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THOROUGHBRED FARM MANAGERS' WILLINGNESS-TO-PAY FOR ALTERNATIVE DEWORMING REGIMENS IN HORSES

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THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
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By

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ABSTRACT OF THESIS

THOROUGHBRED FARM MANAGERS' WILLINGNESS-TO-PAY FOR ALTERNATIVE DEWORMING REGIMENS IN HORSES

Parasite control is important to horse health and horse owners should feel highly concerned about the proper treatment of parasites. In the past 30 years, veterinary science has made important advances in treating parasites and provided new products and strategies to optimize treatment and prevention. However, horse owners and managers have been slow to adopt these new recommendations.

This study investigates why the transition has not occurred as expected. It examines issues related to the decision-making process of horse owners and managers as they relate to deworming strategies. In addition, it investigates current deworming approaches as well as attitudes towards alternative parasite control strategies, and tries to describe the financial considerations corresponding to each strategy.

To this end, a questionnaire was distributed to Thoroughbred farms in Kentucky. The first part of the questionnaire examined the actual approaches of farm managers and characterized the Kentucky Thoroughbred farms. Most farm managers appear to be concerned about drug resistance in parasites and incorporated veterinarian advice in defining their deworming program; however, almost three-quarters of them were still following the traditional rotational deworming program. Based on a conjoint experiment, we were able to evaluate the willingness-to-pay of farm managers for different attributes of a deworming strategy – time and effort spent, decrease in health risks, drug resistance in parasites, and price. The study showed that farm managers were willing to pay a premium for a strategy that is guaranteed “non-resistant” and that decreased health risk by 5%, while they expected a discount for a strategy that requires much time and effort.

KEYWORDS: Equine, Parasite, Willingness to pay, Kentucky Thoroughbred Farms, Mixed Logit Model.

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Chapter I: Introduction

Deworming is important to horse health and aims at ridding them of intestinal parasites by giving him a specific drug known as an anthelmintic. In the past 30 years, veterinary science has made important advances in treating parasites and provides new anthelmintics and strategies to optimize treatment and prevention. However, horse owners and managers have been slow to adapt these new recommendations, and this study investigates why the transition has been difficult.

I.1. Parasites in horses and deworming strategies

Parasites are organisms which live in or on another organism (its host) and benefits by deriving nutrients at the host's expense, and nearly always causes some harm in doing so (Oxford dictionary). In horses, worms are one type of commonly occurring parasite; they are of concern because worm burdens may cause horses to develop a dull or rough coat, have little energy, lose weight, and may even be responsible for colic, intestinal irritation, intestinal ruptures, airway inflammation, and damage to internal organs. The most common and dangerous worms are large and small strongyles, ascarids, bots, pinworms, tapeworms, threadworms, and lungworms (Horsetalk.com.nz, 2012). Once the worm infestation reaches a certain level, it will start to damage the health of the horse host. Mature internal parasites lay millions of eggs which are then excreted in feces, potentially infecting other horses grazing in the same pasture. Indeed, a horse's infection by parasites will be directly related to its exposure to eggs and infective larvae in paddocks.

Parasite control programs, also called deworming programs, aim at maintaining worm numbers below threshold levels to avoid health issues. Thus, deworming will not eliminate all parasites from the horse's system, but it at least ensures a "safe" level of infestation.

Several strategies are currently used to control worm burdens. First, the use of pharmaceutical products called anthelmintics (also called vermifuges or vermicides) became a common strategy to tackle worm burden. Most anthelmintics paralyze the parasite, making it unable to feed; it is then released from the gut and passed out of the animal. However, not all deworming agents are effective against all worm varieties or in all stages of each worm's lifecycle. Anthelmintics impact the parasite population inside the horse when it targets the right worm at its appropriate stage; however, it will not protect the horse from being re-infected by ingesting larvae while grazing. That is why worm control programs also include farm management practices such as pasture management. Depending on the weather, some eggs become infective larvae in under a week. Some worms, such as ascarids, have eggs that can become viable two years after being deposited in a field. To reduce the pasture infection rate, the farm manager can rotate pastures and free the pastures of horses for a year. Rotation with other animals such cattle or sheep is also useful since they ingest the larvae before horses start grazing the field. Finally, manure management is an important parasite control tool. Indeed, once parasite eggs hatch, the larvae will feed on manure. Removing manure reduces the parasite presence in the field, and proper composting then kills parasites. Dragging fields is another beneficial strategy when conducted in appropriate weather conditions. Dragging in hot and dry conditions will kill most eggs and larvae, but if the right climatic conditions are not present, infective larvae will instead be distributed over the entire pasture. In summary, to maintain low parasite levels in horses, it is suggested that farm managers use a combination of pasture management and anthelmintic treatment (Briggs, 2004).

I.2. Research questions and objectives of the study

Based on research in the veterinary science community, new recommendations about deworming programs have been provided to horse owners and farm managers; however, adoption of these recommendations has been slow. This trend leads to the two main objectives of this study.

The first objective is to better understand why the new recommendations are not widely adopted by managers and owners. To this end, this study utilizes a questionnaire to elicit respondents' current approaches to parasite control, knowledge of and concern about drug resistance in parasites, and willingness to consider alternative approaches to managing parasites.

The second objective of this research is to aid in understanding the feasibility of alternative treatment strategies; that is, whether horse owners or managers will actually adopt new strategies. This approach will be done by estimating managers' willingness-to-pay for simpler, more predictable treatment strategies or for more efficacious treatment strategies.

I.3. Thesis structure

Chapter 2 presents background information and related literature. Chapter 3 introduces the research methodology used to identify consumer preferences as well as the empirical model to be use in analyzing the data. Chapter 4 explains the survey design and data collection. Results are presented in Chapter 5 and 6; Chapter 5 presents the results for the demographic analysis and the current deworming strategy in use, while Chapter 6 gives the results of the conjoint analysis. Chapter 7 provides discussion, conclusions and recommendations in accordance with the objectives of the study.

Chapter II: Literature Review

II.1. Background of deworming in equine

II.1.1. History of dewormers

People have been aware of the presence of parasites in horses for centuries, but effective treatments have not been available until recently. The withdrawal of small quantity of blood, or blood-letting, was the first practice to treat worm infestations until people realized that it would be better to utilize oral medication. Numerous drugs were used, like toxic mercury, animal offal, and herbal remedies, but they were often ineffective and poisonous. In the early 1900s, horses were given tobacco, carbon disulfide, and carbon tetrachloride; the carbon products killed parasites but also proved to be toxic to the horse. In the 1940s, phenothiazine was the first ‘modern dewormer’ used by farm managers, and remained popular for 20 years until scientists noted resistance to the drug by the parasites. New active ingredients followed in the 60s and 70s like piperazine, organophosphate and benzimidazoles. The benzimidazole family – thiabendazole, cambendazole, oxfendazole, fenbendazole, oxibendazole, mebendazole – was a big breakthrough in deworming strategies. It was effective against a wide range of parasites, and the dosage rate was very low; this meant that farm managers were able to directly administer the drug safely without the assistance of a veterinarian. Initially, these drugs drastically decreased the number of parasites, but resistance began appearing about ten years after its introduction. In the 1980s, pyrantel, ivermectin and moxidectin arrived in the market and were also highly effective, until parasites developed resistance to them, similar to the benzimidazoles (Bertone and Horspool, 2004).

II.1.2. Farm managers' practices

Until the 1960s, horse farm managers would deworm their horses when it appeared they needed it. Physical symptoms of possible significant parasite infestations included a pot-belly appearance, tail-rubbing, and a dull coat. In 1966, Lyons and Drudge published a paper on rotational deworming. They introduced an equine parasite control program aimed at suppressing large strongyles, which were the most dangerous worm at that time. Their suggestion was to treat all horses every 6 to 8 weeks, alternating between chemical agents to target all parasites. This practice became known as "rotational deworming" and remains very common; however, drug resistance has become widespread. If the same active ingredient is provided more than necessary, there is the potential to create drug resistance.

II.1.3. Definition of drug resistance in parasites

Drug resistance is a universal problem, and it occurs when a part of the parasite population develops the ability to tolerate the chemical agent used to kill it. Once this ability is acquired and the parasite reproduces, it will likely be transferred to future generations of parasites (Guillot, et *al*., 2008).

Today, scientists know more about equine parasites and their life cycle. Moreover, they determined that only 20% of the horses in a herd carry 80% of the parasites (Vidyashankar, et *al*., 2011). Resistance can occur with treatment frequency and repetition of treatments with drugs from the same chemical class. Also, treating a horse who does not have a significant worm infestation can increase resistance (Guillot, et *al*., 2008). That is why the most recent veterinary advice is to treat for parasites according to each horse's needs rather than relying on the same calendar-based schedule for all horses.

Fecal egg counts are proving to be a good strategy in developing an effective deworming plan. Indeed, this laboratory test determines the number of parasite eggs per gram of feces as well as the type of worms concerned. It identifies which of the horses are high, medium, or low “shedders” and which parasites are present. This tool helps determine whether a horse needs to be treated or not, and which drug should be used.

Drug resistance is more often a farm problem than a horse problem; the deworming strategy used over time by a farm manager can influence the effectiveness of a drug. This suggests it is important to determine which drugs are still working against the farm’s parasites, and fecal egg counts can be used to monitor the effectiveness of the farm’s deworming program. Some farm management practices are also highly recommended by parasitologists as part as the deworming program, such as pasture management techniques and the quarantine of new horses on the farm.

In spite of these new recommendations, many horse owners and farm managers appear to be reluctant to adopt them, at least anecdotally. Another confounding factor is that while relatively firm recommendations exist for treatment of adult horses, less is known about the optimal treatment of foals and young horses. In addition, concerns have been expressed over the possible health risks associated with reducing the treatment intensity. However, there is little to no scientific evidence addressing these issues.

Nielsen, et al. (2013) applied a similar approach in Denmark based on a questionnaire survey performed in 2008 among Danish horse owners. They showed that a majority of respondents were familiar with fecal egg counts and that since the prescription-only restriction of anthelmintic drugs in 1999, most of them declared to seek advice of their veterinarians for parasite control (94%). It also appeared that the strategy in use was almost equally pronounced in foals and older horses. It seemed that the prevention of parasitic disease and drug resistance in parasites were the most important attributes in a deworming program while cost and testing for parasites were less important. Finally, by asking directly to the respondents how much they are willing-to-pay for parasite control and how much they actually pay per horse on a yearly basis, they concluded that more than 40% of respondents declared themselves willing to pay more than what they were spending.

There is need for further research about dewormer performance and efficacy from veterinary science, but it is also important to understand managers' perceptions and expectations (in other words, the consumer side). If a horse owner or a farm manager will not adopt an improved protocol, it is useful to understand why. After investigating horse farm managers' current perceptions and approaches to deworming, the study will then attempt to provide evidence about the most important attributes of deworming strategies as measured by which attributes are most highly valued. These values are estimated by evaluating consumer's preferences and willingness-to-pay.

II.2. Consumer Willingness-To-Pay

Lancaster Demand Theory views a product as a combination of attributes, and supposes that individuals choose from among alternative bundles of products (that differ by those attributes) with the objective of maximizing their overall utility (Lancaster, 1966). One way to determine the preference of horse farm managers over different attributes of deworming strategies is to estimate the price that people are willing to pay for it. Willingness-to-pay (WTP) could be defined as “the maximum price a buyer will pay for a given quantity of goods or services” (Le Gall-Elly, 2010).

II.2.1. Factors affecting consumer WTP

Many studies have demonstrated that internal and external factors may affect WTP. Internal factors are mainly linked to the consumer and his individual characteristics, whereas external factors refer to variables that producers, managers or stores can manipulate like product attributes.

Internal determinants of WTP

Socio-demographic characteristics may affect consumer’s WTP and include age, gender, income, socio-professional category, education, ethnicity, household size, residential area, length of stay in a particular state, etc. Age, gender and income are the most significant individual characteristics that guide WTP in local food product choice. For instance, a study of WTP for blueberry products made in Kentucky reveals that younger and middle-aged consumers with low to moderate income attribute a higher value to Kentucky-grown pure blueberry jam than to the organic designation (Hu, et *al*., 2009). When examining the willingness to purchase local food products in Indiana, consumer with higher income and female consumers are more likely to purchase food produced locally (Jekanowski, et *al*., 2000).

Studies focusing on agricultural issues and targeting farmers as consumers show the importance of age, education, and farm characteristics. For instance, in a paper studying farmer’s preferences for crop insurance attributes, younger farmers with larger farms are willing to pay more for revenue insurance than others (Sherrick, et *al*., 2002).

When studying farmers' preferences for alternative animal health service providers in Kenya, farmers' age and education level as well as gender significantly influenced farmers' decisions. Indeed, older, more educated, and experienced farmers tend to solicit less alternative animal health services (Irungu, et *al*., 2005).

Beliefs, lifestyle, familiarity, perceived risk, involvement, and habits may also influence consumer's WTP for particular products. For instance, in the food industry, consumer perception of the quality of local food, organic food, or certified products are significant drivers of consumers' WTP for that attribute (Angulo and Gill, 2004, Carpio and Isengildina-Massa, 2009, Darby, et *al*., 2006). Perception of food safety and risk are also directly linked to consumers' WTP, particularly with animal diseases or genetically modified products. For example, the European bovine spongiform encephalopathy crisis negatively affected beef consumption due to an increasing concern in food safety (Angulo and Gill, 2004). A consumer's knowledge of the product may also influence his WTP. In a study devoted to farmers' WTP to contribute to tsetse and trypanosomosis control in West Africa, the knowledge of the disease measured by the ability to identify the tsetse fly and information on how the disease can be transmitted, was a significant factor in the decision to contribute labor to tsetse control (Pokou, et *al*., 2010).

In Uganda, factors strongly associated with a higher WTP for antimalarial and/or paracetamol included having a higher socio-economic status, no fever/malaria in the household in the past 2 weeks and if a malaria diagnosis had been obtained from a qualified health worker prior to visiting the drug shop (Hansen, et al., 2013).

External determinants of WTP

The product attributes such as quantity of product served, service packages, and marketing strategies are external determinants that can influence the consumer's WTP (Le Gall-Elly, 2010, Sevdalis and Harvey, 2006).

Means of payment and type of pricing may also influence WTP. In a study determining the WTP for a sporting ticket, Prelec and Simester (2001) showed that consumers paying with credit cards were likely to have a higher WTP than consumers paying with cash regardless of price and whether the amount is known in advance or not (Le Gall-Elly, 2010, Prelec and Simester, 2001). Service pricing plans for internet access, cell phones, car rental, and fitness clubs are strategic ways to influence consumers' WTP. Studies showed that consumers were willing to invest more money for a subscription that disconnects consumption from payment (they pay a fixed amount a month, independently from their internet consumption) and better manage risks against price fluctuations (Lambrecht and Skiera, 2006, Le Gall-Elly, 2010).

In health, the choice of a drug can depend on its efficacy. Indeed, in Baltimore, MR, the value that clients place on drug rehabilitation services at the time of intake has been evaluated and varies with the probability of success and availability of social services (Bishai and Sindelar, 2006).

II.2.2. Methods to WTP estimation

Methods for estimating WTP can be categorized in two main groups: revealed preference and stated preference (see Figure 2.1).

Revealed preference: The notion of revealed preference was introduced by Paul Samuelson in 1938 under the name of "selected over" when he formulated consumer theory as a statement about observable data. His idea was to define the data set of observed consumer choices that should be consistent with some utility function. He developed the Weak Axiom of Revealed Preference (WARP) that indicated that "if an individual selects batch one over batch two, he does not at the same time select two over one" (Samuelson and Puttaswamaiah, 2002). However, this axiom was for two goods only. Houthakker then extended Samuelson's work and found that the data set that is consistent with utility maximization has to satisfy the Strong Axiom of Revealed Preference (SARP), which added transitivity and the idea of indirectly revealing preferences to the first axiom. Thus if an individual selects batch one over batch two and batch two over batch three, SARP and transitivity dictate that batch one is also preferred to batch three, so batch one is indirectly revealed to be preferred to batch three. It was the general proof needed for multiple goods.

The supporters of the revealed preference approach assert that "the Strong Axiom of Revealed Preference was a necessary and sufficient condition for data to be consistent with utility maximization" (Varian, 2006). Analysis could start from market data or experiments such as laboratory experiments, field experiments, or auctions (Breidert, et *al*., 2006). However, one of the most common critiques formulated against revealed preference is that if an individual picks one good among two, one can definitely say that this selected good is revealed preferred to the other one. However, in the real world, when it is observed that a consumer purchased a certain good, it is impossible to say what other good or set of goods were discarded in preference of purchasing this specific item.

It shows that preference is not revealed at all in the sense of ordinal utility (Koszegi and Rabin, 2007).

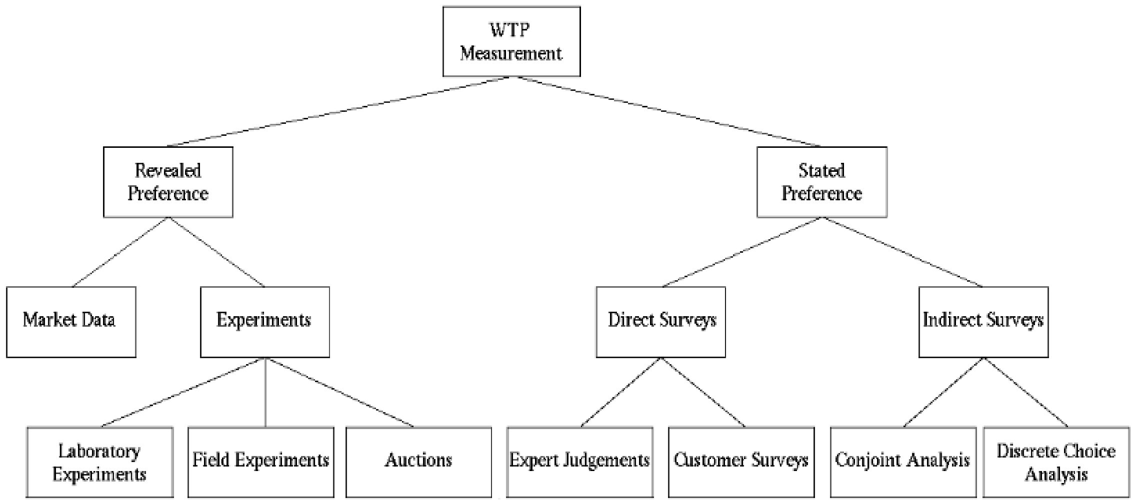
Even with its limitations, the revealed preference approach has been used to measure demand for food (Famulary, 1995, Manser and McDonald, 1988), for broadband (Edell and Varaiya, 1999), and for auction value (Varian, 2012).

Stated preference: While revealed preference analysis uses actual data corresponding to direct observations of consumer's behavior, the stated preference approach uses individual respondents' statements about their preferences in a set of hypothetical options to estimate their utility function. Data are collected through the use of surveys. Different stated preference methods are available through direct and indirect surveys (Breidert, et *al*., 2006, Pearce, et *al*., 2002). Direct surveys, also called contingent valuation (such as expert judgment or customer surveys), directly ask the respondents their WTP; indirect surveys, also known as choice modeling (conjoint analysis or discrete choice analysis), will use a variety of procedures to elicit respondent's WTP from sets of rankings or ratings of alternative options (Pearce, et *al*., 2002) .

The stated preference approach presents some advantages over the revealed preference approach. It is easier to control since the researcher defines the conditions and alternatives, it is more flexible by including a wider variety of variables, and it may be less costly since each respondent is able to provide multiple observations when explanatory variables vary (Kroes and Sheldon, 1988). However, one disadvantage is that there is no way to verify that people necessarily do what they say they will, which may produce results that differ from those in real life (Abley, 2000, 2002).

This study will use indirect method of the stated preference approach and will focus on conjoint analysis. More details concerning this technique will be provided in Chapter 3.

Figure 2.1: Classification Framework for Methods to Measure WTP
(Breidert et al., 2006)



Chapter III: Empirical Model

III.1. Conjoint analysis: General statements

Conjoint analysis is a stated preference technique often applied in marketing, psychology, and environmental economics (Green and Srinivasan, 1978, Green and Srinivasan, 1990, Hensher, et al., 1988). These methods are used to represent individual judgments facing multi-attribute stimuli and to derive the utility from a good or service related to these different attributes (Louviere, 1966, Batsell and Louviere, 1991)

Conjoint analyses are based on the following features:

1) They are built on a set of attributes describing the good, and each of them have different “levels” of those attributes;
2) Hypothetical profiles for the good are built by combining these levels and attributes using experimental design techniques. An example of a hypothetical profile is shown in Figure 3.1.
3) Individuals are asked to express their preferences between two hypothetical alternatives plus the status quo;
4) Responses are analyzed to derive preferences on attributes.

III.2. Choice experiment and derived utility

A choice experiment is one of the conjoint analysis techniques. Individuals are asked to choose their preferred alternative from a choice set made up of two options using differences in attributes and a status quo. In addition, by including price as an attribute, it is possible to derive the economic values of the other attributes. Since individuals derive utility from their choices, the alternative chosen implies a greater utility. This approach is consistent with random utility theory, which assumes that individuals aim at maximizing their utility probabilistically, while recognizing certain randomness due to the inability of the analyst to identify all the aspects affected by choices (McFadden, 1974, Thurstone, 1927). Thus, indirect utility could be decomposed in two parts, one deterministic (or explainable assumed to be determined by individuals and attribute specifics) and one stochastic.

Suppose individual i chooses alternative j in the t-th choice set and characterized by the observable vector of attributes $\mathbf{X}_{ijt}$. His indirect utility (U_{ijt}) is expressed as the following linear function:

$$U_{ijt} = \beta\, \mathbf{X}_{ijt} + e_{ijt} \quad \text{(1a)}$$

β is a vector of unknown parameters to be estimated and e_{ijt} is the stochastic component reflecting the randomness of this utility expression. Then, it is possible to predict which option will be most likely selected by the individual from choice set *t* by determining the probability of choosing option j against any other option. Specific expression for this probability depends on assumptions made about the error term. In general, the error terms are assumed to be independent and identically distributed (*iid*) (Hanley and Mourato, 1999, Hensher and Green, 2002)

The choice probability of individual i selecting option j in the t-th choice set is expressed in term of the logistic distribution (McFadden, 1973), and specified as a conditional logit model:

$$P_{ijt} = \frac{\exp(\beta\, \boldsymbol{X}_{ijt})}{\sum_{k=1}^{J} \exp(\beta\, \boldsymbol{X}_{ikt})} \quad (2a)$$

The main limitation of the conditional logit model is the *iid* condition that has an equivalent behavioral association with the Independence of Irrelevant Alternatives (IIA) property. The IIA assumption states that the probability ratio of individual choosing between any pair of alternatives does not depend on the presence or absence of the other alternatives or attributes in a choice set. Consider the probability that individual *i* chooses option *j* and option *l*:

$$P_{ijt} = \frac{\exp(\beta\, \boldsymbol{X}_{ijt})}{\sum_{k=1}^{J} \exp(\beta\, \boldsymbol{X}_{ikt})} \quad \text{and } P_{ilt} = \frac{\exp(\beta\, \boldsymbol{X}_{ilt})}{\sum_{k=1}^{J} \exp(\beta\, \boldsymbol{X}_{ikt})} \quad (3)$$

The probability ratio of choosing between *j* and *l* is:

$$\frac{P_{ijt}}{P_{ilt}} = \frac{\sum_{k=1}^{J} \exp(\beta\, \boldsymbol{X}_{ikt})}{\sum_{k=1}^{J} \exp(\beta\, \boldsymbol{X}_{ikt})} * \frac{\exp(\beta\, \boldsymbol{X}_{ijt})}{\exp(\beta\, \boldsymbol{X}_{ilt})} = \frac{\exp(\beta\, \boldsymbol{X}_{ijt})}{\exp(\beta\, \boldsymbol{X}_{ilt})} \quad (4)$$

In this case, the probability ratio depends only on the attributes of *j* and *l*, and does not depend on the attributes of other alternatives.

To relax the IIA assumption, different models have been developed such as the nested logit, the mixed logit, the multinomial probit, and the heteroscedastic extreme value models. This study applies the mixed logit model to fully relax the IIA assumption. Unlike the conditional logit model, the mixed logit model allows parameter estimates β to vary across individuals and to be stochastic (Train, 2003). The indirect utility becomes:

$$U_{ijt} = \beta_i\, \boldsymbol{X}_{ijt} + e_{ijt}\ , \quad (1b)$$

where β differs across individuals and is specified as $\beta \sim F$ (θ, ν). F is a probability distribution function with mean θ and variance ν. The probability density function (pdf) will allow the estimation of U_{ij}. Thus, the mixed logit model incorporates taste variations that exist across individuals. The four most common distributions for F are the normal, lognormal, uniform and triangular distributions (Hensher and Greene, 2002). Being unable to obtain a converging model when the price coefficient was estimated as following a lognormal distribution, the normal distribution was chosen for the estimate coefficients of the attributes $\mathbf{X}_{ijt}$.

The choice probability can be estimated by estimating P_{ijt} in equation (2) over all the possible values of β. It becomes:

$$P_{ijt} = \int \frac{\exp(\beta \, \boldsymbol{X}_{ijt})}{\sum_{k=1}^{J} \exp(\beta \, \boldsymbol{X}_{ikt})} h(\beta) d(\beta) \qquad \text{(2-b)}$$

where $h(\beta)$ is the joint density function for the random parameter β. Thus, the mixed logit probability is a weighted average of the formula (2) evaluated at different values of β, with the weights given by the density $h(\beta)$. [1]

III.3. Goodness-of-fit of the model

The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are used to define the goodness of fitness of the model. Briefly, AIC and BIC identify the model that minimizes the negative likelihood while penalizing for the number

[1] The integral must be solved through simulation with 200 Halton draws per iteration in the simulated maximum likelihood estimator (Train, 2003).

of parameters (the penalty is larger in BIC than in AIC). These information criteria are defined as:

$$\text{AIC} = -2 \ln L + 2\,k$$

$$\text{BIC} = -2 \ln L + \ln(n) * k$$

L refers to the likelihood, k is the number of parameters in the model, and n is the sample size. While comparing two models based on the same data, the one that has the smaller value of the information criteria is considered "better" (Acquah and Carlo, 2010).

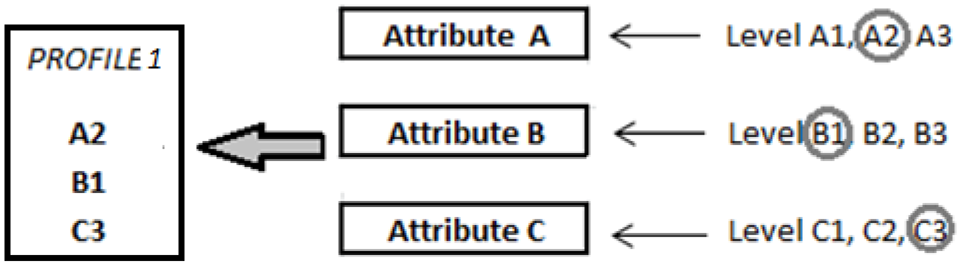
The McFadden R^2 is also an important fitness criterion and is expressed as:

$$\text{McFadden } R^2 = 1 - \frac{\ln L_A}{\ln L_0}$$

L_A is the estimated likelihood of the alternative model with predictors, and L_0 is the estimated likelihood of the model without predictors. Since these likelihood are between 0 and 1, the log of these values will be less than or equal to zero. While the likelihood is decreasing, the log is increasing. The alternative model A is better than the zero model when the likelihood ratio is small; thus, the McFadden R^2 is larger in this case. To reduce the overestimation of the McFadden R^2 due to an increase of the number of regressors k, it is advised to use the adjusted-McFadden R^2, as follows:

$$\text{Adjusted-McFadden } R^2 = 1 - \frac{\ln L_A - k}{\ln L_0}$$

Figure 3.1: Relationship among Profile, Attributes, and Levels



Chapter IV: Survey Design and Data Description

In this chapter, the questionnaire designed to investigate current deworming approaches and attitudes towards alternative parasite control strategies is discussed, as well as the description of the data obtained from the respondents.

IV.1. Survey design

IV.1.1. Demographic information

The questionnaire is composed of two parts. The first collects demographic information concerning the farm and asks a series of questions regarding farm managers' attitude towards deworming strategies and parasite drug resistance. Information requested includes the farm ZIP code, the number and age of horses on the farm as well as current deworming strategies used on those horses. This information allows the researchers to elicit respondents' current approaches to parasite control, knowledge of and concern about drug resistance in parasites.

IV.1.2. Conjoint experiment: Attribute choice

The second component contains three choice experiment questions. Respondents were asked to choose which strategy they preferred most from a series of 3 dichotomous choice questions. These choice questions featured two alternative treatment strategies varying on the attributes of the drug resistance and health consequences of treatment, the effort involved in administering the treatment, and the direct price of the treatment. Respondents may also indicate that neither strategy is preferable (strategy A, strategy B or the status quo), where "A" and "B" varied over the different choice sets.

Questionnaire design and selection of attributes and levels are very important for conjoint analysis. The analyst selects the attributes that he or she considers relevant to describe the most important characteristics of the good. The only information concerning the good that the respondent provides is his choice among the different options, which are then decomposed into the value of each attribute and level. Consequently, attributes selected must be relevant. A relevant attribute is defined such as its exclusion from the description of the good would change the conclusions about the consumer's choice. The attribute is considered as irrelevant if it does not influence positively or negatively consumer's utility and hence choice (Lancaster, 1991).

A number of experts, as well as a focus group, helped refine the attributes and their levels. The attributes ultimately selected are: price, effort and time, decrease in health risks, resistance in parasites. Each will be discussed in turn.

The annualized price levels for each strategy have been estimated based on an analysis of the actual horse anthelmintic market. Three types of deworming strategies are distinguished for the purposes of price level determination: daily deworming, rotational deworming every two months, and deworming depending on fecal egg counts results. Considering the foal and weanling category, and comparing prices from veterinarian clinics and other stores, the average annual prices were $25, $50, and $95 for the rotational deworming strategy, daily deworming strategy, and fecal egg counts deworming strategy, respectively. Consequently, price levels chosen were $25, $50, and $100 per annum.

Consultations with experts and focus groups[2] help to identify relevant non-cost attributes and their levels. While Zoetis and equine researchers were focusing on parasite drug resistance and health consequences such diarrhea, colic, and airway inflammation, veterinarians and their clients developed interests in cost of effort and time of administrating the treatment to the foal.

Time and effort costs are some of the more important factors in farm managers' organization of their daily tasks. According to the focus group, a monthly time cost attribute was more relevant than an annual one. Consequently, three ranges of time have been selected on a per foal basis: Low (1/2 hour or less per month), Medium (1.5 hours per month) or High (5 hours or more per month) which roughly correspond to time for rotational, daily and fecal egg counts strategy.

Due to the suspicion of resistance in several deworming drugs presented in the literature review, three levels of the attribute "Drug resistance" have been chosen: no drug resistance known, suspect drug resistance, and confirmed drug resistance[3].

Health risks such as colic, diarrhea, and airway inflammation could be caused by numerous factors such as stress, respiratory diseases, diet, etc. Infestation by worms could increase these risks, but no research has shown their real implication in these health issues. Three levels of decrease in health risks (0%, 5%, and 10%) have been arbitrarily

[2] The questionnaire has been reviewed by experts and a focus group before being distributed. Experts were utilized from the Gluck Equine Research Center (Dr. Martin Nielsen) and Animal Food sciences (Dr. Bob Coleman, Dr. Mary Rossano) department at the University of Kentucky. The focus group was built with a private veterinarian (Dr. Ruel Cowles) and 15 horse owners who have deliberately answered the questionnaire on Qualtrics.

[3] If after deworming a drop of more than 90% of eggs occurs, the drug is considered effective (no resistance); 80-90% means resistance can be suspecte,; and less than 80% means resistance is present and the drug is not effective (Briggs, 2004).

chosen (while being in a feasible range) to reveal how sensitive farm managers are to the health consequences of a deworming strategy.

Combining all the options, four attributes with three levels each have been established. This represents a maximum possible number of 81 dichotomous choice combinations (called a full-factorial design), which is too many for respondents. Following Kuhfeld (2010), it is possible to identify a minimum efficient set of combinations with a fractional orthogonal factorial experimental design. The design was generated in software JMP10 and yields 18 possible combinations for deworming strategies. As 18 choices sets is still to many, six questionnaires with three distinct choice sets have been developed in order to ensure optimal answers from the respondents. The D-efficiency coefficient and A-efficiency coefficient were respectively 94.66% and 89.34% which show a satisfactory goodness of the design relative to hypothetical orthogonal designs (Kuhfeld, 1997).

IV.2. Data collection and sample description

IV.2.1. Collection of the data

Kentucky is famous for its horses and highly reputed farms. Many are Thoroughbred farms and are managed by well-educated horse man. Both breeding and training farms are present in Kentucky and consist of horses of all age in the state. Thus, Kentucky Thoroughbred farm managers were targeted in this study. 496 eligible participants were obtained from the 2012 Kentucky Thoroughbred Farm Managers' Club[4] directory.

In general, surveys can be administered by mail, in person, or by telephone. Due to the large geographical area covered by the survey, it was too expensive and time consuming to drive directly to each farm. Phone calls are similarly expensive and time consuming. Mail surveys are relatively low cost, easy to administer, and geographically flexible. However, their disadvantages are low response rates, potential misinterpretation of questions, and providing incorrect answers. To limit incorrect interpretation, the survey has been administered to the focus group and discussed in order to make it as clear as possible.

The Dillman method was utilized to maximize the response rate (Dillman, 1978). The first survey was mailed the 6th of May 2013, and a reminder postcard was sent to non-respondents the 20th of May 2013. A second mailing occurred the 3rd of June 2013 to non-respondents, followed by a reminder postcard the 17th of June 2013 to non-respondents. Instructions which accompanied the mail survey also provided a link to an identical online survey (using Qualtrics) for participants wishing to complete the survey electronically. An e-mail was sent after the first mailing to 264 persons having their e-mail addresses in the 2012 Kentucky Thoroughbred Farm Managers' Club directory; it also provided a link to the online survey.

[4] This club gathers numerous of Kentucky thoroughbred farm managers. Its mission is "to foster cooperation and understanding among members; to provide a forum for the discussion of topics critical to [the horse] profession, which will enhance and protect [their] professional interests; to promote fellowship among members."

IV.2.2. Sample description

In total, 57 farms addresses were incorrect or not in business anymore, resulting in a sample size of 439. Of those, 129 farm owners or managers (29.38 %) answered the questionnaire, 21 of which were online. Of the responses received, 17 were not usable due to incomplete responses. After accounting for incorrect addresses and incomplete responses, the response rate was 25.51%. The following discussion is based on data from usable responses.

Horse Farm Location

From the ZIP code, we were able to identify the county where the respondents' farms were located in the state of Kentucky. From this information, we estimate the distance from the farm (center of the ZIP code area) to central Kentucky, since this area is home to the biggest equine hospitals and research laboratory of the region, as well as educational equine opportunities. Lexington was considered as the reference of central Kentucky.

The north and center of Kentucky were home to the majority of respondents' farms (see Figure 4.1); the number of farms in Fayette County, Woodford County, Bourbon County and Scott County are 34, 24, 23, and 11, respectively. Four farms are from Franklin County, three are from Jessamine County, and two farms each are in Oldham, and Boyle Counties. Henry, Shelby, Jefferson, Boone, Taylor, Mercer, Nicholas, and Harrison Counties each have only one responding horse farm. Those information are in accordance with the results presented in the 2012 Kentucky Equine Survey[5].

Horse Farm Composition

In this sample, horse farms have 2 to 525 horses. On average, these Thoroughbred farms are home to about 90 horses, including 39 young horses, 38 mares, one stallion, 5 racehorses and 6 “other” horses (see Table 4.1). Most of the farms (88%) had growing horses, such as foals and yearlings, and broodmares (93%). 54% of the farms have less than 30 young horses, with 30% having fewer than 10 foals and yearlings, but 16% having more than 50 young horses. A similar distribution exists for broodmares. More than 60% of the farms have less than 30 mares, while 20% have more than 50 mares. In addition, 45% of the farms had at least one stallion[6] (26% have only one stallion, 19% have between 2 to 22 stallions). The high concentration of breeding stock and growing horses is not surprising, as Kentucky is known for the highest quality bloodlines in the Thoroughbred industry. Finally, more than half of the respondents had racehorses on their farm (53%), many with fewer than 10 horses (40% of the farms). 80% had also other type of horses such as ponies, idle horses, and senior horses.

Deworming Strategy in Use

Only two farms in the study indicated using daily deworming regimen. 67.9% of the respondents indicated using only rotational deworming on all of their horses, 13.8% used only fecal egg counts on all horses, and 17.4% followed a mixed strategy, switching between rotational and fecal egg counts strategies depending of the age and category of

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[5] http://equine.ca.uky.edu/kyequinesurvey
[6] It is possible that respondents included teasers as stallions.

the horse. It is apparent that rotational deworming is, by far, the main deworming strategy used for all type of horses (see Table 4.2) which supports anecdotal evidence that new recommendations are being infrequently adopted. Fecal egg counts are used in more than 15% of the farms in each category, while less than 2% use daily deworming (see Table 4.2).

If a respondent used rotational deworming, they were asked to indicate how often they rotated dewormers; responses included 1 month, 2 months, 3 months, 4 months, 6 months or 8 months. Respondents were allowed to identify different frequencies according to age and type of the horse. The most common rotation is every two months, (65.8% for young horses, 66.2% for broodmares, 71.9% for stallions, 62.5% for racehorses, and 61.1% for other horses). The second most preferred strategy is a rotation of three months (15% to 28% across categories). Finally, some farm managers and owners like to deworm young horses and race horses every month (15.2% and 10%, respectively) (see Table 4.3).

Turnover of Horses on Farms

Respondents were asked to indicate the number of horses on the farm on May 1st, 2013, as well as the number of horses that will return to another state before December 31, 2013. These two measures provide an idea of the movement of horses going in and out of a farm during the course of a year. This is useful information because infested horses can carry worms from one farm to another when their location changes. On average, about 10% of horses on a Thoroughbred horse farm in Kentucky move out of the state by the end of the year. 46.5% of the farm owners and managers indicate that none of their horses moved out of the state during this time period. It shows that a significant portion of the breeding stock remains in the state of Kentucky (see Table 4.4).

The presentation of young horses at sales is also a good factor to identify the primary function on the farm. Indeed, farm managers and owners raise foals to race or sell. On average, 32.2% of the foals born in a Kentucky farm are intended to be sold at yearling sales. More than 26% of the farms are expecting to sell at least half of their crop and only 34.1% of the farms are breeding foals with the intention to race them (see Table 4.4).

Parasite control program and drug resistance

Recent studies have shown that fecal egg counts approaches have reduced drug resistance in parasites. However, more than 67% of Kentucky farm managers and owners use only rotational deworming for all ages and types of horses (see Table 4.2). A new deworming protocol is scientifically proven to be better, and is recommended by parasitologists, but its adoption by farm managers and owners is limited. Is the information not reaching the farm level, or are the owners and managers reluctant to adopt it? Over 75% of farm managers and owners indicated having their veterinarian help in the formulation of their deworming program, but nearly 70% are still using rotational deworming. Thus, either the information may not be well distributed by the horse health professional themselves to the farm level, or the farm manager is unwilling to follow the veterinarian's recommendation. It is the latter explanation on which this study focuses.

Finally, in general, farm owners and managers are concerned about drug resistance in parasites. In fact, nearly 80% of the respondents consider themselves to be aware of drug resistance, even though few farms deworm their horses using a fecal egg counts strategy.

However, over 80% of the respondents affirm having already performed at least one fecal egg. This suggests that at one time, they had a doubt concerning the efficiency of the current dewormer they were using or were experimenting with a new approach. About 15% of the respondents already had a documented case of drug resistance in parasites on their farm.

Table 4.5 presents the definition and statistics of the demographic variables that result from the below data description.

Table 4.1. Composition of Kentucky Thoroughbred Horse Farms

Average Horse Farms Composition		# Horses	% Farms
YOUNG HORSE(S)	**39 ± 52** (min. 0 - max. 251)	0	12.00%
		1-10	30.00%
		11-30	24.11%
		31-50	17.86%
		51 +	16.07%
BROODMARE(S)	**38 ± 48** (min. 0 - max. 250)	0	7.00%
		1-10	29.00%
		11-30	31.25%
		31-50	13.39%
		51 +	19.64%
STALLION(S)	**1 ± 3** (min. 0 - max. 22)	0	55%
		1	26%
		2 +	19%
RACEHORSE(S)	**5 ± 13** (min. 0 - max. 90)	0	48%
		1-10	39%
		11 +	12%
OTHER HORSE(S)	**6 ± 7** (min. 0 - max. 47)	0	20%
		1-10	68%
		11 +	13%
TOTAL	**90 ± 107** (min.2 – max. 525)	2-50	47.60%
		50 +	52.40%

Table 4.2. Deworming Strategies across Different Horse Categories

	YOUNG HORSE(S)	**BROODMARE(S)**	**STALLION(S)**	**RACEHORSE(S)**	**OTHER HORSE(S)**
Type of Strategy	***% Farms***				
ROTATIONAL	81.44%	70.87%	65.31%	68.97%	80.90%
FECAL EGG COUNT	15.46%	27.18%	32.65%	29.31%	19.10%
DAILY	2.06%	0.97%	2.04%	1.72%	0.00%

Table 4.3. Proportion of Farms Utilizing Rotational Deworming: Frequency of Rotation

	YOUNG HORSE(S)	**BROODMARE(S)**	**STALLION(S)**	**RACEHORSE(S)**	**OTHER HORSE(S)**
Frequency of Rotation	***% of Farms***				
Every month	15.19%	4.05%	3.13%	10.00%	2.78%
2 months	65.82%	66.22%	71.88%	62.50%	61.11%
3 months	15.19%	27.03%	21.88%	27.50%	27.78%
4 months	1.27%	1.35%	0.00%	0.00%	0.00%
6 months	1.27%	1.35%	3.13%	0.00%	8.33%
8 months	1.27%	0.00%	0.00%	0.00%	0.00%

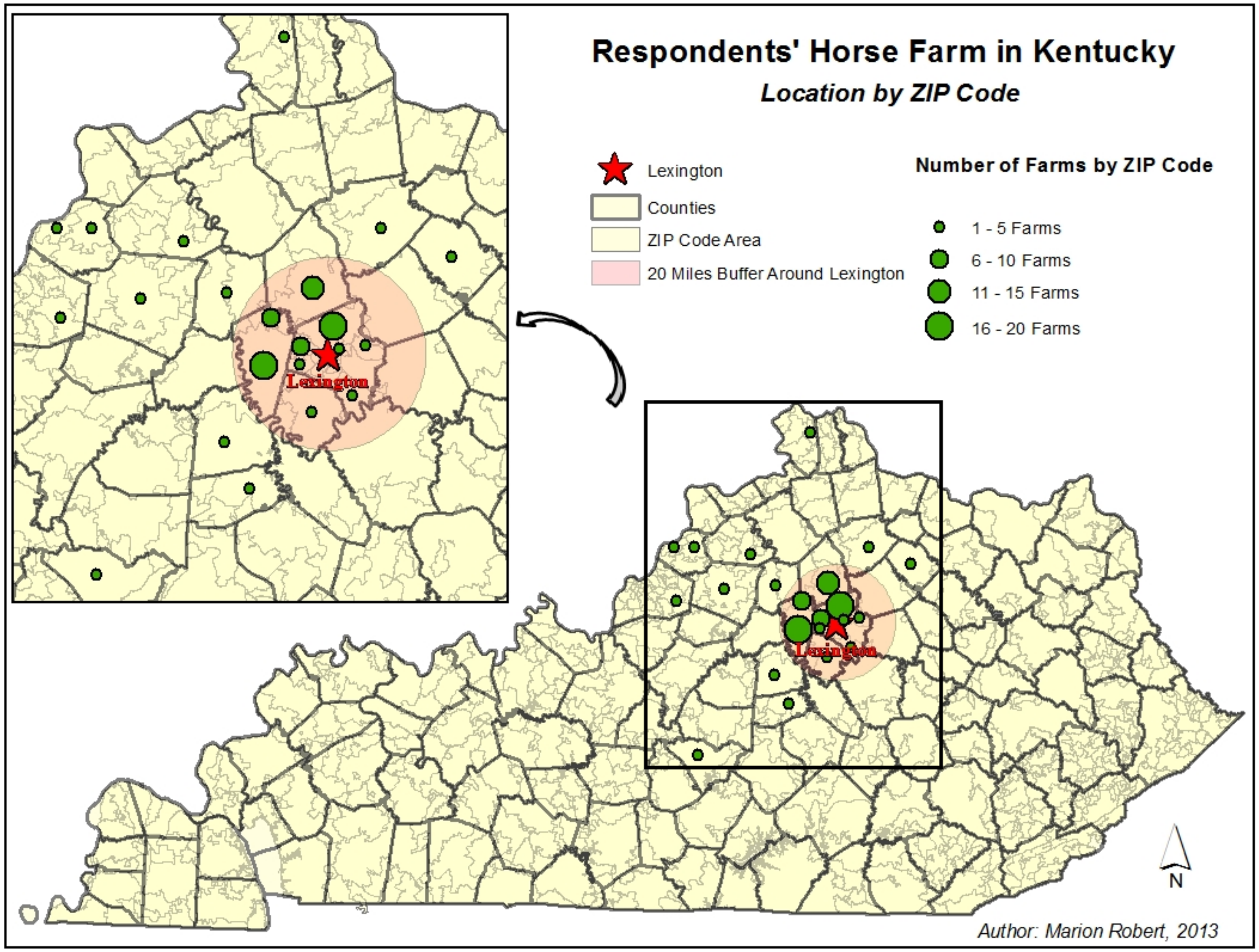
Table 4.4. Horses Leaving the State and Young Horses Being Sold

	Average Percentage	**% Horses**	**% Farms**
Horses leaving the farm between May 1st and December 31th, 2013	9.66% ± 16.56% (Min. 0% - Max. 80%)	0	46.53%
		1%-20%	36.63%
		21%-50%	11.89%
		51% +	4.95%
Foals expected to be sold at yearling sales	32.18% ± 37.12% (Min. 0% - Max. 100%)	0	34.09%
		1%-20%	21.59%
		21%-50%	18.18%
		51% +	26.14%

Table 4.5. Definition and Statistics of the Demographics Variables

Variable	Definition	Mean	St. Dev.	Min.	Max.
TOTAL	Total number of horses on the farm	90.047	107.369	5	525
TOTAL_50	=1 if total # horses > 50 horses	0.524	0.500	0	1
BROODMARE	# of broodmares	37.992	47.717	0	250
%BROODMARE	% broodmares in the farm	0.402	0.165	0	1
YOUNG	# of young horses	38.832	51.999	0	251
%YOUNG	% young horses in the farm	0.362	0.150	0	1
STALLION	# of stallions	1.229	2.776	0	22
%STALLION	% stallion in the farm	0.017	0.0171	0	1
RACEHORSE	# of racehorses	5.464	13.151	0	90
%RACEHORSE	% racehorses in the farm	0.085	0.161	0	1
OTHER	# of other horses	6.382	7.648	0	47
%OTHER	% other horses in the farm	0.127	0.158	0	1
LEAVE	# of horses leaving the state	12.975	27.311	0	150
% LEAVE	% horses leaving the state	0.109	0.138	0	0.5
SOLD	# of young horses expected to be sold	16.644	23.758	0	110
% SOLD	% young horses expected to be sold	0.457	0.340	0	1
DISTANCE	Distance in miles from central Kentucky	17.064	13.505	2.5	66.17
ROTATIONAL	= 1 if only use rotational deworming	0.723	0.448	0	1
VET_ADVICE	=1 if receive veterinarian advice	0.792	0.406	0	1
RESISTANCE_CASE	=1 if already had a drug resistance case	0.167	0.373	0	1
RESISTANCE_CONCERN	=1 if feel concern about drug resistance	0.813	0.390	0	1
FECAL_EGG_COUNT	=1 if performed a fecal egg count on the farm	0.840	0.366	0	1

Figure 4.1. Horses Farms Location



Chapter V: Demographic Data Analysis and Current Deworming Practices

This chapter will investigate relationships between farm demographics, current approaches to parasite control, and knowledge of drug resistance in parasites.

V. 1. Methodology and empirical models

V.1.1. Descriptive analysis

A descriptive analysis is used to compare differences in variable means between groups of Kentucky horse farms. Groups of farms are defined by total number of horses on the farm. In this sample, managers and owners have a minimum of 2 to a maximum of 525 horses on their farm. Three groups of farms are defined: "small" farms with less than 30 horses, "medium" farms with 31 to 99 horses, and "large" farms with more than 100 horses, to determine if the "size' of the farm is correlated with composition of types of horses (proportion of young horses, broodmares, stallions, racehorses, and other horses), deworming strategies used, turnover of horses in a year, selling strategy of young horses, the type of parasite control program utilized, and the knowledge of drug resistance of managers and owners.

The differences in means by farm size are evaluated using a t-test. For variable *i*, let be μ_i the mean of variable *i*. To test whether μ_i is the same between groups *j* and *k*, we suppose for variable *i* that: H_0: $\mu_{i\ group\ j} - \mu_{i\ group\ k} = 0$.

The t-statistic is defined as **t-statistic** = $\frac{\mu_{i\ group\ j} - \mu_{i\ group\ k}}{\sqrt{\frac{\boldsymbol{\sigma_j^2}}{\boldsymbol{N_j}}+\frac{\boldsymbol{\sigma_k^2}}{\boldsymbol{N_k}}}}$, where σ_j^2 and σ_k^2 are the variance of group j and of group k, respectively. N_j and N_k are the sample size of group *j* and group *k*, respectively.

Three groups will be compared: small (less than 30 horses), medium (between 31 to 99 horses), and large (more than 100 horses) sizes, respective degree of freedom, and interval of significance testing are presented in Table 5.1.

For example in comparing means of variables between group 1 and 2, if -1.989 < t-statistic < 1.989 we fail to reject H_0, assuming 95% level of confidence. This means there is no statistical difference between the means of the variable between group 1 and 2.

V.1.2. Multivariate regression analysis

With the exception of two farms in our sample, farm managers and owners are using rotational deworming, fecal egg counts, or a combination of the two. To establish a relationship between the deworming strategy used and farm demographics, knowledge of drug resistance in parasites, and attitudes toward alternative treatment strategies, we will use a logistic model.

Logistic models are used to predict the probabilities of the different values *y* of a categorical dependent variable, given a group of independent variables. In our case, the dependent variable is binary and takes the value *y*=1 for ‘uses rotational deworming strategy” and *y*=0 for “uses fecal egg count strategy for at least one horse category”; the independent variables **z** are all case-specific regressors such as total number of horses on the farm, use of a veterinarian, concern about drug resistance, whether fecal egg counts have ever been performed, and confirmed cases of drug resistance on the farm.

The probability that individual *i* chooses alternative *y* is defined as:

$$p_i = \text{pr}[y = 1 \mid z] = F(\mathbf{z}_i{}', \beta)$$

F is selected so that the probabilities p_i lie between 0 and 1 and is defined as:

$$p_i = \text{pr}[y = 1 \mid z] = \frac{\exp(\mathbf{z}_i{}'\beta)}{1 + \exp(\mathbf{z}_i{}'\beta)}$$

The coefficient estimates β_i can be interpreted as follows: an increase in the independent variable increases/decreases the likelihood that y=1. In other words, an increase in the independent variable makes the outcome of y=1 more likely if $\beta > 0$ and less likely if $\beta < 0$. Only the sign of the coefficient is interpreted because different models have different scales of coefficients. However, marginal effects are reported to reflect the change in the probability of y=1 given a 1 unit change in the independent variable.

Marginal Effects

The marginal effect of an increase of a regressor k on the probability of selecting alternative y is defined as:

$$\frac{\partial p}{\partial z_k} = F'(z'\beta)\beta_k = \frac{\exp(z_i{}'\beta)}{(1+\exp(z_i{}'\beta))^2}\,\beta_k$$

As the marginal effects still depend on z, we need to estimate the marginal effects at a specific value of z, such as the mean. In the case of marginal effects at the mean, it is estimated for the average respondent in the sample $\bar{z}$ such as:

$$\frac{\partial p}{\partial z_k} = F'(\bar{z}_i{}'\beta)\beta_k$$

A limitation of the marginal effect at the mean is that there may not be such a respondent in our sample. A better approach to estimating marginal effects is the average of the individual marginal effects:

$$\frac{\partial p}{\partial z_k} = \frac{\Sigma\left(F'(z_i{}'\beta)\right)}{n}\beta_k$$

The marginal effect interpretation gives the range (in percent) of change in the probability of selecting alternative *y*=1 for each unit increase in the continuous independent variable or in comparison to the base category (*z*=0) for the dummy independent variables.

Predicted Probabilities and Goodness of Fit Measures

Once the model has been estimated, we can predict the probability that *y*=1 for each observation:

$$\hat{p} = \mathrm{pr}[y = 1 \mid z] = F(z'\hat{\beta})$$

If the predicted probability is greater than 0.5, we predict that *y*=1; otherwise, *y*=0. Then, the goodness-of-fit measures the proportion of true predictions to total predictions.

V.2. Results

V.2.1. Descriptive analysis

Table 5.2 presents the results of the descriptive analysis. Note that throughout the results, a 5% level of significance is assumed. The pairwise t-test shows that farm size influences the composition according to age and type of horse; it rejects the hypothesis that the proportion of young horses, broodmares, and other type of horses are the same between the different farm groups. According to this sample, the more horses there are on the farm, the greater percentage of young horses, which increases from 21% to 45% at the mean groups.

For the broodmares, a difference exists only between the small farms (less than 30 horses) and the biggest farms (more than 100 horses). On average, the broodmare proportion increases by 10% between the small farms and big farms. Smaller farms seem to have a bigger proportion of "other" types of horses. However, no significant differences in proportions of stallion or racehorses exist.

Choice in deworming strategy appears to be insensitive to farm size or horse category. Tests show that the proportion of horses shipping from the farm out of state before December 31, 2013, is similar between the three groups (small, medium, large sizes) of farms. In addition, the proportion of young horses expected to be sold at yearling sales is not significantly different between farms.

Finally, neither having a veterinarian involved in the design of the parasite control program nor concern about drug resistance is significantly different by farm size. In the three groups, more than 76% of the respondents indicate having already performed at least one fecal egg count on their farm, and less than 19% have experienced a documented case of drug resistance on their farm.

V.2.2. Multivariate regression analysis

In our sample, 70.3% of the respondents used only rotational deworming for all horses on the farm, while 29.7% incorporated fecal egg counts strategy for at least one group of their herd (see Table 5.3). Statistically, those two types of farm differ by five criteria. Farms that have performed fecal egg counts on at least one horse category have a greater proportion of young horses and are incorporating veterinary advice to establish their parasite control program more often than farms that only use rotational deworming. In addition, a greater percentage is concerned about drug resistance in parasites, and a higher proportion of them had a confirmed drug resistance case in parasites on their farm. Moreover, farms that have performed at least one fecal egg count are more prevalent in the "fecal egg count group" than "rotational group"; this is not surprising because each farm manager that are using fecal egg count strategy answered "yes" to the question "Have you ever had a fecal egg count performed for any of your horses?".

At the 10% level of significance, the total number of horses and the number of young horses are higher in farms that include fecal egg count in their parasite control program.

Several models with different independent variables including farm and farm managers characteristics, have been tested to predict the likelihood of using either of the two alternative strategies. The selected model had the highest pseudo-R^2 and was statistically significant with the lowest model Chi-Square statistic. The probability that individual *i* chooses alternative *y* becomes:

$$p_i = \mathrm{pr}[y = 1 \mid \mathbf{z}] = \frac{\exp(\mathbf{z}_i{}'\beta_i)}{1 + \exp(\mathbf{z}_i{}'\beta_i)}$$

$\mathbf{z}_i$ = [TOTAL_50, %BROODMARE_50, %LEAVE, %SOLD, VET_ADVICE, RESISTANCE_CONCERN, RESISTANCE_CASE, DISTANCE]

Table 5.4 presents the results of the logit model. First, the logit coefficients show that farms with more than 50 horses and farms that experienced a drug resistance case in parasites are less likely to use only rotational deworming, while respondents who have more than 50% of their herd as broodmares are more likely to use rotational deworming for each of their horses. The variable VET_ADVICE shows a trend toward significance ($p<0.20$) and suggests that farm managers incorporating a veterinarian's advice to design their deworming program are more likely to introduce fecal egg counts in their program.

The magnitude of the marginal effects at the mean and the average marginal effects are very similar. While looking at average marginal effects, we can see that farms with more than 50 horses are 20.6% less likely to use only rotational deworming, while farms with more than 50% of broodmares are 22.5% more likely to use only rotational deworming ($p<0.01$ and $p<0.05$, respectively). Farms that had resistance cases in the past are 17.1% less likely to use only rotational deworming in their strategies. Finally, respondents who followed advice from a veterinarian to design their deworming program are 16.7% less likely to use rotational deworming in every case relative to those that do not incorporate a veterinarian's advice.

Based on the data, the average predicted probability for using only rotational deworming is about 70.1%, which is similar to the actual frequency for using only rotational deworming. The percentage of correctly predicted value assumes that if the estimated probability is greater than or equal to 0.5, then the event is expected to occur; it is expected to not occur if $\hat{p}$<0.5. The logit model predicts 74.8% of the values and the rest are misclassified[7].

V.3. Summary

The size of the farms and the experience of drug resistance cases predicted a movement towards the new recommendation of incorporating fecal egg count testing as part of a deworming regimen. Farms that have at least 50% broodmares, however, are more likely to continue using traditional rotational deworming strategy.

In addition, farm managers that incorporate veterinary advice are more likely to introduce fecal egg counts in their parasite control program. Concern about drug resistance, movement of horses out of state, and sale of young horses are insignificant.

In general, the data indicate some movement toward new recommendations on deworming. However, more research is needed to understand the barriers to adoption by farm managers.

[7] This overall predictive accuracy of the logit model is called the hit ratio. By comparing the calculated hit ratio with what you could achieve by chance, most researchers would accept a hit ratio that is 25% larger than that due to chance. In our case, the hit ratio is around 75%, which is acceptable.

Table 5.1. Group Size and Degrees of Freedom

j	***k***	N_j	N_k	**Degree of Freedom**	**Interval of Significance Tested**
1	2	43	42	83	-1.989< t-statistic < 1.989
2	3	42	26	66	-1.997< t-statistic < 1.997
1	3	43	26	67	-1.996< t-statistic < 1.996

Table 5.2. Distribution of Means According to the Farm 'Size'

		Means # of horses by farms			***t-statistic***		
		GROUP 1 (GP 1) ≤ 30 horses n = 43	**GROUP 2 (GP 2) 31-99 horses n = 42**	**GROUP 3 (GP 3) ≥100 horses n = 26**	**GP 1 *vs* GP 2**	**GP 2 *vs* GP 3**	**GP 1 *vs* GP 3**
Farm Composition							
% young horses		0.211	0.379	0.447	**-5.010**	**-2.403**	**-7.649**
% broodmares		0.348	0.402	0.439	-1.233	-1.169	**-2.314**
% stallions		0.026	0.012	0.010	1.125	0.687	1.332
% racehorses		0.108	0.101	0.052	0.165	1.393	1.779
% other horses		0.307	0.096	0.052	**4.318**	**2.517**	**5.300**
Deworming strategies							
YOUNG HORSES	ROTATIONAL	0.884	0.810	0.692	0.942	1.058	1.828
	FECAL EGG COUNT	0.093	0.167	0.231	-1.002	-0.626	-1.443
	DAILY	0.000	0.024	0.038	-1.000	-0.324	-1.000
BROOD-MARES	ROTATIONAL	0.837	0.667	0.615	1.832	0.420	1.967
	FECAL EGG COUNT	0.163	0.286	0.385	-1.356	-0.823	-1.967
	DAILY	0.000	0.024	0.000	-1.000	1.000	NA
STALLIONS	ROTATIONAL	0.465	0.500	0.500	-0.318	0.000	-0.276
	FECAL EGG COUNT	0.140	0.262	0.308	-1.406	-0.398	-1.576
	DAILY	0.023	0.024	0.000	-0.017	1.000	1.000
RACE-HORSES	ROTATIONAL	0.605	0.500	0.615	0.964	-0.925	-0.087
	FECAL EGG COUNT	0.116	0.262	0.269	-1.721	-0.065	-1.506
	DAILY	0.000	0.024	0.000	-1.000	1.000	NA
OTHER HORSES	ROTATIONAL	0.814	0.714	0.769	1.076	-0.500	0.432
	FECAL EGG COUNT	0.116	0.262	0.231	-1.721	0.286	-1.172
	DAILY	0.000	0.000	0.000	NA	NA	NA
Horses leaving the state and young horses being sold							
% horses leaving		0.0753023	0.156	0.084	-1.626	1.429	-0.245
% foals expected to be sold		0.3644292	0.442	0.242	-0.629	1.755	1.264
Parasite control program and drug resistance							
Veterinarian advice		0.744	0.714	0.885	0.307	-1.789	-1.513
Drug resistance concerns		0.744	0.810	0.846	-0.717	-0.387	-1.033
Fecal egg count performed		0.814	0.762	0.923	0.581	-1.891	-1.359
drug resistance case		0.163	0.119	0.192	0.574	-0.782	-0.304

Table 5.3. Actual Frequency and Summary Statistics of Deworming Strategies

	Only ROTATIONAL Deworming (y=1)				**FECAL EGG COUNTS Used on at least One Horse (y=0)**				
Frequency	**75**				**32**				
Percent	**70.09**				**29.91**				
Variable	*Mean*	*Std. Dev.*	*Min*	*Max*	*Mean*	*Std. Dev.*	*Min*	*Max*	***t-statistic***
YOUNG HORSE(S)	29.31	49.57	0.00	154.00	48.22	44.43	0.00	251.00	1.95
% young horses	0.31	0.17	0.00	0.64	0.40	0.15	0.00	0.73	**2.73**
BROODMARE(S)	30.99	44.75	0.00	158.00	43.84	44.10	0.00	250.00	1.37
% broodmares	0.41	0.20	0.00	0.55	0.36	0.13	0.00	1.00	-1.53
STALLION(S)	1.11	2.93	0.00	12.00	1.28	2.36	0.00	22.00	0.32
% stallions	0.02	0.06	0.00	0.05	0.01	0.01	0.00	0.50	-1.40
RACEHORSE(S)	5.76	14.66	0.00	30.00	5.22	8.64	0.00	90.00	-0.24
% racehorses	0.10	0.20	0.00	0.41	0.07	0.11	0.00	0.89	-0.99
OTHER HORSE(S)	5.19	6.74	0.00	25.00	7.59	7.14	0.00	47.00	1.62
% 'other' horses	0.16	0.22	0.00	1.00	0.16	0.21	0.00	1.00	0.00
TOTAL	72.35	102.85	5.00	330.00	106.69	89.75	2.00	525.00	1.73
Horses leaving the farm between May 1st and December 31th, 2013	12.09	26.93	0.00	100.00	9.69	19.14	0.00	150.00	-0.52
% horses leaving	0.11	0.14	0.00	0.43	0.09	0.13	0.00	0.50	-0.80
Foals expected to be sold at yearling sales	13.42	22.53	0.00	110.00	17.69	23.98	0.00	100.00	0.86
% expected to be sold	0.44	0.38	0.00	1.00	0.37	0.31	0.00	1.00	-0.91
Veterinarian's Advice	0.71	0.46	0.00	1.00	0.91	0.30	0.00	1.00	**2.66**
Drug Resistance Concern	0.75	0.44	0.00	1.00	0.91	0.30	0.00	1.00	**2.18**
Fecal Eggs Count Performed	0.75	0.44	1.00	1.00	1.00	0.00	0.00	1.00	**4.92**
Drug Resistance Case	0.09	0.29	0.00	1.00	0.28	0.46	0.00	1.00	**2.16**
Distance	16.94	13.81	6.06	37.86	15.47	7.32	2.50	66.17	-0.72

Table 5.4. Logit Model Coefficients and Marginal Effects Predicting Likelihood of Deworming Strategy Choice

Variables	Logit Coefficient	Marginal Effect at the Mean	Average Marginal Effects
Farm Composition			
TOTAL_50	-1.265 **	-0.232 **	-0.206 ***
	(0.505)	(0.091)	(0.073)
% BROODMARE_50	1.377 *	0.252 **	0.225 **
	(0.709)	(0.124)	(0.109)
Horses leaving the state and young horses being sold			
% LEAVE	1.249	0.229	0.204
	(1.921)	(0.352)	(0.311)
% SOLD	0.050	0.009	0.008
	(0.734)	(0.135)	(0.120)
Parasite Control Program and Drug Resistance			
VET_ADVICE	-1.022	-0.187	-0.167
	(0.713)	(0.128)	(0.112)
RESISTANCE_CONCERN	-0.765	-0.140	-0.125
	(0.720)	(0.131)	(0.115)
RESISTANCE_CASE	-1.047 *	-0.192	-0.171 *
	(0.640)	(0.119)	(0.099)
Distance from Central Kentucky			
DISTANCE	0.012	0.002	0.002
	(0.022)	(0.004)	(0.004)

N=107

Log likelihood = -52.792

Pseudo R2 = 0.1913

Note 1: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1% levels, respectively.
Note 2: Standard error in ().

Chapter VI: Horse Farm Managers' Willingness-to-Pay for Parasite Control

In this chapter, a dichotomous choice experiment is developed to better understand the extent to which farm managers value different attributes of a deworming program. Respondents are faced with two multi-attribute deworming strategies on each card and are asked to choose the option that best represents their individual judgment; they have the option to choose neither. From these decisions, the utility from a good related to these different attributes can be derived.

VI. 1. Choice set description

In our study, respondents were asked three choice experiment questions. Each question proposed two alternative deworming treatment strategies and a status quo option. Treatment strategies vary on the attributes of the expected drug resistance and health consequences of treatment, the effort involved in administering the treatment, and the direct cost of the treatment (see Table 6.1).

VI.2. Model and specification

The models follow the Random Utility Model framework developed by McFadden (1974). The indirect utility (U_{ijt}) of respondent *i* for choosing alternative *j* in the *t*-th choice set is expressed as the following linear function:

$$U_{ijt} = \beta \mathbf{X}_{ijt} + e_{ijt} \quad \text{(1a)}$$

It is assumed that individual *i* makes the choice which provides his highest satisfaction. The choice probability of individual *i* selecting option *j* in the *t*-th choice set in term of the logistic distribution (McFadden, 1973), and is specified as a conditional logit model (CL):

$$\text{CL: } P_{ijt} = \frac{\exp(\beta\, X_{ijt})}{\sum_{k=1}^{J} \exp(\beta\, \boldsymbol{X}_{ikt})} \quad (2a)$$

To relax the IIA assumption, we apply a mixed logit model (ML). It assumes that coefficient estimates β are random and allow variations across individuals. Then, the choice probability of individual *i* selecting option *j* in the *t*-th choice set in terms of the logistic distribution (Train, 2003) specified as a mixed logit model becomes:

$$\text{ML: } P_{ijt} = \int \frac{\exp(\beta\, \boldsymbol{X}_{ijt})}{\sum_{k=1}^{J} \exp(\beta\, \boldsymbol{X}_{ikt})} h(\beta) d(\beta), \quad (2b)$$

where $h(\beta)$ is the joint density function for the random parameter β and is specified as normally distributed in this study.

In both conditional logit and mixed logit models, the utility function (1.a) can be decomposed into an observable component C_{ijt} and an error term e_{ijt} as follows:

$$U_{ijt} = C_{ijt}(P_{ijt}, \boldsymbol{X}_{ijt}) + e_{ijt} \quad (1b)$$

with $C_{ijt} = \alpha_i \ P_{ijt} + \beta\, \boldsymbol{X}_{ijt}$

and X_{ijt}= [NOT_BUY, TIME_L, TIME_H, HR_5, HR_0, R_NO, R_CONF] $_{ijt}$

The observable component is composed of two parts: the price (P_{ijt}) and its fixed coefficient α; the price coefficient is specified as fixed in order to avoid unrealistic positive welfare coefficients associated with price (Meijer and Rouwendal, 2006, Olsen, 2009). Then, $\boldsymbol{X}_{ijt}$ is a 7x1 vector of the dewormer attributes in the choice experiment. These categorical variables are described in Table 6.1. The base case is TIME_M in effort and time spent, HR_2.5 in decrease in health risks, and R_SUS in level of drug resistance in parasites. Consequently, the choice probability becomes:

$$\text{CL: } P_{ijt} = \frac{\exp(\alpha_i \ P_{ijt} + \beta \, \boldsymbol{X}_{ijt})}{\sum_{k=1}^{J} \exp(\alpha_i \ P_{ikt} + \beta \, \boldsymbol{X}_{ikt})}$$

$$\text{ML: } P_{ijt} = \int \frac{\exp(\alpha_i \ P_{ijt} + \beta_i \, \boldsymbol{X}_{ijt})}{\sum_{k=1}^{J} \exp(\alpha_i \ P_{ikt} + \beta_i \, \boldsymbol{X}_{ikt})} h(\beta) d(\beta), \text{ where } \beta \sim N(\mu, \nu)$$

The marginal value[8] for an attribute j is defined as the negative ratio of the attribute coefficient to the price coefficient such:

$$\text{Marginal value} = WTP_j = -\frac{\beta_j}{\alpha}$$

where j= $[\mathrm{NOT\_BUY}, \mathrm{TIME\_L}, \mathrm{TIME\_H}, \mathrm{HR\_5}, \mathrm{HR\_0}, \mathrm{R\_NO}, \mathrm{R\_CONF}]$. The marginal value is the estimated WTP for attribute j.

VI.3. Results

First, the results of the conditional logit will be presented, followed by the results from the mixed logit model.

VI.3.1. Conditional logit model: Coefficient estimates and WTP

The results of the conditional logit model are provided in Table 6.2. The variables BUYNO and PRICE are not significant. A direct interpretation is that respondents are indifferent between deworming and not deworming their horses and are not price sensitive. This seems unlikely, since each of them was using anthelmintics to treat their horses against parasites. One explanation could be that the guidelines used to introduce the choice set experiments were not clear enough to let the respondent understand that the

[8] The standard deviation of the marginal willingness to pay was calculated based on the Delta methods (Hole, 2007).

status quo option referred to “not deworm” instead of implying “not those two strategies but keeping doing the one I am actually using”. That is why, an insignificant BUYNO is interpreted as the two strategies offered do not increase the respondents’ utility compared to what they are already doing.

Concerning the time and effort required by the respondent to administer deworming strategies, only the “high” variable (5 hours or more) is significant and shows that respondents strongly disprefer having higher time and effort compared to the base case – “medium” (1.5 hours). Compared to a decrease in health risks by 2.5%, respondents strongly prefer a decrease by 5%, and do not prefer a strategy that does not decrease health risks. Finally, a deworming strategy that does not develop drug resistance in parasites is preferred to one with suspect resistance, everything else constant.

Concerning price, it is possible that some farm managers are sensitive to price changes while others are not. In order to determine if farms characteristics influence their sensitivity to price variation, we will use interaction terms between the variable PRICE and some farm demographic variables presented in Table 6.3.

In Chapter V, it was shown that the actual deworming strategy depends on the total number of horses, the proportion of broodmares, and on a veterinarian’s advice to design a parasite control program. We will interact these variables with the PRICE. In addition, we test interaction terms with the current strategy in use, the distance of the farm from central Kentucky, the proportion of horses leaving the state or being sold, and managers’ concern about drug resistance in parasites.

In this case, the utility function (1b) is separated into an observable component C_{ijt} and an error term e_{ijt}:

$$U_{ijt} = C_{ijt}(P_{ijt}, X_{ijt}, D) + e_{ijt}$$

with $C_{ijt} = \alpha'_i \; P_{ijt} + \beta'_i \, X_{ijt} + \gamma'_i \, (D_i * P_{ijt})$,

and X_{ijt}= [NOT_BUY, TIME_L, TIME_H, HR_5, HR_0, R_NO, R_CONF] $_{jt}$, and

D_i = [TOTAL_50, %BROODMARE, % LEAVE, % SOLD, DISTANCE, ROTATIONAL, VET_ADVICE, RESISTANCE_CASE, RESISTANCE_CONCERN].

Interactions with continuous demographic variables were conducted at the mean. Since the variable DISTANCE ranged from 2.5 to 66.17 miles, the value was divided by 10 in order to avoid small coefficients, which assists in convergence of the model.

Table 6.4 presents the results. The log-likelihood is greater when interaction terms are included than without (Table 6.2). Moreover, the pseudo-adjusted McFadden R^2 is higher and the Akaike Information Criterion (AIC) is smaller, indicating a better fit to the data.

Once again, higher effort and time and no decrease in health risks are less preferred than the base case (TIME_M, HR_2.5, R_SUS), while a decrease by 5% in health risks is more preferred. Respondents also prefer a strategy with no drug resistance compared to a strategy with suspect resistance.

Concerning price, the estimated coefficient of price itself[11] and three interaction terms (PRICE*TOT_50; PRICE*DISTANCE, PRICE*ROTATIONAL) are significant at the 5% level, and PRICE*%BROODMARE is significant at 20%. Interactions with veterinarian advice, drug resistance concern, and past cases of drug resistance in parasites were not significant. The size of the farm seems to be the most important determinant in respondents' sensitivity to price fluctuation. When the farm has more than 50 horses, farm managers are negatively influenced by a price increase. In addition, the further the farm is from central Kentucky, the less likely managers and owners are to accept more expensive deworming strategies. Finally, farm owners or managers that are using only rotational deworming might be less likely to accept more expensive deworming strategies than respondents that have already introduced a fecal egg counts practice in their parasite control program.

The WTP is calculated as a negative ratio, where the numerator is the coefficient estimate of attribute j (β_j) and the denominator is the combination of the estimated mean values of the coefficients associated with price (α_{price}) and its interaction effects ($\gamma'_{price} * d$).

$$WTP_j = -\frac{\beta_j}{\alpha_{price} + \gamma'_{price} * d} \quad ,$$

where d = [TOTAL_50=1, % BROODMARE, % LEAVE, % SOLD, DISTANCE, ROTATIONAL=1, VET_ADVICE=1, RESISTANCE_CASE=0, RESISTANCE_CONCERN=1].

[11] Interpretation of the price coefficient estimate by itself is not feasible since interaction effects have to be considered simultaneously.

The relative WTP follows the interpretation of dummy variables, where the base case is TIME_M in effort and time spent, HR_2.5 in decrease in health risks, and R_SUS in level of drug resistance in parasites. The standard errors of the WTP estimates were produced using Delta methods with 2,000 iterations. Table 6 presents the results calculated for a hypothetical farm that:

- Has more than 50 horses
- Has the average proportion of broodmares (40.2%)
- Has the average proportion of horses going out of state (10.9%)
- Sells the average number of young horses (45.7%)
- Is located at the average distance from central Kentucky (17.06 miles)
- Only uses rotational deworming
- Had veterinary advice
- Never had a case of drug resistance in parasites
- Has concerns about drug resistance

Four parasite control programs' attributes have significant marginal WTP estimates. Farm managers are willing to pay $92.48 to go from a suspect resistance in parasite to a strategy with no resistance. They are also willing to invest $41.67 more in a strategy that decreases health risks by 5% relative to a strategy that only decreases health risks by 2.5%. Time spent in implementing the deworming regimen the horses is also a factor of consideration for managers. Respondents expect to pay $87.57 less for a strategy that requires more than 5 hours a month compared to one that needs around 1.5 hours a month. Marginal WTP estimates of HR_0 trends toward significance ($p<0.20$)

and suggests that managers expect to pay $38.33 less for a strategy that does not reduce health risks compared to a strategy that reduces health risks by 2.5%. Marginal WTP estimates of TIME_L and R_CONF were not significant. It seems that respondents are not making any distinction between those levels and the base case. It is possible that managers do not see enough difference between ½ hour and 1.5 hours in a month to be able to decide if they should pay a premium for 1 hour of work less in a month.

The price interaction terms show that respondents' WTP depends on the farm location (see Figure 6.1). While keeping the other demographics variables at the mean, when the distance to Lexington increases, managers are willing to pay less for a strategy with no resistance in parasites and which decreases health risks by 5% compared to strategy with suspect resistance and which reduces health risks by 2.5%. However, they are also less sensitive to the time spent delivering the product. A farm manager located 20 miles from Lexington expects to pay $79 less for a strategy that requires more than 5 hours per month compared to a strategy that only needs 1.5 hours in the month whereas a farm manager at 60 miles from Lexington will estimate the dollar value of this difference in time and effort at $37. When the farm is located inside a 20 mile buffer from Lexington, WTP is not significant at 5% level for any of the product's attributes.

Figure 6.2 presents the effects of change in proportion of broodmares on farm managers and owners' WTP, holding everything else constant and at the mean. Notice that marginal WTP estimates are not significant for farms with more than 35% broodmares. Managers' WTP to use a parasite control program that reduces health risks by 5% or is identified as having no resistance in parasites is slightly increasing as the proportion of broodmares increases. Indeed, a farm with 35% of the herd composed in broodmares is ready to invest $12 more to reduce health risks by 5% and $28 more to have no resistance in parasites compared to a farm without broodmares. However, as the proportion of broodmare increases, farm managers would be willing to pay less for a strategy that requires more than 5 hours per month compared to 1.5 hours per month.

VI.3.2. Mixed logit model: Coefficient estimates and WTP

As the interaction terms used in the conditional logit indicate, it seems that heterogeneity in preferences for attributes exist. In this case the mixed logit model is appropriate in order to provide a distribution of preferences. Then the utility function from becomes:

$$U_{ijt} = C_{ijt}(P_{ijt}, X_{ijt}) + e_{ijt} \quad (1b)$$

with $C_{ijt} = \alpha_i \ P_{ijt} + \beta_i \ X_{ijt} + \gamma_i (D_i * P_{ijt})$,

X_{ijt}= [NOT_BUY, TIME_L, TIME_H, HR_5, HR_0, R_NO, R_CONF] $_{ijt}$, and

D_i = [TOTAL_50, %BROODMARE, DISTANCE, ROTATIONAL,

VET_ADVICE, RESISTANCE_CASE, RESISTANCE_CONCERN][12].

The price (P_{ijt}) has a fixed coefficient α; the price coefficient is again specified as fixed in order to avoid unrealistic positive welfare coefficients associated with price (Meijer and Rouwendal, 2006, Olsen, 2009). Then, X_{ijt} is a 7x1 vector of the dewormer attributes in the choice experiment. These variables are dummies and are described in Table 6.1. The base case is TIME_M in effort and time spent, HR_2.5 in decrease in health risks, and R_SUS in level of drug resistance in parasites. The random parameters β_i are specified to have a normal distribution, thus, the mixed logit model will provide mean and standard deviation estimates. The last component captures the effect of the

[12] %LEAVE and %SOLD were omitted in the mixed logit because the model did not converge when either were included.

demographic interactions with price conducted at the means with the coefficient γ_i fixed. Table 6.6 presents the results. The fit of the mixed logit model is better than the conditional logit model according to a number of criteria. The log-likelihood is greater than before. Moreover, the adjusted McFadden R^2 is higher and both the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are smaller than before, all indicating better fit to the data.

In the mixed logit model, the variable HR_5 is no longer significant. HR_0, R_NO and TIME_H are still significant at the 5% level. The sign of the significant attributes remain the same as in the conditional logit model. Once again, PRICE and three of its interaction terms are significant at least at the 10% level.

Two standard deviation estimates are significant at the 10% level. This suggests some heterogeneity in preferences for attributes HR_0 and HR_5 among farm managers and emphasizes the flexibility of the mixed logit model compared to the conditional logit model.

For those two variables, we can estimate the share of farm managers that hold a positive or a negative view on the attributes given that $\beta_{HR\_0} \sim N\ (\mu_{HR\_0}, {\sigma_{HR\_0}}^2)$ and $\beta_{HR\_5} \sim N\ (\mu_{HR\_5}, {\sigma_{HR\_5}}^2)$, which is equivalent to defining $z_{HR\_0} = \frac{\beta_{HR\_0} - \mu_{HR\_0}}{\sigma_{HR\_0}} \sim Z(0, 1)$ and $z_{HR\_5} = \frac{\beta_{HR\_5} - \mu_{HR\_5}}{\sigma_{HR\_5}} \sim Z\ (0, 1)$ (see Figure 6.1) About 73% of the respondents do not prefer a deworming strategy that does not decrease health risks compared to one that will decrease health risks by 2.5%, while 27% of managers seem to experience no decrease in utility from a strategy that decreases health risks by 2.5% or a strategy that does not prevent health risks at all, *ceteris paribus*. Concerning HR_5, it appears that 51% of the managers do not receive more utility by using a strategy that reduces health risks by 5% compared to 2.5%, while 49% do improve their utility by using the strategy with the highest percentage decrease in health risks.

No significant heterogeneity between farm managers' preferences exists for the other attributes. Interpretation of those coefficients is identical to that in the conditional logit model. For all managers, higher effort and time is less preferred than the base case (TIME_M), while a strategy that is certify with no resistance in parasites is much significantly more preferred to suspect resistance.

Again, WTP is calculated as a negative ratio, where the numerator is the coefficient estimate of attribute j (β_j) and the denominator is the combination of the estimated mean values of the coefficients associated with price (α_{price}) and its interaction effects ($\gamma'_{price} * d$).

$$WTP_j = -\frac{\beta_j}{\alpha_{price} + \gamma'_{price} * d} \quad ,$$

where d = [TOTAL_50=1, % BROODMARE, DISTANCE, ROTATIONAL=1, VET_ADVICE=1, RESISTANCE_CASE=0, RESISTANCE_CONCERN=1].

Table 6.7.a presents the results for a hypothetical farm that:

- Has more than 50 horses
- Has the average proportion of broodmares (40.2%)
- Is located at the average distance from central Kentucky (17.06 miles)
- Only uses rotational deworming
- Had veterinary advice

- Never had a case of drug resistance in parasites
- Is concerned about drug resistance

In this case, only the estimate WTP coefficient of TIME_H, HR_0, and both of the resistance variables (R_NO, R_CONF) are significant. That means on average, this farm manager is willing to invest $85 more to get a strategy with no resistance, while expecting to pay $81 less when time and effort increases, $117 less when the health risks do not decrease, and $359 less for a product with confirmed resistance, compared to the base case strategy and *ceteris paribus*.

In the mixed logit model, some coefficient estimates were random and had a normal distribution (Figure 6.3). Consequently, the resulting WTP estimates also follow a normal distribution. Table 6.7.b gives the standard deviation estimates that go along with the statistically significant WTP estimates presented before. For the average farms, respondents' WTP for HR_5 is not significantly different from zero at the mean, but the distribution is heterogeneous so that half of the group will attribute a premium and half of the group a discount. Concerning the increase in time and effort (TIME_H), farm managers are homogeneous in their answer; the standard deviations are not significant. For HR_0 and R_CONF, it appears that the willingness-to-pay estimate and the standard deviation are significant, revealing heterogeneity between respondents inside respondent profiles. Finally, the premium that people are ready to pay to be assured of no resistance in parasites (R_NO) follows a normal distribution.

For those variables with significant standard deviation, we can estimate the share of farm managers that pay a premium or require a discount on the attributes (see Table

6.8.). Concerning health risks, 73% will expect a discount when the strategy does not decrease health risks, while only 49% would pay a premium to go from a 2.5% decrease to a 5% decrease in health risks. 85% of the people will pay a premium to be sure that the strategy does not lead to resistance in parasites. It is for the strategy with confirmed resistance in parasites that farms managers seems to be the most heterogeneous. Indeed, the standard deviation of the normal distribution of the WTP in this case is more than $2,000, and it appears that 57% would pay less money for a strategy that has confirmed resistance in parasites compared to a strategy with suspect resistance. One explanation could be that farms managers treat a strategy that has suspect and confirmed resistance similarly.

Holding everything else constant and at the mean, Figure 6.4 shows that respondents' WTP depends on the farm location. As in the conditional logit model (Figure 6.1.), when the distance to central Kentucky increases, managers are willing to pay less for a strategy with no resistance in parasites However, they are also less sensitive to the time spent delivering the strategy. A farm manager located 20 miles from Lexington expects to pay $69 (compared to $79 in the conditional logit model) less for a strategy that requires more than 5 hours per month compared to a strategy that only needs 1.5 hours per month, whereas a farm manager 60 miles from Lexington will estimate the dollar value of this difference in time and effort at $24 (compared to $37 in the conditional logit model). While HR_5 was significant in the conditional logit model, it is HR_0 that becomes significant in the mixed logit model. Indeed, at a 10% level of significance and ceteris paribus, an increase in distance of the farm from central Kentucky reduces the discount that farm managers would expect for a strategy that does not decrease health risks, going from $100 less to $34 less compared to a strategy that decrease health risks by 2.5%. When the farm is located inside a 20 miles buffer from Lexington, WTP is no longer significant at 10% level or better for any of the strategy's attributes.

Figure 6.5 presents the effects of a change in proportion of broodmares on farm managers and owners' WTP, holding everything else constant and at the mean for the mixed logit model. Notice that marginal WTP estimates were not significant for more than 35% broodmares at 10% level of significance. Managers' WTP to use a parasite control program that is identified as having no resistance in parasites is slightly increasing as the proportion of broodmares increase. More specifically, a farm with 35% of the herd composed of broodmares is willing to pay $27 more to have no resistance in parasites compared to a farm without broodmares. However, as the proportion of broodmares increases, farm managers are willing to pay less for a strategy that requires more than 5 hours per month compared to 1.5 hours per month, as well as for a strategy that does not decrease health risks compared to a decrease by 2.5%. The discount for a strategy that does not improve health is $20 to $30 more than for the attribute "high effort and time".

Several respondent profiles based on the total number of horses, the proportion of broodmares, and the distance of the farm from Lexington[13] have been considered to see if certain groups of farm managers were willing to pay more or less for specific attributes, but no significant difference was found at 5% level.

[13] Only TOTAL_50, %BROODMARE, and DISTANCE have been considered to make the respondents' profiles because for the other dummies variables, more than 72% of the sample are taking the same value (see Table 6.3), thus we consider ROTATIONAL = 1, VET_ADVICE = 1, RESISTANCE_CASE = 0, RESISTANCE_CONCERN = 1.

In general, farm managers would expect a discount when choosing a strategy with suspect resistance (R_SUS) as compared to a product with confirmed resistance (R_CONF) that is four times bigger than the premium they would invest in to get rid of the resistance (R_NO). This suggests some behavioral implication of loss aversion, which is a tendency of strongly prefer avoiding losses to acquiring gains. There appears to be little difference between a health risks decrease by 2.5% (HR_2.5) and 5% (HR_5), but a strategy that does not reduce health risks (HR_0) is penalized. Finally, managers are reluctant to adopt a strategy that requires significant time and effort (TIME_H), but they do not appear to be sensitive to an additional hour of work in a month per horse (TIME_L compared to TIME_M).

VI.4. Summary

We investigated the preference of attributes of parasite control programs and the WTP of horse farm managers and owners for those attributes. First, comparing a strategy with medium time and effort to treat the horses, a decrease in health risks by 2.5%, and with suspect resistance in parasites, it appears that managers most preferred deworming strategies which decrease health risks by 5% and have no drug resistance in parasites, but were averse to strategies which demand more than 5 hours per month.

However, on average, the price of the strategy does not affect respondents' behavior. To detect any difference in choice determination between farm managers, demographic variables are interacted with the price. It appears that price sensitivity was present for farms that have less than 35% broodmares or are located further than 20 miles from Lexington, holding all other demographic variables constant at the mean. Then, WTP estimates were calculated at the mean for significant coefficient estimates.

Respondents were willing to pay $41.67 more for a strategy that decreases health risks by 5% compared to 2.5%, and $92.48 to use a resistance-free product, while they will expect to pay $87.57 less for a strategy that requires more than 5 hours of time per month.

The dependence on the results to demographic characteristics suggests heterogeneity in farm managers' behavior when choosing between strategies with different attributes. To avoid the need to assume IIA, we introduced a mixed logit model that allowed coefficients of the attributes to vary among respondents. It appeared that the premium or discount related to the attribute "decrease in health risks" follows a normal distribution. Investigation about WTP also revealed heterogeneous behavior among specific farm groups and suggests a smaller range of discounts or premia than in the conditional logit model while distance from central Kentucky or proportion of broodmares were changing.

Table 6.1. Attributes Level and Descriptions

Attributes	Levels	Abbr.	Descriptions
Price			Annual cost of implementing the strategy per foal.
	$25/year		
	$50/year		
	$100/year		
Effort and Time			Effort and time spent on administering strategy per foal per month.
	Low (1/2 hour or less)	TIME_L	
	Medium (1.5 hours)	TIME_M	
	High (5 hours or more)	TIME_H	
Health Risks			Decrease in risk of health problems, such as colic, airways inflammation and diarrhea.
	Decrease risk by 5%	HR_5	
	Decrease risk by 2.5%	HR_2.5	
	Decrease risk by 0%	HR_0	
Drug Resistance			Level of drug resistance in parasites.
	No Resistance	R_NO	
	Suspect Resistance	R_SUS	
	Confirmed Resistance	R_CONF	
Would-Not-Buy	YES NO	BUYNO	Alternative option

Table 6.2. Strategies' Characteristics and Utility - Conditional Logit Model Result.

Variables	Coefficient		Std. Err.	P-value	[95% Confidence Interval]	
BUYNO	0.419		0.408	0.305	-0.381	1.218
PRICE	-0.002		0.004	0.590	-0.011	0.006
TIME_L	-0.068		0.213	0.750	-0.486	0.350
TIME_H	-1.030	***	0.265	0.000	-1.549	-0.510
HR_5	0.563	***	0.219	0.010	0.134	0.992
HR_0	-0.484	**	0.250	0.052	-0.974	0.005
R_NO	1.162	***	0.201	0.000	0.768	1.558
R_CONF	0.139		0.299	0.642	-0.446	0.724
N = 909			AIC = 631.444			
Log Likelihood = -307.722			BIC = 670.177			
Adjusted McFadden R2 = 0.052						

Note: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1% levels, respectively.

Table 6.3. Demographic Variables: Definition and Statistics

Variable	Definition	Mean	St. Dev.	Min.	Max.
TOTAL	Total number of horses on the farm	90.047	107.369	5	525
TOTAL_50	=1 if total # horses > 50 horses	0.524	0.500	0	1
BROODMARE	# of broodmares	37.992	47.717	0	250
%BROODMARE	% broodmares in the farm	0.402	0.165	0	1
% LEAVE	% horses leaving the state	0.109	0.138	0	0.5
% SOLD	% young horses expected to be sold	0.457	0.340	0	1
DISTANCE	Distance in miles from central Kentucky	17.064	13.505	2.5	66.17
ROTATIONAL	= 1 if only use rotational deworming	0.723	0.448	0	1
VET_ADVICE	=1 if receive veterinarian advice	0.792	0.406	0	1
RESISTANCE_CASE	=1 if already had a drug resistance case	0.167	0.373	0	1
RESISTANCE_CONCERN	=1 if feel concern about drug resistance	0.813	0.390	0	1

Table 6.4. Strategies and Farm Characteristics - Conditional Logit Model Result.

Variables	Coefficient	Std. Err.	P-value	[95% Confidence Interval]	
BUYNO	0.333	0.420	0.427	-0.489	1.156
PRICE	0.018 **	0.009	0.035	0.001	0.035
TIME_L	-0.097	0.218	0.655	-0.524	0.329
TIME_H	-1.128 ***	0.278	0.000	-1.673	-0.582
HR_5	0.537 **	0.226	0.018	0.094	0.979
HR_0	-0.494 *	0.256	0.054	-0.996	0.009
R_NO	1.191 ***	0.208	0.000	0.782	1.599
R_CONF	0.131	0.309	0.671	-0.474	0.737
PRICE*TOT_50	-0.008 **	0.004	0.034	-0.015	-0.001
PRICE*% BROODMARE	0.020	0.013	0.112	-0.005	0.045
PRICE*% LEAVE	-0.006	0.013	0.631	-0.032	0.019
PRICE*% SOLD	-0.006	0.006	0.306	-0.017	0.005
PRICE*DISTANCE	-0.004 **	0.002	0.011	-0.008	-0.001
PRICE*ROTATIONAL	-0.011 **	0.004	0.011	-0.019	-0.003
PRICE*VET._ADVICE	-0.004	0.005	0.426	-0.013	0.005
PRICE*RES._CASE	-0.002	0.005	0.670	-0.012	0.008
PRICE*RES._CONCERN	-0.004	0.005	0.421	-0.014	0.006
N = 909		AIC = 613.122			
Log Likelihood = -289.561		BIC = 694.932			
Adjusted McFadden R2 = 0.079					

Note: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1% levels, respectively.

Table 6.5. Marginal Willingness-To-Pay Estimates - Conditional Logit Model

Variables	Marginal WTP Estimates	Std. Err.	P-value	[95% Confidence Interval]	
BUYNO	25.898	41.707	0.535	-55.845	107.642
TIME_L	-7.566	16.332	0.643	-39.577	24.445
TIME_H	-87.571 *	47.010	0.062	-179.710	4.567
HR_5	41.672 *	24.670	0.091	-6.680	90.023
HR_0	-38.332	26.387	0.146	-90.049	13.385
R_NO	92.481 *	49.339	0.061	-4.220	189.183
R_CONF	10.209	26.387	0.699	-41.508	61.926

Note: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1% levels, respectively.

Table 6.6. Strategies and Farm Characteristics - Mixed Logit Model Result.

Variables	Coefficient	Std. Err.	P-value	[95% Confidence Interval]	
PRICE	0.082 **	0.041	0.046	0.001	0.162
BUYNO	1.063	0.929	0.252	-0.757	2.883
BUYNO-S.D.	-0.479	1.456	0.742	-3.332	2.374
TIME_L	-0.104	1.111	0.925	-2.282	2.074
TIME_L-S.D.	-3.611	2.361	0.126	-8.234	1.017
TIME_H	-3.028 **	1.213	0.013	-5.406	-0.650
TIME_H-S.D.	0.368	2.365	0.876	-4.267	5.003
HR_5	-0.138	1.092	0.899	-2.279	2.002
HR_5-S.D.	-6.731 *	3.824	0.078	-14.230	0.764
HR_0	-4.407 *	2.54	0.083	-9.385	0.571
HR_0-S.D.	-7.165 *	3.78	0.058	-14.570	0.244
R_NO	3.220 **	1.208	0.008	0.852	5.588
R_NO-S.D.	3.141	2.244	0.162	-1.256	7.538
R_CONF	-13.544	9.429	0.151	-32.030	4.937
R_CONF-S.D.	81.193	55.598	0.144	-27.780	190.160
PRICE*TOT_50	-0.032 *	0.019	0.085	-0.069	0.005
PRICE*% BROODMARE	0.065	0.047	0.168	-0.028	0.158
PRICE*DISTANCE	-0.021 **	0.02	0.038	-0.041	-0.001
PRICE*ROTATIONAL	-0.047 **	0.021	0.024	-0.088	-0.006
PRICE*VET._ADVICE	-0.014	0.015	0.33	-0.043	0.014
PRICE*RES._CASE	0.018	0.016	0.265	-0.013	0.049
PRICE*RES._CONCERN	-0.016	0.017	0.324	-0.049	0.016
N = 909		AIC =591.764			
Log Likelihood = -280.882		BIC = 663.949			
Adjusted McFadden R2 = 0.111					

Note: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1% levels, respectively.

Table 6.7.a. Marginal Willingness-To-Pay Estimates - Mixed Logit Model

Variables	Marginal WTP Estimates	Std. Err.	P-value	[95% Confidence Interval]	
BUYNO	28.126	31.786	0.376	-34.174	90.427
TIME_L	-19.327	202.833	0.924	-416.873	378.219
TIME_H	-80.093 **	40.707	0.049	-159.877	-0.309
HR_5	-3.661	28.771	0.899	-60.050	52.728
HR_0	-116.570 *	61.633	0.059	-237.368	4.229
R_NO	85.188 **	39.686	0.032	7.404	162.972
R_CONF	-358.271 *	210.870	0.089	-771.568	55.027

Note: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1% levels, respectively.

Table 6.7.b. SD Willingness-To-Pay Estimates - Mixed Logit Model

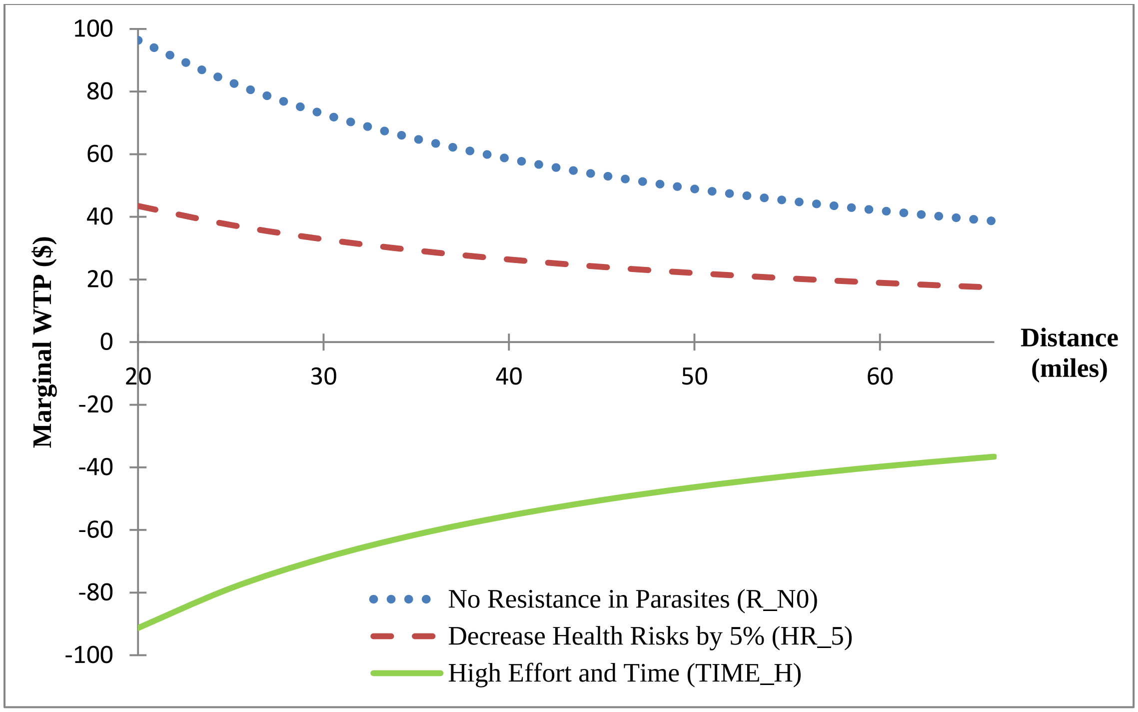
Variables	SD Estimates	Std. Err.	P-value	[95% Confidence Interval]	
BUYNO	12.670	38.005	0.739	-61.818	87.157
TIME_L	669.563	1548.773	0.666	-2365.970	3705.102
TIME_H	9.737	61.135	0.873	-110.086	129.558
HR_5	178.037 **	81.668	0.029	17.9713	338.104
HR_0	189.512 **	91.280	0.038	10.606	368.419
R_NO	83.073 *	46.596	0.075	-8.253	174.399
R_CONF	2147.555 *	1285.357	0.095	-371.698	4666.800

Note: Single, double, and triple asterisks (*, **, ***) denote statistical significance at 10%, 5%, and 1% levels, respectively.

Table 6.8. Repartition of Respondents' WTP for Attributes with Random Coefficient - Mixed Logit Model

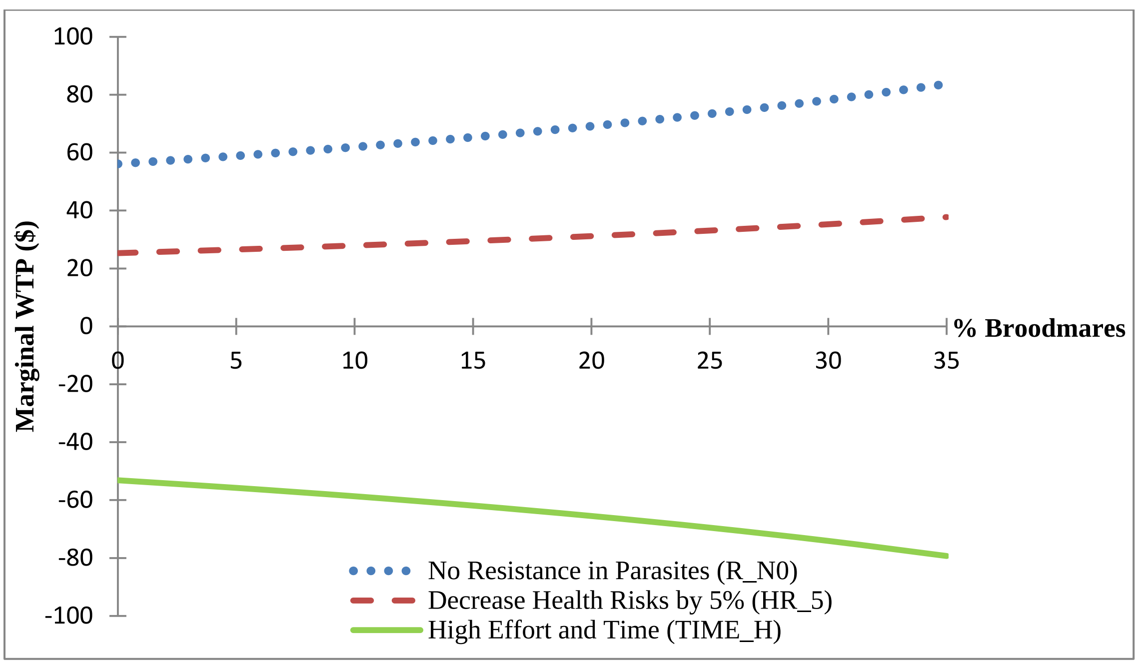
Variables	Positive WTP	Negative WTP
TIME_L	N.A	N.A
TIME_H	N.A	N.A
HR_5	49.18%	50.82%
HR_0	26.93%	73.07%
R_NO	84.74%	15.26%
R_CONF	43.38%	56.62%

Figure 6.1. Farm Managers' Willingness-To-Pay Estimates: Influence of Farm Location - Conditional Logit Model



Note: Only WTP estimates significant at 5% level are shown.

Figure 6.2. Farm Managers' Willingness-To-Pay Estimates: Influence of Broodmares Proportion - Conditional Logit Model



Note: Only WTP estimates significant at 5% level are shown.

Figure 6.3. Normal Distribution of Coefficient HR_0 (left) and HR_5 (right)

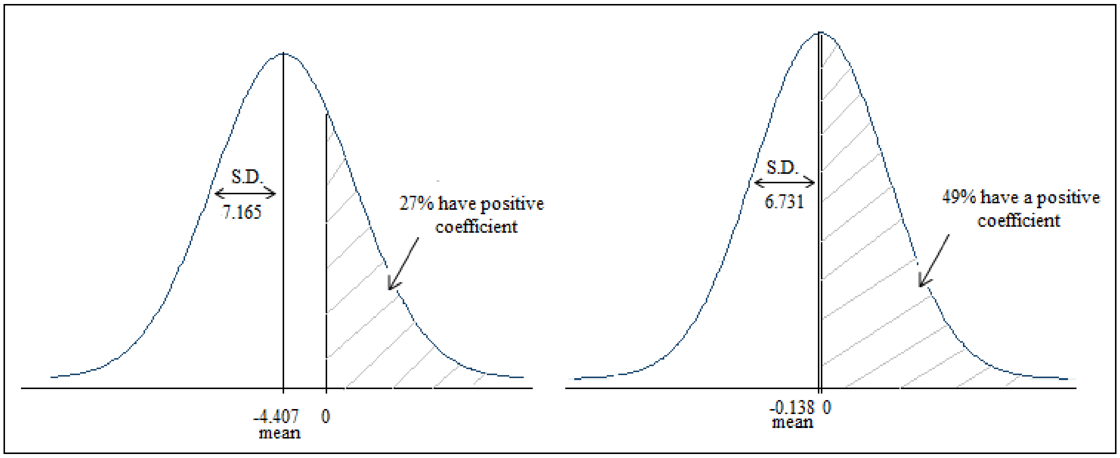
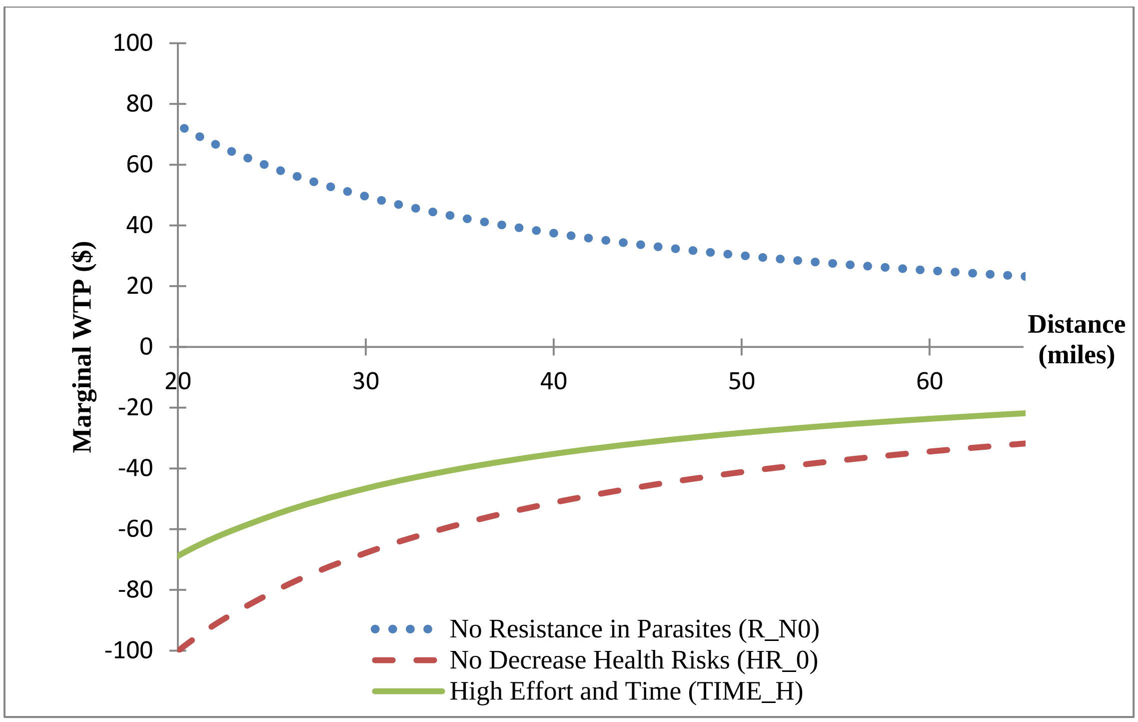
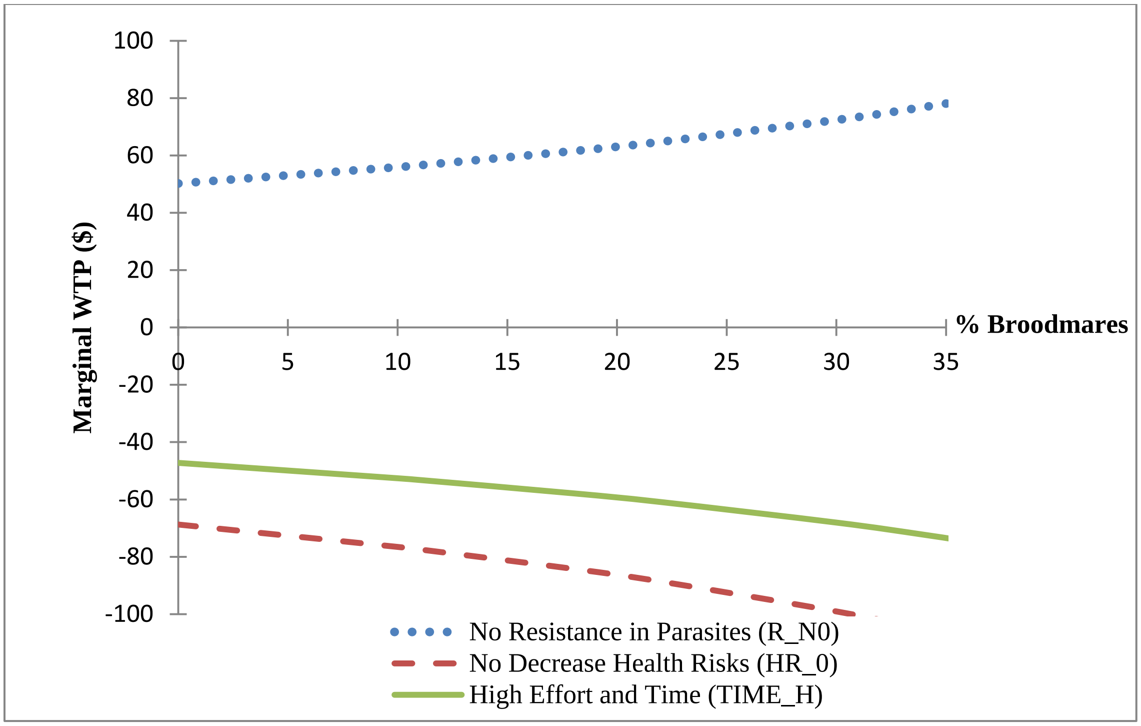


Figure 6.4. Farm Managers' Willingness-To-Pay Estimates: Influence of Farm Location - Mixed Logit Model



Note: Only WTP estimates significant at 5% level are shown.

Figure 6.5. Farm Managers' Willingness-To-Pay Estimates: Influence of Broodmares Proportion - Mixed Logit Model



Note: Only WTP estimates significant at 5% level are shown.

Chapter VII: Discussions and Conclusions

This research offers an overview of the deworming practices used on Kentucky Thoroughbred farms. It confirmed anecdotal evidence that most of the farm managers still use traditional rotational deworming on all horses, even if they indicate that a veterinarian was consulted in the definition of their parasite control program. It also gives an idea of what strategy attributes they would pay a premium or expect a discount for depending on demographic farm characteristics.

Parasites in horses can lead to health problems and can threaten a horse's life when they are not properly managed. Overuse of anthelmintics has resulted in drug resistance in parasites; this often goes unnoticed by the farm manager, which means the treatment is suboptimal for the health of the horse. In the past 30 years, the field of veterinary science has made important advances in treating parasites, providing new products and strategies to optimize treatment, and reduce resistance. However, considering the importance of parasite control for horse health, it is surprising to see that horse owners and managers have been slow to adopt these new recommendations. Most still follow a rotational deworming strategy that was first recommended in the 1960's.

Based on this knowledge, there were two main objectives of this study. First, to begin to understand why new recommendations have not been widely adopted, this study utilized a questionnaire to elicit respondents' current approaches to parasite control, knowledge of, concern about, and experience with drug resistance in parasites. The second objective of this research was to aid in understanding the feasibility of alternative treatment strategies; it investigates whether horse owners or managers will be likely to adopt new deworming strategies. This is achieved by estimating managers' WTP for several attributes of a deworming program, such as ease of implementation, impact on health risks, and potential for drug resistance.

Most of the farms from our sample were located within 20 miles from Lexington and mainly consisted of breeding stock and growing horses. Most farm managers were concerned about drug resistance in parasites and sought the advice of a veterinarian in developing their deworming program; however, almost 70% of them were exclusively using the traditional rotational deworming program for all horses. The size of the farms and experience with drug resistance predicted a movement towards adopting the new recommendations. However, farms highly involved in breeding, with more than half of their herd composed of broodmares, were more likely to be utilizing the traditional rotational deworming strategy because of time and explicit costs.

A conjoint experiment was utilized to evaluate the WTP of farm managers for different attributes of a deworming strategy. These attributes include time and effort required, percentage decrease in health risks, resistance in parasites, and price. Farm managers were more likely to pay for a strategy that is identified as having no resistance and that decreases health risks by 5%, but they dispreferred a strategy that requires significant time and effort. Farm characteristics such as total number of horses, the proportion of broodmares, the distance from central Kentucky, and the actual deworming strategy currently in use influence farm managers' sensitivity to strategy price, as well as revealing some heterogeneity in farm managers' behavior. A mixed logit model allowing coefficients of the attributes to vary among respondents showed that the premium or discount given to an improvement or a devaluation of the attribute "decrease in health risks" followed a normal distribution. Investigation about WTP and its associated standard deviation also revealed heterogeneous behavior among specific farm groups. As farms were further from Lexington, the premium that managers were willing to pay for a strategy with no resistance was decreasing, while the discount expected for no decrease in health risks or for a strategy that required more time and effort were also lower. The results predicted by proportion of broodmares were just the opposite. A farm with higher proportion of broodmares would pay more to ensure no resistance in the strategy, while it would expect a higher discount for no decrease in health risks or for a strategy that required more time and effort.

Other possible explanations to this slow adoption of new recommendations that are not addressed by this study are that farm managers can not see any immediate benefits to the horse (such as body condition, coat condition, etc.) between what they observe with the rotational strategy and the introduction of fecal egg counts; however, they do experience the time consuming aspect of the fecal egg count. Another explanation is that rotational deworming will most of the time prevent important burdens that can cause the horse to look unhealthy without providing any sign of resistance in parasites to the farm manager. In those cases, farm managers may not see any benefit of changing the deworming regimen if the horses appear to be in good health. Moreover, in this study, 77% of the farm managers affirmed having a veterinarian involved in developing their parasite control program, but we are not sure what advice they are giving. If veterinarians were not encouraging their clients to use fecal egg counts, then the slow adoption of new recommendations is not only seen at the farm level.

Taken together, equine health providers have better information with which to educate horse owners. Since farm managers are sensitive to health risks properties and resistance in parasites, those providers may need to better present the benefits of new recommendations and the disadvantages of the traditional deworming strategy, knowing that time and effort is also an important criteria in farm managers' decision process.

A few caveats should be mentioned. Some questions should have indicated only one answer was needed. Foals and weanlings should have been separated in two different categories since it is hard to collect a fecal sample when the foal is still with the mare. It would have been helpful to collect information on number of workers on the farm, number of acres, and pasture management. In the choice set, it might have been better to present price and time and effort could for a group of 10 foals instead of a per foal basis; in this way, total costs may be more apparent at the farm level.

Further areas of research may focus on other types of farms. Indeed, questionnaires were sent only to Thoroughbred farms, but additional work on other type of horse farms such as Standardbred farms or Quarterhorse farms would be useful to determine if the definition of a parasite control strategy depends on the farm activity and specialization. Finally, targeting owners of pleasure horses that only have few horses would be a good opportunity to understand how these types of horse owner have responded to the new recommendations.

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Appendix 1: Questionnaire

A001

UNIVERSITY OF KENTUCKY

Deworming on Thoroughbred Farms in Kentucky

BACKGROUND INFORMATION

Farm zip code: ______________

For your farm, please answer the following items for each group of horses identified below:

	1. Number of all horses in age group on farm on May 1, 2013, owned or boarded	**2. Which regimen best describes the current de-worming program in use?** Please enter the appropriate letter in each cell. A. Rotation de-worming every ___ months (indicate frequency) B. Fecal egg count, treat according to results C. Daily de-worming
Example: *My farm has 20 foals and utilizes rotation deworming every 2 months*	20	A, 2 months
# of young horses (<16 months)		
# of broodmares		
# of stallions		
# of horses in training		
# of other (Idles, senior, etc.)		

3. How many of the total number of horses on your farm will return to another state before December 31, 2013? ☐

Yes No

4. Is your veterinarian involved in developing your parasite control program? ☐ ☐

5. Are you concerned about drug resistance in parasites? ☐ ☐

6. Have you ever had a fecal egg count performed for any of your horses? ☐ ☐

7. Have you ever had a documented case of drug resistance in parasites on your farm? ☐ ☐

The remaining portion of the survey concerns only foals, weanlings, and yearlings (0 – 16 months).

8. How many of the foals on your farm are intended to be sold as yearlings? [ ]

9. What types of de-worming drugs are utilized over the course of a year for your young horses? (Please circle the corresponding number of times used per year)

	Number of times used per year
IVERMECTIN (ex: *Zimecterin*)	0 1 2 3 4 5 6 +
IVERMECTIN/PRAZIQUANTEL (ex: *Equimax, Zimecterin Gold*)	0 1 2 3 4 5 6 +
MOXIDECTIN (ex: *Quest*)	0 1 2 3 4 5 6 +
MOXIDECTIN/PRAZIQUANTEL (ex: *Quest +*)	0 1 2 3 4 5 6 +
FENDENDAZOLE (ex: *Panacur, Panacur Powerpac, Safe-Guard, Safe-Guard powerdose*)	0 1 2 3 4 5 6 +
OXIBENDAZOLE (ex: *Anthelcide EQ*)	0 1 2 3 4 5 6 +
PIPERAZINE	0 1 2 3 4 5 6 +
PYRANTEL PAMOATE (ex: *Stongid Paste, Exodus*)	0 1 2 3 4 5 6 +
PYRANTEL TARTRATE (ex : *Strongid C 2X daily dewormer*)	If yes, number of months used ______

CHOICE OF DEWORMING PROGRAM

In this section, you will be asked to choose between different **hypothetical** deworming strategies for your foals. These strategies differ according to how much time and effort they require, how they decrease certain health risks, the possibility of developing drug resistance in parasites, and monthly cost. More specifically:

- **Effort and Time** — Effort and time spent on administering strategy per foal *per month.* (**Low** (1/2 hour or less); **Medium** (1.5 hours); **High** (5 hours or more))
- **Health Risks** — Decrease in risk of health problems, such as colic, airway inflammation, and diarrhea. (**Decrease risk by 5%**; **2.5%**; **0%**)
- **Drug Resistance** — Level of drug resistance in parasites. (**No resistance**; **Suspect resistance**; **Confirmed resistance**)
- **Price** — Annual cost of implementing the strategy per foal. (**$25**; **$50**; **$100**)

Given this information, you will now be asked to **choose between different strategies**. Please read each of these cards carefully. Each card refers to two different strategies your veterinarian proposed; you also have a third option, which is to choose neither. There is no "right" or "wrong" answer; simply **pick the one that best reflects what you would actually choose**. Please select only one response per card, and do not compare across cards.

Card 1

Strategy A	Strategy B	Strategy C
High effort and time	**Medium** effort and time	I would not choose either A or B
5% decrease in health risks	**0%** decrease in health risks	
No drug resistance	**Suspect** drug resistance	
$ 50 per year	**$ 25** per year	

I would likely choose:

☐ ☐ ☐

Card 2

Strategy A	Strategy B	Strategy C
Low effort and time	**Medium** effort and time	I would not choose either A or B
5% decrease in health risks	**0%** decrease in health risks	
Suspect drug resistance	**No** resistance	
$ 100 per year	**$ 100** per year	

I would likely choose:

☐ ☐ ☐

Card 3

Strategy A	Strategy B	Strategy C
Medium effort and time	**Low** effort and time	I would not choose either A or B
2.5% decrease in health risks	**0%** decrease in health risks	
No drug resistance	**Suspect** drug resistance	
$ 100 per year	**$ 50** per year	

I would likely choose:

☐ ☐ ☐

Thank you very much for completing the survey.
Please return it in the postage paid envelope included with this survey.

Appendix 2: Choice Set for the Six Surveys

Survey A:

Card 1

Strategy A	Strategy B	Strategy C
High effort and time	**Medium** effort and time	I would not choose either A or B
5% decrease in health risks	**0%** decrease in health risks	
No drug resistance	**Suspect** drug resistance	
$ 50 per year	**$ 25** per year	

Card 2

Strategy A	Strategy B	Strategy C
Low effort and time	**Medium** effort and time	I would not choose either A or B
5% decrease in health risks	**0%** decrease in health risks	
Suspect drug resistance	**No** resistance	
$ 100 per year	**$ 100** per year	

Card 3

Strategy A	Strategy B	Strategy C
Medium effort and time	**Low** effort and time	I would not choose either A or B
2.5% decrease in health risks	**0%** decrease in health risks	
No drug resistance	**Suspect** drug resistance	
$ 100 per year	**$ 50** per year	

Survey B:

Card 1

Strategy A	Strategy B	Strategy C
Medium effort and time	**Low** effort and time	I would not choose either A or B
2.5% decrease in health risks	**0%** decrease in health risks	
Suspect drug resistance	**No** drug resistance	
$ 25 per year	**$ 50** per year	

Card 2

Strategy A	Strategy B	Strategy C
Low effort and time	**Medium** effort and time	I would not choose either A or B
2.5% decrease in health risks	**0%** decrease in health risks	
Confirmed drug **resistance**	**Suspect** drug resistance	
$ 25 per year	**$ 100** per year	

Card 3

Strategy A	Strategy B	Strategy C
Low effort and time	**High** effort and time	I would not choose either A or B
5% decrease in health risks	**2.5%** decrease in health risks	
Suspect drug resistance	**No** drug resistance	
$ 100 per year	**$ 50** per year	

Survey C:

Card 1

Strategy A	Strategy B	Strategy C
Medium effort and time	**High** effort and time	I would not choose either A or B
2.5% decrease in health risks	**0%** decrease in health risks	
Confirmed drug resistance	**Suspect** drug resistance	
$ 50 per year	**$ 25** per year	

Card 2

Strategy A	Strategy B	Strategy C
Medium effort and time	**Low** effort and time	I would not choose either A or B
5% decrease in health risks	**0%** decrease in health risks	
Suspect drug resistance	**No** drug resistance	
$ 50 per year	**$ 25** per year	

Card 3

Strategy A	Strategy B	Strategy C
Low effort and time	**High** effort and time	I would not choose either A or B
5% decrease in health risks	**2.5%** decrease in health risks	
Suspect drug resistance	**No** drug resistance	
$ 100 per year	**$ 50** per year	

Survey D:

Card 1

Strategy A	Strategy B	Strategy C
Low effort and time	**High** effort and time	I would not choose either A or B
0% decrease in health risks	**2.5%** decrease in health risks	
Confirmed drug resistance	**Confirmed** drug resistance	
$ 25 per year	**$ 50** per year	

Card 2

Strategy A	Strategy B	Strategy C
Medium effort and time	**Low** effort and time	I would not choose either A or B
5% decrease in health risks	**2.5%** decrease in health risks	
Suspect drug **resistance**	**No** drug resistance	
$ 50 per year	**$ 25** per year	

Card 3

Strategy A	Strategy B	Strategy C
High effort and time	**Low** effort and time	I would not choose either A or B
5% decrease in health risks	**0%** decrease in health risks	
No drug resistance	**Suspect** drug resistance	
$ 100 per year	**$ 50** per year	

Survey E:

Card 1

Strategy A	Strategy B	Strategy C
Low effort and time	**High** effort and time	I would not choose either A or B
5% decrease in health risks	**0%** decrease in health risks	
Confirmed drug resistance	**Suspect** drug resistance	
$ 50 per year	**$ 25** per year	

Card 2

Strategy A	Strategy B	Strategy C
Medium effort and time	**High** effort and time	I would not choose either A or B
0% decrease in health risks	**5%** decrease in health risks	
Confirmed drug resistance	**Confirmed** drug resistance	
$ 25 per year	**$ 50** per year	

Card 3

Strategy A	Strategy B	Strategy C
Low effort and time	**High** effort and time	I would not choose either A or B
5% decrease in health risks	**2.5%** decrease in health risks	
Confirmed drug resistance	**Suspect** drug resistance	
$ 25 per year	**$ 100** per year	

Survey F:

Card 1

Strategy A	Strategy B	Strategy C
High effort and time	**Medium** effort and time	I would not choose either A or B
2.5% decrease in health risks	**2.5%** decrease in health risks	
Suspect drug resistance	**Suspect** drug resistance	
$ 100 per year	**$ 100** per year	

Card 2

Strategy A	Strategy B	Strategy C
Medium effort and time	**Low** effort and time	I would not choose either A or B
5% decrease in health risks	**2.5%** decrease in health risks	
No drug resistance	**Suspect** drug resistance	
$ 100 per year	**$ 50** per year	

Card 3

Strategy A	Strategy B	Strategy C
Low effort and time	**High** effort and time	I would not choose either A or B
5% decrease in health risks	**2.5%** decrease in health risks	
Confirmed drug resistance	**Suspect** drug resistance	
$ 25 per year	**$ 100** per year	

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M.S.	Agricultural Economics, (Expected Dec. 2013) University of Kentucky, Lexington, KY
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PROFESSIONAL EXPERIENCE

07/2013-11/2013	Price reporter at Farmers markets (Lexington, Louisville) (Supervisor: Tim Woods)
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03/2012-Present	Translator, France-Tabac Group, ANITTA (Supervisor: Larry Wells, PhD) Worked with American and French tobacco researchers, helping to coordinate studies, communications, and visits
05/2011-Present	Assistant Veterinary Intern, Gunston Hall Farm LLC (Supervisor: Ruel Cowles DVM), Lexington, KY Experienced all stages of Thoroughbred breeding operations while living on-farm

RESEARCH EXPERIENCE

05/2012-11/2013	*Thoroughbred farm managers' willingness-to-pay for alternative deworming regimens in horses* (Advisor: Jill Stowe, PhD) Questionnaire survey – multivariate regression analysis Cost benefit analyses – conjoint analysis, mixed logit model
01/2013-11/2013	*Ready to Run: Price determinants of Thoroughbreds from two-year-olds in training sales* (Advisor: Jill Stowe, PhD) Analysis of auction prices at two-year-olds sales
04/2012-12/2012	Kentucky Equine Survey Collecting field data through surveys, data analysis
01/2012-12/2012	*Thoroughbred industry in Republic of Korea and imports - Hedonic Price Analysis of Horses Purchased at Foreign Sales by Koreans* (Advisors: Jill Stowe, Véronique Julliand) Analysis of auction prices paid for thoroughbred horses by Korean buyers amidst the presence of a policy-mandated price cap

ACADEMIC DEVELOPMENT

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