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Home off the Range: The Role of Wild Horse Internet Adoptions in Informing Sustainable Western United State Rangeland Management

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Abstract: According to the Bureau of Land Management (BLM), there are about 60,000 more wild horses and burros roaming the rangelands in the western United States than the land can sustain. While the BLM is pursuing a number of strategies to address this imbalance, placing wild horses and burros in private homes is one of the most preferred options. However, little is known about the demand for wild horses. This paper utilizes data from internet adoptions of wild horses to better understand the demand side of the market. More specifically, results from a Heckman selection model provide estimates of the market value of various characteristics of wild horses. By describing adopter preferences, these estimates can aid policy makers in optimizing strategies to manage the wild horse population.

Keywords: wild horses and burros; bureau of land management; public adoption; resource policy

1. Introduction

Wild horses and burros have roamed the western United States since the 16th century. In 1971, an Act of Congress deemed wild horses and burros to be "living symbols of the historic and pioneer spirit of the West" and "an integral part of the natural system of the public lands" [1]. This Act officially characterized wild horses and burros as federally protected animals and assigned management responsibilities to the Bureau of Land Management (BLM) within the Department of the Interior. Under this Act, the charge to the BLM is to "preserve and maintain a thriving natural ecological balance and multiple-use relationship in that area." Other uses of public lands include wildlife conservation, livestock grazing, and recreational activities. To accomplish this charge, the BLM established an "appropriate management level (AML)" of 26,690 wild horses and burros. However, with no natural predators or fertility control program, herds double in size every four years, creating a growing imbalance [2]. As of 1 March 2019, there were an estimated 71,892 wild horses and burros on lands managed by the BLM and another 46,767 in BLM holding facilities, resulting in a surplus of over 90,000 wild horses and burros [3].

This essay explores the current and future roles private placements play in the BLM's herd management policy by estimating demand for wild horses using data from internet adoptions. This study is especially timely because, in a recent interview, the BLM's acting head indicated that a key step in controlling the overpopulation of wild horses on federal lands, which he expects will take $5 billion and 15 years, is increasing adoptions [4]. Our objective is accomplished in two ways. First, characteristics that increase the probability that a horse will be adopted are explored. Second, a Heckman selection model is utilized to examine buyers' values of different characteristics of wild horses, including training. Both exercises are beneficial because they allow the BLM to identify what

types of horses are most likely to be demanded by adopters; this information is important to their management strategies since placing wild horses in private homes allows the government to forgo the cost of caring for the animal for the rest of its life.

1.1. Wild Horse Management Strategies and Private Placement of Wild Horses

The BLM utilizes a number of strategies to manage herd sizes. Some animals, often those available for adoption, are held in short-term holding facilities, while others reside in long-term, off-range holding facilities. In some instances, the BLM contracts with private landowners to create off-range corrals capable of holding 500–3500 wild horses. In addition, the BLM adopts out or sells individual horses to approved private homes. Finally, sterilization techniques continue to be explored to slow reproduction rates of wild horses on the range, with some promising methods nearing large-scale implementation.

Long-term management costs provide the BLM with a strong incentive to place wild horses in private homes. In 2008, the average cost of caring for a horse in short-term and long-term facilities was $5.08 and $1.27 per day, respectively [5]. While the cost of short-term care has not changed significantly, it is estimated that the cost of long-term care has increased to around $2.00 per horse per day. On average, a horse will stay in a short-term holding facility for 210 days and up to 25 years in a long-term holding facility. Consequently, each young horse taken off the range and kept in a holding facility for the remainder of its life can cost the government, and therefore taxpayers, more than $19,000.

There are four primary ways that the BLM places wild horses in private homes: onsite adoption events, adoptions directly from a BLM adoption center, internet adoptions, and private sales. At onsite adoption events, private individuals adopt a horse for a flat adoption fee on a first-come, first-served basis. Adoptions from BLM adoption centers function similarly but can vary depending on the location. Internet adoptions function like auctions. The highest bidder adopts the horse and pays the winning bid. The adopter then picks up the horse from its current location or has the horse transported to other pre-determined locations closer to the adopter's residence. In FY2019, these three forms of adoption accounted for 3774 private placements. In addition, the BLM may sell, rather than adopt out, certain animals. The Burns Amendment directs the BLM to sell wild horses that are more than 10 years of age or have been passed up for adoption at least three times; in FY 2019, 1538 placements were the result of these private sales. The distinction between an adoption and a sale is that under the adoption guidelines, the ownership title of the horse remains with the BLM for one year, whereas in a sale, the title transfers immediately. In this study, we focus on internet adoptions. The auction-like design of the internet adoptions yields variation in prices, which allows the market value of various characteristics to be estimated and demonstrates the use value that individuals place on wild horses.

There are many requirements surrounding the adoption or purchase of a wild horse. The minimum adoption fee is $25, although prices from internet adoptions infrequently enter the $2000–$3000 range. Adopters must be pre-approved by the BLM and are allowed to adopt no more than four equines every six months. The title to the horse is not transferred to the new owner for one year; during that time, BLM employees perform welfare inspections. Specific transport means and fencing are required before an individual can adopt a wild horse. These latter requirements may increase the cost of adopting a wild horse [6]. In addition, the cost of care for a wild horse can be higher than a domesticated horse since wild horses may require specialized professional training, veterinary, and farrier services. A survey of wild horse adopters in New England indicated that owners are not always aware of the long-term costs associated with wild horses at the time of adoption [7].

1.2. Related Literature to Wild Horse Markets

Much of the current literature on managing wild horse populations has focused on the supply side of the market and, in particular, methods of controlling population growth [8–12]. To our knowledge, few papers consider the demand side of the market [6,7,13]. The revealed preference paper [13] examines the market prior to the 2008 recession and the cessation of horse slaughter in the United

States. Since these events had a dramatic effect on the equine industry, our study provides a more current assessment of the demand side of the market.

Elizondo, Fitzgerald, and Rucker (2016) study wild horses adopted through the BLM's Adopt-a-Horse Program, which includes internet adoptions and satellite adoption events, from 1997 to 2010 [13]. They find that adopters had gender, color, and training preferences. More specifically, they find that mares (female horses) are more likely to be adopted than geldings (castrated male horses), but that geldings command a higher price when sold. Bay or brown solid-colored horses are the least likely to sell or be adopted. Finally, horses with some type of training brought in an average of $120 more than the sum of the price of an untrained horse and training costs. In their sample, all horses who received training were adopted.

Our study provides an up-to-date understanding of the potential for adoption because our data follow three closely-timed events that collectively had a significant impact on the equine industry: the cessation of slaughter of horses for human consumption in the United States, the Great Recession of 2008–2009, and a widespread drought. Ahern (2006) and Lenz (2009) discuss the general problem of unwanted horses in the wake of the 2007 closure of the two slaughter houses that processed horses for human consumption [14,15]. Activities at these two facilities ceased when the USDA eliminated funding for inspectors. With no slaughter market to establish the minimum value for a horse [16], the prices of lower quality horses declined [17], although not all research supports that conclusion [18]. There is a degree of substitutability between riding horses and mustangs; consequently, the cessation of slaughter affected the market for mustangs indirectly through prices for riding horses [7].

The effect from the 2007 cessation of slaughter in the United States was closely followed by the Great Recession in 2008–2009, which also had a significant impact on the entire equine industry. From 2007–2012, median household income fell by 9% [19]. Since horses are considered luxury goods, the decline in disposable income resulted in a widespread contraction in the equine industry; examples of the contraction are evident in the roughly 50% decline in annual revenues from Thoroughbred auctions [20] and significant declines in memberships in major breed and discipline organizations (see, for example, the American Quarter Horse Association ([21], p. 6)). Finally, a severe, widespread drought across parts of the U.S. and near-record oil prices around this time period resulted in a significant increase in the cost of managing horses. For example, from 2006 to 2008, the price of alfalfa hay increased 58.6%, while the price of corn increased 111% [22]. The price of crude oil increased about 425% from 1998 to 2008 [23].

The estimation approach used in this paper has been applied in other equine markets [24–27]. It was applied to estimate demand for retired Thoroughbred racehorses, which was also considered a horse in transition [28]. The authors of that study found that adopters of retired racehorses have gender, color, age, and most significantly, soundness (ability to perform) preferences.

The results from this study have several implications. First, a simple summary of the data shows that in the span of two years, fewer than 650 wild horses were rehomed through internet adoptions. So, while internet adoptions might not currently be a primary tool for placing greater quantities of wild horses, the data obtained help us understand adopter preferences. Among those horses successfully adopted, adopters did not appear to have any gender preference but did exhibit color, age, and training preferences. These results can inform gather, training, and adoption decisions made by the BLM; for example, the BLM might not invest in training horses with physical traits preferred by adopters as the marginal benefit from training would be smaller for those horses than horses with less desirable physical traits.

2. Data and Empirical Approach

2.1. Data

Data were hand-collected from the BLM Internet Adoption Program's online gallery from November 2012 through November 2014. Each horse selected for internet adoption has a dedicated

webpage posted before the event with basic information including color, height, gender, age, capture date, capture location (herd management area), potential pickup locations, and at least one photograph. If the horse has received trained, a description of the training may appear on the page as well. The webpages are grouped together based on location of the horses, which is determined by the short-term holding facility at which the horses are housed. At the end of the internet adoption event, horses can be shipped to different locations for pickup at the buyer's/adopter's request (from this point forward, we use the terms buyer and adopter interchangeably). For the duration of this study, bidding begins at $125 with a minimum increase of $5 per bid. Bidding is open for two weeks at which time the winner is notified, pays the amount of their winning bid, and arranges for pickup of the horse.

Initially, there were 1524 observations entered in the internet adoption events. Data on adoption of burros were dropped because there were relatively few burros available, and more importantly, the market for burros is different than that for wild horses. There were also a small number of colts (young male horses) that were too young to geld; they were removed from the sample. Finally, horses with missing information on height, gender, or capture date were also dropped. The result was a total of 1256 observations. While the majority of horses only appear once in the data set, some horses appear multiple times if they failed to be adopted in previous events. On average, horses were offered twice, although one horse was offered nine times and several were offered eight times.

Table 1 presents the variable name, variable description, and descriptive statistics of all horses entered in internet adoption events (first column) and the subsample of horses that were sold/adopted (we will use these terms interchangeably for ease of exposition) via the events (second column). The table presents mean values with standard deviations in parentheses. The average age was three years, with the youngest horse being six months and the oldest being 14 years. The ages are skewed toward younger horses, with 86% of the sample being between one and four years old. This is likely due to the policy of prioritizing the removal of horses under five years of age from herds during gathers. Horses range in height from 11 to 16.1 hands (one hand is equivalent to four inches), with an average height of about 14.1 hands (57 inches).

The level of training the horse has received is measured as being halter trained or started under saddle. Training progresses from a horse learning to wear a halter and be handled from the ground to accepting a saddle and having rider on its back; therefore, all horses that have been started under saddle must be halter trained first. A total of 93 horses (7.5%) in the sample are halter trained; of those, 41 (3.3%) are also started under saddle. Both of these tasks take a considerable amount of time to achieve with a wild horse, so these low numbers are not surprising.

Just over half of the internet adoption entries were sold, with 630 sales and 626 failures. The minimum bid for internet adoptions is $125, which equals the lowest price for which any horse sold. Among the horses that sold, 90% sold for less than $500 and 45% sold for the $125 minimum bid. An untrained, three-year-old pinto mare sold for the highest bid of $2595. The average winning bid among the horses that sold was $233.92. The majority of internet adoption events, about 93%, are held between March and November.

Table 1. Variable Names, Descriptions, and Means (Standard Deviations) of Horses in Internet Adoption Events.

Variable	Description	Entered	Sold
Physical characteristic			
Mare	= 1 if female horse	0.613	0.578
		(0.487)	(0.494)
Age	Age of horse at time of adoption event	3.060	2.980
		(1.470)	(1.530)
	Minimum age	6 months	6 months
	Maximum age	14 years	9 years
Base	= 1 if solid base coat color	0.506	0.359
		(0.500)	(0.480)
Pattern	= 1 if gray, roan or white coat color	0.210	0.221
		(0.408)	(0.415)
Dilute	= 1 if diluted coat color (palomino, buckskin, dun)	0.194	0.289
		(0.396)	(0.454)
Spotted	= 1 if spots or blanket pattern on coat color	0.019	0.021
		(0.137)	(0.142)
Pinto	= 1 if pinto coat color	0.081	0.129
		(0.273)	(0.335)
Height	Height at the withers in inches	56.80	56.95
		(3.31)	(3.64)
Bornincap	= 1 if born in captivity	0.236	0.224
		(0.425)	(0.417)
Training			
Halter	= 1 if horse is trained to lead	0.075	0.127
		(0.263)	(0.333)
Saddle	= 1 if horse is started under saddle	0.033	0.634
		(0.178)	(0.244)
Event Characteristic			
Available	Number of horses available in adoption event	98	91
		(42)	(41)
Spring	= 1 if adoption event was in March, April, or May	0.209	0.219
		(0.407)	(0.414)
Summer	=1 if adoption event was in June, July, or August	0.321	0.298
		(0.467)	(0.458)
Autumn	= 1 if adoption event was in September, October, or November	0.393	0.383
		(0.489)	(0.486)
Winter	= 1 if adoption event was in December, January, or February	0.076	0.100
		(0.266)	(0.300)
Chances	Number of times horse went to adoption events	2.07	1.37
		(1.70)	(0.83)
Adopt	= 1 if horse successfully was adopted at adoption event	0.502	1.000
		(0.500)	0.000
Price	Winning bid of horse sold at adoption event	–	233.92
			(265.11)
Observations		1256	630

2.2. Empirical Methods

First, a probit model is utilized to examine the factors that affect the probability a horse is sold. This model is important to the BLM because it predicts the ability to avoid the expense of caring for a horse for the rest of its natural life. Determining the characteristics that get a horse transitioned from the government's care into a private owner's care could allow the BLM to more efficiently decide which horses to offer for adoption and when to offer them. As part of a broader strategy for herd management, this knowledge could be used to aid in removal or fertility control decisions.

$$\pi_{ij} = \beta_0 + \beta_1 \boldsymbol{X}_i + \beta_2 \boldsymbol{W}_j + \varepsilon_{ij}$$

π_{ij} is the probability of horse i being adopted through internet adoption event j; $\boldsymbol{X}_i$ is a vector of horse-specific characteristics including age, gender, color, training, captivity history, and captivity

interacted with age; and $\boldsymbol{W}_i$ is a vector of adoption event-specific characteristics including season and the number of horses entered in the event.

Age is interacted with *captivity* in this model since being held in captivity could be viewed differently based on the age of the horse. The relationship between time spent on the range and time spent in captivity may influence buyers' decisions. A horse who was captured young may have acquired fewer "wild" characteristics than a horse captured at a later age, which may be perceived positively or negatively. *Chances* specifies the number of times a horse has been a part of an internet adoption event. The expected effect of *chances* is negative because the horse has failed to get adopted all previous times it was offered.

According to previous studies, buyers' preferences for gender are mixed [6,13,28]. Internet adoption events held in later months are expected to have a negative effect on whether a wild horse is adopted; managing horses is typically more expensive in the winter since feed requirements are greater, causing a decline in demand heading into winter. Buyers may have a preference for horse height; in general, we expect taller horses to be more likely to be sold as they are more suitable for adult riders. Buyers may have color preferences; in particular, unique colors may be more preferred to more common base coat colors. *Training* should improve the probability of sale, while the number of horses in the adoption event (*availability*) should lower the chance of being sold. The effect of being born in captivity may also affect buyer preferences; the "social etiquette" of a foal born in captivity may differ from one born in the wild.

Ultimately, four logit models are estimated with different combinations of location and year fixed effects. *Location* identifies the facility where the horse is currently held, and if horse characteristics differ across herds, location fixed effects will control for it since horses gathered from a herd are sent to the same holding facility. Marginal effects at the mean for the coefficient estimates are also determined.

Next, a model is developed to identify determinants of prices for wild horses that were adopted. Rather than utilizing a standard hedonic pricing model, which is the model of choice in the related literature, this paper adopts a Heckman approach to account for selection bias. More specifically, not all of the horses in the data set (in fact, about half) received a bid; consequently, the set of wild horses that successfully adopted may be subject to selection bias. In addition, the prices that are observed in the data are the highest bid conditional on meeting or exceeding the minimum bid of \$125. This restriction on the adoption prices yields truncated data. The Heckman model is specified as follows:

$$\ln(price) = \xi(\Pr(adopt), age, gender, height, color, training, auction\ month)$$

The inverse Mill's ratio is generated using the probit model previously specified, and the values used to account for the probability of a horse being adopted. The second stage of the Heckman model utilizes the natural log of the winning bid, ln(*price*), as the dependent variable. The natural log transformation is applied because the distribution of ln(*price*) more closely matches a normal distribution than the distribution of *price*, which is skewed right. The independent variables (*age*, *gender*, *height*, *color*, *training*, *event month*) are largely drawn from previous studies in other markets and from data that are available to the researcher.

3. Results

3.1. Estimating the Probability That a Wild Horse Is Adopted in an Internet Adoption Event

Table 2 presents the coefficient estimates and marginal effects for the four probit models estimating the probability that an individual wild horse will successfully sell in the internet adoption event. Model 1 does not control for horse location or year, Model 2 controls for year, Model 3 controls for location, and Model 4 controls for both year and location. Goodness-of-fit measures suggest that Model 4 is the best model; the discussion below focuses on the results from Model 4.

A wild horse's gender may influence the likelihood it sells successfully in an internet adoption event. Mares are 7.0 percentage points less likely to sell than geldings when facility and time fixed

effects are included ($p < 0.1$), which contrasts the results of [13]. In this sample, the older the horse, the less likely it is to sell, but this is only true within the age range, 6 months to 14 years, of this sample ($p < 0.01$). The coefficient estimate for height is positive and significant at the 1% level; on average, a one-inch increase in height increases the probability of sale by 2.9 percentage points. Similar to the results of [13], all the color covariates are positive and significant at the 1% level compared to the base coat colors. The unique colors of a pinto and a base color with a diluted gene are the most likely colors to sell, each increasing the probability of sale by about 33 percentage points. The spotted pattern partially or fully covering the body and color pattern (gray, roan, or white) increase the probability of sale by about 26 percentage points and 18 percentage points, respectively. These results indicate that a solid colored wild horse is the least desirable.

Three of the variables corresponding to the history of the horse are significantly related to the probability of a successful sale at the 10% level or better. The length of time spent in captivity decreases the probability of sale for a young horse more than it does for an older horse. This supports the hypothesis that a horse that was captured young may be perceived to be less of a true mustang than one who grew up in the wild; on the other hand, a longer period of captivity for an older horse may be seen as beneficial to the domestication process. The number of times a horse is entered in an internet adoption event is negative and significant ($p < 0.01$) as expected since these horses appear in the data set multiple times due to their failure to sell.

As anticipated, horses entered in the spring internet adoption events are the most likely to sell than horses entered in autumn internet adoption event ($p < 0.01$). Horses entered in internet adoption event in winter and summer may also be more likely to sell than horses entered in autumn ($p < 0.1$). The market for horses usually declines heading into winter as weather increases the costs of caring for a horse through limited pasture and therefore increased nutritional needs; winter weather also decreases the ability to ride and train, which is a main benefit of owning a horse. The number of wild horses entered in each internet adoption event is negative and significant ($p < 0.01$), with each additional horse decreasing the probability of sale by 0.2 percentage points.

The effects of training are positive in all four models, but the effect of halter training is statistically insignificant once location fixed effects are added. This suggests that certain facilities may have a better reputation than others or follow different horse management strategies. Halter training is part of the gentling process, but a halter-trained horse does not necessarily indicate a fully gentled horse. Saddle training is a more involved process as it requires an immense level of trust for a horse to allow a human to sit astride it, a feeling similar to a predator attacking a horse in the wild. Therefore, the difference between an untrained horse and a halter-trained horse can be minimal, while the difference between an untrained horse and a saddle-trained horse is significant. It is expected, then, that the effect of saddle training is greater than that of halter training. Saddle training a horse has a positive and significant effect on the sale of a horse ($p < 0.01$), increasing the probability of the horse selling by 45.1 percentage points.

Table 2. Effect of Horse and Internet Adoption Event Characteristics on Sale.

Dependent Variable: Sold								
	(1)		**(2)**		**(3)**		**(4)**	
	Probit	**Marginal Effect**	**Probit**	**Marginal Effect**	**Probit**	**Marginal Effect**	**Probit**	**Marginal Effect**
Physical Characteristic								
Mare	−0.087	−0.035	−0.128	−0.051	−0.118	−0.047	−0.175 *	−0.070
	(0.088)		(0.090)		(0.097)		(0.098)	
Age	−0.182 ***	−0.073	−0.166 ***	−0.066	−0.167 ***	−0.067	−0.162 ***	−0.065
	(0.058)		(0.058)		(0.061)		(0.062)	
Color Pattern	0.374 ***	0.148	0.377 ***	0.149	0.456 ***	0.179	0.475 ***	0.186
	(0.105)		(0.106)		(0.111)		(0.112)	
Dilute	0.854 ***	0.322	0.851 ***	0.319	0.874 ***	0.328	0.877 ***	0.328
	(0.112)		(0.113)		(0.116)		(0.117)	
Spotted	0.764 **	0.281	0.754 **	0.277	0.708 **	0.263	0.726 **	0.267
	(0.320)		(0.317)		(0.329)		(0.328)	
Pinto	0.923 ***	0.335	0.947 ***	0.339	0.895 ***	0.326	0.935 ***	0.335
	(0.162)		(0.163)		(0.169)		(0.170)	
Height	0.066 ***	0.026	0.064 ***	0.025	0.075 ***	0.030	0.073 ***	0.029
	(0.014)		(0.015)		(0.019)		(0.019)	
Training								
Halter	0.447 **	0.174	0.442 **	0.172	0.284	0.112	0.235	0.093
	(0.206)		(0.209)		(0.294)		(0.300)	
Saddle	1.334 ***	0.424	1.351 ***	0.423	1.443 ***	0.442	1.532 ***	0.451
	(0.469)		(0.476)		(0.535)		(0.545)	
History								
Born in Captivity	−0.207 **	−0.082	−0.179 *	−0.071	−0.158	−0.063	−0.155	−0.062
	(0.106)		(0.106)		(0.116)		(0.117)	
Time in Captivity	−0.034 ***	−0.014	−0.031 ***	−0.012	−0.029 ***	−0.012	−0.025 **	−0.010
	(0.009)		(0.009)		(0.010)		(0.010)	
Captivity * Age	0.006 ***	0.002	0.005 **	0.002	0.005 **	0.002	0.005 **	0.002
	(0.002)		(0.002)		(0.002)		(0.002)	
Chances	−0.380 ***	−0.152	−0.383 ***	−0.153	−0.465 ***	−0.185	−0.482 ***	−0.192
	(0.038)		(0.040)		(0.043)		(0.046)	
Event Characteristic								
Spring	0.380 ***	0.150	0.390 ***	0.154	0.375 ***	0.148	0.388 ***	0.153
	(0.119)		(0.121)		(0.127)		(0.129)	
Summer	0.102	0.041	0.149	0.059	0.142	0.057	0.211 *	0.084
	(0.110)		(0.111)		(0.116)		(0.117)	
Winter	0.481 ***	0.187	0.475 ***	0.184	0.375 **	0.147	0.341 *	0.134
	(0.173)		(0.179)		(0.186)		(0.193)	
Available	−0.004 ***	−0.001	−0.004 ***	−0.002	−0.004 ***	−0.002	−0.005 ***	−0.002
	(0.001)		(0.001)		(0.001)		(0.001)	
Year FE	No		Yes		No		Yes	
Location FE	No		No		Yes		Yes	
Pseudo R^2	0.264		0.274		0.297		0.307	
Observations	1256		1256		1256		1256	

*, **, *** indicates significance at the 10%, 5%, and 1% levels, respectively. Marginal effect at the mean reported. Standard errors in parentheses.

3.2. Estimating the Determinants of Wild Horse Internet Adoption Prices

Table 3 presents the results from three Heckman models in which price determinants for wild horses successfully sold in an internet adoption are estimated. In all models, the dependent variable is ln(*price*). The first column presents the results from the full sample, while the second column presents results only for the subsample of horses three years of age or older. Three years old is generally accepted as the age a horse is mature enough to be trained under saddle. The third column, then, presents results from the subsample of horses under three years of age; these horses are too young to be saddle trained, and, for this reason, *saddle* is dropped from the model.

After accounting for the selection bias, few covariates have a significant effect on the price for which the horse is sold. Across the full sample, age has a negative effect on sale price, with each additional year of age reducing the sale price by 4.8 percentage points ($p < 0.01$). Examining this effect across the two subsamples, it appears from six months up to three years, age does not affect sale price. Another interesting result that emerges once selection bias is corrected is that the coat color of the horse has minimal influence on sale price. In the combined model, buyers appear to place a premium on pinto horses, increasing sale price by an average of 29.4 percentage points over solid base coat colors ($p < 0.01$). Among horses three year of age or older, those with a diluted coat color also command a 21.4 percent price premium over horses with solid base coat colors ($p < 0.05$). Across the three models,

horses born in captivity bring a consistently lower price (between 13.6% and 19.9%) than those born on the range, although the level of significance varies from 5% to 10%.

Table 3. Effect of Horse and Internet Adoption Event Characteristics on Sale Price.

Dependent Variable: ln(*price*)	**All Ages**	**Age ≥ 3**	**Age < 3**
	Heckman	**Heckman**	**Heckman**
Physical Characteristics			
Mare	−0.047	−0.090	−0.031
	(0.045)	(0.068)	(0.064)
Age	−0.048 ***	−0.051 **	−0.068
	(0.017)	(0.025)	(0.109)
Pattern	0.015	0.056	0.003
	(0.060)	(0.082)	(0.092)
Dilute	0.092	0.214 **	0.023
	(0.063)	(0.088)	(0.092)
Spotted	0.011	0.059	−0.168
	(0.152)	(0.184)	(0.267)
Pinto	0.294 ***	0.398 ***	0.273 **
	(0.077)	(0.106)	(0.114)
Height	0.010	0.032 **	0.001
	(0.007)	(0.013)	(0.012)
Training			
Halter	−0.081	0.308	0.015
	(0.096)	(0.201)	(0.115)
Saddle	0.926 ***	0.544 **	–
	(0.128)	(0.214)	
History			
Bornincap	−0.136 **	−0.199 **	−0.140 *
	(0.057)	(0.095)	(0.081)
Event Month			
Spring	0.073	0.222 **	−0.108
	(0.065)	(0.096)	(0.099)
Summer	−0.010	0.028	−0.100
	(0.058)	(0.082)	(0.085)
Winter	0.041	0.187 *	−0.312
	(0.085)	(0.102)	(0.195)
Constant	4.797 ***	3.351 ***	5.438 ***
	(0.419)	(0.782)	(0.600)
Observations	1,256	746	510
Uncensored Observations	630	350	280
Rho	−0.413	−0.216	−0.511
Lambda	−0.223 ***	−0.115	−0.274 **

*, **, *** indicates significance at the 10%, 5%, and 1% levels, respectively. Standard errors in parentheses.

Height and training should be analyzed across the subsamples since these groups of horses are at very distinct stages in their lives. Horses grow until they are five years old, but most of the growth is complete by the time they reach three. In addition, once a horse has reached three, their expected mature height is more apparent. Height is insignificant in the subsample of horses under three years old, as expected. For horses three years and older, height has a positive and significant effect on sale price ($p < 0.05$). Each one-inch increase in height is associated with an average 3.2 percentage point increase in price. Starting a wild horse under saddle is a time-consuming and risky task but has the greatest effect on sale price, increasing it by 54.4 percentage points ($p < 0.05$). If the marginal effect is computed at the minimum bid price, $125, this premium equates to a $68 increase. Across the full sample and both subsamples, halter training does not have a significant effect on sale price.

The season in which the internet adoption event occurs has little effect on sale prices. In the subsample of horses ages three years and older, horses offered in the spring sell for an average of 22.2% more than autumn ($p < 0.05$), while horses offered in winter sell for an average of 18.7% more than in autumn ($p < 0.1$). As previously mentioned, horses three years and older are able to be trained under saddle. In most parts of the U.S., training begins in the late winter or early spring, which could explain the significance of the season on sale price.

4. Discussion and Conclusions

The BLM faces a growing problem with the number of wild horses roaming the western United States. Currently, the only way to disperse captured horses to the public with no long-term cost commitments is through adoption or sale. The results from this study indicate that there are specific characteristics of horses that increase the probability of adoption and, to a lesser extent, the price at which they are adopted. However, we also find that during the period under analysis, the use of internet adoptions did not result in the transition of a large quantity of wild horses into private homes; over a two-year span, fewer than 650 wild horses were transitioned. The internet adoption event data are informative, though, because they allow us to identify which traits are more desirable to adopters. Also, from a revenue perspective, the price variability that exists in internet adoptions may generate more revenue than public adoptions, although we suspect that in the long run, decreasing long-term care costs through private placements is a far bigger benefit than generating revenue.

With only half of the horses offered for adoption through internet adoption being rehomed, it may be that horses with less desirable traits have market values below the minimum $125 bid price. In early 2019, the BLM decreased the minimum bid from $125 to $25, and while the impact of this change has yet to be determined, it should be recognized that $125 is minimal relative to the cost of caring for a horse. Because such a small percentage of the surplus of wild horses were successfully rehomed, the results from this study underscore the notion that proper management of wild horses will require the BLM to adopt a comprehensive, multi-faceted policy incorporating incremental changes to all parts of the management process addressing both the supply and demand sides of the market.

The positive effect of training on adoption is evident in this sample and supports earlier findings [13]. The number of potential adopters with the ability and time to safely and effectively domesticate a wild horse is small, so training prior to sale makes wild horses far more suitable for private placement. In particular, starting a horse under saddle appears to be an effective strategy to place wild horses in private homes. It follows that, where possible, more money should be budgeted for starting horses under saddle. Currently, most training is provided by inmates as part of the Wild Horse Inmate Program under the supervision of professional trainers; there are five facilities in the nation with such a program (located in Arizona, California, Colorado, Kansas, and Nevada). Budgeting more for training programs should be done with caution, however, as scaling up such programs could decrease the magnitude of the effect of training. In other words, the marginal buyer currently may be willing to purchase a trained mustang, but once that demand is satisfied, there could be a significant reduction in the willingness-to-pay for training to the next category of buyers.

After saddle training, the color pattern of the horse most influenced the probability of the horse selling. Adopters appear to prefer horses with unique coat colors or patterns. In the sample used in this analysis, coat color has an insignificant effect on the probability of a horse being selected for either halter or saddle training. Taken together, these results suggest it may be possible for the BLM to establish an approach to selecting which horses receive training. For example, the BLM may consider training horses with the more common base coat colors, since the more uniquely colored horses are more likely to sell even without training.

The value, and thus desirability, of specific physical characteristics of horses should be considered when conducting gathers and administering fertility control. The question of which horses to remove from the wild is an inherently dynamic decision. Horses that have desirable traits are more likely to be placed in private homes, decreasing the BLM's costs in the short-run. However, in the long-run, this

lowers the number of horses with desirable traits in the remaining reproducing population. The lower quality of stock could increase the BLM's future costs.

A limitation of this study is that the model used is static, not dynamic. Higher sales in one period are likely to drive down sales in the next period, especially with a small pool of potential adopters who are equipped to care for a wild horse. As discussed in the previous paragraph, selecting horses with desirable traits to remove from the range for adoption could increase future costs through the lower quality of reproducing stock; however, the stock of horses in long-term holding facilities is significant and currently unmanaged in terms of private transfers. Once a horse is moved to a long-term holding facility, it no longer appears at adoption events or in internet adoption events. This unmanaged stock could be part of an initial correction by the BLM to sell desirable horses in long-term care to private individuals. Newly gathered horses whose characteristics make them unlikely to sell could be moved to the long-term facilities where the cost of care is lower than that of short-term facilities, thus minimizing the stress on these horses and decreasing the cost of care, outcomes that would be heralded by both government officials and wild horse advocates alike.

Other approaches have been pursued to increase demand for wild horses, many of which occurred after the time under analysis. On 12 March 2019, the BLM announced a new incentive program to adopters of wild horses [29]. Qualified adopters are eligible to receive $1000, paid in two installments over one year, to help with initial training and care costs. In addition, the BLM partners with the Mustang Heritage Foundation (MHF), a 501(c)(3) organization. MHF has established at least three programs with a goal of increasing demand for wild horses. First, the Extreme Mustang Makeover is a competition in which trainers have 100 days to train a wild horse. At the end of the 100-day period, a competition is held to showcase the versatility and trainability of wild horses, while also incentivizing trainers with cash and prizes. An auction is held at the end of the competition. Second, the Trainer Incentive Program (TIP) supports trainers who gentle, train, and find homes for wild horses. Third, America's Mustang was developed to educate the public about wild horses. The effect of these programs on demand for wild horses among the general population is, to our knowledge, unknown.

The number of wild horses on the range, in short-term holding facilities, and in long-term holding facilities continues to grow under the BLM's current policies. This growth is ecologically, financially, and politically unsustainable. Since the demand for wild horses is small, managing the on-range stock is going to be a key part of the long-term management plan. Results from this study can inform a number of BLM's long-term management strategies, including the types of wild horses selected for adoption, the types of wild horses selected for training prior to adoption, and implementation of fertility control strategies. These results are one part of determining a comprehensive management program that satisfies the public demand for protection of these wild horses under financial and ecological constraints. Further research may also investigate avenues to increase demand by better understanding barriers to adopting a wild horse.

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