ON THE ECONOMICS OF CHOICE OF INVASIVE SPECIES CONTROL OPTIONS

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Abstract

Many methods are available to analyze rank-ordered data. We used spectral analysis to identify the most preferred option of Formosan Subterranean Termites (FST) control as ranked by Louisiana homeowners. Respondents were asked to rank four termite control methods from the most preferred option to the least preferred option. Spectral analysis of both complete and partial ranked data indicates that the most preferred termite control choice is a relatively cheap ($0.13 per square foot) option of a liquid treatment. Multinomial logit analysis indicated that survey location, household pre-tax income, and knowledge of FST determined Louisiana homeowners' ranking pattern choices.

Keywords: Complete and partial ranked data, Formosan subterranean termite, invasive species, multinomial logit, rank-ordered data, spectral analysis

JEL Classifications: C65

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Invasive species are non-indigenous species that cause major environmental damage (biodiversity and habitat losses) (Fernandez, 2007; Eiswerth and Johnson, 2002) and are responsible for as much as $120 billion damage every year to the U.S. economy (Pimentel et al., 2005). Consider a case of Formosan Subterranean termites (FST) (*Coptotermes formosanus* Shiraki), a species native to China, which were introduced after the Second World War primarily in U.S. states of Louisiana, South Carolina, and Texas by the returning ships. These termites are known as super termites as a single colony may consist of 1-10 million termites. These species are known to attack structural woods as well as living plants. The colonies are established through its route from the ground to the wooden structures but they are equally likely to establish aerial colonies (Su and Scheffrahn, 1987). As of 2010, these invasive species have been present in the following U.S. states: Alabama, California (an isolated infestation in San Diego County), Florida, Georgia, Hawaii, Louisiana, Mississippi, North and South Carolina, Tennessee, and Texas. The damage from the FST infestation in the U.S. exceeds $1 billion per year. In Louisiana alone, the most affected state in the continental U.S., the damage from the FST is about $500 million a year.

In order to control FST, researchers and government agencies are attempting to identify the most preferred option of FST control methods so that economic damage can be minimized. Additionally, if needed, a subsidized treatment program can be implemented based on respondents' preference ranking information. In fact, this type of subsidized treatment system has been in existence in the French Quarter area of New Orleans since

2000[1]. The treatment subsidy is paid by the United States Department of Agriculture to participating homeowners in the area. Because FST can move easily during the breeding season from outside the subsidized treatment zone to the subsidized treatment zone, the treatment subsidy may need to be expanded to a larger area to control FST.

We collected data using a contingent ranking method to find preferences for alternative FST control options by Louisiana homeowners. Respondents ranked alternative FST control options in categorical forms with each category reflecting the preference intensity. These types of preference ranking data are often coded as consecutive integers from one to the number of categories to their degree of preference, but the number does not represent their distance. When preference intensity is presented, economists try to find the factors affecting these rankings but fail to identify the most preferred treatment option. This paper attempts to fill this void in economics literature using a case of FST control options ranked by Louisiana homeowners.

A group of respondents may rank alternative choices as their first, second, third, fourth preference and so on. Existing research discusses the ranking of preference data in two cases: when there are complete rankings and when there are partial rankings. A comprehensive review of both complete and partial data is available in both Diaconis (1988) and Critchlow (1985). If respondents rank all items available in a survey, it represents a complete ranking or full ranking. However, some of the respondents in a

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[1] The Louisiana State University Agricultural Center (in cooperation with the USDA Agricultural Research Service [ARS]) began a large-area pilot test in the New Orleans French Quarter in the summer of 1998 designed to demonstrate the effectiveness of area-wide management of the Formosan subterranean termite. Under this program, all 323 properties in a contiguous 15-block area in the French Quarter were treated by pest control companies. Treatments included commercially available baits or nonrepellent liquid termiticides. The primary goal of the program was to reduce densities of the Formosan termite and validate the effectiveness of area wide management. Five years after the beginning of the program, data indicated that the Formosan termite population in this test area had been reduced by about 50% (Morgan 2003; Morgan et al. 2004; Lax and Osbrink, 2003).

survey only rank a few items and leave others. In such a case, we do not know the ranks of remaining options in the survey. This type of incomplete ranking represents a partial ranking. Hence, a partial ranking is a preference list of r (r < n) items out of n items. Generally, the way of analyzing this type of data is to remove partial ranking and estimate the result using complete data and analyze only the subset of complete rankings (Murphy and Martin, 2003). This type of practice decreases sample size by removing partial ranking observations, which can result in a significant decrease of estimation accuracy (Busse et al., 2007).

We used a spectral analysis method to analyze complete and partial ranked preference data. We provide a brief review of how ranked data have been handled in literature. We present a method section detailing the theory of spectral analysis as used in rank-ordered data analysis. We will discuss complete details of data features in the data section. We will analyze complete rankings and then extend the analysis to partial rankings. We expand the analysis to identify how a complete bundle of rankings are impacted by the demographic and cognitive risk/benefit variables.

Relevant Literature

There exist several approaches available to analyze rank- ordered data. A few examples include nonparametric analysis of unbalance paired-comparison of ranked data (Andrew and David, 1990). Andrew and David compared simple and nonparametric methods of analyzing unbalanced ranked data to an existing method of rank analysis for unbalanced data. Busse et al. (2007) used a cluster analysis of heterogeneous rank data and found that the parameter estimation improved when incomplete ranking data were included in the inference process. Another way of analyzing ranked data is to use a Markov Chain Monte Carlo Technique (Eriksson, 2006). In addition, Lebanon and Mao (2008) improve analysis of partial ranking data using a nonparametric methodology and derive a computationally efficient procedure which is also suitable when there are large numbers of items to be ranked. In addition, Fagin et al. (2006) provided a broad image of methodology to compare partial ranking using several metrics. Although all of the above methods are computationally efficient to analyze, they are not easy to conceptualize in different dimensions. Thompson (1993) applies a generalized permutation polytopes and exploratory graphical method for ranked data. The author presents an exploratory graphical method to display frequency distribution for fully and partially ranked data. In addition, Kidwell et al. (2008) build an approach for the visualization of ranking data for large n, which is easy to use and computationally efficient. An alternative way of investigating preference ranked data is completely randomized factorial design (Scheirer et al., 1976). However, this procedure as an extension of the Kruskal-Wallis rank test allows for the calculation of interaction effects and linear contrasts. Paudel et al. (2007) applied exploded logit and ordered probit models to identify the most preferred Formosan termite control method in Louisiana. A new way, generalized spectral decomposition by Diaconis (1988) and Diaconis (1989), is a very useful methodology to analyze full and partial rank preference data. Lawson and Orrison (2002) used these ideas to detect hidden coalition in the vote of nine judges of the United States Supreme Court. Recently, Pedrotti et al. (2006) used generalized spectral analysis to find preference for cars. As the theory of spectral analysis, they use first order and second order effects to compare preference for different attributes in cars by male and female survey respondents.

Method

We applied spectral analysis to find the most preferred treatment option for FST control as ranked by homeowners in Louisiana. Spectral analysis captures the natural symmetries present in the data which is generally hidden in the existence of a symmetric group. One can interpret the information by decomposing the data according to these symmetries (Pedroti et al., 2006). We briefly outline a general theory of spectral analysis applicable for rank-ordered data. Most of the materials used in this section are based on Diaconis (1988), Diaconis (1989), and Iwasaki (1992).

Let us suppose we have n types of FST treatment option provided to Louisiana homeowners for ranking denoted by i, $i = 1,2,\dots,n$. Let $\pi(i)$ denotes the rank given to i^{th} treatment option. This type of data can be represented using permutation. A permutation π is a bijective function π: {1,2…n}→{1,…,n} associated with each item i∈{1,…,n} and rank π(i) ∈ {1,…,n} (Critchlow, 1985). Hence, the number of respondents choosing ranking preference π forms a data set which is denoted by $f(\pi)$ and can be expressed as

$$f(\pi) = \begin{pmatrix} 1 & 2 & \dots & n \\ \pi(1) & \pi(2) & \dots & \pi(n) \end{pmatrix}.$$

If we are ranking n items, the permutation of the number of items multiplied by their frequencies gives the sample size of the data for complete ranking. And for partial ranking, let q denote the number of ranking option out of n, then the sample size for the partial ranking with each $q \leq n$ is given by $q!\binom{n}{q}$. Suppose there are four available FST treatment options that are provided to respondents to rank from the most preferred to the least preferred. Then, there will be 4! (=24) complete rankings. These possible ranking patterns and the number of respondents choosing these ranking patterns are shown in Table 1 for our data. The partial ranking combinations for q=1 is 4 and for q=2 is 12 as shown in Table 2. From group theory, we can represent it as a symmetric permutation group denoted by S_n. Then, S_n is a finite group operating transitively on π. Let V be the space of all functions on π with values in real space R. V is also a vector space on which S_n acts linearly as a group transformation $\sigma f(\pi) = f(\sigma^{-1}\pi)$. Then, k subspace of V are invariant with respect to S_n for every $f(\pi) \in V$ and every $\sigma \in S_n$ implies that $\sigma f(\pi) \in V$. Hence, V decomposes into a direct sum of invariant irreducible subspace, as follows:

$\mathrm{V} = V_0 \oplus \mathrm{V}_1 \oplus \ldots \oplus \mathrm{V}_\mathrm{k}$

In other words, every function $f(\pi) \in V$ may be written uniquely as a sum

$f = f_0 + \cdots + f_k$ Where $f_i \in V_i$ and $\sigma f_i \in V_i$ for all $\sigma \in S_n$

Let $f(\pi)$ be a set (the number of times π appears in the sample), the spectral analysis is the projection of f onto the invariant subspaces and the approximation of f by as many pieces as required to give a reasonable fit.

In situations when rankings are not complete (partially ranked) we can follow Diaconis (1988) to analyze the data. Let $\lambda = (\lambda_1, \ldots, \lambda_r)$ be a partition of n, where $\lambda_1 \geq \lambda_2 \geq \lambda_3 \geq \cdots \geq \lambda_r$ and $\lambda_1 + \lambda_2 + \lambda_3 + \cdots + \lambda_r = n$. Then Young's rule gives the appropriate irreducible subspace in the decomposition of M^{λ}, where M^{λ} represents a partially ordered data "in configuration λ." To illustrate, $M^{(n-m,m)}$ is the data vector of the form "pick the best m of n". The spectral decomposition of $M^{(n-m,m)}$ gives l invariant subspaces. According to this rule,

$$M^{(n-m,m)} = S^{(n)} \oplus S^{(n-1,1)} \oplus S^{(n-2,2)} \oplus \ldots \oplus S^{(n-m,m)}$$

and dimensions of $S^{(n-m,m)} = \binom{n}{m} - \binom{n}{m-1}$.

The subspaces of $S^{(n-m,m)}$ have the following interpretations:

$S^{(n)}$ - It is the grand mean or number of people in the sample

$S^{(n-1,1)}$ - This denotes the effect of item i where $1 \leq i \leq n$

$S^{(n-2,2)}$ - The effect of items $\{i, j\}$ adjusted for the effect of i and j where $1 \leq i, j \leq n$.

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$S^{(n-k,k)}$ -The effect of a subset of k items adjusted for lower order effects.

The procedural details to decompose higher dimension are available in Diaconis (1988).

Here, we are only interested on first order i.e. $\lambda = (n-1, 1)$ and second order unordered λ = (n-2, 2) effects[2]. Hence, If π is the set $\{1, 2, \ldots, n\}$ and $f(\pi)$ is the number of people choosing π, then the decomposition with their dimensions are:

First order: $\underset{n}{M^{(n-1,1)}} = \underset{1}{S^{(n)}} \oplus \underset{n-1}{S^{(n-1,1)}}$ and

Second order: $\underset{n}{M^{(n-2,1,1)}} = \underset{1}{S^{(n)}} \oplus \underset{n-1}{S^{(n-1,1)}} \oplus \underset{n(n-3)/2}{2S^{(n-2,2)}} \oplus \underset{(n-1)(n-2)/2}{2S^{(n-2,1,1)}}$.

As mentioned previously, the spectral analysis is the projection of f onto the invariant subspaces. This type of projection is also called isotypic projection. Many researchers use spectral analysis in time series data where the dimensions are smaller and easy for computation. However, rank-ordered data have higher dimensions compared to time series

[2] The first order effect measures the average attraction that a treatment option has when it is coupled with another treatment option. The second order effect detects the positive (or negative) power of combination of two coupled treatment options.

data, so we cannot find the orthogonal basis to compute projection in the isotypic subspace easily. Mallows (1957) provides an approach to deal with such difficulty. This paper uses his approach to compute both first and second order analyses. We use inner products to compute the final projection of the data

$\langle f_1 | f_2 \rangle = \sum_{\pi} f_1(\pi) f_2(\pi)$.

First order analysis

The space V_0 is the set of constant function that is the average frequency of the data, so it has one dimension. The space V2 is the space of first order function evaluated using Mallows' approach. Therefore, consider a function

$$\pi \to \delta_{i\pi(j)} \Big\} \begin{matrix} = 1 \; if \; \pi(j) = 1 \\ = 0 \; otherwise \end{matrix}$$

Where i is the control method and j is the rank given to the control method.

The first order function becomes

$\sum_{i,j} a_{ij} \delta_{i\pi(j)}$. In order to get direct sum decomposition, the coefficients should satisfy the following condition

$\sum_{i,j} a_{ij} = 0$.

If we consider our data set, it consist of three three-dimensional subspaces, so it projects a nine-dimensional space which can be shown using hook-length formulae following Young's rule as presented in Table 3 .

Second order analysis

Second order analysis consists of ranking a pair of control options to a pair of ranks. For example, someone can choose first and second control options on third and fourth or fourth and third ranking positions. The rank can be in ordered or unordered positions. Therefore, there are two types of second order functions. Again following Mallow's approach, let

$\pi \rightarrow \delta_{\{i,i'\}\{\pi(j)\pi(j')\}} \begin{cases} = 1 \; if \; \{\pi(j)\pi(j')\} = \{i,i'\} \\ = 0 \; Otherwise \end{cases}$ then, the general, unordered second ordered (V_2) function will be of the following form

$$\sum_{i,i',j,j'} a_{ii',jj'} \delta_{\{ii'\}\{\pi(j)\pi(j')\}}.$$

Where, $a_{ii',jj'}$ are chosen so that V_2 is orthogonal to $V_0 \oplus V_1$. In this case, the order does not matter and it has two two-dimensional subspaces so the second ordered unordered effect has a four-dimensional space. In a similar way we can find the higher order function, which is beyond the objective of this paper.

Data

Data were collected by means of a survey of homeowners regarding their preference of FST treatment options in Louisiana. FST are an invasive species of termite that is currently present in more than 13 states in the U.S. It has been found that the damage by the species is so severe that infested houses become uninhabitable if not controlled in time. Damage estimates due to FST infestations reach approximately one billion dollars per year (Lax and Osbrink, 2003).

Dillman's (2000) tailored design method was used to collect the data from survey. The survey was conducted in 2002. The survey population consisted of all owners occupying homes in four metropolitan areas in Louisiana. These respondents might own single-family houses, multi-family houses, apartments, condominiums, or townhouses. Four metropolitan areas, New Orleans, Baton Rouge, Monroe and Alexandria, were taken as a stratum of the sample. During the survey period, these cities had100017, 104149, 38559, and 35386 homeowners, respectively. Selective random samples of 6,000 homeowners were chosen from the sampling frame maintained by Best Mailing List, Incorporated, a private list company. A total of 5,641 single family homeowners were contacted through the use of our mail survey: 1,490 from Monroe, 1,305 from Alexandria, 1,395 from Baton Rouge, and1,451 from the New Orleans Metropolitan areas. Pre-survey and focus group discussions were conducted prior to mailing the survey. A survey response rate of 25% was obtained, although not all respondents ranked the treatment options.

Four FST treatment options were provided for each individual homeowner to rank from the most preferred choice to the least preferred choice. The FST treatment choices provided are:

i. No control option: cost \$0/square foot,

ii. Liquid treatment option: cost \$0.13/square foot,

iii. Bait treatment option: \$0.43/ square foot,

iv. Liquid + Bait treatment option: \$0.56/square foot.

The details on these treatment choices are given in endnote. Individual homeowners ranked these options as their first, second, third and fourth most preferred option to control FST. There were a total of 972 observations obtained from the survey in which individuals ranked termite control options. Out of those, only 747 respondents provided complete rankings, which are shown in Table 1. The remaining respondents provided partial rankings as shown in Table 2. The column entries of Table 1 show the control method ranked in the given permutation. For example, an entry of “1234” means that those respondents ranked the “No Control” option method as their first preferred method, “Liquid Treatment” as their second preferred option, “Bait Treatment” as their third preferred option, and “Liquid+Bait Treatment” as their fourth preferred option. Zeroes or blanks in Table 2 indicate respondents did not rank all control options. For example, 42 homeowners ranked “No Control” first and left others unranked.

Results from spectral analysis

We present the results from completely ranked observations first which is then followed with the analysis of partially ranked data. The percentage of respondents ranking preference i in position j is shown in Table 4. This table indicates that 52.2% of respondents preferred the Liquid treatment option as the first choice and 55.7% of respondent favored Bait as their second choice.

Complete Ranking

Let M be the space of all real valued functions on the symmetric group S_4. This vector space decomposes uniquely into the direct sum of five subspaces. These are shown with their dimensions in Table 5. V_0 is the set of constant functions with one dimension. Second, V_1 is the set of functions whose sum is zero with 9 dimensional space and orthogonal to V_0. Similarly, V_2 is the second order unordered effect with 4 dimensional space and orthogonal to $V_0 \oplus V_1$. The result of first order spectral analysis is shown Table 6.

First order space decomposed in two invariant subspaces for each preference. For example, first order, first preference space $V^{(3,1)}$ with its data vector $f^{(3,1)}$ consists of two invariant subspaces: $V_0^{(3,1)}$ mean effect with its data vector $f_0^{(3,1)}$ and $V_1^{(3,1)}$ the first order pure effects with its data vector $f_1^{(3,1)}$. $f_0^{(3,1)}$ is found by projecting $f^{(3,1)}$ onto $V_0^{(3,1)}$ and $f_1^{(3,1)}$ is found by projecting $f^{(3,1)}$ onto $V_1^{(3,1)}$. And finally, this gives the following decomposition:

$$f^{(3,1)} = \begin{pmatrix} 142 \\ 400 \\ 93 \\ 112 \end{pmatrix}, f_0^{(3,1)} = \begin{pmatrix} \frac{747}{4} \\ \frac{747}{4} \\ \frac{747}{4} \\ \frac{747}{4} \end{pmatrix}, f_1^{(3,1)} = \begin{pmatrix} -\frac{179}{4} \\ \frac{853}{4} \\ -\frac{375}{4} \\ -\frac{299}{4} \end{pmatrix}$$

$$f^{(3,1)} = f_0^{(3,1)} + f_1^{(3,1)}$$

The largest number 213 in the first column of Table 6, indicates Liquid treatment option received the most votes as respondents' first choice of control option. The largest number in the second column, 231, shows that Bait received the most votes as the second most favorable control option. The Liquid plus Bait treatment option is the third choice and no treatment option is the fourth choice. This means that respondent homeowners want to control FST using some form of control measure.

The result of the second order analysis is shown in Table 7. This is second order unordered effects. The second order unordered effect space $V^{(2,2)}$ with its data vector $f^{(2,2)}$ decomposes into three invariant subspaces: $V_0^{(2,2)}$ mean effect with its data vector $f_0^{(2,2)}$, $V_1^{(2,2)}$ first order effect with its data vector $f_1^{(2,2)}$, and two dimensional second order unordered pure effect $V_2^{(2,2)}$ with its data vector $f_2^{(2,2)}$. In particular, the decomposition for the pair of Liquid and Bait treatment option is illustrated below. The vector space $V^{(2,2)}$, the number homeowners who favor control options as two most preferred options, uniquely can be written as sum of $f_{(0}^{(2,2)}, f_1^{(2,2)}, f_2^{(2,2)}$, and they are orthogonal to each other.

$$\|f^{(2,2)}\|^2 = \|f_0^{(2,2)}\|^2 + \|f_1^{(2,2)}\|^2 + \|f_2^{(2,2)}\|^2$$
$$188301 \quad 93001.5 \quad 66678.5 \quad 28621$$

$$\begin{pmatrix} 180 \\ 12 \\ 10 \\ 370 \\ 46 \\ 129 \end{pmatrix} = \begin{pmatrix} 124.5 \\ 124.5 \\ 124.5 \\ 124.5 \\ 124.5 \\ 124.5 \end{pmatrix} + \begin{pmatrix} 25.5 \\ -17 \\ -180 \\ 180 \\ 17 \\ 25.5 \end{pmatrix} + \begin{pmatrix} 30 \\ -95.5 \\ 65.5 \\ 65.5 \\ -95.5 \\ 30 \end{pmatrix}$$

$$f^{(2,2)} = f_0^{(2,2)} + f_1^{(2,2)} + f_2^{(2,2)}$$

Details of all pair choices are shown in Table 7. Each pair can be chosen as 6 easily interpreted functions. Geometrically, the function projects to 36 points in a four-dimensional space. This means there are only four independent values in the table consisting 36 values. It is easy to interpret second order unordered effects when there are more choices (greater than four, see Diaconis, 1989). Since we have only four-dimension in second order, decomposition, this gives some equal values as shown in Table 7. The largest value 66 in first column indicates that there is huge effect between control methods Liquid and Bait in ranking (1, 2). For pairs of methods like Liquid and Liquid+ Bait, there is an opposite effect: Every homeowner likes both or hates both because the row entry begins and ends (-,-) with the same value. Based on the highest value of Liquid treatment option and Bait treatment option in the second ordered effect and the highest value of liquid treatment option in first ordered effect, it can be said that these two are the two most desirable options chosen by homeowners in Louisiana.

Partial Ranking

The subspace decomposition, dimensions, sum of squares and first and second ordered projections are illustrated in Tables 8 and 9. There are 131 respondents who only ranked q=1 of the 4 control methods. Thus, $f(i)$ the number of homeowners who ranked control option i first. The space of all such functions is denoted by $M^{(4,1)}$. There are two invariant subspaces in the isotypic decomposition with constant function and first order function (that sum to zero). These are denoted by $S^{5}, S^{4,1}$.

Table 8 illustrates that the first order coefficient is highest for the Liquid control option. Therefore, homeowners prefer the Liquid control option the most. The value for Liquid + Bait is -27.7, which is considered to be a least preferred option because it has the highest negative value. This indicates that homeowners do not want Liquid + Bait treatment control option applied in FST deterrence. This result coincides with the complete ranking result.

The foregoing analysis shows that homeowners prefer treatment 2 (Liquid treatment option) in the first order complete and partial ranked situations. It also tells us that the two most preferred choices are Liquid treatment option and Bait treatment option. However, it does not tell us how different characteristics of respondents affect the choice pattern. Further analysis indicated that both groups (YES to socioeconomic characteristics and NO to the socioeconomic characteristics) of respondents prefer treatment 2 although the strength of preference is low as we go from YES to NO categorical characteristics. For example, an individual living in New Orleans ranks option 2 as the most preferred option which is the same case for homeowners living outside of New Orleans but the strength of preference value is less in the latter group. Using second order analysis, we found (2,3) treatment option as the two most preferred options. However, these choice patterns did not vary by socioeconomic characteristics[3]. This has created a need to look into the preference issue even further, which we expand by using a Mallow's approach and a multinomial logit regression.

Mallow's approach again

We can be more precise on overall preference of the termite treatment option given what respondents preferred in the first and second order analyses. We used the Mallow's method to further evaluate this contribution. The result of preference for different combinations is given in Table 10. To illustrate, for income category 0, we calculate the inner product between the function $f_1^{2,2}$ and a function$f_T^{2,2} \in V_T^{2,2}$ where T represents the treatment option. This function $f_T^{2,2}$ identifies the elements of $f_1^{2,2}$ "containing" treatment option (1,2,3,4) with

[3] Tables presenting these results are not shown here but are available from the corresponding author.

1 and those “non containing” T with 0, if T= 1 $f_{T=1}^{2,2}$ = (1, 1, 1, 0, 0, 0). The contribution of the attribute treatment 1 is $f_{1,T=1}^{2,2} = f_1^{2,2}.f_{T=1}^{2,2}$. We can use Figure 1 that plots the frequencies of choices by first and second order effects to better understand data.

Table 10 shows that a treatment option choice differs by socio-economic characteristics. Consider the case of preference difference by an income category (variable name: annual pretax household income). Liquid treatment option and Bait treatment option are positive for both income categories. The effects of both Liquid treatment and Bait treatment are greater in the respondent category having household income below $125K. The absolute values of all treatment options are higher in this category of income as well. The highest value of 206.5 in Liquid treatment option shows that respondents with income less than $125K prefer the Liquid treatment option whereas the respondents with more than $125K income prefer the Bait treatment option. Below we show these calculations and how each value is obtained in Table 10.

Income less than $150K (income category = 0)

$$f^{2,2} = \begin{pmatrix} 173 \\ 12 \\ 9 \\ 323 \\ 34 \\ 96 \end{pmatrix} = \begin{pmatrix} 107.83 \\ 107.83 \\ 107.83 \\ 107.83 \\ 107.83 \\ 107.83 \end{pmatrix} + \begin{pmatrix} 38.50 \\ -11.00 \\ -157.00 \\ 157.00 \\ 11.00 \\ -38.50 \end{pmatrix} + \begin{pmatrix} 26.67 \\ -84.83 \\ 58.17 \\ 58.17 \\ -84.83 \\ 26.67 \end{pmatrix} \begin{matrix} 1,2 \\ 1,3 \\ 1,4 \\ 2,3 \\ 2,4 \\ 3,4 \end{matrix}$$

$$f^{2,2} = f_0^{2,2} + f_1^{2,2} + f_2^{2,2}$$

Income equal or more than $150K (income category = 1)

$$f^{2,2} = \begin{pmatrix} 7 \\ 0 \\ 1 \\ 47 \\ 12 \\ 33 \end{pmatrix} = \begin{pmatrix} 16.67 \\ 16.67 \\ 16.67 \\ 16.67 \\ 16.67 \\ 16.67 \end{pmatrix} + \begin{pmatrix} -13.00 \\ -6.00 \\ -23.00 \\ 23.00 \\ 6.00 \\ 13.00 \end{pmatrix} + \begin{pmatrix} 3.33 \\ -10.67 \\ 7.33 \\ 7.33 \\ -10.67 \\ 3.33 \end{pmatrix} \begin{matrix} 1,2 \\ 1,3 \\ 1,4 \\ 2,3 \\ 2,4 \\ 3,4 \end{matrix}$$

$$f^{2,2} = f_0^{2,2} + f_1^{2,2} + f_2^{2,2}$$

To get the first value in Table 10 with income category=0, we need to follow this calculation:

$$f_{1,T=1}^{2,2} = f_1^{2,2} . f_{T=1}^{2,2} => \begin{pmatrix} 38.50 \\ -11.00 \\ -157.00 \\ 157.00 \\ 11.00 \\ -38.50 \end{pmatrix} . \begin{pmatrix} 1 \\ 1 \\ 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} = -129.5$$

Likewise, we found that if home market value is less than $300K, respondents prefer the Liquid treatment option, but the respondents prefer Bait as a treatment option if their household market value is greater than or equal to $300K. In addition, households who considers termite as an existing problem in the neighborhood prefer Bait treatment option whereas Liquid treatment option are preferred by those who do not consider termites to be an existing problem in the neighborhood. Finally, respondents from New Orleans preferred the Bait treatment option whereas respondents from outside New Orleans chose liquid as a treatment option. For other socio-economic-physical characteristics of respondents, we found no difference between two categories studied as reflected from the results presented in Table 10.

Multinomial Logit Regression

So far we have presented results based on data-analytic method. One must also consider inferential aspects which depend on a probabilistic model. One of the most frequently observed inferential based method in the existing literature in economics for ranked data is to analyze only the first choice using an ordered probit model. When an individual ranks alternatives in order such as ranking the most preferred first, the second most preferred second and so on, until all n choices are ranked, the most frequently observed model is the rank-ordered logit model developed by Beggs et al. (1981). If we have both characteristics of choice and characteristics of respondents, we can use an exploded logit model or rank-order logit model. If there are specific characteristics associated with choice, then an attribute-specific random order probit or random order logit model can be used. In our case, the difference between the four treatment methods revolve around the pest control operator's monitoring frequency and the total cost of each treatment option. Some (e.g. Johnston and Roheim, 2006) have interacted these choice specific variables with socio-demographic variables and identified the characteristics affecting the ranking pattern. We argue that it may not be correct to employ this type of model to identify the variable affecting ranking patterns, because *a priori* we lack information regarding whether or not these variables interact. Therefore, we have chosen a different analytical approach for analyzing choice data.

As indicated in the earlier section, there are 4! (or 24) possible orderings of four FST treatment methods by an individual household. Out of these 24 individual rankings, Louisiana homeowner survey respondents chose only 20 different ranking patterns. It is also evident from Table 1 that only a few ranking combinations were chosen by a large majority of respondents. Based on these responses, we can develop eight distinct choice patterns and one "fringe choice pattern" consisting of all remaining choice patterns. We combined these fringe choice patterns into one group called "other." Therefore, we have a total of nine choice combinations. We identify variables that affect a respondent's distinct ranking combinations based on their socioeconomic characteristics.

The basic framework for analysis was provided by the random utility model. Let U_{ij} denote homeowner i's utility from choosing alternative j ranking pattern. Then the homeowner i chooses alternative j if $U_{ij} > U_{ik}$ for all $k \neq j$. It is standard to assume that $U_{ij} = V_{ij} + \varepsilon_{ij}$ where V_{ij} is the deterministic components of the utility and ε_{ij} is the random component that represents the researcher's ignorance about the consumer utility function. Assuming ε s are independent and have a type I extreme value distribution, the model for the ranking bundle is

$$\Pr(Y_i = j) = \frac{e^{V_{ij}}}{\sum_{k=1}^{9} e^{V_{ik}}}, k = 1, \ldots, 9.$$

Here, the respondent i's observed choice (Y_i) takes the value 1 through 9 depending on how she ranks the different treatment option in the ordering. The log likelihood function for the multinomial logit model was then given by

$$\ln L = \sum_{i=1}^{n} \sum_{j=1}^{9} d_{ij} \ln \frac{e^{V_{ij}}}{\sum_{k=1}^{J} e^{V_{ik}}}$$

The empirical model was obtained by specifying the component in the vector $\mathbf{x}_i$ of $V_{ij} = x_i \beta_j$. We included a constant, LOCATION, MKTVAL, HOMFOUND, TERMNEIGH, FSTHEARD, GENDER, AGE, EDU, INCOME, ETHNIC. These are both demographic variables and variables that measure a respondent's risk and benefit perceptions regarding termite infestation. Generally speaking, we expect that the market value of a house (MKTVAL) will have a positive sign, because we hypothesize that residents owning more expensive homes are more likely to pay for termite control. We assume that homeowners owning homes with concrete slab foundations (HOMFOUND) are less likely to pay for termite control because homes with slab foundations are pre-treated at construction and because there may be a perception that concrete slab foundations are "safer" and "more protected" against termite infestation. Therefore, we expect the sign to be negative. We also hypothesize that those homeowners responding to our survey and stating that they consider termites to be a problem in their neighborhoods (TERMNEIGH) are more likely to pay for termite control. Therefore, we expect the sign to be positive. Education and income are hypothesized to have a positive impact on willingness to pay.

Results from multinomial logit

An important feature of the multinomial logistic regression coefficients is that it estimates k-1 models, where k is the number of levels of the dependent variable (in our case k=9). Since the parameter estimates are relative to the reference group, the standard interpretation of the multinomial logit is that for a unit change in the explanatory variable, the logit of the outcome m relative to the reference group is expected to change by its respective parameter estimate given the variables in the model are held constant. Since most of the variables we have included in the multinomial regression model are binary in nature, we will describe the results obtained from the relative risk ratio (or odds ratio). Odds ratios are obtained by exponentiating the multinomial logit coefficients.

We used a ranking ordered 1>2>3>4 as the base category as this is the ranking pattern provided by people who preferred no treatment option as their first choice. Their least preferred choice was to pay $0.56 per square foot per year for the most costly FST treatment option as evidenced by their ranking of it as the last choice.

Before analyzing the data, we tested for the Independence of irrelevant alternatives (IIA) assumption which states that by removing any categories from the choice set, the probability of ranking of the remaining categories stays unchanged. According to Hausman test statics, we found that we could not reject the null hypothesis; hence, the IIA assumption holds.

We presented the results from the multinomial logit analysis in Table 11. This table shows coefficients from the regression model, relative risk ratios (odds ratio) and marginal effects. The values in the parentheses below the coefficients are p-values. Coefficient significance holds in most cases between multinomial logit coefficient and relative risk ratiocoefficients, although the same is not true for the marginal effects[4]. Coefficients associated with survey location New Orleans are positive and significant in six of the seven choice categories. The range of RR value is between 2.391 to 7.345. This is the relative risk ratio comparing preference of residents in New Orleans to residents of other locations for each choice category relative to the base category given that the other variables in the

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[4] Powers and Xie (2000) recommend using the odd-ratios for interpretation since the marginals may not have the same sign as the coefficients. We obtained marginals using STATA's margin command with dydx(.) option.

model are held constant. For residents in New Orleans compared to other locations in the state, the relative risk for those choosing 4>3>2>1 category relative to base category would be expected to increase by a factor of 7.345 given the other variables in the model are held constant.

Whether or not respondents' homes are constructed with a concrete slab foundation is significant in only one case – the case where respondents with a concrete slab foundation are likely to choose 2>4>3>1 by a factor of 3.613 relative to the base category given the other variables in the model are held constant. Although owning a home with a concrete slab foundation should theoretically reduce the risk of termite infestation, respondents were still likely to choose this option (an option that incurs costs) compared to the base option (an option that does not incur costs). Respondents owning a house with a market value over $300,000 were likely to choose ranking bundle 2>3>4>1 by a factor of 6.2412 and 2>1>3>4 by a factor of 2.915 compared to those respondents who preferred the base category given the other variables in the model are held constant. Those who indicated that termites were an existing problem in their neighborhoods were most likely to choose 2>3>4>1 (by a factor of 3.848 times) compared to those choosing the base category. This coefficient was positive and significant in six out of the seven ranking bundles. Those respondents who had heard of FST were likely to choose a ranking pattern 4>3>2>1 by a factor of 7.013 than those who chose the base category. We also found that these individuals were less likely to choose "other" category. Females were likely to choose ranking bundle 3>4>2>1 by a factor of 1.488 and 4>2>3>1 by a factor of 2.158 compared to the base category given the other variables in the model are held constant. We hypothesize that this indicates that females are more likely to choose what they perceive to be a "better" termite treatment package because they are more risk averse in the context of this study when compared to males in the study. Older respondents were likely to choose 2>3>4>1 ranking compared to the base category. The odds ratio of choosing this ranking increased by a factor of 0.038 for every one year increase in respondent's age given the other variables in the model are held constant. College education was insignificant in most of the cases and negatively significant in one case. These individuals were less likely to choose ranking pattern 4>3>2>1. Perhaps this indicates that more highly educated respondents did not perceive that potential marginal benefits incurred from more costly termite treatments outweighed the additional costs or that these more educated respondents were less risk averse. Respondents with higher incomes were likely to choose ranking pattern 4>3>2>1 by a factor of 12.751 than respondents choosing the base category given the other variables in the model are held constant. Caucasians were less likely to choose the "other" ranking pattern than the base category.

Conclusions

The contributions of this study are twofold. First, a generalized spectral analysis method was applied to identify the preference of Louisiana homeowners for four FST control options. The first and second order analyses showed that the Liquid treatment option was the most preferred option to control FST and Liquid treatment option and Bait treatment option are the two most preferred options. The results were consistent in both partial and complete ranking cases. Second, we took an unusual but comprehensive approach to identifying what factors affect termite treatment ranking patterns in treatment bundle options. To identify that, we estimated a multinomial logit regression model. Our results indicated that most of the demographic groups preferred a choice ranking other than the base "no cost first" category. The highest odds ratio coefficients were contributed by variables such as whether or not a survey respondent was from New Orleans, whether or not a respondent had heard of FST, and whether or not a respondent had a pretax income greater than $125,000. Awareness of the government – subsidized FST control program in the New Orleans French Quarter increased the likelihood of choosing a higher cost treatment option.

If the federal government is to continue subsidizing termite treatments, this study indicates that their subsidy efforts should be concentrated on making liquid barrier treatments most available compared to other treatment alternatives.

This study revealed that New Orleans respondents preferred expensive termite treatment options. This could be due to several factors, including a "subsidy effect" that occurs because some areas in that city are already under subsidized termite control, and it could also be due to an "information effect" resulting from heavy damages that have occurred in New Orleans over the past 20 years. Regardless, the result is that, from a policy perspective, in order for a subsidy to have a desired effect of increasing control, a greater subsidy would have to be paid to homeowners in New Orleans than in other cities. Perhaps a tiered subsidy system in which New Orleans residents receive a higher subsidy and other residents in the state receive a smaller subsidy may help prevent further termite infestation. Alternately, rather than some sort of cash or in-kind subsidy, the subsidy provided could be in the form of information, knowledge, and education. Using the information alternative, citizens in Louisiana could be educated regarding the need for treatment and the currently existing treatment options. This study reveals that the information imparted should be targeted to different groups in Louisiana according to where they live, their prior experience with termites, and other demographic categories that relate to termite control option preferences and risk tolerances.

Endnotes

Sample Ranking Question

There are different alternatives that homeowners can choose to protect their homes from Formosan Subterranean Termites. We'd like you to evaluate and rank your preferences from the alternatives listed below. Please indicate your ranking selection on the "Rank" space.

1= First preference

2= Second preference

3= Third preference

4=Fourth preference

Rank

____ **Alternative 1** Do not engage in any sort of activities, such as contracting with a pest control operator or company, to protect against termites. This option will cost you no money. With no form of termite protection or control, however, the chance that your home will be attacked by termites over the next five years is significant.

____ **Alternative 2** Contract with a pest control operator or company to install a liquid termite prevention solution (an insecticide that is applied in a trench dug around your home) around the exterior of your house. The cost of this option is as follows (based on a hypothetical 2,000 square foot home): initial inspection and installation fee = $750, annual renewal fees = $113 per year (including first year). This equates to an average cost over the next five years of $0.13 (thirteen cents) per square foot per year. With this service you will receive one home inspection per year. The contract lasts for five years.

____ **Alternative 3** Contract with a pest control operator or company to install a termite baiting system around the exterior of your home (small, self-contained insecticide bait stations are placed into the ground around the perimeter of your house) to assist in preventing termite infestation. The cost of this option is as follows (based on a hypothetical 2,000 square foot home): initial inspection and installation fee = $2,000, annual renewal fees = $450 per year (including the first year). This equates to an average cost over the next five years of $0.43 per square foot per year. With this service you will receive a minimum of one inspection per month. The contract lasts for five years.

____ **Alternative 4** Contract with a pest control operator or company to install a liquid termite prevention solution around the exterior of your house PLUS a termite bait system which further prevents termites. The cost of this option is as follows (based on a hypothetical 2,000 square foot home): initial inspection and installation fee = $2,750, annual renewal fees = $563 per year (including the first year). This equates to an average cost over the next five years of $0.56 (fifty-six cents) per square foot per year. With this service you will receive a minimum of one inspection per month. The contract lasts for five years.

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Table 1. Preference of FST control option in Louisiana complete rankings.

	Ranking(π)				Number of respondents
Combinations	First	second	Third	Fourth	
1	1	2	3	4	123
2	1	2	4	3	1
3	1	3	2	4	6
4	1	3	4	2	4
5	1	4	2	3	1
6	1	4	3	2	7
7	2	1	3	4	55
8	2	1	4	3	1
9	2	3	1	4	15
10	2	3	4	1	305
11	2	4	3	1	24
12	2	4	1	3	0
13	3	1	2	4	1
14	3	1	4	2	1
15	3	2	1	4	2
16	3	2	4	1	48
17	3	4	1	2	2
18	3	4	2	1	39
19	4	1	2	3	2
20	4	1	3	2	0
21	4	2	1	3	2
22	4	2	3	1	20
23	4	3	1	2	0
24	4	3	2	1	88
Total					747

Table 2. Preference of FST control options in Louisiana.

q=1		q=2	
Partial Ranking	No. of votes cast on this type	Partial Ranking	No. of Votes cast of this type
1000	42	1200	1
100	67	1020	0
10	17	1002	0
1	5	2100	0
		2010	0
		2001	0
		120	0
		102	0
		210	0
		201	0
		12	0
		21	0

Table 3. Young Tableaux for subspaces.

Sub Space			Young Tableaux notation		
Constant	[4]	V1	4 3 2 1		
First Order	[3,1]	V2	4 2 1 3	4 3 1 2	4 3 2 1
Second Order (Unordered)	[2,2]	V3	4 3 2 1	4 2 3 1	
Second Order (Ordered)	[2,1,1]	V4	4 3 2 1	4 1 3 2	4 2 3 1
	[1,1,1,1]	V5	4 3 2 1		

Table 4. Percentage of respondents ranking preference i in position j.

	Rank			
Method	1	2	3	4
No Control	22.8	7.98	2.8	70.2
Liquid	52.2	26.5	18.3	1.9
Bait	12.6	55.7	30.7	0.9
Liquid +Bait	12.5	9.8	48.2	27

Table 5. Decomposition of the regular representation.

$M^{11111}=S^{4} \oplus 3S^{3,1} \oplus 2\, S^{2,2} \oplus 3S^{2,1,1} \oplus S^{1,1,1,1}$

	V	=	V_1	$\oplus$	V_2	$\oplus$	V_3	$\oplus$	V_4	$\oplus$	V_5
Dim	24		1		9		4		9		1

Table 6. First order effects - complete ranking.

	Rank			
Method	1	2	3	4
No Control	-45	-127	-166	337
Liquid	213	9	-50	-173
Bait	-94	231	42	-180
Liquid +Bait	-75	-114	173	15

Table 7. Second order, unordered effects.

	Rank					
Method	1,2	1,3	1,4	2,3	2,4	3,4
No Control and Liquid	30	-79	49	49	-79	30
No Control and Bait	-96	141	-45	-45	141	-96
No Control and Liquid+Bait	66	-62	-4	-4	-62	66
Liquid and Bait	66	-62	-4	-4	-62	66
Liquid and Liquid+Bait	-96	141	-45	-45	141	-96
Bait and Liquid+Bait	30	-79	49	49	-79	30

Table 8. Spectral analysis of partial ranked data (for q=1, n=131).

$$M^{3,1} = s^4 \oplus S^{3,1}$$

Dim 4 1 3

Option	Projection
No Control	9.25
Liquid	34.25
Bait	-15.75
Liquid +Bait	-27.75

Table 9. Spectral analysis for partial ranked data q=2, n=1.

	$M^{2,1,1} =$	$s^{4} \oplus$	$2S^{3,1} \oplus$	$s^{2,2} \oplus$	$S^{2,1,1}$
Dim	12	1	6	2	3

Table 10. Preference of a single treatment method.

Variables	Termite control options	Category 0	Category 1
Annual pretax household income: $125K or more (1=yes)	1	-129.5	-42
	2	**206.5**	16
	3	107.5	**30**
	4	-184.5	-4
Survey location New Orleans (1=yes)	1	-106.5	-65
	2	**186.5**	36
	3	89.5	**48**
	4	-169.5	-19
Concrete slab home foundation (1=yes)	1	-44	-127.5
	2	**48**	**174.5**
	3	42	95.5
	4	-46	-142.5
Home market value $300K or more (1=yes)	1	-133.5	-38
	2	**211.5**	11
	3	104.5	**33**
	4	-182.5	-6
Termites an existing problem in neighborhood (1=yes)	1	-51	-120.5
	2	**143**	79.5
	3	37	**100.5**
	4	-129	-59.5
Gender female (1=yes)	1	-104	-61.5
	2	**143**	**73.5**
	3	76	56.5
	4	-115	-68.5
Heard of FST (1=yes)	1	-6	-164.5
	2	**47**	**173.5**
	3	11	127.5
	4	-52	-136.5

Table 11. Results of multinomial logistic regression, termite control preferences (Base category: 1>2>3>4).

Variables	4>3>2>1			2>3>4>1			2>1>3>4			2>4>3>1		
	Coeff.	RR	Marginal Effects	Coeff.	RR	Marginal Effects	Coeff.	RR	Marginal Effects	Coeff.	RR	Marginal Effects
N	88				305		55			24		
Intercept	- 3.931 **			- 4.352 **			-1.398			- 3.123 **		
	(0.017)			(0.000)			(0.140)			(0.043)		
Survey location New Orleans (1=yes)	1.994**	7.345**	0.025	-0.311	0.732	-0.034**	0.959 *	2.608*	0.010	1.816 **	6.150**	0.028
	(0.002)	(0.002)	(0.127)	(0.596)	(0.596)	(0.004)	(0.067)	(0.067)	(0.717)	(0.004)	(0.004)	(0.146)
Concrete slab home foundation (1=yes)	0.826	2.285	0.009	-0.589	0.555	-0.033	0.309	1.362	0.013	1.284 *	3.613*	0.020**
	(0.204)	(0.204)	(0.194)	(0.190)	(0.190)	(0.112)	(0.478)	(0.478)	(0.555)	(0.070)	(0.070)	(0.035)
Home market value $300K or more (1=yes)	-1.633	0.195	-0.016**	1.831 **	6.242**	0.128**	1.070 *	2.915*	0.083*	0.003	1.003	-0.004
	(0.169)	(0.169)	(0.020)	(0.003)	(0.003)	(0.016)	(0.081)	(0.081)	(0.098)	(0.997)	(0.997)	(0.759)
Termites an existing problem in neighborhood (1=yes)	0.993 *	2.699*	0.007	1.347 **	3.848**	0.033**	0.724 *	2.062*	0.013	-0.071	0.931	-0.012
	(0.085)	(0.085)	(0.391)	(0.002)	(0.002)	(0.028)	(0.058)	(0.058)	(0.517)	(0.890)	(0.890)	(0.210)
Heard of Formosan Subterranean Termites(1=yes)	1.948 *	7.013*	0.017**	0.812	2.252	0.017	0.517	1.677	0.013	1.216	3.374	0.015
	(0.072)	(0.072)	(0.027)	(0.188)	(0.188)	(0.295)	(0.276)	(0.276)	(0.577)	(0.132)	(0.132)	(0.131)
Gender female (1=yes)	0.479	1.614	0.002	0.480	1.616	0.006	0.022	1.022	-0.019	-0.814	0.443	-0.021**
	(0.379)	(0.379)	(0.756)	(0.251)	(0.251)	(0.660)	(0.955)	(0.955)	(0.322)	(0.179)	(0.179)	(0.029)
Age of respondents in years	0.005	1.005	0.000	0.037 **	1.038**	0.001**	-0.010	0.990	-0.001	-0.017	0.983	-0.001
	(0.833)	(0.833)	(0.885)	(0.020)	(0.020)	(0.027)	(0.510)	(0.510)	(0.150)	(0.428)	(0.428)	(0.216)
Education: some college or more (1=yes)	- 1.232 **	0.292**	-0.026	0.654	1.923	0.023	0.130	1.139	0.014	0.758	2.133	0.014
	(0.048)	(0.048)	(0.157)	(0.342)	(0.342)	(0.134)	(0.796)	(0.796)	(0.573)	(0.359)	(0.359)	(0.163)
Annual pretax household income: $125K or more (1=yes)	2.546 **	12.751**	0.044	0.684	1.982	-0.010	0.171	1.187	-0.041**	2.066 **	7.894**	0.034
	(0.002)	(0.002)	(0.151)	(0.309)	(0.309)	(0.501)	(0.810)	(0.810)	(0.043)	(0.004)	(0.004)	(0.171)
Caucasian ethnic group (1=yes)	- 1.315 **	0.268**	-0.028*	-0.984*	0.374*	-0.047*	-0.538	0.584	-0.035	- 1.174 **	0.309**	-0.033*
	(0.021)	(0.021)	(0.088)	(0.052)	(0.052)	(0.095)	(0.219)	(0.219)	(0.240)	(0.033)	(0.033)	(0.095)

Table 11 (cont.). Results of multinomial logistic regression termite control preferences (Base category: 1>2>3>4)

Variables	3>2>4>1			3>4>2>1			4>2>3>1			Other Categories		
	Coeff.	RR	Marginal Effects	Coeff.	RR	Marginal Effects	Coeff.	RR	Marginal Effects	Coeff.	RR	Marginal Effects
N	48			39			20			45		
Intercept	-0.406			-0.672			- 3.599 **			-1.080		
	(0.625)			(0.244)			(0.000)			(0.215)		
Survey location New Orleans (1=yes)	0.238	1.269	-0.028	0.872 **	2.391**	0.025	1.387 **	4.001**	0.071**	0.968 *	2.633*	0.009
	(0.706)	(0.706)	(0.193)	(0.025)	(0.025)	(0.639)	(0.002)	(0.002)	(0.049)	(0.086)	(0.086)	(0.737)
Concrete slab home foundation (1=yes)	-0.089	0.915	-0.012	0.164	1.178	0.026	0.122	1.130	0.001	-0.010	0.990	-0.007
	(0.821)	(0.821)	(0.562)	(0.545)	(0.545)	(0.575)	(0.733)	(0.733)	(0.957)	(0.981)	(0.981)	(0.738)
Home market value $300K or more (1=yes)	-0.223	0.800	-0.020	-0.021	0.980	-0.093	0.141	1.152	-0.006	-0.958	0.384	-0.045**
	(0.800)	(0.800)	(0.515)	(0.966)	(0.966)	(0.168)	(0.800)	(0.800)	(0.866)	(0.295)	(0.295)	(0.024)
Termites an existing problem in neighborhood (1=yes)	-0.564	0.569	-0.062**	0.580 **	1.785**	0.026	1.156 **	3.178**	0.069**	0.666 *	1.947*	0.008
	(0.172)	(0.172)	(0.002)	(0.018)	(0.018)	(0.528)	(0.000)	(0.000)	(0.008)	(0.092)	(0.092)	(0.665)
Heard of Formosan Subterranean Termites(1=yes)	0.141	1.151	-0.010	0.499 *	1.647*	0.086*	0.497	1.644	0.019	- 0.910 **	0.402**	-0.105**
	(0.717)	(0.717)	(0.632)	(0.070)	(0.070)	(0.093)	(0.238)	(0.238)	(0.539)	(0.025)	(0.025)	(0.004)
Gender female (1=yes)	0.194	1.214	-0.007	0.397 *	1.488*	0.036	0.769 **	2.158**	0.052*	0.320	1.378	0.000
	(0.580)	(0.580)	(0.656)	(0.095)	(0.095)	(0.366)	(0.015)	(0.015)	(0.050)	(0.395)	(0.395)	(1.000)
Age of respondents in years	-0.012	0.988	-0.001	0.008	1.008	0.000	0.034 **	1.034**	0.003**	0.009	1.009	0.000
	(0.406)	(0.406)	(0.101)	(0.389)	(0.389)	(0.954)	(0.007)	(0.007)	(0.002)	(0.563)	(0.563)	(0.937)
Education: some college or more (1=yes)	0.182	1.200	0.014	-0.124	0.883	-0.015	-0.264	0.768	-0.020	-0.390	0.677	-0.019
	(0.676)	(0.676)	(0.418)	(0.674)	(0.674)	(0.781)	(0.529)	(0.529)	(0.601)	(0.376)	(0.376)	(0.456)
Annual pretax household income: $125K or more (1=yes)	-0.905	0.405	-0.061**	0.957 *	2.603*	-0.012	1.928 **	6.877**	0.146**	1.156	3.176	0.010
	(0.429)	(0.429)	(0.000)	(0.057)	(0.057)	(0.855)	(0.001)	(0.001)	(0.010)	(0.122)	(0.122)	(0.774)
Caucasian ethnic group (1=yes)	0.080	1.084	0.009	0.238	1.268	0.137**	-0.256	0.774	-0.019	-0.024	0.976	0.003
	(0.854)	(0.854)	(0.637)	(0.430)	(0.430)	(0.005)	(0.516)	(0.516)	(0.555)	(0.957)	(0.957)	(0.869)

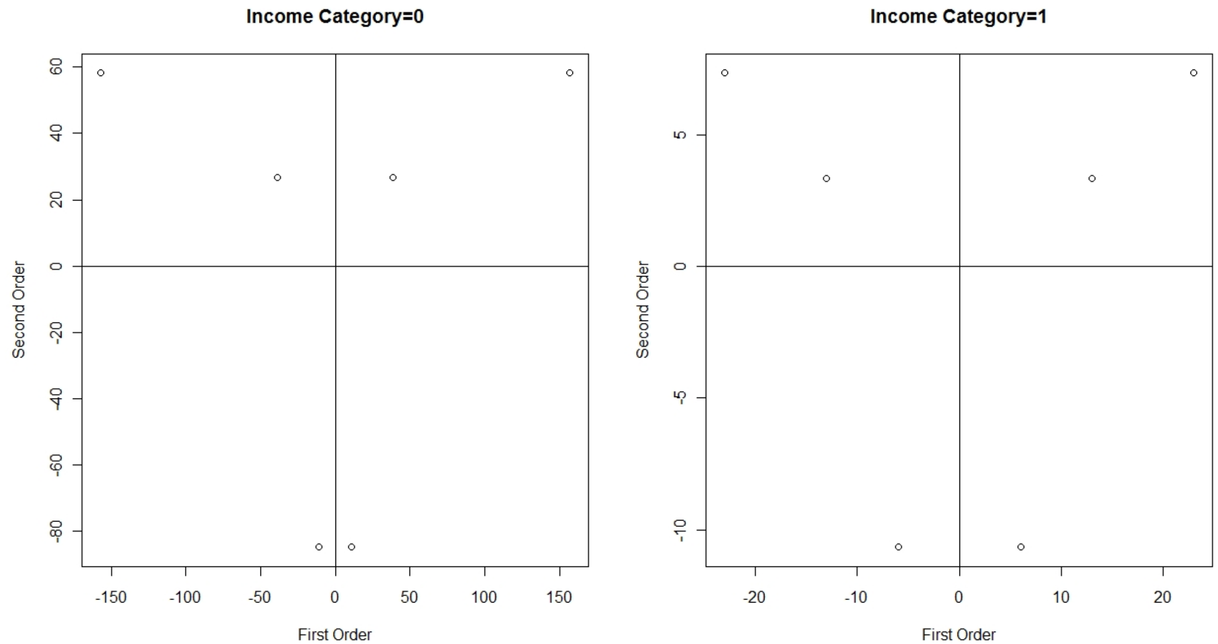

Figure 1. Joint first and second order effects by income