University of Illinois Urbana-Champaign

Department of Statistics

Commodity Price of Beef

Group Members:
Yvonne Ho
Yue Shao
Shuyuan Chen

A project report submitted for the course of

STAT-429 Time Series Analysis

December 5, 2022

Contents

1 Introduction

Meat is an important nutrition and ingredient in our cuisines, especially beef, which triggers a great demand and supply in a particular period of time.

The data used in this study are secondary data, namely Commodity Price - Beef, for the period October, 2010, to September, 2022, sourced from IndexMundi. It has 120 observations without missing values and two main variables, namely date (yyyy-mm-dd) and price($/Kg). The dataset was splitted into training and testing data. The training data extracted the first 115 rows of the original dataset; the testing data remained the last 5 rows. The training data was applied spectral analysis to determine the periodicity of the training data by seeking for periodograms; the testing data was using Seasonal Autoregressive Integrated Moving Average (SARIMA) models to forecast the price. This way, the cycles of the price change by time was found.

2 Preliminary Analysis

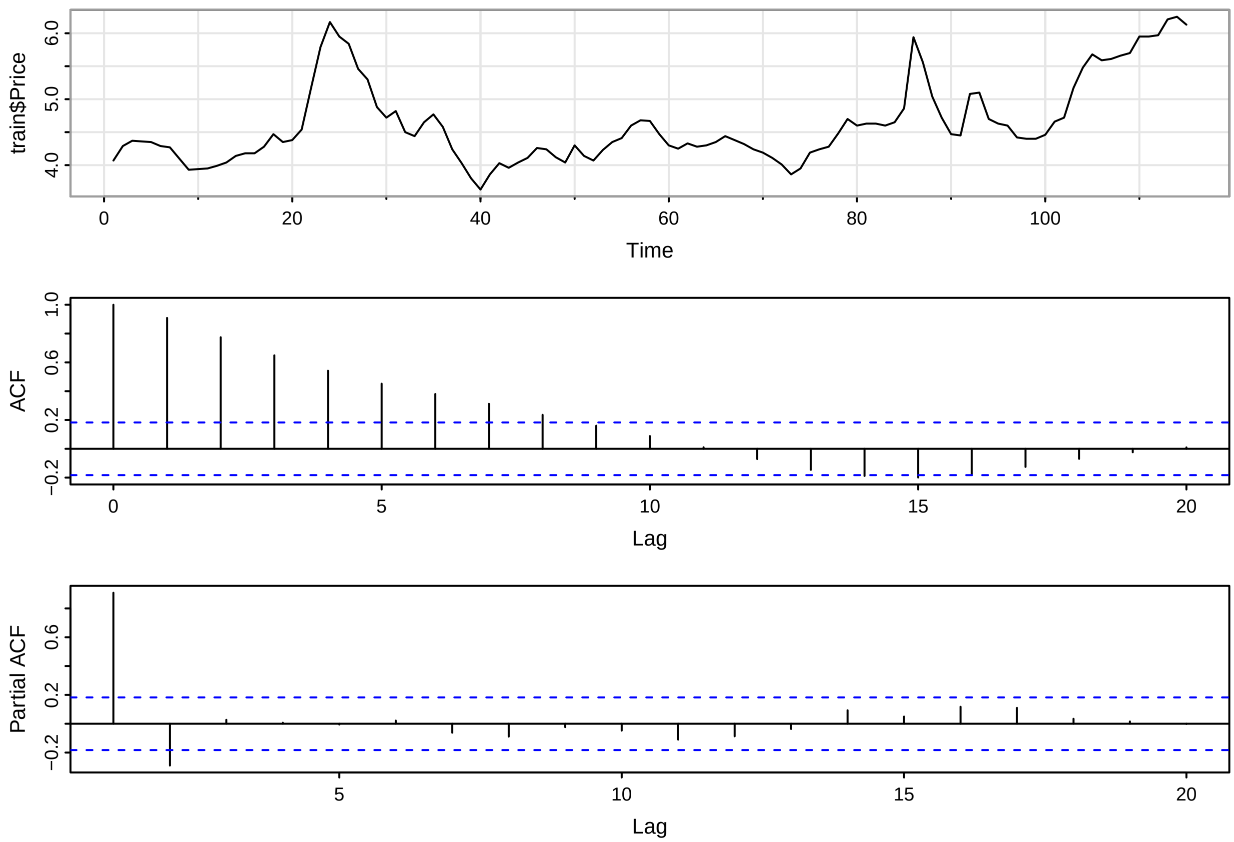

Figure 2.1: Time Series Plots of Beef Price with its ACF and PACF

The time series plot indicates the price is not stationary. The price increases when time goes by. Especially, in the last few months, the price has been rapidly increasing. The ACF of beef price tails off, and the PACF cuts off after lag 2. However, they do not reflect a seasonal pattern.These cannot imply the price is an AR(1) model.

Table 2.1: Stationarity Tests

	Augmented Dickey-Fuller Test	KPSS Test for Trend Stationarity
Test Statistic	-2.0268135	0.2366723
Lag	4.0000000	4.0000000
P-value	0.5654711	0.0100000

The p-value of the Dickey-Fuller test is greater than 5% significance level, the p-value of KPSS test is smaller than 5% significance level, which proves that the training data is neither stationary nor trend stationary. Therefore, it is necessary to consider the differencing process on the beef price.

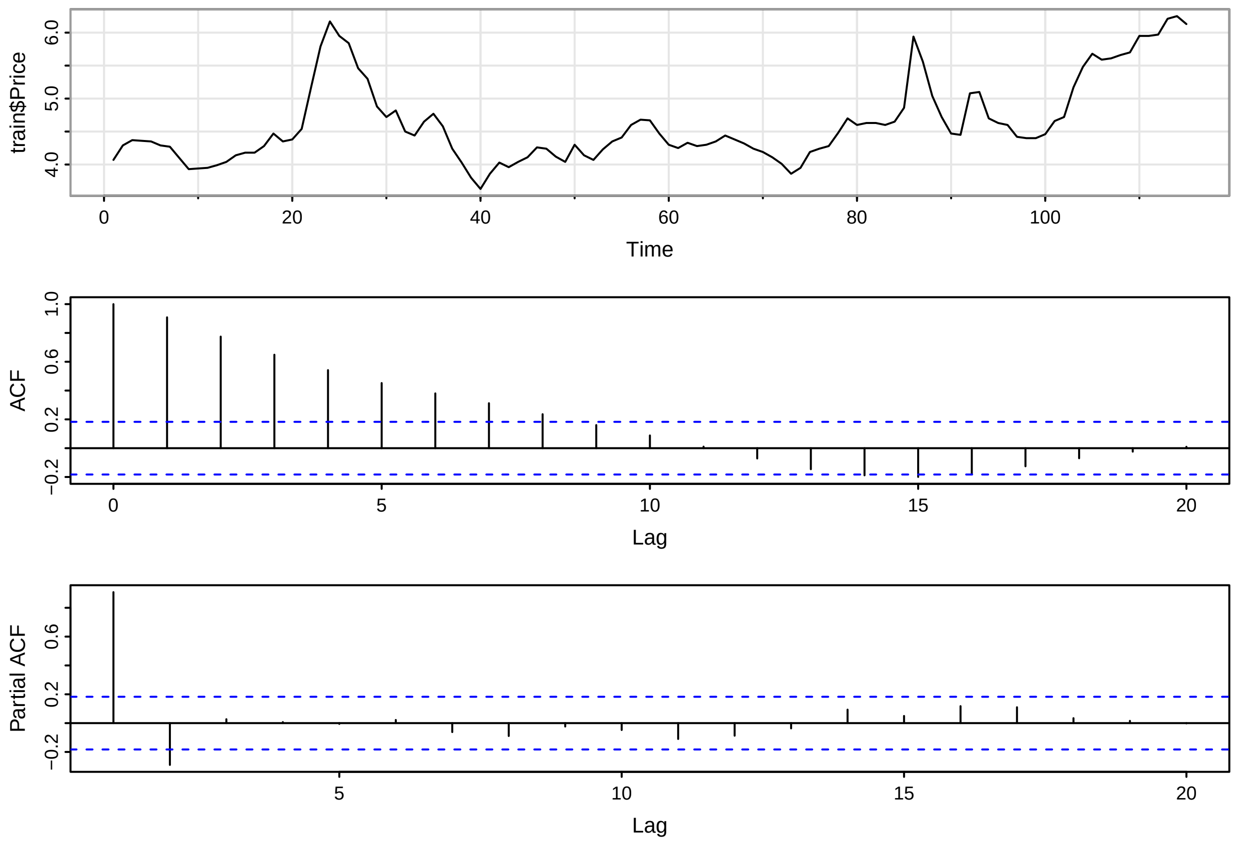

Figure 2.2: Time Series Plot of Training Data in the First Differencing with its ACF and PACF

After differencing the price, it becomes more stationary in Figure 2.2, comparing the original time series plot in Figure 2.1.

The beef price in the time series plot (Figure 2.2) becomes stationary and trend stationary, according to the stationary tests (Table 2.2). The ACF cuts off after lag 1, and the PACF tails off. This implies an ARIMA(0,1,1) model, but the ACF and PACF plots can not provide a reasonable ARIMA model. The price of beef is recorded monthly, which is a seasonal component effect in the ARIMA model.

Table 2.2: Stationarity Tests

	Augmented Dickey-Fuller Test	KPSS Test for Trend Stationarity
Test Statistic	-2.0268135	0.2366723
Lag	4.0000000	4.0000000
P-value	0.5654711	0.0100000

Through spectral analysis in the next section, different cycles of beef price will be found and determined as the price's seasonality in later SARIMA modeling.

3 Spectral Analysis

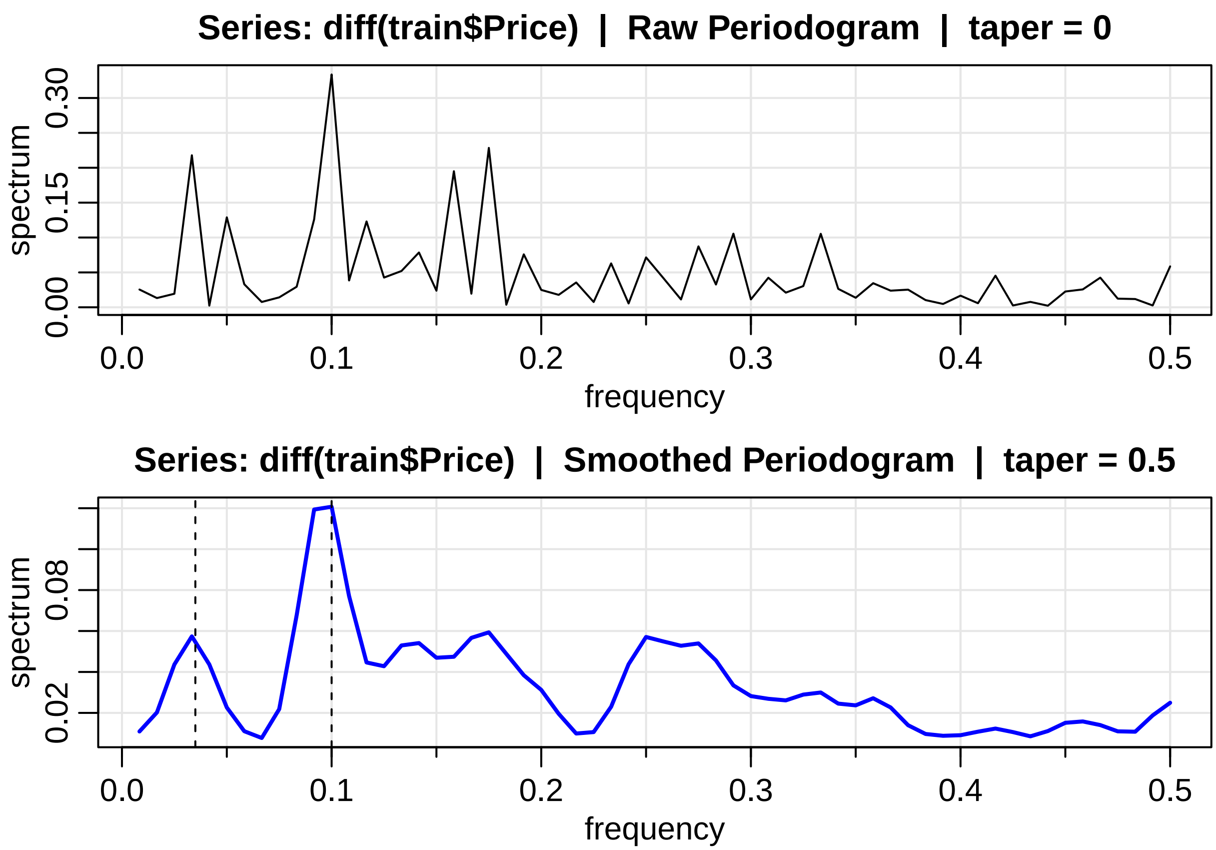

Figure 3.1: Periodograms of the Beef Price in the First Differencing

The periodograms in Figure 3.1 represent the predominant periods. The upper graph is the original raw periodogram from the beef price with first differencing. The bottom raw periodogram is smoothed by setting bandwidth of (3,3). There are two peaks in the smoothed periodogram, which reflects two cycles. The confidence intervals for the beef price at the 30-year cycle, $\omega = \frac{1}{30}$, and the possible EI Nino cycle of 10 years is $\omega = \frac{1}{10}$.

Table 3.1: 95% Confidence Intervals for the Spectra of Beef Price

Omega	Period	Power	Lower	Upper
0.1000000	10	0.8388136	0.0526448	0.5036042
0.0333333	30	0.3986985	0.0250227	0.2393694

Table 3.1 is a summary of the spectra of the bee price in 95% confidence intervals. As a result, the seasonality are 10-month and 30-month cycles.

4 SARIMA Modeling

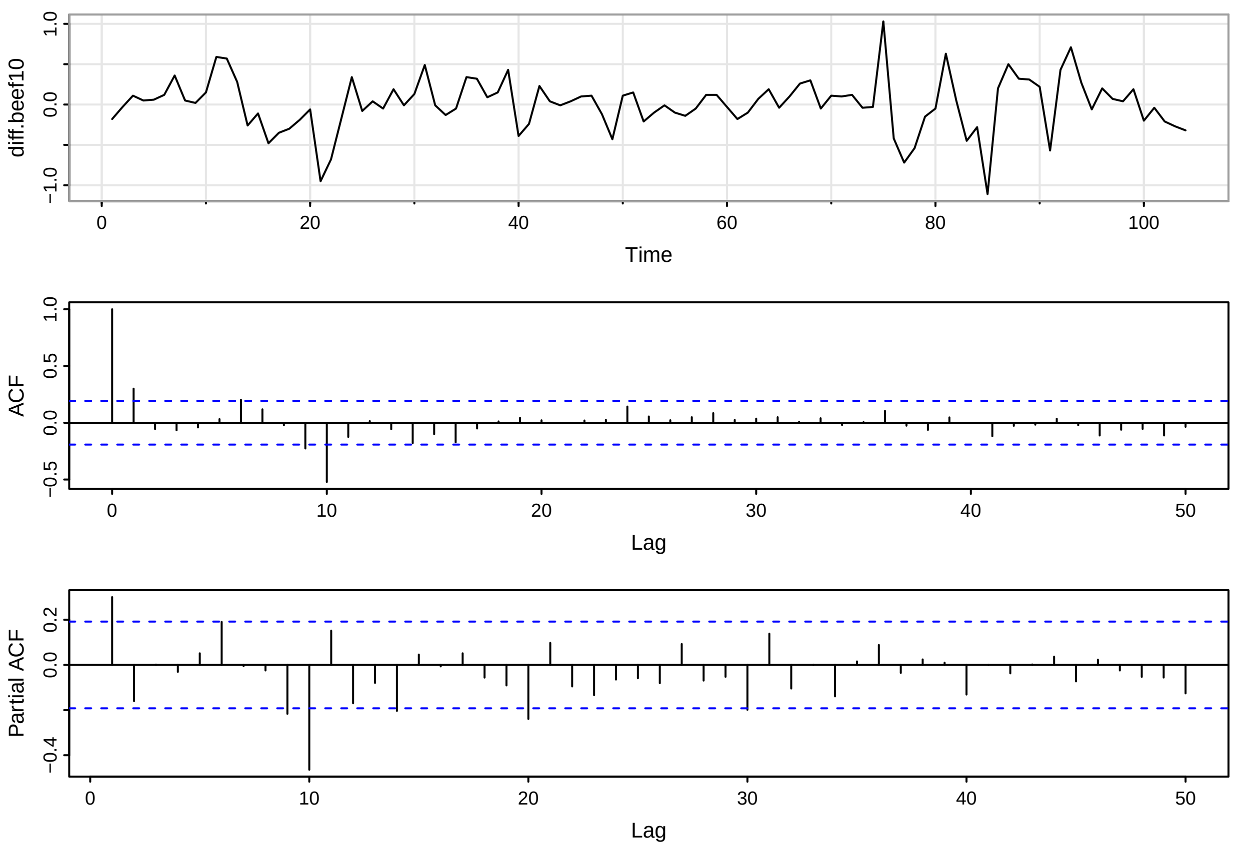

Figure 4.1: Time Series plot of Beef Price in the Second Differencing with its ACF and PACF

The beef price in the top plot pf Figure 4.1 looks stationary. The seasonal and non-seasonal PACF tails off. The seasonal ACF cuts off after lag 9; the non-seasonal ACF cuts off after lag 2. The 10-month cycle is suggested as $ARIMA(0,1,2) \times (0,1,9)_{10}$.

Table 4.1: SARIMA Models Summary

	ARIMA (0,1,2) x (0,1,9)_10	ARIMA (0,1,1) × (0,1,1)_10
Significance.of.Coefficients	The coefficients of MA(1) and SMA(1) are significant.	All of them are significant.

	ARIMA (0,1,2) x (0,1,9)_10	ARIMA (0,1,1) × (0,1,1)_10
AIC	0.04107909	-0.07843407
BIC	0.346201119	-0.002153566
Standardized.Residuals	Like White Noise	Like White Noise
ACF.of.Residuals	Between the Blue Lines	Between the Blue Lines
QQ.Plot	Distributed Normally	Distributed Normally
P.values.of.Ljung.Box.Statistics	Half of them are above the blue line	All of them are above the blue line

Table 4.1 summarizes residuals and errors characteristics of $ARIMA(0,1,2) \times (0,1,9)_{10}$. Since only the coefficients of MA (1) and SMA(1) are significant, $ARIMA(0,1,1) \times (0,1,1)_{10}$ is suggested.

5 Results

Table 5.1: SARIMA Forecasting Accuracy Comparison

	ME	RMSE	MAE	MPE	MAPE
ARIMA (0,1,2) x (0,1,9)_10	-0.1981527	0.2044768	0.1981527	-3.368305	3.368305
ARIMA (0,1,1) × (0,1,1)_10	-0.1395735	0.1453772	0.1395735	-2.405020	2.405020

Table 5.1 shows the RMSE and MAE in $ARIMA(0,1,2) \times (0,1,9)_{10}$ are greater than the RMSE and MAE in model $ARIMA(0,1,1) \times (0,1,1)_{10}$. Thus, $ARIMA(0,1,1) \times (0,1,1)_{10}$ is considered as the best optional model in the 10-month cycle.

Table 5.2: Actual and Predicted Beef Price ($/Kg)

Model	May.2022	June.2022	July.2022	August.2022	September.2022
ARIMA (0,1,2) x (0,1,9)_10	6.336828	6.190524	6.071086	5.892530	5.759796
ARIMA (0,1,1) × (0,1,1)_10	6.174471	6.070840	5.995391	5.871761	5.845405
Actual Values	6.080000	5.980000	5.840000	5.710000	5.650000

$ARIMA(0,1,1) \times (0,1,1)_{10}$ is the best model to represent the beef price because it has smallest errors (Table 5.1) and few differences between its actual and predicted beef price (Table 5.2).

6 Conclusion

Beef is one of the most popular meats in the market. This may reflect a high demand and supply in the meat market. The data used are monthly data on the commodity price of beef in the period from October 2010 to September 2022. The purpose of this study is to determine the periodicity of the commodity beef price by spectral analysis, obtain the results of forecasting the historical beef price through SARIMA models, and investigate the patterns of the price change by time. The results obtained in the spectral analysis are the characteristics of price change in the price that tend to increase or decrease in every 10 months. The best model for predicting the beef price is $ARIMA(0,1,1) \times (0,1,1)_{10}$. The predicted price is decreasing from May, 2022, according to forecasting the next 5 months of the price.