The Impacts of Policy and Macroeconomic Conditions on Horse Markets

By

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In the United States, horses have long served people as work animals, recreation companions, and even as family pets. Consumption, however, has never been a culturally accepted practice in the United States. The practice of slaughtering horses for meat is politically contentious and, over the past decade, several attempts have been made to ban horse slaughter in the United States. In September of 2007, the three remaining U.S. slaughter plants, located in Texas and Illinois, were closed due to passage of state laws banning horse slaughter.

Horses are not typically raised solely for slaughter, but the availability of a slaughter market does provide a salvage value for horses that do not have sufficient value in the recreation or work horse markets and are of an age and physical conformation suitable for slaughter. Closure of domestic slaughter plants in 2007 did not eliminate the slaughter market entirely because horses could still be exported for slaughter to Canada or Mexico. However, it did increase the costs incurred by slaughter buyers to get live horses to a processing plant. As a result of slaughter buyers facing higher costs of doing business, they bid less for live horses at market, thereby decreasing the salvage value of horses suitable for slaughter.

While ending domestic slaughter may have devalued horses, a nearly simultaneous factor putting downward pressure on prices in the horse market was the economic downturn that began in 2008. A recent report by the Government Accountability Office (GAO) suggests that the number of horses either abandoned or given to horse rescue facilities increased dramatically in the past four years (GAO 2011). This trend suggests that as household incomes decline, the ability of some households to continue caring for or to buy additional horses is reduced. The impact is a decline in the number of buyers and an increase in the supply of horses in the market. Both factors are expected to decrease the value of horses.

With the beginning of a recession and a slaughter ban taking effect in such a short time period, it is important to investigate not only if there are effects on the price of horses but also the relative magnitude of those effects. An estimate of the effects would serve to inform policy makers, horse owners, and potential slaughter plant investors of the change in live horse prices if the slaughter ban were lifted, as well as how prices would have to change to return to pre-recessionary levels.

Since horses are not raised as meat animals, a single market for slaughter horses does not exist. This means that buyers looking to purchase horses for slaughter (known as slaughter buyers) are mixed in with other types of buyers at horse auctions. The lack of a distinct meat market for horses makes it difficult to track changes in prices that may be due to closing slaughter plants. Therefore, we estimate the effects of slaughter plant closings on live horse prices using prices from a large regional auction in Billings, Montana. A hedonic model is specified that allows us to control for the variability of horse characteristics, marketing tactics by sellers, feed costs, and time-dependent effects including the start of the national recession in 2008. The model is estimated in a quantile regression framework that allows for the effect of the slaughter ban to vary across sale price levels.

Results from our model suggest that horse prices have been negatively impacted by the closing of slaughter plants in 2007. This negative effect is limited, however, to horses within a certain price range ($850 to 1,100 per head), suggesting that horses with an option value for uses other than meat have not been adversely affected by the slaughter ban. The economic downturn that began in 2008 has also negatively affected horse prices. However, lower prices due to the recession are not limited to any particular price range.

Background on Horse Slaughter in United States

While consumption of horse meat has never been a culturally accepted practice in the United States, there are several other countries where horse meat is consumed and often considered a delicacy. With a large supply of horses and no domestic demand for meat, the United States has historically been a net exporter of horse meat. In 2006, the United States exported horse meat to the following countries (listed in order by highest value importer): Belgium-Luxembourg, Switzerland, France, Russia, Japan, Mexico, Germany, Italy, Netherlands, Taiwan, and the Bahamas (FAS-GATS 2011).

In the 1990's, animal welfare groups began to actively exert political pressure to end the slaughter of horses for human consumption. A 2005 federal amendment to ban the use of government funds for slaughter plant inspectors stopped processing for a short time, but was eventually circumvented when plant owners agreed to pay for inspectors' services privately. Although unsuccessful at the federal level, progress toward ending horse slaughter was being made through state legislative channels. By 2007, only three horse slaughter facilities remained in the United States, two in Texas and one in Illinois. Slaughter in Texas was ended in January of 2007 when the U.S. Court of Appeals for the 5th Circuit upheld a 1949 Texas law that banning the sale of horsemeat. In May of the same year, the Illinois state legislature passed a law banning horse slaughter in the state, thus closing the last U.S. slaughter facility.

A ban on horse meat processing in the United States has not ended the purchase of horses for slaughter. Slaughter buyers continue to purchase live horses for export. The number of horses exported for slaughter in 2010 was 137,000; nearly the same as the total of horses slaughtered domestically and exported for slaughter in 2006 (GAO 2011). Although a slaughter market still exists, U.S. slaughter buyers face increased costs in the form of both higher transportation costs (horses may be hauled longer distances) and higher transaction costs of moving live animals across international borders (e.g., paperwork, health inspections).

Literature Review

Several studies of horse auctions have been conducted, most using a hedonic model to measure the value of implicit characteristics on sale prices (see Landsford et.al. 1998; Vickner and Koch 2001; Robbins and Kennedy 2001; Taylor et.al. 2006). Other factors, such as macroeconomic conditions, have also been shown to affect prices at auction (Buzby and Jessup 1994; Neibergs and Thalheimer 1997).

Studies comprising the existing literature on horse auctions have several commonalities. First, sale prices of horses tend to be highly skewed. While the majority of horses sell within a small range, there are typically a few horses that sell for very high prices. This may be due to pedigree, training, or performance record. The skewed distribution typical of horse auction data has lead researchers to employ semi-log functional forms for estimation of hedonic models. Another commonality is certain characteristics of horses tend to consistently be statistically significant determinants of price. These characteristics are horse-specific and include age, sex, and pedigree. Lastly, the data used in horse auction studies originate from sales that have a particular theme or requirement for participation. Sales tend to be organized around discipline (showing, racing), sex (broodmares), or age (yearling). This provides an element of uniformity in the data available on horses sold at auction. The data used in this article contrast sharply with themed sales in that both the fall and spring auctions in Billings, Montana are general sales and no specific requirements are made of the horses being brought to auction. Age, sex, discipline, training, and breed all vary across a wide range.

This lends a great deal of variability in the data, which can be beneficial for statistical analysis or constrain the number of independent variables due to a lack of consistent information on horses sold. For example, performance record (showing or racing) has been shown to be a statistically significant predictor of sale price (Vickner and Koch 2001; Taylor et.al. 2006). But this information will not be present for a green broke horse because they have never performed in a manner that can be objectively measured. Therefore, model specification and the inclusion of certain horse-specific characteristics are drawn from previous literature as much as possible.

This is the first known study to address the impacts of slaughter cessation on market prices for horses. In a related study, North, Bailey, and Ward (2005) estimate the potential economic impacts from a proposed slaughter ban. With the existence of a slaughter market, horses with no other use (culls) still have a salvage value. Removal of the slaughter market drives this salvage value to zero and the impact on the economy is estimated to be \$20-\$29 million from increased disposal costs of cull horses. The loss of the slaughter market would also cause the U.S. export market for horsemeat to disappear, resulting in an additional economic cost of \$26 million. The authors point out that the use of the a net present value method for determining the cost of disposing cull horses does not include potential impacts on prices of horses that are not slaughtered and, at the time of the study, data to measure this impact were not available.

This article contributes to the existing literature by estimating a hedonic pricing model to determine if there has been an effect from the cessation of horse slaughter in the United States on the price of horses. This estimate is obtainable through the use of a proprietary dataset spanning a time period of several years before and after the closing of all U.S. slaughter facilities. The results of our estimation serve to inform policy makers, horse owners, and potential slaughter plant investors of the change in live horse prices if the slaughter ban were lifted as well as how prices would have to change to return to pre-recessionary levels.

Model of the Horse Market

The events of the past few years and the hypothetical effects on price and quantity that correspond to those events are represented graphically in figure 1. Panel A represents the supply and demand for slaughter horses before the slaughter plants closed or the recession began. The quantity Q would be equivalent to the total number of horses slaughtered domestically or exported to Canada or Mexico for slaughter. With the closure of domestic plants and the higher transportation and transaction costs borne by U.S. slaughter buyers, demand for slaughter horses shifts in from D to D’. This depresses the price for slaughter horses from P^1 to P^2, as shown in panel B. If this were the only event affecting the slaughter horse market, then we would expect the quantity of horses that are purchased for slaughter and exported to be less than the quantity Q. However, the economic downturn has caused an increase in the number of horses available in the slaughter market, causing the supply to shift out from S to S', as shown in panel C. The scale of the shifts in supply and demand would have to be roughly equivalent to result in the same quantity of horses slaughter before and after both events, as appears to have happened between 2006 and 2010. As a result, even more downward pressure is put on slaughter horse prices with prices dropping from P^1 to P^3.

The economic model estimated in this article is intended to test whether or not the shifts in supply and demand presented in figure 1 occured and estimate the impacts on price from each event, separately. This is done using a hedonic price regression. Following Rosen's 1974 model of implicit prices, horses are assumed to be a heterogeneous good and the price paid for them at auction is influenced by the horses' characteristics. We specify the price of a given horse at auction as

$$P(\boldsymbol{x}, \boldsymbol{z}) = f(x_1, \dots, x_n, z_1, \dots, z_n) \qquad (1)$$

where $\boldsymbol{x}$ is a vector of horse-specific characteristics, $\boldsymbol{z}$ is a vector of time-specific characteristics. The price function is continuously differentiable up to the second order. The price function is simultaneously determined by bid and offer functions of buyers and sellers. Assuming a fixed supply of horses at auction, the bid functions are sufficient to identify an equilibrium price function.[1] The regression variables are listed in table 2, along with descriptions of the variables.

The vector of horse-specific characteristics used in the hedonic pricing model includes physical attributes and training or experience level of the horse. Physical attributes of the horses, including their age, gender, and breed are used. The age of a horse enters the model as both a linear (*Age*) and quadratic (Age^2) term to account for the potential non-linear impact of more years of training or experience of the horse. It is expected that while additional years of age would be valuable to a buyer, that price effect will decline once the horse passes a particular age threshold.

Gender is categorized into one of three parameters: *Mare* equals one for female horses and zero otherwise; *Stallion* equals one for male horses and zero otherwise; and *Gelding* equals one for neutered male horses and zero otherwise. We do not have any expectations of price impact of the gender variables *a priori*.

Horses can be characterized as either purebreds (Quarter Horse, Apaloosa/Paint, Thoroughbred) or a mixed/unknown breed (grade) and this information is given to buyers at auction. The breed parameters in this model are categorized into five distinct groups: *Breed_QH* are horses whose breed is listed as Quarter Horse; *Breed_AP* are Apaloosa or Paint breeds; *Breed_Other* are a mixture of other specified breeds; and *Breed_Grade* are horses of unknown breed. The effects of these factors on sale price is not clear and, therefore, left to be determined empirically.

The training and experience of a horse is very likely to affect the number of potential buyers and, therefore, the overall sale price. Horses with training for specific tasks or performance records that indicate high skill levels are likely to fetch a higher price in the market. To capture these potential effects, the training of each horse was categorized into six distinct groups of binary indicator variables.[2] The first variable is *NoStart*, which indicates that the horse has not been broke to ride or received any other specific training. The next variable is *Broke*, indicating a horse has been broke to ride, but does not have other training. The third training variable is *Mountain* and it indicates a horse has experience being ridden or used as a pack animal in mountainous terrain. The fourth category of training is measured by the variable *Ranch* and indicates a horse that has experience doing a variety of tasks commonly needed for ranch work. The fifth training variable, *Showing*, indicates a horse that has experience in the show ring and is likely to be trained for a variety of disciplines including cutting, reigning, Western pleasure, etc. The final training variable is *Breeding*, which indicates a horse is most suitable for breeding purposes only. The effect of these training parameters on sale price is difficult to determine *a priori* and is left as a quantitative effort.

Other horse-specific factors that may affect the selling price of a horse at auction are not considered physical, but rather reflect marketing strategies of a seller or management of the auction. For example, the order in which the horses are sold; the extent of information provided by a seller to potential buyers; and the distance travelled by the horse to the sale are all specific to each horse sold, but are not characteristics of the horses themselves. Sale order (commonly referred to as the hip number) is a continuous variable that enters the model as both a linear term (*Hip*) and a quadratic term (Hip^2) to capture any nonlinear effects that sale order may have on the final bids of buyers.

The effort that sellers put forth to market their horses may also affect the sale price. A catalog of all the horses entered in the sale is published prior to the sale and available to potential buyers. The information listed in the catalog for each horse varies widely, from two or three lines of basic information to an extensive description of the horse; its pedigree, training, and competition earnings; a picture of the horse; and contact information for the seller. The amount of information provided in the sale catalog may signal quality of the horse to potential buyers. Therefore, variables are included in the model to account for this signaling effect. The first parameter (*Picture*) is a binary variable equal to one if a picture of the horse is included in the catalog and equal to zero otherwise. The second variable (*Contact*) is also binary and equals one if the seller's contact information is listed in the catalog. It is equal to zero if no contact information is provided. Also included in the model is a binary variable indicating if a horse has documentation of a negative Coggins test (*Coggins*). A negative Coggins test is required for a horse to be transported across state lines and for participation in many organized horse events. We expect the marketing variables to positively affect sale price.

The remaining horse-specific variable included in the model is the distance traveled to the sale. The catalog description for each horse contains a reference to the home town and state of the horse. This information can be used to calculate the approximate distance traveled to get the horse to auction. The variable *Distance* enters the model as an inverse quadratic term defined as

(2) $$Distance = [1/(miles)^2]$$

where *miles* is the distance from the home town and state to the auction location. It is possible that sellers traveling further have a lower reservation price than others, especially if travel costs are high for hauling a horse back home. Therefore, the expected sign for $IDist^2$ is positive.

For a given auction, the observations of horses sold constitute a cross-section of data. The data presented in this article are observations on horses sold at the same auction, but over a period of seven years. However, the number of horses that are sold more than once at this sale during the time period analyzed is unknown. Therefore, we consider these data to be a repeated cross-section of observed sale prices rather than a panel dataset. Given the potential for both seasonal and annual changes in the macroeconomic conditions that may affect buyers willingness to pay for horses, we add fixed effects to the model that are time-specific. The parameter *Fall* is included in the model as a binary variable equal to one if an observation is from a fall sale and zero if it is from a spring sale. Annual fixed effects are included in the model to account for any factors that may be pertinent to the horse industry or horse buyers and occur in certain years of the data sample (*Year1*-*Year7*). The individual year and season effects on sale price are to be determined empirically.

The cost of feeding horses is expected to have an impact on the price buyers are willing to pay. Depending on the way a horse is boarded, feed cost can be comprised of pasture grazing fees, hay and grain prices, and feed supplement prices. Drought or wet conditions, can impact not only the quality and carrying capacity of pasture, but also the availability of hay. For both feed sources, drought conditions can greatly increase the cost of feeding horses. As a proxy for the cost of feed a horse, the hedonic model estimated includes a historical drought index variable, *Drought_Index*. It is expected that as the price of feed increases (drought conditions worsen); the price people are willing to pay for horses will decline.

The focus of this article is to determine if, and to what extent, policies pertaining to horse slaughter and recessionary macroeconomic conditions have affected horse markets in the United States. A fixed effect variable is used to measure impacts of the last three domestic plants ending operations in the summer of 2007. The variable *No_Slaughter* is equal to one if an observation comes from a sale that occurred after the plant closures and zero if the observation is from a sale held prior to the closures. The economic downturn that began in 2008 is proxied by a twelve-month moving average of the Bureau of Labor Statistics unemployment index. The unemployment index variable, *Unemp_Index*, represents the changes in household disposable income that are likely to be used for purchases of horses. As discussed previously, both events are expected to negatively affect the value of horses, as measured by prices at auction.

Data

The data used for this analysis include over 4,500 auction transactions. The horses sold in the sale came from 32 states and Canadian provinces, with the majority from Montana (29%) and Wyoming (16%). This auction averages over 390 horses sold per sale, with an average sale price of $1,492 per head and a median sale price of $1,100 per head. Summary statistics of sale prices, by year and sale are given in table 1. As seen in figure 2, the distribution of horse sale prices is highly skewed. Therefore, the dependent price variable in the hedonic model is a natural log transformation of the sale prices (*ln(Sale_Price)*). Summary statistics of the variables used in the hedonic regression are given in table 2.

The data used to estimate the model were collected from several sources. The sale price data and corresponding sale catalog information on each horse in the dataset were gathered from sales held at the Billings Livestock Commission Company. Each horse entered in the sale is featured in a sale catalog, which is posted to a public website for potential bidders to read. The information available on each horse in the catalog varies, depending on what the seller provides to the auction company. The variables included in the hedonic model were based on information that was available for all the horses in the final dataset.

Additional data used in the model were collected for the variables used to proxy feed costs (*Drought_Index*) and the economic downturn (*Unemp_Index*). The variable *Drought_Index* was created using six-month historical average of the Palmer Drought Severity Index (PDSI) for the state of Montana (NOAA, 2011). For each fall and spring sale in the dataset, the average value of the PDSI in the previous 6 months for Montana was calculated. The variable *Unemp_Index* was calculated using a seasonally-adjusted unemployment index for the Mountain region, published by the Bureau of Labor Statistics (BLS, 2011).[3] This index enters the model as an average of the index value for the twelve months preceding each sale in the dataset.

Econometric Model Results

The hedonic model specified in equation (1) is estimated using the quantile regression method. A quantile regression is used rather than ordinary least squares for several reasons. Quantile regression (QR) has several statistical properties that make it attractive for this application. First, a normally distributed data population is not required for quantile regression. As shown in figure 2, the sale prices are not normally distributed. We applied a natural log transformation to the data to reduce the skewness of the data, but skewness tests applied to the transformed data indicate the null hypothesis of normality is rejected, indicating OLS would still be susceptible to biased estimates. Second, applying the natural log to the data does not complicate the QR regression, as it is invariant to monotone transformations (Koenker 2005).

The QR method is appropriate in this application for reasons based on economic intuition as well. The Billings, Montana horse auction is not a market purely for one kind of horse. That is, it is comprised of work horses, recreational horses, breeding stock, and horses that would be suitable for slaughter. This heterogeneity in the type of horses, and buyers, is likely the source of the variability in observed sale prices. As such, it is likely that a policy specific to slaughter horses will not necessarily impact all the horses at this sale in the same way. Slaughter buyers are constrained by both the physical suitability of a horse for slaughter, but also the per pound price they will receive for the animal from the slaughter plant, both of which are unobservable to the researcher. As such, there is a range of prices in which slaughter buyers will be competitive bidders. This range is not known; therefore we use the flexibility of the QR to be estimated at various price levels to determine which horses may be affected by the slaughter ban policy.

The coefficient estimates of the QR over 10 percent quantile intervals are presented in table 3. Interpretation of the QR coefficients directly is not useful, as they are related to the data transformed by the natural logarithm. Therefore, the coefficient estimates are re-transformed using the *mean effect* (ME) method of determining the impact of a covariate on the raw scale ($/head), rather than the transformed scale (*ln*($/head)) (Hao and Naiman 2007, pp. 83-85). The formula for obtaining the mean effect estimate of the change in price for any continuous variable *x* from quantile *q* is as follows

(4) $$ME_x^{(q)} = \frac{1}{n}\sum_{i=1}^{n}\left[e^{\hat{\alpha}^{(q)}+\hat{\beta}_x^{(q)}(x_i+1)+\hat{\beta}_d^{(q)}d_i} - e^{\hat{\alpha}^{(q)}+\hat{\beta}_x^{(q)}x_i+\hat{\beta}_d^{(q)}d_i}\right]$$

where *d* denotes a discrete variable and *n* is the number of horses in the sample. The impacts of a one unit change in variable *x*, is calculated for each horse (*i*) in the sample and then averaged over all the horses. Similarly, the mean effect estimate of the change in price for any discrete variable is as follows

(5) $$ME_{d,0,1}^{(q)} = \frac{1}{n_0}\sum_{i:d_i=1}^{n}\left[e^{\hat{\alpha}^{(q)}+\hat{\beta}_x^{(q)}(x_i)+\hat{\beta}_d^{(q)}} - e^{\hat{\alpha}^{(q)}+\hat{\beta}_x^{(q)}x_i}\right]$$

where the mean effect is calculated only over the subgroup of $d_i = 0$ and n_0 denotes the number of horses in that subsample. The ME estimates and the corresponding 95 percent confidence intervals, are shown in table 4. The confidence intervals are calculated from the median QR coefficients using a 500-draw bootstrap.

The results of median QR suggest that both the slaughter ban and the recession negatively affected sale prices of horses sold at the Billings, Montana auction. However, the effects of the slaughter ban vary, depending on the price of the horse. The estimated mean effect of the ban on the median priced horse, which sold for $1,100, is a decrease of $190 per head. This decline assumes that all other factors are held constant. In other words, if the same horse were sold before the slaughter ban, it would have sold for approximately $190 more than if it were sold after the slaughter ban. This negative price effect does not impact all horses equally. The results suggest that horses priced near the bottom of the price distribution (e.g. less than $300 per head) have not been affected by the slaughter ban. This may be due to the age and conformation of the horses sold well below the median price, which likely is not suitable for slaughter. Also, horses that sold at prices above the median (greater than $1,400) were not affected by the slaughter ban.[4] These horses are likely to still have a high enough value for other purposes that they are too expensive for slaughter buyers to competitively bid on.

The recessionary effects, as measured by the BLS unemployment index, suggest a much larger negative impact on sale prices and this impact affects horses at all but the very highest price levels. For horses sold at the median price of $1,100, the effect is a $147 per head decrease in price for each 1 unit increase in the unemployment index (see figure 3). To put this effect in context, the 12-month historical average of the unemployment index at the time of the spring sale in 2009 was 6.02. By the fall sale in 2009, the 12-month historical average of the index had risen 2.24 points to 8.26. This was the largest change in the index between sales in the data period observed. This change would have caused a $330 per head discount for a median priced horse, if nothing else about the horse or market conditions had changed during that time period.

The effects of the remaining covariates in the median QR hedonic model are mostly statistically different from zero using the 95 percent confidence intervals. The variables measuring the age of a horse (*Age*, Age^2) indicate that while horse will increase in value as they age, that effect will diminish and will become a negative effect between ages 9 and 10 years. The sex covariates (*Gelding*, *Stallion*) indicate geldings sell at a premium of $437 relative to mares, while stallions sell at a discount of $297 per head. All breed categories of horses included in the model (*Breed_Grade*, *Breed_AP*, *Breed_Other*) sell at a discount relative to registered Quarter Horses. The discounts are $295, $259, and $297 per head for grade, Appaloosa or Paint, and other breeds, respectively. All horses classified with a discipline (*Broke*, *Mountain*, *Ranch*, *Showing*, *Breeding*) sell at a premium relative to horses that have not been started (*Not_Started*). The largest premium is for horses trained to show, which sell at a premium of $1,546 per head relative to horses that have not been started.

Additional effort spent on marketing by sellers appears to improve the sale price of horses. The variables for marketing strategies (*Picture*, *Contact*, *Coggins*) add a premium relative to horses that do not have this information in the sale catalog. The order in which horses are sold at an auction does impact the sale price (*Hip*, Hip^2). Prices tend to rise as the hip number increases until approximately half of the horses have sold. After that point in the sale, price decline with hip number. The increase in price between the first horses sold and horses sold at the midpoint of the sale is approximately 14 percent. This premium is eroded to zero as the sale progresses. The impact of distance traveled ($Rdistance^2$) is not statistically different from zero for the median regression.

Fixed effects parameters denoting when a horse was sold reveal statistically significant seasonal and annual impacts on sale price. Horses sold in the fall (*Fall_Sale*) sell at a discount of $275 per head relative to horses sold in the spring sale. Horses sold in 2005 received a premium relative to horses sold in 2004 and 2006 to 2009, holding all other parameters constant. Horses sold in 2010 were not significantly different than those sold in 2005.

The covariate used to proxy for feed costs and pasture conditions (*Drought_Index*) is statistically different from zero. The positive sign indicates that as pasture conditions improve, hay costs will decline due to more supply. This, in turn, strengthens demand for horses at the Billings auction. Sale prices for horses will increase by approximately $50 per head for each unit increase in the Palmer Drought Index. As an example, the Palmer Drought Index moved from -1.71 in the spring of 2008 to 0.20 in the fall of 2008. This 1.91 unit change would cause a price increase of approximately $95 per head, holding all other factors in the model constant.

Summary

The primary objective of this analysis was to determine if the ban on horse slaughter and the recent recession impacted sale prices of U.S. horses. The results of the econometric model, estimated from several years of data from a large horse sale in Montana, suggest that both events adversely affected horse values. The relative magnitude of the events, however, may be quite different depending on the value of the horse.

The slaughter ban impacted horses selling near the median price level of $1,100 per head, presumably horses most likely to be bid on by slaughter buyers. Horses priced well above or below the median price do not appear to have been measurably affected by the slaughter ban. This result supports the idea that the slaughter market creates a salvage value for horses suitable for slaughter, but does not affect the value of horses unsuitable or too valuable for slaughter.

The recession, however, has a negative price effect on most horses sold at this auction. The estimated impact on sale price for a median-priced horse is a discount of 13.4 percent for every one point increase in the unemployment index. Changes in the index observed during the study period ranged from 0.2 to 2.24, suggesting relatively large effects on the price of horses if the macroeconomic conditions, as measured by the BLS unemployment index, are changing quickly.

The results of this analysis indicate that policy changes affecting horse slaughter will affect the value of certain horses. With the lifting of the slaughter ban in December 2011, if slaughter resumes to pre-ban levels and geographic location, horse owners can expect the value of their horses to increase by as much as 17.3 percent. If legislation passes ending the export of live horses for slaughter, a further devaluation can be expected. The extent of these effects may be compounded by macroeconomic conditions if the recession continues or unemployment does not return to pre-recessionary levels.

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Table 1. Summary Statistics of Auction Prices from Billings, Montana ($/head)

	Spring Sale			Fall Sale		
Sale Year	**# of Horses Sold**	**Average Sale Price**	**Median Sale Price[1]**	**# of Horses Sold**	**Average Sale Price**	**Median Sale Price[1]**
2004	--	--	--	320	1,166	825
2005	402	1,558	1,300	527	1,690	1,000
2006	358	1,768	1,600	455	1,307	900
2007	396	1,741	1,550	478	1,570	1,000
2008	421	1,604	1,300	443	1,485	900
2009	339	1,484	1,000	318	1,011	550
2010	260	1,520	1,400	--	--	--

1 The median sale price is the midpoint of the price distribution. The average sale price is higher, due to a few horses sold at very high prices, but less representative of the full distribution (See Figure 1).

Table 2. Summary Statistics of Hedonic Regression Variables

Variable	Description	Mean	Standard Deviation	Minimum	Maximum
Sale_Price	Sale price ($/head)	1,522.351	1,734.869	10	43,000
ln(Sale_Price)	Natural log of sale price	6.917	0.952	2	10.669
Age	Age of horse (years)	6.357	4.208	1	26
Age^2	Age of horse, squared	58.122	77.375	1	676
Gelding	Binary variable equal to 1 if horse is a gelding, 0 otherwise	0.598	0.490	0	1
Stallion	Binary variable equal to 1 if horse is a stallion, 0 otherwise	0.067	0.251	0	1
*Mare**	Binary variable equal to 1 if horse is a mare, 0 otherwise	0.335	0.472	0	1
Breed_Grade	Breed of horse: grade (not specified as registered breed)	0.307	0.461	0	1
Breed_AP	Breed of horse: Appaloosa, Paint	0.095	0.293	0	1
Breed_Other	Breed of horse: all other breeds	0.023	0.151	0	1
*Breed_QH**	Breed of horse: Quarter Horse	0.574	0.495	0	1
Broke	Horse is broke, but not otherwise trained	0.131	0.337	0	1
Mountain	Horse is trained for mountain, pack work	0.149	0.357	0	1
Ranch	Horse is trained for ranch work	0.251	0.434	0	1
Showing	Horse is trained for showing	0.132	0.338	0	1
Breeding	Horse training listed as breeding stock	0.087	0.281	0	1
*Not_Started**	Horse training has not been started	0.250	0.433	0	1
Hip	Order of horse in the auction	305.205	186.824	1	755
Hip^2	Order of horse in the auction, squared	1.28E+05	1.25E+05	1	570,025
Picture	Picture of horse appears in sale catalog	0.273	0.446	0	1
Contact	Contact information of seller given in sale catalog	0.152	0.359	0	1
Coggins	Coggins paperwork available	0.759	0.428	0	1
Distance	Miles from auction horse was transported	1.273	4.197	7.21E-05	54.019
Fall_Sale	Binary variable equal to 1 if horse sold at fall sale, 0 otherwise	0.542	0.498	0	1
*Spring_Sale**	Binary variable equal to 1 if horse sold at spring sale, 0 otherwise	0.458	0.498	0	1
Year 2004	Binary variable equal to 1 if horse sold in 2004, 0 otherwise	0.069	0.254	0	1
*Year 2005**	Binary variable equal to 1 if horse sold in 2005, 0 otherwise	0.194	0.396	0	1
Year 2006	Binary variable equal to 1 if horse sold in 2006, 0 otherwise	0.173	0.378	0	1
Year 2007	Binary variable equal to 1 if horse sold in 2007, 0 otherwise	0.185	0.388	0	1
Year 2008	Binary variable equal to 1 if horse sold in 2008, 0 otherwise	0.184	0.387	0	1
Year 2009	Binary variable equal to 1 if horse sold in 2009, 0 otherwise	0.140	0.347	0	1
Year 2010	Binary variable equal to 1 if horse sold in 2010, 0 otherwise	0.055	0.228	0	1
Drought_Index	Palmer drought severity index	-0.953	1.526	-4.480	0.660
Unemp_Index	BLS unemployment index	4.964	1.561	3.525	9.267
No_Slaughter	Binary variable equal to 1 if horse sold after slaughter ban in place, 0 otherwise	0.480	0.500	0	1

*The dataset contains 4,543 observations. A * denotes variables omitted from hedonic regression for model identification.*

Table 3. Regression Results of the Hedonic Pricing Model by Quantile (%)

Variables	Q 10	Q 20	Q 30	Q 40	Q 50	Q 60	Q 70	Q 80	Q 90
Age	0.147	0.136	0.110	0.099	0.090	0.082	0.075	0.060	0.035
	(0.014)	(0.014)	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.014)	(0.014)
Age2	-0.008	-0.007	-0.006	-0.005	-0.005	-0.005	-0.004	-0.004	-0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gelding	0.616	0.577	0.548	0.561	0.504	0.447	0.393	0.303	0.135
	(0.039)	(0.040)	(0.033)	(0.033)	(0.033)	(0.032)	(0.034)	(0.038)	(0.037)
Stallion	0.166	0.091	0.175	0.172	0.221	0.354	0.442	0.550	0.493
	(0.065)	(0.066)	(0.054)	(0.053)	(0.055)	(0.053)	(0.057)	(0.063)	(0.061)
Breed_Grade	-0.271	-0.275	-0.302	-0.283	-0.288	-0.295	-0.315	-0.285	-0.273
	(0.038)	(0.038)	(0.031)	(0.031)	(0.032)	(0.030)	(0.032)	(0.035)	(0.033)
Breed_AP	-0.198	-0.298	-0.271	-0.274	-0.236	-0.252	-0.266	-0.222	-0.240
	(0.052)	(0.052)	(0.043)	(0.043)	(0.044)	(0.042)	(0.045)	(0.050)	(0.048)
Breed_Other	-0.072	-0.159	-0.222	-0.252	-0.279	-0.283	-0.343	-0.338	-0.325
	(0.098)	(0.101)	(0.083)	(0.083)	(0.085)	(0.081)	(0.086)	(0.095)	(0.093)
Broke	0.492	0.483	0.542	0.523	0.576	0.592	0.586	0.512	0.417
	(0.061)	(0.062)	(0.051)	(0.052)	(0.053)	(0.052)	(0.055)	(0.062)	(0.060)
Mountain	0.593	0.543	0.590	0.514	0.558	0.571	0.565	0.537	0.445
	(0.063)	(0.065)	(0.054)	(0.054)	(0.056)	(0.055)	(0.059)	(0.065)	(0.063)
Ranch	0.683	0.673	0.707	0.636	0.679	0.683	0.669	0.626	0.551
	(0.056)	(0.058)	(0.048)	(0.049)	(0.050)	(0.049)	(0.053)	(0.059)	(0.057)
Showing	0.761	0.738	0.833	0.824	0.870	0.910	0.930	0.972	0.968
	(5.93E-02)	(6.21E-02)	(5.16E-02)	(5.22E-02)	(5.41E-02)	(5.31E-02)	(5.69E-02)	(6.37E-02)	(6.17E-02)
Breeding	0.181	0.084	0.078	0.060	0.097	0.126	0.188	0.219	0.149
	(0.072)	(0.074)	(0.061)	(0.061)	(0.062)	(0.060)	(0.065)	(0.072)	(0.069)
Fall_Sale	-0.425	-0.355	-0.300	-0.261	-0.212	-0.211	-0.231	-0.183	-0.102
	(0.047)	(0.047)	(0.039)	(0.039)	(0.040)	(0.038)	(0.041)	(0.045)	(0.043)
Hip	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
	(2.86E-04)	(2.96E-04)	(2.40E-04)	(2.41E-04)	(2.47E-04)	(2.39E-04)	(2.54E-04)	(2.85E-04)	(2.71E-04)
Hip2	-1.90E-06	-2.11E-06	-2.04E-06	-2.41E-06	-2.80E-06	-3.14E-06	-2.89E-06	-3.04E-06	-3.89E-06
	(4.33E-07)	(4.47E-07)	(3.63E-07)	(3.64E-07)	(3.73E-07)	(3.60E-07)	(3.82E-07)	(4.29E-07)	(4.09E-07)
Picture	0.097	0.185	0.222	0.230	0.247	0.248	0.223	0.210	0.180
	(0.034)	(0.035)	(0.029)	(0.029)	(0.029)	(0.028)	(0.030)	(0.033)	(0.031)
Contact	0.162	0.199	0.243	0.248	0.239	0.231	0.248	0.287	0.289
	(0.045)	(0.046)	(0.038)	(0.038)	(0.039)	(0.037)	(0.040)	(0.044)	(0.042)
Coggins	2.34E-01	2.02E-01	1.78E-01	1.71E-01	1.60E-01	1.61E-01	1.67E-01	1.77E-01	1.32E-01
	(3.50E-02)	(3.52E-02)	(2.90E-02)	(2.91E-02)	(2.99E-02)	(2.91E-02)	(3.11E-02)	(3.48E-02)	(3.36E-02)
Distance	-0.004	0.003	0.000	0.003	0.003	0.001	0.003	0.002	0.009
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Y1	0.121	-0.037	-0.134	-0.146	-0.163	-0.128	-0.095	-0.126	-0.176
	(0.088)	(0.088)	(0.072)	(0.071)	(0.073)	(0.070)	(0.074)	(0.083)	(0.080)
Y3	-0.247	-0.212	-0.189	-0.314	-0.325	-0.386	-0.381	-0.322	-0.381
	(0.066)	(0.069)	(0.057)	(0.057)	(0.058)	(0.056)	(0.060)	(0.067)	(0.063)
Y4	-0.560	-0.397	-0.395	-0.447	-0.423	-0.475	-0.478	-0.378	-0.341
	(0.087)	(0.089)	(0.073)	(0.073)	(0.075)	(0.072)	(0.077)	(0.085)	(0.082)
Y5	-0.847	-0.550	-0.489	-0.470	-0.371	-0.442	-0.414	-0.479	-0.433
	(0.112)	(0.114)	(0.094)	(0.093)	(0.095)	(0.092)	(0.097)	(0.109)	(0.104)
Y6	-0.717	-0.460	-0.444	-0.458	-0.418	-0.526	-0.600	-0.767	-0.925
	(0.179)	(0.179)	(0.147)	(0.146)	(0.149)	(0.144)	(0.152)	(0.170)	(0.164)
Y7	-0.296	-0.079	-0.102	-0.089	-0.009	-0.125	-0.274	-0.651	-0.992
	(0.251)	(0.254)	(0.208)	(0.207)	(0.212)	(0.204)	(0.216)	(0.241)	(0.232)
Drought_Index	0.047	0.021	0.019	0.039	0.040	0.062	0.073	0.068	0.083
	(0.021)	(0.021)	(0.017)	(0.017)	(0.018)	(0.017)	(0.018)	(0.020)	(0.019)
Unemp_Index	-0.126	-0.126	-0.131	-0.137	-0.130	-0.126	-0.099	-0.041	0.014
	(0.036)	(0.036)	(0.030)	(0.029)	(0.030)	(0.029)	(0.031)	(0.034)	(0.033)
No_Slaughter	0.084	-0.092	-0.105	-0.121	-0.155	-0.085	-0.044	0.122	0.242
	(0.089)	(0.089)	(0.073)	(0.073)	(0.075)	(0.072)	(0.076)	(0.085)	(0.082)
Constant	5.896	6.182	6.488	6.790	6.890	7.117	7.257	7.223	7.454
	(0.178)	(0.182)	(0.149)	(0.149)	(0.152)	(0.145)	(0.152)	(0.168)	(0.158)
Pseudo R2	0.363	0.338	0.320	0.298	0.280	0.258	0.224	0.194	0.171
Ln(Sale Price)	5.652	6.109	6.477	6.745	7.003	7.244	7.496	7.696	8.006
Sale Price ($)	285	450	650	850	1,100	1,400	1,800	2,200	3,000

Table 4. Estimated Mean Effects and Confidence Intervals ($/head) of the Median QR

Variable	Mean Effect	95% Confidence Interval Lower Bound	Uppder Bound
Age	114.17	111.91	116.43
Age ^{2}	-6.09	-6.13	-6.05
Gelding	437.50	434.36	440.65
Stallion	-297.28	-297.33	-297.22
Breed_Grade	-294.61	-297.16	-292.06
Breed_AP	-259.08	-263.07	-255.10
Breed_Other	-297.30	-304.77	-289.83
Broke	935.63	925.60	945.66
Mountain	889.30	878.90	899.70
Ranch	1,032.65	1,023.64	1,041.65
Showing	1,545.88	1,532.97	1,558.79
Breeding	129.72	121.79	137.65
Hip	1.43	1.39	1.46
Hip ^{2}	-0.003	-0.003	-0.003
Picture	312.99	309.33	316.65
Contact	315.62	310.61	320.63
Coggins	159.22	156.49	161.95
Distance	3.64	3.30	3.98
Fall_Sale	-274.87	-278.96	-270.79
Year 2004	-184.74	-191.42	-178.07
Year 2006	-335.77	-340.15	-331.38
Year 2007	-410.34	-415.57	-405.10
Year 2008	-379.37	-386.19	-372.56
Year 2009	-430.82	-441.26	-420.37
Year 2010	-11.05	-34.12	12.03
Drought_Index	49.67	47.82	51.52
Unemp_Index	-147.39	-148.54	-146.24
No_Slaughter	-190.36	-197.67	-183.05

** Confidence intervals were estimated by bootstrapping over 500 draws of the coefficient.*

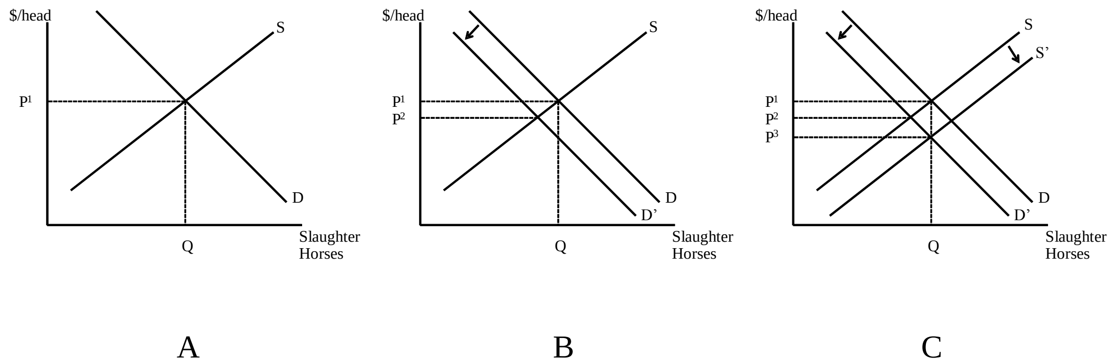

Figure 1. Effects of the closure of U.S. slaughter plants and the recession on slaughter horse prices.

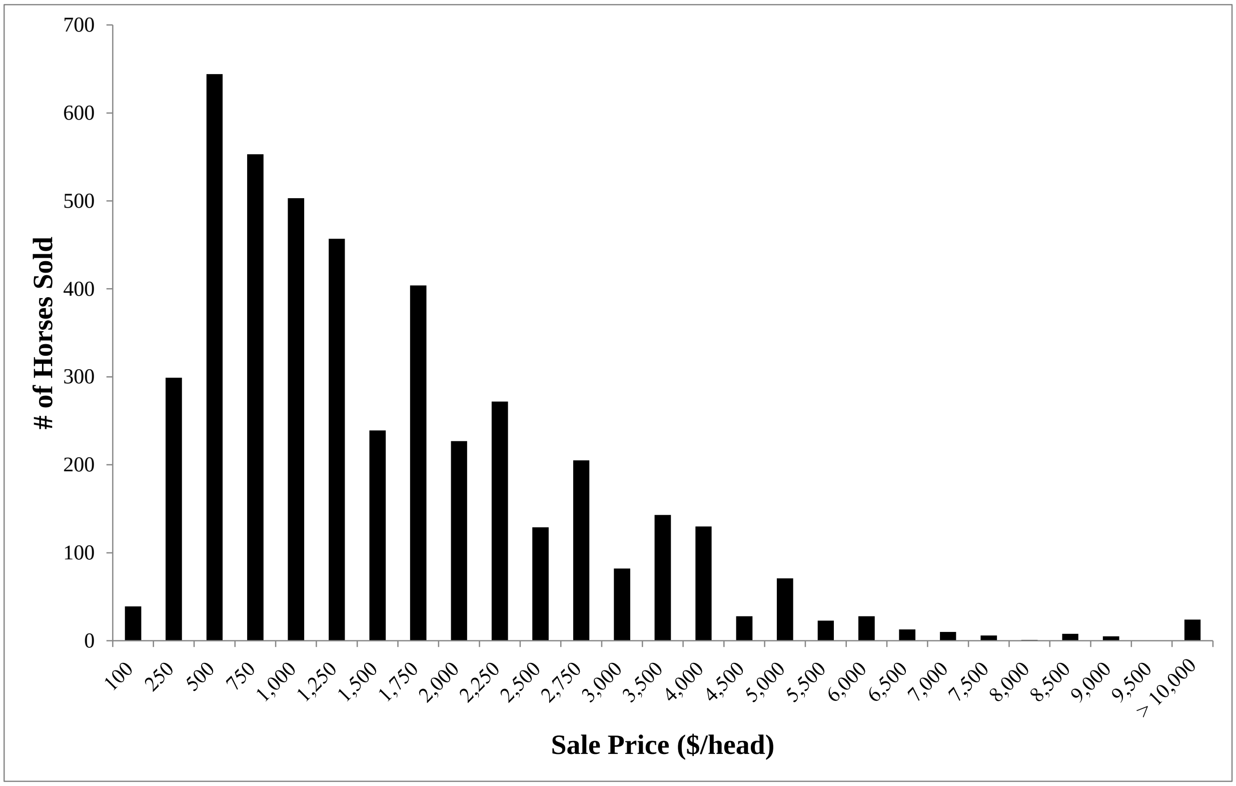

Figure 2. Distribution of horse sale prices from Billings, Montana auction, years 2004 to 2010.

Figure 3. Estimated impact of changes in the unemployment index on a median priced horse ($1,100/head).

[1] Not all horses taken through the sale ring at auction are sold. If the final bid does not exceed the reservation price of a seller, then a sale is not made. The final bid for these 'no-sale' horses is not an equilibrium sale price and, therefore, they are not included in the observations used to estimate this model.

[2] The information regarding training was taken from the sale catalogs and is provided by the seller. There is no third party confirmation of the extent of the training. Therefore, while this information provides a signal to potential buyers, it is not a totally objective measure.

[3] The BLS Mountain division includes the states Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming.

[4] The exception to this is the statistically significant coefficient of the *No_slaughter* variable for the 90th quantile. This quantile includes horses priced at $3,000 or above. The positive sign of this variable is not intuitive; however, it is likely that this regression is not correctly specified. Previous research suggests that breeding reputation of horses in this price category is a very important factor in the sale price (Taylor, et. al. 2004, Vickner and Koch 2001, Landsford et.al. 1998). The QR model does not include variables measuring quality of pedigree, as it was not typically provided in the sale catalog for lower priced horses.