Analysis of Retail Meat Trends and Price Spreads over Market Share Concentration

Kushaan Jain, Gokulraj Kumarassamy, Aryan Malik, Subhronil Mukherjee, Rahul Rajkumar, and Alex Zhang

Rutgers Economics Labs, Rutgers University
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Abstract

This paper examines inflation-adjusted price spreads in the U.S. meat industry—pork, beef, and poultry—using USDA, BLS, and AMS data to assess whether farmers are receiving fair value. It finds that while farm and wholesale prices have remained relatively consistent, retail prices have risen disproportionately, suggesting increased retailer markups. Seasonal effects are minimal, and forecasting models like ARIMA and LSTM show limitations in their ability to accurately predict price movements. Regression analysis reveals a general inverse relationship between industry concentration (CR4) and price spreads, suggesting that retail price-setting power may be growing.

Index Terms: Meatpacking, Market Concentration, Retail, Wholesale.

1 Introduction

The purpose of the Packers and Stockyards Act of 1921 is "to assure fair competition and fair trade practices, to safeguard farmers and ranchers...to protect consumers...and to protect members of the livestock, meat, and poultry industries from unfair, deceptive, unjustly discriminatory and monopolistic practices."(United States Department of Agriculture, Agricultural Marketing Service, *Packers and Stockyards Act, 1921*). The U.S. Department of Agriculture's Packers and Stockyards division is responsible for upholding the Packers and Stockyards Act and ensuring the meat industry is fair and competitive.

A key aspect of monopolistic behavior is the prevalence of price spreads. Price spreads occur when there is a difference in the price of a product at one stage of the supply chain process compared to another stage. In the context of the meat industry, three price spreads are relevant. The first is the difference between the farm price of a given meat product and the wholesale price of the same product. The second is the difference between the wholesale price and the retail price. The third is the overall price spread between the farm price and the retail price. Examining these price spreads can help determine whether farmers are being paid a significantly cheaper amount for their products compared to the price in retail stores.

The purpose of this paper is to conduct a trend analysis of meat prices over time in the farm, wholesale, and retail sectors to determine if farmers are being cheated for the value of their product. This paper specifically looks into the hog, poultry, and cattle industries, with a further breakdown of the cattle industry by cuts. We study the trends of the three described price spreads across these three industries, decomposing seasonal patterns and identifying peaks and troughs. We further examine patterns for these trends while adjusting for inflation using specific deflators to determine long-term directions. We also analyze price spreads by cut to identify any erroneous spreads and determine whether they signify monopolistic practices by wholesalers. Lastly, we regress the time series data on CR4 concentration and forecast future prices using an ARIMA model.

1.1 Key Data Sources

The key data sources used to conduct the analysis are the Meat Price Spreads product from the USDA Economic Research Service (ERS), the Bureau Labor Statistics Series Report, and the USDA Agricultural Marketing Service (AMS). The ERS provides initial overall retail, wholesale, and farm values for each meat (United Stated Department of Agriculture, Economic Research Service). The BLS Reports provides retail pricing data for specific meat cuts (U.S. Department of Labor, Bureau of Labor Statistics), and the AMS data provides wholesale pricing data for specific meat cuts (United States Department of Agriculture, Agricultural Marketing Service, MPR Datamart).

1.2 Paper Organization

This paper starts with a deflator analysis to properly adjust price data for inflation. Then, there is an analysis on retail trends for each meat—beef, pork, and broiler/poultry—including seasonality and forecasting. There is also a brief discussion on certain exogenous price shocks that may have created certain outliers in the data. Finally, the paper describes our methodology for obtaining price spreads that are then regressed over the CR4 ratio of the meats' respective industries.

2 Retail Price Analysis

Before analyzing the data, it must be properly deflated. Using PPI as a deflator, based on the graphs below, it is clear that the signal of 'adjusted price' does not decrease or show any kind of long-term trend. Deflating the retail price of chicken cuts using PPI is similar to comparing apples to oranges—it is not informative and cannot be interpreted meaningfully. It is also unsafe to use this index to draw conclusions about fair pricing for retail chicken cuts versus what farmers receive.

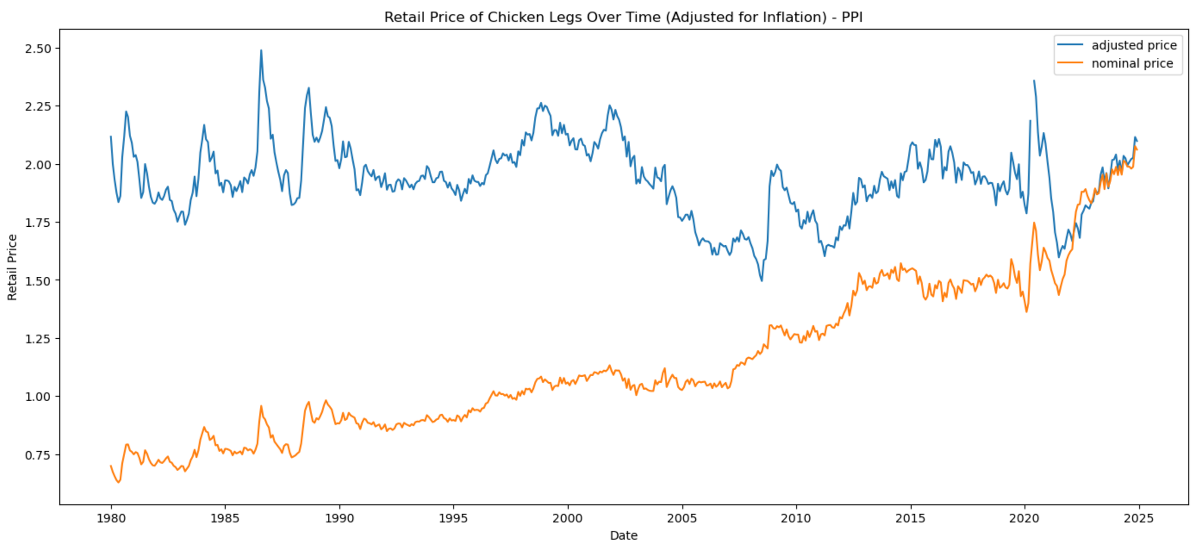


Figure 1. Retail Chicken Legs using PPI as a deflator.

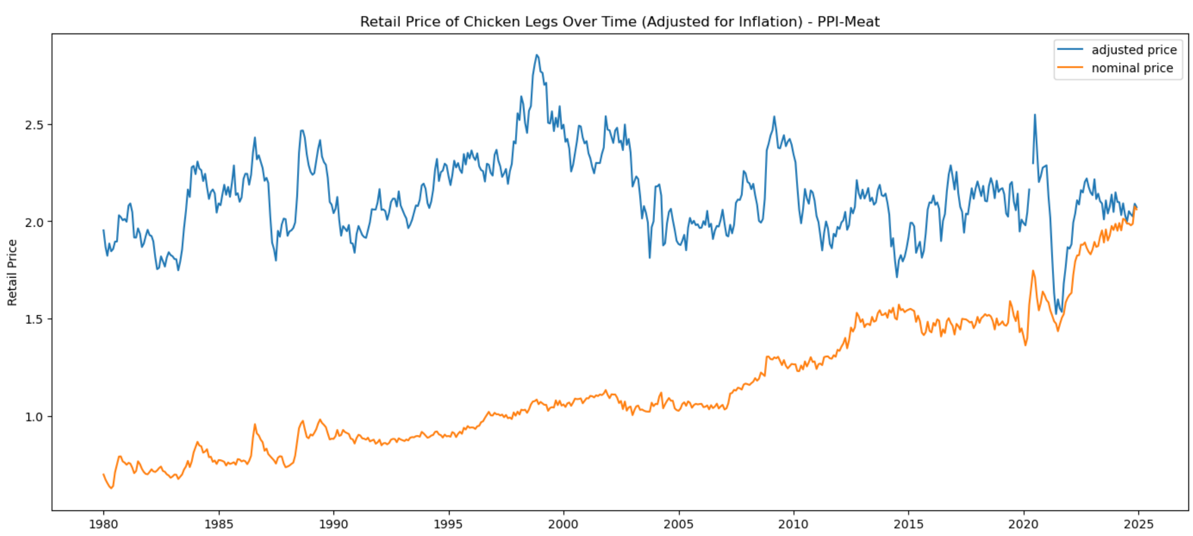


Figure 2. Retail Chicken Legs using PPI-Meats as a deflator.

Using PCE vs. CPI as deflators, no significant difference emerges in overall trends. PCE accounts for substitution and weights from business surveys, while CPI uses consumer surveys and focuses on urban households. Both show a downward trend in real chicken prices, though CPI is more appropriate for consumer price trends.

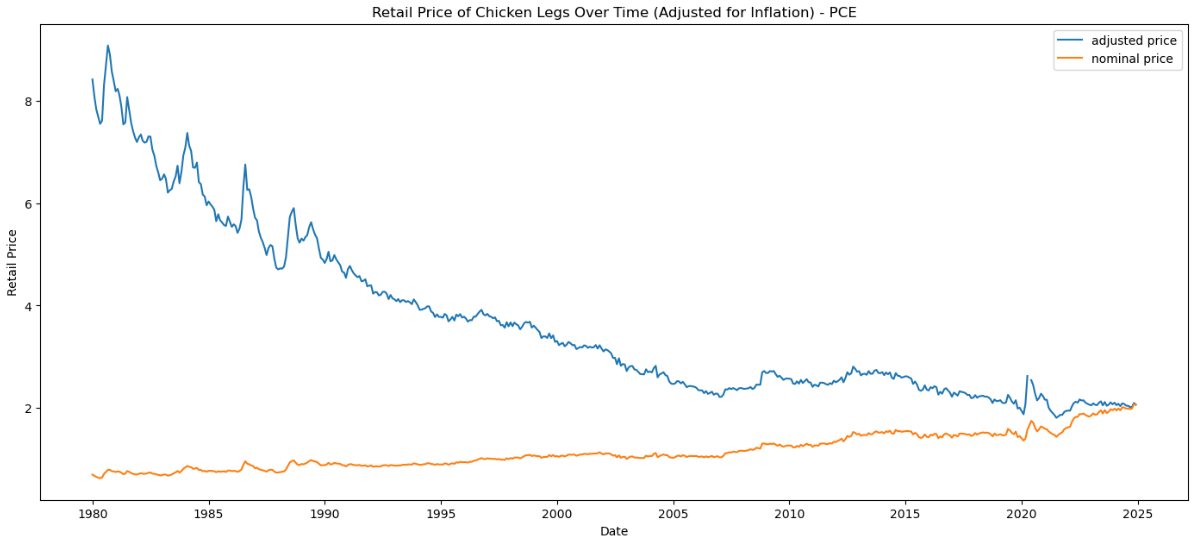


Figure 3. Retail Chicken Legs using PCE as a deflator.

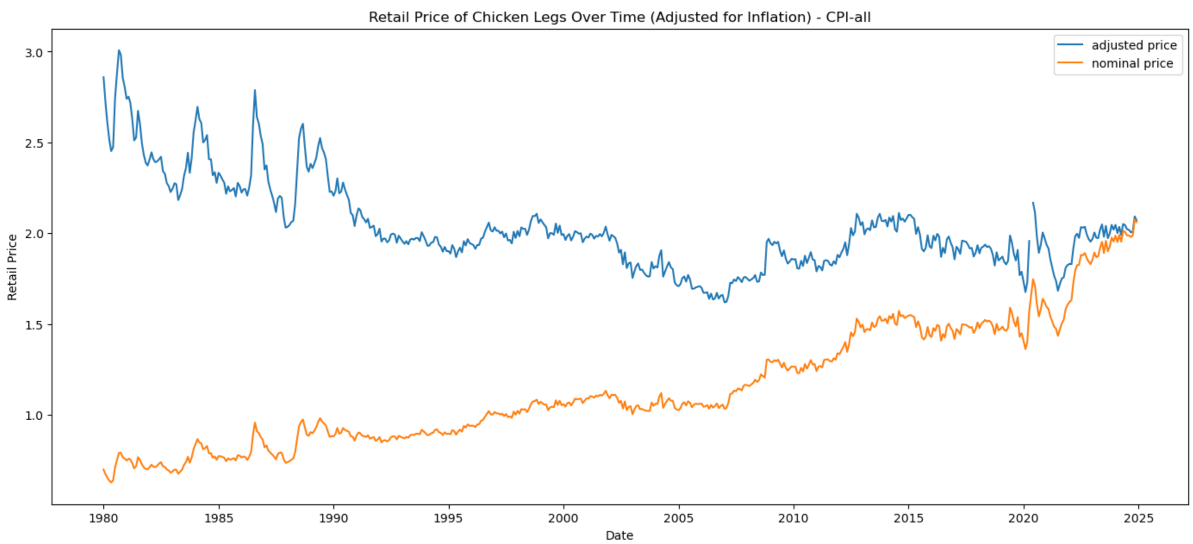


Figure 4. Retail Chicken Legs using CPI-All as a deflator.

Using CPI-Meat as a deflator compares chicken cuts to other meat prices but is limited in its broader inflation relevance.

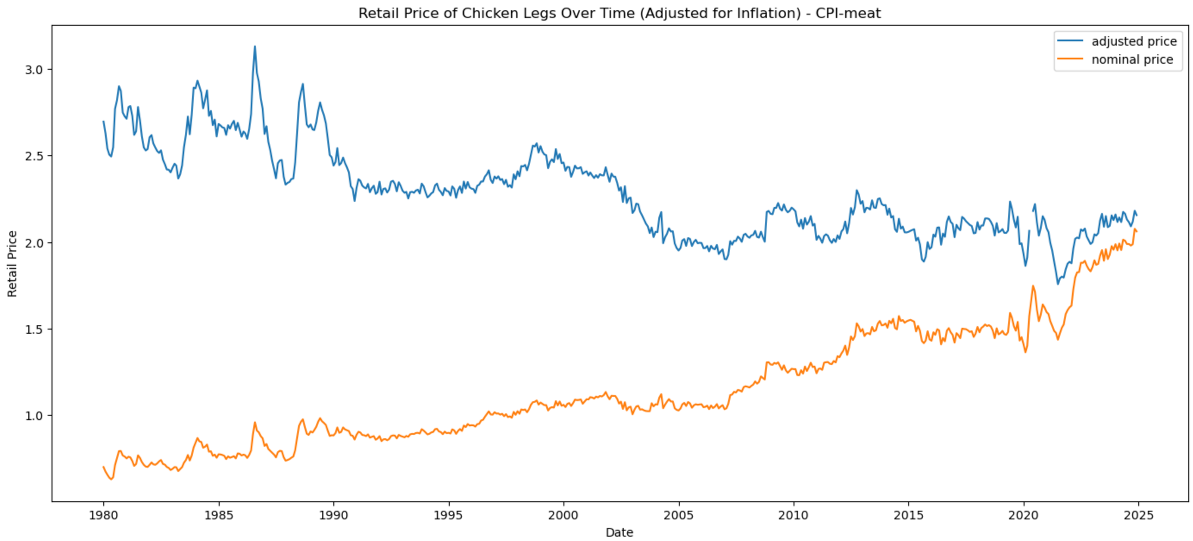


Figure 5. Retail Chicken Legs using CPI-Meat as a deflator.

In conclusion, the best deflator is the overall CPI index, as it most accurately reflects consumer-facing inflation over time.

2.1 Retail Trends of Chicken, Beef, and Pork

We now analyze retail prices of each protein adjusted using the CPI-All deflator. Each meat is broken down by cut, ordered by general market price from cheapest to most expensive. We also include seasonality data.

2.1.1 Chicken All chicken cuts—Chicken Breast Bone-In, Chicken Breast Boneless, and Chicken Legs—demonstrate a decreasing long-term trend in real prices. Although nominal prices have increased since 1980, the inflation-adjusted values have been falling.

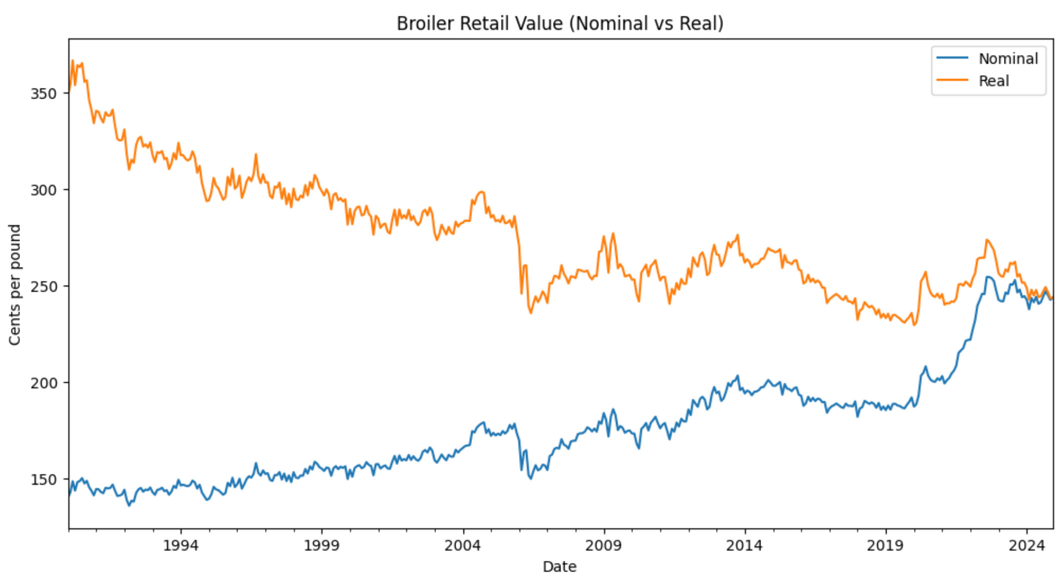
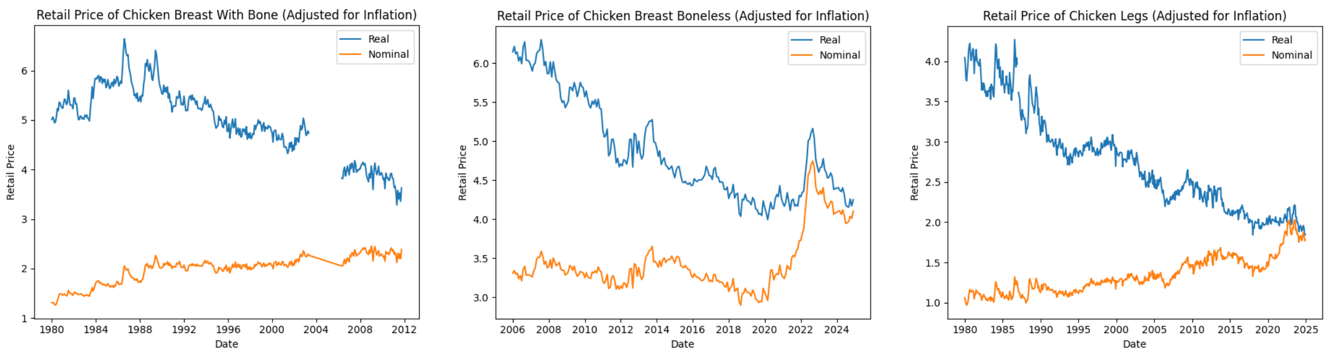


Figure 6. Inflation-adjusted retail prices of chicken overall.



(a) Chicken Breast (Bone-In) **(b)** Chicken Breast (Boneless) **(c)** Chicken Legs

Figure 7. Comparison of chicken cuts.

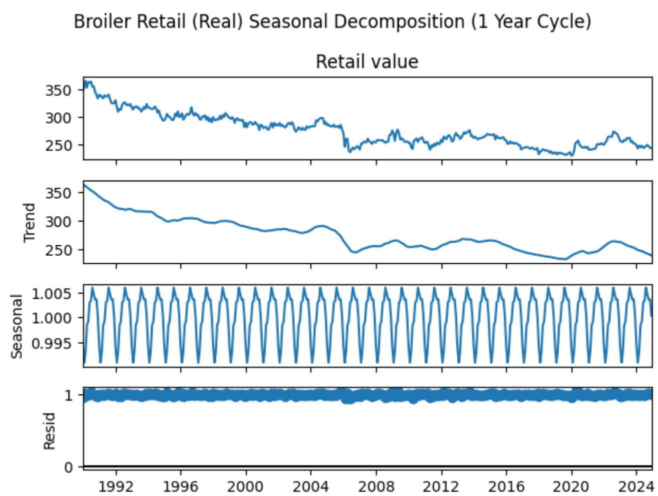


Figure 8. Chicken seasonality using STL decomposition.

2.1.2 Beef However, this was not the case for cuts associated with beef. In fact, not all cuts posed the same long-term pattern. Over time, after adjusting for inflation, the more expensive cuts for beef, such as round steak, had decreased in retail price over time, while the less expensive cuts like ground and chuck beef had increased in retail price since 1980.

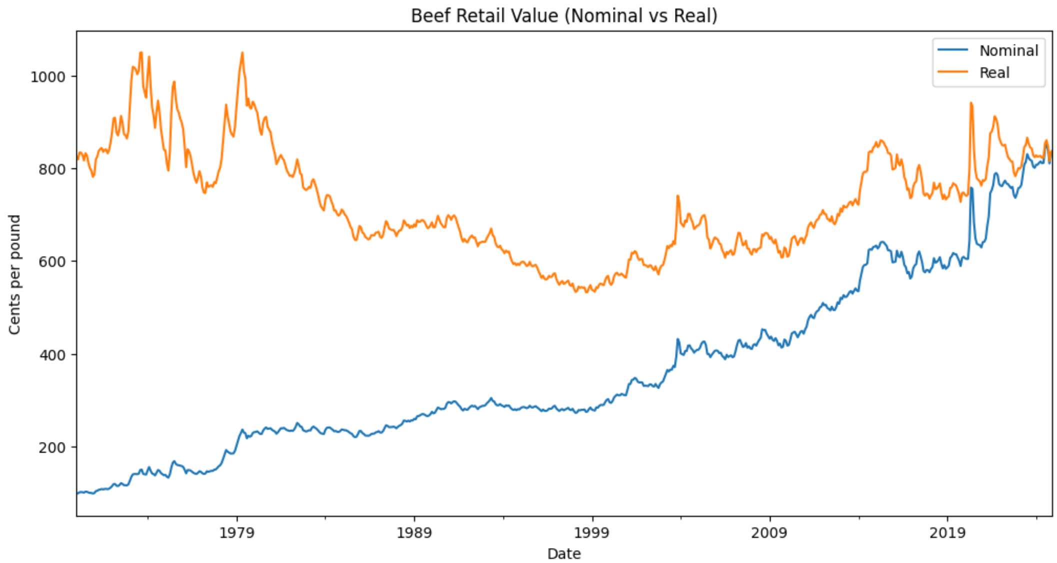
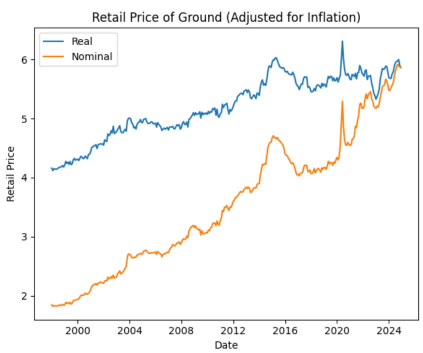
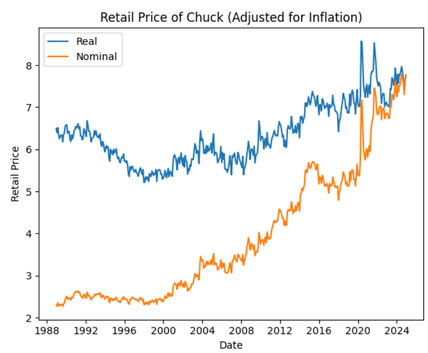


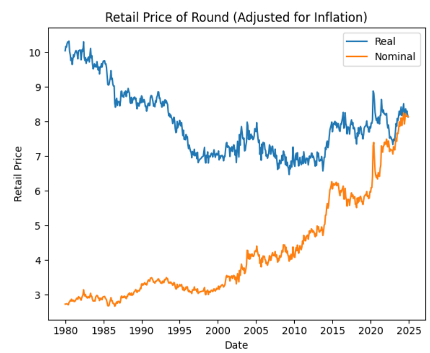
Figure 9. Inflation-adjusted retail prices of beef overall.



(a) Ground Beef



(b) Beef Chuck



(c) Beef Round

Figure 10. Comparison of beef cuts.

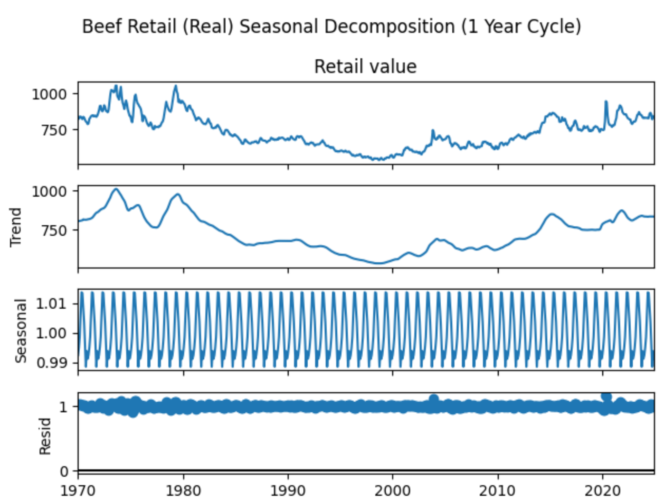


Figure 11. Beef seasonality using STL decomposition.

2.1.3 Pork The long-term trend of retail prices of pork, adjusted for inflation, also varied based on each cut. Based on the graphs above, it is evident that while the retail prices of ham and bacon initially went down near the end of the 20th century, they later rose back up. However, the retail prices of chops have been consistently decreasing since the 1980s. For overall prices, these trends decreased slightly and show a seasonal trend of 2%, which is very minor.

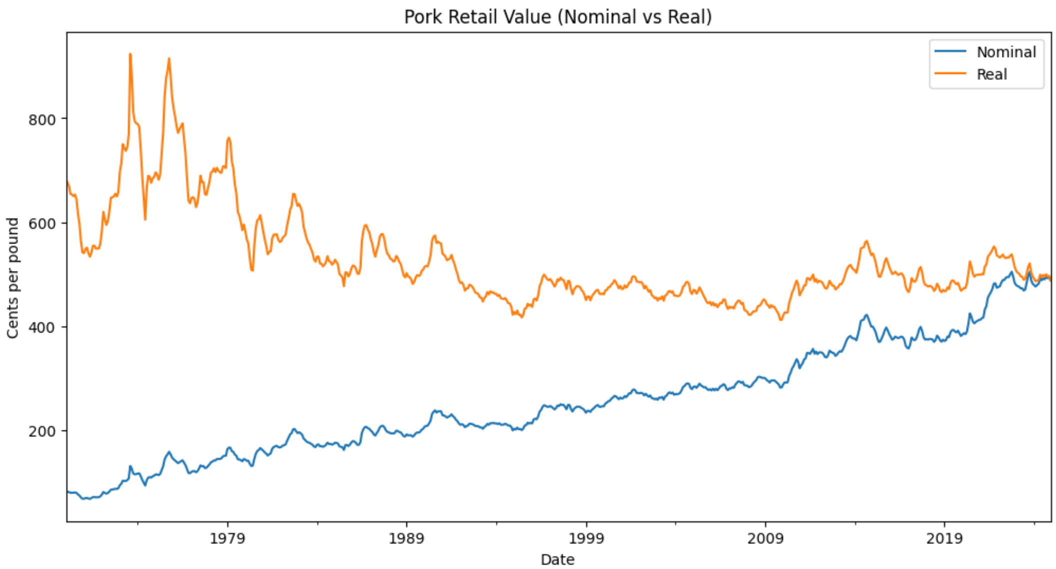
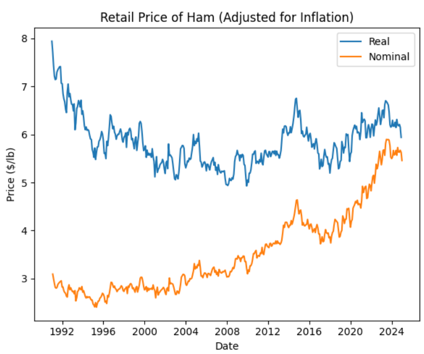
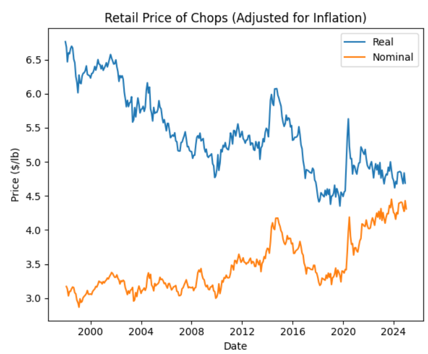


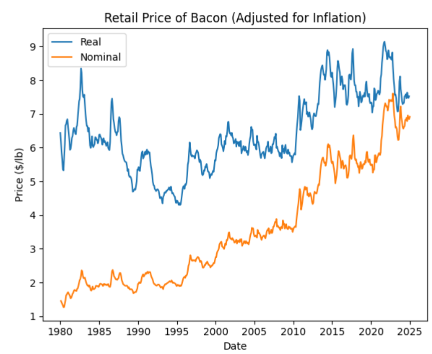
Figure 12. Inflation-adjusted retail prices of pork overall.



(a) Ham



(b) Pork Chops



(c) Pork Bacon

Figure 13. Comparison of pork cuts.

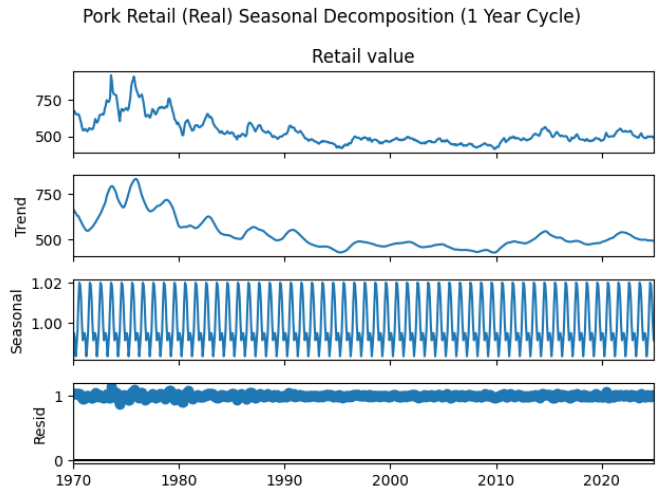
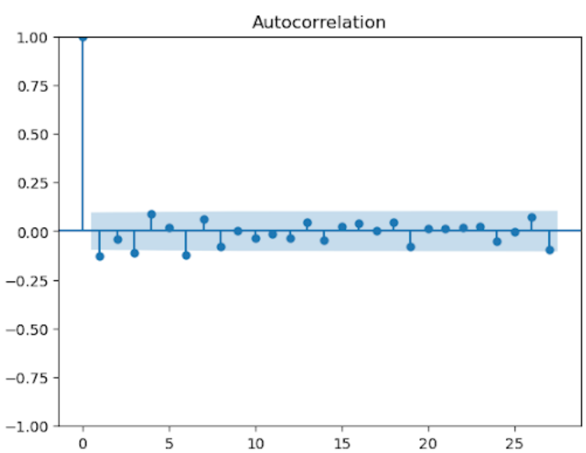


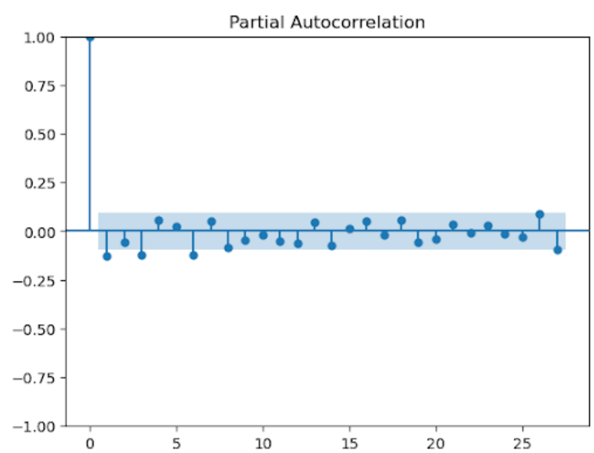
Figure 14. Pork seasonality using STL decomposition.

2.2 Forecasting

Our primary goal with forecasting was to create a model that had a comfortable goodness of fit of the retail prices of meat based on the historical retail prices that were adjusted for inflation. This way, we could use this model to predict future retail prices of meats. For simplicity, we decided to start our forecasting venture with the Auto Regressive (AR) model and chose a time series that was best representative of the other time series—in this case, the retail prices of chicken. Using Autocorrelation and Partial Autocorrelation Functions, we determined the number of lags (or number of previous observations to predict future estimates) would be around two, which meant there was a weak correlation between each point.



(a) Autocorrelation



(b) Partial Autocorrelation

Figure 15. Results of Autocorrelation and Partial Autocorrelation.

To process our data, we performed a box-cox transformation and differencing on the time series data. After this, we fitted the AR model to the training data. However, due to the weak correlation between each observation as mentioned before, our model did not have a perfect fit. The graph is shown below.

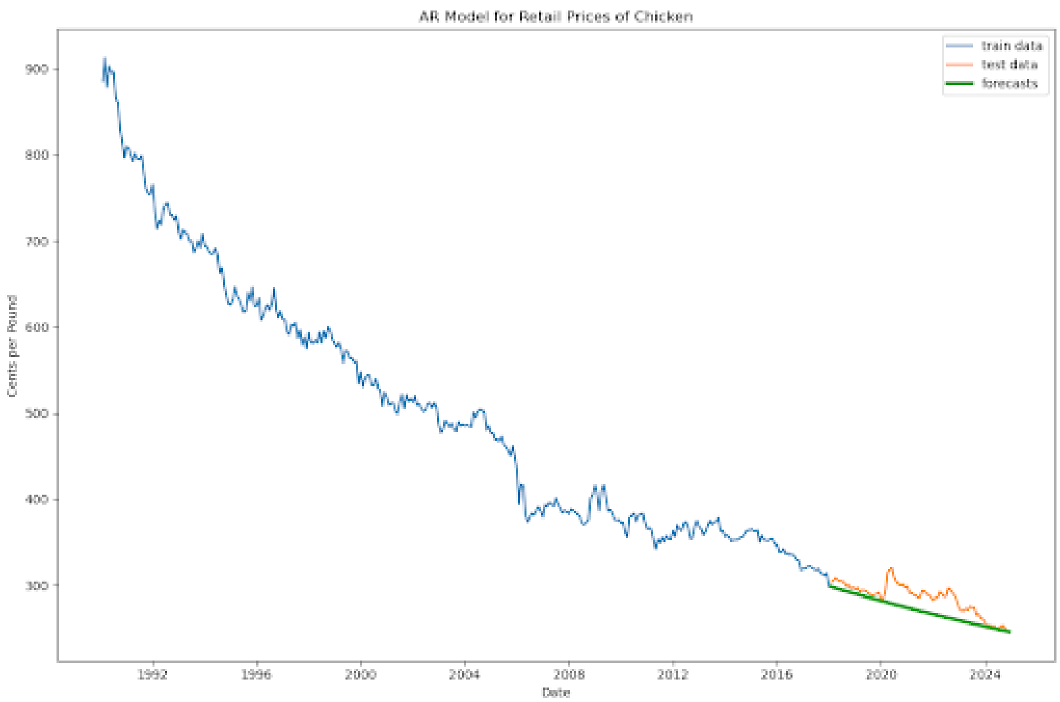


Figure 16. Initial Autoregressive Model for Retail Chicken Price.

Although our model was able to capture the original trend line of the historical data, it didn't perform well in adjusting for the seasonality component of the retail prices. In fact, taking a look at the Akaike's Information Criterion (AIC), which gauges how well our model has achieved a goodness of fit, seems relatively low (the lower the better).

AutoReg Model Results

Dep. Variable:	stationary_data	No. Observations:	336
Model:	AutoReg(1)	Log Likelihood	1883.311
Method:	Conditional MLE	S.D. of innovations	0.001
Date:	Sun, 25 May 2025	AIC	-3760.622
Time:	23:43:37	BIC	-3749.180
Sample:	03-01-1990	HQIC	-3756.061
	- 01-01-2018		

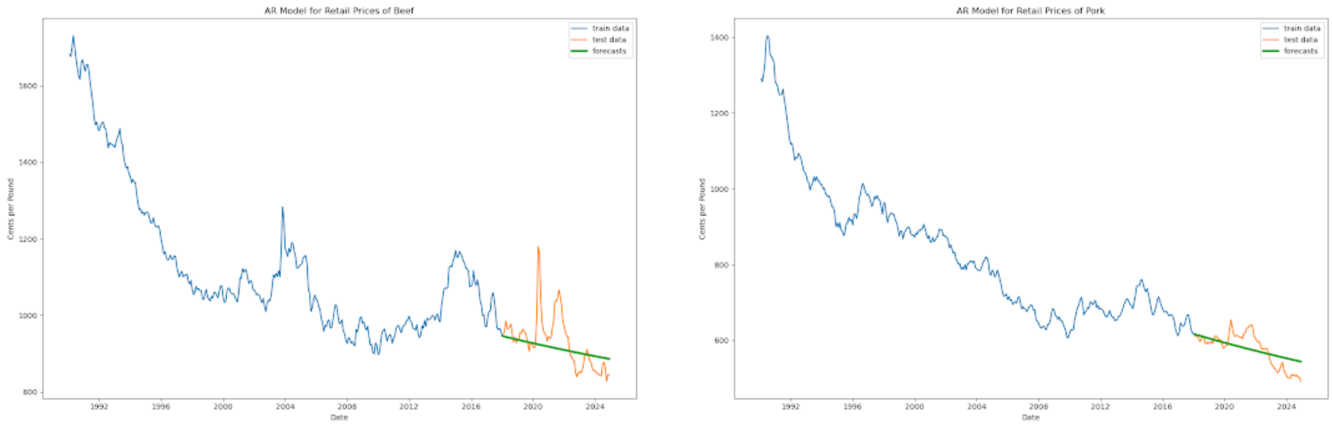
	coef	std err	z	P>|z|	[0.025	0.975]
const	-0.0002	4.83e-05	-3.329	0.001	-0.000	-6.62e-05
stationary_data.L1	-0.1764	0.055	-3.236	0.001	-0.283	-0.070

Roots

	Real	Imaginary	Modulus	Frequency
AR.1	-5.6674	+0.0000j	5.6674	0.5000

Figure 17. Results of initial Auto-regressive model for retail chicken prices.

Based on this information, we attempted to see if we had better luck in creating an improved model for the retail prices of beef and pork. The results are shown below.



(a) AR Model for Retail Beef

(b) AR Model for Retail Pork

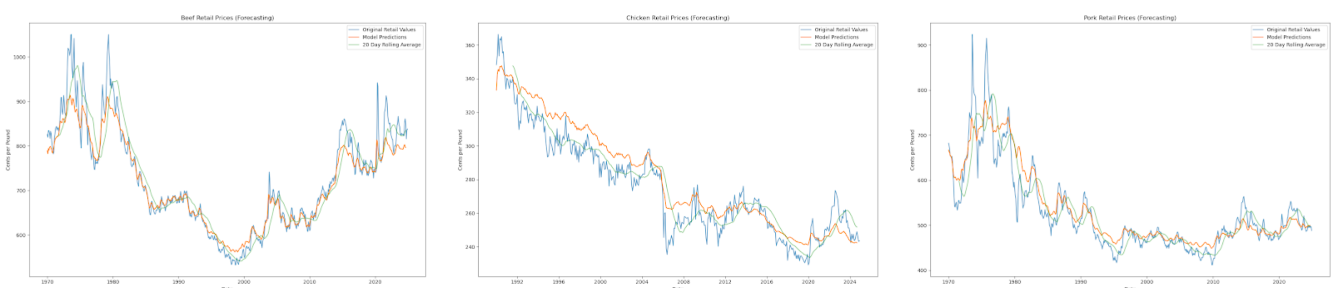
Figure 18. AR models for beef and pork retail prices.

Again, while the model did a good job of capturing the trend line of the respective historical data for retail prices, it failed to capture the noise associated with the retail prices of each meat. Similar results were demonstrated from an Auto Regressive Integrated Moving Average (ARIMA) model when fitted with the same data.

Despite the low model performance, we continued to forecast future retail prices for the next 3 years. The retail price predictions for each meat for December 2027 are as follows: Chicken with 227.23 cents per pound; Beef with 864.18 cents per pound; Pork with 517.33 cents per pound.

However, we cannot guarantee that these prices will be the true retail prices of each meat on that specific date. These predictions should be taken with caution since our model's performance was relatively low.

As a bonus, we also experimented with deep learning to create a model based on the retail prices of each meat. Specifically, we were interested in learning how well a Long Short-Term Memory (LSTM) model predicts these retail prices. Although these models couldn't be used to precisely predict the future retail prices of each meat, we thought it might be intriguing to show how these models were able to predict historical retail prices. Graphs are shown below.



(a) Beef

(b) Chicken

(c) Pork

Figure 19. LSTM models for retail meat prices.

2.3 Exogenous Price Shocks

To correct for noise in our models that is not captured by regression, we now take exogenous variables into account. Several factors affect the prices of pork, beef, and poultry across the United States, and they occur randomly and are difficult to predict. These factors are largely common among the three industries, but there are also specific variables that affect each industry.

Disease affects primarily the cattle and hog industries, although there have been no major outbreaks in the last decade. Porcine Reproductive and Respiratory Syndrome (PRRS) has been prevalent among hogs since the 1990s and "is the most economically important disease now affecting producers" (Iowa State University College of Veterinary Medicine). However, there was little observable effect on retail prices due to this disease. The Porcine Epidemic Diarrhea Virus (PEDv) outbreak in 2014 affected pigs and could have contributed to a price spike in 2015. Retail prices for beef were affected by Bovine Spongiform Encephalopathy (BSE) in 2004, though a larger impact was seen globally than specifically in the United States. However, there was still an economic impact on the U.S. beef industry. (Mintert et al.).

Trade and supply chain issues are another major factor across all three industries. Three recent events highlight the importance of the supply chain in meat prices. The COVID-19 pandemic led to the largest price spike in meat prices due to massive supply chain issues, signifying the supply-side determinants of meat prices. The Russia-Ukraine conflict has also had a particularly large impact on beef prices. This is due to sanctions imposed on Russia, a country that exports essential fertilizer inputs. The increased costs of these inputs resulted in increased costs of corn and feed, which are necessary for cattle production.

A third factor to consider is state and federal policies that impact meat prices. In the last few decades, none have caused a significant price spike; however, some are useful as contributing factors to larger trends and effects. The 2005 Renewable Fuel Standard required more corn to be used for ethanol production, raising the price of corn and making cattle feed more expensive. This exacerbated price shocks due to drought at the time, since corn became even more expensive. The Country of Origin Labeling standards, implemented in 2009, simply raised production costs due to increased work in identifying the origin of supplies for producers. Lastly, California's Proposition 12 raised animal welfare standards and similarly increased production costs due to these new regulations. This might have had an impact nationally, as any meat producer who wants to access the California market must also adhere to these standards.

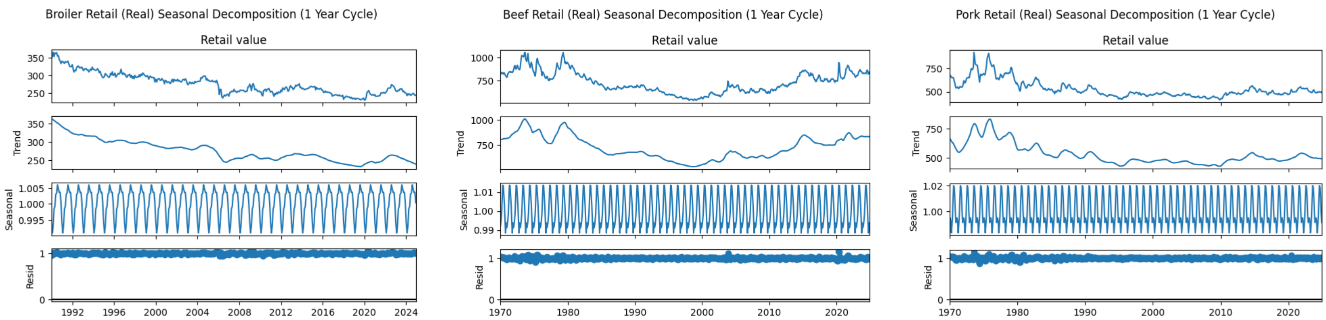
Practically any significant event affecting retail meat prices is supply-side, since consumer demand has been steady. In general, North America has an abundant supply of animals, which mitigates the effect of supply shocks on prices. Most of these factors are not perfectly represented in a subsequent price spike when looking at a time series of meat prices, but they are indicative of larger patterns and useful to keep in mind.

2.4 Seasonality

Seasonality measures repeating or cyclical patterns in time-series data over a given period. To analyze these patterns, we employed STL, which stands for Seasonality and Trend decomposition using LOESS. This breaks down the time-series data into a trend, seasonal component, and residuals. The trend shows the overall movement of the data, which is found by LOESS to smooth the data with local estimates. The seasonal component will then show oscillating peaks and troughs found in the data. The remaining residuals account for the random variations and help detect anomalies within the process (Seabold et al.).

There are two ways to decompose the data into these components: additive and multiplicative. Additive will break down each component into an addend, while multiplicative will break down each component into a factor. Additive models are used when the variance in the data is expected to be constant while multiplicative models are used when the variance is expected to change. As we expect variance in meat prices to change based on increasing market concentrations in later analyses, we use the multiplicative model.

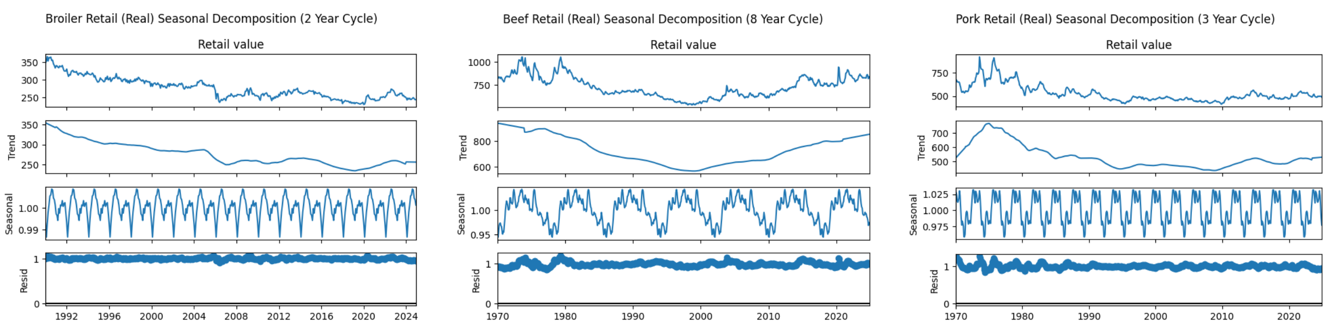
When performing STL decomposition on real retail prices, we found insignificant seasonal components as shown below.



(a) Chicken **(b)** Beef **(c)** Pork

Figure 20. Seasonality of each meat shows very minimal percent change over a period.

For retail pork, the seasonal component roughly varies from 0.99 to 1.02, which suggests that prices only vary from -1% to +2% each year, with the beginning of the year becoming a trough with peaks towards the end of the year. The patterns continue for beef and broilers as well with -1% to +1% and -0.5% to +0.5% respectively. This suggests that seasonality has minimal impact on retail prices. When increasing the period to search for cycles, we get slightly better results. For pork, beef, and broilers best results are achieved using 3 years, 8 years, and 2 years, respectively. The 8-year cycle found is in line with the expected cattle cycle. However, it is still not perfect.



(a) Chicken (2 Year Cycle) [-1% to +1%] **(b)** Beef (8 Year Cycle) [-5% to +5%] **(c)** Pork (3 Year Cycle) [-2.5% to +2.5%]

Figure 21. Shown are cycles for chicken, beef, and pork at 2 year, 8 year, and 3 year periods respectively.

3 Price Spreads

Instead of calculating price spreads as the absolute difference between prices, we consider the ratio between prices. This allows us to more accurately interpret the data. For example, if some extraneous phenomenon increased both wholesale and retail prices by 150%, the ratio between wholesale and retail would not reflect this change, while the absolute difference in prices would. Since chicken does not have any data on farm value, we exclude it from our price spread analysis. Without this ratio, we cannot create a proper comparison between the other values.

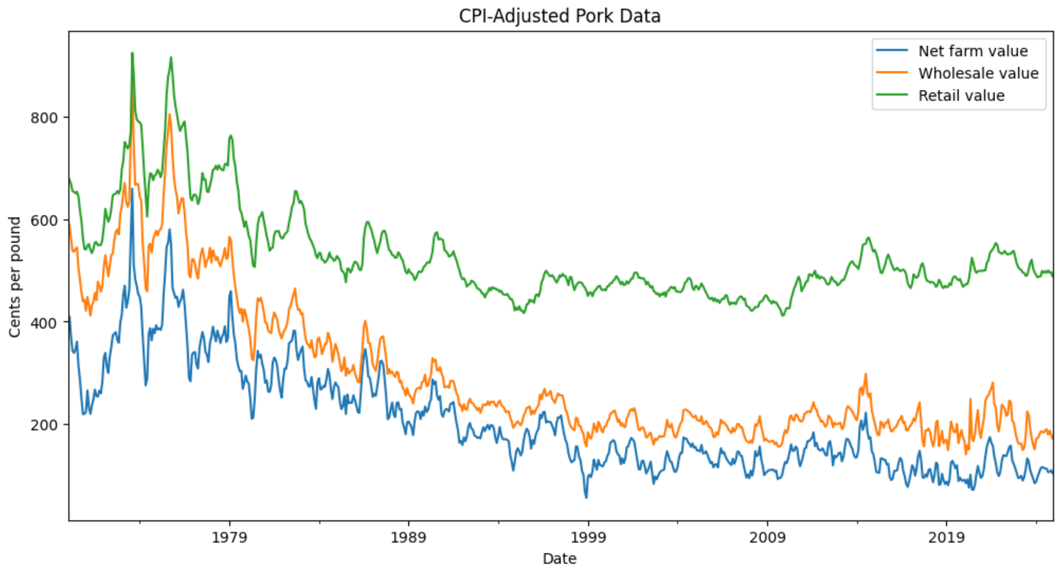


Figure 22. Farm, wholesale, and retail values of pork overall adjusted for inflation.

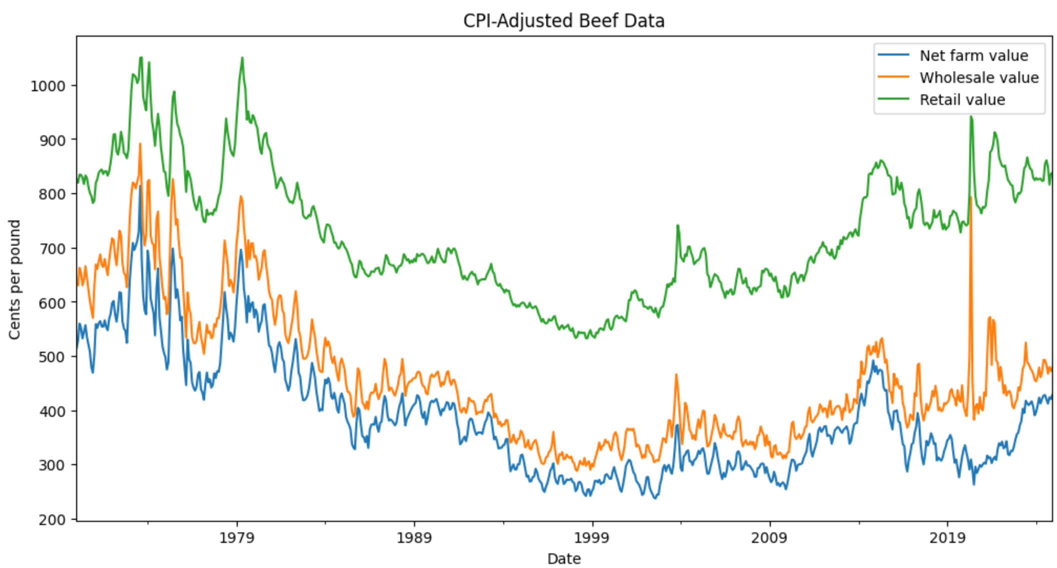


Figure 23. Farm, wholesale, and retail values of beef overall adjusted for inflation.

Above are the overall farm, wholesale, and retail values for pork and beef, adjusted for inflation. From both graphs, it is apparent that farm and wholesale prices stick quite closely together while the gap between retail and wholesale seems to grow over time. This observation is made even more obvious as we look at the price spread ratios. Each ratio is calculated as follows: an X/Y Price ratio will measure for each date X Price / Y Price.

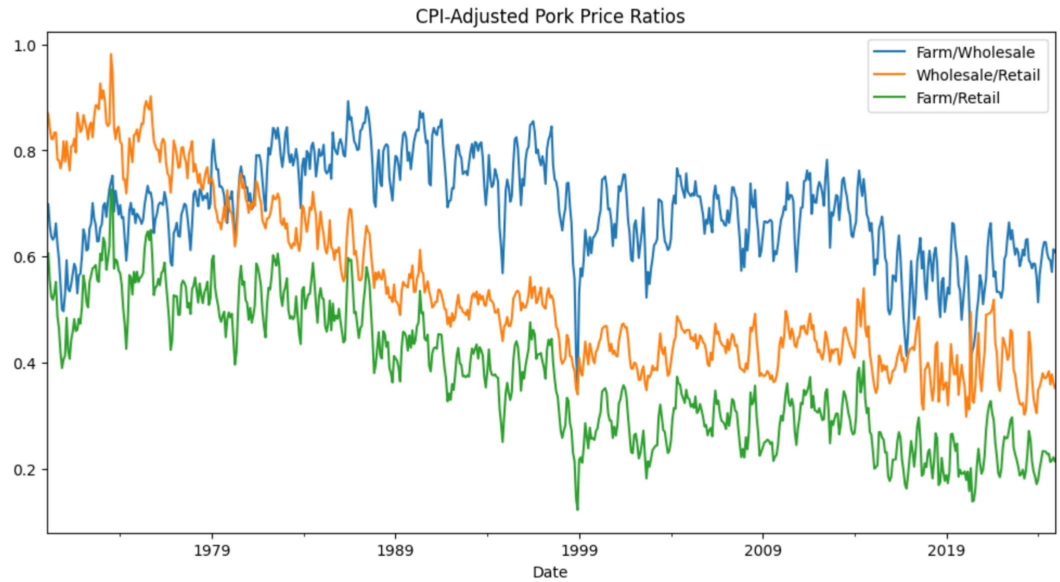


Figure 24. Price spread ratios for pork overall

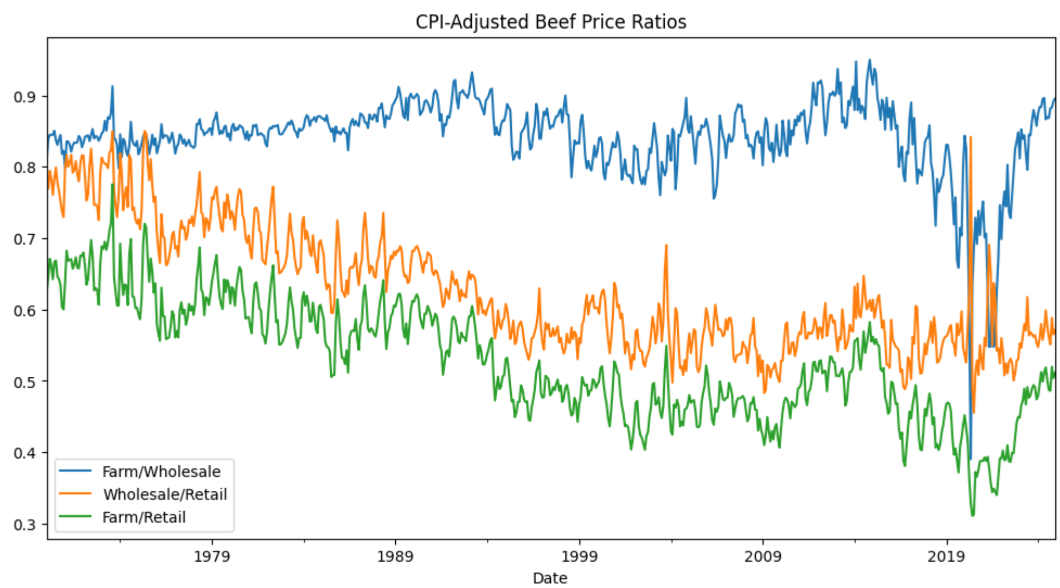
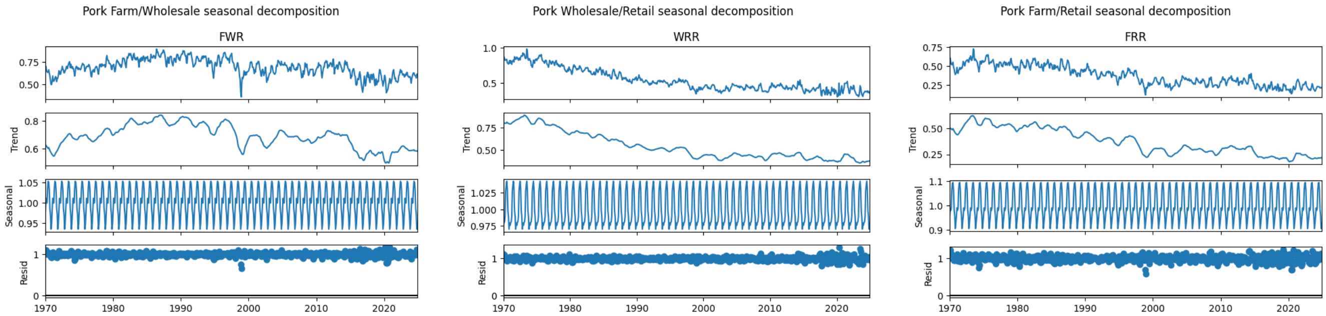


Figure 25. Price spread ratios for beef overall.

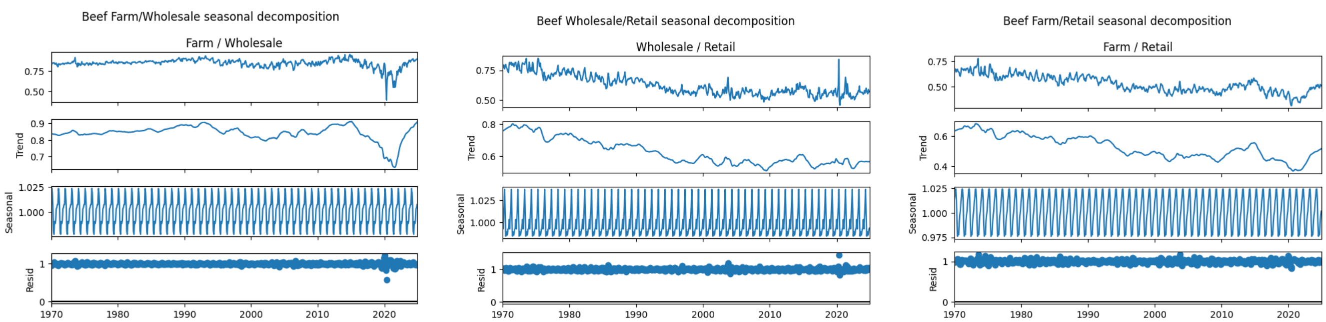
In both graphs, it is apparent that the Farm/Wholesale ratios remain relatively constant in comparison to the Wholesale/Retail and Farm/Retail ratios, except for some extraneous outliers such as the 2020 pandemic. As the Farm/Wholesale ratios remain constant, we should expect the Farm/Retail and Wholesale/Retail ratios to follow a similar pattern. As such, the Farm/Retail and Wholesale/Retail ratios trend downwards for both meats. This means that farmers and wholesalers are earning a decreasing percentage of the retail sale price each year. This suggests that retailers may have a higher price-setting power than previously thought. Thus, the ratio between Wholesale/Retail may require more investigation.

3.1 Price Spread Seasonality



(a) Farm/Wholesale **(b)** Wholesale/Retail **(c)** Farm/Retail

Figure 26. Seasonality analysis of pork price spread ratios.



(a) Farm/Wholesale **(b)** Wholesale/Retail **(c)** Farm/Retail

Figure 27. Seasonality analysis of beef price spread ratios.

When running STL seasonal decomposition on pork and beef price spread ratios, we get similar seasonal components to our analysis on retail prices. One interesting difference to point out is that the Pork Farm/Retail ratio experiences a seasonal component that ranges from -10% to 10%. This suggests that retail prices are more susceptible to seasonal fluctuations than farm values, especially for pork and hogs.

3.2 Price Spread Ratios by Cut

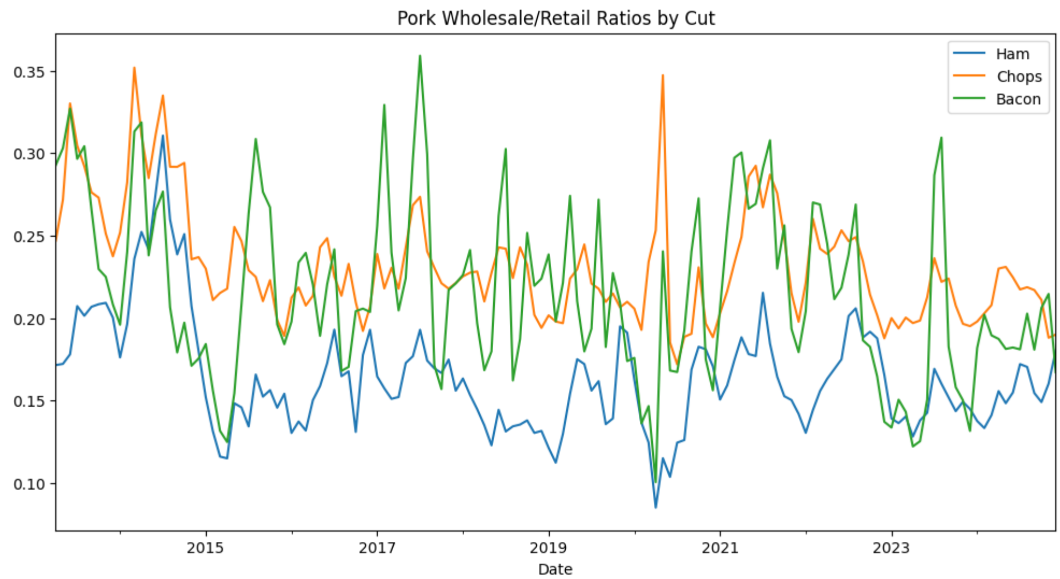


Figure 28. Wholesale/Retail price spread ratios for pork by cut

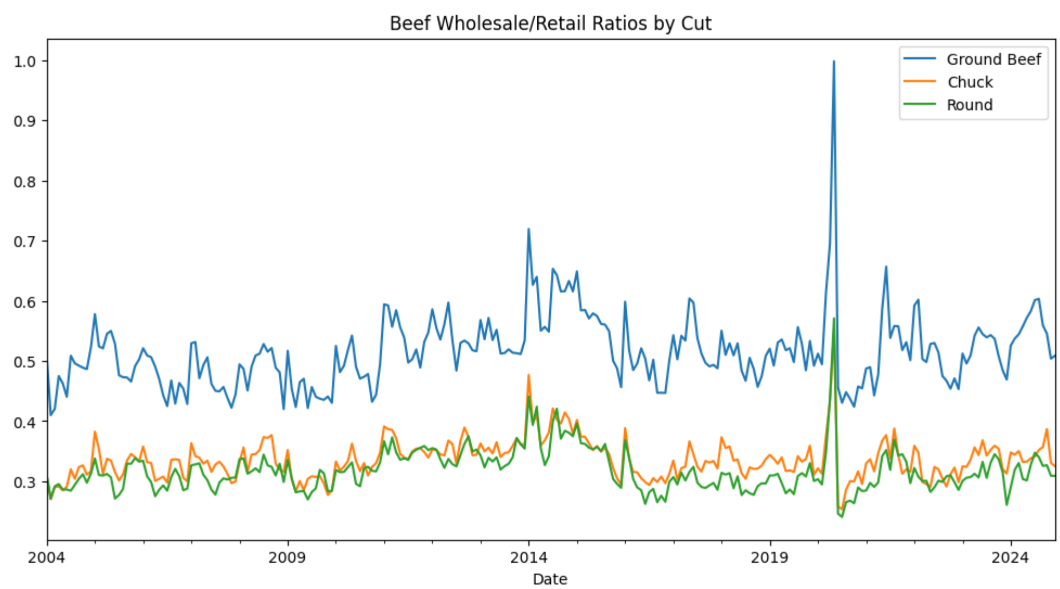


Figure 29. Wholesale/Retail price spread ratio for beef by cut.

We continue by breaking down pork and beef cuts into three different price levels. The cuts for pork, in order of cheapest to most expensive, are as follows: (1) ham, (2) chops/loin, and (3) bacon/belly. For beef, the order is (1) ground beef, (2) chuck, and (3) round (steak). For each cut, wholesale prices are retrieved from the AMS data as primal values from where the cut comes from, and retail prices are retrieved from the BLS. For Beef, wholesale prices tend to make up less of the retail prices for cheaper cuts like chuck and round, while they make up more for ground beef. This indicates a higher markup on the retailer's end. This finding is less obvious for pork. The more expensive cut, bacon, tends to show the opposite trend. Note that we only show Wholesale/Retail ratios, as Farm values did not waver greatly from Wholesale values, meaning that Farm ratios will follow similar patterns.

4 Regressions

Our hypothesis for the effect of meatpacking concentration is that higher concentrations correlate with a lower wholesale/retail ratio and a lower farm/wholesale ratio. The reasoning is as follows: while a higher concentration should lower costs for meatpackers, decreasing the wholesale/retail ratio, a higher concentration should also correspond with more price-setting power on farm value, allowing meatpackers to to lower the selling price of animals.

In order to determine the correlation between the concentration of meatpackers and prices, we used the standard Four-Firm Concentration Ratio or CR4. This is calculated as the percentage market share that the four largest firms take up within the industry, where a larger ratio means higher concentration and less competition. We hypothesized that by regressing the inflation-adjusted price spread data on CR4 values, we could quantify the direct effect of meatpacker conglomeration on the markup of pork and beef prices.

Referencing the Bureau of Labor Statistics (BLS) for retail prices and the Agricultural Marketing Services (AMS) for wholesale prices, we calculated the difference and ratio between the two prices and adjusted for the effect of inflation using deflators. Next, we acquired CR4 data from USDA resources. The last step in preparing the data for regression analysis was to normalize the timestamps by either downsampling the price data or upsampling the CR4 data. Ultimately, we ran regressions on both versions, but opted to visualize only the upsampled data for better granularity. The data is shown below.

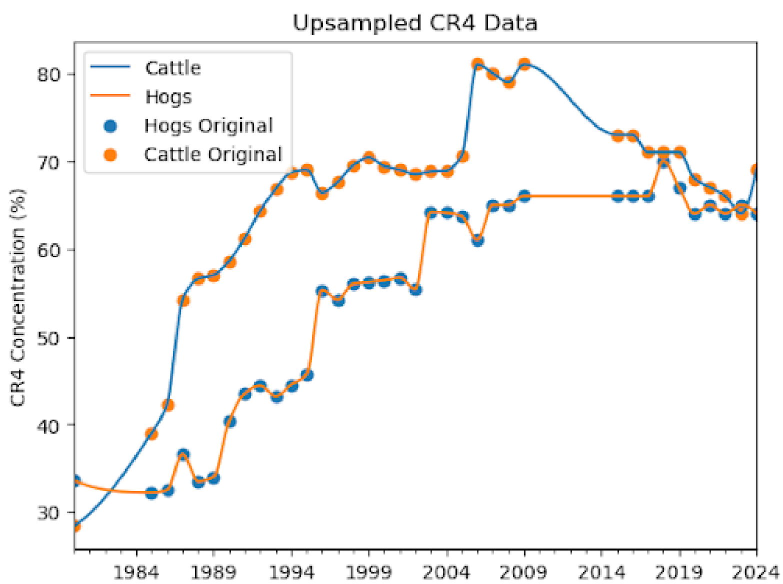
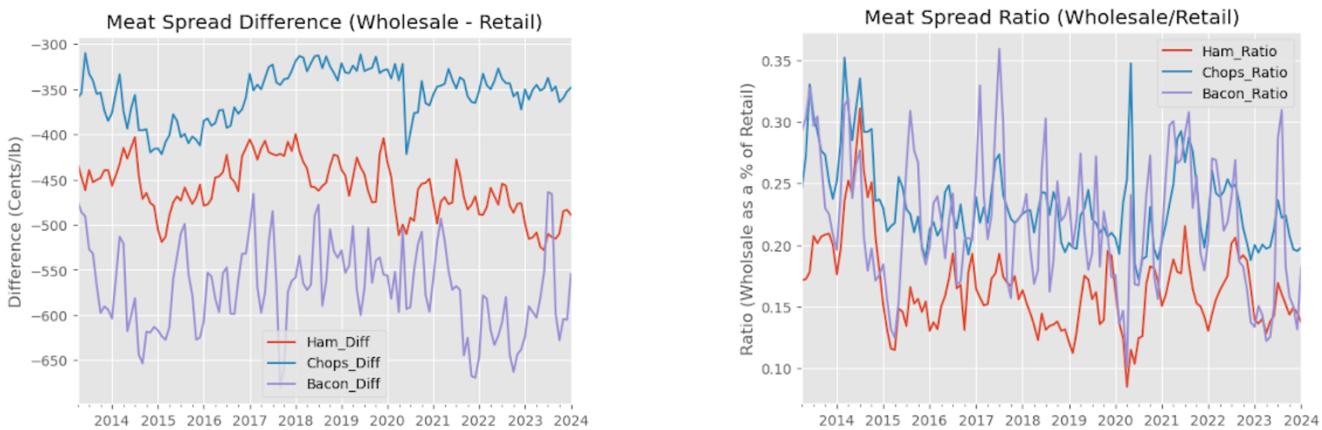


Figure 30. Results of upfilling CR4 data to estimate monthly values.

Additionally, we reproduced the meat spreads over time for reference and to ensure that the absolute differences and ratios do not have significantly different results. On the left are the differences, and on the right are the ratios. Note that while the differences trend "down," the magnitude grows, indicating that retail prices increased more than their wholesale counterparts. Furthermore, the ratios reveal that wholesale prices largely remain less than a quarter of retail prices; in other words, retail prices are marked up approximately 300 cents/lb.



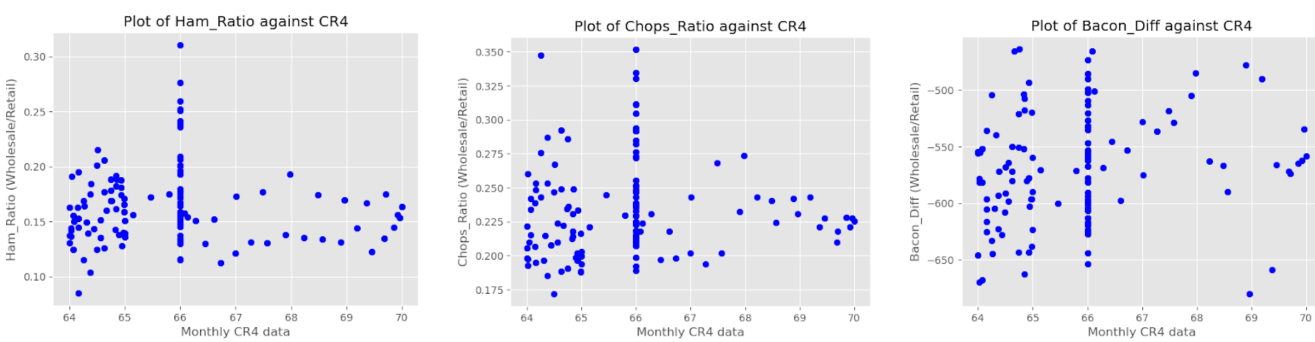
(a) Retail - Wholesale difference

(b) Wholesale/Retail ratio

Figure 31. Retail and Wholesale price spreads for pork cuts by both ratios and differences.

For our regressions, we first compare retail and wholesale price spreads for each meat by their cuts at different price points. To recall, pork is broken down into ham, chops/loin, bacon/belly, and beef is broken down into ground beef, chuck, and roast(steak) in order from cheap to expensive. Then we move onto a general comparison of all spreads for farm, wholesale, and retail values for the overall values of pork and beef.

4.1 Wholesale and Retail Price Spreads by Cut



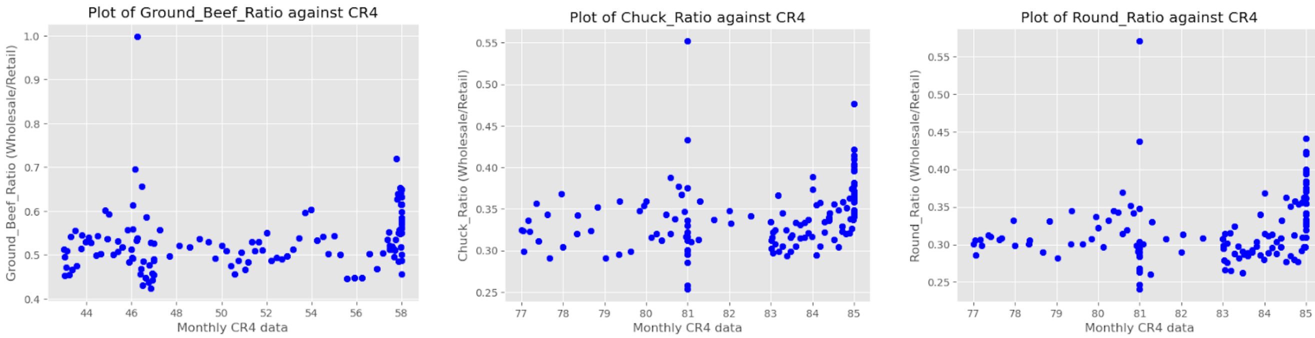
(a) Ham Wholesale/Retail ratios

(b) Chops Wholesale/Retail ratio

(c) Bacon Retail - Wholesale difference

Figure 32. Pork Wholesale and Retail price spreads by cut over the CR4 for pork meatpacking.

Above are three scatter plots for pork wholesale and retail price spreads over the respective CR4. Note that for bacon, we show a difference instead of a ratio to highlight that there is no significant change in results using ratios vs. differences. For all three plots, we did not see a statistically significant correlation, meaning that there is no clear line or trend in the scatter plot. This may be due to the fact that AMS wholesale data only goes back about 15 to 20 years, preventing us from having enough data points to see a correlation.



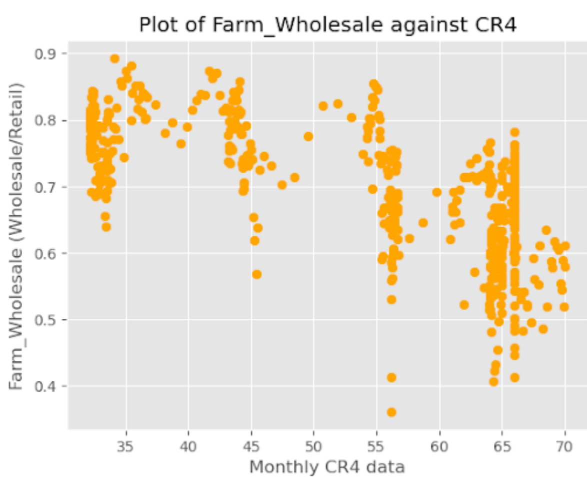
(a) Ground Beef Wholesale/Retail ratios **(b)** Chuck Wholesale/Retail ratio **(c)** Round Wholesale/Retail ratio

Figure 33. Beef Wholesale and Retail price spreads by cut over the CR4 for beef meatpacking.

We see a very similar story for beef as well, in that there is no significant correlation between price spread ratios and CR4. Another potential reason is that as the data only goes back 15 to 20 years, in that time span, neither have the prices nor CR4s have moved significantly. The greatest period of change occurred before the 2000s which is not represented.

4.2 Regressions for Overall Price Spread Ratios

When performing regressions on price spread ratios for the overall values of each meat, we get much more interesting results. We only regressed the Farm/Wholesale and Wholesale/Retail ratios, as we believe that they are able to tell the whole story.

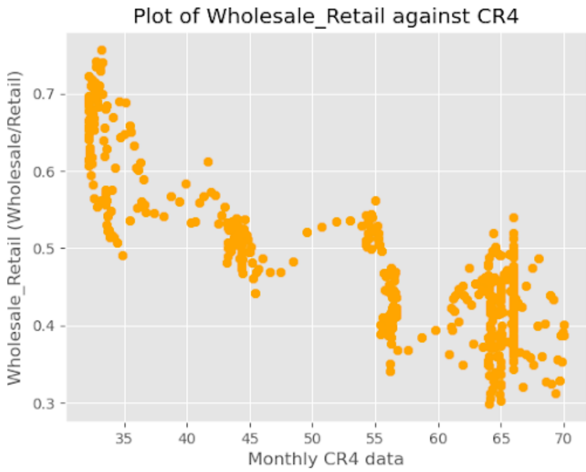


(a) Farm/Wholesale

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Farm_Wholesale   R-squared:                       0.442
Model:                             OLS   Adj. R-squared:                  0.441
Method:                  Least Squares   F-statistic:                     417.8
Date:                 Fri, 23 May 2025   Prob (F-statistic):           8.06e-69
Time:                         14:56:01   Log-Likelihood:                 631.46
No. Observations:                  529   AIC:                            -1259.
Df Residuals:                      527   BIC:                            -1250.
Df Model:                            1
Covariance Type:             nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      0.9628      0.013     71.360      0.000       0.936       0.989
Hogs          -0.0050      0.000    -20.441      0.000      -0.005      -0.004
==============================================================================
Omnibus:                       30.990   Durbin-Watson:                   0.243
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               36.447
Skew:                          -0.553   Prob(JB):                     1.22e-08
Kurtosis:                       3.655   Cond. No.                         234.
==============================================================================
```

(b) Regression Results

Figure 34. Scatter plot and regression results of pork overall Farm/Wholesale ratios over the CR4 for pork meatpacking.



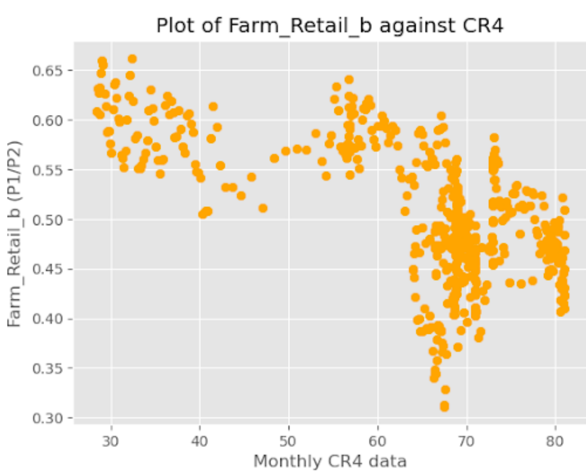
(a) Wholesale/Retail

```
                            OLS Regression Results
==============================================================================
Dep. Variable:       Wholesale_Retail   R-squared:                       0.739
Model:                            OLS   Adj. R-squared:                  0.739
Method:                 Least Squares   F-statistic:                     1495.
Date:                Fri, 23 May 2025   Prob (F-statistic):          5.18e-156
Time:                        14:56:02   Log-Likelihood:                 818.24
No. Observations:                 529   AIC:                            -1632.
Df Residuals:                     527   BIC:                            -1624.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      0.8377      0.009     88.381      0.000       0.819       0.856
Hogs          -0.0066      0.000    -38.669      0.000      -0.007      -0.006
==============================================================================
Omnibus:                       15.213   Durbin-Watson:                   0.294
Prob(Omnibus):                  0.000   Jarque-Bera (JB):                8.196
Skew:                           0.088   Prob(JB):                       0.0166
Kurtosis:                       2.416   Cond. No.                         234.
==============================================================================
```

(b) Regression Results

Figure 35. Scatter plot and regression results of pork overall Wholesale/Retail ratios over the CR4 for pork meatpacking.

For the regression of pork Farm/Wholesale, we get an AIC value of -1259 and a negative coefficient of -0.0050, and for the regression of pork Wholesale/Retail, we get a slightly better AIC value of -1632 and a negative coefficient of -0.0066. This means that both ratios have a negative linear relationship with the CR4. More specifically, the data suggests that for each 1% increase in the CR4, the Farm/Wholesale ratio drops by 0.5% and the Wholesale/Retail ratio drops by 0.66%. This means that as the pork meatpacking industry is more concentrated, wholesalers get a smaller percentage of the retail value and farmers get a smaller percentage of the wholesale value. This suggests that either wholesalers or other processes after the farmer are adding more value to the product to justify the increased markup, or that there is evidence of monopoly-oligopoly market power.

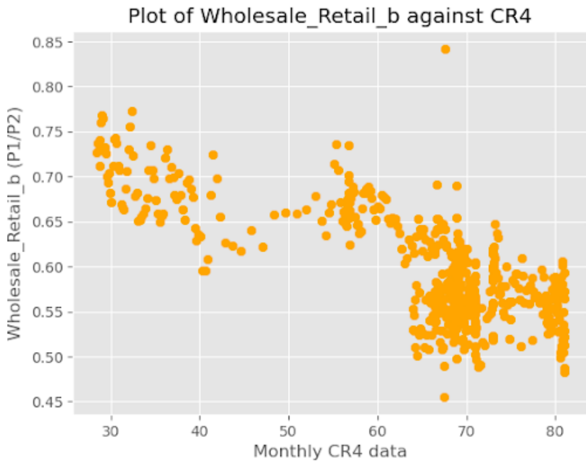


(a) Farm/Wholesale

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Farm_Retail_b   R-squared:                       0.393
Model:                            OLS   Adj. R-squared:                  0.392
Method:                 Least Squares   F-statistic:                     341.4
Date:                Fri, 23 May 2025   Prob (F-statistic):           3.86e-59
Time:                        15:11:43   Log-Likelihood:                 798.00
No. Observations:                 529   AIC:                            -1592.
Df Residuals:                     527   BIC:                            -1583.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      0.7034      0.011     63.398      0.000       0.682       0.725
Cattle        -0.0031      0.000    -18.477      0.000      -0.003      -0.003
==============================================================================
Omnibus:                       21.384   Durbin-Watson:                   0.125
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               22.895
Skew:                          -0.483   Prob(JB):                     1.07e-05
Kurtosis:                       3.323   Cond. No.                         314.
==============================================================================
```

(b) Regression Results

Figure 36. Scatter plot and regression results of beef overall Farm/Wholesale ratios over the CR4 for beef meatpacking.



(a) Wholesale/Retail

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     Wholesale_Retail_b   R-squared:                       0.573
Model:                            OLS   Adj. R-squared:                  0.572
Method:                 Least Squares   F-statistic:                     707.8
Date:                Fri, 23 May 2025   Prob (F-statistic):           1.67e-99
Time:                        15:11:43   Log-Likelihood:                 944.04
No. Observations:                 529   AIC:                            -1884.
Df Residuals:                     527   BIC:                            -1876.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      0.8161      0.008     96.940      0.000       0.800       0.833
Cattle        -0.0034      0.000    -26.604      0.000      -0.004      -0.003
==============================================================================
Omnibus:                       45.138   Durbin-Watson:                   0.537
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              127.074
Skew:                           0.394   Prob(JB):                     2.55e-28
Kurtosis:                       5.268   Cond. No.                         314.
==============================================================================
```

(b) Regression Results

Figure 37. Scatter plot and regression results of beef overall Wholesale/Retail ratios over the CR4 for beef meatpacking.

The results are very similar for overall beef prices and overall pork prices, as both the Farm/Wholesale and Wholesale/Retail ratios show negative linear relationships. Therefore, we reach the same conclusions for both pork and beef. More specifically, we observe an R-Squared value of 0.393 and negative coefficient of -0.0031 for Farm/Wholesale, and an R-Squared value of 0.573 and a negative coefficient of -0.0034 for Wholesale/Retail. This means that for each 1% increase in the CR4 for beef meatpacking, the Farm/Wholesale ratio decreases by 0.31% and the Wholesale/Retail ratio decreases by 0.34%.

5 Conclusions

From our analyses, we observe an increase in premiums across the supply chain as the respective meatpacking industries become more concentrated. The decrease in the Farm/Wholesale ratios for both beef and pork suggests that as Wholesalers become more concentrated, farmers are making less of a percentage of profit for each animal sold. The decrease in Wholesale/Retail ratios for both beef and pork suggests that Wholesalers are saving costs through economies of scale, but Retailers are maintaining their high prices. In general, real retail prices are decreasing, which is beneficial for consumers, but farmers are not seeing much benefit from the concentration in the meatpacking industry, with retailers ultimately having the most price-setting power.

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