SEARCHING FOR THE BIG DIE-OFF: AN EVENT STUDY OF 19TH CENTURY CATTLE MARKETS

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The nineteenth century range cattle industry continues to capture the imagination of many. Researchers maintain that the industry experienced a rapid rise and then a spectacular collapse, as overstocking resulted in the big "die-off" in 1886-87. However, the story rests largely on anecdotal evidence rather than statistical testing. We subject the claim of a big die-off to modern statistical testing. We fail to find evidence supporting the claim, but find a substantial disruption beginning in 1892, several years after the supposed event. Financial disruptions during the 1890s appear to have had a greater impact in ending the industry.

The nineteenth century open range era is iconic to many Americans. Countless novels, movies, and historical narratives detail and, often, romanticize the period. Amongst historians, there is near universal agreement concerning the rise and fall of the predominant industry of the era, the range cattle industry. Short-term investment horizons, distorted by government land policies, encouraged a speculative boom. Here, greedy cattlemen, failing to adapt to environmental realities, overestimated the carrying capacity of Western ranges. Together the pursuit of excessive profits and an "ecological

maladaptation" to environmental realities ended the dramatic rise of the range cattle industry (Jordan, 1993, p. 236).

Most historians of the era appear to believe that open access *inevitably* leads to overstocking and thus, the tragedy of the commons. During the open range era, overstocking was so severe that a harsh winter in 1887 lead to a *die-off* of range cattle. A noted historian, Patricia Limerick succinctly states, "In the 1880s, overstocking and overgrazing had led to the tragedy of 1887, in which the cattle, already weakened by drought, died in massive numbers during a severe winter" (1987, p. 156). In the end, the cattle industry collapsed due to overstocking and considerable losses.

The narrative's impact on public land management is profound and lasting. Land Acts in 1891, 1897, and 1936 depend upon natural resource exploitation under open access as theoretical justification for regulation. In the early 1900s, The U.S. Commission on Public Lands (1905) published a report concerning the disposition of the public lands. While the primary aim was an examination of how public land laws impeded Western settlement, it also contains detailed results of a survey regarding the condition of public lands. In this report, 68 percent of survey respondents report diminished range capacity and attribute this to overgrazing.[1]

Additionally, a Secretary of Agriculture's report (1936) details range conditions in response Senate Resolution 289, which states, "Whereas large parts of the western range have been subject to unrestricted use since settlement and are commonly believed to be more or less seriously depleted." Both documents reflect the role that supposed overstocking played in the creation of public land policy during the early twentieth century. Today, policy battles still criticize cattlemen for continued abuse 120 years after the era ended.

The basis for overstocking is a straightforward application of the tragedy of the commons where legal barriers to land ownership prevented cattlemen from excluding potential rivals. In turn, overuse was the norm as ranchers attempted to appropriate the grass first. An implicit assumption is that individuals did not (or could not) collectively create social institutions to prevent rent dissipation that overuse causes. However, recent theoretical developments with respect to collective decision-making challenge the notion of a predetermined outcome when property rights are missing or poorly defined.

Yet what is the evidence that overstocking took place or was so severe that a harsh winter ended the industry? Relatively little statistical evidence and no systematic empirical studies supporting widespread overstocking or massive losses exist in the literature. Moreover, there is plenty of anecdotal evidence suggesting overstocking was not an issue.

Directly testing for overstocking after the fact is difficult, if not impossible. Nonetheless, the notion that overstocking magnified average winter losses does have testable implications. If true, then measures of either industry inputs or outputs should reflect disruptions resulting from such an event. However, using measures of inputs such as published herd counts is problematic. Therefore, we focus on industry output—cattle shipments—in an econometric analysis to detect the presence of the big *die-off*.[2]

To provide motivation for the analysis, we first summarize the significance of the causal linkage between overstocking and the *die-off* to the narrative. Next, we introduce counter evidence, equally anecdotal, which challenge the magnitude of winter losses and overstocking. Finally, we discuss recent theoretical developments in collective decision-making.

The Big Die Off

Classic narratives by Edward Everett Dale (1960), Maurice Frink (1956), T.A. Larson (1965), Ernest Staples Osgood (1970) and Walter Prescott Webb (1981) recount the era in detail. They colorfully describe the period where "The whole world was urged to participate in the good fortune that the latest El Dorados offered" (Osgood, 1970, p.83) and a "fever of excitement" (Dale, 1969, p.80). Dale suggested the era was a "minor" version of the famous South Sea Bubble of 1720 (Dale, 1969, p.90). Moreover, to Webb, the rapidity of growth was unparalleled in American history and was "…the first step in the progress to that dizzy height of speculation where men make money not out of cattle or oil, but out of rising market and the folly of their fellow men" (Webb, 1981, pp. 234-235).

Osgood extensively used the terms overstocked, overcrowded, and exceeding carrying capacity. He argued in testimony before regulatory agencies that, "… ranges were becoming overstocked and the grass was playing out" (Osgood, 1970, p. 91). Removal of Indian Territory cattle before the winter of 1885/86 made overstocking worse. According to Webb (1981, pp. 234-235), "high prices and the realization on the part of some of the wiser

cattlemen that the days of free grass and open range were nearing a close resulted in an overstocking of the range."

By 1886, cattlemen had so reduced the ranges that provisioning for the following winter by cattlemen were but "eleventh-hour measures" (Osgood, 1970, p. 219). Webb (1981, p. 237) suggests that "by 1885, the time of reckoning had come. Overstocking the range had so reduced the grass that either a drought or hard winter would bring disaster." Cattlemen not only reduce range capacity, but made disaster inevitable.

Prior to the event, newspaper accounts warned of possible losses resulting from poorly conditioned cattle and lack of winter feed. During the spring of 1887, they paint a bleak picture of the disaster. The following account by a local individual is typical. "The fact that we have now to face is that the range of the present is gone; that of the present is of little worth and cannot be relied upon in the future. Range husbandry is over" (Osgood, 1970, p. 221).

Modern range historian Terry Jordan (1993) attributed the failure to the rapid expansion of the Anglo-Texan system on the northern ranges. He writes, "The free-grass policy permitted in the United States, except in Oklahoma, greatly encouraged overstocking, as did a serious misreading of the pastoral capacity of the fragile short grass plains and the speculation-fueled, hyper commercialized cattle boom of the early 1880s" (1993, p. 239). Jordan clearly believes that there was a causal linkage between overstocking and the catastrophic winter of 1886-87.

An oft-told response to the catastrophe was liquidation of remaining herds to satisfy creditor demands. In many instances, the "general unloading" of range cattle "practically cleared the ranges." Liquidations continued until the "deflation of the stock industry of the northern ranges was complete" (Osgood, 1970, pp. 222-223). The following is an example of how many view the era today:

> "Perhaps the year 1885 marks the peak of the open-range cattle industry. By that time, most of the range was fully stocked and much of it overstocked. During the summer of 1886, ranchers drove large herds north from Texas and spread them over the ranges in the most reckless fashion possible. Then came the terrible winter of 1886–87 in which hundreds of thousands of cattle died of cold and starvation. Spring came to find nearly every

> rancher on the central and northern plains facing ruin. The open-range cattle industry never recovered from the results of that tragic winter" (Isely, 2003).

Counter Evidence

As convincing as the narrative appears, the exclusion of opposing eyewitness accounts is important to recognize. Moreover, as people well understood at the time, cattlemen had a stake in convincing everyone the ranges were full, and many believed that some seriously exaggerated overstocking. Contemporaries also suggest cattlemen intentionally distorted winter losses to cover up financial mismanagement.

The *Daily Drovers Journal*, the leading trade journal of the Chicago Union Stockyards, contains numerous accounts detailing the summer drought and following winter losses. In 1886, The *Journal* published accounts of the summer drought. One suggests that current information was "extremely conflicting" so that any "reading of forty letters from as many correspondents would leave you or anyone else entirely in the dark." Another suggests, "There is no suffering among cattle on account of drought in the western portion of Wyoming. On the contrary, the cattle are in splendid condition, with abundant feed. It is believed the same can be said of the entire territory."

With respect to actual losses, another *Journal* report states, "In no part of the country has there been the same losses that are reported in the press." In Colorado, it was reported, "Stockmen who reached the city today after an extended tour over the ranges from the Arkansas Valley north to the state line are almost unanimous in their reports that the cattle are in good condition and doing well."

Efficient operation of a trading entity such as the Union Stockyards requires precise information. As such, they had a vested interested in obtaining, to the extent possible, accurate knowledge regarding market conditions. Many of these accounts such as the ones above directly contradict the traditional narrative.

W. Turrentine Jackson (1956) suggests ranchers exaggerated the following winter losses to hide financial mismanagement. Joseph Nimmo (1885) in his report makes similar accusations of substantially overstated losses. Other reports argued contemporary cattlemen spread misinformation as a strategic entry barrier given the lack of legal title to large portions of their

land holdings. Joseph Nimmo, E.V. Smalley (Nimmo, 1885, pp. 20; 83-84), and R. S. Fletcher (1929, p. 188) all seemed to suggest this was an issue.

All of the above issues are plausible and examples of asymmetric information where high verification costs allow one individual to exploit a situation to their advantage. Current cattlemen had superior information regarding existing stocking rates. Under these conditions, spreading disinformation as strategic deterrence or financial excuse makes sense.

New Institutionalist View

Recent theoretical developments with respect to collective decision-making cast further doubt on overstocking's certainty. Terry Anderson and P.J. Hill (2005), Elinor Ostrom (1990) and Gary Libecap (1981), among others, argue natural resource exploitation is not a theoretical certainty. Ranchers have a financial interest in creating institutions to maximize the long-term benefits of a range by managing the strong motivation towards first appropriation. If successful, they will prevent or minimize overstocking.

Anderson and Hill detail how institutions such as informal range rights and Cattlemen's Associations evolved on the range. These institutions arose to manage both the internal and external competition for the range. Their existence does not imply success, but limited evidence does exist. Rogers Dennen (1976) provides examples of buying and selling of informal range rights. For anyone to pay for extralegal rights, they must be effective in controlling the overstocking incentive on some level. However, while numerous field studies exist on collective-decision making under open access, to our knowledge, none relate to the effectiveness of the institutions surrounding the open range era.

In a recent paper, Louis Hotte, Randy McFerrin and Douglas Wills model open access where the disincentive on stocking arising from cattle theft is an important factor in stocking decisions. Open access encourages overstocking to capture the grass first, but given high monitoring costs, higher stocking levels increase a thieves' productivity. Under the conditions of open access and high cattle theft, conflicting incentives exist. The first encourages overstocking while the latter under stocking. If severe enough, theft may dominate the open access incentive and result in under stocking. In extreme cases, ranchers may abandon the range altogether.

By itself, counter evidence does not negate the accepted narrative but reinforces the subjective nature of the narrative's foundation Moreover; the prevailing narrative implies existing institutions failed. New Institutionalists reject the inevitability of overstocking and maintain institutional effectiveness is empirical. We contribute to the discussion by using a structural stability analysis designed to detect unusual events. Such events alter the underlying structure of a time series. In the narrative, the *die-off* was such an event.

We apply the analysis to a monthly time series of Texas and Western range cattle received at the Chicago Union Stock Yards. During the era, Chicago served as the main shipping point for range cattle and was the locus of the meatpacking industry. Any disruptions like large losses should be detectable in cattle shipments.

Market Data

We gathered data on monthly range cattle receipts at The Stockyards from 1881 to 1903 from the Woods Brothers (1904) report. They reported range cattle as Texas and Indian cattle (Texans) and Northwestern range (rangers) cattle. The first originated in the arid regions of Texas and the Indian Territory while rangers shipped primarily from Colorado, New Mexico, Wyoming and Montana. Figure 1 displays annual receipts over this period.

Total cattle shipments rose steadily from 1881 to 1891 when shipments peaked at 1,059,170. Texans followed the trend closely and peaked at 717,153 shipments during 1892. Over the period, Texans increased 7.4 percent annually with 5,868,653 total cattle shipped. On the other hand, ranger shipments trend up until 1895 where maximum shipments of 400,526 cattle occurred. Over this period, ranger shipments increased 7.6 percent annually with 3,899,335 shipped.

In addition, the range cattle market was highly seasonal as displayed in Figure 2. While Texans shipped year round, rangers shipped June through December. Peak shipping months occurred in September and October with average shipments of 125,833 and 136,459 respectively.

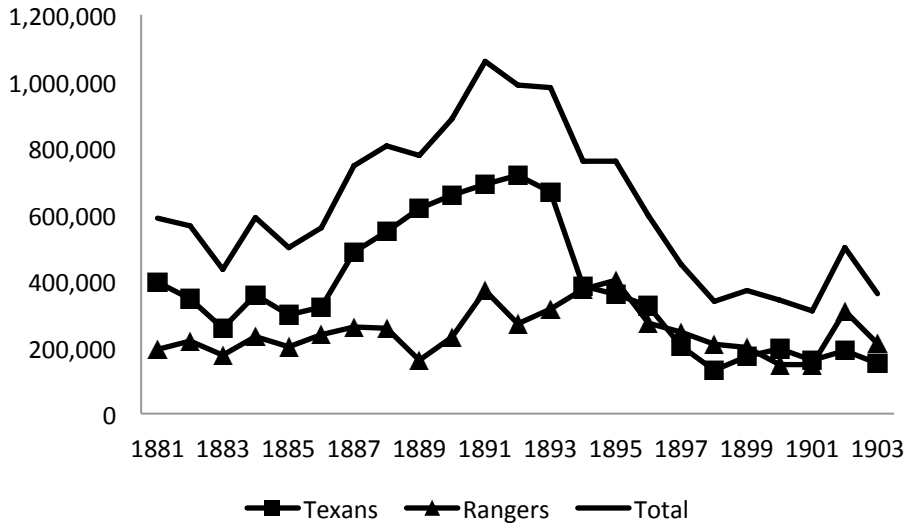

Figure 1
Yearly Cattle Shipments 1881 – 1903

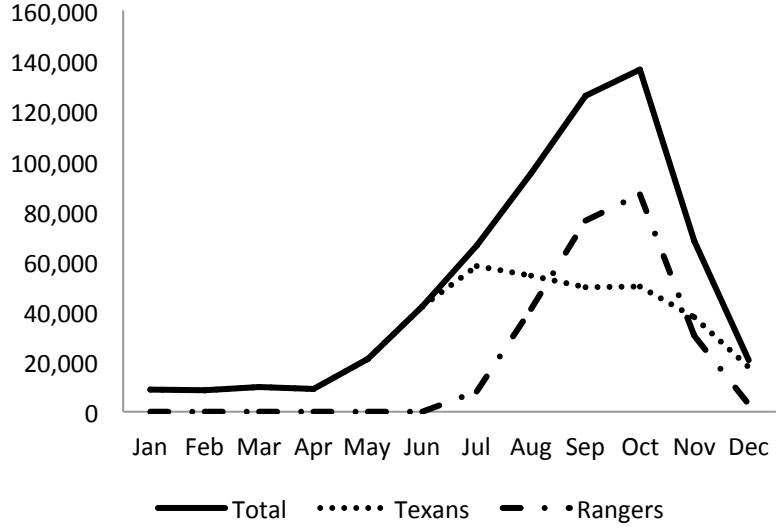

Figure 2
Average Monthly Cattle Shipments

Importantly, ranger shipments constituted a majority, 63.5 percent, during peak months. Given their importance, any significant disruptions to the northern range cattle industry should be visible in total cattle shipments.

A disruption like a significant *die-off* would also alter the time path of cattle prices. If cattlemen reacted by liquidating stock, then prices should drop dramatically and increase thereafter as the long-run stock of cattle dwindled. Figure 3 presents the twelve-month average price for Texans and six-month average price for rangers from 1882 to 1903.

As seen in the figure, prices for Texans trended downward until 1888 and then began a steady upward path until 1902. Ranger prices followed the same pattern with 1888 being an exception when they spiked at $3.9 per hundred-weight. However, prices returned to the general trend quickly.

A visual inspection of the data suggests no significant disruption associated with 1886 or 1887 occurred. However, visuals alone cannot detect unusual events. Therefore, the following section details the statistical methodology applied to the data in Figure 1.

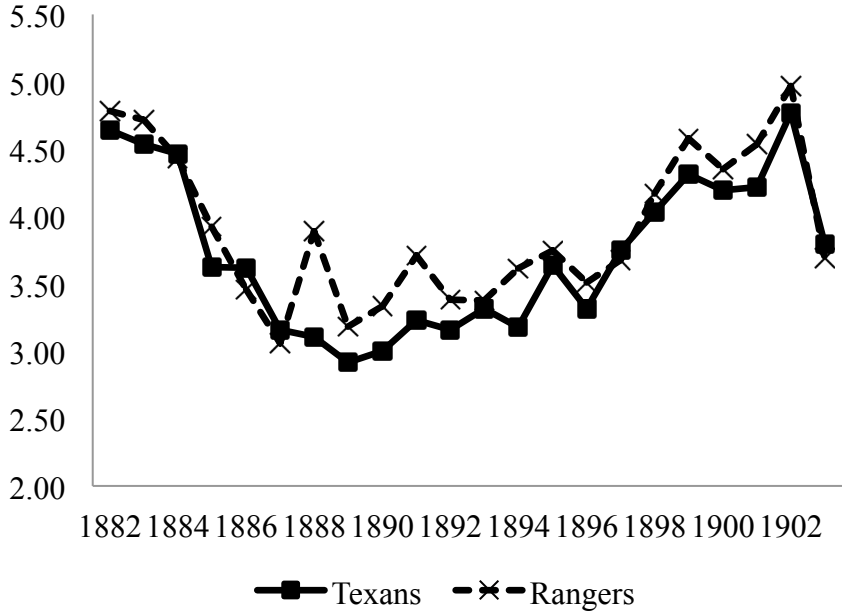

Figure 3
Average Prices from 1882 to 1903

Statistical Methodology

Donald Andrews (1993), Jushan Bai (1997), and Bruce Hansen (1995) provide a methodology for detecting disruptions in time series data. Figure 4 presents the methodology. Here, *t* is the start date and *T* the end date. *k* represents the event date. The pre-event sample spans January 1881 to April 1886 and the post-event sample from May 1886 to December 1903.

After determining the event date, we estimate the structural regression model that generated the pre-event observations of cattle shipments, which is independent of any contaminating event effects. To determine the model, we regressed the pre-event sample on a constant and inspected the auto and partial autocorrelation plots of the residuals. Regression results indicate a first-order autoregressive (AR) process with a seasonal moving average component (SMA) generated the pre-event observations. In other words, current monthly shipments correlate with the preceding month, the AR term, and shipments one year prior, the SMA term. We then estimated the model using the pre-event data based upon the above specification.

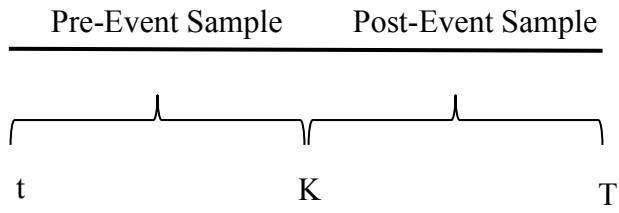

Figure 4
HBA Methodology

Table 1 presents the regression results. The resulting model fits the observations well accounting for over 80 percent of the variation in monthly cattle receipts.

Both the autoregressive and moving average coefficients are statistically significant at the 1 percent level. The sign of the AR term suggests a positive correlation between current monthly shipments and last month's shipments. Moreover, the sign of the SMA term indicates a negative correlation with shipments one year earlier.

After identifying the pre-event model, we applied the Andrews, Bai and Hansen methodology to the entire data set, which consists of three regressions. The first uses the entire sample while the latter two uses subsamples determined by *k*. We followed an iterative process by moving *k* forward one month until the usable subsamples are exhausted. For the first iteration, *k* is December 1884.

Table 1

Pre-Event Regression Results

Sample 1882:07 1885:12				
Included Observations: 42				
Convergence After 10 Iterations				
Variable	Coefficient	Std. Error	T-Stat	Probability
AR(1)	0.733	0.105	6.99	0.000
SMA(1)	-0.908	0.025	-36.41	0.000
R-Squared	0.807	Mean Dependent Variable		0.127
Adjusted R^2	0.803	S D Dependent Variable		1.112
S E of Regression	0.494	Akaike Information		1.474
SSR	9.768	Schwartz Criterion		1.558
Log Likelihood	-28.965	Durbin-Watson Statistics		1.879

We ran two separate regressions: one for the sample observations from January 1881 to December 1884 and the other for January 1885 to December 1903. Afterwards, we constructed a Wald chi-squared statistic according to equation (1).

$$W(k)_t = \frac{SSR_T - SSR_k}{\sigma^2} \qquad (1)$$

Here, SSR_T is the sum of squared residuals from the restricted regression using the full sample observations and SSR_K are from the regression on the pre k observations. The denominator, $\sigma^2 = SSR_T(k)/(T\text{-}p\text{-}q)$, is the unrestricted sum of squared residuals constructed from separate regressions

on the subsamples, pre and post *k*, adjusted for the number of possible break points, p and the coefficients estimated, q.

Under the null hypothesis, the AR and SMA coefficients are time invariant. In other words, they are the same pre and post event. If correct, then the numerator and the denominator are essentially the same in equation (1) producing a statically insignificant Wald statistic. However, if the alternative were correct, then the $SSR_T(k)$ term is less. Essentially, the procedure attempts to find the value of *k* that minimizes the unrestricted sum of squared residuals and correspondingly the maximum Wald statistic. When the statistic exceeds a critical value, this suggests the presence of a statistically significant structural change associated with a major event.

Statistical Results

Candidates for structural breaks occur on dates associated with the largest Wald statistic. A global maximum statistic occurs on May 1899, which exceeds the Andrews critical value at the 5 percent level. We, therefore, conclude a structural break exists in cattle shipments. Additionally, a local maximum occurs on June 1892, which also exceeds the critical value. Therefore, two possible structural breaks or significant events appear in the cattle series.[3]

To verify other breaks, we split the sample at May 1899 and continued the procedure on the two subsamples. The first is [July 1882, April 1899], and the second is [June 1899, December 1903]. In each sample, we vary *k*. In the first period, the global maximum Wald statistics occurs on June 1892. However, the value is 13.35 but still exceeds the 5 percent critical value. Therefore, we conclude a statistically significant structural break occurred around June 1892. We continue the process of refinement until no evidence exists of structural breaks within each potential subsample.

Table 2 presents a summary of the results. Two statistically significant events happened around June 1892 and May 1899. To determine the range in which the event dates appear, we constructed 95 percent confidence intervals using Bai's methodology.

We date the first event between March and September of 1892 and the second event occurring between February and August of 1899. In both cases, the short intervals indicate a relatively precise dating of the two events.[4]

Table 2

Estimated Event Dates

Date	Wald Stat	Critical Value	Event Date	P Value*	Confidence Interval**
Jan 1882 - Dec 1903	20.64	11.79	May 1899	0.001	Feb 1899 - Aug 1899
Jan 1882 – Apr 1899	13.35	11.79	Jun 1892	0.023	Mar 1892 - Sep 1892
May 1899 - Dec 1903	4.70	11.79	----	0.608	
Jan 1882 – May 1892	8.67	11.79	----	0.159	
June 1892 – May 1899	6.94	11.79	----	0.300	

Financial and Banking Evidence

We find no statistical evidence supporting the historical narrative of a market disruption around 1886-87. However, we do find significant evidence of a major disruption from around 1892 to 1899. Interestingly, these dates coincide with substantial financial turmoil during the 1890s.

Gene Gressley (1966) argues that low population levels in the West meant the range cattle industry relied primarily on eastern and foreign capital. Principle capital sources were in the eastern population centers of the United States and abroad, especially Great Britain. However, during the initial stages of the industry, many individuals started cattle companies by issuing stock for initial capitalization. Funds for daily operating expenses were short-term loans primarily from local banks, personal connections, familial relations, and personal funds. However, with industry expansion came the need better institutional arrangements to meet higher capital requirements.

The main asset and security for short-term loans—cattle—spent most of the year unsupervised on the public domain. As operations increased in size, local banks and other traditional methods could not handle the capital requirements or the risk involved. Cattle commission companies emerged to address the new capital requirements. Gressley (1966, p. 204) estimated one company placed between $12 and $14 million in capital from 1880 to 1900.

Overall, the British invested through commission agents nearly $45 million in Western cattle ranching.

As a result, commission companies had integrated cattle ranching into national and international financial markets by the late 1800s. As such, business cycle fluctuations influenced the industry to a greater extent than previously. A particularly noteworthy period from 1891 to 1897 corresponds to a statistically significant structural break in the time series. Monetary historians Milton Friedman and Anna Jacobson Schwartz (1993) describe the period as "by far the most interesting for the historian of money." They attribute the uncertainty to the Sherman Silver and the McKinley Tariff Acts. Both undermined the United States' ability to maintain the gold standard, which produced a series of dollar flights and a general price deflation.

Regional banking performance during the 1880s suggests that financial instability affected the range cattle markets in a profound manner. Figure 5 presents a weighted average of net earnings to owner's equity (ROE) for national banks in Colorado, Montana, New Mexico, and Wyoming. Data for fina ncial performance are from *The Report of the Comptroller of the Currency of National Banks in the United States* (1883-1904). We selected these states as they correspond to the geographical region of the open range cattle industry. As such, their financial position should reflect changes in economic conditions of the cattle industry given its substantial contribution to state income during the period under study.

Here, the solid line represents the weighted average ROE for the four states. The other represents the average ROE for the nation. The figures further support earlier findings of no significant disruptions in the cattle markets in or around 1886-87, but of a significant disruption occurring during the 1890s. If the historical narrative were correct, then the disaster would have decreased the financial performance of selected banks. However, from March 1886 to March 1888, net earnings as a percent of owner's equity were above the national average and rising. During the turmoil of the late nineteenth century, the ROE figures were below the national average and negative in some instances.

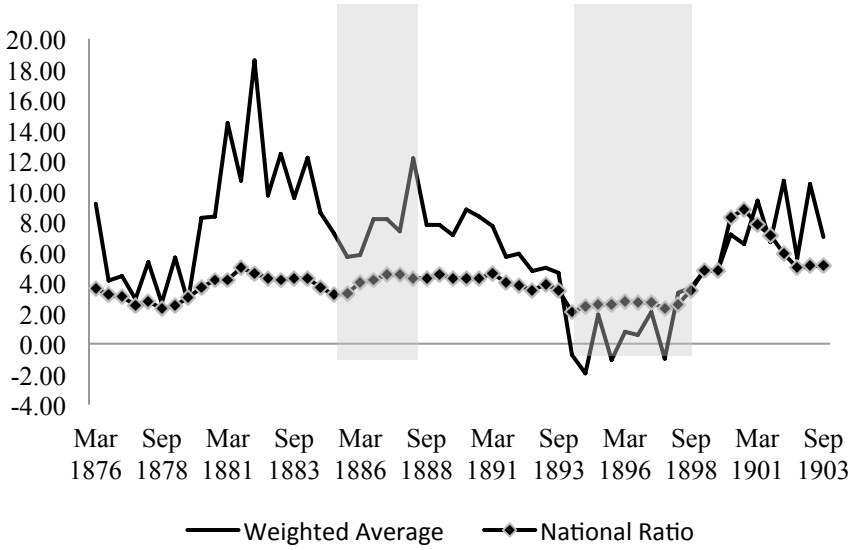

Figure 5
Weighted Average Net Earnings to Owner's Equity 1876 – 1903

Discussion of Results

The goal of economic and business historians is to interpret historical facts and explain their changes over time. During the nineteenth century changes in cattle shipments, banking ratios and other outcomes resulted both from individual decisions and from external influences like weather and macroeconomic shocks. This can be seen in time series data. Event study methodology provides an excellent tool to enhance our understanding of important factors that affected the open range industry.

In the context of historical research, the major strength of event study analysis is its ability to test assertions implied by eyewitness accounts. Sometimes these accounts generate conflicting interpretations. The big *die-off* is one such instance as stories surrounding the open range contradict themselves. Yet from these we can formulate directly testable hypotheses. For example, by the mid 1880's many accounts assert that overstocking had so reduced the range that an abnormally harsh winter devastated range herds. This is directly testable. Either it happened or it did not. A reliable set of industry output measures like cattle shipments and market prices exists to test

this implied causal effect. Results from an event study analysis applied to nineteenth century cattle shipments and prices do not support the severity of any *die-off* as generally assumed.

Conclusion

The historical narrative implies a direct causal relationship among overstocking, winter losses, and industry collapse. While difficult to determine actual stocking levels during the era, researchers hold that the winter's aftermath is unmistakable evidence of overstocking. However, using an event study analysis we find no evidence winter losses had the devastating impact on cattle markets as believed. Indeed, the range cattle industry continued to increase until 1895 contrary any perceived depletion of the northern ranges after 1887. Moreover, neither cattle prices nor banking statistics contains significant disruptions around 1886 or 1887.

There can be no doubt that individual examples of overstocking or large losses happened, but the results here suggest that they were not as widespread or severe as previously believed. Indeed, our results lend credibility to an alternative hypothesis that relatively infrequent and unusual events merged over time into a story of widespread environmental and economic devastation.

The industry development appears neither as dramatic as told nor the environmental morality play as often assumed. The chaotic evolution seems reasonable especially given the lack of formal or informal economic and legal institutions. As with any new industry, bankruptcies are common as entrepreneurs experiment with different business plans, size of firms, and methods of production.

Additionally, our finding of a major structural break at the end in 1892 corresponds not only with financial disruptions of the time, but to other well-known changes. Settlement patterns and fencing were rapidly reducing the open range. Methods of production were shifting from open range to enclosed pastures and the setting aside of land for winter forage. Both are indicative of a maturing industry. Moreover, institutions such as stronger state governments and Livestock Commission boards were emerging to regulate the remaining public domain. Not surprisingly, the time series data reflect these changes.

A final quote published in a report by the U.S. Department of Agriculture (1890, p. 439) further illustrates the problems inherent in using eyewitness accounts. In describing Wyoming, McNeely said, "Last winter was the

severest ever known by cattlemen in Wyoming, the mortality being far greater than in any former year, reaching from 25 to 40 per cent, although in a few localities it is reported as high as 50 per cent." The tendency to view the current situation as the greatest on record seems to be a recurring theme in the accounts of the era. Using a measure of industry output, we overcame the inherent limitations of anecdotal evidence or published herd counts. As such, our paper contributes to the expansion of the literature concerning the open range era.

NOTES

[1] Land Acts referenced are The Creative Act of 1891, The Organic Act of 1897, and The Taylor Grazing Act of 1936.

[2] Individual company records do survive containing herd counts. However, herd counts are notoriously inaccurate during the period the event occurred. For example, in 1892, the Matador Land and Cattle Company wrote off approximately twenty percent of its herd after acknowledging the count carried on financial statements was incorrect. Moreover, companies had to estimate winter losses. The main issue was the inability to count cattle on the open range or determine actual losses. Statistical testing requires reliable data. Therefore, we use industry outputs rather than measures of inputs such as herd counts. Output measures such as shipments survive as well and are more reliable.

[3] See Andrews (1993) Table 1 with $\pi_0 = .15$ and $p = 2$ where π_0 is the beginning trimming factor and p is the number of parameters estimated.

[4] We applied the methodology to Texan and Northern shipments separately. The results are consistent with what we report in the paper. No significant disruptions occurred in or around 1886. Additionally, no statistically significant disruptions are contained in the price series.

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