Methane Emissions Status for Manure Management across USA

https://github.com/sultzerk/SultzerSwit_ENV872_EDA_FinalProject.git

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1   Rationale and Research Questions

For this project, we were interested in manure management and greenhouse gas emissions created by livestock. Our initial dataset considered methane, nitrous oxide, and carbon dioxide. Research revealed that "livestock are reckoned to be responsible for up to 14% of all greenhouse emissions from human activities" (BBC article). With such a substantial amount of human activities, we wanted to see how livestock factored into emissions. When considering different emissions types, we focused on methane because methane is a very detrimental greenhouse gas: it traps heat at a rate 25 times greater than carbon dioxide (BBC article). Methane gas explored here is produced by the anaerobic decomposition of manure stored or treated.

Question:

Question 1: Have methane emissions changed over time?

- Create time series of methane produced by one or two livestock for general trend
- Use CH4 emissions variable – want to see if the gigagrams of methane have increased over time
- Filter for one element for time series?

* Question 2: Does the average methane emissions rate differ between each animal category?* Specifically:

- Is there a difference in rate produced by each animal? Looking for statistical difference between the rates of different livestock
- Run an ANOVA test - check whether or not there is a significant difference between livestock
- Use the Implied emissions factor variable
- Make fancy summary tables

2 Dataset Information

Dataset used for this project was found from the Food & Agriculture Organization of the United Nations (FAO), specifically from FAOSTAT. FAOSTAT provides free access to statistics pertaining to agriculture and for over 245 countries. For this analysis, we focused on emissions in the United States. *more info on how data was collected*

Metadata!

what values should be in the table? total dataset or just specific to methane and our years? Remember to create README file **remmber to write csv's for all processed data

3 Exploratory Analysis

3.1 Data wrangling steps

First, we viewed a summary of our data to decide how to pare it down and wrangle it.

We wanted to make our dataset more manageable, so we filtered for the specific columns we wanted to retain, the variable we were interested in (methane emissions), and only focused on the past years.

3.2 Basic visualizations

First, when considering our first research question, we wanted to see how methane emissions appear over time. When combining all animals, we can see there is a general increasing trend over time (Figure 1). However, there is a sharp decrease in methane emissions at the beginning of the dataset (~1980-1985) that might warrent investigation later. For our analysis, we wanted to investigate whether this trend was significant.
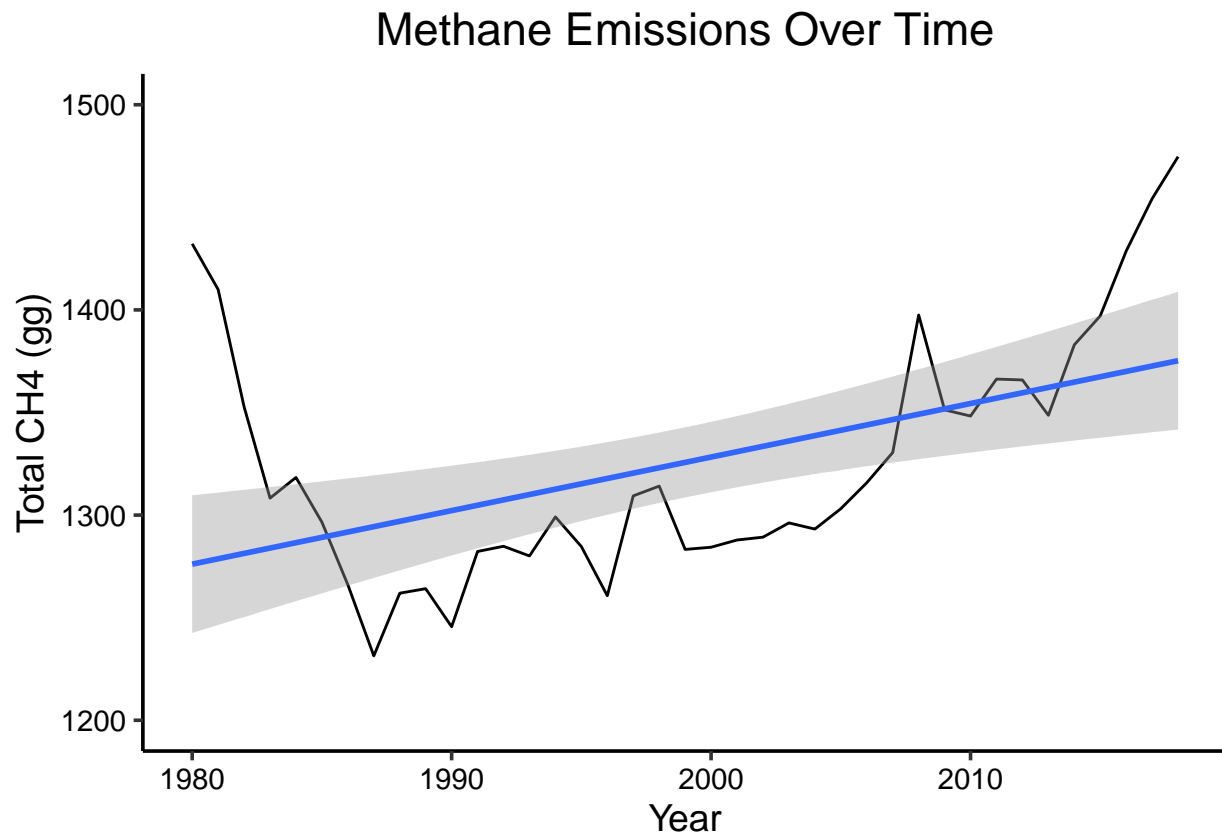

Figure 1: Methane Emissions Over Time

Our second research question focused on the different emission rates between animals. We were curious about this question when we explored a boxplot showing the different rates

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(Figure 2). According to this boxplot, we suspected that there might be statistical differences since for, example: dairy cattle and market swine had higher rates than others.
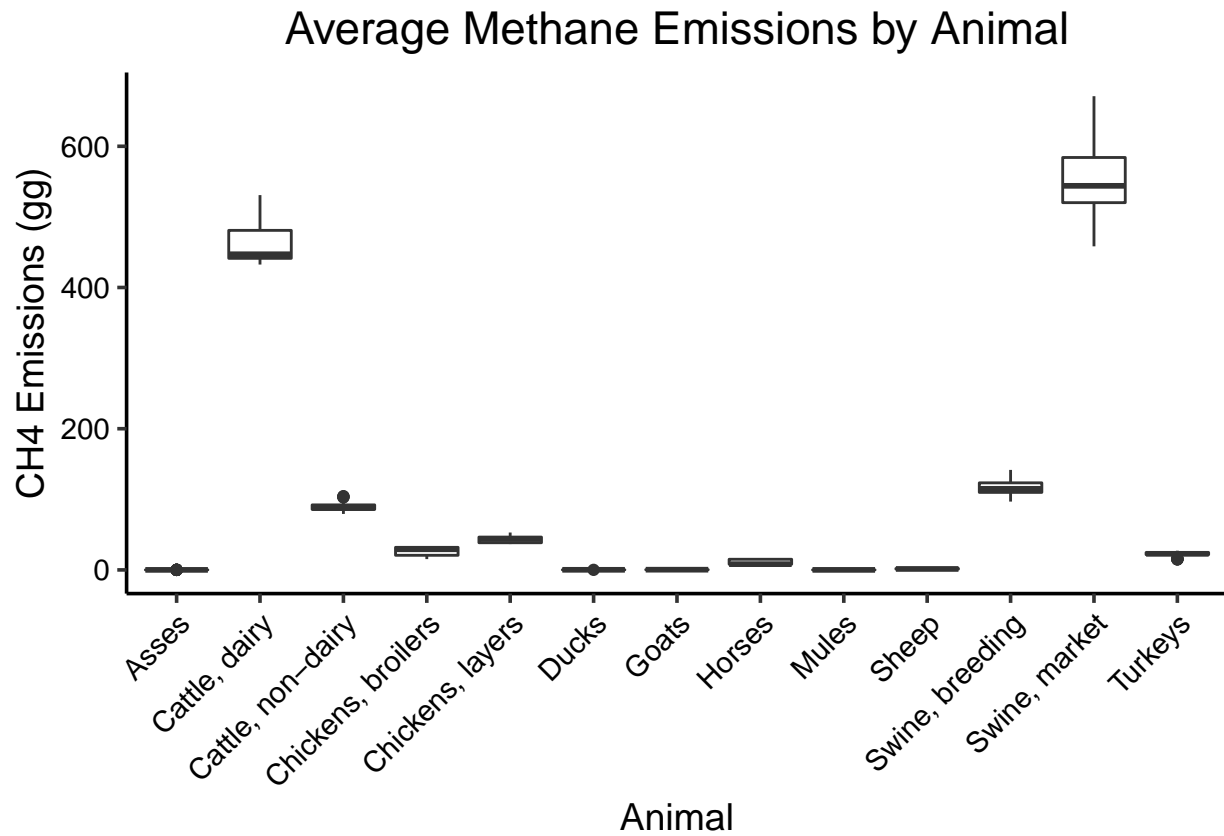

Figure 2: Average Methane Emissions by Animal

4 Analysis

4.1 Research Question 1

To answer our first research question, we conducted a time series on the overall methane production for all livestock. Since methane was only calculated once a year, there was no seasonality to our data, and we were not able to decompose our time series. However, we conducted a Mann-Kendall test, which confirmed that there was a significant trend (p-value < 0.05). From our data exploration, we can say that overall that trend is increasing: methane emissions between 1980 and 2018 have increased across 13 livestock in the United States.

4.2 Research Question 2

To answer the second research question, we conducted a one-way ANOVA test to evaluate whether the different animals, on average, have different emission rates. To begin this process, we had to test the emission rates for normality. The important assumption for generalized linear models is the normality of residuals. The Shapiro-Wilk test showed that, of the 13 livestock, only ducks, breeding swine, and market swine were normally distributed. When viewing a Q-Q plot, once can see the data does not follow a normal distribution (Figure 3). Lastly, Bartlett's test for homogeneity of variances was run, which revealed that the variances were not equal (p < 0.05). Even though all of the tests for normality failed, we proceeded on with the analysis.

Our analysis then revealed that there was a significant difference in mean emissions among animals (ANOVA; F: 4394 on 12 and 494 DF,p<0.05). But which animals had different means? A Tukey's HSD test helped show which means were different between the animals. We extracted groupings for pair-wise relationships where the letters in Figure 4 represent the different groupings. Thus, asses, ducks, goats, mules, and sheep all had statistically similar emission rates (Figure 4). Most of the other animals, such as market swine and dairy cattle, have their own grouping.

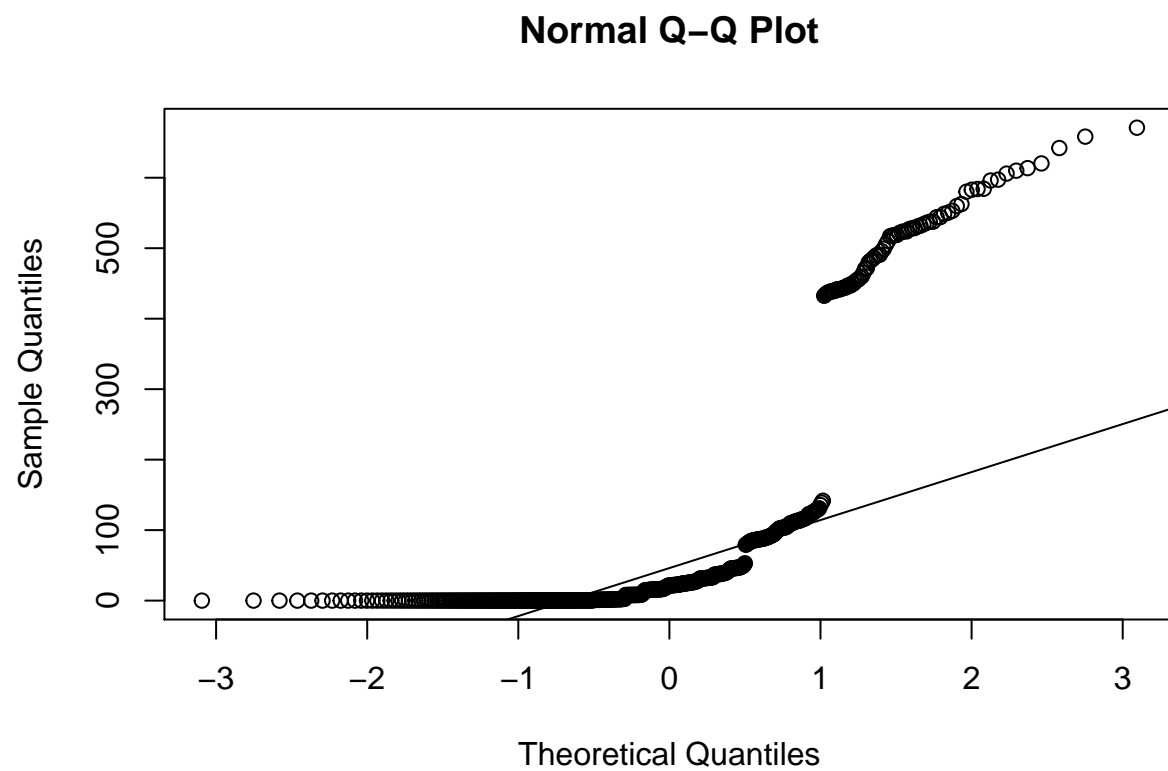Nadia: Time series Kendra: ANOVA and grouping
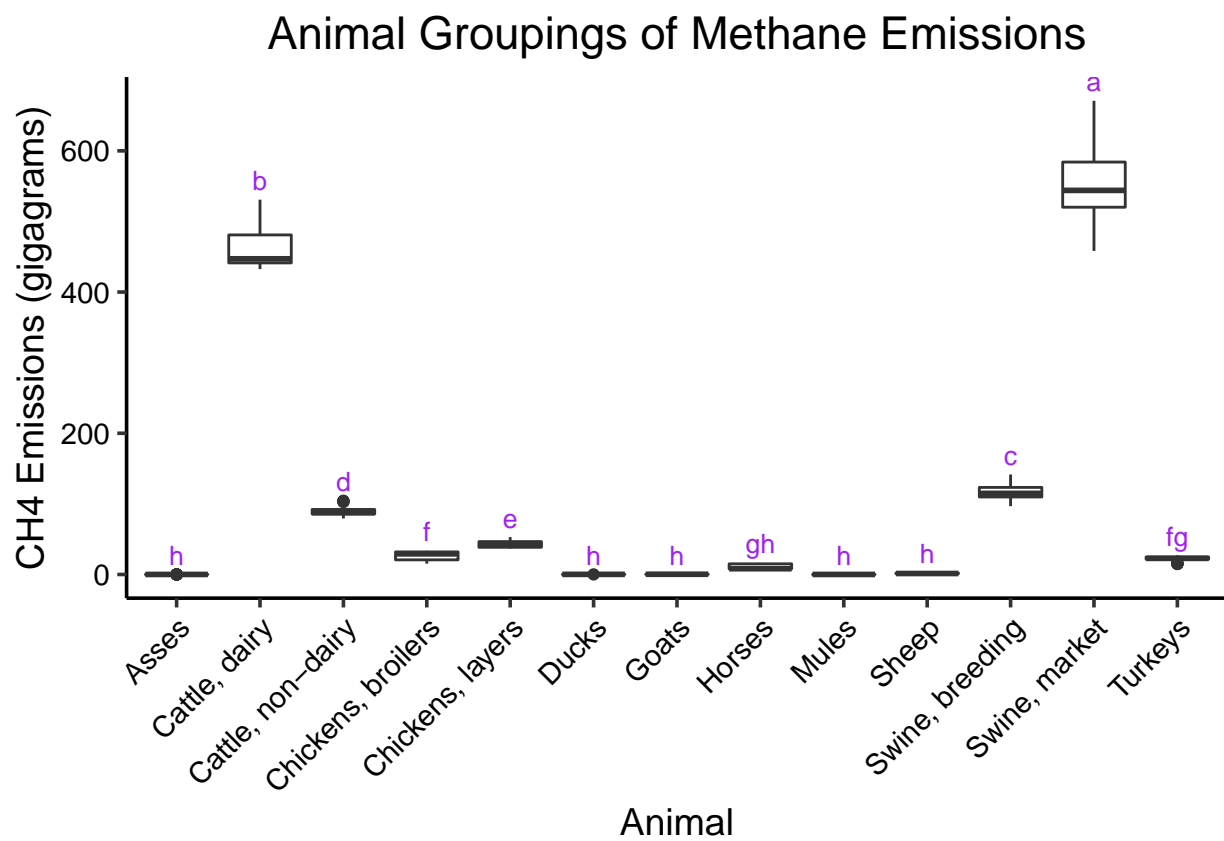
Normal Q–Q Plot

Figure 3: QQ plot

Figure 4: Animal Groupings of Methane Emissions

5   Summary and Conclusions

Conclusions from time series and ANOVA Include normality test results

6 References

BBC citation article: https://www.bbc.com/future/article/20190806-how-vaccines-could-fix-our-problem-with-cow-emissions <add references here if relevant, otherwise delete this section>