Final Project – Yearling Cattle Weight Gains

Ander Eguiluz

Bellevue University

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Business Problem

The cattle industry plays a vital role in the agricultural sector, with weight gain in yearling cattle being a critical factor that directly influences profitability. Livestock managers and ranchers face the challenge of optimizing weight gain while managing resources like pasture and feed efficiently. This project aims to explore the relationship between treatment strategies, pasture duration, and stocking rates to identify the most effective ways to improve cattle weight gain. By analyzing these variables, the goal is to provide actionable insights that will help ranchers enhance cattle growth and increase operational efficiency, ultimately leading to better resource management and improved profitability.

Background/History

Cattle ranching has a long-standing tradition where ranchers historically relied on experience and intuition to make decisions about stocking rates, pasture durations, and general management practices. However, modern agricultural practices increasingly rely on data-driven methods to improve outcomes. The dataset used for this project, obtained from the USDA Agricultural Research Service, focuses on yearling cattle weight gains. This analysis builds upon years of research in pasture management, livestock growth, and cattle industry trends. By leveraging this dataset, we seek to objectively analyze the effectiveness of various management strategies and optimize the conditions under which cattle experience the greatest weight gains.

Data Explanation

The dataset used in this analysis was sourced from data.gov and the U.S. Department of Agriculture. It includes information on cattle weight at the start and end of the study, the number of days spent on pasture, assigned treatment groups, and stocking rates. Key variables include

initial weight, final weight, weight gain (the difference between initial and final weight), pasture duration, treatment groups, and stocking rates. The dataset was cleaned and prepared by renaming columns to reflect that values are in pounds (lbs), handling missing values through median imputation, and filtering out rows containing "heifer." A data dictionary was used to maintain consistency in terminology and variables.

Methods

The analysis utilized descriptive statistics to summarize key variables such as weight gain, stocking rates, and treatment groups. Comparative analysis was conducted to examine the differences in weight gain across treatment groups, allowing us to identify which strategies led to better outcomes. A correlation analysis was performed to explore the relationships between factors like pasture duration, stocking rates, and weight gain. Finally, linear regression models were employed to quantify the relationship between these variables and predict the impact of stocking rates and pasture duration on weight gain. Python was the primary tool used for data manipulation, statistical analysis, and visualization.

Analysis

The following analysis explores key factors influencing weight gain in yearling cattle, focusing on variables such as days on feed, treatment intensity, stocking rates, and initial weights. By utilizing descriptive statistics, group-wise comparisons, correlation analysis, and a linear regression model, we aim to uncover the relationships between these variables and their impact on cattle growth. The results provide valuable insights into how management practices can be optimized to enhance weight gain and improve overall efficiency in cattle farming operations.

Descriptive Statistics:

	Year	days	treatment	SR_AUDperHa	on lbs	off lbs	gain lbs
count	813.00	813.00	813.00	813.00	813.00	813.00	813.00
mean	1998.01	113.72	1.95	28.35	629.75	863.96	234.20
std	9.58	17.94	0.83	13.91	96.49	103.72	62.70
min	1982.00	70.00	1.00	6.90	351.32	531.48	81.07
25%	1990.00	107.00	1.00	13.50	570.51	794.71	191.17
50%	1997.00	113.00	2.00	31.40	630.57	858.23	233.21
75%	2006.00	128.00	3.00	39.20	696.62	930.83	280.25
max	2014.00	141.00	3.00	52.50	901.03	1199.08	402.36

The dataset used for this analysis contains 813 observations, covering the period from 1982 to 2014. The average number of days cattle spent on feed was 113.72 days, with the shortest duration being 70 days and the longest being 141 days. Treatments were categorized into three groups, with an average treatment level of 1.95, indicating that most cattle received either moderate or heavy treatment intensities. The stocking rate, measured as Stocking Rate Animal Unit Days per Hectare (SR_AUDperHa), ranged from 6.90 to 52.50, with a mean value of 28.35. Initial cattle weights (on lbs) ranged from 351.32 lbs to 901.03 lbs, with an average starting weight of 629.75 lbs. Final weights (off lbs) ranged from 531.48 lbs to 1199.08 lbs, with an average weight of 863.96 lbs. The mean weight gain across all cattle was 234.20 lbs, with the lowest gain recorded at 81.07 lbs and the highest at 402.36 lbs. These statistics provide a foundational understanding of the dataset and highlight the variation in key factors influencing cattle weight gain.

Group-wise statistics by 'treatment' (in lbs):

	gain lbs		days		off lbs	on lbs
	mean	max	mean	max	mean	mean
treatment						
1	247.12	394.35	113.47	141	872.96	625.84
2	239.99	386.35	113.95	141	871.47	631.48
3	213.55	402.36	113.78	141	846.07	632.52

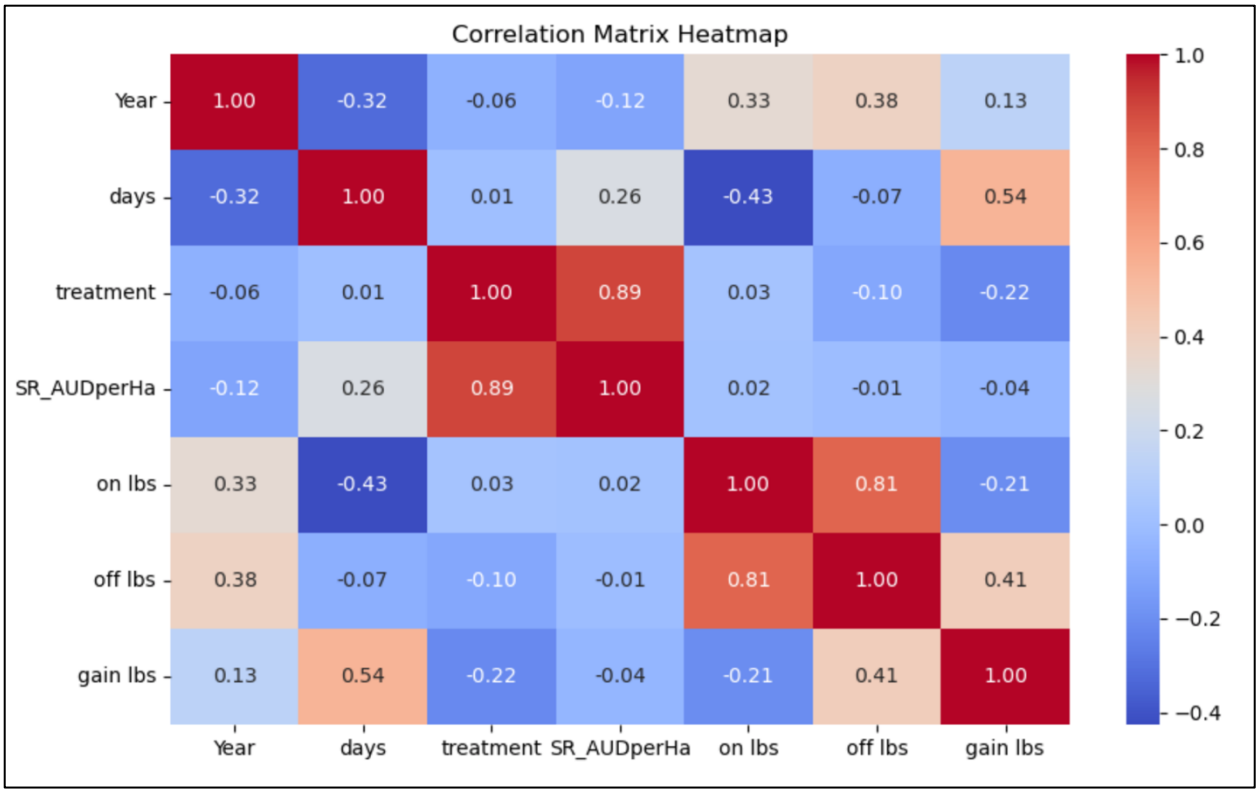
In the group-wise analysis by treatment that is visible above, it was observed that cattle in Treatment 1 (Continuous Light) had the highest average weight gain of 247.12 lbs, with a

maximum gain of 394.35 lbs. Treatment 2 (Continuous Moderate) resulted in a slightly lower average gain of 239.99 lbs, while Treatment 3 (Continuous Heavy) had the lowest average gain at 213.55 lbs, although the maximum weight gain in this group reached 402.36 lbs. Despite similar average days on feed across all treatments (around 113-114 days), the results suggest that lighter stocking rates and less intense treatments tend to yield better weight gain outcomes.

Gain per day (shown horizontally for each treatment, in lbs):

treatment	1	2	3
Year			
1982	1.41	1.96	1.58
1983	2.18	2.23	2.01
1984	2.09	2.31	2.39
1985	2.08	1.88	1.49
1986	1.82	1.72	1.46
1987	1.86	1.71	1.30
1988	1.74	1.79	1.53
1990	2.27	2.02	1.86
1991	1.99	1.75	1.54
1992	2.10	1.93	1.37
1993	2.44	2.01	1.68
1994	2.12	1.83	1.56
1995	2.41	2.51	2.22
1996	1.87	2.08	1.76
1997	2.14	2.01	2.10
1998	1.98	1.99	1.88
1999	2.27	2.24	1.82
2001	2.30	2.26	2.12
2003	2.19	1.94	1.91
2004	2.39	2.33	1.98
2005	2.24	2.19	2.01
2006	2.13	2.00	1.56
2007	2.54	2.49	2.28
2008	2.33	2.22	2.08
2009	1.79	2.00	1.98
2010	2.32	2.05	1.98
2011	3.51	3.54	3.61
2012	2.11	2.14	1.84
2013	2.00	2.19	1.93
2014	2.36	2.37	2.10

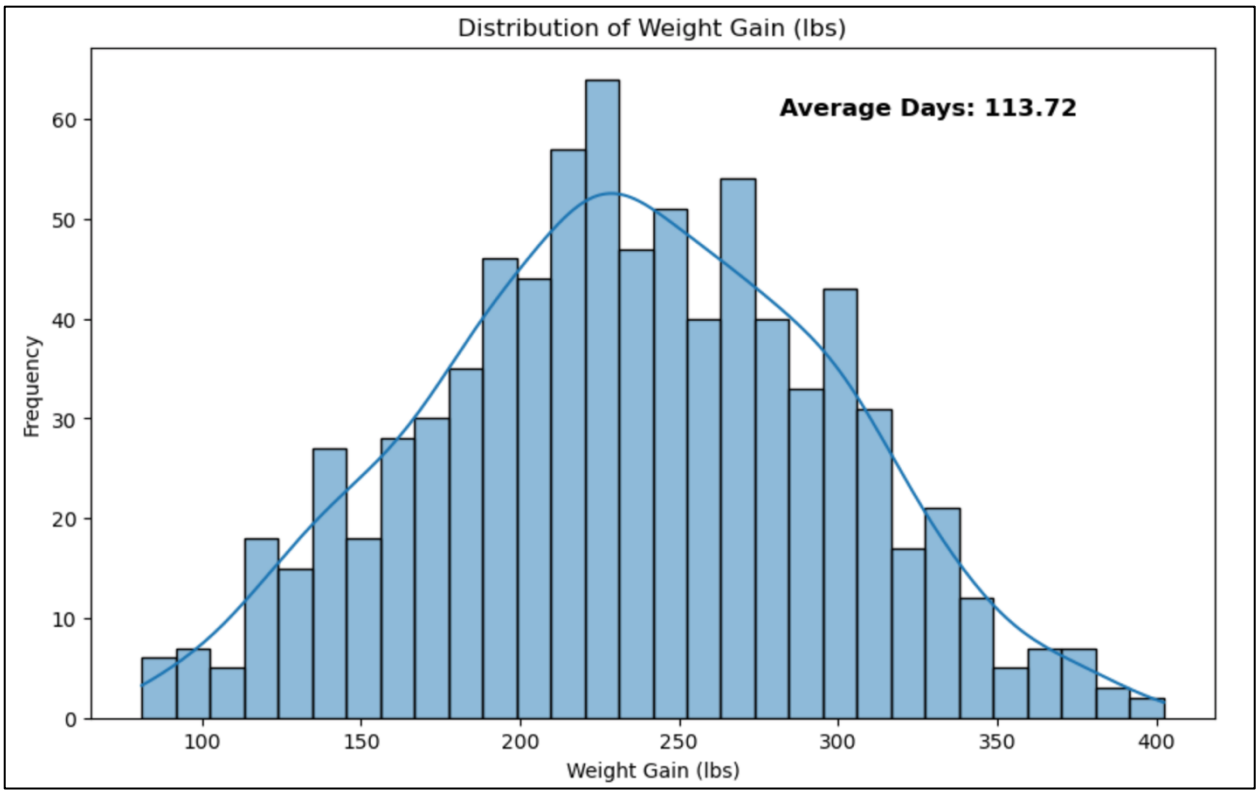
The group-wise analysis by year and treatment further highlighted how weight gain rates (lbs/day) varied over time. In most years, Treatment 1 outperformed the other two treatments in terms of weight gain per day, indicating that lighter management strategies were more effective at driving consistent growth. For instance, in 2011, cattle in all treatments achieved notably higher weight gains per day, peaking at 3.61 lbs/day in Treatment 3, which may be attributable to favorable environmental or management conditions during that year. This finding underscores the importance of optimizing stocking rates and treatment strategies to align with yearly conditions to maximize weight gain efficiently.



The correlation matrix provides insights into the relationships between the key variables in the dataset. Notably, there is a moderate positive correlation (0.54) between days on feed and weight gain (gain lbs), indicating that as cattle spend more days on pasture, they tend to gain more weight. However, the correlation between initial weight (on lbs) and weight gain is slightly negative (-0.21), suggesting that cattle that start heavier tend to experience relatively lower gains compared to lighter cattle.

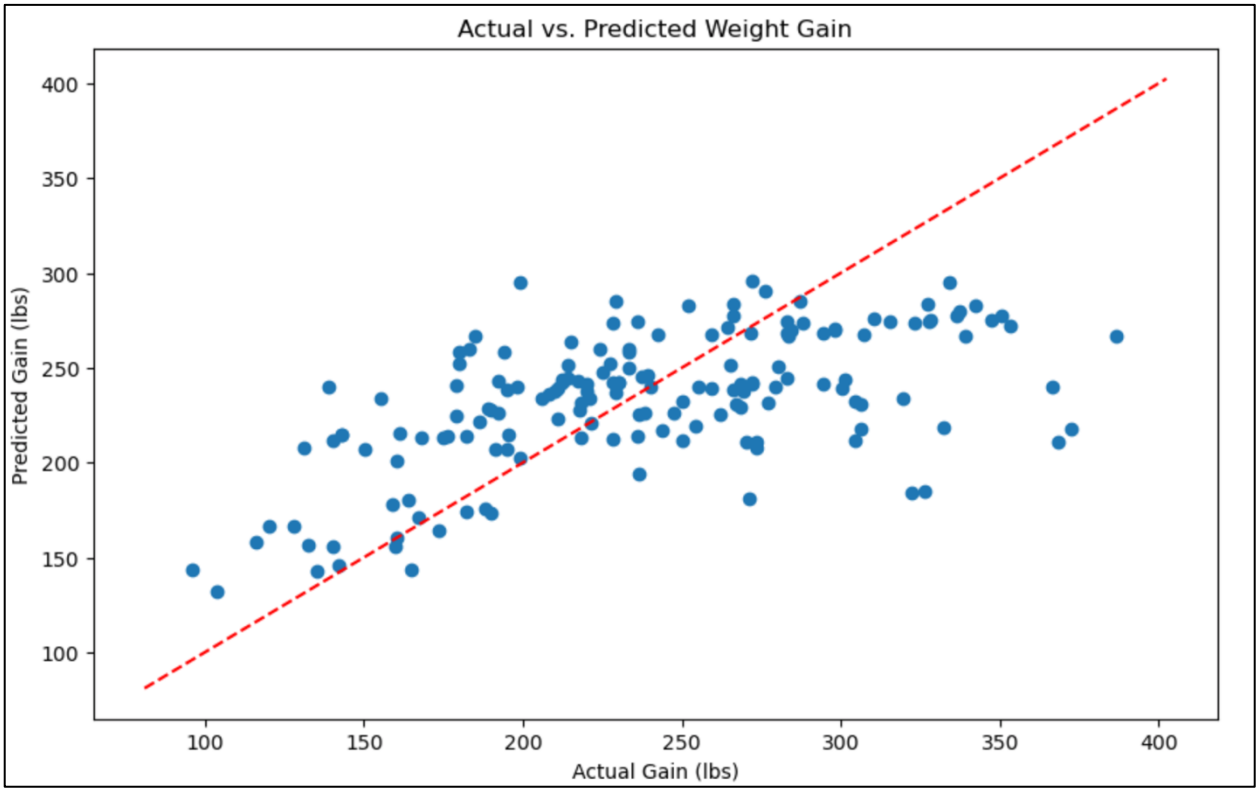
There is also a strong positive correlation (0.81) between initial weight and final weight (off lbs), as expected, since cattle that begin with higher weights tend to maintain higher weights at the end of the feeding period. Interestingly, treatment shows a negative correlation with weight gain (-0.22), indicating that more intensive treatments (heavier stocking rates) tend to lead to lower average weight gains, reinforcing the finding that lighter treatments yield better growth outcomes.

The correlation between stocking rate (measured by SR_AUDperHa) and weight gain is very weak (-0.04), suggesting that stocking rate alone may not directly drive weight gain without considering other factors like pasture duration and environmental conditions. This highlights the need to optimize multiple management variables simultaneously to achieve the best weight gain results.



The distribution of weight gain for the cattle in this study ranged from 81.07 lbs to 402.36 lbs, with a mean weight gain of 234.20 lbs. A histogram of the weight gain distribution showed that most cattle experienced moderate weight gains, with fewer cattle achieving gains at the extreme low or high ends. The distribution also suggests a slight right skew, indicating that a small number of cattle achieved exceptionally high weight gains. This variability could be attributed to differences in initial weight, treatment intensity, or other factors such as pasture conditions. The

average number of days on feed was 113.72 days, further emphasizing that the duration of time spent on pasture plays a critical role in determining overall weight gain.



Mean Squared Error: 2532.72
R^2 Score: 0.35
Model Coefficients:

	Coefficient
days	1.97
on lbs	0.03
treatment_2	-7.76
treatment_3	-32.87

A linear regression model was developed to predict weight gain in yearling cattle based on key factors, including the number of days on feed, initial weight, and treatment group. The model revealed that for each additional day on feed, cattle gained an average of 1.97 lbs, highlighting the critical role of time spent on pasture in driving weight gain. Initial weight had a smaller, positive impact, with heavier cattle at the start gaining slightly more weight, although this effect was minimal. Treatment strategies showed a significant influence on weight gain, with cattle in the more intensive treatments (Treatment 2 and Treatment 3) experiencing lower weight gains

compared to those in Treatment 1. Specifically, cattle in Treatment 3 gained 32.87 lbs less than those in the lighter treatment group, suggesting that lighter stocking rates may be more effective for optimizing growth. The model's R^2 score of 0.35 indicated that 35% of the variation in weight gain could be explained by these factors, leaving room for additional influences such as environmental conditions or feed quality. Overall, the results suggest that ranchers should carefully manage both stocking rates and days on feed to maximize cattle weight gain.

Conclusion

The analysis confirms that careful management of days on feed and treatment strategies is crucial for optimizing weight gain in yearling cattle. The results suggest that lighter treatments (Continuous Light) tend to produce higher weight gains, while more intensive treatments (Continuous Heavy) lead to reduced gains. Additionally, there is a clear correlation between time on feed and weight gain, though diminishing returns may occur if cattle remain on feed for extended periods. The findings recommend that ranchers focus on balancing stocking rates and optimizing the duration of pasture use to achieve the best weight gain outcomes. Implementing these insights will help ranchers manage their resources more efficiently while maintaining profitability.

Assumptions

Several assumptions were made during the analysis. It was assumed that treatments were uniformly applied across all groups, and that environmental conditions, such as weather and feed quality, remained consistent throughout the study. The model also assumed that missing values were representative and appropriately handled through median imputation, and that the cattle weights were measured accurately and consistently. Finally, it was presumed that the dataset was reflective of typical cattle management practices during the study period.

Limitations

Although the analysis provides valuable insights, it is subject to several limitations. The dataset does not account for external factors like weather conditions, which can significantly affect cattle weight gain. The scope is also limited to specific regions and years, potentially affecting the generalizability of the results. Moreover, variables such as feed quality or breed differences were not included in the analysis, even though they are known to impact cattle growth. Future research could benefit from including these variables for a more comprehensive understanding of weight gain dynamics.

Challenges

One of the main challenges encountered in this project was handling missing data, as some observations lacked complete information on key variables. Another challenge was addressing outliers in the dataset, which may have been due to measurement errors or extreme conditions. Additionally, understanding the interaction between stocking rates, pasture duration, and treatment intensity required careful statistical modeling to avoid oversimplification. Ethical considerations around cattle welfare were also paramount, ensuring that the recommendations derived from the analysis prioritize animal well-being alongside operational efficiency.

Future Uses/Additional Applications

The findings of this project can be expanded to include other livestock, such as sheep or goats, or to explore how different environmental conditions impact weight gain outcomes. Future applications could also focus on building more complex predictive models using machine learning techniques, incorporating additional variables like feed quality or weather patterns. Furthermore, ranchers could use these predictive models as decision-making tools to simulate

different management strategies and forecast weight gain outcomes based on changing conditions.

Recommendations

Based on the analysis, several recommendations can be made. First, ranchers should consider using lighter stocking rates and less intensive treatments to achieve better weight gain results. It is also recommended to closely monitor and adjust the number of days cattle spend on feed to avoid diminishing returns, ensuring that weight gains are maximized without overextending resources. Finally, ranchers could benefit from incorporating additional data, such as environmental factors and feed quality, into their management strategies to further optimize cattle growth. By doing so, they can refine their practices to balance cattle health, sustainability, and profitability.

Implementation Plan

The implementation plan consists of three phases. In Phase 1, ranchers will pilot the recommendations—such as adjusting stocking rates and pasture duration—on a small scale to test the effectiveness of the strategies. In Phase 2, successful strategies will be scaled up across larger herds and more extensive pasture areas, with ongoing data collection and monitoring to track results and make necessary adjustments. Finally, in Phase 3, ranchers will incorporate real-time data analysis tools, such as dashboards or mobile apps, to monitor cattle weight gain and management practices more efficiently. Continuous data collection will help refine the predictive models and improve cattle management over time.

Ethical Assessment

Ethical considerations were prioritized throughout the project, particularly regarding animal welfare. The analysis focused on ensuring that recommendations do not negatively impact the

health or well-being of the cattle. Lighter treatments and optimized pasture durations were recommended to prevent overstocking or excessive stress on the animals. Additionally, since the dataset did not contain personal or identifiable information, privacy concerns were minimal. Overall, the project balances the goals of optimizing cattle weight gain with the responsibility of ensuring humane treatment and sustainable farming practices.

References

Agricultural Research Service (2024). Yearling Cattle Weight Gains. *U.S. Department of Agriculture.* Retrieved from https://catalog.data.gov/dataset/data-from-usda-ars-high-plains-grasslands-research-station-east-unit-near-cheyenne-wy-1982-059cb