Supply and Cross-sector Effects in the Veterinary Medicine Industry

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Introduction

Supply management practices are commonly used to control the market-clearing price, quantity and quality of commodities when growth in demand is being out-paced by growth in supply. Cartels, cooperatives, and marketing boards have proven the basic economic theory that supply controls can increase economic profits to suppliers. As one example, Bolotova (2015) discusses the legal and economic effects of controlling the output of milk and potatoes and how this implication has improved the price received by farmers.

Supply management practices are also applied in education and professional services, with the most common examples being the accreditation criteria used by schools of medicine and law, and the board exams their graduates must pass before practicing their profession. Much like medical doctors and lawyers, veterinarians must obtain the proper amount of education and pass a licensing exam. As with any other medical training, those interested in veterinary medicine must first be accepted into an accredited educational program. Acceptance into veterinary medicine is limited by the veterinary schools, representing a form of supply control.

The American Veterinary Medical Association (AVMA) has prominently voiced its members' concerns regarding prices paid for veterinary services and the high costs of veterinary operations, reminiscent of agricultural commodity groups. In recent years, the debt to income ratio for veterinarians has been rising faster than similar other professions (AVMA Report on Veterinary Debt and Income, 2015). The level of debt the students take on is increasing due to the cost of operation of a veterinary school, while the decrease in future incomes is a result of a perceived increase of veterinarians in the marketplace (Segal, 2013). Much like agricultural commodity supply control, one incentive for restricting the number of future students entering into veterinary education is to prevent the corresponding future incomes from decreasing.

This research hopefully contributes to the few existing studies examining the supply of veterinary medical services (i.e. veterinarians) and demand for services by the food/agriculture, companion animal, and research sectors. Significant emphasis is placed on the market causes of veterinary income disparity and stagnation, including demand factors, surplus in supply, or a combination of the two.

Veterinary Services Demand and Supply

A rich literature base exists for medical services demand (including significant research specifically analyzing demand for rural health services), but the economics-based literature for veterinary medicine is sparse. Brown and Silverman (1999) show that the own price elasticity of demand for veterinary services is inelastic in the United States, but they do not show how this measure has changed across time. Demand for veterinarians is arguably a function of the demand for veterinary services. However, the demand for veterinary services (and, therefore, veterinarians) is thought to vary between the small and large animal sectors of veterinary medicine (Wang et al., 2012; Prince et al., 2006). Demand for veterinary services has evolved to serve more companion type animals (dogs, cats, etc.) over the past few 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 has decreased (Wang, Hennessy and Park, 2015; Sumner, 2014).

As for supply, there has been an obvious increase in the number of veterinarians in the marketplace, but understanding how this increase has affected their corresponding incomes is relatively uncertain (Brown and Silverman, 1999). Demand for veterinary series in 2012 was sufficient to fully employ just 78,950 of the 90,200 licensed US veterinarians (approximately 87.5%) currently working in clinical and non-clinical settings (U.S. Veterinary Workforce Study:

Modeling Capacity Utilization, 2013). In 2014, the total number of veterinarians has grown to over 102,000. There is concern from the AVMA that the disparity in demand and supply could be getting worse (AVMA Report on Veterinary Compensation, 2015). While economic theory tells us that an increase in quantity will decrease price (income in this case), *ceterius paribus*, there is a concern that the changes in supply are outpacing the changes in demand. This issue is also occurs on a gender basis, where females are less likely to work with large/food animals and in rural areas (Heath, 2007; Kostelnik et al., 2010; Wang et al., 2014). This is also supported by results from an AVMA survey showing that only 4% of female veterinary graduates entered large animal practice compared with 13% of male counterparts (Wang et al., 2014).

Conceptual Framework

The market for veterinarians is a complex system that is not well researched in its entirety. The demand for veterinarians is implicitly a function of the demand for veterinary services:

$$(1)\ \mathrm{Q_D} = D_V(D_L)$$

where $\mathrm{Q_D}$ is the quantity of veterinarians demanded, D_V is the demand for veterinarians, and D_L is the demand for labor (or, in this case, the demand for veterinary services). The demand for veterinary services, and therefore veterinarians, can be further defined by partitioning the different sectors of veterinary medicine:

$$(2)\ \mathrm{Q_{D_L}} = D_L(P_M, P_F, P_E,\ \boldsymbol{X})$$

where $\mathrm{Q_{D_L}}$ is the quantity demanded for veterinary labor (services), P_M is the price of small animal services, P_F is the price food animal services, P_E is the price of equine (horse) services, and $\boldsymbol{X}$ is a vector of demand shifters. Previous research has shown that demand elasticities vary by the type of animal services (Brown and Silverman, 1999; Daneshvary and Schwer, 1993; R.K.

House & Associates Ltd, 1992). The three main categories of veterinarians directly interacting with consumers are companion animal (small), food animal (cattle, hogs, and poultry), equine (horse) veterinarians, and those that have a mixed animal (large and small) practice. Incomes for companion animal and food animal veterinarians are similar, but there is a distinct difference between those and equine veterinarians (AVMA Report on Veterinary Markets, 2015).

When considering demand shifters, it is important to note that functional form can affect how the demand curve shifts. Goddard and McCutcheon (1993) show that the empirical specification can cause a parallel shift, a rotation, or a shift and rotation. This will be taken into consideration with the empirical methodology.

The supply of actual veterinarians theoretically is a function of services provided by the veterinarians:

(3) $Q_S = S_V(S_L)$

where Q_S is the quantity of veterinarians supplied, S_V is the supply of veterinarians, and S_L is the supply of labor (in number of services). However, there is insufficient data to estimate this empirically, so that the supply equation is

(4) $Q_S = S_V(I, \boldsymbol{Y})$

where I is the income of the veterinarian and $\boldsymbol{Y}$ is a vector of supply shifters. The collected data on the supply of veterinarians is lacking in the depth of variables. Much of the supply data is focused on capturing a raw number of veterinarians operating within the market. While this data is often collected at a disaggregate level, the demand side data is collected at an aggregated level.

Data and Methods

The demand for veterinary services data is from the American Veterinary Medicine Association's (AVMA) Pet Demographic survey. The Pet Demographic Survey is administered every 5 years to approximately 50,000 households with a response rate of at least 60 percent. The two most recent surveys were conducted in 2007 and 2012. The collected data includes 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.

The supply of veterinarians is from the Bureau of Labor Statistics Equal Employment Opportunity database. In addition, county level livestock numbers were obtained from the USDA Census of Agriculture from the census year 2012 (USDA, 2014). The livestock considered were all cattle (excluding dairy), and all hogs. Human population density in the year 2012 and the average per capita income were included in the analysis to account for consumer willingness to pay. This data was obtained from the U.S. Census Bureau (U.S. Census, 2012). County size, measured in square miles, was included to account for the differences between counties. A summary of statistics of variables used in all models is presented in Table 1.

Table 1. Summary of Statistics

Variable	Description	Mean	Std Dev
Agefem	Age of female pet owner	45.71	19.84
Agemale	Age of male pet owner	38.29	25.57
Region	Region of the United State (0-9) in which the pet owner lives	5.10	2.48
Race	Race of the pet owner	1.10	0.61
Income	Household income of the pet owner	3.27	1.39
Sizehh	Size of the pet owners household	2.57	1.31
Edcfem	Level of education of female pet owner	4.11	1.99
Edcmale	Level of education of male pet owner	3.35	2.46
Smanimalservices	Number of companion animal services the previous year	2.95	2.57

Smprice per service	Average price per companion animal service	193.27	430.11
Lganimalservices	Number of equine services the previous year	3.46	1.02
Lgprice per service	Average price per equine service	65.00	20.44
County Population	County population in thousands of people	882.90	1593.51
Livestock Density	County population of all cattle and hogs in thousands	8.84	17.01
County Size	The size of the county in thousand square miles	1.25	1.90
County Income	Average county per capita income in thousands	44.66	11.89
Rural	Whether the county is considered rural	0.26	0.44
Veterinarian Density	Number of veterinarians in a county	29.85	43.00

The nature of demand and supply for veterinary services is inherently not a normal distribution, but rather a distribution based on count. The two main types distributions used for count data are the negative binomial and the Poisson. The Poisson model is often referred to as the fundamental starting point for modeling count data and is used to model both supply and demand (Greene, 2012). For the standard Poisson model, elements of the likelihood function assume the form

$$(5)\ f(y_i, \boldsymbol{X_i};\ \beta) = \frac{e^{-\lambda_i}\lambda_i^{y_i}}{Y_i!},$$

where $\boldsymbol{X_i}$ is a vector of explanatory variables and $\lambda_i = \exp(\boldsymbol{X_i'}\beta)$ (Page, Lichtenberg, and Saavoss, 2015). The main assumption of the Poisson model is that the variance of y_i is equal to its mean. While this is a concern, the Lagrange multiplier test for overdispersion suggested by Cameron and Trivedi (1990) is used.

Along with the Poisson model, a Heckman two stage procedure is used to address non-response bias. During the calendar year of each Pet Demographic Survey, many pet owners report that they did not take their pets to the veterinarian for various reasons. These reasons are summarized in Table 2

Table 2. Reasons for not taking Pet to Veterinarian

Could not afford it	7.98%
Too hard to transport animal	57.62%
Animal did not get sick or injured	13.94%
Animal did not need vaccines	2.56%
Did not know of veterinarian/ veterinary clinic in my area	1.28%
Other	9.68%
Administer own vaccinations	0.5%
Stray	0.09%
Don't believe in veterinary care/don't feel that veterinarians are necessary	0.08%
Did not answer	6.28%

The first stage of the Heckman procedure requires a probit regression, in which the probability that a given pet owner took their pet to a veterinarian and paid for services is estimated (Holcomb, Park, and Capps Jr., 1995). From this information, an inverse Mills ratio for the i^{th} pet owner in year *t* is computed. All observations are used for the probit analysis, where the dependent variable equals one if the starting salary is nonzero and zero otherwise. Saha, Capps, and Byrne (1994) mathematically characterized the process. Denoting the normal cumulative density function by Φ, they show that

(6) $pr[Q_{it} = 0] = 1 - \Phi(W_{it}\delta_i), \quad i = 1, \ldots, n; t = 1, \ldots, T$

where W_{it} is a vector of regressors related to pet owner *i* in year *t*, and δ_i is the coefficient vector associated with these regressors. The first-stage provides estimates of the inverse Mills ratio (MR_{it}) as follows:

(7) $\widehat{MR}_{it} = \left\{\frac{\phi(W_{it}\hat{\delta}_i)}{1-\Phi(W_{it}\hat{\delta}_i)} \text{ for } Q_{it} = 0\right\}$

where ϕ represents the probability distribution function. In the second stage, the inverse Mills ratio is used as an instrument that incorporates the latent variable in the estimation of the demand model. Only observed values of *H* (i.e. non-zero responses) are used for the second-stage estimation (Park et al., 1996). It is important to note that the variables used in the first stage of the Heckman procedure are not used in the second stage. The first stage uses other explanatory variables about the pet owner, which can be seen in Table 1.

Results

Demand Models

Results from demand models for years 2007 and 2012 are presented in tables 3-7. Table 3 presents the companion animal service demand for 2007 with own and cross price elasticities. The own price elasticities for companion animal services are inelastic. The cross price elasticity with equine services are positive but insignificant. The inverse mills ratio is positive and significant showing that there is a positive selectivity bias.

Table 3. Companion Animal Service Poisson Demand 2007

Parameter	Estimate	Standard Error
Intercept	0.2265	0.0712***
Companion Animal Own Price Elasticity	-0.1589	0.0048***
Equine Cross Price Elasticity	0.0151	0.0101
Inverse Mills Ratio	0.3291	0.0622***

Note: *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels respectively.

Table 4 presents the equine service demand for 2007 with own and cross price elasticities. The own price elasticities for equine services is also inelastic. The cross price elasticity with companion animals is positive and significant, representing a compliment. The inverse mills ratio is not significant in this instance.

Table 4. Equine Service Poisson Demand 2007

Parameter	Estimate	Standard Error
Intercept	4.3039	3.71381
Companion Animal Cross Price Elasticity	0.0889	0.0323***
Equine Own Price Elasticity	-0.4135	0.0317***
Inverse Mills Ratio	-4.0424	4.6858

Note: *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels respectively.

Table 5. Companion Service Poisson Demand 2012

Parameter	Estimate	Standard Error
Intercept	0.1649	0.5872
Companion Animal Own Price Elasticity	-0.1583	0.0435***
Food Animal Cross Price Elasticity	0.0522	0.0326*
Equine Cross Price Elasticity	-0.0340	0.0295
Inverse Mills Ratio	0.6872	0.4431

Note: *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels respectively.

The 2012 companion animal service demand elasticities are presented in Table 5. The own price elasticity is, once again, inelastic. The cross price elasticity with food animal services is positive and significant, indicating a complement. The cross price elasticity with equine nor the inverse mills ratio is significant. As seen in Tables 6 and 7, the own price elasticity of equine services is inelastic, but no other parameters are significant.

Table 6. Equine Service Poisson Demand 2012

Parameter	Estimate	Standard Error
Intercept	1.4212	42.0267
Companion Animal Cross Price Elasticity	0.0990	0.2153
Food Animal Cross Price Elasticity	0.1065	0.1942
Equine Own Price Elasticity	-0.6505	0.2935**
Inverse Mills Ratio	0.6582	51.4271

Note: *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels respectively.

Table 7. Food Animal Service Poisson Demand 2012

Parameter	Estimate	Standard Error
Intercept	72.8544	58.6293
Companion Animal Cross Price Elasticity	0.1073	0.0884
Food Animal Own Price Elasticity	-0.0622	0.0709
Equine Cross Price Elasticity	-0.0553	0.158
Inverse Mills Ratio	-90.6252	73.1451

Note: *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels respectively.

Supply Model

Table 8 shows the supply elasticities results. All of the explanatory variables are independent. As the county population, livestock density, county size, and county income per capita increases there is a positive effect on the number of veterinarians within a county. Also, if a county is classified as rural then there is a decrease in the number of veterinarians within the county.

Table 8. Veterinarian Poisson Supply 2014

Parameter	Estimate	Standard Error
Intercept	-1.3500	0.0736***
County Population Elasticity	0.2580	0.0049***
Livestock Density Elasticity	0.0059	0.0019***
County Size Elasticity	0.0229	0.0048***
County income per Capita Elasticity	0.2246	0.0207***
Rural	-0.0500	0.0124***

Note: *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels respectively.

Conclusion

The results of the demand models reveal own price elasticities for companion animals similar to those reported in Brown and Silverman (1999). The nature of this data, however, allows for cross price elasticity estimation and shows that there is a significant complementary effect with food animal services. This is something not seen in previous literature, as this type of data is not easily acquired.

The demand for all of types of veterinarian services is inelastic which is important to note as it allows for a better understanding for veterinarian demand. The demand for equine services, while inelastic, is over four times more elastic than the demand for companion animal services. While causality cannot be proven, the AVMA has reported lower incomes for equine veterinarians which may be a result of a more elastic demand function. It is not surprising that the demand for food animal services is not significant given the small sample and these food animals are considered pets which is not necessarily an accurate representation of actual food animal demand.

On the supply side, there has been much debate about rural versus urban location of veterinarians. The supply function shows that there are less veterinarians in rural counties compared to urban counties. This could be a result of the lower county population. It is difficult to fully distinguish the type of practice that a veterinarian participates in and where they locate due to data limitations.

This study represents a truly unique examination of supply and demand factors related to veterinary services. However, further research is needed to better understand the geo-dependent nature of the veterinary services market. Future research should focus on understanding the difference in demand between rural and urban areas. The Pet Demographic Data is aggregated at the state level which makes it difficult to estimate these differences. Also, having more complete supply data set related to veterinarians and their type of practice would be beneficial for more accurate data. In general, a better understanding of the veterinary market is needed, but requires more precise data.

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