Choice Models in Policy Analysis

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Abstract:

The survey article provides a selected review of studies on econometric choice modeling of different agricultural policy issues. The study discusses how one model is preferred over the other and in what circumstances a particular model should be used.

Keywords: Qualitative Choice Models, Discrete Choice, Agricultural Policy, Food Policy.

Introduction

A rich literature exists on the contributions of agricultural economists to the analysis of policy issues in agricultural, resource and environmental economics, and agribusiness marketing. Contemporary policy fields of research interest include agricultural policy, the environment, food safety, biotechnology and consumer preferences for genetically modified food products. Over the past three decades, there has been a parallel growth in the economics literature on explaining how individuals make choices and the econometric models used to measure such behavior. Often, the choice made by individuals can be elicited through a qualitative choice (or response) variable, which can be explained by various factors in the specification of a choice model. These models have improved our understanding of policy impacts and the factors of significance in explaining how decision makers choose when provided with alternative policy choices. Some examples include analysis of farm subsidies and price floors, the demand for organic foods, and choices related to the interplay between agricultural production and the protection of the environment. This survey reviews recent work on the application of choice models to policy issues that have been of interest worldwide. The paper briefly identifies choice models and cites prominent econometric references and software programs used in the empirical literature. Applications are reviewed with a focus on recent policy issues. The field of emphasis for this survey is agricultural economics; therefore, most major journals in this field are reviewed. This literature survey should be of interest to a wide audience, including policy makers, individuals impacted by policy options, and the research community with interest in applying the latest methods to policy issues.

Econometric Methods

The survey article by Amemiya (1981) provides the foundation of econometric research with qualitative choice models up to the early 1980s. Standard univariate dichotomous models (logit and probit) found wide applicability in agricultural economics to study technology adoption, conservation reserve programs and other agricultural policy questions.

Today, there is an extensive use of choice models, including binary logit/probit, censored probit, conditional logit, finite mixture logit, group logit, heteroscedastic logit, random effects and random parameter models, nested logit, mixed logit and multivariate probit. We do not provide details on the econometrics of these models to save space. Useful references explaining these models can be found in Amemiya, 1981; Francis and Paap, 2001; Greene, 2003; Long, 1997; and Train, 2003. It should also be pointed out that Limdep/Nlogit, Stata, Gauss, and SAS, in that order, are some of the most frequently cited software used in the econometric estimation of these models.

Research on Policy Issues:

Natural Resource and Environment Policies:

Qualitative choice models have found extensive use in agricultural policy research. Perhaps more inclusively, the label for this section should be "public policy research by agricultural economists" given the number of public choice issues found in this literature. A standard application of logit models is the paper by Mehmood and Zhang (2001) examining the Endangered Species Act (ESA) amendments using a traditional roll and call analysis model. The dependent variable is a vote with a 1=yes (or in favor of) and 0=no (or against) ESA amendments at the house. The explanatory variables included house members' party affiliation, ideology, state location, number of endangered species in the members' election district, and the demographic and economic characteristics of the districts. This paper provides a good explanation of expected signs and sources of data on voting specific attributes, along with a descriptive statistical analysis of the data. The empirical analysis is based on four amendments: 1) the Tellico Dam Exemption, 2) the Leopard Darter Removal, 3) the Turtle Excluder Device, and 4) the California Dessert Protection. Three sets of each of the four models are estimated to analyze a particular vote and log-likelihood ratios were used to test vote significance. Coefficients and marginal effects are calculated for each model, and their t-values and standard errors are reported, respectively. Model success in predicting voting outcomes are also provided by calculating the percentage of correct predictions; no and yes correct predictions were ranged from 72 to 75% for the first amendment.

The role of agri-environmental incentives on the performance of U.S. agriculture has been a topic of recent interest (Cooper, 2003). One assumption of these studies is that farmers respond to incentives and are willing to accept incentive payments in return for adopting a bundle of environmentally benign best management practices (BMP). Cooper uses a multinomial probit analysis (MNP) of a survey of farmers facing five adoption decisions in a voluntary program. The problem is how a farmer chooses from a set of BMPs (say, j=1,2,3,4,5, with 1=conservation tillage, 2=integrated pest management, 3=legume crediting, 4=manure testing, and 5=soil moisture testing) under an incentive payment program. In this framework, a farmer is willing to accept a cost share per acre to switch to a new BMP if the difference between the observable portion of her indirect utility function at an initial state versus the new practice is greater than or equal to zero (i.e., $\Delta V_{ij} \geq 0$). The model can be specified as:

$$\Delta V_{ij} = X_{ij}^{'}\beta_j + \varepsilon_{ij},\ j = 1,2,\ldots,J;\ i = 1,2,\ldots,n.$$

Here, X_{ij} is a vector of explanatory variables for choice j for farmer i, and β are the coefficients. In this specification, the parameters of the willingness-to-accept (WTA) function can be estimated via maximum likelihood and restrictions were tested using likelihood-ratio tests. The MNP model is used to allow interdependence in choice of various management practices, which the underlying multinormal distributions is able to simulate. Because numerical approximations of the multivariate normal cumulative distribution functions are not yet developed, the authors propose the MNP by estimating the parameters of the random utility model (RUM) with parametric and semi-nonparametric (SNP) econometric model. The SNP approach uses a Fourier functional form as a substitute for the parametric functional form of the RUM associated with the incentive payment offer to adopt a BMP. This paper contributes to the literature by introducing a more flexible, nonparametric, estimator of the RUM specification of the MNP model. The MNP regressions for parametric and SNP models are reported under unrestricted and restricted models. The restricted models are specified with the assumption of independence among the various BMPs, that is, the correlation matrices are assumed to be diagonal matrices. A multinomial probit model was used to predict actual BMP use/nonuse, with explanatory variables including demographics of operators, cultural practices, conservation practices, and geographic location of sample. The results show how farmer's perceptions of the desirability of various bundles change with the offer amounts and with which practices are offered in the bundle. Although the use SNP procedures is novel, the functional form of SNP approximation is rather simplistic and leaves much room for enhancing an understanding of the factors that contribute to an explanation of how farmers make BMP choices (see Cooper and Keim for a similar application). Scrogin et al. (2004) analyzed the effects of environmental regulations on expected catch, expected harvest, and site choice of freshwater recreational anglers of Maine. The authors employed a two-stage quasimaximum likelihood (2SQML) count data estimator to estimate a joint model of expected catch and expected harvest separately for four species of fish. Estimated Zero Inflated Poisson (ZIP) was used to generate expectations of catch and harvest at the lakes and ponds comprising angler choice sets. Conditional logit models estimated anglers' site choice with catch and harvest regulations included in the ZIP models and with the regulations excluded from the ZIP models. Results indicate that regulations have a significant impact on angler catch, harvest and site choice. Also, regulations on recreational activities may be perceived as desirable attributes by some recreationists and undesirable by others (see also Morrison and Bennett, 2004 for analysis of Valuing New South Wales rivers for use in benefit transfer employing conditional and nested logit models).

Various other agricultural/public policy applications have appeared in the literature. An econometric analysis of conservation reserve program participation in the U.S. with ex post analysis of uncertainty and irreversibility is introduced in Isik and Yang using group logit analysis; a latent demand model of conservation practice adoption estimated with a single probit model is reported in Lichtenberg (a variation on the model of conservation reserve programs with multinomial logit models is found in Skaggs et al.).

Agricultural Production Policies:

Predicting agricultural production practices and the resulting levels of agricultural runoffs has been of interest for Conservation Policies. Wu et al. (2004) developed a model for data on more than 43,000 sites in the upper-Mississippi river basin under alternative conservation policies using a comprehensive National Resource Inventory (NRI) database collected by USDA Natural Resources Conservation Center. Because the model uses microlevel data, it captures the critical choice variables and spatial variability needed to accurately assess the economic and environmental consequences of agricultural land use changes. A set of microlevel, discrete choice empirical models (McFadden) were estimated using data to predict crop choice and tillage practice at each site. Environmental production functions were then used to predict nitrate runoff and leaching, water and wind erosion at each site based on crop choice, tillage practices, soil characteristics and climatic factors. Responses to policies designed to encourage adoption of conservation tillage and to alter crop rotations were simulated and the environmental impact estimated at each NRI site. The upper-Mississippi river basin is primarily a corn and soybeans production area. The modeling framework assumes that a farmer maximizes expected utility from choosing a crop-tillage practice combination, which is made simultaneously. Since preferences of farmers are unknown to the researcher, the utility generated from a crop and tillage practice is assumed to be a random variable. It is then possible under certain assumptions to estimate the probability that a farmer will choose a given crop and tillage practice using a multinomial logit model (Maddala). The final model adopted estimates the probability that a tillage practice is chosen conditional on the choice of a given crop (corn or soybeans). Coefficient estimates and their t-statistics are reported for corn, soybeans and hay. Typical independent variables include expected profit for corn, expected profit for hay, variance of corn profit, previous crop, mean maximum and minimum temperatures and rainfall for crop growing season along with corresponding standard deviations, land quality and location dummy variables. Marginal effects are also calculated, including marginal effects for dummy variables. A logistic tillage choice model is also estimated along with elasticities for the nondummy variables. In both models, the significance and predictive performance of both models is high. The changes in crop choices and tillage practices are then combined with site-specific environmental production functions to determine the effect of conservation payments on nitrate runoff and leaching and water and wind erosion at each NRI site. The multinomial logit results are expanded through a case study focusing on the issue of costs and environmental consequences of reducing nitrate and soil loadings in the upper Mississippi river basin. Similar applications have appeared in the economics literature to study choice of transportation modes, occupations, asset portfolios, and the number of automobiles demanded. In agricultural economics, similar applications have appeared with respect to modeling land allocation decisions (e.g., Lichtenberg, and Wu and Segerson), the choice of irrigation technologies (Caswell and Zilberman), and the choice of alternative management practices (Wu and Babcock). Another application on the sequential adoption of site-specific technologies is found in Khanna et al.

Windle and Rolfe (2005) analyzed farm diversification choices of sugarcane growers in three regions of Central Queensland cane growing area- Mackay and Sarina, Proserpine, and Bundaberg and Childers. The survey respondents were asked to make a series of choices about alternative options of diversification, which include: not to diversify, beef cattle, tree crops, annual horticulture, nonannual horticulture, field crops and forestry. The attributes involved in the model were: start-up costs, production costs, risk, management effort, and net annual income. The survey results indicated that most of the farmers preferred to continue sugarcane production (64%, 66%, and 41% in the Mackay, Proserpine and Bundaberg regions, respectively). The authors employed a nested multinomial logit model to estimate the farmers' preference for diversification choices. Results indicated significant differences among the three regions. Gross margins and risk were found to be the most significant factors affecting the farmers' diversification choices.

Organic farming and the willingness of consumers to pay for organic foods have been of interest to many countries. Recent findings suggest market demand for organic food has not been as strong as initially expected. To reduce market failures and stimulate the supply of organically produced food, the Finish government developed a programme in which a premium subsidy is paid to organically cultivated land. The key research question relates to identifying the factors that contributed to a switch from standard production technologies to organic farming and vice versa. This question is studied using a switching probit model that calculates the probability of a switch from one technology to another. It is found that at 1997 prices; the average probability of a switch from standard to organic farming is 1.2 percent whereas the probability of switching back from organic to the standard technology is estimated at 10 percent. It is found that economic incentives to farmers play an important when choosing standard and organic technologies. It is concluded that agricultural prices and subsidies can be effective policy instruments for guiding farmers' choice of production technologies. Pest control programs are of much concern to various countries. Government policy instruments that offset the cost of an eradication program can provide an incentive for farmers to adopt programs. In the U.S., producers resisting change and low voter participation often results in initially weak referendum results. A principal-agent model for regional pest control adoption and the characteristics of farmers that help explain it is measured using a multinomial logit model (Ahouissoussi, 1995). The study finds a difference in the type of producer who will early adopt industry versus firm specific technologies. The study finds that the characteristics of producers resisting change vary by industry-specific technologies (say Boll Weevil Eradication) versus firm-specific technologies; the multinomial logit model is estimated for a sample of cotton producers in Georgia.

Foltz (2004) uses sunk cost theory to justify the optimality of price floors created by New England Dairy Compact in the U.S. and tests the effectiveness of the price floors in mitigating the effects of sunk costs and as policy instruments in maintaining farm numbers (entry/exit choice numbers). The econometrics of the latter question can be formulated as a farmers' decision (choice) to stay in business using a random effects probit model (if the expected utility of staying in business is greater than that of exiting, then it is assumed a farmer will stay in business). The data used in the analysis represents a complete census of Connecticut's dairy farms during a six-year period from 1996 to 2001. For the exit equations, the dependent variable is defined as an indicator variable equal to 1 if farm i is in business in period t and 0 otherwise; thus, the model estimates the probability that a farmer stays in business. Test of random effects support their use in a panel data framework (as opposed to a pooled model). The results find qualified support for price support programs as a method of keeping dairy farmers in business.

Government Food Policies:

Welfare effects of various government programs have been measured in various studies. The largest non-categorical welfare program in the United States in terms of dollars spent and number of recipients, the Food Stamp Program (FSP), administered through the U.S. Department of Agriculture, has been the subject of much research inquiry over the years. One aspect of this program that has gained recent interest is the nutrition contribution of the program to food stamp recipients. Recipients receive food stamps or electronic-benefit-transfer (EBT) accounts instead of cash for approved food items. The program is aimed at alleviating hunger and malnutrition among poor households. The performance of the FSP is measured by how the assistance impacts food stamp recipients and how efficiently that assistance is provided. These two criteria are impacted by store access and store characteristics (i.e., larger vs. smaller stores). Feather (2003) developed a two-stage discrete choice/count model (Deaton and Muelbauer) to assess how store access policies would impact food stamp recipients. More specifically, the models explain both the choice of where to shop as well as to how many shopping trips to take in a given time period. The econometrics of this problem is explained in Hausman et al. using a utility-consistent, combined discrete choice and count data model. The two-stage approach works in reverse, that is, the store selection process (the food stamp recipient decides what store to visit) is modeled first (stage 2), and then the demand functions for shopping trips are estimated (stage 1). The second stage begins by maximizing the utility derived from a trip to a particular store and obtains a conditional indirect utility function (V_j) which in linear form can be written as

$$V_j = \Theta W_j + \Gamma z_j + \beta(y_i - c_j) + e_j,$$

where W_j is a vector of prices, z_j is destination characteristics and (y_i-c_j) is income less travel cost. The parameters to be estimated are Θ, Γ, and β. These parameters can be estimated using a multinomial logit utility model which can be written as:

$$P(j) = \exp(V_j) / \sum_l \exp(V_l), \quad l = 1,2, \ . \ . \ ., \ K,$$

where P(j) is the probability of choosing the j^{th} store and K is the total number of stores. The estimation of V_j and related coefficients is used in calculating welfare effects, which in this paper are defined as inclusive value (IV) and compensating variation (CV). The empirical use of IV and CV can be ad hoc (Feather) or theoretically consistent with the two-stage budgeting process (Hausman et al.). Hausman et al.'s approach is to estimate a trip demand function h(.) using the per trip welfare measure (CV) as a price index (not as a measure of welfare):

$$T = h(CV, D),$$

where T is the grocery shopping trips and D denotes the demographic variables. Consumer surplus in this model can be estimated by integrating CV out in the h(.) function prior and post some change. Since the dependent variable T is a count variable that is truncated at zero, a truncated Poisson regression (Grogger and Carson) is used to estimate the model. The data used to estimate the models were obtained from an EBT demonstration project conducted in Dayton Ohio. Electronic transitions were recorded over a one-month shopping history of 6,357 households participating in the food stamp program in May 1992. The random utility model of grocery store destination choice was specified as a function of income less transit cost, annual sales, a grocery store dummy and a supermarket dummy (dummy variables were used to proxy store-type attributes such as product prices which could not be collected from the data); estimated coefficients and t-statistics for parameter significance were also reported. The Poisson regression model of number of shopping trips was specified as a function of a constant, a price index, age, car ownership dummy, number of adults in household, monthly income and number of nearby supermarkets and grocery stores; estimated coefficients and asymptotic z-statistics for parameter significance were reported, along with a Pearson R-squared for goodness-of-fit. The results indicate that improving store access by improving closeness to food stamp recipients results in a gain in welfare ranging from \$2.78 to \$7.76 per month depending on how close the improved store is to the food stamp recipient and how the food stamp recipient's time is valued. In the scenarios considered in the study, female-headed households and persons not owning automobiles were the most severely affected. Welfare losses from choices studied were also calculated. A related application is that by Gundersen and Oliveira who use a simultaneous equation (bivariate probit model) to measure the impact of participation in the FSP on the food sufficiency status of households and the impact of food insufficiency on the probability of participating in the program. The results are compared to those of univariate probit models. In general, their findings show that participation in the FSP has no impact on food insufficiency.

Personal health is another public policy issue that has gained the attention of agricultural economists. Carlson and Senauer (2003) use data from the third National Health and Nutrition Examination Survey (NHANES III, U.S. Department of Health, 1994) to examine the impact of the Special Supplemental Nutrition Program for Women, Infant and Children (WIC) on the overall health of preschool age children using a health production function model (Becker). This study could be classified as an international economic development contribution as health production and demand functions have been used to study children's health in developing countries. Based on the production function model of Becker, the household is assumed to maximize utility in terms of the family members' health, consumption of other household produced goods and services, and leisure. A child's health (H_i) equation can be written as:

$$H_i^* = \beta' x + \varepsilon$$

where X is a vector of explanatory variables such as food consumption, medical care, child's age and gender, parent's education, and other demographic and spatial characteristics. Although health is a continuous variable, the actual data is recorded as a physicians score on child's health with categories given by H=0 for excellent health, H=1 for very good health, H=2 for good, and H=3 for fair/poor, with the mapping from H* to H is defined by cut-off values $\mu_0 < \mu_1 < \mu_2$, $H^* \leq \mu_0$ for H=0, and $H^* > \mu_2$ for H=3. The probabilities of a child's health taking values 0,1,2, or 3 [i.e., P(H=0), P(H=1) P(H=2) P(H=3)] can be calculated from an ordered probit model. The β coefficients in the ordered probit model do not have a meaningful interpretation. Thus, the authors calculate the marginal effects (i.e., the first derivatives with respect to the independent variables for each of the probabilities except for binary variables that require special formulas). The explanatory variables included race, sex, WIC participation, marital status, participation in food stamp program and geographic location, among others. The ordered probit model was estimated for a WIC sample and the full sample (2,632 children ages 2-5). Hausman tests were calculated to determine the exogeneity between WIC and food stamp program participation (exogeneity found). A salient finding of the study was the significant effect of WIC on a child's health.

Country of Origin Labeling (COL) is one of the main areas of agricultural food policies where choice models are applied. Increasing public concern about food safety as well as increasing standards of living resulted in consumer interest in information regarding the safety, origin, and content of food they buy. This resulted in mandatory regulations for promoting and protecting agricultural and food products to a specific place of origin. The 2002 U.S. Farm Security and Rural Investment Act mandated retailers provide consumers with COL information for beef, lamb, pork, seafood, peanuts, and fruits and vegetables (Loureiro and Umberger, 2005). The European Union Regulation in 1992 established rules such as, Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI), to encourage diversity in agricultural production, ensure consumer safety, and protect brand names (Van der Lans and De Cicco, 2001). Loureiro and Umberger (2005) analyzed consumer willingness to pay (WTP) for a mandatory COL program applied to beef ribeye steaks, chicken breasts and pork chops, labeled "Certified U.S." products. Specific objectives were to estimate consumer WTP for meat products and examine the role of sociodemographic characteristics in determining WTP using a binary logit model. The authors also estimated a binary logit model with random effects to account for the non-observed heterogeneity, which indicated preference differences that are not related to sociodemographic variables. The authors found the random effects binary logit model to be more appropriate based on the Loglikelihood tests, number of statistically significant variables, and the estimated correlation coefficient which was very close to 1 and statically significant. Results indicated that consumers give high priority to food safety and consider the U.S. meat to be the safest among countries included in the model.

However, authors found that consumer WTP for Certified U.S. studied products is relatively small. Similarly, Bonnet and Simioni (2001) examined consumers WTP for a PDO-labeled food product, French Camembert cheese, using scanner data on purchases in the French national market and found that consumers do not value the quality signal provided by the PDO label. They found brand image to be more important from consumer point of view (also see Mojduszka et al., 2001).

Another area of agricultural food policy that is of prime importance is a regulatory policy related to food biotechnology. McCann-Hiltz et al. (2004) analyzed Alberta consumers' preferences for three biotechnology policy options. The policy options included are: 'a more restrictive regulatory policy', 'increase food inspection', and 'provide information on food labels'. Each respondent was presented with two hypothetical situations related to policy options. The first situation compares 'increase food inspection policy' with 'a more restrictive regulatory policy.' The second compares 'provide information on food labels policy' with 'a more restrictive regulatory policy'. There were cost consequences of the choice and respondents were also provided with an option of not to choose any policy, keeping the food prices constant. Conditional logit and mixed logit models were applied to each hypothetical situation. The advantage of mixed logit models is that they account for consumers' taste heterogeneities and also relaxes the Independence of Irrelevant Alternatives (IIA) assumption of the conditional logit model. Results indicate that for both scenarios the mixed logit model yields better fit as suggested by the chi-square statistic. Consumers prefer 'increase food inspection policy' and 'provide information on food labels policy' compared to 'a more restrictive regulatory policy.' Authors indicated that females were willing to pay more than males for both the food policy option of labeling and inspection of agricultural biotech food. Petrick (2004) assesses credit rationing in the Polish farm sector and estimates the marginal willingness to pay for short-term credit using a cross-section survey. The response variable takes a one when the farm household in Poland is credit constrained and zero otherwise and is explained by land owned, land rented, age of newest tractor (collateral), capital stock of farm net of land, and other financial and demographic variables. A probit model was estimated to calculate probabilities of being credit rationed. Neither farming experience nor the farmer's education had a significant effect on credit rationing. The study contradicted the conjecture that higher public transfer payments to females increase the availability of liquidity; thus, the study leads to an interpretation that women contribute less than expected to farm performance relative to lenders' preferences. It was also found that the farmers' willingness to pay for credit was 209 percent net of principle. This finding was consistent with evidence for other countries.

Summary

This survey article provided a selected review of studies on econometric choice modeling of policy issues. Significant progress has been made by agricultural economists in the application of economic theory of individual choice behavior in understanding farmers, consumers, and other decision maker choices that arise from policy prescriptions. A salient finding in the reviewed literature is that revenue enhancing policies do not necessarily lead to universal acceptance of choices; understanding the factors that contribute to choice making can lead to better policy making. Numerous choice modeling advances are being introduced to the econometrics literature that will further enhance the ability of agricultural economists to study individual choice behavior, including Bayesian analysis of individual decision processes, semiparametric estimation of choice models, and spatiotemporal analyses of choice. Empirical applications using these methods should be forthcoming in the near future.

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Table 1. Selected Qualitative Choice Models Applications and References

Model	Mathematical Equation	Application
(I) Binomial Dependent Variable		
(i) Binary Probit model	$\Pr[Y_i = 1 \mid X_i] = \int_{-\infty}^{X_i\beta} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{z^2}{2}\right) dz$ Source: Franses and Paap Reference: Verbeke et al. (2000)	When dependent variable takes on two values (for example, a choice with yes or no option, y=1 if yes, 0 otherwise). Errors associated with utility generated by each choice are assumed to be correlated.
(ii) Binary Logit model	$\Pr[Y_i = 1 \mid X_i] = \frac{\exp(X_i\beta)}{1+\exp(X_i\beta)}$ Source: Franses and Paap References: Mojduszka and Caswell (2000) and Loureiro and Umberger (2005).	When dependent variable takes on two values (for example, a choice with yes or no option, y=1 if yes, 0 otherwise). Here errors associated with utility generated by each choice are assumed to be independent.
(II) Unordered Multinomial Dependent Variable		
(i) Multinomial Logit Model	$\Pr[Y_i = j \mid X_i] = \frac{\exp(\beta_{0,j} + \beta_{1,j} x_i)}{1+\sum_{l=1}^{J-1} \exp(\beta_{0,l} + \beta_{1,l} x_i)}$ for j=1,….,J-1 Source: Franses and Paap Reference: Ahouissoussi (1995)	When there are more than two alternatives/choices available. For example, an individual is asked to choose one brand among Brand A, Brand B, Brand C, and Brand D. "Individual choices are correlated with individual-specific explanatory variables, which take the same value across the choice categories." (Franses and Paap)
(ii) Conditional Logit Model	$\Pr[Y_i = j \mid W_i] = \frac{\exp(\beta_{0,j} + \gamma_1 w_{i,j})}{\sum_{l=1}^{J} \exp(\beta_{0,l} + \gamma_1 w_{i,l})}$ for j= 1,….,J. Source: Franses and Paap Reference: Scrogin et al. (2004)	This model is used over multinomial logit model when explanatory variables take on different values across the choice options. The main drawback of conditional logit model is that it assumes that the alternatives are independent of each other (IIA-Independence of Irrelevant Alternatives).
(iii) Nested Logit Model	$\Pr[C_i = m \mid Z] = \frac{\exp(Z_m\alpha + \tau_m I_m)}{\sum_{l=1}^{M} \exp(Z_l\alpha + \tau_l I_l)}$ Source: Franses and Paap Reference: Morrison and Bennett (2004)	This model employed when IIA assumption of conditional logit model is rejected (Hausman test). In this model alternatives/choices are divided into clusters such that the variances of error terms of the random utilities are same within each cluster but differ across clusters. This means IIA assumption holds within a cluster but it does not hold between the clusters.

(iv) Mixed Logit Model / Random Parameters Logit Model	$$P_{j,n} = \int_{-\infty}^{+\infty} \frac{\exp(\sum_{h}^{H} \beta_{h,n} \tilde{x}_{j,h,n})}{\sum_{h \varepsilon H} esp(\sum_{h}^{H} \beta_{h,n} \tilde{x}_{j,h,n})} f(\mu,\sigma) d\beta$$ Source: Scarpa et al. (2005) Other References: Bonnet and Simioni (2001).	This model allows for heterogeneity of taste preferences, unrestricted substitution patterns and correlation in unobserved factors over time. Basically the model identifies the impact of socioeconomic and demographic characteristics of individual on his choice preference.
(v) Multinomial Probit Model	$$p(j) = \int_{-\infty}^{+\infty} du_j \int_{-\infty}^{(p_j - p_l)\alpha + (x_j - x_l)\beta + u_j} du_1 \ldots \int_{-\infty}^{(p_j - p_J)\alpha + (x_j - x_J)\beta + u_j} du_j . f(u)$$ Source: Chen and Cosslett (1998) Reference: Chen and Cosslett (1998) and Cooper (2003)	This model is employed when IIA assumption of conditional logit model does not hold. Multinomial model is hard to estimate in cases where there are more than four alternatives /choices.
(vi) Random Parameters Multinomial Probit Model	$$p(j) = \int_{-\infty}^{+\infty} du_j \int_{-\infty}^{(p_j - p_l)\alpha + (x_j - x_l)\beta + u_j} du_1 \ldots \int_{-\infty}^{(p_j - p_J)\alpha + (x_j - x_J)\beta + u_j} du_j . f(u)$$ $$\bar{U} = \int_{-\infty}^{+\infty} \max(p_j \alpha + x_j \beta + u_j) f(u) du$$ Source: Chen and Cosslett (1998)	This model allows for heterogeneity of taste preferences and does not assume IIA.
(III) Ordered Multinomial Dependent Variable		
(i) Ordered Probit Model	$$F(\alpha_j - \tilde{X}_i \tilde{\beta}) = \Phi(\alpha_j - \tilde{X}_i \tilde{\beta}) = \int_{-\infty}^{\alpha_j - \tilde{X}_i \tilde{\beta}} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{z^2}{2}\right) dz$$ Source: Franses and Paap References: Carlson and Senauer (2003), and Foltz et al. (1999).	This model is used commonly when an individual is asked to rank or rate some scenario. For example, an individual is asked to indicate whether he strongly agree, agree, neutral, disagree or strongly disagree with a certain statement. It is also used in cases where an individual is asked to rate a scenario over a scale of 1 to 10, where 10 being the best and 1 being the worst.
(ii) Ordered Logit Model	$$F(\alpha_j - \tilde{X}_i \tilde{\beta}) = \Lambda(\alpha_j - \tilde{X}_i \tilde{\beta}) = \frac{\exp(\alpha_j - \tilde{X}_i \tilde{\beta})}{1 + \exp(\alpha_j - \tilde{X}_i \tilde{\beta}}$$ Source: Franses and Paap Reference: Jensen and Davis (1998).	This model is applied in similar conditions as mentioned for ordered probit model. Refer to Harrison et al. (2002) and Harrison et al. (2005), for comparison of ordered probit, ordered logit, and tobit models.

(IV) Count Data Models		
(i) Poisson Regression	$f(Y_i) = \frac{\mu^Y e^{-\mu_i}}{Y!}$ $E(Y) = \mu \quad Var(Y) = \mu$ Reference: Scrogin et al. (2004)	This model is used when dependent variable is discrete, taking only a finite number of values. For example, dependent variable is: number of vacations taken by family per year, number of technologies adopted by a farmer, or number of patents received by a farm per year.
(ii) Negative Binomial	$f(Y_i) = \frac{\mu^Y e^{-\mu_i}}{Y!}$ $Var(Y_i) = \mu_i + \alpha\mu_i^2$ when α=0, indicates Poisson Reference: Norro and Gillespie (2004).	Poisson regression does not count for overdispersion or underdispersion. This means variance may be greater or lower than mean. Poisson estimates are not efficient in this case. So, when ever variance and mean of dependent variable are not close, use Negative Binomial.
References for other models in Agricultural Economics: *Censored probit model* (Hudson and Herndon, 2002*), Double-Bounded Dichotomous Choice Model* (Aadland and Caplan (2003); and Cunha-E-Sá et al. (2004)), *Finite Mixture Logit model* (Provencher et al., 2002), *Heteroskedastic probit model* (Rejesus et al., 2005), *Random effects binary logit* (Loureiro and Umberger, 2005), *Random effects binomial probit model* (Coble et al.,1996), *Simultaneous ordered probit model* (Aradhyula and Tronstad, 2003).		