A Hedonic Price Analysis of Internet Auctions for the BLM's Wild Horses and Burros

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Abstract: This paper is an analysis of the BLM's internet auctions for wild horses and Burros from November 2012 through March 2013. This study uses the Hedonic pricing model to determine the magnitude in terms of demand elasticity at which physical characteristics of each horse influences buyers' decisions to bid for a horse. OLS regressions are run and compared where physical characteristics of wild horses and burros are the independent variables and the winning bid price of horses is the dependent variable. The most statistically significant physical characteristics from the most appropriate OLS regression model are identified for the purpose of increasing the public adoption rates.The highly desirable physical qualities of wild horses and burros are identified to be the proximity of a bidder to sale location, horses that are captured out of BLM's holding facility, a horse that is a mare or stallion, a colored horse and a horse with a unique quality such as pinto. Sterilization of horses in the BLM's holding facility is a significant way of increasing public adoption rates and controlling the population of wild horses.

Key Words: BLM, Public Adoption Rate, Sterilization, Hedonic Pricing, Demand Elasticity

Introduction and Background

Wild horses are referred to as the pioneer spirit of the west and as a symbol of the American freedom (Graham 2008).The catching of wild horses is an old sport which was preeminent in the mid-20th century. The Indians were the first group of people to chase after wild horses. In the 1840's, Mexicans who already had Spanish horses made their living from capturing wild horses (Thomas, 2000). In the 1920's, the demand for wild horses increased as they were slaughtered for hooves, glue making and human consumption (Elizondo et al 2000). About seventy years ago there became awareness about the declining number of wild horses roaming in the wilds. The killing of wild horses for meat or production of other substances is now inhumane due to a protection law that was established for the safety of these animals. The law was inspired when Velma Johnston a woman from Nevada began a campaign that led to the US 1959 law enactment that was set to protect wild horses.

In 1971 the US government established public rule 92-195 known as the Wild Free Roaming Horses and Burro Act (WH &B Act) which emphasized on the healthy management of wild horses on US public lands (Elizondo et al 2000). The protection law of 1971 authorized that wild and free roaming horses are managed in a way that promotes ecological balance on public lands. The Bureau of Land Management (BLM) supported the protection law of 1971 by establishing a Wild Horse and Burro program through which range lands with wild horses are maintained. As of February 29, 2012 forty four BLM offices managed 37300 wild horses and burros roaming on herd management areas of 10 western states; Arizona, California, Idaho, Montana, Wyoming, New Mexico, Nevada, Utah, and Oregon. Currently, the BLM manages 264 million acres of rangeland which takes up about 1/8th of the US rangelands (Gorey, 2009). The BLM achieves ecological balance of rangelands by conducting round ups on excess animals. After these round

ups wild horses and burros are placed in holding facilities (private care) majorly to control herd sizes and also for public adoptions. Presently, about 32000 horses are held in private care through an adoption program. The purpose of the adoption program is to provide good homes for wild horses that have been rounded up and sell through internet or live auctions to potential buyers or adopters that are interested in owning a huge part of America's heritage.

Problems and Challenges faced by the BLM program

One of the present challenges to the BLM is that the numbers of excess horses on rangelands increase exponentially every year. With the escalating number of wild horses it has been difficult for the BLM to meet up with the standard appropriate management level (AML) of 26 500. AML is the number of horses that the BLM has determined can thrive on rangelands in balance with ecological and land resources (Elizondo et al 2000). The current number of horses roaming on rangeland is estimated to be 37,500; a number which exceeds the AML by 11,000. Despite the difficulty of the BLM in attaining AML, almost 10,000 animals are rounded up and placed in holding facilities every year. The BLM stated that 220,000 wild horses have been removed from public rangelands since 1971. From 2001 to 2008 the BLM recorded that 79,000 wild horses were removed from public rangelands. At the end of September 2012, about 8,283 animals had been removed from public rangelands and placed in holding facilities for adoptions. In spite of all the roundups the numbers wild horses on rangeland still remain massive.

A second challenge to the BLM is the declining rate of public adoptions which fails to meet up with the level of round ups. In other words, the actual number of animals in holding facilities exceeds the anticipated number due to low public adoption rate. An explanation for low public adoption rate could be poor public awareness and marketing strategies. A third challenge faced by the BLM is the perception by the general public that unsold horses are sent to slaughter

houses. There have been some speculations about some buyers sending horses to Mexico for inhumane slaughtering (Philips, 2012). When horses are not adopted they remain in holding facilities and are placed on internet auction a couple more times before they are finally sent to buyers who receive the ownership of these animals from the Federal government (Gorey, 2009). These buyers are usually not like adopters who care about the wellbeing of these horses. There is a limit to what the BLM can do to prevent these buyers from the inhumane treatment of horses because BLM gives full ownership transfer at the point of sale. However, it is indeed clear that the BLM does not directly send unsold animals to slaughter houses. The BLM does follow up on buyers after purchasing horses that have not been adopted or purchased during auctions. In 2005, the BLM made buyers sign a no slaughter agreement (Graham, 2008).

A fourth challenge to the BLM is that the cost of maintaining a holding facility is particularly high when horses are not adopted. Maintenance costs singularly accounted for more than half of the amount spent on the entire wild horse and burro program in 2007. The BLM's records from the fiscal year 2007 show that $33.8 million was spent on the entire wild horse program; with a separate amount of $21.9 million spent only on holding facilities (Gorey, 2009). In 2008, the cost of maintaining the entire program increased to an amount of $36.2 million with a separate amount of $27 million for maintaining holding facilities. As of 2010, maintenance costs of holding facilities doubled the amount budgeted on sustaining the whole BLM's adoption program. The BLM spends an excessive percentage of government funds on the removal, feeding, and vaccination of wild horses and burros.

In 2012, the government provided $74.9 million to maintain the BLM program and more than 70% of this amount was spent on the removal and gathering of wild horses excluding the cost of feeding and vaccination. To moderate the cost of maintaining holding facilities the BLM may

have to reduce the rate of roundups. This is not the best option because wild horses have no natural predators and allowing horses to multiply on rangelands without control is a disastrous option. Roundups of excess horses will prevent overgrazing which can lead to starvation or complete extinction of wild horses and burros (Graham, 2008). It is essential for the BLM to find ecologically profound ways of dealing with the challenges posed by the escalating population of wild horses and burros.

Research Objectives and Goals

This study evaluates the BLM's internet auctions for wild horses and burros by examining all the physical characteristics of wild horses and burros that buyers find remarkable. An estimation of the sale price (winning bid price) of wild horses and burros is done based on the physical characteristics of these animals at the time of sale. The hedonic pricing model is used to measure the magnitude in terms of demand elasticity at which the change in each physical feature of a wild horse or burro changes final sale or bid price. Hedonic pricing models are used to determine the sale price of a good based on its qualities and attributes. Lancanster (1966) developed the hedonic pricing model where a product's price was a function of its attributes. Ladd and Suvunnat (1976) first used hedonic pricing in the demand for agricultural inputs and consumer goods. Ever since the late 70's, the hedonic pricing model has been extended to other markets including the milk, Iceland fishing auctions, and pre bred dairy bull production (Buccola and lizuka (1997); Kristofersson and Rickertsen (2004); and Schroeder, Espinosa, and Goodwin (1992)).

The main objective of this study is to determine the physical qualities that most affect the sale price of wild horses placed on the BLM's internet auctions. A horse with mostly desirable qualities attracts more number of bids and higher final bid or sale price. Due to the high cost of

maintaining unsold horses better marketing, advertising and public awareness alternatives are examined for the purpose of increasing public adoption rates. Buyers of thoroughbreds are often interested in the age of a horse as younger horses could be better trained for races than older ones. Wild horse and burro buyers purchase horses mainly for preservation purposes and also to protect the American pride. A second objective is to determine if age (a racing quality in thoroughbreds) influences buyer's willingness to pay for wild horse and burros. Wild horses and burros are saddle and halter -trained but are usually not trained like thoroughbreds to be energetic and aggressive for races.

A third objective is to determine the significance of horse training (saddle or halter) to the final sale price of wild horses and burros.Wild horse and burro buyers often want to know the length of time a horse has been held in the holding facility before it was placed on auction. The longer wild horses and burros stay in holding facilities the longer horses would have undergone through training, vaccination and feeding sessions and interactions with humans. A horse that has just been captured and placed in the facility has a lower chance of being in good health compared to those that have stayed longer in the facility. An unsterilized horse could reproduce in the holding facility. In the case that a horse is born in the facility, the number months it would have stayed in the facility will be equal to its exact age. It is hypothesized that there is an exact linear relationship between the age of horses and the number of months they stay in the holding facility. There may also be other multicollinearity problems in the model as age and height of an animal may have such problems because horses may grow taller as age progresses.

A fourth objective is to check for multicollinearity problems between age and the number of months an animal has been held in the facility and also between age and the height of an animal. It is also hypothesized that the distance of a buyer from the location of sale is a relevant quality

that long distances from the sale location of horses may bid less for horses due to transportation cost and mobility inconveniences. A fifth objective is to check whether the proximity of a buyer to sale location is a relevant factor that determines the final sale price of wild horses and burros.

The final objective of this study is to determine the relevance of sterilization as a method of reducing the population of wild horses and increasing public adoption rate. We do this by comparing buyers preferences for animals that are born in the facility to those that are captured out of the facility. If animals captured out of the facility are preferred to those born in the facility we establish that animals kept in the facility should be kept sterile.

Literature review and Previous Approaches

Several studies have been done in the equine industry with the hedonic pricing model on thoroughbreds. Chezum and Wimmer (2001) used the hedonic pricing model to estimate the characteristics of yearling where the expected value was measured against the actual sales price. Taylor et al (2004) used hedonic pricing to examine the genetic and physical characteristics of Quarter horses where individual performance, genetic and physical characteristics all significantly determined the price of Quarter horses. Neiberg (2001), Maynard and Stoeppel (2007) carried out a study on thoroughbred broodmares where the impact of market, breeding and racing characteristics on auction prices were estimated as significantly determining bidding prices. The racing qualities of thoroughbred were the most significant determinants of bidding prices.

Elizondo, Fitzgerald, Rucker (2000) did an economic analysis of the wild horse and burro program which examined the probability of using disposal method on wild horses. They discovered an alternative technique of dealing with overpopulation of wild horses and burros which supported the disposal of additional horses captured from rangelands. Sterilization was

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confirmed as a way to avoid reproduction of animals in the holding facility. As far as our understanding goes, Elizondo et al (2000) is the only study that has examined the BLM's adoption program proposing maintenance cost reduction strategies such a disposal and sterilization of wild horse and burros. A major question that has been left unanswered is how to increase public adoption rate of wild horses and burros. This study is different from previous studies because it uses a hedonic price method to analyze the internet auctions for wild horses and burros managed by the BLM with the objective of identifying qualities that most favor internet sales and public adoption of wild horses and burros. We focus on how sterilization can not only control population or reduce cost but also increase public adoption rate.

Data Description

The data used are extracted from BLM's mustang internet auctions for wild horses and burros from the months of November 2012 through February 2013. Originally, we had a sample size of 153 but some data was missing because of horses that were not bid for. With an adjusted sample size of 93 which restricted data with zero sale prices, this study is executed. The BLM provided information on the *month of sale, location of capture, holding facility born horses, sale location, buyers location, gender, age, color, height, accessories, month captured, saddle and halter training status, winning bid prices (final sale price) and number of bids* of each horse. Animals with high number of bids also had high final sale prices, so the variable *number of bids* was restricted due to problems with perfect linear correlation.

Another problem with the original sample size (153) was with the missing observations from the variable *height*. This variable had missing observations that accounted for more than half of both the original and also the adjusted sample size (93). The variable *height* will most likely create estimation or missing observation problems which we discuss in the methodology section. The

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BLM provided 15 different colors of horses which we grouped into roan (strawberry roan, blue roan, appaloosa roan, sorreal roan, and bay roan), dun (red dun), brown (bay, sorreal, and chestnut) palomino (buckstin and grula) and black (all black and gray). For estimation purposes the colors are regrouped into black and colored; black being (black and gray) and colored being all the categories of roan, brown, palomino and dun. Dummy variables are then created for color where the variable *colored* takes a value of 1 if horse is colored and 0 if horse is *black* or *gray* and no horse was both black and gray.

The variable for the length of stay in the holding facility (*monfac)* is created by calculating the time interval (in months) between the day of capture and the day of sale. In the case where a horse is born in the facility, *monfac* is calculated by measuring the time interval from the birth day to the day of sale. The distance of buyer from sale location is derived by comparing the location of buyer to the location of sale using the zip codes of location of buyer and the location of sale. Dummy variables are created for proximity of buyers to sale location such as *bidder close* and *bidder far.* Where *bidder close* takes a value of 1 if buyer is close (within the state of sale) and 0 if buyer is far (out of state) from sale location; *bidder far* is the restricted dummy variable for proximity.

The gender of horses is grouped into *stallion* and *mare,* and dummy variables are created where *stallion* takes the value of 1 if horse is *stallion* and 0 if horse is Mare, Jenny or Gelding. Mare takes a value of 1 if horse is *mare* and 0 if horse is jenny or gelding. Dummy variable *Captoutfac* represents horses that are captured out of facility, *bonfac* refers to horses born in the facility. The variable *captoutfac* takes a value of 1 if the horse was captured out of the facility and 0 if horse was born in the facility. Meanwhile, the variable *bonfac* is used as the restricted dummy for location of capture. Information on whether each horse had been saddle trained or halter trained

or both saddle and halter trained was provided by the BLM. Dummy variables *saddle* and *halter* are created such that a horse that has been saddle trained at the time of sale takes a value of 1 and a horse with no saddle training takes a value of 0; similarly a horse that has been halter trained takes a value of 1 and a value of 0 if it has not been halter trained.

Additionally, the data included information on unique accessories of horses such as blaze and stockings and pinto. Variables *blasstock and pinto* are created for accessories where horses without blaze and stockings take a value of 0 and a value of 1 for horses with blaze and stockings; similarly horses with pinto take a value of 1 and horses without pinto take a value of 0. In summary, *mare, stallion, pinto*, *bidderclose, colored*, *captoutfac, saddle, halter, blasstock* are all dummy variables, while *age*, *height* and *monfac* are all continuous variables.

Methodology and Estimation

For the purpose of this study we run separate OLS or hedonic regressions. The first hedonic regression is run using the log of sale price (winbid) as the dependent variable and *colored*, *age, height*, *captoutfac*, *halter*, *saddle*, *bidderclose*, *blasstock*, *monfac*, *stallion*, *mare* and *pinto* as explanatory variables. A log linear functional form is selected because it was the same used in previous literature involving hedonic pricing. Maynard and Stoeppel (2007) used log of price to estimate the hedonic pricing model which measured the effect of racing qualities on the actual price of thoroughbred broodmare in foals. In addition Veerbeek (2012) explains that using log of dependent variable *log y* instead of *y* may help to reduce heteroskedasticity problems. The log of sale price is used and since dummy variables cannot be logged a linear relationship with the dependent variable is assumed. Also, linear relationship with the log of sale price is assumed for continuous variables *age*, *monfac* and *height* making this model a log-linear. The empirical model for the first hedonic regression is as follows:

$$\log price\ (logwinbid) = \beta_1 colored - \beta_2 Age + \beta_3 height + \beta_4 Captoutfac +$$

$$\beta_5 halter\ trained + \beta_6\ saddle\ trained + \beta_7 bidderclose + blasstock + \beta_9 monfac +$$

$$\beta_{10} Stallion + \beta_{11} Mare + \beta_{12} pinto + \in_1 \text{ (OLS regression model 1)}$$

The hedonic model above is checked for multicollinearity problems because there are more dummy variables than continuous variables. Using a variance inflation approach with the rule of thumb that if VIF >10 collinearity exists; we check if variables *age* and *monfac* are exact or somewhat linear combinations of each other. Secondly, a Ramsey's Rest test is done to check for omitted variable or missing observation bias. A White test is done to check for heteroskedasticity which occurs if the variance of the error term varies across different observations. In the presence of heteroskedasticity estimates of OLS remain unbiased and inefficient and inferences on t and F tests will be wrong, however the variances of the estimates are biased and inconsistent. The data being time series is tested for autocorrelation which occurs when the covariance of error terms are correlated. Specifically, an asymptotic t test is used to check for autocorrelation and an additional Breusch Godfrey LM test is done to check for possible problems with serial correlation.

The Estimation of Hedonic Regression Model 2

The variable *height* had 33 missing observations out of a sample size of 93. The reason for this is unknown, however it was observed that the BLM on its website emphasizes on potential use, color and the buyer's level of connection to desired horse as criteria for adopting horses but excluded height. Wild horse adopters based on BLM's suggestions may not consider height as criteria for making purchasing decisions. *Height* is treated like an irrelevant variable and restricted from OLS regression model 2. The empirical model for the second hedonic regression model without the variable *height* is as follows:

$$\log price\ (winbid) = \beta_1 colored - \beta_2 Age + \beta_3 Captoutfac + \beta_4 halter\ trained +$$

$$\beta_5\ saddle\ trained + \beta_6 bidderclose + \beta_7 blasstock + \beta_8 monfac + \beta_9 Stallion +$$

$$\beta_{10} Mare + \beta_{11} pinto + \in_2 \text{ (OLS regression model 2)}$$

On OLS regression model 2, we test for multicollinearity problems between *age* and *monfac*. A

Ramsey's Reset test is carried out to check for missing observations or misspecification bias.

Furthermore, asymptotic t test and Bresuch Godfrey's LM tests are done to check for

autocorrelation problems among error terms.

The Estimation of Hedonic Regression Model 3

To estimate OLS regression model 3, *age* is restricted due to multicollinearity problems between

age and *monfac*. The log linear functional form of OLS regression model 3 now excludes both

variables *age* and *height*. We test for other possible multicollinearity problems and a Ramsey's

Reset test is done to check for missing observation or misspecification bias. The following is the

empirical form of OLS regression model 3.

$$\log price\ (winbid) = \beta_1 colored + \beta_2 Captoutfac + \beta_3 halter\ trained +$$

$$\beta_4\ saddle\ trained + \beta_5 bidderclose + \beta_6 blasstock + \beta_7 monfac + \beta_8 Stallion + \beta_9 Mare +$$

$$\beta_{10} pinto + \in_3 \text{ (OLS regression Model 3)}$$

At this point, we transform OLS regression model 3 from log-linear into linear-log, linear-linear,

linear-log, log-log models. We check for misspecification error or missing variable bias using the

Ramsey' Reset test are on the different functional forms of OLS regression model 3. The

following are the empirical models for transformed version of OLS regression model 3 (all

restricting the variables *age* and *height*).

1) $\log price\ (winbid) = \beta_1 colored + \beta_2 Captoutfac + \beta_3 halter\ trained +$

$$\beta_4\ saddle\ trained + \beta_5 bidderclose + \beta_6 blasstock + \beta_7 logmonfac + \beta_8 Stallion +$$

$$\beta_9 Mare + \beta_{10} pinto + \in_3 \text{ (Log-log form of OLS model 3)}$$

2)

$$Price\ (winbid) = \beta_1 colored + \beta_2 Captoutfac + \beta_3 halter\ trained + \beta_4\ saddle\ trained +$$

$$\beta_5 bidderclose + \beta_6 blasstock + \beta_7 monfac + \beta_8 Stallion + \beta_9 Mare + \beta_{10} pinto + \in_3$$

(Linear-linear form of OLS model 3)

3) $Price\ (winbid) =$

$$\beta1\ colored + \beta2\ Captoutfac + \beta3\ halter\ trained + \beta4\ saddle\ trained +$$

$$\beta5\ bidderclose + \beta6\ blasstock + \beta7\ logmonfac + \beta8\ Stallion + \beta9\ Mare +$$

$$\beta10\ pinto + \in 3$$ (Linear-log form of OLS Model 3)

On the initial log-linear form of OLS regression model 3, a White test is done to check for

heteroskedasticity problems among the variance of the error terms. When misspecification or

missing observation bias exists it is possible that autocorrelation problems exist too. We test for

autocorrelation problems because the data used is time series. An asymptotic t test and a Breusch

Godfrey's LM test are then used to check for autocorrelation problems among error terms. Due

to the fact that the log-linear forms of OLS regression models 1-3 have the same dependent

variables (log price) the models could be compared and inferences could be made on Adjusted R

squares, R squares and T and F statistics. This study emphasizes on the log-linear form of OLS

model 3 as our primary hedonic model because it excludes the hypothetical troublesome

variables which are *age* and *height* and it was the model used in previous literature on this study.

The Empirical Results

 Based on an F test done on Model 1, all the variables are jointly significant as F statistics is

large value of 87.41 (87.41>4) and p is a small value of 0.001 (see results on table 1). We reject

the null hypothesis that all the variables are jointly not significant at both 1% and 5%

significance levels. A T statistical test on the model shows that the variables *colored, captoutfac,*

halter, bidderclose, stallion, mare and pinto are all significant at a 5% significance level.

Specifically, at both 1% and 5% significance levels the variables *colored*, *capoutfac, bidderclose* and *mare* are highly significant. However, *age, height, saddle, blasstock* and *monfac* are not significant at either 5% or 1% significance levels. OLS regression model 1 shows a high R square of 0.93 and adjusted R square of 0.92.

Interpreting signs on estimates in OLS regression model 1

All the estimates in OLS regression model 1 had positive signs except for the variables *age and saddle* (see table 1). The coefficient of *age* although not a statistically significant, had a negative sign which is in accordance with our theoretical expectation that horse adopters prefer to purchase younger horses. The negative sign on *age* can be interpreted as ceteris paribus, on average, the younger the horse the higher the sales price (winning bid price) for that horse and vice versa. The variable *saddle* which was also not significant had a negative sign on its coefficient which means that ceteris paribus, on average, horses with no saddle training compared to horses that have been saddle trained have higher bidding prices. This is not in accordance with our theoretical expectation that a saddle trained horse is more preferred to a horse with no saddle training. The positive signs on the other estimates (*colored, height, captoutfac, halter, bidderclose, monfac, stallion, mare, pinto, blasstock*) simply mean ceteris paribus, on average, horses with predominantly these qualities should increase the winning bid price of horses compared to horses without these or with less of these qualities. We theoretically expected variables *colored height, captoutfac, halter, bidderclose, monfac, stallion, mare, pinto, blasstock* to increase the winning bid prices

Further statistical tests done on OLS regression model 1

From the multicollinearity test on OLS regression model 1 (results on Table 2a), we fail to reject the null hypothesis that multicollinearity exists between variables *age and monfac.* The variables *age* and *monfac* showed VIF values of 14.240 and 16.192 respectively; we reject null hypothesis

based on the rule of thumb VIF>10 and there are no multicollinearity problems among other variables. The Ramsey's Reset test for misspecification or missing variable bias (see table 2b) shows a p value of less than 0.0001, hence, we have evidence to support the fact that misspecification error or missing variable bias exist. In other words, we reject the null hypothesis that there is no misspecification or missing variable bias. Ramsey's Reset test does not specify exactly whether the model has misspecification problems, or missing variable bias problems or whether both problem exits. It is should be noted however that missing variable bias problem is highly suspected considering that the variable *height* had 33 missing observations. The data used is truncated as the sample size was adjusted from 153 to 93 due to major problems with missing observations which is discussed in the data description section.

The White test for heteroskedasticity resulted in a large p value of 0.1905 (see table 2c) and a large chi-square of 76.94; hence we fail to reject the null hypothesis that no heteroskedasticity problems exists in the model. A further asymptotic t test for autocorrelation resulted in rho hat of 0.16075, so we calculate asymptotic t with square root of T (92)*0.16075(rho hat) to be 1.542; which is a value less than chisquare (3.84) at 1 degree of freedom (see table 2d). We therefore fail to reject the null hypothesis that no autocorrelation problems exists in the model. Breusch Godfrey test (see table 2e) showed a large LM's p value of 0.2269, again we fail to reject the null hypothesis that there are no autocorrelation problems in the model. As a result of the multicollinearity problems discovered in OLS regression model 1, all the inferences made on all estimates may be statistically imprecise.

The Results from estimating OLS regression Model 2(which restricted height)

OLS regression model 2 shows high R square value of 0.93 and adjusted R square value of 0.92 which is statistically satisfactory and are both the same as the R square and adjusted R square derived from OLS regression model 1 (see table 3). OLS regression model 2 shows a large F

statistics of 96.02 (96.02>4) and a small p value of 0.001. Therefore, there is strong evidence to support the fact that all the independent variables are jointly significant at both 1% and 5% significance levels. A T statistical test on Model 2 shows that *colored, captoutfac, bidderclose, halter, monfac, stallion, mare and pinto* are all significant at 5% significance level. Precisely, at both 5% and 1% significance levels the variables *colored*, *captoutfac*, *bidderclose* and *mare* are highly significant; these same variables were significant at both 5% and 1% level in OLS Model 1. However, *age, blasstock and saddle* are not significant at either 5% or 1% significance levels. Note that *monfac* which is not significant in OLS regression model 1 becomes significant in OLS regression Model 2. All the independent variables in OLS Model 2 had positive signs except for the variables *age* and *saddle*. Restricting *height* from Model 2 did not change the statistical insignificance of *age* and *saddle* although *monfac* which was insignificant in Model 1 becomes significant in Model 2. The signs on all the coefficients in OLS regression Model 2 have the same interpretations just as in OLS regression model 1.

Further Statistical tests done on OLS regression Model 2

From the multicollinearity test results of Model 2 (see table 4a) we fail to reject the null hypothesis that multicollinearity exists between the variable *age* and *monfac*. Variables *age* and *monfac* show high VIF's of 14.167 and 14.236 respectively. There are no multicollinearity problems among other variables except for *age* and *monfac*. A Ramsey's reset test for misspecification error or missing variable bias (see table 4b) resulted in a Reset value of 96.54 and a small p value of less than 0.0001. Hence, we reject the null hypothesis that no misspecification error or missing variable bias exists at both 1% and 5% significance levels. Again the Ramsey's Reset test does not tell us exactly which of the two problems exists but we are sure that missing variable bias exists due to the fact that height was restricted from the model. The white test for heteroskedasticity (see table 4c) in OLS model 2 showed a large p value of

0.054 (>0.05) and a large chisquare of 62.46. We therefore fail to reject the null hypothesis that

no heteroskedasticity problems exist in OLS regression model 2. A further asymptotic t test for

autocorrelation (see table 4d) showed rho hat is 0.13342, so we calculate asymptotic t with

square root of T (92)*0.13342(rho hat) to be 1.542; which resulted in 1.280 and this value is less

than 3.84 (chi-square value at 1 degrees of freedom). We therefore fail to reject the null

hypothesis that there is no autocorrelation problem in OLS regression model 2. Bresusch

Godfrey's test (see table 4e) showed a large LM's p value of 0.2499. We again fail to reject null

hypothesis that there are no autocorrelation problems in OLS model 2.We do not have strong

support that any economic inference made on OLS regression model 2 is precise because

multicollinearity problems still exists between the variables *age* and *monfac* .

The Results from estimating OLS regression Model 3 (which restricts both age and height)
The values of R square and adjusted R square in OLS regression Model 3 remains the same as

the values in OLS regression models 1 and 2.OLS model 3 (see table 5) has a large F statistics of

105.81(105.81>4) and a small p value of 0.001. Therefore, there is strong evidence to support the

fact that independent variables are jointly significant at a both 1%and 5% significance levels. A

T statistical test done on OLS regression model 3 shows that the variables, *colored*, *saddle,*

halter, mare, pinto, bidderclose, captoutfac, stallion, and monfac are significant at 5%

significance level. At both 5% and 1% significance levels the variables *colored*, *captoutfac,*

bidderclose, and *mare* remain highly significant as they are in OLS regression models 1 and 2.

However, only the variable *blasstock* is highly insignificant at both 5% and 1% significance

levels. All the independent variables in OLS regression Model 3 had positive signs except for

saddle (age has been excluded from the model). In OLS regression models 1 and 2 age and

saddle had negative signs and were both statistically insignificant. *Saddle* in OLS model 3 has a

negative sign and became statistically significant at 5% significance level. Theoretically, it is

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expected that a horse that has been saddle trained will attract higher bidding prices; OLS

regression model 3 contradicts this expectation. We have stronger evidence to conclude that

ceteris paribus, on average a horse that has no or less saddle training. The positive signs on other

variables *colored*, *halter, mare, pinto, bidderclose, captoutfac, stallion, and monfac* can be

interpreted as ceteris paribus, on average, a horse with any of the above mentioned qualities will

attract higher bidding prices.

Further statistical tests on OLS regression model 3

From the multicollinearity test on OLS regression model 3 (table 6a), the null hypothesis that

multicollinearity exists in the model is rejected. The VIF's of all the independent variables are

less than 10. In addition, the Ramsey's Reset test for misspecification error or missing variable

bias (see table 6b) e on OLS regression model 3 shows a Reset F statistics is 96.94 (>4) and a

small p value of less than 0.0001. We fail to reject the null hypothesis that no misspecification

error or missing variable bias exists. Ramsey's Reset test on the log-log functional form of OLS

regression model 3 shows a small p value of 0.0001 and a Reset F value of 44.3792 (see table

$6b_1$). We conclude that misspecification or missing variable bias exists in the log-log form of

OLS regression model 3. Ramsey's Reset test on the linear-linear form of OLS regression model

3(see table $6b_2$) shows that misspecification error or missing variable bias exists as Reset F value

is 4.5141 and p value is a small value of 0.0056. The null hypothesis that no misspecification

error or missing variable bias exists is rejected. Ramsey's Reset test on the lin-log form of OLS

regression model 3 (see table $6b_3$) showed a small p value of 0.03. We therefore reject the null

hypothesis that the model has no misspecification or missing variable bias (at 5% significance

level). In summary, misspecification error or missing variable bias exists in the log-linear, log-

log, linear-linear and linear-log, functional forms on OLS regression model 3. The log-linear

functional form of OLS regression model 3 remains our primary model of estimation. From the

White test for heteroskedasticity done on OLS regression model 3 (see table 6c) , p is a large value of 0.0534 and chi-square is a large value of 62.46. We therefore fail to reject the null hypothesis that there are no heteroskedasticity problems in OLS model 3. The asymptotic t test for autocorrelation (see table 6d) resulted in rho hat of 0.16802, so we calculate asymptotic t as 92*0.16802 which is 1.612 and is less than 3.84 (chisquare value at 1 degree of freedom). A second check for autocorrelation using Breusch Godfrey's test (see table 6e) showed p is a large value of 0.2779. We therefore fail to reject the null hypothesis that there is no autocorrelation problem in OLS regression model 3.

Discussions

From OLS model 1 *colored, captoutfac, halter, bidderclose*, *stallion, mare* and *pinto* are all statistically significant. The variables *age, height, saddle, halter, blasstock* and *monfac* are not statistically significant either at 5% or 1% significance levels. Theoretically, the variable *height* had a positive sign that indicates higher winning bid prices for horses that are taller compared to shorter horses. Although this variable is statistically insignificant, the theoretical sign on *height* was confirmed by the OLS results of Model 1. It is possible that wild horse buyers are more interested in preserving the heritage of wild horses than the height of the horses. Maynard and Stoeppel (2007) found racing quality like height as statistically significant and also as increasing auction prices in the thoroughbreds industry. Race horse buyers are most likely interested in the height of a horse compared to wild horse buyers. From this study, we can infer that height may not be one of the major qualities that wild horse buyers are interested in.

OLS Model 2 (which excluded height) discussed

The variable *monfac* which was insignificant in OLS model 1(see table1) became significant in OLS regression model 2 (see table 3). The statistically insignificant variables in OLS regression

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model 2 are *age*, *blasstock* and *saddle*. Theoretically, *age* and *saddle* are expected to be highly

significant with negative and positive coefficient signs respectively. This is because wild horse

buyers are expected to prefer younger horses to older ones similarly horses that have more saddle

training are expected to attract higher bidding prices. The negative sign on the coefficient of age

(see table 3) confirms the theoretical expectation of higher bidding prices for younger horses.

Wild horse buyers according to the report of a BLM representative, Shayne Banks, prefer and

pay more for younger horses than older ones. Theoretically the negative sign on *saddle* (see

table 3) is not expected. However, we observe based on the negative sign on *saddle* that wild

horse buyers prefer horses with less or no saddle training. In OLS model 2, saddle training is not

statistically significant which leaves us with not much evidence to conclude that wild horse

internet bidders do consider saddle training as important. The variable *halter* is statistically

significant with a positive sign on it coefficient as expected. The positive sign on *halter* indicates

that wild horse buyers prefer horses that have been halter trained to those that have not which is

in accordance with our theoretical expectation. Multicollinearity problems exists between

variables *age* and *monfac* which makes it difficult to make strong conclusions from OLS

regression model 2.

OLS Model 3 (which excluded age and height) discussed

The variable *saddle* became significant in OLS regression model 3. The coefficient of *saddle*

maintained its negative sign as it was in OLS models 1 and 2. There is now more evidence to

support the fact that internet bidders prefer horses that are not saddle trained to those that are

saddle trained. The variable halter is statistically significant with a positive sign which means

that wild horse buyers prefer horses that have been halter trained to those that have no halter

training. OLS regression Model 3 has no problems with multicollinearity which makes it easier

to make strong conclusions on estimates.

Economic Inferences on log-linear form of OLS Model 3 and demand elasticity

The variable *colored* has a positive sign on its coefficient and we infer that ceteris paribus, on average, a 1% increase in demand for a horse with a unique color (such as of roan, brown and palomino) compared to a horse that is either black or gray increases the winning bid price of a horse by 114% ($e^{0.761(\beta 1)} - 1 * 100$). For the variable *halter* we can infer that ceteris paribus, on average a 1% increase in bids for horses that have been halter trained compared to a horse without training increases the winning bid price of a horse by 66.86% ($e^{0.512(\beta 3)} - 1 * 100$). For the variable mare we can infer that ceteris paribus, on average, a 1% increase in bid for a horse that is mare compared to other sexes increase the winning bid price of a horse by 78.96% ($e^{0.582(\beta 9)} - 1 * 100$). The variable *Pinto* has a positive coefficient sign as expected and ceteris paribus, on average a 1% increase in bids for a horse with pinto compared to a horse with no pinto increases the winning bid price of a horse by 64.5% ($e^{0.498(\beta 10)} - 1 * 100$). The positive sign on the coefficient of *bidderclose* was expected and we infer that ceteris paribus, on average, a 1% increase in the number of bidders who are in the same state of sale compared to bidders who are out of the state of sale will increase the winning bid price of a horse by 92.32% ($e^{0.654\ (\beta 5)} - 1 * 100$).

The positive sign on *captoutfac* was expected and ceteris paribus, on average a 1% increase in bid for a horse captured out of the facility compared to a horse born in the facility, is expected to increase the winning bid price of a horse by 100.3% ($e^{0.695\ (\beta 2)} - 1 * 100$). It makes sense that horse buyers who are interested in wild horses prefer to buy the horse that have been captured out of facility because horses born in the facility have been domesticated such that they cannot be referred to as wild. The positive sign on *stallion* is expected and it indicates that ceteris paribus, on average a 1% increase in bids for a stallion compared to other sexes increases the

winning bid price of by 101.78% ($e^{0.702(\beta 8)} - 1 * 100$). The positive sign on *monfac* was expected and indicates that ceteris paribus, on average a 1% increase in the bids for horses that have stayed longer in the holding facility is expected to increase winning bid price by 0.32% ($e^{0.016(\beta 7)} - 1 * 100$). It is most likely that a horse that has stayed longer in the holding facility is in better health with a more controlled behavior and temperament compared to horses that have not stayed long enough in the holding facility. The variable *saddle* has a negative sign which was not expected and can be interpreted as ceteris paribus on average, a 1% increase in time spent saddle training a horse is expected to decrease the winning bid price by 90.98% ($e^{0.647(\beta 4)} - 1 * 100$).

Conclusions

This study measures the physical characteristics of wild horses and burros placed on internet auctions that significantly contribute to the winning bid price of horses. We identify these characteristics as *colored, halter, mare, pinto, bidderclose, captoutfac, stallion,* and *monfac*. The highly significant variables at (5% and 1%) levels were *bidderclose, captoutfac*, *mare* and *colored*. Saddle training was significant with a negative impact on bidder's desire to bid for a horse. Halter training was significant with a positive impact on bidder's desire to bid for a horse. A 1% increase in bids for horses that are colored, halter trained, mare, pinto, stallion, captured out of facility, stayed long in the facility, is expected to increase the winning bid price of a horse by 114%,66.86%, 78.96%, 64.5%, 100.78%, 100.3%,0.32% respectively. We can infer that colored, mare, stallion, and captured out of the facility have demand elasticity higher than 70%. These qualities have the most tendencies to increase the winning bid price or final sale price and number of bids of a horse. On the one hand, saddle training decreases the likelihood for buyers to bid on a horse. The variable saddle has a negative coefficient and a negative demand elasticity of

90.98% .Halter training, on the other hand, has a positive demand elasticity of 66.86%. The location of a bidder matters to how well a horse is bid for. Buyers who are close to the location of sale of wild horses bid higher for these horses. The multicollinearity between age of an animal and months spent in facility was removed when the variables age and height were dropped from OLS regressionmodel.3 Height was dropped because of the missing observations it had and age was dropped because it was statistically insignificant and it linearly correlated with the number of months a horse has stayed in the facility. Age was found to be statistically insignificant probably because wild horse buyers are more concerned about the "wild" that is where the horse was captured. Wild horse buyers are generally people who care about preserving horses from extinction. In addition, wild horse buyers prefer horses that are captured out of the facility to the ones born in the facility which means that there is a smaller chance that horses born in the facility will increase adoption rate. This study shows that sterilization of animals in the facility is a great strategy to increase adoption rate because animals born in the facility are less preferred to those captured out of the facility. Finally, it was discovered that wild horse buyers will purchase horses that have been captured out of the facility and have spent a long time in the holding facility. In other words, wild horse buyers would buy wild horses for prestige and for the sake of the wild origin but at the same time want the horses to have stayed long enough in the facility. In summary, purchasing an animal born in the facility may not fulfill the purpose of owning one of America's most cherished heritage.

Agribusiness Policy Implications

The BLM's goal is to increase adoption rate and maintain the number of wild horses on rangelands. Sterilization could be done after horses are captured and kept in the facility. At the same time the adoption rate of animals can be increased because we know from our results that animals born in the facility are not as preferred as those captured out of the facility. The BLM

can also use the results from this study to change its auction strategy such that the characteristics that most increase adoption rate can be emphasized during marketing and advertisement. Presently the BLM's suggestions for bidders fails to emphasize on halter training information , mare or stallion, pinto, horses captured out of the facility and months held in facility. The BLM could display these great qualities on billboards and on its website page. To increase public adoption rate the BLM could try to target buyers that are in the same state as sale location since bidders that are close place higher bids on horses.

It should be noted that there are other econometric models to approach the analysis of hedonic pricing in Wild horses. A major weakness of this study is the missing observations from the variable height and horses that were not bid for. The data used in this study is truncated which makes OLS models not the most appropriate method of estimation. Another model to use will be torbit which works well for trauncated data. Further research could be done in this field using the torbit model. Another weakness is internet auctions are not live such that buyers can see the physical attributes of these horses. This may affect the bidding interest of buyers compared to live auctions.

Appendix

Table 1: **OLS regression** results for *Model 1* which included age and height

Variable	Coefficients	T values	P values
Colored	0.757	5.43	0.0001**
Age	-0.074	-0.84	0.406
Height	0.002	0.64	0.526
Captoutfac	0.713	4.47	0.0001**
Halter	0.470	2.17	0.033*
Saddle	-0.514	-1.49	0.141
Bidderclose	0.611	2.96	0.004**
Blasstock	0.164	1.18	0.243
Monfac	0.021	1.83	0.071
Stallion	0.742	2.45	0.016*
Mare	0.604	4.26	0.0001**
Pinto	0.454	2.11	0.031*

| No of Obs 93 | R square 0.93 | Adj R 0.92 | F value 87.41 |
| | | | P value 0.001 |

** indicates significance at 1% level * indicates significance at 5%
Table 2a: Multicollinearity test results for *OLS Model 1* which included age and height

Variable	Coefficients	P value	Variance Inflation
Colored	0.757	0.0001**	3.451
Age	-0.074	0.406	**14.240**
Height	0.002	0.526	3.641
captoutfac	0.713	0.0001**	4.077
Halter	0.470	0.033*	2.310
Saddle	-0.514	0.141	2.657
Bidderclose	0.611	0.004**	1.258
Blasstock	0.164	0.243	2.108
Monfac	0.021	0.071	**16.192**
Stallion	0.742	0.016*	1.355
Mare	0.604	0.0001**	2.821
Pinto	0.454	0.031*	1.260
No of Obs 93	R square 0.93	Adj R 0.92	F value 87.41
			P value 0.001

** indicates significance at 1% level * indicates significance at 5%
Table 2b: *Ramsey's Reset test* result for misspecification/missing variable bias on **OLS Model 1**

Power	Reset	Pr>F
4	**96.6707**	**<.0001**

Table 2c: *White test for Heteroskedasticity* result on *OLS Model 1*

DF	Chisquare	Pr>Chisq
67	**76.94**	**0.1905**

Table 2d: *Asymptotic t test for Autocorrelation* result of *OLS Model 1*

Variable	label	DF	Parameter Estimate	Standard Error	T value	Pr> t
Intercept	**Intercept**	**1**	**0.11060**	**0.06173**	**1.79**	**0.0766**
resdlg		**1**	**0.16075**	**0.10340**	**1.55**	**0.1235**

Table 2e: Breusch Godfrey LM (serial correlation) test result for autocorrelation for OLS Model 1

Alternative	LM	Pr>LM
AR(1)	**1.3236**	**0.2499**

Table 3: OLS regression results of OLS *Model 2* which excluded variable height

Variable	Coefficient	T values	P values
Colored	0.755	5.44	0.0001**
Age	-0.078	-0.89	0.3780
Captoutfac	0.744	4.91	0.0001**
Halter	0.473	2.20	0.031*
Saddle	-0.546	-1.60	0.114
Bidderclose	0.624	3.05	0.003**
Blasstock	0.166	1.19	0.236
Monfac	0.024	2.19	0.031*
Stallion	0.707	2.38	0.020*
Mare	0.602	4.27	0.0001**
Pinto	0.478	2.26	0.027*
No of Obs 93	R square 0.93	Adj R 0.92	F value 96.02
			P value 0.001

** indicates significance at 1% level * indicates significance at 5%
Table 4a: Multicollinearity test results for *OLS Model 2* which excluded height variable

Variable	Coefficients	P value	Variance inflation

Variable			
Colored	0.755	0.0001	3.449
Age	-0.078	0.378	**14.167**
Captoutfac	0.744	0.0001	3.702
Halter	0.473	0.003	2.309
Saddle	-0.546	0.114	2.603
Bidderclose	0.624	0.003	1.245
Blasstock	0.166	0.236	2.108
Monfac	0.024	0.031	**14.236**
Stallion	0.707	0.020	1.309
Mare	0.602	0.0001	2.820
Pinto	0.478	0.027	1.224
No of Obs 93	R square 0.93	Adj R 0.92	F value 96.02 P value 0.0001

Table 4b: *Ramsey's Reset test* result for misspecification/missing variable bias on **OLS Model 2**

Power	Reset	Pr>F
4	**95.0871**	**<.0001**

Table 4c: *White test for Heteroskedasticity* result on **OLS Model 2**

DF	Chisquare	Pr>Chisq
56	**73.96**	**0.0542**

Table 4d: *Asymptotic t test for Autocorrelation* result of *OLS Model 2*

Variable	label	DF	Parameter Estimate	Standard Error	T value	Pr> t
Intercept	**Intercept**	**1**	**0.11381**	**0.06219**	**1.83**	**0.0706**
resdlg		**1**	**0.13342**	**0.10382**	**1.29**	**0.2020**

Table 4e: Breusch Godfrey LM (serial correlation) test result for autocorrelation for OLS Model 2

Alternative	LM	Pr>LM
AR(1)	**1.4599**	**0.2269**

Table 5: OLS regression results for *Model 3* which excluded height and age variables

Variable	Coefficients	T value	P value
Colored	0.761	5.49	0.0001**
Captoutfac	0.695	4.93	0.0001**
Halter	0.512	2.43	0.017*
Saddle	-0.647	-2.02	0.047*
Bidderclose	0.654	3.25	0.002**
Blasstock	0.161	1.16	0.2478
Monfac	0.016	2.33	0.023*
Stallion	0.702	2.37	0.020*
Mare	0.582	4.18	0.0001**
Pinto	0.498	2.37	0.020*
No of Obs 93	R square 0.93	Adj R 0.92	F value 105.81 P value 0.001

** indicates significance at 1% level * indicates significance at 5%

Table 6a: **Multicollinearity** results of *Model 3* which excluded age and height

Variable	Coefficients	P value	Variance Inflation
Colored	0.761	0.0001**	3.441
Captoutfac	0.695	0.0001**	3.213
Halter	0.512	0.017*	2.214
Saddle	-0.647	0.047*	2.309
Bidder close	0.654	0.002**	1.212
Blasstock	0.161	0.2478	2.015
Monfac	0.016	0.023	6.135

Stallion	0.702	0.020*	1.309	
Mare	0.582	0.0001**	2.745	
Pinto	0.498	0.020*	1.209	

** indicates significance at 1% level * indicates significance at 5%

Table 6b: *Ramsey's Reset test* result for misspecification/missing variable bias on the log-linear form of **OLS Model 3**

Power	Reset	Pr>F
4	**96.9421**	**<.0001**

Table 6b₁: *Ramsey's Reset test* result for misspecification/missing variable bias on the log-log form of **OLS Model 3**

Power	Reset	Pr>F
4	**44.3792**	**<.0001**

Table 6b₂: *Ramsey's Reset test* result for misspecification/missing variable bias on the *linear-linear* form of **OLS Model 3**

Power	Reset	Pr>F
4	**4.5141**	**0.0056**

Table 6b₃: *Ramsey's Reset test* result for misspecification/missing variable bias on the linear-log form of **OLS Model 3**

Power	Reset	Pr>F
4	**3.0491**	**0.0333**

Table 6c: *White test for Heteroskedasticity* result on **OLS Model 3**

DF	Chisquare	Pr>Chisq
46	**62.46**	**0.0534**

Table 6d: *Asymptotic t test for Autocorrelation* result of *OLS Model 3*

Variable	label	DF	Parameter Estimate	Standard Error	T value	Pr> t
Intercept	**Intercept**	**1**	**0.11105**	**0.06216**	**1.79**	**0.0774**
resdlg		**1**	**0.16802**	**0.10328**	**1.63**	**0.1073**

Table 6e: Breusch Godfrey LM (serial correlation) test result for autocorrelation for OLS Model 3

Alternative	LM	Pr>LM
AR(1)	**1.1774**	**0.2779**

Table 7: Summary Statistics

Variable	Description	Observation	Mean	Standard deviation	Min	Max
logwinbid	**Log of winning bid**	**93**	**2.199**	**0.302**	**1.041**	**3.000**
Black	**Black**	**93**	**0.226**	**0.420**	**0**	**1.000**
Colored	**Other colors**	**93**	**0.774**	**0.420**	**0**	**1.000**
Age	**Age**	**93**	**2.328**	**1.568**	**0.500**	**8.000**
Height	**height**	**93**	**32.978**	**28.250**	**0**	**62.000**
Bonfac	**Born in holding facility**	**93**	**0.301**	**0.461**	**0**	**1.000**
Captoutfac	**Captured out of facility**	**93**	**0.699**	**0.461**	**0**	**1.000**
Monfac	**Months in facility**	**93**	**20.054**	**11.308**	**2.000**	**65.000**
Halter	**Halter trained**	**93**	**0.215**	**0.413**	**0**	**1.000**
Saddle	**Saddle trained**	**93**	**0.097**	**0.297**	**0**	**1.000**
Bidderclose	**Bidder close**	**93**	**0.129**	**0.337**	**0**	**1.000**
Bidderfar	**Bidder far**	**93**	**0.871**	**0.337**	**0**	**1.000**
Stallion	**Stallion**	**93**	**0.064**	**0.247**	**0**	**1.000**
Mare	**Mare**	**93**	**0.613**	**0.489**	**0**	**1.000**
Pinto	**Pinto**	**93**	**0.118**	**0.325**	**0**	**1.000**

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