Is the Veterinary Industry Chasing its Tail? An Equilibrium Analysis of Veterinarian Service Hours

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The American Veterinary Medical Association (AVMA) has prominently voiced its members' concerns regarding consumer's low willingness to pay for veterinary services and the high costs of veterinary operations, reminiscent of agricultural groups' voiced concerns regarding low commodity prices and rising production costs. A rich literature base exists for medical services demand but the economics-based literature for veterinary medicine is sparse. As one example, Brown and Silverman (1999) show that the own price elasticity of demand for veterinary services is inelastic in the United States.

Further nullifying previous market assessments for veterinary services has been the transition out of food animal concentration and increased pet animal ownership by US households (AVMA Report on the Market for Veterinary Services, 2015). As a result, demand for veterinary services and service providers is now predominantly focused on companion type animals (dogs, cats, etc.) relative to previous decades. Prior to 1980, a majority of veterinarians engaged in treating food animals (cattle, hogs, etc.), but due to changes in commercial herd sizes the demand for large animal service providers has possibly decreased but also become more regionally concentrated (Wang, Hennessy and Park, 2015; Sumner, 2014).

As for supply, there has been an observed increase in the number of veterinarians, but understanding how this increase has affected their corresponding incomes is relatively uncertain (Brown and Silverman, 1999; Prince, Andrus, and Gwinner, 2006). In 2012, 78,950 of the 90,200 licensed US veterinarians (approximately 87.5%) were employed full-time in clinical and non-clinical settings (U.S. Veterinary Workforce Study: Modeling Capacity Utilization, 2013). In 2014, the total number of veterinarians had grown to over 102,000 with 66.5% working predominately or exclusively with companion animals (AVMA Report on Veterinary Markets, 2015). The AVMA has repeatedly stressed the importance of understanding changes in both supply and demand of veterinary services, including an emphasis on the geographic dispersion of practitioners and the different growth rates in demand for different practice types (AVMA Report on Veterinary Compensation, 2015).

This research contributes to the few existing studies (Wang, Hennessy, and Park, 2015; Wang, Hennessy, and O'Connor, 2012) examining the market of veterinary medical services (i.e. veterinarians) in the companion animal sector. Specifically, this studies focus is on estimating supply and demand elasticities. The elasticities will then be used to simulate changes to market equilibrium, and subsequent changes in producer and consumer surplus. From the simulations, the impacts of economic forces on the price and availability of veterinary services is better understood.

Background

Complexities in the demand for veterinary services include consumer tradeoffs between time spent in a veterinarian's office relative to the number of services received, and even these can vary by animal species. The few studies that have reported demand estimates have faced the common challenges of data availability and distributional assumptions (Brown and Silverman, 1999; Kilkenny, Johnson, Shonkwiler, and Helmar, 2014; Shonkwiler, Kilkenny, and Johnson, 2015). The aggregate demand for veterinarians is implicitly a function of the demand for veterinary services (or, in this case, the demand for the number of veterinary services). Furthermore, the demand for veterinary services, and therefore veterinarians, can be defined by partitioning the different types of labor into expected service times. Thus, the demand for an actual veterinarian is measured in the expected time a consumer demands from a veterinarian to perform specific services.

Previous research (Brown and Silverman, 1999; Daneshvary and Schwer, 1993) has shown that demand elasticities vary by the type of animal (i.e. cats or dogs) and are generally inelastic (ranging between -0.15 and -.35). However, several of these previous studies also made the additional assumption that demands for all services (e.g. vaccinations, surgeries, dental examinations, etc.) for each species are equal (Brown and Silverman, 1999; Daneshvary and Schwer, 1993; R.K. House & Associates Ltd, 1992). For example, the AVMA collects and reports data on the number of services paid for by pet-owning households and the annual overall expenditure (AVMA Report of Veterinary Capacity, 2016). Yet, imposing assumptions of equally weighted time spent with a veterinarian for each service discounts the importance of the marginal value of time on the part of the consumer and veterinarian.

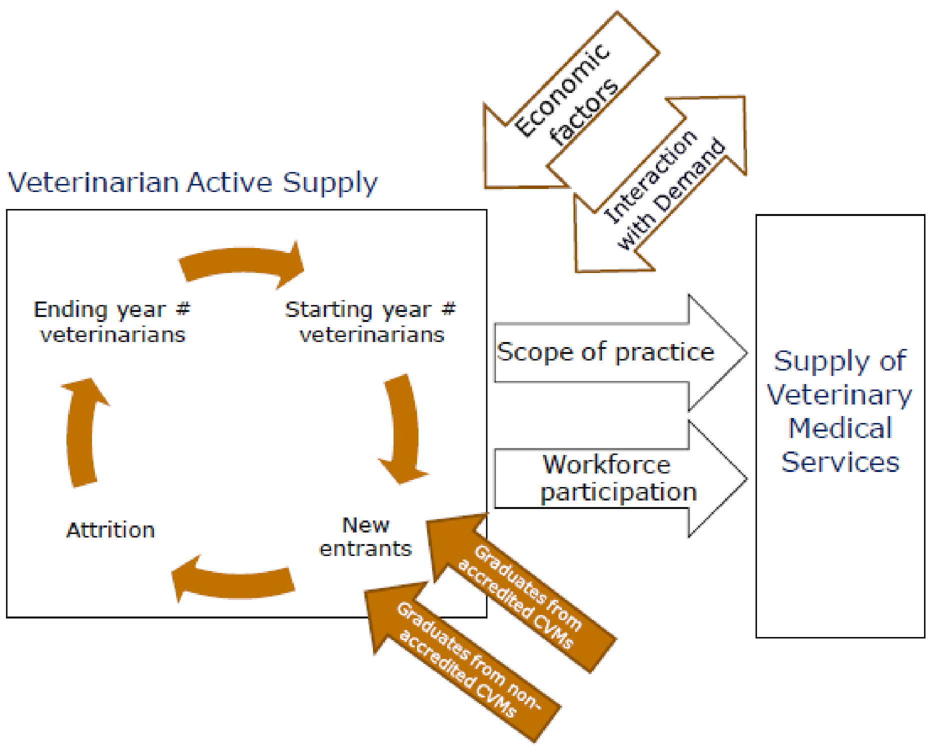

Figure 4.1. Components of Total and Active Supply of Veterinarians

Like demand, supply can be a function of services provided or hours worked by the veterinarians. A veterinarian can only supply a limited amount of time for services (meaning that the number of services provided is more stochastic), this study estimates supply as a function of hours worked. Figure 4.1 illustrates the different components of the total and active veterinarian workforce. What Figure 4.1 does not show is an increasing trend of new veterinarians entering the market and an inverse trend in older veterinarians retiring (AVMA Report on Veterinary Employment, 2015). However, there is insufficient data to estimate the entering and exiting of veterinarians.

Data

The data for quantities of veterinary services demanded are from the AVMA's 2012 Pet Demographic Survey. The Pet Demographic Survey is administered every 5 years to approximately 50,000 households and has a response rate of at least 60%. The collected data include demographic data about the pet owner, the number and type(s) of pets owned, the number of times each pet was taken to the veterinarian and corresponding expenditures, and the number and types of services performed within the last calendar year.

In order to transform the number of services performed into service times, a group of five practicing veterinarians were asked to provide a range of time (in minutes) for performing specific veterinary services. Table 4.1 presents the range of times suggested by the veterinarians and the description of each service. The veterinarians assumed they were performing each service "in house" and accounted for their time performing each procedure. It is common for veterinarians to have a veterinary technician assist with clients, and thus the participating veterinarians were asked to only account for their time. The veterinarians were also asked to assume that there were no major complications with any of the procedures. The purpose of this assumption was to simulate what pet owners expect when they request each specific service, albeit each individual occurrence may be shorter or longer in time.

Table 4.1. Veterinary Service Time Ranges in Minutes

Veterinary Service	Description	Average Time
Physical exam	Not including deworming, vaccinations, etc.	15 minutes
Vaccination	Prep, time spent explaining anything to pet owner, to administering and any follow-up	12.5 minutes
Spay/neuter	For a typical veterinarian at a practice. From prep through observation of recovery.	160 minutes
Radiographs (Please specify study being estimated)	Most common radiographic study done on each animal, assuming equipment is readily available	30 minutes
Lab test	Prep, time spent obtaining consent from owner, obtaining sample (blood/fecal matter), running the test, interpreting and explaining results to owner	60 minutes
Deworming	Time spent explaining to owner what is needed (medication and any side effects) and administration of any medication. Includes heartworm preventives.	15 minutes
Dental care	Routine dental care, including induction/sedation through observation of recovery	30 minutes
Drugs/medication	Time spent explaining the product(s) and administration procedures, side effects, etc., as well as filling script (assuming a veterinarian does this in-house).	15 minutes
Flea/tick products	Time spent explaining the product(s) and administration procedures, side effects, etc.	15 minutes
Euthanasia	Time spent discussing, counseling, and letting the owners say "good-bye" along with time required for the procedure and disposal.	30 minutes
Microchip/tattoo	Time spent in prep, inserting/doing the microchip/tattoo, and clean-up and any discussion needed with the owner.	15 minutes

Table 4.2. Summary Statistics for Companion Animal Veterinary Services Supply and Demand Models

Variable	Description	Mean/Percent	Std Dev
Supply			
Year hours	Number of hours worked by the veterinarian in a year	1897.3	756.6
Vet Price	Price charged per hour by the veterinarian in dollars	149.6	152.9
Experience	Years of experience the veterinarian has been practicing	22.23	47.6
Board certified	Whether or not the Veterinarian has a specialty certification	28.3%	0.5
Male	Whether the veterinarian is male	46.1%	0.5
Veterinarian age	Age of the Veterinarian	51.3	13.7
Demand			
Male	Whether the pet owner taking the survey is male	16.2%	0.4
Non-response	Percentage of respondents that did not respond about their ethnicity	1.12%	-
Caucasian	Percentage Caucasian/ White	92.7%	-
Black/ African American	Percentage Black/ African American	2.5%	-
Asian/ Pacific Islander	Percentage Asian or Pacific Islander	1.4%	-
American Indian/ Aleut/ Eskimo	Percentage American Indian, Aleut, Eskimo	0.6%	-
Other Ethnicity	Percentage Other	1.7%	-
High school	Percentage of respondents with a high school degree of less	16.8%	-
Some college	Percentage of respondents with some college	32.2%	-
College degree	Percentage of respondents with a college degree	31.3%	-
Advanced degree	Percentage of respondents with an advanced degree	19.3%	-
Did not specify	Percentage of respondents who did not specify their educational level	0.3%	-
Price_per_hour_perdog	Price paid per hour per dog in dollars	74.6	218.2
Price_per_hour_percat	Price paid per hour per cat in dollars	29.8	89.5
Total_time_Hours_dogs	Total time spent, in hours, at the veterinarian per dog for the year	1.6	4.6
Total_time_Hours_cats	Total time spent, in hours, at the veterinarian per cat for the year	0.9	3.7
Expenditure_dogs	Total expenditure on all dogs in last year in $/person	226.6	590.3
Expenditure_cats	Total expenditure on all cats in last year in $/person	99.4	353.8
price_per_hour_percomp	Price paid per hour for across all companion animals in dollars	143.7	252.9
total_hours_comp	Total time spent at the veterinarian in hours/companion animal (year)	2.6	5.9
Exp_comp	Total expenditure spent across all companion animals in $/person	326.0	694.5
Income1000	Income of the pet owner ($1000/year)	58.9	40.7
Consumer age	Age of the pet owner	50.7	13.9

Previously, the overall number of veterinarians was ascertained from public sources such as the Bureau of Labor Statistics Equal Employment Opportunity database (Wang, Hennessy, and Park, 2015). For this study, the interest is in the number of hours worked by companion animal veterinarians and the factors affecting that number. Data from the AVMA's 2012 Biennial Economic Survey (BES) was used to estimate the supply elasticity of veterinarian work hours. The BES collects data on weekly work hours and annual income, demographic information about veterinarians, and the corresponding practice types. This data was collected using a random stratified-disproportionate sample from the AVMA's database of U.S. veterinarians. This sampling method was used to increase the likelihood of sufficient responses across each employment and practice category (AVMA Report on Veterinary Compensation, 2015). Only the labor times for performing services in companion animal and equine practices were used for supply models. Summary statistics of variables used in all models are presented in Table 4.2.

The Model

Demand Models

As previously mentioned, the demand for veterinary services is implicitly a function of the time a consumer expects to spend with a veterinarian while receiving one or more services. Companion animal demand was estimated by animal type (i.e. cats, dogs, and horses) and by considering a pooled model (for cats and dogs only), as the focus of this study is aggregate demand. It has become common in the literature to use a demand system; unfortunately, few respondents to the AVMA survey own both cats and dogs (and significantly less own cats, dogs, and horses). Since few veterinarians specialize in one specific companion animal, it is reasonable to assume that aggregate demand for service hours is a combination of animal types. Thus, the animal specific linear inverse demand model is:

$$(2) \quad \ln\left(Q_{D_{L_{ik}}}\right) = \alpha_0 + \alpha_1 \ln(P_{ik}) + \alpha_2 \ln(M_i) + \alpha_3 \ln(A_i) + \alpha_4 G_i + \sum_{j=1}^{4} \gamma_{1j} E_{ij} + \sum_{n=1}^{8} \beta_{1n} R_{in} + \varepsilon_{ik}$$

where Q_{D_L} is defined as the quantity demanded for labor hours by consumer *i* for pet *k*; P_{ik} is the price per hour that consumer *i* spent for each pet *k*; M_i, A_i, G_i, are the income, age, and gender, respectively, for consumer *i*; E_{ij} is a dummy variable for ethnicity, *j*, of consumer, *i*; R_{in} is an indicator variable for the region, *n*, where consumer, *i*, resides; $\varepsilon_{ik} \sim N(0, \sigma^2)$ error term; and $\alpha, \gamma,$ and β are the parameters to be estimated. Once aggregated across cats and dogs, equation (6) becomes

$$(3) \ln\left(Q_{D_{L_{i\sum k}}}\right) = \alpha_0 + \alpha_1 \ln\left(P_{i\sum k}\right) + \alpha_2 \ln(M_i) + \alpha_3 \ln(A_i) + \alpha_4 G_i + \sum_{j=1}^{4} \gamma_{1j} E_{ij} + \sum_{n=1}^{8} \beta_{1n} R_{in} + \varepsilon_{i\sum k}.$$

The demand for horse service hours was estimated separately because there are veterinary practitioners that specialize in treating horses.

The Pet Demographic Survey collects data on pet ownership of more than cats, dogs, and horses, with other species/types including birds, reptiles, ferrets, rabbits, hamsters/gerbils, and fish. Because not all respondents own all pet types, nonresponses for certain pet types can lead to a selectivity, or nonresponse, bias in models. Within each demand model, a Heckman two stage procedure was used to address this selectivity issue. The first stage of the Heckman procedure requires a probit regression, in which the probability that a given consumer owns a specific pet was estimated. From this information, an inverse Mills ratio for the i^{th} consumer was computed. All observations were used for the probit analysis, where the dependent variable equals one if they own at least one companion animal (in this case a cat, dog, or horse) and zero otherwise. Heckman (1976) mathematically characterized the process. Denoting the normal cumulative density function by Φ, Heckman (1976) shows that

(4) $$pr[W_i = 1] = \Phi(\boldsymbol{G_i}\delta_i), \quad i = 1, \dots, n$$

where $\boldsymbol{G_i}$ is a vector of regressors related to consumer i , and δ_i is the coefficient vector associated with these regressors. The first-stage provides estimates of the inverse Mills ratio (MR_i) as follows:

(5) $$\widehat{MR}_i = \left\{\frac{\phi(G_i\hat{\delta}_i)}{1-\Phi(G_i\hat{\delta}_i)} \text{ for } W_i = 1\right\}$$

where ϕ represents the probability distribution function. In the second stage, the inverse Mills ratio was used as an instrument that incorporates the latent variable in the estimation of the demand model in equation (7). Only observed values of W_i (i.e. non-zero responses) were used for the second-stage estimation (Park et al., 1996). It is important to note that not all variables used in the first stage of the Heckman procedure were used in the second stage. The first stage used a set of other explanatory variables about the pet owner.

Supply Model

The supply of companion animal veterinarians is measured as the time (in hours per year) they were willing to work. This model is specified as:

(6) $$\ln(H_v) = \theta_0 + \theta_1 \ln(I_v) + \theta_2 \ln(Exp_v) + \theta_3 Cert_v + \theta_4 G_v + \sum_{n=1}^{9} \beta_{1n} R_{vn} + \mu_v$$

where I_v is the hourly income of the veterinarian, *v*; H_v is the number of hours worked by each veterinarian; Exp_v is the experience in number of years of the veterinarian; $Cert_v$ is a binary variable for whether or not the veterinarian has a specialty certification; $\mu_v \sim N(0, \sigma^2)$ is the error term; and all other terms are defined as before. The region variable, R_{vn}, was separated into 10 regions as defined by the AVMA, which can be seen in Figure 4.2. The AVMA defined these regions based on the first number of the zip code for each area.

In order to match the demand models, the difference between price paid by consumers (which would be considered revenue) and “take-home” income of veterinarians was adjusted upward by a factor of 0.33, which is the income to revenue ratio reported in the AVMA Report on Veterinary Compensation (2015). Again, a supply model for companion animal and equine (horse) veterinarians was estimated. This adjusted hourly income represented the price per hour that the veterinarian charges.

Figure 4.2. AVMA defined Regions of the United States (Source: AVMA Report on Veterinary Markets, 2015).

Market Simulations

By aggregating the demand and supply equations, an equilibrium can be estimated. The demand equation from equation (3) is aggregated to be:

(7) $$\sum_{k=1}^{K} \ln\left(Q_{D_{L_{i\sum k}}}\right) = \sum_{k=1}^{K} \left(\alpha_0 + \alpha_1 \ln\left(P_{i\sum k}\right)\right)$$

and the supply equation from equation (6) is aggregated to be:

(8) $$\sum_{v=1}^{V} \ln(H_V) = \sum_{v=1}^{V} (\theta_0 + \theta_1 \ln(I_v)).$$

By assuming $P_{ik}=I_v=P$, equations (7) and (8) can be equated to solve the equilibrium price and quantity. The change in equilibrium from various demand and supply shocks is estimated by shifting α_0 and θ_0.

Results

Demand Models

Since a two-stage Heckman approach was used for the demand models, the results are presented in the same way. The first stage Heckman procedure (Table 4.3) revealed distinct differences between dog and cat ownership. Specifically, the probability of owning a dog is not statistically affected by education, but the probability of owning a cat is positively affected by education. Region variables present something similar in that the probability of owning a dog in all regions except New England, the Mid-Atlantic, and East North Central (not significant) are higher relative to the Pacific Region; however, the probability of owning a cat is comparably less in all regions except New England.

The base for ethnicity is Caucasians since they comprise the majority of the sample (92.7%). African Americans and those with a nonresponse had significantly lower probabilities of owning a dog compared to Caucasians. The probability of owning a cat is also lower for African Americans, along with Asian/ Pacific Islanders and those that self-classify as “other” compared to Caucasians.

Table 4.3. Factors Impacting the Probability of Owning Specific Pet: Probit Estimates for the 1st Stage Heckman Procedure (Data Source: AVMA Pet Demographic Survey)

	Companion Animals		Dogs		Cats	
Parameter	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	-0.492**	0.113	0.407**	0.084	-0.408**	0.116
Consumer age	0.006**	0.001	-0.005**	0.001	0.002**	0.001
Male	-0.187**	0.020	-0.030	0.020	-0.171**	0.020
Non-response to ethnicity	-0.006	0.020	-0.131**	0.066	-0.030	0.066
Black/ African American	-0.377**	0.041	-0.097**	0.041	-0.552**	0.043
Asian/ Pacific Islander	-0.244**	0.056	-0.055	0.056	-0.467**	0.058
American Indian/ Aleut/ Eskimo	-0.145	0.090	-0.015	0.090	0.100	0.090
Other ethnicity	-0.019	0.056	0.057	0.056	-0.235**	0.055
Caucasian	.	.	.	.	.	.
New England	0.131**	0.039	-0.234**	0.038	0.158**	0.039
Middle Atlantic	0.102**	0.028	-0.063**	0.027	-0.038	0.026
East North Central	0.116**	0.027	0.037	0.026	-0.064**	0.026
West North Central	0.090**	0.033	0.112**	0.032	-0.089**	0.032
South Atlantic	0.135**	0.027	0.142**	0.026	-0.129**	0.026
East South Central	0.060*	0.036	0.290**	0.036	-0.130**	0.036
West South Central	0.123**	0.031	0.293**	0.031	-0.202**	0.031
Mountain	-0.046	0.033	0.116**	0.032	-0.145**	0.032
Pacific	.	.	.	.	.	.
High school	0.268**	0.099	-0.001	0.099	0.340**	0.103
Some college	0.454**	0.098	-0.014	0.098	0.458**	0.102
College degree	0.611**	0.098	-0.039	0.098	0.440**	0.102
Advanced degree	0.717**	0.099	-0.124	0.099	0.454**	0.103
Did not specify	.	.	.	.	.	.
Log likelihood	-19912.59		-20992.73		-21350.44	
Number of observations	31600		31600		31600	

Note: * and ** denote statistical significance at the 0.10 and 0.05 levels respectively.

As for gender differences, males have a lower probability of owning either dogs or cats with only cats being statistically significant. The probability of owning a dog decreases with age but the probability of owning a cat increases with age.

The pooled model for companion animals (dogs and cats together) reveals similar results. The probability of owning either animal is increased by education. In addition, most regions (except Mountain, which is negative and insignificant) have a higher probability of ownership compared to the Pacific region. African Americans and Asian/Pacific Islanders have a lower probability of owning either animal as compared to Caucasians, and males have a lower probability of either dog or cat ownership relative to females.

In regards to horse ownership (Table 4.4), males are less likely to own a horse but older people have a higher probability of horse ownership than younger people. Only African Americans have a lower probability of owning a horse as compared to Caucasians (no other ethnicities are statistically different from Caucasians). People in New England and the Middle Atlantic are less likely to own a horse, but those in West South Central are more likely to own a horse as compared to those in the Pacific region. Unlike dog and cat ownership, horse ownership appears to be more dependent on geographic region, as might be expected due to necessary land requirements, rather than education or ethnicity.

As noted before, the results of the first stage probit model were transformed into an inverse Mill's ratio and included in the second stage, inverse demand model (Table 4.5). In the dog model, the inverse Mill's ratio was negative and significant suggesting there was some negative selectivity bias from those that chose not to own a dog. An opposite effect for the inverse Mill's ratio was found for cat owners. Specifically, the negative (positive) selectivity bias from the inverse Mill's ratio indicates that those dog (cat) owners who are most similar to those who did not report purchasing any veterinary services tend to spend less (more) per hour of veterinary care.

Table 4.4. Factors Impacting the Probability of Owning a Horse: Probit Estimates for the 1st Stage Heckman Procedure (Data Source: AVMA Pet Demographic Survey)

Parameter	Estimate	SE
Intercept	-1.588**	0.186
Consumer age	-0.003**	0.001
Male	-0.075*	0.02
Non-response to ethnicity	0.113	0.130
Black/ African American	-0.301**	0.116
Asian/ Pacific Islander	0.015	0.117
American Indian/ Aleut/ Eskimo	0.133	0.171
Other ethnicity	-0.062	0.123
Caucasian	.	.
New England	-0.303**	0.039
Middle Atlantic	-0.217**	0.028
East North Central	-0.144**	0.027
West North Central	0.061	0.033
South Atlantic	-0.067	0.027
East South Central	0.105	0.036
West South Central	0.128**	0.031
Mountain	0.07	0.033
Pacific	.	.
High school	-0.22	0.099
Some college	-0.247	0.098
College degree	-0.237	0.098
Advanced degree	-0.201	0.099
Did not specify	.	.
Log likelihood	-3309.49	
Number of observations	31600	

Note: * and ** denote statistical significance at the 0.10 and 0.05 levels respectively.

In accordance with traditional theory, the price elasticities for both individual pet models are negative and suggest inelastic demand, with the price elasticity for dog services being less elastic than the elasticity for cat services. Dog owners' income elasticities are positive and inelastic indicating a normal and necessary good, but as age increases a dog owner demands less veterinary service hours. The results are similar for cat owners. Males tend to take their cats to the veterinarian more often than females, but male dog owners tend to patronize a veterinarian less often than females. African Americans tend to spend less time at a veterinarian's office as compared to Caucasians, but African American cat owners, along with American Indians/Aleuts/ Eskimos and those that classify as "other", demand more hours. Asian/Pacific Islander cat owners demand less hours as compared to Caucasians.

All regions, except New England, demand more service hours for dogs as compared to the Pacific region (with the Middle Atlantic, West North Central, and Mountain regions not being statistically significant). Cat owners in the Middle Southern Atlantic visit a veterinarian more often, while those in West North Central and East South Central visit less often, as compared to the Pacific region.

The inverse Mill's ratio in the pooled model is positive and significant but less than the cat specific model. Again, this indicates that those pet owners who are most similar to those who did not report purchasing any veterinary services tend to spend more per hour of veterinary care. The price elasticity in the pooled model was negative and similar to that of the dog price elasticity (inelastic). The income elasticity is between those estimated for the dog and cat models, indicating a normal good.

In general, male pet owners spend less time at the veterinarian, as do older pet owners. There are no significant differences between the ethnicities regarding time spent at a veterinarian's office. Living in the West North Central region has a negative impact on quantity demanded for veterinary service hours as compared to living in the Pacific region. A likelihood ratio test between the pooled and pet specific demand models rejects the pooled model. However, the pooled model is convenient in estimating an own price elasticity for use in aggregate market simulations for all companion animal veterinarians since most do not specialize in one animal (i.e. only dogs or only cats). In addition, all data classifies veterinarians as companion animal rather than a canine or feline specialist.

Table 4.5. Quantity of Service Hours Demanded for Specific Pets: 2nd Stage Heckman Procedure (Data Source: AVMA Pet Demographic Survey)

	Companion Animal Model		Dog Model		Cat Model	
Parameter	Estimate	SE	Estimate	SE	Estimate	SE
Intercept	2.661**	0.173	7.861**	1.471	-0.462	1.270
ln(Price)	-0.456**	0.010	-0.454**	0.013	-0.531**	0.009
IMR	1.142**	0.261	-4.574**	1.026	2.642**	1.169
ln(Income1000)	0.124**	0.014	0.156**	0.018	0.110**	0.014
ln(Consumer age)	-0.095**	0.036	-0.129*	0.072	-0.086**	0.043
Male	-0.113**	0.030	-0.195**	0.039	0.057**	0.064
Non-response to ethnicity	-0.050	0.088	-0.036	0.131	0.025	0.088
Black/ African American	-0.086	0.082	-0.364**	0.113	0.313**	0.191
Asian/ Pacific Islander	0.139	0.096	0.074	0.134	0.457**	0.175
American Indian/ Aleut/ Eskimo	0.005	0.117	-0.073	0.136	-0.118**	0.125
Other ethnicity	0.017	0.079	0.132	0.097	0.124**	0.113
Caucasian	.	.	.	.	.	.
New England	0.017	0.048	-0.176*	0.099	-0.057	0.070
Middle Atlantic	0.043	0.037	0.021	0.052	0.041**	0.038
East North Central	-0.046	0.036	0.129**	0.048	-0.039	0.042
West North Central	-0.135**	0.043	0.058	0.065	-0.155*	0.053
South Atlantic	0.035	0.036	0.220**	0.062	0.110**	0.056
East South Central	-0.054	0.049	0.338**	0.104	-0.129**	0.067
West South Central	-0.048	0.043	0.325**	0.100	0.030	0.081
Mountain	-0.058	0.045	0.072	0.067	-0.032	0.066
Pacific	.	.	.	.	.	.
Log likelihood	-14,984.7		-6,730.0		-10,922.65	
Number of observations	20297		14720		8592	

Note: * and ** denote statistical significance at the 0.10 and 0.05 levels respectively.

Table 4.6 presents the demand results for horse services. The inverse Mill's ratio for horse demand is not significant, indicating no selectivity bias for horse owners. Horse veterinary service demand shows a similar price elasticity as compared to the companion animal models. As horse owners' income elasticity is higher than the companion animal models, but those living in the West North Central region spend significantly less time with a veterinarian as compared to the Pacific Region. A higher income elasticity shows that pet owners view horses more as a luxury good as compared to dogs/cats, albeit they still view it as a necessary good. There seem to be no differences in ethnicity as compared to Caucasians.

Supply Model

The estimation of a supply elasticity of companion animal veterinarian yearly work hours (Table 4.7) is unique to the literature. The supply is highly inelastic, which is similar for human health practitioners (Nicholson and Propper, 2011). Male companion animal veterinarians tend to work more hours over the course of a year. However, as veterinarians gain more experience, which is arguably a proxy for age, they decrease the number of hours worked. There are some differences in work hours across AVMA defined regions. In particular, companion animal veterinarians in AVMA regions four through seven work more hours a year as compared to region nine.
While still inelastic, equine veterinarian (Table 4.8) supply is more elastic than that of companion animal veterinarians. For equine veterinarians, the only regional difference from AVMA region nine is in AVMA region two, where equine veterinarians work a greater number of hours.

Table 4.6. Quantity of Service Hours Demanded for Horses: 2nd Stage Heckman Procedure (Data Source: AVMA Pet Demographic Survey)

Parameter	Estimate	SE
Intercept	15.117	40.027
ln(Price)	-0.491**	0.030
IMR	-15.369	48.263
ln(Income1000)	0.218**	0.059
ln(Consumer age)	-0.257	0.237
Male	-0.088	0.179
Non-response to ethnicity	0.262	0.492
Black/ African American	-0.025	0.486
Asian/ Pacific Islander	-0.117	0.281
American Indian/ Aleut/ Eskimo	1.235	0.641
Other ethnicity	0.007	0.417
Caucasian	.	.
New England	-0.621	0.482
Middle Atlantic	-0.388	0.351
East North Central	-0.461	0.268
West North Central	-0.745**	0.213
South Atlantic	-0.251	0.190
East South Central	-0.562	0.298
West South Central	-0.410	0.307
Mountain	-0.080	0.218
Pacific	.	.
Log likelihood	-440.35	
Number of observations	380	

Note: * and ** denote statistical significance at the 0.10 and 0.05 levels respectively.

Table 4.7. Factors Affecting the Yearly Supply of Companion Animal Veterinarian Work Hours (Data Source: AVMA Biennial Economic Survey)

Parameter	Estimate	SE
Intercept	7.185**	0.129
ln(Vet price)	0.079**	0.024
ln(Experience)	-0.096**	0.022
Board certified	0.027	0.033
Male	0.175**	0.033
Region 0[a]	0.099	0.067
Region 1	0.093	0.068
Region 2	-0.032	0.062
Region 3	0.062	0.060
Region 4	0.154**	0.062
Region 5	0.148**	0.060
Region 6	0.116*	0.063
Region 7	0.136**	0.059
Region 8	0.041	0.069
Region 9	.	.
Log likelihood	-1464.15	
Number of observations	1645	

Note: * and ** denote statistical significance at the 0.10 and 0.05 levels respectively.
[a] See Figure 2 for definition of AVMA regions.

Table 4.8. Factors Affecting the Yearly Supply of Equine Veterinarian Work Hours (Data Source: AVMA Biennial Economic Survey)

Parameter	Estimate	SE
Intercept	6.849**	0.220
ln(Vet Price)	0.128**	0.045
ln(Experience)	-0.007	0.044
Board Certified	-0.038	0.065
Male	0.096	0.069
Region 0	0.007	0.124
Region 1	0.096	0.113
Region 2	0.258**	0.111
Region 3	0.140	0.118
Region 4	-0.006	0.112
Region 5	0.069	0.140
Region 6	0.006	0.174
Region 7	0.151	0.126
Region 8	0.112	0.130
Region 9	.	.
Log likelihood	-347.6	
Number of observations	394	

Note: * and ** denote statistical significance at the 0.10 and 0.05 levels respectively.

Market Simulations

When the demand and supply models are aggregated, the solved equilibrium price per hour is $89.64 and the corresponding aggregate hours of veterinary service is about 125,334,005. In other units, the number of hours in equilibrium is enough to service about 48,205,387 animals. Changes in equilibrium are analyzed under various demand and supply changes. Table 4.9 shows the variation in price and Table 4.10 shows the variation in aggregate hours. The range of price variation at equilibrium is $31.83 and the range of hours is about 3,089,426. The variation in hours is equivalent to about 1,188,241 animals.

Currently, on average, the average price per hour that consumers pay is $143.70. Since this is above equilibrium price, there is potential market inefficiency. This results in only 23,478,362 animals obtaining services. If supply were to remain constant, then demand would have to increase by about 8% to be in equilibrium.

Conclusions

Literature on demand and supply for veterinary services is sparse, but so is the data necessary to estimate elasticities. By taking a labor/work hour approach to measuring supply and demand elasticities for companion animal and equine service markets, market simulation are used to demonstrate how varying shocks in demand and supply can have a significant effect on market outcomes. This study also looks at the probability of owning a specific pet and those effects within demand estimation.

Veterinarians are concerned about stagnant incomes across the industry. From the equilibrium analysis, this may be due to a market inefficiency resulting from a price floor above equilibrium. Veterinarians are thought to be monopolistically competitive, which means they are price setting firms leading to the market inefficiency. In addition, all previous studies suggest that veterinary services are price inelastic. This study has also concluded that prices are inelastic, albeit more elastic than prior studies, and there are some regional differences in demand for specific pet types. By measuring veterinary services as an exchange of time, it becomes possible to estimate changes in equilibrium from exogenous shocks within the market. Prior to this study, little research has been conducted to determine the effects of supply and demand shifters on market equilibrium. This research adds to the growing literature on veterinary demand and supply, but also creates a potential framework for future research.

From the equine market, a more elastic supply (albeit still inelastic) lead to similar results as the companion animal market. It is also interesting to note that consumers view veterinary services as normal, necessary goods. Future research should focus on gathering precise data on demand for veterinary services, and, ideally, track this information across time. From the demand estimations of this study, it is apparent that demand is pet- and region-specific. This study is also the first to estimate supply elasticities for companion animal and equine practitioners. It would be of interest to determine changes across time in supply along with demand.

While there are apparent limitations in data and estimation, it is hoped that this study constructs an appropriate method to analyze demand and supply in the veterinary service industry. The AVMA is collecting data that are more precise on both aspects of the market. This will provide a better understanding of supply and demand in the future.