Does It Matter Who We Ask in Household Surveys? A Study on Gendered Effects and Decision Making Processes in Ecuador

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ABSTRACT

The understanding of how households make decisions may improve the success of an economic development program and enhance targeted training efforts. Technology adoption and farm management decisions depend on intra-household decision making. If a relevant decision maker can be clearly identified and specifically trained to meet his or her needs, the development program may be enhanced. Many approaches have been developed to help understand household decision making processes and the responses to household surveys provide the basis for this. Survey questions are often asked of a single person, and proxy responses are commonly used. Though potential bias from proxy responses is well documented, there is less information regarding the relationship between the proxy and his or her characteristics and the veracity of responses to subjective questions like who makes decisions within the household or who is in charge of major responsibilities. This paper employs the methods of mining contrast-set (Bay and Pazzani, 1999, 2001) and association rule (Agrawal et al., 1993) to answer the general question of whether and under what conditions proxy responses to survey questions are acceptable. It also analyzes how factors such as gender of the respondent matters and how other factors affect the suitability of using proxy responses.

The findings show that gender matters for household decisions. For instance, more male than female respondents are likely to claim that they are responsible for household decision-making. Respondents answer differently not only to some subjective questions such as who sells crops, but also to objective survey question such as the number of female workers in a family. Factors such as the age of the respondent are found to influence responses of the interviewees to certain activities such as preparing and applying pesticides. The pattern of responses to both objective and subjective questions as well as the effect on responses by characteristics differ by areas where the survey is conducted, etc..

DEDICATION

This Master's thesis is dedicated to my beloved parents, my mom Xia Li and dad Ming Yang, for their endless and unconditional love and support throughout my entire life and academic journey. I am extremely happy and fortunate to have such wonderful parents just like you.

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CHAPTER I: Introduction and Motivation

The understanding of how farm households make decisions may be meaningful and important since it may improve a development program's success and information about who makes which decisions will allow better-targeted training. For instance, in developing countries, agricultural productivity is often accompanied with pesticide use and pesticides have the potential for adverse human health and environmental problems. A program to provide training in management practices with a focus on pest management practices can increase the efficiency of agricultural production.

Households do not make decisions by following static rules. Life experiences, traditions, customs and the social environment may influence their decision-making. Decisions about farm management may be crucial especially for developing countries where households make technology adoption decisions as part of an overall strategy to meet food security needs (Thangata, et al. 2002). Investments, technology adoption, and other decisions may change resulting from an intervention and such decisions are related to a program's success. On account of the importance of decision making, if a relevant decision maker can be clearly identified and specifically trained to meet his or her needs, the development program may be enhanced.

Several approaches exist for understanding how farm decisions are made. Participatory methods are commonly used help engage stakeholders to share ideas (Gurung and Leduc 2009). Baseline surveys may identify livelihood clusters, and participatory appraisals are used to gain information regarding the identification of productive activities, assets and knowledge (Barrera, et al. 2012). Participatory approach may be potentially influenced from questionable external validity, and the validity of baseline survey information may be dependent on questionnaire designs (Bardasi, et al. 2010). For example, men and women might have differing opinions about who makes which decisions.

In understanding household decisions, researchers often rely on responses to household survey questions. These questions are often asked of a single person, and proxy responses are commonly used. By interviewing a single person who responds to questions about himself and others in the household, researchers can lower survey costs and improve survey efficiency. For example, when other respondents are missing, reliance on a single responder can avoid "incomplete" surveys, and reduce costs of tracking down missing members or revisiting the household. Proxy reporting literally means that the questioner is collecting information about all members of household from a single respondent (Bureau of Labor Statistics).

A key issue is whether proxy responses provide accurate answers and allow reliable inferences. In some cases they may, while in others it may be important to ask specific household members. Knowledge about the specific types of survey questions that are amenable to proxy responses can enhance survey design.

The answer to whether proxy responses provide accurate answers in all cases is, unfortunately, no. According to an assessment of this literature, "the use of proxies can reduce data quality introducing biases in the survey estimates. … These findings suggest that proxy-reports are systematically biased. When respondents are asked to report about other people but do not have sufficient information, they appear to rely on inferences grounded in lay theories about the domain of questions" (Todorov 2003, pp. 215 and 222). And "if many people do not respond to surveys, and those who do not respond are different from those who do, then survey estimates may be biased" (Hendershot July 2, 2014, http://dsq-sds.org/article/view/481/658).

Even responses to objective questions such as labor force participation and working hours have been found to be potentially biased when proxy are interviewed (Bardasi, et al. 2010).

Though potential bias from use of proxy responses is well documented, there is less information regarding the relationship between the proxy and his or her characteristics and the veracity of responses to different questions (Shaw 2012). Subjective questions like who makes decisions within the household or who is in charge of major responsibilities may be especially vulnerable to proxy bias. To design an effective training program, answers to such questions are needed. The main issue is does it matter who we ask when conducting surveys about household responsibilities? Do we need a balance between men and women to make proper inferences about household decision making?

Gendered differences in responses to questions may be important. For example, a husband's estimate of his wife's income does not always produce reliable results. In a study on proxy responses in Malawi estimates of the wife's income provided by the husband and wife are in agreement in only 6% of households, and in 66% of households, the husband underestimated his wife's income by 47% on average (Fisher, et al. 2010). Factors related to gender bias may affect the optimal design of a farmer training program. A growing body of literature shows evidence of differences between male and female responses to survey questions in developing countries. One example is the husband's estimates of wives' income in Malawi, where accurate estimates are obtained in only 6% of the surveys and husbands tended to underestimate female income (Fisher et al. 2010).

Survey designs trade off costs and benefits, such as costs of enumeration versus response accuracy, or more generally, a tradeoff between the increased costs and more accuracy in reporting (Bureau of Labor Statistics). It is important to understand this tradeoff, especially since substantial costs and resources can be saved through use of particular designs. If a proxy response to a question is close enough at an acceptable level to the one answered by many respondents, then the single respondent is sufficient to be interviewed.

This paper uses the results from a randomized experiment in Ecuador to examine perceptions about roles in farming and, particularly on pesticide decisions and management. Responding households are randomly assigned to one of three contrasting groups: a male respondent, a female respondent, and households with both male and female respondents who are interviewed jointly but separately. The approaches of mining contrast-sets (Bay and Pazzani 1999, 2001) and the association rule (Agrawal et al., 1993) are employed to examine whether and in what way this treatment effect depends on household characteristics or type of question, specifically whether the question is objective or subjective. It also addresses specific questions such as what factors impact gender-specific responsibilities in farm and pesticide management decisions.

Findings show that few of the objective responses are affected by the treatment assignment; perceptions about household decision making processes differ significantly between males and females, and across treatment groups; and men are found to be more likely to claim their own roles and responsibilities in making household decisions, agricultural management and sales. The effect of treatment assignment is related to some household characteristics (e.g., the number of female workers and the age of respondent), but not in a significant manner. The pattern of the responses and effect on survey answers by characteristics vary by different areas of survey conducted. The remainder of this paper is as follows: background, methodology, data analysis and results, comparisons to multinomial logistic regressions and conclusions.

REFERENCES

Agrawal, R., Imielinski, T., and Swami, A.N. 1993. "Mining Association Rules between Sets of Items in Large DataBases", In Proceedings of the 1993 ACM SIGMOD International Conference on Management of Data, P. Buneman and S. Jajodia, Eds. Washington, D.C., 207-216

Bay, S. D. and Pazzani, M. J., 1999. "Detecting Change in Categorical Data: Mining Contrast Sets". In Proceedings of the Fifth International Conference on Knowledge Discovery and Data Mining. http://www.ics.uci.edu/~pazzani/Publications/stucco.pdf

Bay, S. D. and Pazzani, M. J., 2001. "Detecting Group Differences: Mining Contrast Sets. Data Mining and Knowledge Discovery". Vol.5, No.3 213-246.

Barrera, V.H., Escudero, L.O., Alwang, J., Andrade, R. May 2012. "Integrated Management of Natural Resources in the Ecuador Highlands". Agricultural Sciences, Vol.3, No.5, 768-779 (2012). Accessed 03/21/14 http://dx.doi.org/10.4236/as.2012.35093

Bardasi, E., Beegle, K., Dillon, A., Serneels, P. 2010. "Do Labor Statistics Depend on How and to Whom the Questions Are Asked? Results from a Survey Experiment in Tanzania". Policy Research Working Paper 5192. The World Bank, Development Research Group, Poverty and Inequality Team. http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-5192

Bureau of Labor Statistics. "Proxy Reporting in the Consumer Expenditure Surveys Program". First Workshop of the Consumer Expenditure Surveys Redesign Paper, Proxy Reporting. Accessed 03/20/14 http://www.bls.gov/cex/methwrkshpproxyrpting.pdf

Fisher M., Jeffrey J. Reimer, Edward R. Carr, 2010. Who Should be Interviewed in Surveys of Household Income? Development Strategy and Governance Division. IFPRI Discussion Paper 00949. International Food Policy Research Institute. http://www.ifpri.org/sites/default/files/publications/ifpridp00949.pdf

Gurung, M.B. and Leduc, B. November 2009. "Guidelines for a Gender Sensitive Participatory Approach". International Centre for Integrated Mountain Development (ICIMOD). Electronic pdf file. Accessed 12/01/14 https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB4QFjAA&url=http%3A%2F%2Fwww.icimod.org%2Fresource%2F1288&ei=e1-FVIbvF5PhsATE2YCACw&usg=AFQjCNEupfttyxDFFYqhj9QNdH9B20GlOA&sig2=ft4KgUzKG2jJz3g8uI39VA&bvm=bv.80642063,d.cWc

Hendershot, G.E. 2004. "The Effects of Survey Nonresponse and Proxy Response on Measures of Employment for Persons with Disabilities". Disability Studies Quarterly. Spring 2004, Vol.24, No.2. Abstract. http://dsq-sds.org/article/view/481/658

Shaw, C. 2012. “Farm Decision Making and Gender: Results from a Randomized Experiment in Ecuador”. FDM. Blacksburg, AAEC.

Thangata, P.H., Hildebrand, P.E., and C.H. Gladwin, 2002. “Modeling Agroforestry Adoption and Household Decision Making in Malawi”. African Studies Quarterly, Vol. 6, Issues 1 & 2 Accessed 2/01/14. http://asq.africa.ufl.edu/files/Thangata-Hildebrand-Gladwin-Vol6-Issue-12.pdf

Todorov, A. 2003. “Cognitive Procedures for Correcting Proxy-response Biases in Surveys”. Page 215 Summary and Page 222. Applied Cognitive Psychology. Appl.Cognit.Psychol. 17: 215-224 (2003). Published online in Wiley InterScience 28 November 2002. DOI: 10.1002/acp.850.

CHAPTER II: Background

II.1. Background Information:

In highland Ecuador, pesticide use is widespread and farmers face serious exposure to pesticide and health problems (Cole, et al. 2002). As a response to pesticide-related problems, the Ecuador government is interested to reduce the use of pesticides and is seeking solutions to the tradeoff between human health problems such as pesticide handling, storage, and agricultural production.

Bolivar is one of the two poorest provinces in Ecuador (Fair World Project). It has "the lowest levels of economic development in Ecuador due to the lack of infrastructure investment – agricultural and industrial – throughout the region. According to statistics generated by the Integrated Social Indicators of Ecuador (SIISE), 75% of the population in the province of Bolivar lives in poverty" (July 2, 2014, http://www.nesst.org/wp-content/uploads/2012/07/2012-Ecuador-Texal-EN.pdf). Since agriculture is the main economic activity in Bolivar Province (Crop Biodiversity), it is important to realize agricultural development in the province in order to reduce poverty.

II.2.Survey Experiment:

Data analyzed come from a survey conducted in the Illangama and Alumbre sub-watersheds of the Chimbo River watershed, Bolivar Province, Ecuador. The survey was implemented from September-November 2011 by randomly selecting households from 72 communities. The number of households surveyed per contrasting group was: 91 for individually interviewed male respondent, 131 for individually interviewed female respondent, and 98 households where males and females were surveyed jointly but separately within the household, a total of 418 responding farmers from 320 households. The survey covers areas such as household socio-economic conditions and demographics, marketing, pest management practices, knowledge of IPM, and household decision making processes. Descriptive statistics are shown in Table 1 and 2 for Alumbre and Illangama, respectively.

The study focuses on two broad issues of whether membership in a randomly assigned contrasting group has an effect on survey responses, and whether this effect depends on other household characteristics. We also investigate whether the effect in each contrasting group differs meaningfully by objective and subjective types of questions. We also address specific questions such as what factors impact gender responsibilities in farm decisions, what types of survey questions can be combined or shortened, and does it matter who to interview.

REFERENCES

Cole, D.C., Sherwood, S., Crissman, C., Barrera, V., Espinosa, P., 2002. "Pesticides and Health in Highland Ecuadorian Potato Production: Assessing Impacts and Developing Responses". Int J Occup Environ Health 2002, 8:182-190.

Crop Biodiversity, to Reduce Pest and Disease Damage, Ecuador. Accessed 03/22/14. http://agrobiodiversityplatform.org/cropbiodiversity/the-countries/the-americas/ecuador/

Ecuador Fair Trade Visit Part I: Adventures in Organic Fair Trade Alcohol. Fair World Project. Accessed 3/21/14 http://fairworldproject.org/blogs/ecuador-fair-trade-visit-part-i-adventures-in-organic-alcohol/

Investment Brief: Ecuador, 2012. Texal Association. Cited from "Social Challenges" section. Accessed 03/26/14 http://www.nesst.org/wp-content/uploads/2012/07/2012-Ecuador-Texal-EN.pdf

CHAPTER III: Methods

To address the objectives, this study employs the methods of contrast-set (Bay and Pazzani, 1999 and 2001) and association rule (Agrawal et al., 1993) mining. The contrast-set mining method is used first to access whether and to what specific objective and subjective type of questions do gendered effects impact the survey responses. Based on the contrast-set results, association rule mining is then used to examine if there exist specific household characteristics that influence such effects on the responses. Samples are divided into four sub-groups for measuring pure gendered effects on survey responses based on different categories of questions. Categories of questions include: six household decision-making related subjective questions (e.g. who sells crops?), questions about features of the respondents (e.g. age and education level of the respondents), household characteristics (number of male and female workers in farm per family or area of land available for production), and other related questions (knowledge about pest management, irrigation access, and crop production styles such as rotations and contour practice, etc.).

For each sub-group, contrast-set mining was conducted as follows: the mining process, similar to the one given by Bay and Pazzani 1999 and 2001, first counts the frequencies of responses to each question across contrasting groups. It then identifies all pairs of responses whose corresponding frequency differs statistically significantly. Once all such conjunctions of survey questions and responses that are significantly different in their distribution across groups are identified, hypothesis tests are conducted. In these tests, the null is that the frequency or the probability of a response to a survey question is equal across the three groups. This hypothesis is that the probability is independent among groups. Lastly, an adjusted Bonferroni inequality is used to control the Type I error due do operating multiple hypothesis testing. A detailed description of the methods follows:

III.1. Contrast-set Mining:

<u>Definition 1:</u> *"Let $A_1, A_2, \dots, A_k$ be a set of k variables, and call them attributes. Each A_i can take on a finite number of discrete values from the set $\{V_{i1}, V_{i2}, \dots, V_{im}\}$. Then a* ***contrast-set*** *is a conjunction of attribute-value pairs defined on groups $G_1, G_2, \dots, G_n$ "(Bay and Pazzani 1999 p.2 http://www.ics.uci.edu/~pazzani/Publications/stucco.pdf), where n is the number of mutually exclusive groups.*

The attributes under examination are the survey questions, the values are the corresponding responses to the questions, and the groups are the three contrasting groups. For example, assume that we have a contrast-set: $(Gender\ of\ respondent = male) \cap (Who\ is\ in\ charge\ of\ purchasing\ pesticide = self)$. This set literally says that, based on the survey data, a respondent responded to the gender question as being a male and he also subjectively claims that he alone is in charge of purchasing pesticides.

<u>Definition 2</u>: *"The* ***support*** *of a contrast-set for a group G is the percentage of examples in G where the contrast-set is true."(Bay and Pazzani, 1999* p. 2 *http://www.ics.uci.edu/~pazzani/Publications/stucco.pdf)*

In the current case, the support can be considered as a frequency or the probability of the occurrence of a contrast-set within a given group G_i, $\forall\ i = 1, 2, 3$.

Given these two definitions, the challenge is to find all such contrast-sets (cset) whose frequency differs significantly across groups in order to detect relationships among variables.

Through this approach, the question "Does it matter who we ask for certain survey questions?" can be addressed. Mathematically, the process identifies contrast-sets such that the following two conditions are jointly satisfied (Bay and Pazzani 1999):

"$\exists ij \; P(cset = True|G_i) \neq P(cset = True|G_j)$, where $P(\cdot) \equiv$ probability (1)

$\max_{ij} \mid support(cset, G_i) - support(cset, G_j) \mid \geq \delta$ " (2)

The contrast-set is called ***significant*** if inequality (1) is satisfied, and ***large*** if Inequality (2) is met. Notice that in (2), δ is a user-defined threshold which can take $\delta \in [\, 0 \,, 1 \,]$. If both inequalities are satisfied, we call it a ***deviation***. By identifying such deviations, significantly different survey responses across groups can be determined. For instance, assume a threshold with $\delta = 0.5$. By counting relative frequencies, we get: $\forall i = male, j = female, P(Responsibility\ 1 \mid G_i) = 0.95,\ P(Responsibility\ 1 \mid G_j) = 0.25$, then we know that responses to the survey question "Responsibility 1" across the groups of male and female are, by inequality (1), *significant*, and the absolute value of the difference between their supports is 0.7. Since this is larger than the threshold 0.5, it is deemed to be, by inequality (2), *large*, and therefore represents a *deviation*. Based on the sample probability distribution, this result indicates that men and women answer this survey question differently. If the statistical significance test is also met, this finding will imply that male and female respondents answered the question significantly differently, and it is necessary to interview both households on "responsibility 1".

The method described above needs to be extended to account for the presence of continuous, discrete and mixed variables in the dataset (the methods previously mentioned are appropriate for discrete variables). Agricultural survey data tend to include mixes of categorical, ordinal and continuous data. Though ordinal data can be analyzed the same way as categorical data, continuous data may not be most accurately analyzed in this way. Thus, this paper introduces an additional method, use of optimal bandwidth of Kernel density estimates of continuous variables, to transform the continuous data into categorical form. This method not only provides an approximation of the original probability distribution, but also offers smoothness and continuity, which may better reduce information loss from the data transformation. Alternatives for the conversion to discrete variables include histograms and discretizations. The method of histograms is a basic and commonly known approach to mimic the original continuous variable by drawing adjacent rectangles and the method of discretizations is common in machine learning to convert continuous data. The goal of discretization is to "find a set of cut points to partition the range into a small number of intervals that have good class coherence, which is usually measured by an evaluation function" (Kotsiantis and Kanellopoulos, pp. 47-58).

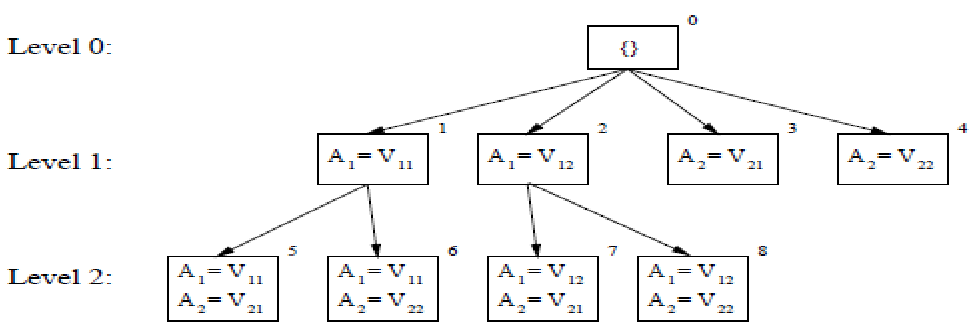
Kernel density estimators have the properties of smoothness, no end points and the dependence on bandwidth rather than on width of bins, compared to the histogram method (Duong 2001). The use of an optimal bandwidth in a kernel approach provides an improved decision with respect to the optimal width of bins (the degree of approximation in a histogram approach). The optimal bandwidth for the case of Gaussian distribution with a Gaussian kernel (Zucchini 2003) is given by:

$$h_{opt} = (\frac{4}{3n})^{1/5}\sigma.$$

where n stands for the sample size and σ the standard deviation of the continuous variable that is to be transformed. The above equation is then used to categorize such variables. Age and education, are categorized using common intervals rather by the optimal bandwidth. Age is broken into ≤18 years, 18~44, 45~64, and ≥65; education is divided into primary school (6 years or less), secondary (6 to 11 years) and post-secondary (12 years and above).

III.2. An Algorithm for Mining Contrast-sets:

In order to systematically detect contrast-sets, this paper employs an algorithm, STUCCO (Search and Testing for Understandable Consistent Contrasts) (Bay and Pazzani 1999 and 2001). In practice this algorithm works efficiently to mine numbers of potential candidates even at a low support difference defined by inequality (2) (Bay and Pazzani 1999). The Figure 1 shows how STUCCO works with two attributes each taking two possible values:



(Figure 1. A Mining Process by STUCCO)

(Source: "Detecting Change in Categorical Data: Mining Contrast Sets", by Stephen D. Bay and Michael J. Pazzani, the Department of Information and Computer Science, University of California, Irvine, http://www.ics.uci.edu/~pazzani/Publications/stucco.pdf , Page 2)

This figure assumes two survey questions (A_1 and A_2) and two responses for each question: {V_{11}, V_{12}} for A_1 and {V_{21}, V_{22}} for A_2. The algorithm begins by searching contrast-sets with an empty set at Level 0. Then for each subsequent level, it adds an additional term into this system and continues, similar to taking permutations: for instance, at Level 1, a single survey question is taken into account at a time, and each possible response is assigned to the corresponding survey question. At Level 2, two different survey questions are taken into consideration simultaneously with permutations of their possible answers.

III.3. Finding Significant Contrast Sets:

When deviations are identified, it is necessary to conduct tests of statistical significance on whether the deviations are statistically significant. A Chi-square test is used, since "the support counts from each group is a form of frequency data which can be analyzed in contingency tables … The standard test for independence of variables in contingency tables is the chi-square test." (Bay and Pazzani, pp.220). Let the null hypothesis be that the contrast-set supports are equal across contrasting groups, or in other words, the frequencies of the responses to each survey question are significantly different at 5% level, rather than being different by random causes. Under these conditions, the support can be conceived of as a form of frequency data which can be analyzed in 2×2 contingency tables.

III.4. Controlling for Type I Error:

When testing a single hypothesis, the significance level sets the maximum probability of falsely rejecting the null hypothesis. However, when conducting multiple hypothesis tests the probability of false rejection can be high, and there still exists no optimal solution to address this problem. One way to control for Type I error in the case of multiple tests is to use a more stringent α cutoff for the individual tests. Relate the α_i levels used for each individual test to a global α using the following:

Bonferroni Inequality: "Given any set of events e_1 , e_2 ,⋯ , e_n , the probability of their union $e_1 \cup e_2 \cup \cdots \cup e_n$ is less than or equal to the sum of the individual probabilities." (Bay and Pazzani 1999 p.3 http://www.ics.uci.edu/~pazzani/Publications/stucco.pdf)

A different level of significance can be used for each level in the searching process (Bay and Pazzani 1999):

$$\alpha_l = \min(\frac{\alpha}{2^l} / |C_l| , \alpha_{l-1})$$

where α_l is a test cut-off at each level l , and $|C_l|$ is number of candidates at each level l . In this study, the potential contrast-set candidates at level one are used to estimate the pure gendered effects (men answer the question differently from women) on the responses related to decision-making and other types of survey questions. Because the Bonferroni inequality may be too conservative, especially given the small sample size in this study, potentially interesting results at contrast-set level two may be missed by its strictness. Thus, after the level one contrast-set mining process, an association rule mining first proposed by Agrawal (Agrawal et al., 1993) is used as an alternative to examine whether the gendered effect differs by type of questions and household characteristics based on the final results found by level one contrast-set mining.

III.5. Association Rule:

As previously mentioned, given a relative sample size in this study, the prior method of finding contrast-set may miss some of the interesting results due to the conservativeness of Bonferroni inequality imposed at level two to address the issue of whether and what factor or characteristics may influence households' decisions. Therefore, the method of association rule is used to address the above questions. This rule was first developed to study market transactions with an implication statement. For instance, in a market, let X and Y be coffee and cream respectively. A rule $X \rightarrow Y$ indicates that if a customer buys coffee (X), he or she is also likely to purchase cream (Y). Association rules are now applied in various fields and they "have been broadly used in many application domains for finding patterns in data. … areas where association rule mining can be applied, are finding pattern in biological databases, market basket analysis of library circulation data, to study protein composition, to study population and economic census etc." (Rajak and Gupta, 2007, pp. 3). A detailed example is provided later to explain how association rule is applied in this work. The formal definition of the association rule (Dunham et al.) is:

Definition 3: *"Let $I = \{ I_1 , I_2 , \dots , I_m\}$ be a set of m distinct attributes, also called literals. Let D be a database, where each record (tuple) T has a unique identifier, and contains a set of items such that $T \subseteq I$. An* ***association rule*** *is an implication of the form $X \Rightarrow Y$, where $X, Y \subset I$, are sets of items called itemsets, and $X \cap Y = \emptyset$."(Dunham et al http://www2.cs.uh.edu/~ceick/6340/grue-assoc.pdf p.2)*

A rule can be simply thought of as an implication: $X \rightarrow Y \ni X, Y \subset I \text{ and } X \cap Y = \emptyset$. After the basic association rules are found, the following theorems (Alvarez, 2003) are applied to conduct chi-squared hypothesis testing of independence:

Theorem 1: *"Consider two binary-valued random variables A and B, a closed-form expression for a chi-squared statistic for a single association rule A⇒B satisfies the following equality whenever the right-hand side is well defined:*

$$\chi^2 = n(lift - 1)^2 \frac{supp \cdot conf}{(conf - supp)(lift - conf)}$$

Theorem 2: *Assume that* $\chi^2/n \neq 1$ *and lift≠0 and 1 are fixed. Then the support is a downward concave function of the confidence over* $conf \in (0,1)$, *with a unique maximum at the following value* $conf^*$*:"(*Alvarez http://www.cs.bc.edu/~alvarez/ChiSquare/chi2tr.pdf p.4,7)

$$conf^* = \frac{lift}{1 + \sqrt{\frac{n(lift-1)^2}{\chi^2}}}$$

The symbols *supp* and *conf* are two common constraints, also known as the minimum thresholds for the association rule. *Lift* is the ratio between the observed and expected supports. In this study, the *Supp* is considered as the fraction of respondents which contain specific responses and characteristics we want to examine and *conf* counts how often the responses to decision-making related questions occur among households which include a gender and specific household characteristics. All three values can be automatically returned by the statistical software *R* with the package *arules* and association rule mining algorithm *apriori*.

When a specific rule passes the chi-squared test, a rule can be in the form *{Gender = Male, Characteristics = A}⇒{Who sells crops = his wife }*. This may be an interesting rule and can be interpreted as saying that males with characteristics *A* tend to claim that their wives are in charge of selling crops. If it is considered as a strong association by the pre-defined thresholds and passes the hypothesis test, the result of this association rule then provides the evidence to show that, with characteristics *A*, male respondents tend to select a certain option to specific survey questions, and thus, the gendered effects may depend on these characteristics. Furthermore, by applying the association rule, many associations, such as younger male respondents are more likely to claim males' or joint responsibilities may be discovered. Only those association rules with the needed attributes and household characteristics (in the form of "gender and characteristics implies household responsibility") were listed in Table 8.

REFERENCES

Agrawal, R., Imielinski, T., and Swami, A.N. 1993. Mining Association Rules between Sets of Items in Large DataBases, In Proceedings of the 1993 ACM SIGMOD International Conference on Management of Data, P. Buneman and S. Jajodia, Eds. Washington, D.C., 207-216

Alvarez, S.A. 2003. Chi-squared Computation for Association Rules: Preliminary Results. Technical Report BC-CS-2003-01 http://www.cs.bc.edu/~alvarez/ChiSquare/chi2tr.pdf P.4 and 7

Bay, S. D. and Pazzani, M. J., 1999. Detecting Change in Categorical Data: Mining Contrast Sets. In Proceedings of the Fifth International Conference on Knowledge Discovery and Data Mining. http://www.ics.uci.edu/~pazzani/Publications/stucco.pdf

Bay, S. D. and Pazzani, M. J., 2001. Detecting Group Differences: Mining Contrast Sets. Data Mining and Knowledge Discovery. Vol.5, No.3 213-246.

Dunham, M.H., Xiao, Y., A Survey of Association Rules, Department of Computer Science and Engineering, Southern Methodist University, Le Gruenwald, Zahid Hossain, Department of Computer Science, University of Oklahoma, Page 2 http://www2.cs.uh.edu/~ceick/6340/grue-assoc.pdf

Duong, T. 2001. “An Introduction to Kernel Density Estimation”. Accessed 3/25/14 http://www.mvstat.net/tduong/research/seminars/seminar-2001-05/

Kotsiantis and Kanellopoulos, “Discretization Techniques: A Recent Survey”, Introduction, GESTS International Transactions on Computer Science and Engineering, Vol. 32(1), 2006, Page 47-58

Rajak and Gupta, 2007, “Association Rule Mining: Applications in Various Areas”, Page 3, International Conference on Data Management

Zucchini, W. 2003. “Applied Smoothing Techniques”, Part I: Kernel Density Estimation, Page 15-19.

CHAPTER IV: Data Analysis and Results

This section provides some detailed discussions regarding the analysis and research results. It first provides the answers to the general question of whether respondents responded the survey questions differently and to what type of questions; then followed by providing some household characteristics which may potentially influence people's responses; furthermore, the results of multinomial logit model are compared with the mining method and lead to the last section of conclusions.

IV.1. Data Analysis:

The analysis shows that the gender of the respondent affects some of the results about who conducts activities and makes decisions. Combining all pairs of contrasting groups together (Tables 3-7), a total of 15 contrast sets for Alumbre and 4 for Illangama were found. All of these passed tests of independence with the threshold of δ=0.1 and the statistically significant level at 0.05.

The sensitivity of contrast-set results subject to the threshold δ is listed in the last column of Table 3 as an example. A total of 13 significant results are listed using a threshold of 0.1; when the threshold increases to 0.2, 10 significant results were found, and at 0.3, only 6 were found. However, the sensitivity may differ by sample and by the parameters of the Bonferroni inequality. For instance, in Table 4, the contrast-set result is less sensitive to the choice of δ, and the sensitivity of results from other survey questions (not listed in the table) stay stable regardless of the threshold as the adjusted significance level is not met. In other words, the statistically insignificant results are always insignificant, and they are not subject to change as the threshold changes.

The Alumbre results from Table 3 show that individually interviewed male and female respondents responded to all of the six decision-making questions significantly differently. More specifically, in Table 3, all results on the decision-making related questions indicate that individually interviewed males and females have different perceptions about whether men or women make household decisions and whether men or women are in charge of agricultural practices. About 60% to 75% of the male and 25% to 30% of the female respondents claimed that males were in charge of managing and selling crops, buying pesticides, and deciding how much to spend on pesticides. About 15% to 37% of the women and 0% to 5% of the men responded that females were responsible for managing and selling crops, purchasing pesticides, and decisions about pesticide purchases and preparing and applying pesticides. Furthermore, results also show that over 50% the women responded that preparing and applying pesticides are man's responsibility and about 76% of the males responded that men were primarily responsible for these two activities and none of the males claimed that their wives were in charge of preparing and applying pesticides. The results in Table 3 suggest that males and females responded significantly differently to the question of "Who prepares pesticides?" but responded indifferently regarding "Who applies pesticides?". Men and women tended to agree that applying pesticides is mainly a male responsibility.

In Illangama, individually interviewed males and females provided more "balanced" responses than in Alumbre. Males and females responded significantly differently only to the question about who is in charge of selling crops: 77% of males and 19% of females stated that selling crops was a man's task (table 4). For all other questions, differences in male and female responses were not statistically significant.

Results in Table 5 and 6 explore whether women interviewed alone respond differently to women interviewed jointly with their spouse. Jointly interviewed women have different responses about gender roles in certain decisions. In Alumbre (Table 5), 29% of individually surveyed females and 57% of jointly interviewed females responded that selling crops was a joint activity conducted with their husbands. Jointly surveyed females (who knew that their husbands were also being interviewed) were more likely to claim joint responsibilities in selling their crops. Table 6 shows that in Illanagma 83% of jointly interviewed females responded that males were in charge of preparing and applying pesticides, while only about 40% of the individually interviewed females said so. Furthermore, roughly 30% of the individually surveyed female respondents claimed that females were in charge of managing crops, but interestingly, the percentage dropped to zero when females were interviewed jointly with their husbands. Female respondents tend to over-value their roles in these two household activities when being asked individually relative to when they are asked jointly.

Jointly interviewed males and females generally provide much more consistent responses and generally have more similar perceptions of who makes decisions household compared to individually surveyed respondents (table 7). In Alumbre, the only question where the males and females in the joint group had different perceptions of gender roles was in respect to who purchased pesticides – 66% of jointly interviewed males said they alone purchased pesticides for the household, but only 37% of the females agreed. In Illangama, joint group respondents had perfect agreement about perceptions of gender roles and household decision making. The results generally indicate that in both watersheds, interviewing both male and female respondents may help decrease differences in their responses. Jointly (but separately) interviewed respondents tended to have similar perceptions about who does what in the household.

Association rules provide answers to the question of what household characteristics may affect people respond questions differently, which we don't already know from the contrast-set method. The results of association rules contained in Table 8 provide evidence that the differences by gender depend on some household characteristics in the Alumbre sub-watershed. The age of the respondent and the number of females working on the farm affect the difference in response between the men and the women. In particular, gender differences in responses about who prepares and applies pesticides are affected by household characteristics. Individually interviewed males less than 65 years old were less likely to respond that such household activities were their wife's domain while individually interviewed females below 65 were less likely to state that they (the wives) were responsible for preparing and applying pesticides. Male respondents with at least one female family member working on the farm were less likely to claim that their wives were responsible for preparing and applying pesticides. Females with the same characteristics (at least one female family member working on farm) were less likely to claim sole responsibility for pesticide-related activities. In addition individually interviewed males with at least one female worker on the farm were more likely to respond that their wives were not in charge of selling crops, purchasing pesticides, managing crops, and deciding how much to spend on pesticides. No such patterns of association were discovered for Illangama suggesting that the gendered effects do not depend on characteristics or type of questions in this area, and it is mainly because no statistically significant differences were found.

Several implications can be identified. Firstly, similar to the pure gendered effects on decision-making, the dependence of the effects on household characteristics differs by area. Responses in the indigenous Illangama sub-watershed are qualitatively different from those in Alumbre. Second, in Alumbre, age of the respondent and the number of female workers on the farm influence the observed gendered effects on decision making-related subjective survey questions. If the male respondents were young, the activities of preparing and applying pesticides would more likely to be claimed to be the domain of men or jointly shared, and this is a statistically significant result. Finally, the results show a remarkable heterogeneity in responses—the structure of the survey has an important influence on the pattern of responses, but this pattern varies by household structure and by the particular area where the questions are being asked.

IV.2. Regression Analysis for Comparisons:

Very limited literature compares the method of mining contrast-sets/association rules and regression analysis. In order to make this comparison, econometric models were estimated using a Multinomial Logistic Model (MNL) to address the same issues examined by the contrast set and association rule methods.

To assess pure gendered effects on survey responses, MNL models are used to explain the effects of independent variables and group assignment over the probability of responding who makes each household decision. In an MNL, the probability that person j selects option i is expressed as (Cameron and Trivedi 2005):

$$P[y_j = i] = P_{ji} = \frac{\exp(x_i'\beta_i)}{\sum \exp(x_j'\beta_k)} \text{ , } where\ 0 < P_{ji} < 1$$

$$P[y_j = i] = P_{ji}(\beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k) = P_{ji}(\beta_0 + x\beta), x\beta = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k$$

where: $y_j \equiv$ the probability that the person j chooses option i (1≡ male, 2≡ female, 3≡ joint responsibility), $P[y_j = i]$; $x_j \equiv$ vector of variables in contrasting groups of gender, for instance, Gender1=single male when comparing male and female responses in this pair; $\beta_i \equiv$ vector of coefficients associated with the i^{th}option which measures the effect across the pair of groups (variables are listed in Table 1 and 2).

To assess the importance of characteristics and other factors on household choices, six regression models are employed. Since the multinomial logit coefficients are the relative possibilities and are not straightforward to explain, marginal effects are used for the interpretations of the models. Results of MNL models are presented in tables 9-12.

IV.3. Result Comparisons:

In this section, the results of contrast-set/association rule mining were compared to the results from the MNL. A total of 10 out of 13 discrete contrast sets in Alumbre were consistent with the MNL methods while in Illangama, 3 out of 4 were. The inconsistent contrast sets for Alumbre come from the responses about who prepares and applies pesticides (Table 3 vs. Table 9).

For the Illangama watershed, the inconsistency comes from the contrasting groups of individually and jointly surveyed females (Table 6 vs. Table 10). The contrast-set mining method suggests that females responded significantly differently regarding females being in charge of managing crops, while MNL model in Table 10 shows that the respondents did not respond differently on these survey questions.

From result comparisons between the two methods, MNL models found more results than the mining method. The inconsistent results between different methods may be due to factors such as the relatively small sample size, the restrictiveness of the Bonferroni inequality, and information loss from data categorizations. Bonferroni inequality may be conservative (Mosler and Scarsin 1989) and because of this, falsely reject the null is strictly restricted, however, it may cause to miss some contrast-set results by contrast set mining. For example, Table 10 suggests that, when comparing individually and jointly interviewed males using MNL, male respondents responded differently to responsibility for selling crops – 38.53% more individually interviewed males claim that they sell crops relative to jointly interviewed males and 38.17% less individually interviewed males than the jointly interviewed believed that crop sales are a joint activity. However, the contrast-set method did not return result to agree with this finding mainly because the corresponding p-value for this set was 0.021. Though such value is statistically significant at the level of 5% for this individual finding, it did not pass the cut-off line of the level of significance adjusted by the Bonferroni inequality

A small sample, regardless of what method employed, is generally associated with less reliable inferences and simulation may be considered to address such potential issues by generating large enough sample size for analysis. Though it may not be necessarily true that more consistency can be achieved between the mining and MNL methods with larger samples, the results show that about 80% of agreement is achieved between the two methods in Alumbre, where the sample was larger (75% for Illangama). Further, a relatively small sample size may also impact the final results through the *supports* of a contrast-set, for instance, the fraction or the difference between two probabilities resulting from a one data point change out of the total of 13 male responses (in Illangama) is relatively large, making the pre-defined threshold less effective.

When converting the continuous variables into discrete or categorical terms, information is lost no matter what measure is used. A method may be considered as being efficient if it can minimize such information loss in the transformation procedure, and that is why the optimal bandwidth of Kernel density was employed in this study. However, this approach also leads to a trade-off between the amount of information lost and the discovery of interesting association rules. These tell us which gendered effects are related to household characteristics. The use of the optimal bandwidth clearly ensures less information loss and thus provides more categories (or options) for continuous variables. The contrast-set and association rule mining were developed to deal with categorical variables, and if given big enough data sample, they may still discover significantly different responses in the presence of discretization using the kernel approach. In this research, the small sample size means that contrast-set and association rule methods may fail to detect differences that might be significant in a larger sample.

For instance, age was transformed into four groups based on common sense rather than by optimal bandwidth. For age the MNL models and contrast-set/association rule found a significant impact on responses to certain decision-making related questions. When age is transformed using the optimal bandwidth approach, neither the contrast-set nor the association rule approach returned it as a result. The continuous variable distance from the house to the road, the optimal bandwidth was employed for categorization; the MNL model showed that the gendered effect may depend on distance for the response to who sells crops, while association rules did not find the same.

There are advantages of using the contrast-set method over the regression method. First, the mining method clearly provides flexibility and imposes no assumption about the functional form of the relationship. Second, it does not require the assumption of independence of irrelevant alternatives in the MNL model, which may be troublesome in empirical practice. Third, the mining process allows all possible statistically significant variables to be efficiently and systematically discovered. It may be used before applying regression analysis in determining which independent variables are potentially significant or necessary to include in a model –

though it is also possible to do it with regression by including all potential independent variables and then test them one by one to arrive at the set of significant ones.

The contrast set method has some disadvantages: with small sample sizes, the method may not be appropriate, and use of the Bonferroni inequality may cause potential problems. As previously mentioned the Bonferroni inequality is conservative and thus, may potentially eliminate some interesting results. Furthermore, the method may work relatively better with discrete variables rather than continuous data. When continuous variables are converted into discrete ones can cause information loss.

REFERENCES

Cameron, A.C. and Trivedi, P.K. 2005. Microeconometrics: Methods and Applications, Cambridge University Press, New York

Mosler, K. and Scarsini, M., "Stochastic Orders and Decision Under Risk" , Institute of Mathematical Statistics, Lecture Notes – Monograph Series, Vol.19 http://books.google.com/books?id=_zZrbW-b39UC&pg=PA75&lpg=PA75&dq=bonferroni+inequality+conservative&source=bl&ots=TyEcUWeJD3&sig=oGOItiobO8E4LwmspzNl6ietfYE&hl=en&sa=X&ei=0tkQVMaCHYf2yQS3-oLoBA&ved=0CD4Q6AEwBg#v=onepage&q=bonferroni%20inequality%20conservative&f=false

TABLES

Table 1. Descriptive Statistics and Model Variables, Alumbre

Variables	Descriptions	Mean	Std. Dev.
Six Decision-making Variables (1=self, 2=spouse, 3=both, 4=other)			
Sellharvest	Who Sells Crops	2.0844	1.0046
WhoPrepare	Who Prepares Pesticides	1.8994	1.0553
WhoApply	Who Applies Pesticides	1.9675	1.0944
ChoicePesticide	Who Decides How Much to Spend on Pesticides	2.0065	0.9918
BuyPesticide	Who Purchases Pesticides	1.8929	1.0040
ChoiceManage	Who Manages Crops	1.9805	1.0240
Other Variables			
Age	Age of the respondent (years)	49.5325	16.1470
Edu	Education of the respondent (years)	6.1661	4.1249
Gender	1=male, 2=female, 3=joint male, 4=joint female	2.4091	1.0925
Mworker	Number of males working in the farm	1.7459	1.5341
Fworker	Number of females working in the farm	1.5375	1.8135
Distance	Meters from the house to the road	1135.1880	2600.8040
HaProd	Hectares of land available for production	4.0358	4.4356
HaOwn	Hectares of land own	2.8278	4.1567
Irrigation*	1 if household has the access to an irrigation system	0.2190	0.4142
ExtVisit	1 if household is visited by extension agent	0.2045	0.4040
IPM*	1 if heard about integrated pest management	0.3127	0.4644
Association	1 if household is part of the organization or association	0.2403	0.4279
Kcurva	1 if knows contour practicing	0.0877	0.2833
Acurva	1 if applies contour practicing	0.0617	0.2410
Krotation	1 if knows crop rotations	0.6461	0.4790
Arotation	1 if applies crop rotations	0.6039	0.4899

Note: * Two observations of "not applicable" for Irrigation and one for "IPM" are deleted.
Note: The following data points are believed to be errors and thus deleted:
For Alumbre: 62 years of education; 66.965, 1041, and 1761 hectares of land for production; 66.965 hectares of land own; 180 male workers in farm per family

Table 2. Descriptive Statistics and Model Variables, Illangama

Variables	Descriptions	Mean	Std. Dev.
Six Decision-making Variables (1=self, 2=spouse, 3=both, 4=other)			
Sellharvest	Who Sells Crops	2.2182	0.9225
WhoPrepare	Who Prepares Pesticides	1.6636	0.8381
WhoApply	Who Applies Pesticides	1.6545	0.8398
ChoicePesticide	Who Decides How Much to Spend on Pesticides	2.4364	0.8937
BuyPesticide	Who Purchases Pesticides	1.9818	0.9185
ChoiceManage	Who Manages Crops	2.2909	0.9321
Other Variables			
Age	Age of the respondent (years)	39.8273	11.3956
Edu	Education of the respondent (years)	5.2909	5.0780
Gender	1=male, 2=female, 3=joint male, 4=joint female	2.7000	1.0005
Mworker	Number of males working in the farm	2.3364	1.6825
Fworker	Number of females working in the farm	1.9909	1.1211
Distance	Meters from the house to a paved road	289.6308	855.9573
HaProd	Hectares of land available for production	1.5504	1.0720
HaOwn	Hectares of land owned	1.2632	1.1767
Irrigation	1 if household has the access to an irrigation system	0.4091	0.4939
ExtVisit	1 if household is visited by extension agent	0.3455	0.4777
IPM	1 if heard about integrated pest management	0.3182	0.4679
Association	1 if household is part of the organization or association	0.6091	0.4902
Kcurva	1 if knows about contour planting	0.3091	0.4642
Acurva	1 if applies contour planting	0.2636	0.4426
Krotation	1 if knows about crop rotations	0.9273	0.2609
Arotation	1 if applies crop rotations	0.9273	0.2609

Table 3. Contrast-set results 1, Alumbre

Contrast Sets (δ = 0.1)	Contrasting Groups		P-values (α = 0.05)	Sensitivity to δ
	Male	Female		
Who Manages Crops = Male	74.36%	27.66%	<0.0001	46.70%
Who Manages Crops = Female	1.28%	30.85%	<0.0001	-29.57%
How Much to Spend on Pesticides = Male	69.23%	27.66%	<0.0001	41.57%
How Much to Spend on Pesticides = Female	3.85%	30.85%	<0.0001	-27.00%
Who Buys Pesticide = Male	75.64%	30.85%	<0.0001	44.79%
Who Buys Pesticide = Female	2.56%	34.04%	<0.0001	-31.48%
Who Prepares Pesticides = Male	75.64%	52.13%	0.001	23.51%
Who Prepares Pesticides = Female	0.00%	15.96%	<0.0001	-15.96%
Who Applies Pesticides = Female	0.00%	15.96%	<0.0001	-15.96%
Who Sells Crops = Male	61.54%	24.47%	< 0.0001	37.07%
Who Sells Crops = Female	5.13%	37.23%	< 0.0001	-32.10%
Age of the Interviewee = 65 and above	33.33%	12.77%	0.001	20.56%
Number of Female Workers in Family = 0	23.08%	4.26%	< 0.0001	18.82%

Note 1: The first column of the table includes different survey questions of interest and the corresponding gender roles selected by the respondents in a given pair of contrasting groups. The second and third columns contain the observed percentages of the respondents who responded with a specific option to the survey question. The last column of the table shows the p-values of chi-squared test of independence at the significant level of 5% for each set.

Note 2: The explanation of the table content, using the first row as an example, is as follows: for the survey question of who manages crops, 74.36% of the individually interviewed males and 27.66% of the females selected the option of "Male", claiming that males are responsible for managing crops. Furthermore, based on the pre-defined thresholds and definitions, this contrast-set indicates that individually interviewed males and females answered the question "who manages crops?" significantly differently. Similarly, for the second contrast-set in the second row of the table, only 1.28% of the males responded that their wives were in charge of selling crops while 30.85% of the females responded that they (the wives) were in major charge. Since the third option of jointly selling crops is not listed in the table, this suggests that the males and females did not respond with this specific answer differently. The explanations for the rest of the results through Table 3 to Table 7 follow this explanation similarly.

Table 4. Contrast-set Results 2, Illangama

Contrast Sets (δ = 0.1)	Contrasting Groups		P-values (α = 0.05)
	Male	Female	
Who Sells Crops = Male	76.92%	18.92%	< 0.0001

Table 5. Contrast-set Results 3, Alumbre

Contrast Sets (δ = 0.1)	Contrasting Groups		P-values (α = 0.05)
	Female	Joint Female	
Who Sells Crops = You and your spouse	28.72%	57.35%	< 0.0001

Table 6. Contrast-set Results 4, Illangama

Contrast Sets (δ = 0.1)	Contrasting Groups		P-values (α = 0.05)
	Female	Joint Female	
Who Prepares Pesticides = Male	40.54%	83.33%	< 0.0001
Who Applies Pesticides = Male	37.84%	83.33%	< 0.0001
Who Manages Crops = Female	29.73%	0.00%	0.001

Table 7. Contrast-set Results 5, Alumbre

Contrast Sets (δ = 0.1)	Contrasting Groups		P-values (α = 0.05)
	Joint Male	Joint Female	
Who Buys Pesticides = Male	66.18%	36.76%	0.001

Table 8. Association Rule Results, Alumbre				
Association Rules	**Support**	**Confidence**	**Lift**	**Chi-sq. Statistic**
{gender=Male, Age of 65 and above=0} => {Your spouse prepares pesticides=0}	0.3023256	1.0000000	1.3983740	29.6921448
{gender=Male, Zero female worker=0} => {Your spouse prepares pesticides=0}	0.3488372	1.0000000	1.3983740	36.7073171
{gender=Male, Age of 65 and above=0} => {Your spouse applies pesticides=0}	0.3023256	1.0000000	1.3650794	27.2105870
{gender=Male, Zero female worker=0} => {Your spouse applies pesticides=0}	0.3488372	1.0000000	1.3650794	33.6394576
{gender=Male, Zero female worker=0} => {Your spouse buys pesticides=0}	0.3372093	0.9666667	1.1791962	13.4578839
{gender=Male, Zero female worker=0} => {Your spouse decides how much to spend on pesticides=0}	0.3313953	0.9500000	1.1426573	9.2467201
{gender=Male, Zero female worker=0} => {Your spouse manages crops=0}	0.3430233	0.9833333	1.1664368	13.7077002
{gender=Male, Zero female worker=0} => {Your spouse sells crops=0}	0.3372093	0.9666667	1.1466667	10.6445901
{gender=Female, Age of 65 and above=0} => {Yourself prepares pesticides=0}	0.3953488	0.8292683	1.4554505	43.0503233
{gender=Female, Zero female worker=0} => {Yourself prepares pesticides=0}	0.4360465	0.8333333	1.4625850	53.4976305
{gender=Female, Age of 65 and above=0} => {Yourself applies pesticides=0}	0.3953488	0.8292683	1.4122193	37.8808190
{gender=Female, Zero female worker=0} => {Yourself applies pesticides=0}	0.4360465	0.8333333	1.4191419	47.1782975

Note: All results in the table pass the hypothesis test of independence at the significant level of 0.05. The explaination of the result, using the first rule in the first row as an example, is as follows: A male respondent whose age is below 65 years old (or whose age is not 65 years old and above) is less likely to state that preparing pesticides was in major charge by their wives.

Table 9. Pure Gendered Marginal Effects of MNL Models, Alumbre

Variables		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender=1 if Male; 0 Female			Gender=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Sells Crops	Male	0.3389	< 0.0001	< 0.0001	0.1529	0.099	0.05	0.0062	< 0.0001	**0.9230**	0.2126	0.0160	0.0030
	Female	-0.3435		< 0.0001	-0.0074		0.8370	-0.1755		0.0120	-0.1196		**0.0470**
	You and your spouse	0.0197		0.7490	-0.1811		0.0120	0.2715		< 0.0001	-0.1072		0.202
Variables		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender=1 if Male; 0 Female			Gender=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Manages Crops	Male	0.4323	< 0.0001	< 0.0001	0.1565	0.112	0.036	0.1049	0.1200	0.1380	0.2005	0.0560	0.0090
	Female	-0.3951		0.0010	-0.0688		0.1530	-0.1159		0.0960	-0.1189		0.0530
	You and your spouse	0.0189		0.7740	-0.0828		0.2300	0.0771		0.2760	-0.0536		0.4900
Variables		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender=1 if Male; 0 Female			Gender=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
How Much to Spend on Pesticides	Male	0.3749	< 0.0001	< 0.0001	0.1595	0.209	0.034	0.1342	0.0290	0.0540	0.1169	0.3530	0.1570
	Female	-0.2876		< 0.0001	-0.0497		0.245	-0.1267		0.0660	-0.0892		0.1380
	You and your spouse	0.0042		0.9450	-0.1061		0.1440	0.0836		0.2380	-0.0132		0.8710
Variables		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender=1 if Male; 0 Female			Gender=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Buys Pesticides	Male	0.4153	< 0.0001	< 0.0001	0.0949	0.434	0.201	0.0652	0.0120	0.3640	0.2772	0.0040	< 0.0001
	Female	-0.3547		< 0.0001	-0.0495		0.229	-0.1080		0.1270	-0.1451		0.0220
	You and your spouse	0.0383		0.4450	-0.0272		0.6800	0.1597		**0.0120**	-0.1325		0.0670
Variables		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender=1 if Male; 0 Female			Gender=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Prepares Pesticides	Male	0.86	< 0.0001	**0.9830**	0.0048	0.001	1.0000	0.2390	0.0010	0.0020	0.1415	0.1190	0.0520
	Female	-1.1856		**0.9850**	-0.2035		0.9920	-0.0119		**0.8230**	-0.1154		0.0600
	You and your spouse	0.0411		0.9930	-0.0344		0.9820	0.0276		0.4610	-0.0126		0.7810
Variables		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender=1 if Male; 0 Female			Gender=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Applies Pesticides	Male	0.8136	< 0.0001	**0.9830**	0.1107	0.002	0.9960	0.2722	< 0.0001	< 0.0001	0.0803	0.2170	0.2940
	Female	-1.1865		**0.9850**	-0.3014		0.9900	0.0059		0.9110	-0.1104		0.0640
	You and your spouse	0.0554		0.9910	-0.0244		0.9910	0.0157		0.6550	0.0152		0.7390

Table 10. Pure Gendered Marginal Effects on Six Decision-Making Questions with MNL Models, Illangama

Variables		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender1=1 if Male; 0 Female			Gender1=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Sells Crops	Male	0.4722	0.002	0.967	0.3853	0.037	0.002	-0.0074	0.0430	0.9990	0.2299	0.0970	0.0260
	Female	-0.1239		0.9950	-0.0036		0.9680	-0.1645		0.9840	-0.0017		0.9810
	You and your spouse	-0.0706		0.9980	-0.3817		0.0080	0.3819		0.974	-0.2282		0.037
		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender1=1 if Male; 0 Female			Gender1=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Manages Crops	Male	1.0329	0.03	0.991	-0.0495	0.2	0.998	0.7214	0.0010	0.9890	0.1126	0.4900	0.9870
	Female	-2.5679		0.9930	–		–	-1.9510		0.9900			
	You and your spouse	1.2682		0.9930	-0.2832		0.9830	1.0764		0.9900	0.1130		0.9910
		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender1=1 if Male; 0 Female			Gender1=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
How Much to Spend on Pesticides	Male	0.8602	0.009	0.989	0.2033	0.022	0.994	0.5577	0.0020	0.9950	-0.0499	0.3740	0.9960
	Female	-2.3482		0.9920	-0.3272		0.996	-2.0141		0.9950	0.2412		0.9930
	You and your spouse	1.2461		0.9930	-0.2012		0.9970	1.3024		0.9950	0.0499		0.9990
		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender1=1 if Male; 0 Female			Gender1=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Buys Pesticides	Male	0.3527	0.086	0.005	-0.1787	0.311	0.997	0.2117	0.0440	0.0460	0.2365	0.4990	0.9800
	Female	-0.2855		0.126	0.0120		0.998	-0.2806		0.0110	-0.0202		0.9870
	You and your spouse	-0.0974		0.5360	-0.2006		0.9870	0.0845		0.4330	0.0088		0.9990
		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender1=1 if Male; 0 Female			Gender1=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Prepares Pesticides	Male	1.3169	0.02	0.9900	0.043	0.098	1.0000	0.3901	0.0040	<0.0001	0.6512	0.2280	0.9900
	Female	0.6641		0.9950	0.6771		0.9940	-0.2564		0.0130	-0.6957		0.9900
	You and your spouse	-0.7429		0.9960	-0.36		0.9980	-0.0377		0.5170	0.0223		0.9910
		Male vs. Female			Male vs. Joint Male			Female vs. Joint Female			Joint Male vs. Joint Female		
		Gender1=1 if Male; 0 Female			Gender1=1 if Male; 0 Joint Male			Gender=1 if Joint Female; 0 Female			Gender=1 if Joint Male; 0 Joint Female		
		dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|	dy/dx	LR P>chi2	P>|Z|
Who Applies Pesticides	Male	1.2716	0.014	0.9900	0.043	0.098	1.0000	0.4055	0.0020	<0.0001	0.6512	0.2280	0.9900
	Female	0.7059		0.9950	0.6771		0.9940	-0.2772		0.0070	-0.6957		0.9900
	You and your spouse	-0.7416		0.9960	-0.36		0.9980	-0.0359		0.5280	0.0223		0.9910

" – " indicates no observation.

Table 11. Gendered Marginal Effect Differences by Type of Question and Household Characteristics, Alumbre

Variables	Variable Discriptions	P>chi2	Who Sells Crops					
			Male		Female		Joint	
			dy/dx	P > |Z|	dy/dx	P > |Z|	dy/dx	P > |Z|
Age	Age of the interviewee (years)	0.019	**0.0049**	0.0050	0.0013	0.3730	**-0.0064**	< 0.0001
Edu	Education of the interviewee (years)	0.002	0.0071	0.3320	0.0075	0.1990	**-0.0237**	0.0020
Fworker	Number of female workers in farm	0.048	**-0.0540**	0.0450	0.0441	0.0630	-0.0117	0.6740
Distance	Meters from house to road	0.009	**0.0000**	0.0030	1.62e(-6)	0.8490	-0.00002	0.1860
Acurva	1 = Applies contour practicing	0.001	1.9236	1.0000	-1.2534	1.0000	1.7695	1.0000
Mworker	Number of male workers in farm	0.658	Statistically insignificant at 5% by likelihood-ratio tests.					
HaProd	Hectares of land available for production	0.641						
HaOwn	Hectares of land own	0.115						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.088						
ExtVisit	1 if households were visited by extensions	0.199						
IPM	1 if heard about integrated pest management (deleted one 0)	0.298						
Association	1 if is a part of an organization or association	0.208						
Kcurva	1= Knows contour practicing	0.740						
Krotation	1 = Knows crop rotation	0.923						
Arotation	1 = Applies crop rotation	0.988						
Variables	**Variable Discriptions**	**P>chi2**	**Who Manages Crops**					
			Male		**Female**		**Joint**	
			dy/dx	**P > |Z|**	**dy/dx**	**P > |Z|**	**dy/dx**	**P > |Z|**
Acurva	1 = Applies contour practicing	0.030	1.7235	0.9810	-1.5426	0.9890	1.1170	0.9790
Age	Age of the interviewee (years)	0.087	Statistically insignificant at 5% by likelihood-ratio tests.					
Edu	Education of the interviewee (years)	0.332						
Mworker	Number of male workers in farm	0.829						
Fworker	Number of female workers in farm	0.060						
Distance	Meters from house to road	0.177						
HaProd	Hectares of land available for production	0.651						
HaOwn	Hectares of land own	0.076						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.163						
ExtVisit	1 if households were visited by extensions	0.190						
IPM	1 if heard about integrated pest management (deleted one 0)	0.562						
Association	1 if is a part of an organization or association	0.610						
Kcurva	1= Knows contour practicing	0.873						
Krotation	1 = Knows crop rotation	0.125						
Arotation	1 = Applies crop rotation	0.239						
Variables	**Variable Discriptions**	**P>chi2**	**How Much to Spend on Pesticides**					
			Male		**Female**		**Joint**	
			dy/dx	**P > |Z|**	**dy/dx**	**P > |Z|**	**dy/dx**	**P > |Z|**
Fworker	Number of female workers in farm	0.043	-0.0517	0.0740	0.0081	0.7240	0.0074	0.7870
Age	Age of the interviewee (years)	0.070	Statistically insignificant at 5% by likelihood-ratio tests.					
Edu	Education of the interviewee (years)	0.507						
Mworker	Number of male workers in farm	0.949						
Distance	Meters from house to road	0.258						
HaProd	Hectares of land available for production	0.051						
HaOwn	Hectares of land own	0.844						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.888						
ExtVisit	1 if households were visited by extensions	0.588						
IPM	1 if heard about integrated pest management (deleted one 0)	0.505						
Association	1 if is a part of an organization or association	0.836						
Kcurva	1= Knows contour practicing	0.989						
Krotation	1 = Knows crop rotation	0.642						
Acurva	1 = Applies contour practicing	0.498						
Arotation	1 = Applies crop rotation	0.838						

Table 11 Continued:

Variables	Variable Discriptions	P>chi2	Who Buys Pesticides					
			Male		Female		Joint	
			dy/dx	P > |Z|	dy/dx	P > |Z|	dy/dx	P > |Z|
Acurva	1 = Applies contour practicing	0.029	1.7858	0.9830	-1.8868	0.9890	0.8341	0.9860
Age	Age of the interviewee (years)	0.305	Statistically insignificant at 5% by likelihood-ratio tests.					
Edu	Education of the interviewee (years)	0.248						
Mworker	Number of male workers in farm	0.441						
Fworker	Number of female workers in farm	0.183						
Distance	Meters from house to road	0.130						
HaProd	Hectares of land available for production	0.074						
HaOwn	Hectares of land own	0.719						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.459						
ExtVisit	1 if households were visited by extensions	0.229						
IPM	1 if heard about integrated pest management (deleted one 0)	0.247						
Association	1 if is a part of an organization or association	0.815						
Kcurva	1= Knows contour practicing	0.720						
Krotation	1 = Knows crop rotation	0.635						
Arotation	1 = Applies crop rotation	0.918						
Variables	**Variable Discriptions**	**P>chi2**	**Who Prepares Pesticides**					
			Male		**Female**		**Joint**	
			dy/dx	**P > |Z|**	**dy/dx**	**P > |Z|**	**dy/dx**	**P > |Z|**
Age	Age of the interviewee (years)	0.002	**-0.0056**	0.0010	-0.00002	0.9830	**0.0026**	0.0150
Edu	Education of the interviewee (years)	< 0.0001	**-0.0148**	0.0350	0.0045	0.2730	**-0.0119**	0.0180
Mworker	Number of male workers in farm	0.031	0.0355	0.1870	-0.0463	0.0510	0.0210	0.0630
Fworker	Number of female workers in farm	0.150	Statistically insignificant at 5% by likelihood-ratio tests.					
Distance	Meters from house to road	0.627						
HaProd	Hectares of land available for production	0.989						
HaOwn	Hectares of land own	0.559						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.305						
ExtVisit	1 if households were visited by extensions	0.156						
IPM	1 if heard about integrated pest management (deleted one 0)	0.396						
Association	1 if is a part of an organization or association	0.065						
Kcurva	1= Knows contour practicing	0.691						
Krotation	1 = Knows crop rotation	0.898						
Acurva	1 = Applies contour practicing	0.714						
Arotation	1 = Applies crop rotation	0.969						
Variables	**Variable Discriptions**	**P>chi2**	**Who Applies Pesticides**					
			Male		**Female**		**Joint**	
			dy/dx	**P > |Z|**	**dy/dx**	**P > |Z|**	**dy/dx**	**P > |Z|**
Age	Age of the interviewee (years)	0.002	**-0.0058**	< 0.0001	-0.0001	0.9500	**0.0024**	0.0270
Edu	Education of the interviewee (years)	< 0.0001	**-0.0156**	0.0270	0.0049	0.2420	**-0.0129**	0.0120
Mworker	Number of male workers in farm	0.037	0.0403	0.1330	-0.0454	0.0580	0.0208	0.0880
Association	1 if is a part of an organization or association	0.042	**0.1931**	0.0080	-0.0334	0.5250	-0.0087	0.8170
Fworker	Number of female workers in farm	0.137	Statistically insignificant at 5% by likelihood-ratio tests.					
Distance	Meters from house to road	0.408						
HaProd	Hectares of land available for production	0.766						
HaOwn	Hectares of land own	0.980						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.246						
ExtVisit	1 if households were visited by extensions	0.107						
IPM	1 if heard about integrated pest management (deleted one 0)	0.837						
Kcurva	1= Knows contour practicing	0.684						
Krotation	1 = Knows crop rotation	0.239						
Acurva	1 = Applies contour practicing	0.571						
Arotation	1 = Applies crop rotation	0.824						

Table 12. Gendered Marginal Effect Differences by Type of Question and Household Characteristics, Illangama

Variables	Variable Discriptions	P>chi2	Who Sells Crops					
			Male		Female		Joint	
			dy/dx	P > |Z|	dy/dx	P > |Z|	dy/dx	P > |Z|
Mworker	Number of male workers in farm	0.030	0.0822	0.0640	0.0183	0.5140	-0.0998	0.3950
Age	Age of the interviewee (years)	1.000						
Edu	Education of the interviewee (years)	0.917						
Fworker	Number of female workers in farm	0.971						
Distance	Meters from house to road	0.678						
HaProd	Hectares of land available for production	0.536						
HaOwn	Hectares of land own	0.992						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.572	Statistically insignificant at 5% by likelihood-ratio tests.					
ExtVisit	1 if households were visited by extensions	0.562						
IPM	1 if heard about integrated pest management (deleted one 0)	0.741						
Association	1 if is a part of an organization or association	0.928						
Kcurva	1= Knows contour practicing	0.730						
Acurva	1 = Applies contour practicing	0.974						

Variables	Variable Discriptions	P>chi2	Who Manages Crops					
			Male		Female		Joint	
			dy/dx	P > |Z|	dy/dx	P > |Z|	dy/dx	P > |Z|
HaProd	Hectares of land available for production	0.026	0.5739	0.9730	0.1500	0.9780	0.5949	0.9780
Age	Age of the interviewee (years)	0.991						
Edu	Education of the interviewee (years)	0.845						
Mworker	Number of male workers in farm	0.059						
Fworker	Number of female workers in farm	0.069						
Distance	Meters from house to road	0.864						
HaOwn	Hectares of land own	0.069						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.436	Statistically insignificant at 5% by likelihood-ratio tests.					
ExtVisit	1 if households were visited by extensions	0.388						
IPM	1 if heard about integrated pest management (deleted one 0)	0.981						
Association	1 if is a part of an organization or association	0.625						
Kcurva	1= Knows contour practicing	0.611						
Acurva	1 = Applies contour practicing	0.982						

Variables	Variable Discriptions	P>chi2	How Much to Spend on Pesticides					
			Male		Female		Joint	
			dy/dx	P > |Z|	dy/dx	P > |Z|	dy/dx	P > |Z|
Age	Age of the interviewee (years)	1.000						
Edu	Education of the interviewee (years)	0.971						
Mworker	Number of male workers in farm	0.228						
Fworker	Number of female workers in farm	0.111						
Distance	Meters from house to road	0.866						
HaProd	Hectares of land available for production	0.078						
HaOwn	Hectares of land own	0.227	Statistically insignificant at 5% by likelihood-ratio tests.					
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.956						
ExtVisit	1 if households were visited by extensions	0.751						
IPM	1 if heard about integrated pest management (deleted one 0)	0.967						
Association	1 if is a part of an organization or association	0.990						
Kcurva	1= Knows contour practicing	0.171						
Acurva	1 = Applies contour practicing	0.651						

Table 12 Continued:

Variables	Variable Discriptions	P>chi2	Who Buys Pesticides					
			Male		Female		Joint	
			dy/dx	P > |Z|	dy/dx	P > |Z|	dy/dx	P > |Z|
Age	Age of the interviewee (years)	0.950	Statistically insignificant at 5% by likelihood-ratio tests.					
Edu	Education of the interviewee (years)	0.651						
Mworker	Number of male workers in farm	0.264						
Fworker	Number of female workers in farm	0.318						
Distance	Meters from house to road	0.824						
HaProd	Hectares of land available for production	0.154						
HaOwn	Hectares of land own	0.142						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.850						
ExtVisit	1 if households were visited by extensions	0.815						
IPM	1 if heard about integrated pest management (deleted one 0)	0.690						
Association	1 if is a part of an organization or association	0.707						
Kcurva	1= Knows contour practicing	0.954						
Acurva	1 = Applies contour practicing	0.655						

Variables	Variable Discriptions	P>chi2	Who Prepares Pesticides					
			Male		Female		Joint	
			dy/dx	P > |Z|	dy/dx	P > |Z|	dy/dx	P > |Z|
HaOwn	Hectares of land own	0.026	-1.9012	0.9880	-0.5060	0.9850	1.0380	0.9910
Age	Age of the interviewee (years)	0.192	Statistically insignificant at 5% by likelihood-ratio tests.					
Edu	Education of the interviewee (years)	0.919						
Mworker	Number of male workers in farm	0.511						
Fworker	Number of female workers in farm	0.482						
Distance	Meters from house to road	0.906						
HaProd	Hectares of land available for production	0.167						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.987						
ExtVisit	1 if households were visited by extensions	0.939						
IPM	1 if heard about integrated pest management (deleted one 0)	0.747						
Association	1 if is a part of an organization or association	1.000						
Kcurva	1= Knows contour practicing	0.864						
Acurva	1 = Applies contour practicing	0.987						

Variables	Variable Discriptions	P>chi2	Who Applies Pesticides					
			Male		Female		Joint	
			dy/dx	P > |Z|	dy/dx	P > |Z|	dy/dx	P > |Z|
HaOwn	Hectares of land own	0.018	-1.9127	0.9880	-0.5002	0.9850	1.0421	0.9910
Age	Age of the interviewee (years)	0.251	Statistically insignificant at 5% by likelihood-ratio tests.					
Edu	Education of the interviewee (years)	0.971						
Mworker	Number of male workers in farm	0.520						
Fworker	Number of female workers in farm	0.302						
Distance	Meters from house to road	0.908						
HaProd	Hectares of land available for production	0.159						
Irrigation	1 if household has access to an irrigation system (deleted two 0's)	0.992						
ExtVisit	1 if households were visited by extensions	0.843						
IPM	1 if heard about integrated pest management (deleted one 0)	0.701						
Association	1 if is a part of an organization or association	1.000						
Kcurva	1= Knows contour practicing	0.884						
Acurva	1 = Applies contour practicing	0.990						

CHAPTER V: Conclusions

This paper provides insights into household decision making in two small watersheds in Ecuador. It addresses the general issue of how the structure of a survey affects subjective responses about gender roles in agricultural decision making. The general finding is that the structure of the survey affects responses: men and women, when interviewed alone have different responses to critical questions about gender roles. When interviewed jointly, but separately, the differences in responses are generally attenuated, but they still persist.

Findings suggest that, in general, male and female farming respondents have different perceptions about who does what. When only one respondent or one household member is interviewed, he or she is more likely to claim or over-value his or her own responsibility for many types of household decisions and agricultural activities. Male respondents are generally more likely to claim responsibility for activities such as crop sales, crop and pesticide management, and pesticide purchases. Men also under-appreciate their wives' contributions to the farm operation. Sole female respondents are relatively more measured than men in attributing sole responsibility for these activities to men. Even though the respondents tend to attribute responsibilities differently, both males and females agree that preparing and applying pesticides are more male-dominated and less female-dominated activities.

Findings also show that male and female respondents respond significantly differently to certain objective type of questions. Specifically, individually interviewed males and females are found to respond differently to the question of how many female workers work on the farm, and more male than female respondents tend to respond that no female workers contribute any work on the farm. When men and women in the same household are interviewed separately many of these gendered differences in responses disappear.

Furthermore, no contrast-sets were found for some survey questions for any of the treatment groups. For questions such as crop production, the importance of reduced costs in purchasing pesticides, the importance of the cost of IPM practices in decisions about whether to adopt and the importance of advice from neighbors, etc., female responses do not differ significantly from those of males. This result does not depend on whether the person is interviewed individually or jointly, and thus, one gender is adequate to be surveyed on such questions.

For activities such as crop sales and management, preparing and applying pesticides and deciding how much to spend on pesticides, jointly interviewed male and female respondents generally provide consistent responses. They have nearly identical perceptions about who does what and who makes what decisions. For such questions, one response from either jointly interviewed male or female may be adequate. The issue here, however, is that we do not have information on the "correct" answer. Since we do not observe decision making processes or farming activities, we do not know who makes what decision and who conducts what activity. However, in terms of saving potential survey costs and time, for those types of survey questions, one proxy may be adequate to interview for other similar surveys, and when both are interviewed, accuracy may be achieved.

Patterns of responses to the treatments are heterogeneous across the population. Certain household or respondent characteristics influence responses. Gender clearly is a big factor. Other factors include the age of the survey respondent and the number of female farm workers in the household. Relatively younger males (or 65 years old below) are more likely to claim either their (the males') or joint roles in preparing and applying pesticides, and less likely to respond that these two activities are conducted by their wives. Females younger than 65 are less likely to claim that they take a major role in preparing and applying pesticides.

Lastly, findings were remarkably different across the two watersheds where the experiment was conducted. While the two areas are geographically close (in the same province in Ecuador) they are culturally very different. They also have different farming systems. These factors are associated with the consistency of survey responses by treatment group. Patterns of responses about decision making and gender responsibility differ by watershed. For instance, gendered differences in responses to questions about decision-making and farming activities are attenuated in Illangama. While this attenuation may be due to far more gender balance in farming activities in the watershed, it underscores the importance of understanding cultural differences when designing a field survey. In Illangama, a single survey to either member may be sufficient, while in Alumbre, who gets asked what is exceedingly important.

Regarding the main issue of does it matter who we ask in a household survey, the answer is clearly yes, but the degree to which it matters depends on cultural factors. For subjective types of questions, there might not be a correct answer: male and female respondents have different opinions about who is making decisions. In such cases, it may be helpful to interview both men and women, but survey responses clearly depend on the gender of the respondent. Furthermore, as indicated in the analysis, even though jointly interviewing males and females does not necessarily guarantee correct answers to the questions, it may help decrease differences in responses. Therefore, if time and survey cost are not big issues, interviewing both male and female respondents is recommended.