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White-tailed Deer Semen Auction Data: A Hedonic Analysis

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ABSTRACT

In 2008, the cervid (i.e., deer) production and hunting industry had an economic impact of $318.4 million in Texas and $3 billion in the US. Antlers of whitetail bucks are prized trophies for hunters. Hence, breeders make great investments to manage genetic potential for antler growth in their herds. Sire selection accounts for up to 90% of genetic changes in managed livestock herds. Therefore, researchers have investigated the value of sire characteristics using hedonic analysis of auction data for race horses, beef cattle, and dairy bull semen. Similar hedonic analyses have evaluated attributes of hunting leases and permits. However, no hedonic studies have been conducted on auction data for semen originating from confined white-tailed deer farms in Texas. Publicly available data on semen prices, buck antler scores, and whether the buck was considered typical or non-typical were collected from the Texas Deer Association. Auction prices ranged from $120/straw to $20,500/straw of semen with a mean of $2,489/straw. Modeling price as a function of white-tailed deer characteristics and breeding location indicates significant premiums for higher antler scores ($p < 0.01$), Texas genetics ($p < 0.01$), and deceased bucks ($p < 0.05$). Therefore, breeders may consider these important characteristics in breeding program development.

KEY WORDS: hedonic price analysis, white-tailed deer, semen prices, cervid

INTRODUCTION

Hunting is a passion for millions of Americans. In 2002, the US hunting industry generated an estimated $25 billion in retail sales, approximately $17 billion in annual salaries and wages, and employed 575,000 Americans (International Association of Fish and Wildlife Agencies 2002). In 2012, hunters spent $38.3 billion on equipment, licenses, and other inputs (Allen et al. 2012). In the southeastern region of the US alone, wildlife-associated recreation generated between $22 and $48 billion in value to the economy,

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depending on assumptions about factor supply and factor mobility, and supported an estimated 783,000 jobs in 2012 (Hussain et al. 2012).

More specifically, hunting in Texas generated $2.1 billion in spending, created $2.79 million in taxes, and supported 36,170 jobs in 2011 (Congressional Sportsmen's Foundation 2013). Although this includes all game species, it is assumed that a large portion of this economic activity was generated from hunting white-tailed deer. Out of 1,146,657 total hunters in Texas in 2012, 929,616 (81%) identified themselves as deer hunters (Allen et al. 2012). According to the Texas Parks and Wildlife Department, over 625,000 white-tailed deer were harvested in Texas in 2014 (Purvis 2014).

It has been estimated that the US cervid industry accounted for $3 billion in economic output and activity, and a projected $652 million in economic activity in Texas, in 2007 (Anderson et al. 2007; Frosch et al. 2008). As noted earlier, most of the value generated by the Texas cervid industry can be attributed to white-tailed deer hunting, where antlers of white-tailed bucks are prized trophies for hunters.

Hunters pursuing white-tailed deer create economic demand in rural economies where these alternative agricultural enterprises are located. Due to the introduction of high fencing, a management practice limiting the natural movement of deer across a property, white-tailed deer breeding enterprises have emerged to provide breeding stock and semen to maintain genetic diversity in these enclosed facilities. This expanding industry is of potential importance to agriculture and to the rural economies that rely on its continued development (Frosch et al. 2008).

A majority of white-tailed deer farms within the state of Texas are breeding operations whose primary purpose is to sell stock to other breeders within the industry and to supply animals to hunting preserves across the state, particularly high-fenced ranches (Frosch et al. 2008). Landowners who have constructed high fences around their property enjoy the advantages of protecting land and habitat improvements, and most of all, resident wildlife. However, to maintain genetic diversity in high-fenced enclosures, the need arises for periodic introduction of superior genetic material.

The introduction of superior genetic material often occurs through the purchase of a breeder buck or doe. Yet, many operations are now using artificial insemination in their breeding programs rather than purchasing live animals. The utilization of laparoscopic intra-uterine insemination has allowed breeders to select genetics that best fit the operation's goals. This method's versatility has given breeders the ability to scientifically match genetic lines so offspring will produce larger antlers with desired characteristics (Willard et al. 2001). Stemming from this breeding practice, semen sales have become increasingly important. Semen provides versatility for breeders to manage genetics through selective breeding and to acquire genetics that would not be readily available to them otherwise. This is critical to breeders as current regulations strictly prohibit the transport of live animals across state lines (Texas Parks and Wildlife Department 2015).

Growth of the White-tailed Deer Breeding Industry. Growth in white-tailed deer breeding has been fueled by demand for nontraditional hunting practices within high-fenced enclosures (Frosch et al. 2008). However, proponents of free-ranging cervids are concerned that native and exotic cervid species held within captive environments represent a potential for increased threats of diseases such as Chronic Wasting Disease (Miller and Thorne 1993). High fencing is also viewed by some as promoting "canned hunts" and privatizing wildlife (DeZelle 2009). Although opposing views exist regarding the ethics of deer production and hunting within the confines of high-fence environments, this industry is important to rural economies and has experienced growth among those seeking alternative production enterprises (Anderson et al. 2007). Between 1996 and 2014, the number of deer breeder permits issued in Texas increased over 600%, illustrating the dramatic growth of the industry over the span of 19 years (Texas Parks and Wildlife Department 2015).

The antlers of white-tailed deer are prized trophies for hunters, and for this reason breeders make great investments in the genetic potential for antler growth in their breeding programs. Breeders often seek sires with "stacked" genetics (the presence of several prevalent bucks within its pedigree) to increase the potential for higher performing progeny. Sire selection can account for up to 90% of the genetic changes in managed livestock herds (White et al. 1993). Therefore, the importance of sire selection, the growing market for white-tailed deer semen, and the economic contributions of the cervid industry warrant research regarding the traits contributing to the value of a straw of semen.

Thus, this study investigated which characteristics contributed to the value of white-tailed buck semen originating from confined white-tailed deer farms in Texas by using hedonic price analysis. The specific objectives of this study were to evaluate: 1) do premiums exist for buck semen possessing Texas genetics?; 2) do premiums exist for semen stored for sale from a deceased animal?; 3) does an antler score impact the value of white-tailed buck semen?; 4) does a buck classified as "typical," based on its antler characteristics, receive a premium semen price?; and 5) do industry-leading ranches command a higher price for semen originating from that ranch?

Hedonic Price Analysis. In most industries, commodities or goods can be seen as a bundle of different characteristics for which no explicit market exists (Brown and Rosen 1982). Early work completed by Lancaster (1966) hypothesized that goods can be considered bundles of attributes; thus, consumers value a particular good by its individual characteristics. Consequently, there is a need to estimate the structural components of such commodities or goods and each component's contribution to the price of a good. Unfortunately, there is often an absence of observable monetary value of each characteristic contributing to the price of a commodity. Nevertheless, this obstacle can be resolved by using hedonic price analysis. Therefore, a commodity's characteristics and its price define a set of implicit or "hedonic" prices (Rosen 1974).

By using regression to measure the value of individual characteristics of a good as explanatory variables, with the price of the good the dependent variable, the value contribution of a characteristic can be determined as illustrated in Equation 1 (Norwood and Lusk 2008).

$$Y = F(X_1, X_2, X_3 \dots \varepsilon) \tag{1}$$

This measure of value derived from hedonic analysis allows for a more advanced understanding of how the price of a good is developed. The use of hedonic price analysis allows insight into the supply and demand for a good, but more importantly exhibits the price of different variations of one particular good resulting from supply and demand (Norwood and Lusk 2008). It is also important to note that the value of each characteristic contributing to the overall price of a good does not identify either supply or demand. The hedonic price characteristics of a product only denote the composition of the price of a particular good and by themselves can neither identify the structure of consumer preference and/or producer technologies that generate them (Brown and Rosen 1982).

Hedonic Price Analysis in Agriculture. Hedonic pricing models have been extensively applied in agriculture to evaluate traits contributing to the price of commodities. Studies have been dedicated to exploring the economic value of wheat (Espinosa and Goodwin 1991), rice (Brorsen et al. 1983), cotton (Bowman and Ethridge 1992), tuna (McConnell and Strand 1999), milk components (Buccola and Lizuka 1997), apples (Carew and Smith 2004), and retail beef and pork products (Parcell and Schroeder 2007).

The capability of hedonic pricing models to estimate the value of a certain attribute of a commodity has also been applied to characteristics of production inputs associated with traits of a specific animal (Ladd and Gibson 1978). Estimation of the monetary value of these traits provides economic insight into what drives prices associated with an animal while allowing producers increased understanding of the value of stock.

Equine. Due to the importance of the racehorse and show horse industries in Kentucky, the majority of hedonic price analyses applied to equine has emerged from the University of Kentucky. Lansford et al. (1998) investigated which individual characteristics of American Quarter Horse yearlings affected price within the marketplace. Genetic and ancestral characteristics of yearling American Quarter Horses were analyzed using a semi-log hedonic pricing model to estimate impacts on price. Several variables including sex, age, paid-up engagements, and 18 of the 21 ancestral characteristics significantly influenced prices paid in the marketplace (Lansford et al. 1998).

Koch and Vickner (2001) extended the work of Lansford et al. (1998) by applying the hedonic price model to Thoroughbred yearlings. They found sellers who breed and race horses do not receive statistically significant penalty on average price compared to sellers whose main goal is to solely breed horses (Koch and Vickner 2001).

Dhuyvetter et al. (2006) estimated the price determinants of show quality horses at auction using a hedonic pricing function with an ordinary least squares regression. Age, color, sex, sale order, and strong pedigrees were all found to be significant.

Due to price variability between markets, Robbins and Kennedy (2001) investigated determinants of auction prices in a local market by applying hedonic price analysis to regional Thoroughbred auctions. They confirmed that the role of the sire was captured in the stud fee at the time of the sale, older yearlings acquire higher values, and male yearlings are valued above females. Furthermore, it was concluded that region-specific factors did play a role in price determination (Robbins and Kennedy 2001).

Beef and Dairy Cattle. The ability to use EPDs (Expected Progeny Differences) has helped researchers obtain secondary data from both auctions and producers to estimate the importance of specific characteristics and their economic values. A hedonic pricing model using a logarithmic-form regression re-examined the role of performance EPDs in determining the value for purebred Angus bulls (Jones et al. 2008). Jones et al. (2008) found that producers valued actual measurements more than progeny predictions, with the exception of the birth EPD, over actual production data. It was also discovered that ultrasound EPDs, marketing factors, pedigree, order of the sale, and retention of semen rights were also highly significant in determining price.

Franken and Parcell (2012) revisited the characteristics contributing to the value generated from bulls at auction by collecting data over a prolonged period of time. The use of extended time series showed how certain EPD traits were valued by producers over time. Volatile market prices, changes in the industry, and inflation were factored into the model.

Another study evaluated the genetic quality of dairy bulls and the market price of semen (Richards and Jeffrey 1996). The endogenous variables used consisted of proofs of each bull including milk, fat, and protein breed class average deviations. Fat and protein percentages predicted by deviations were included, as well as subjective measures such as feet and legs score, mammary system, final class, and capacity. This hedonic pricing model provided a better explanation of semen price than the Life Time Profitability Index, which is considered the industry standard (Richards and Jeffrey 1996).

Hunting Leases and Permits. Hedonic methods have been used to evaluate hunting leases in Mississippi (Buller et al. 2006) and Alabama (Zhang et al. 2006). Similar to applications in pricing of animals and commodities, hedonic pricing models take the characteristics of a lease and estimate how specific attributes contribute to the price of the hunting lease.

Though there are no general competitive markets for hunting leases, Rhyne et al. (2009) used the opportunity provided by the publicly advertised auctions of hunting leases on the Sixteenth Section Lands in Mississippi set aside by the Land Ordinance of 1785 which benefits public education. Using an OLS regression of the log-log form to estimate the relationship between lease prices and the endogenous variables, the study showed that of the 12 independent variables examined (e.g., lease length, size of the lease area, cover type, and county-level Boone and Crockett Scores), nine significantly impacted lease price. It revealed that non-industrial private forest leases possessed a mean price per acre significantly lower than that of the Sixteenth Section leases after adjusting for inflation (Rhyne et al. 2009).

White-tailed Deer Industry. Though hedonic analysis has been conducted in many areas, a void exists in research on white-tailed deer and particularly the value of semen. Therefore, the objective of this study was to use hedonic analysis to evaluate the characteristics and the value they contribute to white-tailed bucks, vis-à-vis semen value.

MATERIALS AND METHODS

Data. Hedonic price analysis was used to estimate the value of white-tailed deer buck semen. Semen prices and buck characteristics were extracted from publicly available Texas Deer Association (TDA) auction data (TDA 2013) or an auction catalog (Issuu 2015) as reported by sellers. Data were obtained from 22 auctions held between 2008 and 2015. Semen prices and number of straws within the lot were obtained from the auction summaries. Data gathered included characteristics of score (size of the antlers measured in inches), whether the buck had Texas genetics, if the buck possessed typical antler characteristics, whether the buck was from a prominent ranch, and if the buck was deceased. The lot number obtained from the data was strictly for identification for each data entry (Table 1).

TEX indicates the buck possessed Texas genetics within its pedigree. This is identified in the auction data. However, this variable does not imply that the entire pedigree was composed exclusively of deer bred in Texas.

TYP identified whether a buck possessed "typical" characteristics regarding its antlers. This is a subjective measurement used by the industry to describe a buck that possesses symmetrical antlers with little to no abnormalities. It is assumed that if a lot was purchased, the buyer agreed that the buck was considered "typical" and confirmed the seller's evaluation of the buck's antler characteristics.

The variable *PR* indicated that the semen was sold by a prominent ranch within the white-tailed deer breeding industry. This variable was recommended for inclusion by an industry advisor recognizing that this is a subjective industry measurement. It is a potential indicator of operations that might contribute premiums to the price of the lot at auction.

SCR is the variable representing the score in inches of the particular animal's antlers. The score of the animal is a primary representation of the performance of the animal that includes length and mass measurements. The score of the animal is the primary way that breeders and those involved within the industry can judge the performance of an individual animal.

DEC indicated that the buck was deceased. Therefore, semen availability was constrained. This is a latent indicator of limited supply, a probable impactor of price.

It is important to note that if the lot was donated (i.e., semen provided for the purpose of raising money for charitable causes) or contained a package deal for straws of semen that were of different sires, the lot was excluded from the data set. Transactions in each of these scenarios likely failed to express the true market value of the product being sold and were excluded. The lots were also labeled by the date of the auction.

Table 1. Definitions of variables included in the hedonic pricing model for white-tailed deer semen.

Variables	Definitions of variables
TEX	White-tailed buck possesses genetics from Texas bloodlines
TYP	White-tailed buck possesses antlers considered to be characteristically classified as "typical"
PR	White-tailed buck semen marketed from and/or originated from a prominent ranch within the industry
SCR	Antler size based in inches
DEC	White-tailed buck deceased at the time of the auction
Price/straw	Average price obtained from dividing the number of straws by the total of the final transaction price of the lot within the auction
ln (Price)	Natural logarithm of price/straw

Analytical Framework. The market price for white-tailed deer semen is determined by the market forces of supply and demand. However, various semen characteristics and market conditions play a major role in price determination. A hedonic model assumes that the implicit prices of attributes contribute towards the market price of a commodity (Rosen 1974). Hence the price of a good is assumed to be function of various attributes as shown in Equation 2.

$$Y = f(x) \tag{2}$$

where Y is the price per unit if a good and x is the vector of various attributes.

The empirical models used in this study is similar to the hedonic pricing models used in previous studies (Jones et al. 2008). The price per straw of semen can be represented as the log linear regression model expressed in Equation 3

$$\ln(price\ per\ straw) = \beta_0 + \beta_1 TEX + \beta_2 TYP + \beta_3 PR + \beta_4 SCR + \beta_5 DEC + \varepsilon \tag{3}$$

where ln is the natural logarithm, the βs are regression coefficients, and ε is the error term. The coefficients were estimated using OLS regression.

Procedure. Using the natural logarithm of price allowed for the use of linear regression despite the fact that some relationships may be curvilinear. While researchers commonly approximate the percentage change in a dependent variable from a one-unit change in an independent variable by the regression coefficient, here percentage changes in price per straw from one unit changes in statistically significant independent variables were precisely calculated using Equation 4 (Wooldridge 2009). Additionally, Equation 5 was used to estimate the marginal impact of each independent variable on price per straw.

$$\%\ change\ in\ price = 100\left[e^{\hat{\beta}_i} - 1\right] \tag{4}$$

$$Marginal\ impact = \left[e^{\hat{\beta}_i} - 1\right] \times \bar{P} \tag{5}$$

In these two equations, $\hat{\beta}_i$ represents the coefficients derived from the results of the OLS regression for $i = 1 \ldots 5$. For the marginal impacts of *SCR*, *TYP*, *DEC*, and *TEX*, respectively, $\bar{P}$ represents average price per straw of semen for bucks with average racks (i.e., \$3,220 for bucks with *SCR* = 293), for non-typical bucks (i.e., \$2,533 for bucks with *TYP* = 0), for alive bucks (i.e., \$2,360 for bucks with *DEC* = 0), and for bucks without Texas genetics (\$1,972 for bucks with *TEX* = 0). Due to difficulty defining and collecting data to evaluate what characterizes a prominent ranch, the variable *PR* was ultimately excluded from this study. However, the variable will be considered in future studies when data is more accessible.

RESULTS

The summary statistics are shown in Table 2. The average price per straw of semen from the 206 lots analyzed was \$2,488.98 with a maximum price per straw of \$20,500.00 and a minimum price of \$120.00, characterizing a diverse market with competition present.

As shown in Table 3, the model had a reasonable goodness of fit, with an R^2 of 0.47. A correlation analysis was run a priori on all explanatory variables. All correlation coefficients were less than 0.36, with the majority less than 0.20. This allows us to reasonably assume that the analysis was not impacted by the issue of multicollinearity. Several independent variables were highly significant suggesting they are implicit traits contributing to the price of white-tailed deer buck semen. One of the statistically significant variables, *SCR*, performed as predicted. It represents the primary basis of animal performance. Buyers are expected to use this performance data, combined with genetic lineages to determine the value of the genetic material being sold. The score provides buyers with a reference to the primary characteristic that is most important to the consumer, antler size.

Likewise, *TEX* and *DEC* were also highly significant. *TEX* is a characteristic that provides insight into consumer demand. This study showed that in the Texas white-tailed deer semen market, Texas genetics commanded a premium price over non-Texas semen straws. This variable had a very high impact on semen price, with a coefficient nearly double that of the next largest semen characteristic value. This highly significant variable supports the hypothesis that Texas genetics in semen straws sold in Texas auctions do command a premium. Furthermore, *DEC* confirms that if a buck is deceased and there is currently a demand for the sire's genetic material, its semen will demand a premium at auction due to restricted supply.

Table 2. Summary Statistics[a].

Variable	*Max*	*Min*	*Mean*	*STDEV*
2009	1	0	0.03	0.18
2010	1	0	0.14	0.35
2011	1	0	0.13	0.34
2012	1	0	0.14	0.34
2013	1	0	0.17	0.38
2014	1	0	0.09	0.29
2015	1	0	0.03	0.18
Price/Straw	20500.00	120.00	2488.98	2466.24
SCR	509.75	140.00	292.77	77.59
TEX	1	0	0.45	0.50
DEC	1	0	0.11	0.32
TYP	1	0	0.32	0.47

[a] n = 206 observations

The only semen characteristic variable that was not significant was *TYP*. Although this subjective measure was significant when the model was applied to an earlier subset of the data, when additional years of auction lots were included the variable was no longer significant. When comparing coefficients it was also least impactful, as shown in Table 3.

The statistically significant variables had varying impacts upon the price per straw of semen. The percentage impact on price and corresponding dollar value was calculated and is shown in Table 4. For every 10 inches of antler size that a buck possesses, *SCR* impacts semen price by over $180 per straw. Results indicate $1,369 per straw premium for buck semen reported to possess Texas genetics (*TEX* = 1). If semen is from a dead buck (*DEC* = 1), it commands a premium of $883 per straw.

Table 3. Regression Results.

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Confidence Interval* *Lower 95%*	*Upper 95%*
Intercept	5.4092	0.2343	23.0817	< .0001	4.9470	5.8714
2009	1.2132	0.3135	3.8704	0.0001	0.5950	1.8314
2010	0.2711	0.1833	1.4790	0.1407	-0.0904	0.6325
2011	0.1856	0.1979	0.9381	0.3493	-0.2046	0.5759
2012	-0.6848	0.1900	-3.6051	0.0004	-1.0595	-0.3102
2013	-0.2663	0.1945	-1.3694	0.1725	-0.6498	0.1172
2014	0.0633	0.2359	0.2685	0.7886	-0.4019	0.5285
2015	-0.5852	0.3342	-1.7509	0.0815	-1.2444	0.0740
SCR	0.0056	0.0008	6.9857	< .0001	0.0040	0.0072
TEX	0.6943	0.1266	5.4820	< .0001	0.4445	0.9441
DEC	0.3530	0.1735	2.0354	0.0432	0.0109	0.6952
TYP	0.1256	0.1217	1.0319	0.3034	-0.1144	0.3656

$R^2 = 0.47$, adjusted $R^2 = 0.44$, Standard Error of the Regression = 0.74

Table 4. Each Independent Variable's Impact on Semen Prices.

Variable	Percentage Change in Price/Straw[a1]	Marginal Impact at Average Price/Straw[a2]
SCR	0.56%***	$18.08***
TEX	100.23%***	$1,369.17***
DEC	42.33%**	$833.02**

[a] ***, **, * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

[1] $\%\ change\ in\ price = 100\left[e^{\hat{\beta}} - 1\right]$.

[2] Marginal Impact = average price/straw × ($e^{\text{Coefficient}} - 1$). For the marginal impacts of *SCR*, *TEX*, and *DEC*, respectively, we use the average price per straw of semen for bucks with average racks (i.e., $3,220 for bucks with *SCR* = 293), for bucks without Texas genetics ($1,972 for bucks with *TEX* = 0), and for alive bucks (i.e., $2,360 for bucks with *DEC* = 0).

CONCLUSION AND DISCUSSION

This analysis identifies several performance and genetic characteristics of white-tailed bucks that significantly impact the price of semen sold at TDA auctions. A log hedonic price model was applied to 206 observations collected over a period of eight years. Of the four variables hypothesized to impact price, three proved to be statistically significant.

Semen possessing Texas genetics, whether with the aim of increasing phenotypical performance or meeting certain consumer preferences, commands a premium when sellers list this information in the lot description. This is not only due to producers seeking genetic improvements to increase phenotypic qualities, but also to meet consumer preferences with the objective of improving their financial performance (Neibergs 2001). *TEX* commanded a relatively larger premium over other traits inherent in semen prices. This suggest that demand for semen containing Texas genetics is greater than from those sires who do not possess Texas genetics, or of those who do not possess sufficient Texas lines within their genetics to be noted in auction lots. This is possibly encouraged by facilities in Texas who may be more proficient in marketing their genetics through trade associations. It could also be due to a lot that possesses antler characteristics that are desirable to the buyer, but only available in Texas lineages. Additionally, it is important to note that the sample used in this study contained only auctions located in Texas, which may have led to a Texas genetics bias among bidders.

The *SCR* variable proved to be highly significant and represents an industry standard that market participants use to reference an individual animal's performance. A similar attribute is evident in beef cattle, where data plays a large part in evaluating the animal's particular usefulness and in estimating its offspring's performance. The score of a white-tailed buck represents similar information and contributes to the buck's value. Antler score is the primary focus of this industry and its significance emerging from the data is as expected. Nevertheless, its low coefficient suggests that unless the score is extremely high, the impact on semen price is relatively low.

Within this study, scores for white-tailed bucks were between 140 inches and 509.75 inches, with an average score of 293 inches. Furthermore, only 8.8% of the bucks in this study possessed scores of 400 inches or greater, and just three bucks (2%) had scores over 500 inches. Considering these parameters, additional premiums for semen would be more likely after a certain score is achieved by a breeder buck. For instance, a certain number of inches (e.g., 300 inches) may be considered average for a successful breeder buck within a production operation. Hypothetically, if a breeder buck's antler score exceeds 300 inches, higher premiums accrue for additional inches added to the score of that sire.

The *DEC* variable was also found to be significant. Supply limitations relative to a static or increasing demand curve drives price upward. However, this does not necessarily mean that semen retained from a deceased sire automatically commands a premium. Rather, a premium occurs when a buck's semen is in demand in the marketplace before his death and competition for the remaining semen increases as the finite supply diminishes.

The *TYP* variable, representing the classification of the buck possessing typical antler characteristics by the seller, proved to be non-significant in this analysis ($p = .3034$). This characteristic may have suffered from diminishing consumer preference over time for "typical" bucks. Yet, when the *TEX* variable was excluded from the model, *TYP* became significant ($p = .0438$), suggesting that bucks possessing Texas genetics may express typical antler characteristics as well. However, Pearson's correlation indicated that the two variables were not strongly correlated ($r = .1784$). From the semen auction lot data used in the analysis, of those bucks reported to possess Texas genetics, 56% also had typical antler characteristics. Even though there were 39% more bucks that had typical antler characteristics than those with Texas genetics, *TEX* was the more dominant variable.

Results from this study establish a baseline set of characteristics that contribute to the price per straw of semen for confined white-tailed bucks. Though these traits emerge as inherent attributes contributing to the price of semen, further research may find other characteristics having a dollar impact on the white-tailed deer breeding industry.

Furthermore, this study contributes to greater understanding of a developing industry that demands more attention regarding its economic drivers.

Study Limitations and Future Work. As economic research is conducted on this industry in the future, it is important to note that data availability was a limiting factor in this study. Data were often difficult to obtain. The white-tailed deer breeding industry, compared to most animal agriculture industries, is much less mature and has yet to establish a set of industry standards for comparison, though results from this study contribute towards a set of criteria. Some lots reported data on spread and mass characteristics of antlers, but not in sufficient quantity to assess the effects of the characteristics in the analysis. As more data become available, continued work may contribute to the development of EPDs for characteristics similar to those used in the cattle industry.

Another potential limitation is that the descriptions of semen lots sold at auction were reported by the seller rather than collected and reported by an independent assessment agency, possibly leading to bias in the data. Although sales of semen originating from other states is included in the dataset, it is unknown how the Texas semen market compares to markets in other states. It is important to note that all the auctions included in this study occurred in Texas. Follow-on research should replicate this study in other white-tailed deer semen markets.

This study acknowledges that buyers may consider other phenotypical characteristics in their decision to purchase genetic material at auction. Genetic lines may influence price, but were not included in this study. As such, future research should be dedicated to investigate how variables that impact the price of semen, such as the ones included in this study, change over time. Geographic origin of the semen sold at auction could also be considered as an explanatory variable in future investigations. Finally, developing a process to identify prominent ranches demands more attention.

Moving beyond hedonic analysis, investigation of exogenous variables and their influence on white-tailed deer semen auction prices appears warranted. It is possible that oil prices and the financial health of other influential industries within the Texas economy could impact semen prices. This points to further research in how changes in the white-tail deer breeding industry are impacted by macroeconomic conditions and what drives the industry as a whole.

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