Variety Characteristics, Transactions Costs and Maize Adoption in Honduras

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Maize is the main annual crop in Honduras, both in terms of its share of total cropped area and its role in direct human consumption. Approximately 25% of all arable land is planted in maize and Hondurans' per capita maize consumption is among the highest in the world. Yet despite the potential yield gains from the adoption of improved varieties, and the fact that seed prices (of hybrids) are relatively low compared to other Latin American countries, the level of adoption of improved varieties of maize in Honduras is below 20%.

This paper summarizes research into the factors contributing to these low levels of adoption of improved maize varieties in Honduras. Our empirical work is based on an agricultural household model that explicitly incorporates variety characteristics and transaction costs into the household's optimization process. We consider a multitude of production characteristics (e.g., yield, yield stability, duration, and plant height) and consumption characteristics (including taste, storability, and husk cover quality) that are valued by farmers, as well as an array of household socioeconomic characteristics and proxy measures of household-specific transactions costs.

We implement our model using data collected in a survey of 167 farmers located across 34 villages in two distinctly different agro-ecological zones. In one of these zones, maize farming is highly commercialized, average farm sizes are comparatively large, and hybrids are planted by 60% of farmers. The other zone is dominated by near-subsistence farm households with smaller land holdings and much lower levels of HYV adoption.

Non-parametric tests indicate that farmers perceive significant differences among varieties. In general, improved varieties dominate in terms of production characteristics but are regarded as inferior with regard to consumption characteristics in both production zones. Zone-specific adoption equations confirm that in both areas production characteristics variables are jointly significant explanators of variety choice, but that consumption characteristics do not have a significant impact on adoption (or non-adoption) of improved varieties. In addition, one proxy for transactions costs (road quality) is consistently found to have a significant impact on the adoption of improved varieties in both areas. In the near subsistence zone, a dominant element conditioning adoption appears to have been whether or not farmers received free HYV seeds in the aftermath of Hurricane Mitch – a result indicating that information deficits may be an important limiting factor to adoption there.

The paper is laid out as follows. The next section describes the analytical framework upon which our empirical analysis is based. Next, we describe the survey area and provide descriptive statistics on farmers' variety choices and seed management practices. The following two sections lays out our empirical analyses of farmer preferences over different varietal characteristics, and the determinants of varietal adoption. Some concluding remarks are found in the paper's final section.

Analytical Framework

The empirical analyses to be presented in the following sections are motivated by an agricultural household model that generates empirically testable hypotheses concerning the role of variety characteristics and transaction costs in determining farm households' varietal choice (Hintze, 2002). The model follows the tradition of the characteristics literature (Lancaster, 1976; Adesina and Zinnah, 1993; Bellon and Smale, 1998). It also draws on recent literature investigating links between market imperfections or transactions costs and households' participation in various markets (Omamo, 1998; Renkow, Hallstrom, and Karanja, 2001).

The model is general enough to be useful as a tool for studying different circumstances faced by farmers and different problems encountered in the context of variety adoption or variety choice studies (e.g. choice among multiple varieties, choice between modern and traditional varieties, allocation of land shares among more than one varieties, etc). Here we are interested in the implications for variety choice.

Two implications of the model that are noteworthy for their uniqueness. First, the marginal rate of substitution (transformation) between two varieties is shown to be a weighted sum of the marginal contribution of each variety to the total amount of each characteristic demanded (supplied). Second, these marginal rates of substitution and transformation are equated to *effective* prices (inclusive of transactions costs incurred in market exchange). Taken together, these features of the model's solution imply that households might simultaneously plant multiple varieties if certain characteristics are unique to a particular variety and transactions costs are high enough to preclude purchasing or selling that variety in the market.

For this reason, in the empirical analysis that follows we will consider a multitude of production characteristics (e.g., yield, yield stability, duration, and plant height) and consumption characteristics (including taste, storability, and husk cover quality) that are valued by farmers, in addition to several measures of transactions costs. Inclusion of consumption characteristics in the varietal adoption estimation amounts to a test of non-separability between household production and consumption decisions. Moreover, because different varieties have different production requirements and respond differently to farmers' circumstances, those circumstances are taken into account as well.

The Study Area

The study was conducted in two departamentos of Honduras: Olancho and Choluteca.[1] These areas were selected to cover two different types of maize farming that are present throughout Honduras and the rest of Central America. In Olancho, most maize is cultivated in relatively productive land; chemical inputs and mechanical traction are widely used; maize yields are among the highest in the country; and farmers' maize output is principally oriented towards commercialization. In Choluteca, smaller farms in marginal lands are more frequent; agriculture face higher risk because of environmental characteristics; and maize yields and marketed surplus levels are much lower than in Olancho.

A survey of the production practices and household socioeconomic characteristics of small maize farmers in these two areas was conducted during the summer of 2000.[2] 90 households (in 21 villages) were surveyed in Olancho and 77 households (in 13 villages) were surveyed in Choluteca. Household

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[1] Honduran territory is divided in 18 *departamentos*. These *departamentos* are in turn divided into *municipios* (roughly equivalent to an Americancounty).

[2] The largest amount of land under cultivation by any farm in the sample was 17.5 ha, and 75% of farms had less than 5.3 ha under cultivation (including other crops) and under 3.5 ha of maize. There are some large farms in both areas, most of which are owned by absentee landlords.

heads were asked about growing practices and output obtained on the maize crops planted in the *primera* and the *postrera* seasons of the 1999-2000 period. The *primera* or first season usually starts in May-June. The *postrera* (second or winter season) starts in August or September, depending on the region, the crop and farming system. Information about planting decisions for the *primera* of 2000 was also gathered. In Honduras, 84% of maize output is obtained in the *primera* season. 93% and 74% of maize production occurs in the *primera* season in Olancho and Choluteca, respectively.

The typical maize farmer from the study areas in Olancho grows maize during the primera season and beans in the postrera. He or she may have some livestock, and may migrate for off-farm work but their main activity and source of income is maize. They may also have coffee plants in the higher areas. The typical farmer of Choluteca, on the other hand, grows maize in both primera and postrera seasons, commonly intercropping maize with sorghum. Off-farm work is more common and a more important source of income. In some areas, farmers may also have fruit trees and beans.

In Olancho, the sample included regions that range from the valley areas next to the main paved highway to villages that are more than two hours away from the main paved road and whose cropping land is in the hillsides. Almost all of the villages visited in Olancho have regular access by dirt roads whose conditions vary from very good to average. All dirt roads are affected during the rainy season, although most of them can still be used most of the time. There is a relatively good road network and bus service to most villages. In contrast, the road network in Choluteca is in much worse condition than the one in Olancho. Most of the roads going to the villages require four-wheel drive vehicles, even in the dry season.

Use of hybrids, traditional varieties and open pollinated varieties

Olancho and Choluteca are markedly different with respect to the use of maize varieties. All Olancho farmers surveyed use modern varieties (MVs) while in Choluteca traditional varieties are still used by most farmers.[3] Seed companies have worked aggressively in Olancho promoting their seed through demonstration plots and sales efforts. On the other hand, seed companies do not consider Choluteca an area in which a significant expansion of modern variety adoption could be achieved.

Table 1 and 2 present a classification of farmers according to the type of seed they used in Olancho and Choluteca, respectively. In the Olancho survey areas, most farmers use hybrids. Those who used hybrids exclusively during the three seasons for which information was collected, or those who used hybrids (including "recycled" hybrid seed[4]) with any other type or seed, accounted for 72% of surveyed farmers. Use of OPVs, is still widespread, however: 50% of farmers used OPVs during the same period (primarily the variety Guayape). Farmers who used any combination of seed were 30% of the whole sample; however, the evidence indicates that this is mainly the result of farmers alternating seed types across seasons, rather than growing multiple varieties during the same season. Farmers who used only first generation hybrids during the three cropping seasons registered accounted for 36% of the sample.

In Choluteca, on the other hand, use of hybrids is uncommon and TVs dominate maize production among farmers surveyed. Many of the farmers that used MVs during the 1999-2000 cropping year, did so for the first time, primarily because they received the seed as relief aid following the Hurricane Mitch disaster. 92% of all farmers in the sample either planted TVs only or TVs and OPVs.

Seed type used during the 1999-2000 cropping year by farm size (as measured by total land under cultivation) is presented in Tables 3 and 4 for Olancho and Choluteca, respectively. The percentage of Olancho farmers that used only hybrids was observed to be higher for the farmers with larger areas under cultivation. On the other hand, the percentage of farmers that used only OPV was higher the smaller the

[3] Maize varieties were classified as hybrids, open pollinated varieties (OPVs), and traditional varieties. Hybrids and OPVs have been developed by professional breeders. In this paper, hybrids and OPVs will be indistinctly referred to as improved or modern varieties. The terms traditional varieties (TV) is used here for those varieties that have been used by local farmers for many generations. Through time, TVs may have mixed with some improved varieties.

[4] Advanced generation or "recycled" hybrid seed is hybrid seed that has been saved from previous harvests. A significant decrease in yields is expected from one generation to the next.

total area under cultivation. In Choluteca, the percentage of farmers using only TV was lower for the farmers with larger land holdings under cultivation.

In Olancho, the percentage of farmers that grow only one variety of maize per season has been around 90% during the period 1998-2000 (Table 5). In the cropping-year 1995-96, the percentage of farmers that grew more than one variety was 18% (compared to 9% in 2000). This may be an indication that, in the past, the use of more than one variety at the same time was not uncommon, and that a tendency towards specialization has been occurring.

In Choluteca, approximately 25% of farmers grew more than one variety during the period 1998-2000 (up from 18% of farmers for 1995-96). It may be possible that the influx of seed from post-Mitch aid has led some farmers who used to grow only one variety to experiment with new varieties on a portion of their land.

In terms of area cultivated, hybrids were planted in 77.7% of Olancho's total maize area during 1999-2000. In almost all of the remaining area, OPVs were used (only in 0.7% of the area, corresponding to two plots, were traditional varieties used). During the same period, 77.9% of Choluteca's maize area was sown with traditional varieties. Besides the 1.7% of maize area that used hybrids, the rest of Choluteca's maize land surveyed was sowed with OPVs.

Maize production and yields by variety

Table 6 provides data on maize production and yields by variety. In Olancho, hybrids from the Cargill and Cristiani brands are the most common varieties. Yields reported for Cargill seeds (2.1 t/ha), are higher than yields for Cristiani seeds (1.7 t/ha).[5] The third variety in terms of production and area is Guayape, an open pollinated variety (OPV) that has been very common in the area for the last 15-20 years. Contrary to what was expected, reported yields from the OPV Guayape are higher than Cristiani's.

[5] These yields are obtained by dividing aggregated production by aggregated area sown by seed variety. If a plot that was planted reported zero production, the values were still added. Total crop failures (no production at all) were reported for 6 (17.5 ha) out of 22 plots that used Cargill in Olancho, against 6 (18.9 ha) out of 42 for Cristiani. In the case of Guayape seed, 5 (10.5 ha) out of 43 plots reported total crop failure.

At the same time, among plots suffering total crop failure, more than twice that area was planted in Cristiani seed than with Guayape seed.

Although the number of observations is small, yields for recycled Cristiani seed drop by 17.7% compared with yields from new seed. Most recycled seed is from second generation (i.e. first time reused). When asked about recycling seed practices, most farmers reported being aware of the fact that the decrease in yield that comes from using recycled seed of third generation is so high they would probably prefer to obtain some OPV seed from members of the community if they cannot afford to buy new hybrid seed.[6]

In Choluteca, the great majority of plots are planted with the two traditional varieties white and yellow *maicito* (literally "little maize"). Both have similar observed average yields (0.6 t/ha), although area and number of plots devoted to the white variety is higher than those with the yellow variety. No large differences in yield between those two varieties appear to exist. Beliefs about normal yields, as well as those for best possible and worst possible yields are very similar.

Characteristics other than yield could help to explain the preference of one variety over the other. One characteristic that was mentioned by farmers as an advantage of yellow maize is that it takes less time to dry (after reaching its maturity). The advantage of white maize is related to its consumption quality. It is common that farmers use both varieties simultaneously. These issues will be analyzed more extensively in the maize characteristics section.

Seed use and management

Farmers in the study areas were observed to obtain their maize seed every year from a variety of sources and using different methods: buying it from commercial suppliers (mostly in Olancho), buying it or exchanging it from other farmers in their communities, or saving it from one year to the other (a common practice in Choluteca).

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[6] The variety referred to by farmers as H5 is likely also one of Cristiani's lines (HS5G) obtained as post-Hurricane Mitch aid.

Farmers were asked about the way they obtained the seed and the source from which it was obtained (Tables 7 and 8). In Olancho, the main method of seed acquisition is purchase (45% of farmers). There are still a considerable number of farmers (27%) that use seed that is saved from the previous harvest. In both areas, the seed selection practice used by most of those farmers that save seed is, after harvesting, to select grains from cobs that seem to be the best. 41% of farmers obtained seed from a store, usually in the capital of the department. A quarter of the farmers still obtain their seed from neighbors or relatives. Thus, farmers who buy seed, usually do it either from stores or from somebody in the village. When seed is obtained in the village it may be grain exchanged for another farmers' maize[7] or it may be bought in cash.In Choluteca, most farmers (64%) use seed saved from their own harvest. Only 12% of farmers purchased seed. None of those purchasing seed did so in a store; rather, they purchased seed from neighbors or relatives. In Choluteca, 23 farmers during 1999 used both their own seed and seed that was donated after Hurricane Mitch. Government agencies are no longer involved in the distribution of seed, even as post-disaster aid.

In Olancho, farmers that used Cargill have used that brand an average of 2.6 years, and those who used Cristiani have done it for 2.8 years. Guayape, on the contrary, has been used for 7.8 years on average. Farmers who use Guayape and save their own seed have had the same seed for five years on average. Because Guayape is an OPV, no large decrease in yields is expected by saving seed for several years. Only three cases of seed recycling were recorded for Cristiani seed, the average number of years they have been maintaining the seed being three years. As mentioned before, saving and using the seed for more than three years would lead to a significant yield decrease in hybrids.

In Choluteca, farmers have been using the traditional white and yellow *maicito* varieties for over twenty years, almost the same amount of time that they say they have been, on average, keeping the seed

[7] A farmer may believe that his or her neighbor's maize is better than his or hers so he/she would prefer to ask the neighbor for some of the grain he/she saved for seed from the previous harvest, instead of using some of the seed he or she saved. A farmer may also need to ask for seed when his or her crop failed and could not save any grain he/she found suitable to be used as seed.

they are currently using. In the case of the modern varieties, the average of years using that variety is 1.8 years. Most farmers used improved varieties for the first time after they received maize seed as post-Mitch aid.

Analysis of farmers' preferences regarding maize characteristics

One of the main objectives of this study is to evaluate how maize characteristics, as perceived by farmers, influence their decision on what variety or varieties to grow. In this section we summarize the results of non-parametric tests of farmers' assessments of the characteristics possessed by different varieties.

Four conclusions can be drawn from the results shown below: (i) Farmers perceive differences among varieties and group of varieties for some of the characteristics they consider to be important; (ii) varieties that are widely used tend to be regarded as having good performance with respect to the most important characteristics; (iii) sometimes, varieties that are used by the majority of farmers are outperformed by other varieties for some of the characteristics evaluated. In those cases, however, the ratings obtained by the more popular varieties indicate that they do not perform badly – just that they are not the best; and (iv) there are important differences in how farmers in Olancho and Choluteca perceive the different varieties available to them.

For each of 15 characteristics thought to be potentially important, farmers were asked to rate each variety using the following scale: 1= very good/good, 2= regular/average/sufficient, 3= bad. These 15 characteristics were as defined during group discussions held before the formal survey was conducted.[8] Using the ratings given by farmers, non-parametric tests were conducted. The Wilcoxon-Mann-Whitney (WMW) and the Kruskall-Wallis (KW) tests are based on the sum of ranks obtained from pooling the

[8] The questionnaire also inquired about what characteristics farmers consider to be more important. However, unsatisfying results were obtained from this line of questioning in that farmers tended to say that all characteristics were very important.

data (ratings) of the different varieties under evaluation. These tests are the most appropriate for ordinal data of the kind used here (Conover, 1999).[9]

Two sets of tests were conducted. The WMW tests are used to compare groups of varieties: hybrids versus open pollinated varieties (OPV) in Olancho and modern varieties (MV) versus traditional varieties (TV) in Choluteca. The KW tests are used to compare individual varieties within each region.

The mean ranks and the tests results are shown in Tables 9 and 10 for Olancho and Choluteca, respectively. The lower the mean rank of a variety, the better it is perceived by farmers (with respect to each characteristic evaluated). The null hypotheses for the WMW and KW tests are no differences among group of varieties or individual varieties, respectively.

Olancho

In Olancho varieties were classified into hybrids (mostly Cargill and Cristiani seeds) and OPVs (mostly Guayape seed). The tests generally show that there are significant differences among varieties and that hybrids usually outperform OPVs.[10] That could help to explain the widespread use of hybrids in Olancho. However, no variety is superior to the others for all characteristics. This implies that farmers face trade-offs and that they have to weight how much they value each characteristic and how good each variety is with respect to each characteristic considered to be valuable.

Comparing hybrids and OPVs as groups of varieties, statistical differences among groups are observed for four characteristics: lodging resistance, taste, resistance to damage in storage and husk cover quality. When disaggregated information (in which farmer assessments of the characteristics of both available hybrids are considered separately) is used, significant differences are observed for up to nine

[9] The WMW test is used to test if differences exist between two independent samples of size n and m. The ratings for each variety (given by a subsample of the farmers) are treated here as independent from each other. Ranks 1 to n+m are assigned to the observations, from smallest to largest. "If several sample values are exactly equal to each other (tied), assign to each the average of the ranks that would have been assigned to them had there been no ties." Conover, 1999, p 272. Because ratings of varieties take only three values, a large number of ties is observed in these tests. The KW test uses the same method of ranking for more than two samples.

[10] No distinction was made between first generation hybrids and recycled hybrids when collecting data on ratings for varieties. It is not expected that this fact will affect the conclusions regarding variety characteristics because the number of farmers using recycled hybrids is relatively small.

characteristics (depending on the significance level). Among individual varieties, Cargill tends to dominate the other two for most characteristics.

Three characteristics are considered to be among the most important by farmers: yield, early maturity and drought resistance. In terms of these three characteristics, although no statistical difference were found between groups, hybrids outperform OPVs as measured by the mean ranks and the percentage of “1” ratings obtained. When individual varieties were compared (KW tests) regarding these three characteristics, only early maturity showed statistical difference among varieties.[11]

Hybrids also outperform OPVs with respect to resistance to lodging, another important characteristic, the difference being statistically significant. The likely explanation is that the OPV used in this area (Guayape) has a taller plant than any of the main hybrids (either from Cargill or Cristiani). Cargill variety obtains a much better rank than the rest of varieties, due probably to its short stature.

The varieties (as groups as well as individually) are also statistically different regarding quality of husk cover, an important trait considering that the practice of leaving the maize to dry in the fields after reaching its maturity is very common in Olancho. The extent to which maize is exposed to damage by insects and other animals during that period is related to the quality of the husk cover.

In terms of consumption related characteristics (taste and tortilla quality), OPVs outperform hybrids as a group, but the hybrid Cargill is individually ranked as the best among all the varieties. It is worth noting that even though OPVs are preferred for consumption, hybrids are still considered acceptable. None of the farmers thought that hybrids were bad for tortillas, and only one (out of 79) thought that they have a bad taste.

One of the hybrids (Cristiani), obtains the best ranking for guaranteeing a minimum output under non-optimal conditions –a characteristic usually associated with TV. When varieties are grouped in hybrids and OPVs, no significant differences could be found.

[11] Unless noted otherwise, when reference to statistical differences are mentioned, a 5% level of significance is used.

No statistically significant differences in labor or input (fertilizer, chemicals) requirements were observed between hybrids and OPVs, either as groups or individually. Farmers in the study area do not believe that hybrids require more effort or care than OPVs.

Three characteristics were not considered to be very important by farmers during group discussions held prior to the formal survey. First, resistance to spoilage or susceptibility to insects in storage was not critical for most farmers because the use of silos guarantee that the grain is going to be kept without damage regardless of its consistency and hardness. Nonetheless, farmers perceive significant differences between groups and varieties in terms of storability, possibly drawing on recollections of storage losses prior to widespread adoption of silos. Second, ease of shelling also is not perceived as being very important in most areas of Olancho because of the extensive use of mechanical shelling (only on 8 out of the 90 farms is maize shelled by hand). Third, fodder production also was not seen as a very important characteristic despite the fact that most farmers own some cattle. It is very common to buy feed for cattle and or to have grazing or fallow land dedicated to the animals. None of the varieties is seen as having a bad performance in this respect although the Kruskal-Wallis showed that individual varieties are significantly different from one other.

Choluteca

In Choluteca, the statistical tests show much greater differences in perception among groups of varieties and individual varieties than in Olancho. Results indicate that traditional varieties outperform modern varieties in most characteristics, yield being an important exception. These perceptions may help to explain why traditional varieties are still widely used in Choluteca.

Traditional varieties (TVs) in the area are what farmers call white and yellow *maicito*. Farmers usually only differentiate between *maicito* and *maizón* (literally, “big maize” – a term used to refer to any improved or commercial variety). Farmers typically do not know whether a variety is an OPV or a hybrid (or if there is any difference between them). Most farmers cannot identify modern varieties by their commercial names either. In contrast, when asking about *maicito* during the survey, enumerators had to ask explicitly to differentiate between white or yellow *maicito*.

As groups of varieties, MVs outperform TVs in terms of yields. Farmers are clearly aware of the advantages of MVs. However, farmers evaluate this yield advantage in relation to the advantages TVs have with respect to other characteristics.

When the two TVs are compared, statistical differences are found with respect to two of the characteristics farmers value the most: early maturity and resistance to drought. In both cases, yellow *maicito* outperforms white *maicito.*[12] For tortilla quality (an important characteristic considering that most maize is for home consumption and that tortillas are consumed daily), on the other hand, white outperforms yellow *maicito*, the differences being also statistically significant at 10%. Yellow *maicito* is also considered to be better in guaranteeing a minimum production level, something that can be important in a risky environment as Choluteca's.

Early maturity is a critical characteristic for farmers in Choluteca because it is linked to the ability to avoid drought: the shorter the growing period, the smaller the risk for the crop of being affected by drought. TVs are ranked as significantly better than MVs regarding early maturity and resistance to drought. Because the risk of drought is large, it is not surprising that even for the well adapted TVs, around one quarter of total answers gave them a "2" rating.

TVs are ranked significantly better than MVs with respect to consumption characteristics (taste and tortilla quality). However, no respondent rated MVs as having bad consumption quality. A substantial number of Choluteca farmers are used to consuming maize that they have purchased in the market: thus they are used to consuming maize grown in other parts of the country, maize which is usually modern varieties. Mean ranks show that white maicito is the preferred variety for consumption.

The results also indicate that TVs are ranked significantly better than MVs with respect to resistance to spoilage or susceptibility to insects in storage. This is probably due to the fact that traditional storage

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[12] Yellow *maicito* is also perceived to significantly outyield white *maicito* (at 5% significance level).

methods are more common in Choluteca. TVs are also ranked as being superior to MVs with respect to shelling ease, probably because most households in Choluteca shell maize manually and the MVs´ grain is usually harder than the grain from TVs.

Finally, TVs as a group are also seen to outperform MVs with respect to the ability to produce at least a minimum amount under less than optimal conditions. Individually, yellow maicito outperform the other varieties.

Determinants of varietal choice

In this section, we present the results of two sets of econometric analyses: multinomial logit models of varietal selection and binary logit models of adoption of improved varieties. Separate analyses were conducted in each region. The multinomial logit models allow us to gauge the impact of an array of household characteristics and transactions costs variables on the probability of selecting one variety over another for all possible pairwise combinations of varieties.[13] The binary logit models allow us to assess the impact of variety characteristics on whether or not households choose to grow improved varieties (hybrids in Olancho, OPVs in Choluteca).

Multinomial logit estimates

The multinomial logit results are presented in Table 11. For both areas the model fit the data well as indicated by the proportion of correctly predicted observations, by the computed values of the pseudo-R^2, and by the fact that the parameter estimates are generally of the expected sign. In Olancho, the results indicate larger farms are more likely to plant one of the two hybrids over the OPV Guayape, and that households with larger family size are more likely to plant Guayape.

Interestingly, the parameter estimates for the transactions costs variables (road quality[14] and distance) indicate that better roads significantly increase the probability of using one or the other of the

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[13] For Olancho, the varieties considered were Cristiani and Cargill hybrids and Guayape (an OPV). In Choluteca, the varieties considered were an unspecified OPV and two TVs (yellow and white *maicito*).

[14] The road quality index ranges from a value of 1 for the best roads to a value of 5 for the worst roads.

two hybrids relative to the OPV, but that distance to the closest input market – the variable of choice in most empirical studies (e.g., Goetz, 1992) – is not a significant explanator of varietal choice. Figure 1 depicts the predicted probabilities of using the three varieties in each area for different levels of quality road.

In Choluteca, as in Olancho, the probability of farmers choosing the MV over either of the traditional varieties was found to be significantly related to farm size and road quality (Figure 2). Most importantly, the results also indicate that the most important factor in explaining whether farmers used the modern variety is if they received seed as post-Hurricane Mitch relief aid. The predicted probabilities of using a MV for those who did not receive seed was only 3%, while for those who actually received the seed the estimated probability was 84%. This is not surprising given that before the disaster, the vast majority of farmers used only traditional varieties and most farmers declared having used improved seed varieties for the first time after the disaster. Nonetheless, the result highlights the possibility that inadequacies in extension and other "normal" channels of transmitting information about improved seed varieties may represent an important limiting factor to adoption in the area.

Binary logit estimates

Binomial logit models for Olancho and Choluteca were estimated to isolate the impact of varietal characteristics on adoption of improved varieties (hybrids in Olancho, improved OPVs in Choluteca). For this analysis, farmers were classified as adopters (1) and non-adopters if they used the high yielding varieties available in their region and (0) otherwise. A dummy variable for each characteristic was created. The dummy takes the value of 1 if the high-yielding variety is rated by the farmers to be at least as good as any other variety in the farmers' choice set. Aggregating the available information in this way had the unfortunate (but unavoidable) side effect of inducing high correlation between the characteristics dummies. Because of this, only a representative selection of varietal characteristics variables could be included in any given regression equation.

Table 12 presents the empirical results. For Olancho, two production characteristics – yield advantage and early maturity – consistently emerged as having a significant positive impact of hybrid maize adoption. On the other hand, consumption characteristics such as tortilla quality, taste or storability were in no case significantly related to adoption. Wald tests confirmed the lack of significance of consumption characteristics as a group. Also, in line with the results of the multinomial logit regressions, transactions costs variables (both road quality and distance) and larger farm size emerge as significant explanators of hybrid maize adoption.

For Choluteca, only yield emerges as having a consistently significant impact on adoption of improved OPVs over traditional varieties. Similar to Olancho, no evidence was detected of consumption characteristics being related to adoption in a statistically meaningful way. Rather, as was the case with the multinomial logit results, the key determinant of adoption of improved varieties in Choluteca appears to be whether or not farmers received post-Hurricane Mitch aid.

Concluding remarks

In this paper we have investigated the factors contributing to these low levels of adoption of improved maize varieties in Honduras. One distinguishing feature of our work is that we have considered a multitude of production characteristics (e.g., yield, yield stability, duration, and plant height) and consumption characteristics (including taste, storability, and husk cover quality) that are valued by farmers, as well as an array of household socioeconomic characteristics and proxy measures of household-specific transactions costs.

We implemented our model using data collected in a survey of 167 farmers located across 34 villages in two distinctly different agro-ecological zones. In one of these zones, maize farming is highly commercialized, average farm sizes are comparatively large, and hybrids are planted by 60% of farmers. The other zone is dominated by near-subsistence farm households with smaller land holdings and much lower levels of HYV adoption.

Non-parametric tests indicated that farmers do indeed perceive significant differences among varieties, and that the specific characteristics most highly regarded by farmers vary across region. In general, however, improved varieties dominate in terms of production characteristics but are regarded as inferior with regard to consumption characteristics in both production zones. Zone-specific adoption equations confirm that in both areas production characteristics are jointly significant explanators of variety choice, but also indicate that consumption characteristics do not have a significant impact on adoption (or non-adoption) of improved varieties These results have implications for agricultural research managers in terms of emphasis of breeding activities.

One proxy for transactions costs – road quality – was consistently found to have a significant positive impact on the adoption of improved varieties in both areas. A question arises in this regard as to whether the negative relationship between road quality and adoption is due to difficulties in accessing inputs or to high costs of marketing output (or both). This is a fertile topic for future research.

Finally, perhaps the most striking result from the near-subsistence area (Choluteca) is that the dominant element conditioning adoption appears to have been whether or not farmers received free HYV seeds in the aftermath of Hurricane Mitch. This result would appear to suggest that information deficits may be an important limiting factor to adoption of modern varieties there. Given the declining role of the public sector in Honduras' seed distribution system, it is difficult to imagine that these information deficits – and hence low levels of MV adoption in such low-productivity areas – are likely to be reversed in the foreseeable future.

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Table 1

Olancho: farmers by seed type used 1999-2000

	1999-2000						2000-2001		All seasons	
	Primera		Postrera		Both seasons		Primera			
Seed type	n	%	n	%	n	%	n	%	n	%
Hybrids only	46	51.7	2	100.0	46	51.7	31	39.2	32	35.5
Recycled hybrids only	7	7.9	0	0.0	7	7.9	11	13.9	5	5.6
OPV only	32	36.0	0	0.0	32	36.0	28	35.4	25	27.8
Hybrids and recycled hybrids	0	0.0	0	0.0	1	1.1	3	3.8	5	5.6
Hybrids and OPV	3	3.4	0	0.0	3	3.4	4	5.1	15	16.7
Recycled hybrids and OPV	0	0.0	0	0.0	0	0.0	1	1.3	3	3.3
Hybrids, recycled h. and OPV	0	0.0	0	0.0	0	0.0	0	0.0	3	3.3
Hybrids and TV	0	0.0	0	0.0	0	0.0	0	0.0	1	1.1
Recycled hybrids and TV	0	0.0	0	0.0	0	0.0	0	0.0	1	1.1
TV only	1	1.1	0	0.0	0	0.0	1	1.3	0	0.0
Total	89	100.0	2	100.0	89.0	100.0	79	100	90	100.0

Table 2

Choluteca: farmers by seed type used 1999-2000

	1999-2000						2000-2001		All seasons	
	Primera		Postrera		Both seasons		Primera			
	n	%	n	%	n	%	n	%	n	%
Hybrids only	2	2.9	1	1.5	0	0.0	0	0.0	0	0.0
Recycled hybrids only	0	0.0	1	1.5	0	0.0	1	1.6	0	0.0
OPV only	20	29.4	7	10.3	7	9.1	4	6.3	3	3.9
Hybrids and recycled hybrids	0	0.0	0	0.0	1	1.3	0	0.0	1	1.3
OPV and TV	2	2.9	2	2.9	21	27.3	0	0.0	26	33.8
Hybrids and TV	0	0.0	0	0.0	2	2.6	0	0.0	1	1.3
TV only	44	64.7	57	83.8	46	59.7	58	92.1	45	58.4
Hybrids, recicled hybrids and TV	0	0.0	0	0.0	0	0.0	0	0.0	1	1.3
Total	68	100.0	68	100.0	77.0	100.0	63	100.0	77	100.0

Table 3

Olancho: farmers by seed type use and total crop land 1999

	Total sample		Total crop land (ha)									
			0 - 1.4		1.4 - 2.8		2.8 - 5.3		5.3 - 8.2		8.2 +	
	n	%	n	%	n	%	n	%	n	%	n	%
Hybrids only	46	51.7	4	19.0	8	40.0	15	57.7	11	78.6	8	100.0
Recycled hybrids only	7	7.9	1	4.8	0	0.0	6	23.1	0	0.0	0	0.0
OPV only	32	36.0	16	76.2	10	50.0	4	15.4	2	14.3	0	0.0
Hybrids and recycled hybrids	1	1.1	0	0.0	1	5.0	0	0.0	0	0.0	0	0.0
Hybrids and OPV	3	3.4	0	0.0	1	5.0	1	3.8	1	7.1	0	0.0
Total	89	100.0	21	100.0	20	100.0	26	100.0	14	100.0	8	100.0

Table 4

Choluteca: farmers by seed type use and total crop land 1999

	Total sample		Total crop land (ha)									
			0 - 1.1		1.1 - 1.4		1.4 - 1.8		1.8 - 2.8		2.8 +	
	n	%	n	%	n	%	n	%	n	%	n	%
OPV only	7	9.1	2	15.4	1	6.7	3	10.7	0	0.0	1	11.1
Hybrids and recycled hybrids	1	1.3	0	0.0	1	6.7	0	0.0	0	0.0	0	0.0
OPV and TV	21	27.3	0	0.0	3	20.0	9	32.1	5	41.7	4	44.4
Hybrids and TV	2	2.6	0	0.0	1	6.7	1	3.6	0	0.0	0	0.0
TV only	46	59.7	11	84.6	9	60.0	15	53.6	7	58.3	4	44.4
Total	77	100.0	13	100.0	15	100.0	28	100.0	12	100.0	9	100.0

Table 5

Number of maize varieties grown per season

	Primera 1995-96		Primera 1998-99		Primera 1999-2000		Postrera 1999-2000		Primera 2000-01	
	n	%	n	%	n	%	n	%	n	%
Olancho										
0	2	2.6	3	4.8	1	1.1	87	97.8	3	3.3
1	61	79.2	56	90.3	81	91.0	2	2.2	79	87.8
2	10	13.0	3	4.8	6	6.7	0	0.0	8	8.9
3	4	5.2	0	0.0	1	1.1	0	0.0	0	0.0
Total	77	100.0	62	100.0	89	100.0	89	100.0	90	100.0
Choluteca										
0	2	2.6	7	9.2	5	6.6	6	7.9	12	15.8
1	63	81.8	57	75.0	57	75.0	59	77.6	58	76.3
2	12	15.6	12	15.8	13	17.1	11	14.5	6	7.9
3	0	0.0	0	0.0	1	1.3	0	0.0	0	0.0
Total	77	100.0	76	100.0	76	100.0	76	100.0	76	100.0

Table 6

Maize production and yields by variety

	Olancho				Choluteca				Total			
Variety	Production (t)	Area (ha)	Yield (t/ha)	Number of plots	Production (t)	Area (ha)	Yield (t/ha)	Number of plots	Production (t)	Area (ha)	Yield (t/ha)	Nuber of plots
Cargill	165.7	79.5	2.1	22	0.2	0.4	0.6	1	166.0	79.8	2.1	23
Cristiani	170.2	101.0	1.7	42	1.7	1.1	1.6	2	171.9	102.0	1.7	44
Guayape	94.0	53.0	1.8	43	0.0	0.0	NA	0	94.0	53.0	1.8	43
HPB	3.2	1.1	3.1	1	0.0	0.0	NA	0	3.2	1.1	3.1	1
White maicito	0.0	0.0	NA	0	52.7	81.1	0.6	83	52.7	81.1	0.6	83
Yellow maicito	0.0	0.0	NA	0	12.4	19.5	0.6	28	12.4	19.5	0.6	28
Non-identified improved	0.0	0.0	NA	0	20.0	26.7	0.7	31	20.0	26.7	0.7	31
Cargill recycled	3.6	1.1	3.5	2	0.0	0.0	NA	0	3.6	1.1	3.5	2
Cristiani recycled	17.3	12.6	1.4	6	1.1	0.7	1.5	1	18.4	13.3	1.4	7
Another OPV	1.8	2.8	0.6	1	0.0	0.0	NA	0	1.8	2.8	0.6	1
H5	15.6	10.5	1.5	6	0.0	0.0	NA	0	15.6	10.5	1.5	6
Another TV	1.3	1.8	0.7	2	1.7	0.7	2.4	2	3.0	2.5	1.2	4
Total	472.7	263.2	1.8	125	89.8	130.0	0.7	148	562.5	393.2	1.4	273

Table 7

Seed acquisition

	Olancho	(%)	Choluteca	(%)	Total	(%)
Own seed	24	27.0	49	63.6	73	44.0
Barter	14	15.7	1	1.3	15	9.0
Purchase	40	44.9	9	11.7	49	29.5
Donation	11	12.4	18	23.4	29	17.5
Total	89	100.0	77	100.0	166	100.0

Table 8

Seed source

	Olancho	(%)	Choluteca	(%)	Total	(%)
Own	24	27.3	49	63.6	73	44.2
Family/neighbor	22	25.0	10	13.0	32	19.4
Store	36	40.9	0	0.0	36	21.8
Government	1	1.1	0	0.0	1	0.6
NGO	0	0.0	17	22.1	17	10.3
Church	5	5.7	0	0.0	5	3.0
Other source	0	0.0	1	1.3	1	0.6
Total	88	100.0	77	100.0	165	100.0

Table 9. Rank mean scores per variety and non-parametric test results for Olancho[a]

Variable	Whitney-Wilcoxon-Mann two sample test			Kruskal-Wallis test				
	Mean score		Test [d]	Mean score			Test [d]	
	Hybrids [b]	OPV [c]	p-value	Cargill [b]	Cristiani [b]	OPV [c]	K-W Statistic	p-value
Yield	60.5	66.7	0.174	58.8	61.2	72.7	5.70	0.126
Early maturity	60.6	66.5	0.303	**51.8**	59.3	83.3	9.64	0.022**
Drought resistance	55.1	59.8	0.404	47.6	55.6	63.4	3.25	0.355
Insect resistance	44.7	44.2	0.928	**32.7**	52.5	41.8	7.44	0.059*
Lodging resistance	**52.1**	78.9	<.001***	**33.5**	53.5	78.4	37.98	<.001***
Grain weight	58.9	66.4	0.160	**51.7**	57.5	79.8	9.32	0.025**
Taste	59.1	**49.5**	0.026**	46.0	54.1	58.0	5.18	0.159
Tortilla quality	51.5	46.8	0.222	**44.1**	53.0	63.0	7.43	0.059*
Storage	**50.5**	62.4	0.030**	**40.5**	72.9	42.8	18.53	<.001***
Fodder	44.7	51.1	0.198	**33.2**	49.5	47.7	7.27	0.064*
Shelling	**36.7**	44.9	0.052*	33.3	41.3	34.7	4.70	0.195
Labor requirement	47.3	44.3	0.553	58.2	45.1	35.9	5.27	0.153
Input requirement	50.1	43.0	0.158	56.6	44.3	50.4	4.44	0.218
Minimum yield	44.1	44.9	0.872	60.8	**38.4**	39.8	8.36	0.039**
Husk cover	**31.7**	40.8	0.025**	35.6	**29.5**	36.5	6.49	0.090*

a. One of each non-parametric test was conducted for each characteristic. The lower the mean score, the better-rated was the variety with respect to each characteristic. For both tests, the null hypothesis is no difference between varieties (or groups of varieties). Bold indicates the variety which is preferred at the 10% significance level or better.

b. Hybrids include Cargill and Cristiani commercial brand seed.

c. OPV seed is of the Guayape variety.

d. Two sided tests.

Table 10. Rank mean scores per variety and non-parametric test results for Choluteca[a]

Variable	Wilcoxon-Mann-Whitney two sample test: Mean score MV[b]	Mean score TV	Test[c] p-value	Kruskal-Wallis test: Mean score MV Not identified	Mean score MV Planta Baja	Mean score TV White	Mean score TV Yellow	Test[c] K-W Statistic	Test[c] p-value
Yield	**52.4**	63.8	0.043*	61.3	**45.5**	67.7	52.0	12.91	0.048**
Early maturity	90.8	**52.6**	<.001***	83.3	84.3	58.6	**39.7**	31.60	<.001***
Drought resistance	78.4	**53.3**	<.001***	68.0	60.7	58.1	**40.3**	11.11	0.011**
Insect resistance	63.2	53.5	0.108	73.0	57.7	52.5	52.4	5.87	0.118
Lodging resistance	**44.0**	67.2	<.001***	50.9	**37.4**	68.6	82.6	14.72	0.002***
Grain weight	**48.7**	64.8	0.010***	58.7	**44.6**	64.7	59.8	6.34	0.096*
Taste	81.6	**55.6**	<.001***	77.2	80.2	56.5	**55.8**	18.79	<.001***
Tortilla quality	74.2	**58.4**	0.003***	82.1	66.1	**55.6**	64.9	13.27	0.004***
Storage	74.9	**49.5**	<.001***	77.1	74.1	51.5	**44.3**	18.07	<.001***
Fodder	50.3	51.9	0.779	63.1	42.9	51.6	52.2	4.35	0.226
Shelling	86.7	**52.9**	<.001***	91.8	83.5	**52.8**	53.2	49.84	<.001***
Labor requirement	70.1	**54.1**	0.011**	80.0	62.6	**53.8**	56.9	8.47	0.037**
Input requirement	50.0	48.3	0.822	76.2	59.4	53.6	**51.8**	7.37	0.061*
Minimum yield	68.2	**51.8**	0.003***	66.0	66.3	51.5	**43.4**	11.20	0.011**
Husk cover	62.7	58.5	0.307	71.7	58.9	58.6	56.5	5.30	0.151

a. One of each non-parametric test was conducted for each characteristic. The lower the mean score, the better-rated was the variety with respect to each characteristic. For both tests, the null hypothesis is no difference between varieties (or groups of varieties). Bold indicates the variety which is preferred at the 10% significance level or better.

b. Modern varieties include Planta Baja and non-identified varieties (some of which were distributed as aid following Hurricane Mitch).

c. Two sided tests.

Table 11. Multinomial logit estimation results (p-values in parentheses)

	Olancho			Choluteca		
Variable	**Cargill hybrid vs. OPV**	**Cristiani hybrid vs. OPV**	**Cristiani hybrid vs. Cargill hybrid**	**OPV vs. White TV**	**OPV vs. Yellow TV**	**Yellow TV vs. White TV**
Farm size	0.396 **	0.413 **	0.017	1.433 **	2.503 **	-1.070
	(.028)	(.012)	(.862)	(.024)	(.016)	(.228)
Road quality[a]	-1.897 ***	-1.564 ***	0.334	-0.909 *	-1.003 *	0.094
	(.009)	(.005)	(.536)	(.083)	(.052)	(.842)
Distance to nearest mkt.	0.021	0.015	-0.006	0.020	-0.018	0.038
	(.601)	(.501)	(.877)	(.754)	(.799)	(.566)
Family size	-0.496 **	-0.217 *	0.279	-0.503 *	-0.310	-0.193
	(.025)	(.081)	(.155)	(.061)	(.268)	(.269)
Vehicle ownership	1.867 *	0.495	-1.372 *			
	(.086)	(.587)	(.091)			
Off-farm income	0.021	-0.009	-0.030			
	(.442)	(.704)	(.136)			
Organization member	0.481	-1.154	-1.635 *			
	(.763)	(.455)	(.097)			
Education				-1.078 ***	0.911 **	-0.167
				(.006)	(.028)	(.514)
Age				-0.062	-0.128 ***	0.066 **
				(.131)	(.008)	(.042)
Ag. income				0.245	2.766	-2.521
				(.825)	(.103)	(.102)
Hurricane Mitch aid				6.069 ***	4.559 ***	1.510
				(.000)	(.004)	(.158)
Constant	4.535 *	4.457 **	-0.077	3.908	6.152	-2.244
	(.051)	(.011)	(.965)	(.280)	(.124)	(.502)
N	89			76		
Log-likelihood	-63.678			-39.027		
Pseudo-R^2	0.300			0.507		
% predicted correctly	64.0			77.6		

a. The road quality index ranges from 1 to 5, with a value of 1 indicating the best road quality and a value of 5 indicating the worst road quality.

Table 12. Logit estimates of adoption of improved maize varieties[a]

	Olancho		Choluteca	
Variable	**Parameter**	**p-value**	**Parameter**	**p-value**
Constant	5.145	0.079	-3.151	0.052
Cropped area	0.371	0.096	0.608	0.166
Family size	-0.277	0.186	–	–
Hurricane Mitch aid	–	–	3.902	0.001
Transactions cost variables				
Road quality index[b]	-1.666	0.050	-0.705	0.136
Distance to nearest market	-0.117	0.101	–	–
Characteristics variables				
Yield	6.314	0.047	3.381	0.021
Early maturity	2.137	0.070	0.992	0.486
Tortilla quality	–	–	-0.788	0.621
N	83		72	
Log likelihood	-15.887		-19.968	
Pseudo R^2	0.704		0.571	
% predicted correctly	90		86	

a. "Improved" varieties are hybrids in Olancho and improved OPVs in Choluteca.

b. The road quality index ranges from 1 to 5, with a value of 1 indicating the best road quality and a value of 5 indicating the worst road quality.

Figure 1. Olancho: Probabilities of variety use by road quality

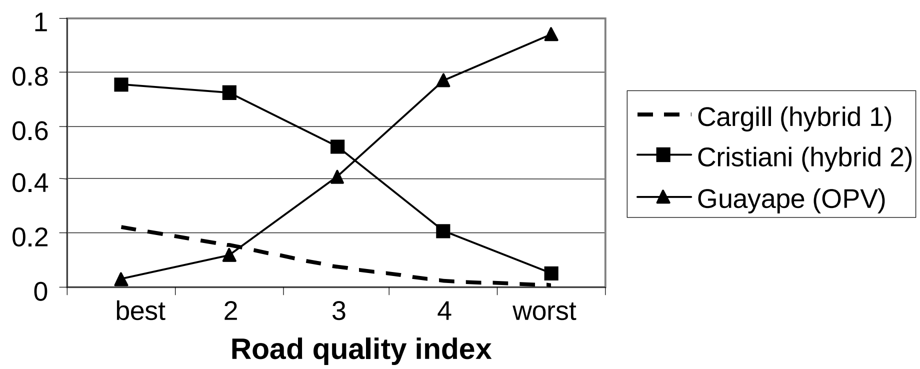

Figure 2. Choluteca: Probabilities of variety use by road quality