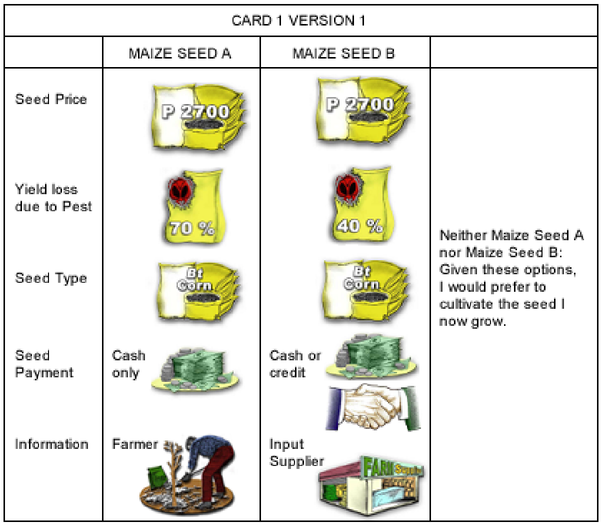

Figure 1. Example of a maize seed choice set.

understanding of the attributes and their levels. An example of a choice set is shown in Figure 1.

Survey Implementation

The choice experiment survey was undertaken from December 2007 to February 2008 in face-to-face interviews with 464 maize farmers. A three-stage sampling framework was adopted for this study. In the first stage, the provinces of Isabela and South Cotabato were selected (Figure 2).

These provinces were selected based on several criteria. First, they are two of the top four major maize-producing provinces in the country. In each, adoption of Bt maize hybrids was reported to be relatively high. Second, confined field trials of Bt maize were conducted in these sites for regulatory compliance. Private seed companies also maintain experimental areas for maize seed in each. Third, seed companies introduced Bt maize in these areas because adoption rates for hybrid maize were known to be among the highest in the country. Fourth, the two sites differ with respect to agro-ecologies, seed markets, and economic development, and the study team sought to better understand the heterogeneity of farmer preferences. It is noteworthy that selection of provinces was purposeful because of the lack of documented adoption statistics for biotech seed at the time of the survey.

In the second stage, 17 top maize producing villages were selected from these two sites to include four villages each in Tampakan, General Santos, and Cauayan, and five villages in Ilagan. This step represents a selection process with probabilities proportional to size of production. Villages selected are primarily agricultural with yellow maize as the primary grain crop, followed by rice paddy, coconut, and some fruit crops. In the third stage, a total of 464 randomly selected households were interviewed in the 17 villages. The farmers interviewed were randomly chosen from lists of all yellow maize growers in each village. Lists were provided by the village heads with a response rate of not less than 15%.

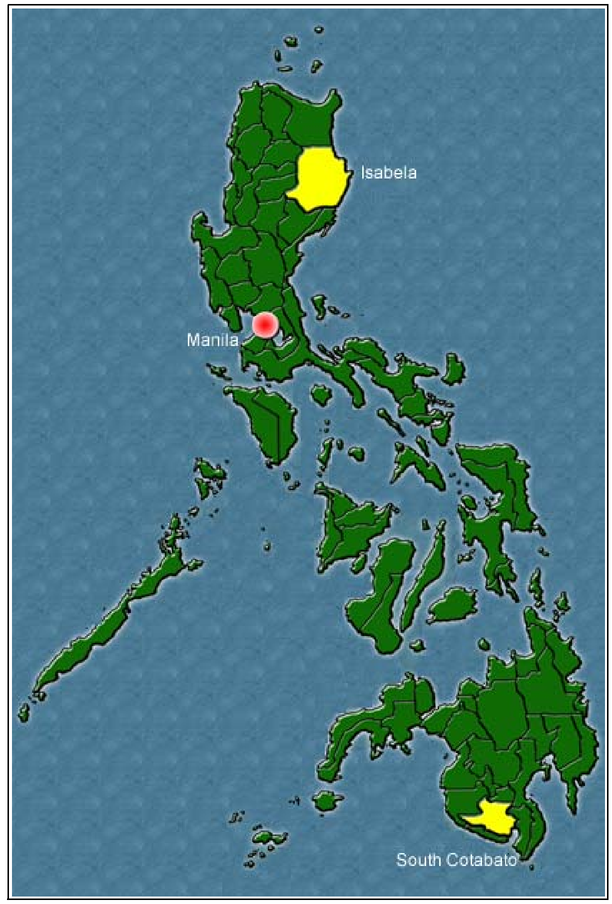

Figure 2. Location of study sites.

Thus, the set of farmers interviewed represent a random sample drawn from major-maize producing villages in the primary maize-producing provinces of the Philippines, where Bt maize is known to have been introduced and farmers are known to have experience growing yellow-maize hybrids. Data cannot be construed as nationally representative, and farmers in these areas were targeted for Bt introduction because they are more favorably disposed to yellow-maize hybrids than farmers in other areas.

The survey instruments consisted of three components. In the first part, respondents were asked questions about their knowledge, attitudes, and perceptions of biotechnology, biotech crops, and food. This was followed by the choice experiment, which consisted of an introductory section that explained the context in which choices were to be made and described each attribute in detail to ensure uniformity in comprehension of the attributes and their levels. Respondents were reminded that this was not an examination, there were no right or wrong answers, and that we were only interested in their opinions. In the third section of the survey instrument, information about farming practices and the social and economic characteristics of farm households was collected. The survey instruments are available from the authors upon request.

Characteristics of Seed Suppliers and Farmers in Study Sites

Seed Supply

Seed is supplied by both public and private institutions in the Philippines. Public institutions include government research institutions (such as the Bureau of Plant Industry), the regional offices of the Department of Agriculture, universities, and state colleges with maize breeding programs. Seeds coming from public institutions are mainly improved open-pollinated varieties of white or yellow maize, distributed through government channels and cooperatives. The market share of improved open-pollinated varieties is estimated to be only 7%.

A devolution of the extension service to local government units occurred after the Local Government Code of 1992, but this process entailed wide variation in the quality of services offered; in surveys led by Gerpacio et al. (2004), maize growers commented that services have been unable to provide sufficient, updated information on agricultural technologies—contributing to low productivity. In that study, farmers cited the cost of inputs as a major concern, including timely delivery. Farmers with adequate resources bought inputs directly from traders and input stores. Since most do not have sufficient capital to purchase them before the season, they often obtain them from private trader-financiers who provide inputs on loan, with prices higher than the prevailing rates and high interest rates (Gerpacio et al., 2004: p. 23). Repayment is charged to the crop harvested. The "bayanihan" system is a traditional form of mutual assistance that is part of Filipino farming culture, and self-help groups are widespread in villages—although, these do not appear to be focused on maize production per se. The authors also report that farmer cooperatives could be an ideal source of inputs, but few are successful enough to meet their members' needs. In addition, farmers stated that the free or subsidized hybrid seed provided by the Department of Agriculture through maize production-intensification programs often showed poor germination rates and field performance (ibid).

The corporate maize seed channel is composed of multinational firms represented by Monsanto, Syngenta, and Pioneer that supply hybrids, including biotech maize seed. These companies have experiment stations and maize seed farms located in northern and southern Philippines, with offices that serve as their seed outlets in the main cities and towns of major maize-growing provinces like Isabela and South Cotabato. These outlets are an outreach strategy to supply dispersed farmers through input suppliers. The input suppliers are generally located in the barangay (the smallest administrative division in the Philippines). Many of them are the progressive and affluent maize farmers in the area. They buy in bulk from the multinational companies at promotional prices and sell to maize farmers on credit. Aside from seeds, they also sell pesticides and fertilizers. Input suppliers usually undergo training or are supported by technicians from the multinational company to provide better information about their seed product to buyers.

In any particular cropping season, maize farmers generally have the option to purchase Bt or non-Bt hybrids or replant seeds saved from the previous harvest of landraces. Improved open-pollinated seeds distributed by the government are not as widely available and farmers who want to grow them must procure them from distant regional and provincial offices of the Department of Agriculture.

Farm and Household Characteristics

Gerpacio et al. (2004) conducted a two-stage, rapid rural appraisal and participatory rural appraisal of 24 villages in eight major maize-growing regions of the Philippines, which provides useful contextual information for our sample survey and choice experiment. The authors classify Isabela as an upland plains agroecology without very well-defined seasons, and South Cotabato as more hilly, with two distinct growing seasons. Prices of most agricultural inputs and products appear to be higher in the villages they surveyed in Isabela compared to those located in South Cotabato, and road conditions were poorer, with more distant markets. In both areas, self-financed maize farmers sell their grain in secondary

Table 2. Comparison of characteristics Bt vs. non-Bt maize farm households in South Cotabato and Isabela.

	S. Cotabato				Isabela				
	Bt N=51	Non-Bt N=71	All N=122	Diff by type	Bt N=199	non-Bt N=143	All N=342	Diff by type	Diff by site
Farmer characteristics	Mean				Mean				
Farmer's age (years)	44.2	42.9	43.4		43.6	41.9	42.9		
Farmer's education (years)	9.6	7.3	8.2		7.1	9.4	8.0	***	
Farmer's experience in maize (years)	13.1	14.2	13.7		19.1	16.6	18.0	**	***
Household monthly non-farm income (Pesos)	7,834	2,313	4,623	***	4,137	1,971	3,231	***	*
Monthly livestock income (Pesos)	5,532	1,060	2,929	*	891	673	800		**
Total maize income (Pesos)	73,107	33,394	49,996	***	58,130	43,770	52,126	**	
Value of all capital assets (Pesos)	108,158	29,540	62,677	***	107,339	76,836	94,637	*	**
Total maize area (ha)	1.70	1.30	1.50	***	1.18	1.20	1.20		***
Seed price (Pesos/18-kg bag)	4,878.0	2,878.0	3,714.0	***	5,447.1	3,293.2	4,547.0	***	***
Yield loss to Asian corn borer (%)	20.0	33.8	28.1	***	21.40	29.10	24.60	***	
Pest management score (0-8)	4.96	5.37	5.20		1.68	2.20	1.90	***	***
Distance to the seed source (km)	9.69	8.13	8.80	***	7.10	5.10	6.30	*	***
	Percent				Percent				
Farmer is male	96.1	98.6	97.5		84.9	89.5	86.8		***
Farmer owns land	74.5	69.0	71.3		87.4	64.3	77.8	***	***
Source of seed information is another famer	54.9	9.9	28.7	***	58.8	21.7	43.3	***	***
Option to pay either by cash or credit	15.7	26.8	22.1		0.5	0.0	0.3		***
Obtained seed from input supplier	92.2	90.1	91.0		30.6	37.8	33.6		***
Obtained seed from trader	5.9	0.0	2.5	**	35.7	25.9	31.6	*	***
Obtained seed from another farmer	2.0	9.9	6.7	*	17.1	23.1	19.6		***
Obtained seed from a cooperative	0.0	0.0	0.0		15.1	11.2	13.5		***

Pair-wise t-tests and Pearson chi-square tests show significant differences at 10% (*), 5% (**), and 1% (***) significance level.

markets, but maize farmers with loans from trader-financiers must sell their grain back to the credit providers who come to the villages during the harvest and haul the harvest. Trucking services may be charged to the farmer, assumed by the trader, or shared.

Table 2 compares the characteristics of Bt maize farmers with non-Bt maize farmers *within* sites and all farmers *between* sites. On average, farmers are 40-45 years of age across grower types and sites, with no significant differences. In Isabela, however, Bt maize farmers are slightly more experienced than non-Bt farmers, although they have fewer mean years of formal schooling. All farmers tend to be more experienced in Isabela, and regardless of whether they grow Bt maize, the vast majority are men. In both sites, as expected, Bt maize growers have much greater maize incomes, higher non-farm incomes, and greater wealth than non-Bt growers. Economic theory and the literature on technology adoption generally suggests that farmers with higher incomes and greater wealth have better access to technology and are less averse to risk. Mean maize incomes are not statistically different between the two sites. In South Cotabato—but not in Isabela—Bt maize growers farm larger maize areas. In Isabela, however, they are more likely to

Table 3. Criteria for determining the optimal number of segments.

Number of segments	Number of parameters	Log likelihood (LL)	ρ^2	AIC3	BIC
1	5	-2,169.05	0.20354	4,353.10	2,189.598
2	15	-1,711.14	0.5804	3,467.28	1,775.079
3	25	-1,709.51	0.5808	3,494.02	1,816.075
4	35	-1,680.45	0.588	3,465.90	1,829.640

*Notes: The sample size is 3,712 choices from 464 households (N). Equations: ρ^2 is calculated as 1-(LL)/LL(0); AIC3 (Bozdogan AIC) as (-2LL+3P); and Bayesian Information Criterion (BIC) as -LL+(P/2)*ln(N).*

own their land than those in South Cotabato. The average value of farm assets is also relatively higher in the Isabela site.

As expected, Bt maize growers in both sites pay more for seed per unit that non-Bt growers, and seed prices are higher in Isabela than in South Cotabato. The estimated yield losses of Bt maize farmers to Asian corn borer tend to be lower in Isabela. To obtain these estimates, respondents were asked to consider all good and bad years for pest infestation in their farming experience and estimate the percentage of yield they expect to lose as a result of this pest in any single season with the variety currently grown. Pest-management scores are also lower in Isabela for Bt farmers and all farmers. Pest-management scores were calculated as a sum of their positive responses (yes=1, no=0) to whether they (i) scouted for pests and diseases; (ii) followed instructions on the label if they had applied pesticides; (iii) used biological control as a pest-management practice; (iv) practiced tilling, plowing down crop residues, and weeding; (v) treated seeds before planting; (vi) adjusted planting date; (vii) used removal as a pest management practice in the most recent maize season; and (viii) have ever attended any training on pest identification and management.

Bt growers are located at a greater distance from seed sources than non-Bt growers. In both sites, more than half of Bt maize growers stated that the source of their seed information was other farmers. Furthermore, in South Cotabato, where farmers generally had the option to purchase seed for credit, a higher proportion of non-Bt growers had this option than Bt growers. More than 90% of both types obtained seed from input suppliers in South Cotabato. In that site, a minor percentage of Bt maize growers purchased seed from traders, while about 10% of non-Bt maize growers obtained seed from other farmers. Seed sources in Isabela are markedly more diversified, with little difference in the distribution of farmers by source between Bt and non-Bt maize growers.

Results

Latent Class Model

The best-fitting LCM includes total maize area the farmer cultivated in the previous season, distance to the maize seed source, the education and age of the farmer, and the farmers' pest management score. Farmer characteristics were tested for multicollinearity using Variance Inflation Factors (VIFs; Maddala, 2001).VIFs are calculated by running "artificial" ordinary least squares regressions using each of the independent variables as the "dependent" variable, with the remaining variables as the independent variables. None of the five characteristics examined here generate multicollinearity.

The model introduced above was estimated for up to four segments. The log likelihood, ρ^2, Bozdogan Akaike Information Criterion (AIC3), and Bayesian Information Criterion (BIC) statistics for the models are reported in Table 3.

Determination of the optimal numbers of segments requires a balanced assessment of the statistics reported in Table 4 (Andrews & Currim, 2003; Louviere et al., 2000; Wedel & Kamakura, 2000). The log likelihood decreases (improves) and ρ^2 increases as more segments are added; both level off after the second segment, indicating the presence of multiple segments in the sample. The BIC is minimized at Segment 2, and AIC3 is minimized at Segment 4, though the difference between 2 and 4 is small. Andrews and Currim (2003) demonstrated that the BIC and AIC3 statistics never under-fit but may sometimes over-fit the number of segments. Over-fitting the true number of segments produces larger parameter bias. Therefore, given BIC is minimized at Segment 2 and the AIC3 (though minimized at Segment 4) may over-fit the model, we chose the two-segment model.

The results of the two-segment LCM are shown in Table 4. The first section of the table presents the utility coefficients associated with the maize seed attributes, while the second section gives the coefficients for seg-

Table 4. Two-segment LCM estimates for maize seed attributes.

	Segment 1 Reluctant Bt farmers	Segment 2 Willing Bt farmers
	Coefficient (s.e.)	
Utility function: Maize seed attributes		
ASC	79.7 (1,170,870)	3.33*** (0.08)
Yield loss	-0.9*** (0.14)	-0.017*** (0.001)
Bt maize	2.65*** (0.75)	0.17*** (0.05)
Information: Input supplier	0.95*** (0.15)	0.19*** (0.05)
Payment: Credit option	5.27*** (0.86)	0.03 (0.05)
Seed price	-0.004*** (0.0006)	-0.00008*** (0.00002)
Segment membership function: Farmer characteristics		
Constant	-5.8*** (0.9)	-
Age	0.04*** (0.01)	-
Education	0.12** (0.05)	-
Pest management score	0.8*** (0.1)	-
Maize area	0.94*** (0.2)	-
Seed distance	-0.01 (0.02)	-
Log likelihood	-1,711.143	
ρ^2	0.5804	
Sample size	3,712	

Notes: Coefficient significant at 10% (*), 5% (**), and 1% (***) significance levels.

ment membership. The membership coefficients for the second segment are normalized to zero, permitting us to identify the remaining coefficients of the model (Boxall & Adamowicz, 2002).

The utility coefficients reveal that farmers in both segments prefer maize seeds with lower prices (in accordance with the economic theory), reduced yield loss from the Asian corn borer and Bt trait. Farmers in Segment 1 also prefer to have a credit option when procuring seed, but this option is not significant for farmers in Segment 2. In fact, for farmers in Segment 1, among the binary attributes, the most important attribute—expressed in the magnitude of the coefficient—is the option to pay with credit. For farmers in Segment 2, the most important binary attribute is to receive information from the input supplier instead of another farmer. For both groups of farmers, Bt seed (as compared to a non-Bt hybrid) is valued second in importance.

We have labeled farmers in Segment 1 "*reluctant Bt farmers*" because, when the corresponding price attribute is used as the normalizing variable, we see that farmers in this segment value the Bt maize attribute less than those in Segment 2. At the same time, they value economic incentives, such as seed credit, highly. By contrast, we have labeled Segment 2 "*willing Bt farmers*."

Characterization of the Segments

The relative size of each segment is calculated by inserting the estimated coefficients into Equation 3 and using it to generate a series of probabilities that a given farmer belongs to a given segment. Farmers are then assigned to a segment based on the larger of the two probability scores. Using this procedure, we find that the size of the two segments are almost equal, with 48.3% of the farmers belonging to Segment 1, and 51.7% of the farmers belonging to Segment 2.

According to the comparison of the characteristics of the farmers in the two segments, "*reluctant Bt farmers*" are older and have more education, though they have fewer years of maize farming experience (Table 5). They are also more likely to be male. Growers in Segment 1 farm larger maize areas, but they are less likely to own their land. They have greater income from maize, as well as higher non-farm and livestock incomes, compared to "*willing Bt farmers*."

Not surprisingly, farmers in the "*reluctant Bt farmers*" segment are significantly less likely to have cultivated Bt maize in the past season as compared to the farmers in the "*willing Bt farmers*" segment. However, they have significantly higher pest-management scores. Related to that, they reported smaller percentages of yield lost to the Asian corn borer.

"*Reluctant Bt farmers*" are located further away from their seed sources. They have a narrower range of sources, and more frequently obtain seed from input suppliers, as compared to traders, farmers' cooperatives, or other individual farmers. These farmers are much more likely to be located in South Cotabato than in Isabela. On the other hand, most "*willing Bt farmers*" are located in Isabela.

Table 5. Characteristics of farmers belonging to the two segments.

Farmer characteristics	Segment 1 Reluctant Bt farmers N=224	Segment 2 Willing Bt farmers N=240
	Mean (Std. dev.)	
Farmer's age (years)***	45 (12.5)	41.2 (11.4)
Farmer's education (years)***	9.5 (11.1)	6.7 (2.7)
Farmer's experience in maize (years)***	16.3 (11.6)	17.5 (11.2)
Household monthly non-farm income (Pesos)***	4,768.6 (9,119.1)	2,503.9 (5,258.7)
Monthly livestock income (Pesos)***	2,147.0 (11,381.0)	625.7 (3,414.5)
Total maize income (Pesos)***	61,151.4 (46,933.7)	42,619.7 (64,853.4)
Value of capital assets (Pesos)***	97,668.0 (178,218.8)	74,897.9 (81,538.0)
Total maize area (ha)***	1.7 (0.98)	0.87 (0.49)
Yield loss due to Asian corn borer (% of total)***	24.1 (15.7)	26.8 (26.5)
Pest management score (0-8)***	4.2 (1.69)	1.4 (1.0)
Distance to the seed source (km)***	7.2 (6.08)	6.7 (9.4)
	Percent	
Farmer is male***	93.3	86.3
Farmer owns land***	68.8	82.9
Farmer cultivated Bt maize***	47.3	60.0
Obtained seed from input supplier***	67.0	31.7
Obtained seed from trader***	11.2	35.8
Obtained seed from another farmer	15.6	16.7
Obtained seed from a cooperative***	5.8	13.8
Farmer is located in South Cotabato***	50.9	2.9

Notes: T-tests and Pearson chi-square tests show significant differences among at least one pair of segments at the 10% (*), 5% (**), and 1% (***) significance levels.

Table 6. Segment-specific valuation of maize seed attributes in Pesos (95% confidence interval).

Seed attribute	Segment 1 Reluctant Bt farmers N=224	Segment 2 Willing Bt farmers N=240
Yield loss	-231.8 (-318.6-168.8)	-226.7 (-311.7-178.0)
Bt maize***	679.5 (578.7-752.7)	2,266.7 (2,189.8-2,404.4)
Information: Input supplier***	244.1 (177.0-335.4)	2,466.7 (1,529.7-3,911.9)
Payment: Credit option	1,352.3 (1,344.8-1,357.7)	--[a]

Welfare measures are calculated with the Delta method of the Wald procedure contained within LIMDEP 9.0 NLOGIT 4.0.
[a] indicates that the Wald procedure resulted in insignificant WTP values for this attribute.
T-tests show significant differences among segments at the 1% (***) significance levels.

Farmer Valuation of Maize Seed Attributes

The marginal value of each maize seed attribute represents the farmer's willingness to accept (WTA) compensation to forego an attribute or marginal willingness to pay (WTP) to adopt an attribute. The marginal value can be derived from the parameter estimates reported in Table 4, by using the formula: $W = -\frac{\beta_k}{\beta_y}$, where β_y is the marginal utility of income—which is the coefficient of the monetary attribute (i.e., seed price in this study)—and β_k is the coefficient of any of the other seed attributes.

The marginal values reported in Table 6 were estimated for the two segments. The figures represent the farmers WTA compensation (in Pesos) in order to forego an attribute or WTP (in Pesos) to adopt an attribute.

Farmers in both segments value the cost of yield loss similarly. The average farmer in each is willing to accept roughly 230 Pesos for 1% loss in yield due to Asian corn borer. In other words, to accept a 1% yield loss to Asian corn borer, the average farmer in each segment would need to be paid this amount to be satisfied. Farmers in both segments are willing to pay for Bt seed, but the magnitudes differ significantly by segment. Farmers in Segment 2 (the "*willing Bt farmers*" segment) are willing to pay three times more than those in Segment 1, who are "*reluctant Bt farmers*." Similarly, both segments prefer to receive information about new seed from input suppliers, as compared to other farmers. Willingness to pay for information from input suppliers is 10 times as great among "*willing Bt farmers*" than among "*reluctant Bt farmers*." The option to pay for seed with credit (as well as with cash) is not significantly valued by "*willing*" growers, but "*reluctant*" growers are willing to pay a significant amount for this option.

The significant differences between the two segments in terms of income and wealth variables merit further discussion. Although farmers who currently grow Bt maize are wealthier than those who do not, it is the less wealthy farmers who are more willing to adopt. This divergence between farmers' "willingness" and actual "ability" to adopt points to a social welfare loss, or put differently, to an unexploited demand for Bt maize seed. In addition, the credit option is not a significant determinant of seed choice for "willing Bt farmers." Perhaps no credit is available, or it is available only conditions that are unacceptable, or these poorer farmers are highly averse to financial risk (see reference above to discussion in Gerpacio et al., 2004). With more favorable credit arrangements and/or improved access to and information about Bt seed, the gap between poorer farmers' willingness and their ability to adopt might be narrowed.

Conclusions

This analysis employed the choice experiment method to investigate the WTP of Filipino farmers for maize seed attributes they consider to be most important: seed price, payment method, susceptibility to Asian corn borer, whether the seed has the Bt trait, and the source of seed information. The purpose of the study is to provide information that can support policy decisions and maize seed supply to farmers, including marketing and extension strategies. Data were collected in personal interviews with a sample of 464 maize farmers in 17 villages in two of the major maize-growing provinces of the Philippines—Isabela and South Cotabato. These provinces have contrasting production and market conditions that generate heterogeneous maize seed preferences. To explore this heterogeneity and account for it in estimates of WTP for Bt maize seed, a latent class model (LCM) was estimated. The LCM simultaneously identifies the characteristics that differentiate farmers and the values that different types of farmers derive from maize seed attributes.

We identified two distinct segments in the sample, which are almost equal in size. On average, farmers in both segments value the cost of yield losses to corn borer similarly. The first, "*reluctant Bt farmers*," are mainly located in South Cotabato. Fewer than half (47%) of this segment planted Bt maize in the past season; they farm larger maize areas and scored higher on pest management scores, experiencing less damage from Asian corn borer. They are more likely to be male, older, and more likely to have procured their seeds from formal input suppliers. Farmers in this segment vastly prefer to receive information from an input supplier, and are willing to pay for that choice. Two-thirds of these farmers currently obtain seed from input suppliers, regardless of whether they grow Bt maize. Similarly, they are willing to pay for the option of paying for seed with credit. Nevertheless, the price they are willing to pay for Bt maize seed is less than a third of what Segment 2 ("*willing Bt farmers*") are willing to pay. Background information on villages in this region (Gerpacio et al., 2004) suggests that prices are generally lower than in Isabela, and seed prices currently paid are lower among farmers sampled, which may explain part of the divergence between the two segments.

Farmers in the second segment, "*willing Bt farmers*," are located primarily in Isabela. About two-thirds (60%) of the farmers planted Bt maize in the survey season. They farm smaller maize areas than farmers in Segment 1 and scored lower on pest-management practices. Their observed yield losses from Asian corn borer were significantly higher, although the magnitude of the difference given the range of measurement error in farmers' estimates, may not be meaningful. More of them are female and they are—on average—younger. These farmers, like all farmers surveyed in Isabela, procure their seeds from a broader range of sources. Although they are not interested in receiving seed on credit, they have an even greater WTP for seed information from an input supplier than "*reluctant*" growers.

There are several important policy implications of these findings. First, we find that farmers in the "*willing Bt farmers*" segment are poorer and have fewer years of education when compared to their counterparts in the "*reluctant*" segment. Similarly, Kikulwe et al. (2011) showed that in Uganda, poorer and less-educated banana consumers (who are also more likely to be banana producers) were more likely to prefer genetically engineered banana. We interpret these results as expressing latent, unexploited demand for better seed (planting material). Like Kikulwe et al. (2011), we posit that poorer farmers may be less concerned about international debates over GM crops and more concerned about access to new technology in general. To address this demand, appropriate institutions that facilitate access to seed, information, and credit on attractive terms must be crafted—not only for Bt crops, but for all improved seed (Tripp, 2009).

Second, the heterogeneity (or bi-modality) of preferences demonstrated in the analyses confirms the importance of marketing and extension strategies that are tailored to the diversity of farm populations and agro-ecologies of the maize sector in the Philippines. Third, the supply of credit for seed acquisition on attractive terms is likely to constitute an important policy instrument for diffusing all improved, yellow-maize seed, including both biotech and non-biotech hybrids. The design of credit systems—given the history of relationships between maize farmers and trader-financiers—requires careful thought by public and private institutions. Fourth, the fact that farmers express a clear preference for receiving seed information from input suppliers rather than other farmers, and are willing to pay for it, suggests that input agents themselves could play a key role in providing technical information to support the use of improved seed. The commercial orientation of yellow-maize farmers in the survey sample is evident. In this setting, the public sector needs to ensure that the information conveyed through these channels is adequate and of good quality.

Methodological Challenges

The main limitation of the choice experiment method, as with other stated preference methods, is that there is the possibility that responses in a hypothetical market setting will tell us little about how respondents would behave in a real market (List & Gallet, 2001). This is an important caveat that should be taken into consideration when using the results of a choice experiment for informing policy.

This "hypothetical bias" problem has been addressed in a number of ways within the choice experiment literature, comparing real with hypothetical responses in terms of how close predicted WTP from hypothetical choices is to real WTP in an actual market. List, Sinha, and Taylor (2006) compared actual with hypothetical scenarios for two choice experiments and found no statistically-significant differences between hypothetical and real WTP when a "cheap-talk" script was used as part of the choice experiment—that is, when respondents were explicitly told about the problem of hypothetical market bias and asked to consider their responses carefully. More recently Chowdhury, Meenakshi, Tomlins, and Owori (2011) also used a "cheap-talk" script and found that the use of the cheap-talk script minimized the hypothetical bias but did not eliminate it.

In the study presented here, a "cheap-talk" script was not used, but respondents were reminded several times about the possible use of their responses for the implementation of policies and programs for delivery of seed in their areas. Given the importance of seed as a major input into production, it is hard to say how "truthful" respondents were in completing their choice tasks. The divergence between the characteristics of actual Bt maize adopters (revealed preferences, reported in Table 2) and those who stated that they would like to adopt Bt maize in the choice experiment (stated preferences, reported in Table 5) highlight a potential hypothetical bias. We contend that in developing countries, this "bias" can be thought of more as an opportunity for farmers to express their "willingness to adopt" under hypothetical, improved conditions, despite their inability to adopt under current conditions.

Bennett and Birol (2010) discuss the limitation and challenges faced when applying the choice experiment method in developing countries. As explained in greater detail in Yorobe, Birol, and Smale (2010), in the study presented here, the choice experiment results are significant, comply with economic theory, and are echoed by other literature on maize production in the Philippines. These "external validity" checks indicate that with careful construction of the choice sets and face-to-face collection of data, the choice experiment method could be employed effectively in this context. The use of visual aids, as well as simple explanation of the conduct of the experiment, has substantially reduced the time needed for data collection and significantly improved the reliability of the results. Similarly to the choice experiment studies implemented in developed countries, discussions with focus groups and key informants conducted prior to experimental design have been instrumental in the identification of the important attributes used in the choice experiment and in the design of the study. This preliminary research also contributed to the understanding of the social, cultural, and linguistic factors that may vary across study sites and, hence, affect the quality of the data.

In addition to the hypothetical bias (which was not corrected for, or at least was not minimized with the use of a "cheap talk"), there are two possible shortcomings of this study. First, it was observed and mentioned by several enumerators that asking eight choice sets, in addition to a long list of questions on maize production and other social and economic characteristics of the households, resulted in respondent burden and fatigue. It is therefore important to minimize the number of choice sets presented to sustain the attention of farmers and maintain the reliability of preferences up to the last choice set. Alternatively, choice experiments could be conducted before the questions on production and social and economic characteristics of the households.

Secondly, for the second segment, the alternative specific constant was found to be positive and significant, indicating a status-quo bias. As discussed in Yorobe et al. (2010), this result implies that Segment 2 farmers are more likely to choose one of the maize seed alternatives presented to them rather than the status quo. This can be explained by the difference between the price levels used in the choice experiment and the prices farmers faced when the survey was implemented. In South Cotabato, three of the price levels used in the choice experiment were lower than the average price at the time, whereas in Isabela all four choice experiment prices were lower than the average price of seed in that region at the time. This oversight was due to the long time lag of five months between the focus group discussions and survey implementation. During this period, maize prices (along with other grains) rose at unexpected rates as part of a global food crisis. It is therefore recommended that in the dynamic economic, political, and natural environments such as those often found in developing countries, choice experiments should be designed and implemented within a short time span to avoid including attributes and levels that reflect neither actual nor expected conditions.

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Appendix

See next page for Appendix Table A1.

Table A1. Choice sets.

		Maize seed A					Maize seed B				
Version	Choice set	Seed price	Yield loss due to pest	Seed type	Seed payment	Info	Seed price	Yield loss due to pest	Seed type	Seed payment	Info
1	1	2,700	70%	Bt	cash only	farmer	2,700	40%	Bt	cash or credit	input supplier
1	2	4,900	15%	non-Bt	cash or credit	input supplier	1,500	70%	non-Bt	cash or credit	input supplier
1	3	4,900	70%	non-Bt	cash only	farmer	4,900	20%	Bt	cash only	input supplier
1	4	1,500	15%	Bt	cash or credit	input supplier	600	70%	Bt	cash only	input supplier
1	5	1,500	20%	non-Bt	cash or credit	farmer	2,700	20%	Bt	cash only	input supplier
1	6	2,700	20%	non-Bt	cash or credit	input supplier	1,500	40%	non-Bt	cash or credit	input supplier
1	7	2,700	15%	Bt	cash only	input supplier	600	20%	Bt	cash only	farmer
1	8	600	40%	Bt	cash or credit	farmer	1,500	15%	Bt	cash only	farmer
2	1	1,500	70%	Bt	cash or credit	farmer	1,500	15%	Bt	cash only	farmer
2	2	600	15%	non-Bt	cash or credit	farmer	2,700	15%	Bt	cash or credit	input supplier
2	3	1,500	70%	Bt	cash only	input supplier	1,500	20%	non-Bt	cash or credit	input supplier
2	4	1,500	40%	non-Bt	cash only	farmer	600	70%	non-Bt	cash or credit	input supplier
2	5	2,700	40%	non-Bt	cash or credit	farmer	4,900	20%	non-Bt	cash or credit	farmer
2	6	600	20%	Bt	cash or credit	input supplier	4,900	15%	Bt	cash or credit	input supplier
2	7	2,700	20%	non-Bt	cash only	farmer	1,500	70%	Bt	cash only	farmer
2	8	4,900	15%	non-Bt	cash only	farmer	1,500	40%	Bt	cash or credit	farmer
3	1	600	70%	non-Bt	cash or credit	input supplier	600	70%	Bt	cash only	farmer

Table A1. Choice sets.

3	2	600	20%	Bt	cash only	farmer	4,900	70%	non-Bt	cash or credit	farmer
3	3	4,900	20%	Bt	cash only	input supplier	600	40%	Bt	cash or credit	farmer
3	4	2,700	70%	Bt	cash or credit	input supplier	2,700	70%	non-Bt	cash or credit	farmer
3	5	4,900	20%	Bt	cash or credit	farmer	600	20%	non-Bt	cash or credit	input supplier
3	6	1,500	40%	non-Bt	cash or credit	input supplier	4,900	40%	Bt	cash or credit	farmer
3	7	600	40%	Bt	cash only	input supplier	1,500	15%	non-Bt	cash only	input supplier
3	8	4,900	40%	Bt	cash only	farmer	2,700	70%	Bt	cash only	input supplier
4	1	600	15%	non-Bt	cash only	input supplier	2,700	20%	non-Bt	cash or credit	farmer
4	2	2,700	15%	Bt	cash or credit	farmer	600	15%	non-Bt	cash only	input supplier
4	3	4,900	40%	Bt	cash or credit	input supplier	2,700	40%	non-Bt	cash only	farmer
4	4	4,900	70%	non-Bt	cash or credit	farmer	4,900	15%	non-Bt	cash only	farmer
4	5	1,500	20%	non-Bt	cash only	input supplier	2,700	15%	non-Bt	cash only	farmer
4	6	2,700	40%	non-Bt	cash only	input supplier	4,900	15%	Bt	cash or credit	input supplier
4	7	600	70%	non-Bt	cash only	farmer	600	40%	non-Bt	cash only	input supplier
4	8	1,500	15%	Bt	cash only	input supplier	4,900	40%	non-Bt	cash only	farmer