FEEDER CATTLE SHRINK IN THE SOUTHERN REGION OF THE UNITED STATES

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Selected Paper prepared for presentations at the Southern Agricultural Economics Association's 2019 Annual Meeting, Birmingham, Alabama, February 2-5, 2019

Introduction

Shrink refers to the weight lost by cattle while in transit or the weight lost between delivery by a seller at an auction market and the weight received by the buyer. Cattle producers are paid a price for feeder cattle that is based on an adjustment to approximate the expected shrink. Delivered weight, on a per head basis, is lower at the time of the delivery due to shrink. It is common for a "pencil shrink" to be applied to the sale price based on an expectation of shrink. Understanding the factors that contribute to an increase or a decrease in shrink can prove important to the profitability of the transaction for both a buyer and seller of cattle.

There has been much study given to shrink of livestock from a biology perspective and to the impacts of shrink on the performance of dairy and beef cattle (Bristol, 1966; Meyer, Judy and Armstrong, 1970; Preston, Vance and Smith, 1970; Wood et al., 1972 and 1973; Cole, 1979, Camp et al., 1981; Fike and Spire). These studies include research on calves, fat cattle, and breeding age stock for both dairy and beef cattle. These studies have led to pre-and post-travel protocols (feeding strategies, and rest) being used by producers to manage shrink of their cattle while in transport (Gonzalez et al., 2012). However, few economic impact studies have analyzed the direct factors that influence shrink on livestock, in particularly, beef cattle. While biological research on the effects of shrink and how it relates to the performance of cattle is important, quantifying the variables that influence the shrink of cattle while on the trailer is just as important for a buyer or seller.

The lack of empirical economic research is due, in part, to a lack of accessibility of a dense data set. This study uses a proprietary data set on feeder cattle provided by a Texas based cattle trucking company. The data set details on and off truck weights of feeder cattle that originate in the South East Region of the United States. This data includes multiple individual trips from single locations. The purpose of this study is to provide a model that will analyze trip specific characteristics that influence shrink and their importance. The specified framework from the model can then be used for future analysis of other feeder cattle data sets and could also be used to evaluate pencil shrink and other contract provisions. Other extensions could be ramifications of the new electronic logging device mandate and its effect on shrink in cattle transportation.

Review of Literature

Shrink in cattle and in particular, feeder cattle, has been a subject of interest in both animal science and applied economics. In general, shrink has been investigated with two research objectives: conditioning (pre and post) and pricing of feeder cattle. Animal science studies have shown pre- and post-conditioning programs help minimize shrink, improve animal welfare and improve performance not only in feeder cattle, but also livestock in general (Bristol, 1966; Meyer, Judy and Armstrong, 1970; Preston, Vance and Smith, 1970; Wood et al., 1972 and 1973; Cole, 1979, Camp et al., 1981; Fike and Spire, 2006; Grandin and Gallo, 2007; Greger, 2007).

From an applied economic perspective, the slight amount of shrink literature has mainly centered around the marketing and pricing of feeder cattle. Turner, Dykes and McKissick (1991) used a hedonic model to show correct shrink estimation increased profits for producers. Coatney, Menkhaus, and Schmitz (1996) used a hedonic model to show that high shrink in feeder cattle can negatively impacts net price. As some marketing strategies have shifted from sale barns to online platforms, hedonic models (Zimmerman et al., 2012) and input characteristic models (Williams et al., 2012) have been used to show that profits can increase from online marketing, but low pencil shrink values can negatively impact price. Pencil shrink is generally 2% in Alabama (Kelly, 2019) and 2-4% in Texas (Machen and Gill, 2014). Literature regarding the economic impacts while cattle are in transport is relatively unexplored. Studies have been conducted to look at the impact of temperature, space, and miles on shrink (Petherick and Phillips, 2009; Cernicchiaro et al., 2012; Theurer et al., 2013; Goldhawk, 2014 and 2015). But economic studies regarding factors that affect shrink have been minimal. The main reason is that industry data is readily not available, a solution, although costly, to this could be surveys. A study conducted surveys of feeder cattle trips in Canada and used a mixed effects model to investigate some shrink factors such as: driver experience, time at loading and unloading, company, miles, temperature, and seasonality (Gonzalez et al., 2012). This study adds to the literature by utilizing a mixed effects model of distinct trips in the Southeast region of the United States.

Data & Methodology

The data for this research is a proprietary set of pre- and post-transportation cattle weights on 407 truckloads of cattle (26,464 head of cattle), and characteristics of the individual truckloads (number of head, miles, pick up and drop off locations).

The supply locations (figure 3.1) are in the states of Alabama, Georgia, and Texas. Texas divided into three regions: TX 1, TX 2 and TX 3. Texas was regionalized due to the state's size, and assumptions of the predominant cattle types (Bos Indicus vs Bos Taurus) sold in each region. Exact delivery locations in our dataset were withheld for privacy reasons, but the general area of feed yards in the region for delivery is known. The delivery locations (green circle in figure 3.1) are in the states of Colorado, Kansas, Nebraska, Oklahoma, and the Texas panhandle. Cattle from each supply region are similar in their preparation leading up to transport.

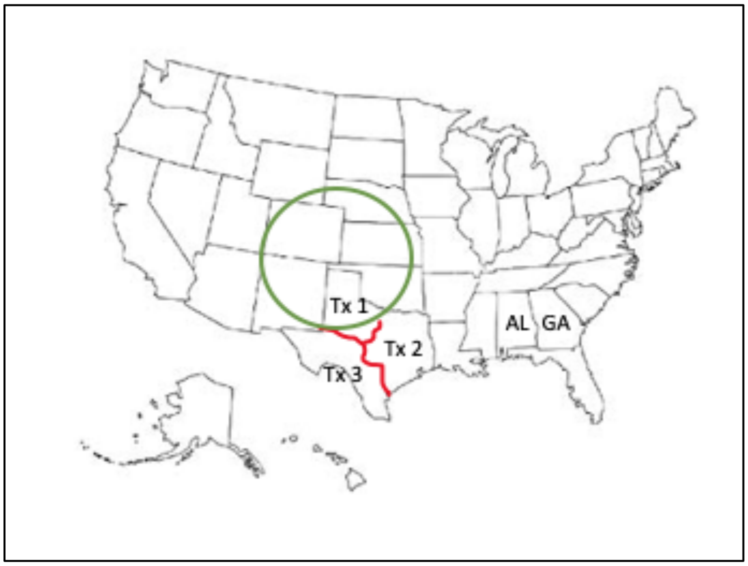

Figure 3.1 Map of Supply and Delivery locations

The loads of cattle were mixed cattle, meaning that there were males and females on the trip (e.g. cattle were not sorted by sex prior to shipment). Table 1 shows the summary statistics for the supply locations.

Table 1 Supply Location Statistics

Alabama					
	Miles	Hours	Avg On Wt	Avg Off Truck	Shrink (%)
Min	1,020	20	560	523	3.763
Max	1,478	30	867	801	10.020
Avg	1,235	25	676	631	6.597
SD			75.6	70.4	

Georgia					
	Miles	Hours	Avg On Wt	Avg Off Truck	Shrink (%)
Min	1,200	24	439	412	3.93
Max	1,580	32	987	917	12.36
Avg	1,369	27	714	665	6.85
SD			108.7	104.3	

TX 1					
	Miles	Hours	Avg On Wt	Avg Off Truck	Shrink (%)
Min	450	9	611	582	2.85
Max	870	17.4	794	755	6.45
Avg	535	11	721	690	4.29
SD			49.7	48.7	

TX 2					
	Miles	Hours	Avg On Wt	Avg Off Truck	Shrink (%)
Min	455	9	518	484	0.22
Max	1,390	28	954	910	9.06
Avg	612	12	787	756	3.90
SD			77.3	76.8	

TX 3					
	Miles	Hours	Avg On Wt	Avg Off Truck	Shrink (%)
Min	484	10	439	421	1.97
Max	850	17	859	818	8.11
Avg	659	13	710	681	4.21
SD			96.8	93.7	

Each distinct route will has an unique ID, Table 2 contains the route numbers. Each specified route then has an individual trip. This lends to a natural “level” nature in the data. This allows for the study to utilize a mixed effects model, with similar framework that Gonzalez et al. (2012) utilized.

Table 2 Unique ID (Route Numbers) for Individual Cattle Hauling Trips.

STATE	CO	KS	TX	OK
AL	1	2	3	4
GA	5	6	7	8
TX 1	9	10	11	12
TX 2	13	14	15	16
TX 3	17	18	19	20

The model utilizes the following formula:

$$Shrink_{\ ij} = \beta_0 + \beta_1 Temperature + \beta_2 Average\ begininng\ weight_{ij} + \alpha \sum_{j=1}^{J-1} U_j D_j + \varepsilon_{ij} \tag{2.1}$$

where *shrink* is actual pounds lost, *temperature* is the average temperature (Fahrenheit) at the location on the day the cattle are loaded, *average beginning weight* is the average weight of cattle at loading. The random effects parameter is captured by $\alpha \sum_{j=1}^{J-1} U_j D_j$. The subscript i, represents the individual trip of distinct route j.

In previous studies, the number of head on a trailer was used as an explanatory variable, but due to the collinearity (table 3) with average beginning weight, we chose to exclude the use of headcount in the model. Trailer space is limited when transporting cattle, thus there is a capacity constraint and using average beginning weight allows the model to avoid an unaccounted space constraint.

Table 3 Correlation matrix for Average on Weight and Head Count per truck

	AvgOnWt	HCperTrk
AvgOnWt	1.0000	
HCperTrk	-0.7650	1.0000

Results

The left-hand side of the model uses actual shrink in terms of pounds which means the left-hand side is negative (begging weight- ending weight), meaning a coefficient with a negative sign increases the amount of shrink. Temperature and average beginning weight were both found to be statistically significant. The *Temp* coefficient (table 4) indicates that as temperature increases one degree, the amount of weight lost increases by 0.33 pounds. The temperature result agrees with previous studies surrounding ambient temperature inside the trailer, which incated that higher ambient temperatures increase weight lost (Gonzalez et al., 2012). The average beginning weight *AvgOnWt* (table 4) coefficient indicated that as on-weight increases by a pound, the amount of weight lost increases by .03 pounds.

Table 4 Mixed Effects Model output

WtDiff	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Temp	-.3220325	.059169	-5.44	0.000	-.4380017	-.2060633
AvgOnWt	-.0395162	.0086881	-4.55	0.000	-.0565445	-.0224879
_cons	12.9476	8.556784	1.51	0.130	-3.823391	29.71859

Random-effects Parameters	Estimate	Std. Err.	[95% Conf.	Interval]
UniqueTrip: Identity				
var(_cons)	89.94977	40.37265	37.32077	216.7951
var(Residual)	112.361	11.23218	92.36877	136.6803

The random effects parameter was also found to be significant as indicated by a calculated p-value. To better understand the explanatory power of the random effects, the residual intraclass correlation (ICC) is calculated (table 5) for the unique trips. The ICC revealed that 44% of the variance of shrink between trips of a route could be explained through random events between trips. Meaning that random events/variables that happen during a trip (e.g. driver, traffic jams, stops, construction, breakdowns, and storms) accounts for the variability of shrink between routes.

Table 5 Residual Intraclass Correlation in the Model of Cattle Shrink

Residual intraclass correlation

Level	ICC	Std. Err.	[95% Conf.	Interval]
UniqueTrip	.4446119	.1142836	.2442416	.6647719

Conclusions

The results revealed factors that buyers and sellers can take into account when they ship cattle in the Southeast Region of the United States. Temperature can be taken into account to adjust pre- and post-transport preparations. High temperatures on the day of shipping may prompt management practices by the buyer to prepare unloading pens to account for the additional pounds lost due to the weather. The seller and/or the buyer might also adjust the negotiated pencil shrink of the load given an increase/decrease in temperature on the day the cattle are shipped.

If cattle are being shipped and on average they are above or below their contracted weight specifications, the model indicated that the average on weight coefficient could be used to adjust pencil shrink as well. These results might suggest some variable shrink contract specifications. However, sellers might refuse this as they would be asked to share a risk that is out of their control.

The explanatory power of the random effect parameter provided some insight for the individual routes and possible opportunities for future research. The 44% indicates that the randomness of the trips could be dissected more and that management techniques on cattle are only part of the shrink causation. The random events sector could be broken down into another level if the driver or driver characteristics were known. Improved driver information would provide information on the trailer used, truck used, and stops made. These variables could then be used inside the model to evaluate practices further reducing shrink.

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