European Journal of Economic and Financial Research
ISSN: 2501-9430
ISSN-L: 2501-9430
Available on-line at: http://www.oapub.org/soc

DOI: 10.46827/ejefr.v7i2.1459
Volume 7 │ Issue 2 │ 2023

PRICE FORECASTING OF FULLY DRESSED CHICKEN IN THE PHILIPPINES

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Abstract:
The Philippine chicken industry has been dominated by backyard farmers. This study was conducted to determine the market trend and forecast the price of fully dressed chicken in Davao City. A monthly time series of secondary data was used in the study obtained from the Philippine Statistics Authority (PSA) from January 1990 to January 2021, analyzed using an ARMA/ARIMA model to forecast the price and analyze the trend. The result revealed that the best-fit model was ARIMA (3, 1, 1), which indicated high price volatility throughout the analysis (p-value = 0.000) and the model indicates that the forecasted price from 2021-2024 is consistent.

JEL: Q10; Q12; Q13

Keywords: chicken, forecasting, ARMA/ARIMA, chicken price

1. Introduction

The Philippines is well-suited for poultry farms due to its good climatic and environmental conditions. In addition to pork, chicken is one of the country's staple foods (PSA, 2021) and is essential for the growth and development of agriculture (DA, 2021). In fact, many farmers depend on poultry farming for a living. Poultry is said to be the second-most produced animal product, and the sector showed growing potentials (DA, 2022).

Similarly, chicken meat, a staple item bought by many households where demand is great, is one of the sources of food. And due to the disruption of the supply chain, limited amount supplied, poor feed quality, chicken diseases, and other factors, as a

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result, this demand created a gap in the market which is the leading cause of the rise in the price of chicken meat (Talavera, 2022).

A number of studies have concentrated on the short-term forecasting of chicken prices (Pezlarová, 2018), analyzing the variables that affect fluctuations in the price of chicken (Akbar, 2021), while others have developed new methods to gauge consumer demand for chicken meat (Widarjono & Ruchba, 2021). However, there is little to no literature that has predicted the retail price of chicken meat in the nation which is the study's main emphasis; this will add to our understanding of how to anticipate chicken retail price volatility in the market and will generate relevant information.

1.1 Objective

The study's main goal is to find an accurate forecast of the fully dressed chicken retail price. Specifically, this study sought to answer the following:

1) To examine the market trend of the chicken retail price.
2) To determine the retail price forecast in time series.

1.2 Theoretical Framework

This study is anchored on the Box-Jenkins Model Theory (Box, Jenkins, & Bacon, 1967) which analyzes time series data for forecasting using different data points to determine the outcome of the variable forecast. The model employs the Autoregressive Moving Average (ARMA)/ Autoregressive Integrated Moving Average (ARIMA) models which finds the best fit to forecast based on its historical values.

According to (Chatfield, 1984; Robert Nau, 2019), the ARIMA (Auto Regressive Integrated Moving Average) model extends the ARMA model by adding an integration component. ARIMA models are to be used with non-stationary time series, while ARMA models must be used with stationary time series. A stationary time series is one in which the mean and variance, among other statistical parameters, stay constant across time. Evidently, most real-world time series is not stationary, and transformations are typically required to make them stable. The transformation process is referred to as integration.

1.3 Significance of the Study

The results from this study will leave its relevance in giving information to the following:

- **Government**. The information obtained from the study will serve as a framework for redesigning the current situation of chicken farms in terms of government funding, assistance, and relevance to farmers in need. This will also help the government to take control over the price to establish price equilibrium and distribution that will help in understanding the movement of the retail price of chicken in the market.
- **Policy Makers**. The study can provide a valuable basis for knowledge on the actual outcome of production results, which has a significant effect on the creation and design of strategic support for poultries to develop the agricultural sector and assist farmers.

- **Businesses**. The study's findings can be used by poultry producers to set prices for the chicken products they sell in the marketplace. In order to obtain the upper hand and plan their marketing strategies for future pricing, company owners or farmers will benefit from price prediction.
- **Future Researchers**. This research may serve as a reference for future studies that may be in line with the present investigation's agenda.

2. Method

The time series employed in the study was a univariate time series, which is a time series made up of single observations that are progressively collected across equal time intervals. Univariate time series may be explored, analyzed, and forecasted using time series. Additionally, the autocorrelations and partial autocorrelations of the series show the direction and strength of the association between each series point and its preceding values (Chattopadhyay & Chattopadhyay, 2014; Vishwas & Patel, 2020).

The time series utilized in the study was a univariate time series, which is a time series comprised of single observations collected at equal time intervals. Using time series, it is possible to investigate, analyze, and forecast univariate time series. In addition, the autocorrelations and partial autocorrelations of the series reveal the direction and magnitude of the relationship between each series point and its antecedent values (Chattopadhyay & Chattopadhyay, 2014; Vishwas & Patel, 2020).

This study employed a time-series analysis with the ARIMA (Autoregressive Integrated Moving Average) model as its research design. The ARIMA model is a prominent time-series analysis technique that can account for the trend, seasonal variation, and irregular fluctuations in data. The model will be used to forecast the market price of completely outfitted chicken in Davao City (Paduloh et al., 2021; Ramos & Ativo, 2023).

2.1 Source of Data

The study used secondary data that was accessible and retrieved from the Philippine Statistics Authority (PSA). There were 372 observations overall, spanning from January 1990 to January 2021, were used to estimate the historical retail price of fully dressed chicken in the Philippines in peso per kilogram. Furthermore, the variable used in the study and its description is as follows:

Variable	Description
Chicken Price	Retail Price of Fully Dressed Broiler Chicken in peso per kilo

Source: Philippine Statistics Authority (PSA).

2.2 Statistical Tool

The research instrument used for the study was Autoregressive Integrated Moving Average (ARIMA). The study utilized ARIMA Model to test, assess, and forecast the price volatility predictions of fully dressed chicken. Notably, ARIMA models were used to model the linear dependence in the data while autocorrelation function (ACF), partial autocorrelation function (PACF), and Ljung-Box test were applied in checking the adequacy of the selected models (Moffat & Akpan, 2019). This section briefly discussed the process of the time series tests.

a. Stationarity

In time series analysis, a unit root is used to determine if a time series is stationary. The alternative hypothesis states that time series are stationary and the null hypothesis states that time series have a unit root.

The unit root test can be represented mathematically as:

$$y_t = TD_t + z_t + \varepsilon_t \quad (1)$$

Where:
y_t = Stationarity (I = 0,1);
TD_t = The deterministic element;
z_t = The stochastic element;
ε_t = The stationary error process;

The fundamental goal of the unit root test is to establish whether or not the zt (stochastic component) contains a unit root (MacDonald, 2015).

b. Dickey-Fuller Test

If an AR (1) with white noise errors accurately describes the time series yt, then the unit root tests previously mentioned are valid. The presence of a unit root indicates that the time series is not stationary, but that differencing will reduce it to stationarity, thus, a straightforward AR (1) model cannot fully reflect the dynamic nature of many time series. The basic autoregressive unit root test was modified by (Said & Dickey, 1984) to accept universal ARMA (p, q) models with uncertain orders; this test is known as the augmented Dickey-Fuller (ADF) test. Assuming that the dynamics in the data have an ARMA structure, the ADF test compares the null hypothesis that a time series yt is I (1) to the alternative that it is I (0). On calculating the test regression, the ADF test is based.

$$y_t = \boldsymbol{\beta}'\mathbf{D}_t + \phi y_{t-1} + \sum_{j=1}^{p} \psi_j \Delta y_{t-j} + \varepsilon_t \quad (2)$$

Where:
Dt is a vector of deterministic terms (constant, trend etc.). The p-lagged difference terms, Δyt−j, are used to approximate the ARMA structure of the errors, and the value of p is set so that the error εt is serially uncorrelated. The error term is also assumed to be homoscedastic. The specification of the deterministic terms depends on the assumed behavior of yt under the alternative hypothesis of trend stationarity Under the null hypothesis, yt is I(1) which implies that φ = 1. The ADF t-statistic and normalized bias statistics are based on the least squares estimates.

c. Autocorrelation and Partial Autocorrelation Functions

This study performed autocorrelation function (ACF) and partial autocorrelation function (PACF) analysis in determining the parameter of ARIMA model (Bakar & Rosbi, 2017). Autocorrelation and partial autocorrelation are measures of the relationship between present and past series values, and both ACF and PACF are used to determine which past series values are most useful in forecasting future values. Where, the correlation between two observations made at various times throughout a time series is known as autocorrelation (Dürre et al., 2015).

- Autocorrelation Function (ACF). This is the correlation between series values at lag k that are differentiated by k intervals. Also, determines the degree to which observations in a time series are correlated for a given set of lags. Furthermore, to understand the patterns and characteristics of the time series, use the autocorrelation function (ACF) to determine which lags have significant correlations. While utilizing that information to model the time series data, evaluating the randomness and stationarity of a time series using the ACF.
- Partial Autocorrelation Function (PACF). This, taking into consideration the values of the intervals between, is the correlation between series values at lag k. Similar to the ACF, the partial autocorrelation function simply shows the association between two values that the shorter lags between those observations do not account for.

The x axis of the ACF plot denotes the lag at which the autocorrelation is computed, while the y axis displays the correlation value (between 1 and 1). An ACF plot indicates a high connection between each value in the series and the value that came before it by a spike at lag 1, a strong correlation between each value and the value that occurred two points earlier by a spike at lag 2, and so on.

d. Ljung-Box Test

The Ljung-Box test is sensitive to the number of lags (H) used in the test, according to theoretical findings and practical data (Hassani & Yeganegi, 2020). A time series' residuals are subjected to the test following the fitting of an ARMA (p, q) model to the data. The analysis determines at the residuals' m autocorrelations. Furthermore, the conclusion is that the model does not display a substantial lack of fit if the autocorrelations are relatively modest. In order to determine if there is autocorrelation in a time series, one of the most crucial tests is the Ljung-Box test (Hassani & Yeganegi, 2019). The test statistic for the Ljung-Box test is as follows:

$$Q = n(n+2)\ \Sigma p_k^2 / (n-k) \qquad (3)$$

Where:
n = sample size;
Σ = a fancy symbol that means “sum” and is taken as the sum of 1 to *h*, where *h* is the number of lags being tested;
p_k = sample autocorrelation at lag *k*;.

When applying the test to residuals, the degrees of freedom must take into account the estimated model parameters so that h=mpq, where p and q represent the number of parameters from the ARMA(p,q) model that were used to fit the data (Bagnato et al., 2017).

e. Autoregressive Integrated Moving Average (ARIMA) Model

ARIMA Model is another method for time series forecasting that aims to characterize the autocorrelations in the data. The model's ultimate goal is to forecast future time series movement by focusing on differences between series values rather than actual values.

The trend and the seasonal components are the most frequent reasons why time series data are non-stationary. Applying the differencing step is how non-stationary data is transformed to stationary. To remove the trend component from the data, one or more times of differencing steps may be used. Similarly to this, seasonal differencing might be used to eliminate the seasonal components from data (Petrova & Deyneka, 2022).

According to (Hyndman & Athanasopoulos, 2018), we can split the model into smaller components as follow:

- **AR**: an **AutoRegressive** model which represents a type of random process. The output of the model is linearly dependent on its own previous value i.e. some number of lagged data points or the number of past observations.
- **MA**: a **Moving Average** model in which output is dependent linearly on the current and various past observations of a stochastic term.
- **I**: integrated here means the **differencing step** to generate stationary time series data, i.e. removing the seasonal and trend components.

An ARIMA model is characterized by 3 terms: (p, d, q) or (AR, I, MA).

Where:

p: the amount of time lags or order of lags in the autoregressive model AR (p)

d: degree of differencing or the number of times the data have been subtracted from historical values.

q: the moving average model MA's order (q)

The AR model only depends on past values (lags) to estimate future values. Let's take a look at the generalized form of the AR model:

$$AR(p): x_t = \alpha + \sum_{i=1}^{p} \beta_i x_{t-1} + \varepsilon \tag{4}$$

The number of past values "p" that will be considered while making the forecast depends on the value. More historical values will be considered as the model's order increases. In a simple form of an AR (1) model:

$$x_t = \alpha + \beta_i x_{t-1} + \varepsilon \tag{5}$$

The AR model can simply be thought of as the linear combination of p past values.

On the other hand, the moving-average MA model relies on previous forecasting errors to generate predictions. In general equation form of MA model is denoted:

$$x_t = \mu + \sum_{i=1}^{q} \Phi_i \varepsilon_{t-1} \quad (6)$$

The MA model can simply be thought of as the linear combination of q past forecast errors.

The forecasting equation for differencing is formed as follows:

If d = 0: $y_t = Y_t$
If d = 1: $y_t = Y_t - Y_{t-1}$
If d = 2: $y_t = (Y_t - Y_{t-1}) - (Y_{t-1} - Y_{t-2}) = Y_t - 2Y_{t-1} + Y_{t-2}$

Where:
y_t = denote the d^{th} difference of Y.

3. Results and Discussions

In this chapter, the outcomes of the study that addressed certain objectives are explained together with their interpretation and analysis. The results are mostly based on information gathered from the fully dressed chicken broiler retail price. The results of the analysis are explained using tables and figures. Additionally, discussion and analysis of tabular and graphical analyses were conducted for simplicity of understanding.

3.1 The Market Retail Price Situation of Chicken

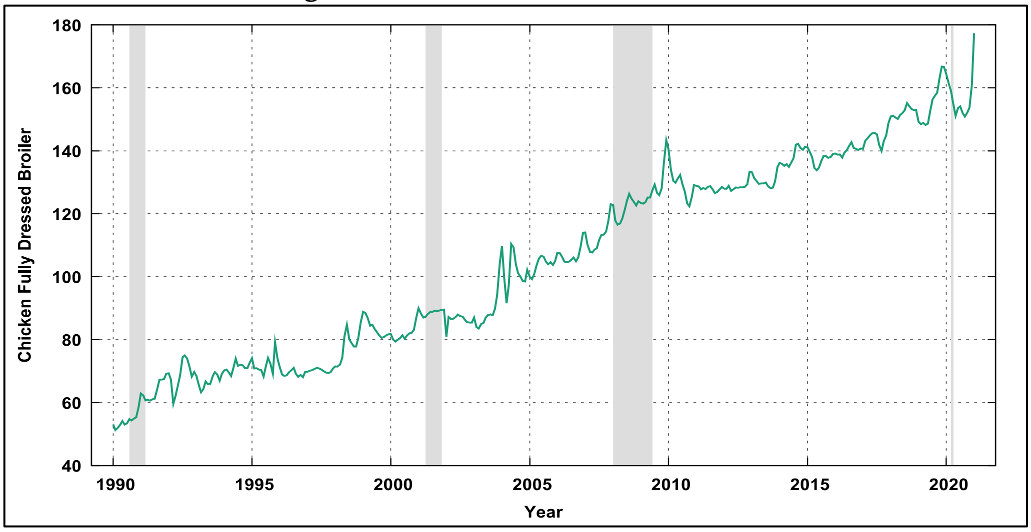
The growth of supermarkets and groceries has caused significant changes in the Philippine food retail industry. Despite the higher expense, the working middle class favors convenience and has chosen one-stop shopping to save time and effort. Given that consumers are looking for convenience, it may not be a surprise to see supermarkets overtaking wet markets as the preferred source of chicken meat. On the other hand, even while spending on dining out is rising, a sizable portion of local food expenditures still goes toward meals made at home. Chicken meat is often purchased by households either at traditional wet markets or from retailers like supermarkets and hypermarkets. Furthermore, the retail industry continues to be dominated by wet markets are the principal supplier of fresh chicken for domestic consumers. The accessibility of the market to purchase fresh chicken meat, bridge the gap between consumer and producers which can drive the increase in the price.

In such, the competitive selling prices of chicken, its value-added goods, and an increase in sales volume were all factors that contributed to the revenue growth of the poultry industry. The industry also benefited from successful market intensifications, extended distribution, and trade penetration. Due to this circumstance, the market price of chicken increased consistently between 2013 and 2017 (Bedford, 2020). Similar to the current market condition, (Akbar, 2021) noted that the cost of local chicken, the cost of local chicken feed, and the cost of local chicken seeds could all impact the price of chicken in the market.

One of the historical events that happened in the world was in 2003, 2007 and 2020 financial crisis and covid-19 situation, this includes the bird flu virus happened where many economies struggled to survive are the drivers for the price of chicken meat increased. Moreover, as of 2009, the SRPs (per kilo), of whole-dressed chicken were PHP135 to P145, this was a price band to serve as a guide for farmers, slaughterhouse operators, meat dealers, wholesalers, retailers, and consumers (Global Ag Media, 2009).

As of January of 2020, the prevailing price of fully dressed chicken was PhP 170.00 while the annual average retail price was PhP 155.71 per kilogram. This was 0.2 percent higher compared with the average retail price of PhP 155.35 per kilogram in 2019. The highest average retail price was recorded in January at PhP 164.54 per kilogram, while the lowest was quoted in September at PhP 150.87 per kilogram. There was a small margin increase in the price of fully dressed chicken from 2018, 2019, to 2020 with an annual average price of 152.29, 155.35, and 155.71, respectively. The price increase was due to the decline of the value of production (-8.5 percent lower) paired with the short volume of imported chicken meat (-6.3 percent lower).

Figure 2: The Price Trend of Chicken



However, the effect of the COVID-19 lockdowns, with the loosening of restrictions triggered the annual average retail price of fully dressed broiler chicken in 2021 was PhP 175.84 per kilogram to increase. This was 9.8 percent higher compared with the average retail price of PhP 160.20 per kilogram in 2020. Despite the increase of imported chicken meat to supply the gap of domestic supply, as of February 2021, the implementation of price control by the government the increase in the price was due to the gained momentum during the Christmas holidays, pushing annual inflation for meat to 10% in December, and adding to overall inflation which hit 3.5%, the highest level in nearly two years (PSA, 2021).

3.2 The Retail Price Forecast and the ARIMA Model

The stationarity assumption was used in the analysis, and the Augmented Dickey-Fuller test (ADF) was used to determine whether or not the series was stationary. The test revealed that the series was non-stationary with a p-value of 0.9733, which is greater than the acceptable significant level of 5%. As a result, further analysis is required to modify the data so that it is stationary, namely through the use of differencing (this already involves integration). The initial differencing was carried out, and the data were examined with ADF in order to validate the stationarity of the data. The outcome of the examination indicated that the data were stationary with a p-value of 8.696e-15, which was lower than the 5% alpha value. In addition, the Lagrange Multiplier (LM) test was utilized in the investigation in order to determine the existence of autocorrelation. The LM Test is identical to the Breusch-Godfrey (BG) Test or the Durbin-Watson Test, all of which are employed in the process of determining whether or not there is a serial correlation. The results of the test demonstrated, consequently, that the data do not include any autocorrelation.

In addition, the AR and MA Model was found by utilizing the autocorrelation function (ACF) and partial autocorrelation function (PACF) to determine the best-fitted parameters of the ARIMA model while avoiding many lags in order to achieve parsimony. This was done in order to determine the best-fitted parameters of the ARIMA model. Similarly, the findings of the ARIMA Model are shown below. These results show that both AR and MA L1 are statistically significant, as shown by a p-value that is lower than the significant threshold of 5%, as well as a positive (1.25561) and negative (0.931355) coefficient, respectively. As a result, the ARIMA model with parameters (3, 1, 1) provides the most accurate forecasts for the series.

3.3 The Findings of ARIMA Model

Function evaluations: 84
Evaluations of gradient: 24

Model 3: ARIMA, using observations 1990:02-2021:01 (T = 372)
Estimated using AS 197 (exact ML)
Dependent variable: (1-L) Chicken Fully Dressed Broiler
Standard errors based on Hessian

	coefficient	std. error	z	p-value
const	0.296786	0.0459094	6.465	1.02e-10***
phi_1	1.25561	0.0725656	17.30	4.46e-67***
phi_2	−0.673653	0.0814169	−8.274	1.29e-16***
phi_3	0.233947	0.0638522	3.664	0.0002***
theta_1	−0.931355	0.0450952	−20.65	9.16e-95***

Mean dependent var	0.334140	S.D. dependent var	2.570988
Mean of innovations	0.007868	S.D. of innovations	2.276871
R-squared	0.994719	Adjusted R-squared	0.994676
Log-likelihood	−834.2908	Akaike criterion	1680.582
Schwarz criterion	1704.095	Hannan-Quinn	1689.919

		Real	Imaginary	Modulus	Frequency
AR					
	Root 1	1.2887	0.0000	1.2887	0.0000
	Root 2	0.7954	-1.6384	1.8213	-0.1781
	Root 3	0.7954	1.6384	1.8213	0.1781
MA					
	Root 1	1.0737	0.0000	1.0737	0.0000

Test for normality of residual –

Null hypothesis: error is normally distributed.
Test statistic: Chi-square (2) = 162.006, with p-value = 6.6191e-36

LM test for autocorrelation up to order 12 –

Null hypothesis: no autocorrelation
Test statistic: Chi-square (8) = 12.9627

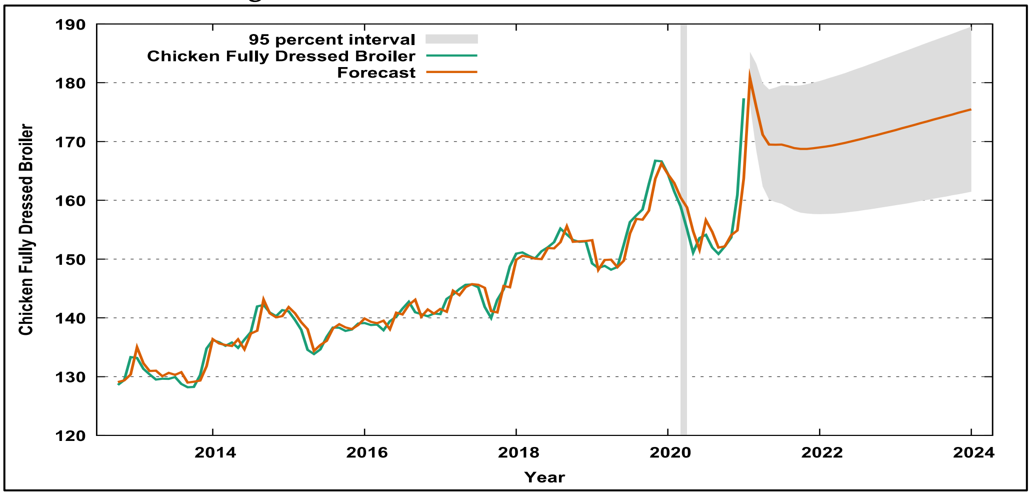
Test for ARCH of order 12 –

Null hypothesis: no ARCH effect is present.
Test statistic: LM = 63.5597,
with p-value = P (Chi-square (12) > 63.5597) = 5.02728e-09

3.3 The Retail Price Four-Year Prediction of Chicken

A four-year prediction (4yrs) was used in the series with the results of the diagnostic test showing that the model is suitable for predicting. The graph below demonstrates how the price trend stabilized between 2021 and 2024.

Figure 3: The Retail Price Forecast of Chicken



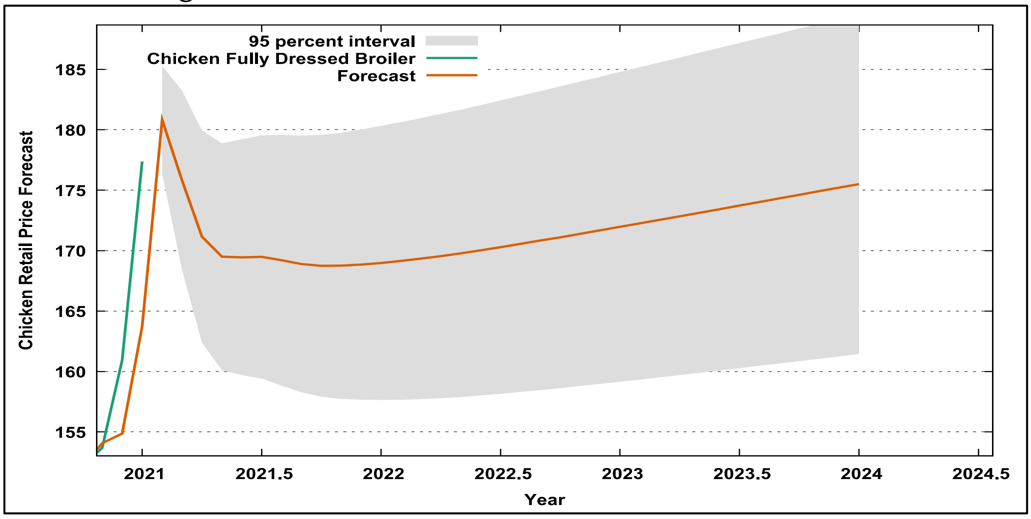
Source: Data Processed from PSA Chicken Retail Price

The coefficient result of ARIMA (3, 1, 1), where a coefficient that is closer to zero suggests that the most recent observations are tied to the current observations more closely than the earliest observations are, was the foundation and support for the consistency of price for the four-year forecast. The predicted value of the retail price for the following year is shown by the red-orange line in the 95% interval funnel-like shade. Additionally, the shaded vertical line in the graph showed the NBER Recession, which is an event that disrupts the business cycle and entails a large decline in economic activity that is widespread throughout the economy and lasts for longer than a few months.

3.4 The Forecasted Retail Price of Chicken

The zoomed-in-four-year forecast of the retail price of chicken has shown a steady fluctuation in its price for the next succeeding years. And true enough with the preliminary report from PSA regarding the average retail price of chicken that fluctuation is present in the forecast, from Php179.71 in the first quarter of 2021 to Php171.11 in the last quarter.

Figure 4: The Four-Year Forecast of Chicken Retail Price



Source: Processed from PSA Data on Chicken Retail Price

4. Conclusions

By understanding the utilization of Time Series model in the study, the information gathered will be used to forecast the upcoming values. In addition, following several criteria and assumptions to perform the best-fitting model for the time series, the study suggests the use of ARIMA model to predict the retail price of chicken in the Philippines.

Moreover, the work of (Mgaya, 2019) validates the study's findings by utilizing an ARIMA model to predict the demand of livestock goods including eggs, milk, poultry, and cow meat which aids in boosting the application of animal feed as a market opportunity for farmers. Similarly to this, a balance between the supply and demand of the product on the market is necessary to stabilize market prices and reduce price volatility (Astuti et al., 2021). In accordance with the findings, (Wickramarachchi et al., 2017) also use the ARIMA model to comprehend the pricing behavior of chicken products, which aids in market strategy. As a result, the ARIMA (3,1,1) model's relevance and functions are justified by employing it for predicting and identifying the best-fit model.

4.1 Recommendations

The following recommendations are made based on the findings of the price forecast result:

The government and policymakers should collaborate with government agencies keenly to develop a system that would enable the market price to be stable. Additionally, price policies including cost-based, market-based, and value-based pricing must be developed and improved in order to create a win-win situation for both consumers and producers.

Businesses must make use of the study's findings to get an advantage over the competition when setting product prices and planning forward for the future. Additionally, to make use of the findings by doing price movement analysis prior to investing in order to minimize potential losses.

Future researchers are encouraged to investigate price volatility using the ARCH/GARCH Model to obtain a more generally applicable estimate of volatility. Likewise, to explore the variables that can influence the market's price volatility for chicken meat.

Conflict of Interest Statement

The authors declare no conflict of interest.

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References

Akbar, M. (2021). Analysis Factors Affecting the Demand and Supply of Free-range Chicken Meat in Pakpak Bharat Regency. *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*. https://doi.org/10.33258/birci.v4i1.1718

Astuti, H. B., Fauzi, E., Putra, W. E., Alfayanti, A., & Ishak, A. (2021). Estimating Model Forecasting the Price of Chicken Eggs in the City of Bengkulu. *AGRITEPA: Jurnal Ilmu Dan Teknologi Pertanian*. https://doi.org/10.37676/agritepa.v8i2.1334

Bagnato, L., de Capitani, L., & Punzo, A. (2017). A diagram to detect serial dependencies: an application to transport time series. *Quality and Quantity*. https://doi.org/10.1007/s11135-016-0426-y

Bakar, N. A., & Rosbi, S. (2017). Autoregressive Integrated Moving Average (ARIMA) Model for Forecasting Cryptocurrency Exchange Rate in High Volatility Environment: A New Insight of Bitcoin Transaction. *International Journal of Advanced Engineering Research and Science*. https://doi.org/10.22161/ijaers.4.11.20

Bedford, R. (2020). Philippine Broiler Market Trends and Prospects. Manila: The United States Department of Agriculture (USDA), Foreign Agricultural Service.

Box, G. E., Jenkins, G. M., & Bacon, D. W. (1967). Models For Forecasting Seasonal and Non-Seasonal Time Series. Retrieved from https://www.semanticscholar.org/paper/MODELS-FOR-FORECASTING-SEASONAL-AND-NON-SEASONAL-Box-Jenkins/bffca73dad7a288d6cd1176a967e4ae3a3c9916e

Chatfield, C. (1984). The Analysis of Time Series: An Introduction. In *The Analysis of Time Series: An Introduction*. https://doi.org/10.1007/978-1-4899-2921-1

Chattopadhyay, A. K., & Chattopadhyay, T. (2014). Time series analysis. In *Springer Series in Astrostatistics*. https://doi.org/10.1007/978-1-4939-1507-1_9

Department of Agriculture (DA). (2021). DA chief highlights poultry sector's crucial role in agri growth. Quezon City: Department of Agriculture.

Department of Agriculture. (2022). The Philippine Poultry Broiler Industry Roadmap (2022-2040). Quezon City: Department of Agriculture - Bureau of Agricultural Research.

Dürre, A., Fried, R., & Liboschik, T. (2015). Robust estimation of (partial) autocorrelation. In *Wiley Interdisciplinary Reviews: Computational Statistics*. https://doi.org/10.1002/wics.1351

Global Ag Media. (2009, November 30). Philippine Govt Sets Pork and Chicken Guide Prices. Retrieved from The Poultry Site: https://www.thepoultrysite.com/news/2009/11/philippine-govt-sets-pork-and-chicken-guide-prices

Hassani, H., & Yeganegi, M. R. (2019). Sum of squared ACF and the Ljung–Box statistics. *Physica A: Statistical Mechanics and Its Applications*. https://doi.org/10.1016/j.physa.2018.12.028

Hassani, H., & Yeganegi, M. R. (2020). Selecting optimal lag order in Ljung–Box test. *Physica A: Statistical Mechanics and Its Applications*. https://doi.org/10.1016/j.physa.2019.123700

Hyndman, R. J., & Athanasopoulos, G. (2018). Forecasting: principles and practice. Melbourne: OTexts.

MacDonald, G. (2015). Elements of Time Series Econometrics: An Applied Approach, 2nd edition, by Evžen Kočenda and Alexandr Černý (Karolinum Press, Prague, 2014), pp. 220. *Economic Record*. https://doi.org/10.1111/1475-4932.12197

Mgaya, J. F. (2019). Application of ARIMA models in forecasting livestock products consumption in Tanzania. *Cogent Food and Agriculture*. https://doi.org/10.1080/23311932.2019.1607430

Moffat, I. U., & Akpan, E. A. (2019). White Noise Analysis: A Measure of Time Series Model Adequacy. *Applied Mathematics*. https://doi.org/10.4236/am.2019.1011069

Paduloh, P., Yuhan, N., Muhazir, A., Zulkarnaen, I., Widyantoro, M., Ilahy, A. R., & Rosihan. (2021). Design Model Forecasting and Delivery Requirement Planning for Fast Food Product. *13th-ISIEM*.

Petrova, A., & Deyneka, M. (2022). ARIMA-Models: Modeling and Forecasting Prices of Stocks. *International Scientific Journal "Internauka". Series: "Economic Sciences."* https://doi.org/10.25313/2520-2294-2022-2-7921

Pezlarová, V. (2018). Analysis of the relation between the price of fodder mixture ingredients and the price of chicken meat. *Agricultural Economics (Zemědělská Ekonomika)*. https://doi.org/10.17221/5359-agricecon

Philippine Statistics Authority (PSA). (2021). 2016-2020 Livestock and Poultry Statistics of the Philippines. Quezon City: Philippine Statistics Authority.

Ramos, K. G., & Ativo, I. J. O. (2023). Forecasting Monthly Prices of Selected Agricultural Commodities in The Philippines Using ARIMA Model. *International Journal of Research Publication and Reviews*. https://doi.org/10.55248/gengpi.2023.4157

Robert Nau (2019). Statistical forecasting: notes on regression and time series analysis. *Fuqua School of Business Duke University*.

Said, S. E., & Dickey, D. A. (1984). Testing for unit roots in autoregressive-moving average models of unknown order. *Biometrika*. https://doi.org/10.1093/biomet/71.3.599

Talavera, C. (2022). Chicken prices up; DA blames low production. The Philippine Star.

Vishwas, B. V., & Patel, A. (2020). Hands-on Time Series Analysis with Python. In *Hands-on Time Series Analysis with Python*. https://doi.org/10.1007/978-1-4842-5992-4

Wickramarachchi, A. R., Herath, H. M. L. K., Jayasinghe-Mudalige, U. K., Edirisinghe, J. C., Udugama, J. M. M., Lokuge, L. D. M. N., & Wijesuriya, W. (2017). An Analysis of Price Behavior of Major Poultry Products in Sri Lanka. *Journal of Agricultural Sciences*. https://doi.org/10.4038/jas.v12i2.8231

Widarjono, A., & Ruchba, S. M. (2021). Demand for Meat in Indonesia: Censored AIDS Model. *Agris On-Line Papers in Economics and Informatics*. https://doi.org/10.7160/aol.2021.130209

Appendices

A. Price Forecasted Value of Chicken

For 95% confidence intervals, z(0.025) = 1.96

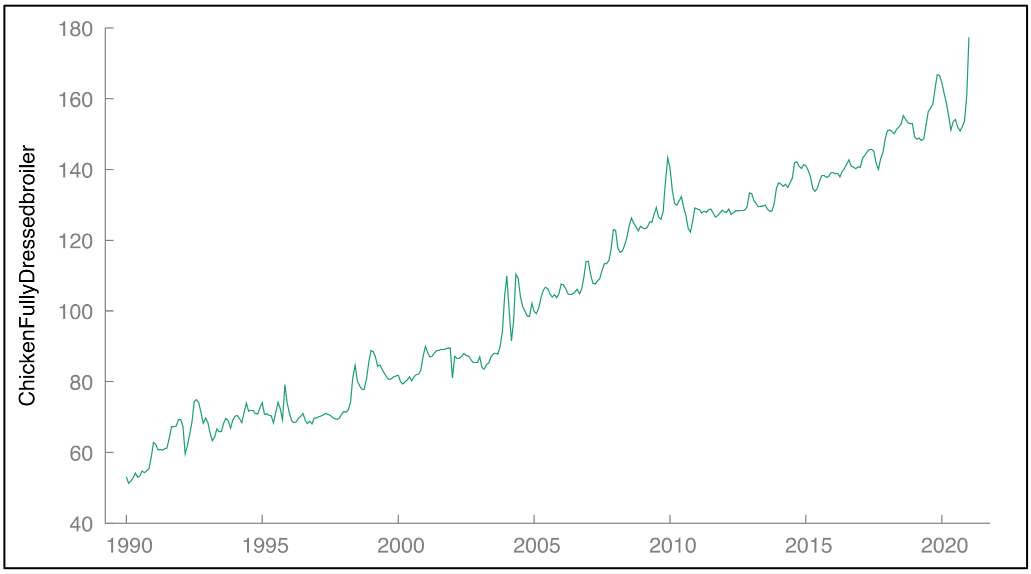
ChickenFullyDres~	prediction	std. error	95% interval
2012:10	128.58	129.06	
2012:11	129.41	129.35	
2012:12	133.33	130.33	
2013:01	133.17	135.00	
2013:02	131.31	132.28	
2013:03	130.37	130.95	
2013:04	129.49	131.00	
2013:05	129.64	130.05	
2013:06	129.62	130.64	
2013:07	129.92	130.29	
2013:08	128.75	130.74	
2013:09	128.18	128.99	
2013:10	128.25	129.13	
2013:11	130.26	129.32	
2013:12	134.78	131.78	
2014:01	136.19	136.38	
2014:02	135.86	135.62	
2014:03	135.23	135.38	
2014:04	135.79	135.19	
2014:05	134.88	136.33	
2014:06	136.29	134.62	
2014:07	137.57	137.31	
2014:08	141.95	137.82	
2014:09	142.19	143.13	
2014:10	140.92	140.77	
2014:11	140.29	140.10	
2014:12	141.31	140.29	
2015:01	141.12	141.82	
2015:02	139.65	140.76	
2015:03	137.96	139.26	
2015:04	134.56	138.04	
2015:05	133.83	134.39	
2015:06	134.63	135.38	
2015:07	136.78	136.08	
2015:08	138.33	138.18	
2015:09	138.31	138.93	
2015:10	137.78	138.37	
2015:11	138.00	138.10	
2015:12	139.04	138.77	
2016:01	139.11	139.88	

2016:02	138.76	139.32
2016:03	138.86	139.09
2016:04	137.87	139.51
2016:05	139.44	138.06
2016:06	140.22	140.87
2016:07	141.55	140.57
2016:08	142.74	142.20
2016:09	140.93	143.08
2016:10	140.63	140.22
2016:11	140.25	141.42
2016:12	140.72	140.70
2017:01	140.63	141.53
2017:02	143.21	141.01
2017:03	143.98	144.62
2017:04	144.92	143.84
2017:05	145.61	145.23
2017:06	145.69	145.73
2017:07	145.17	145.64
2017:08	141.85	145.11
2017:09	139.99	141.14
2017:10	143.06	140.90
2017:11	144.86	145.43
2017:12	148.73	145.21
2018:01	150.92	149.87
2018:02	151.14	150.56
2018:03	150.56	150.36
2018:04	150.11	150.06
2018:05	151.35	150.00
2018:06	152.01	151.87
2018:07	152.87	151.82
2018:08	155.18	152.87
2018:09	154.19	155.56
2018:10	153.24	152.92
2018:11	152.92	153.02
2018:12	153.01	153.07
2019:01	149.26	153.23
2019:02	148.50	148.17
2019:03	148.86	149.84
2019:04	148.20	149.91
2019:05	148.64	148.60
2019:06	152.48	149.74
2019:07	156.30	154.35
2019:08	157.44	156.85
2019:09	158.44	156.70
2019:10	162.78	158.26
2019:11	166.75	163.67
2019:12	166.62	166.23

2020:01	164.54	164.49	
2020:02	161.53	162.95	
2020:03	158.98	160.50	
2020:04	155.09	158.79	
2020:05	151.12	154.72	
2020:06	153.58	151.56	
2020:07	154.13	156.61	
2020:08	151.98	154.60	
2020:09	150.87	151.98	
2020:10	152.16	152.14	
2020:11	153.68	154.06	
2020:12	160.94	154.87	
2021:01	177.37	163.74	
2021:02	180.82	2.277	176.36 - 185.28
2021:03	175.84	3.778	168.43 - 183.24
2021:04	171.16	4.481	162.37 - 179.94
2021:05	169.49	4.786	160.11 - 178.87
2021:06	169.45	4.973	159.71 - 179.20
2021:07	169.48	5.136	159.41 - 179.54
2021:08	169.20	5.286	158.84 - 179.56
2021:09	168.89	5.415	158.27 - 179.50
2021:10	168.74	5.525	157.91 - 179.56
2021:11	168.75	5.620	157.74 - 179.76
2021:12	168.85	5.705	157.67 - 180.03
2022:01	168.98	5.785	157.64 - 180.32
2022:02	169.14	5.860	157.66 - 180.63
2022:03	169.33	5.931	157.71 - 180.96
2022:04	169.55	5.999	157.79 - 181.30
2022:05	169.78	6.065	157.89 - 181.67
2022:06	170.03	6.128	158.02 - 182.04
2022:07	170.29	6.190	158.16 - 182.42
2022:08	170.56	6.251	158.30 - 182.81
2022:09	170.83	6.310	158.46 - 183.20
2022:10	171.11	6.368	158.63 - 183.59
2022:11	171.39	6.426	158.80 - 183.99
2022:12	171.68	6.483	158.97 - 184.38
2023:01	171.97	6.539	159.15 - 184.78
2023:02	172.26	6.594	159.33 - 185.18
2023:03	172.55	6.649	159.52 - 185.58
2023:04	172.84	6.703	159.70 - 185.98
2023:05	173.14	6.757	159.89 - 186.38
2023:06	173.43	6.810	160.08 - 186.78
2023:07	173.73	6.863	160.27 - 187.18
2023:08	174.02	6.916	160.47 - 187.58
2023:09	174.32	6.968	160.66 - 187.97
2023:10	174.61	7.019	160.86 - 188.37
2023:11	174.91	7.070	161.05 - 188.77

2023:12	175.20	7.121	161.25 - 189.16
2024:01	175.50	7.172	161.44 - 189.56

b. Test for Stationarity

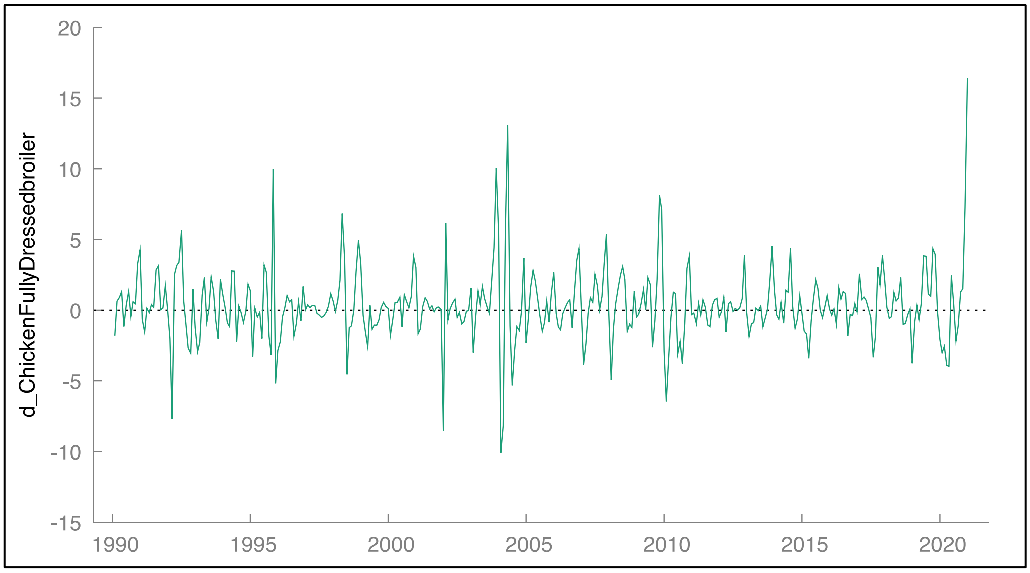


Augmented Dickey-Fuller test for ChickenFullyDressedbroiler
testing down from 16 lags, criterion AIC
sample size 363
unit-root null hypothesis: a = 1

test with constant
including 9 lags of (1-L)ChickenFullyDressedbroiler
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): 0.000828116
test statistic: tau_c(1) = 0.209002
asymptotic p-value 0.9733
1st-order autocorrelation coeff. for e: -0.008
lagged differences: F(9, 352) = 12.466 [0.0000]

with constant and trend
including 9 lags of (1-L)ChickenFullyDressedbroiler
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0.0642581
test statistic: tau_ct(1) = -2.5186
asymptotic p-value 0.319
1st-order autocorrelation coeff. for e: -0.004
lagged differences: F(9, 351) = 11.333 [0.0000]

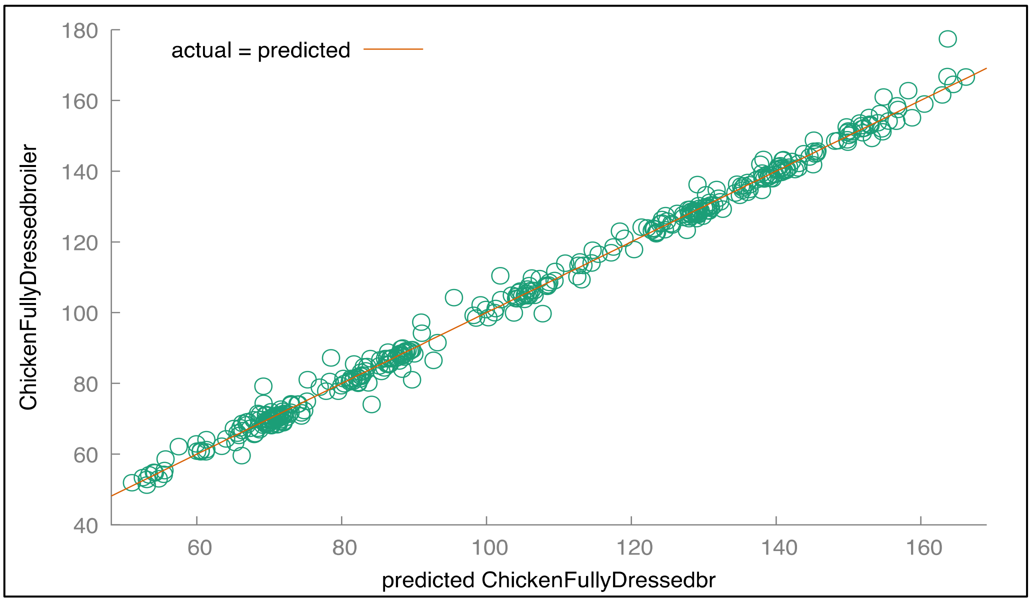
c. Test for Stationarity: 1st Difference



Augmented Dickey-Fuller test for d_ChickenFullyDressedbroiler
testing down from 16 lags, criterion AIC
sample size 363
unit-root null hypothesis: a = 1

test with constant
including 8 lags of (1-L)d_ChickenFullyDressedbroiler
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -1.61177
test statistic: tau_c(1) = -8.58933
asymptotic p-value 8.696e-15
1st-order autocorrelation coeff. for e: -0.008
lagged differences: F(8, 353) = 9.289 [0.0000]

with constant and trend
including 8 lags of (1-L)d_ChickenFullyDressedbroiler
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -1.60904
test statistic: tau_ct(1) = -8.56457
asymptotic p-value 2.283e-14
1st-order autocorrelation coeff. for e: -0.008
lagged differences: F(8, 352) = 9.251 [0.0000]

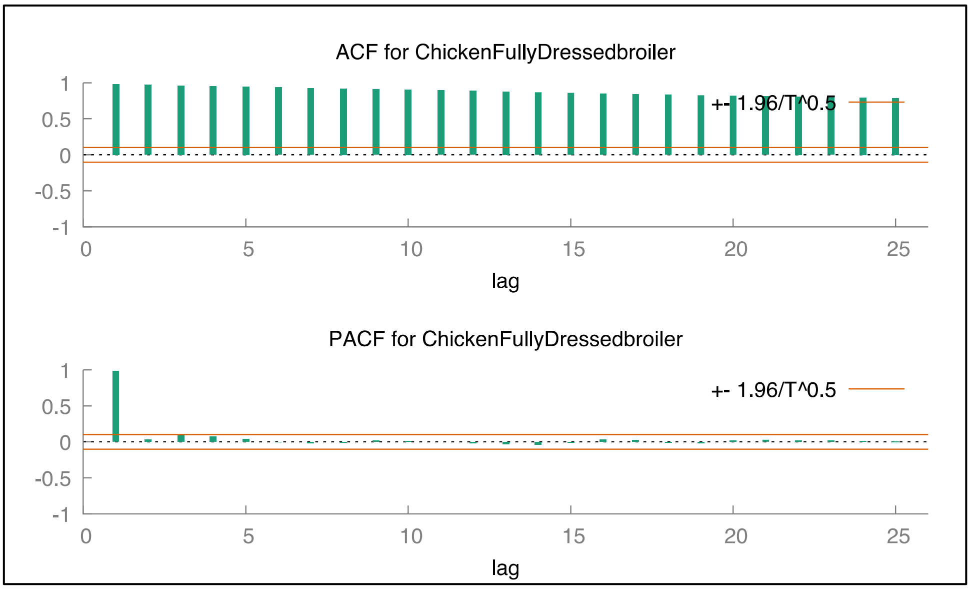


d. Correlogram for ARIMA Model

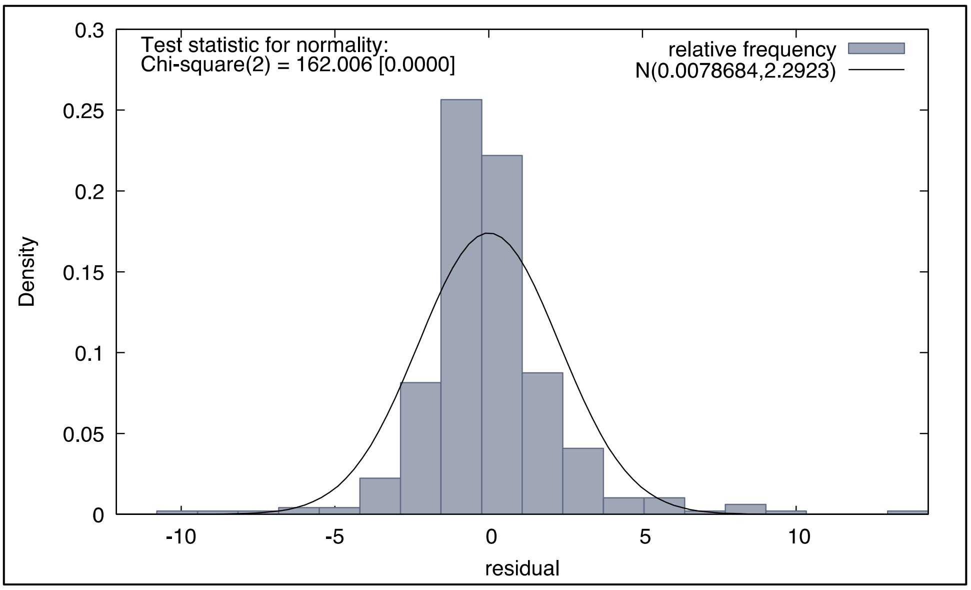
Autocorrelation function for ChickenFullyDressedbroiler
***, **, * indicate significance at the 1%, 5%, 10% levels
using standard error 1/T^0.5

	LAG	ACF	PACF	Q-stat. [p-value]
1.	0.9858 ***	0.9858 ***	365.4294	[0.000]
2.	0.9727 ***	0.0311	722.1760	[0.000]
3.	0.9626 ***	0.0982 *	1072.4341	[0.000]
4.	0.9543 ***	0.0740	1417.6759	[0.000]
5.	0.9469 ***	0.0391	1758.4409	[0.000]
6.	0.9388 ***	-0.0052	2094.3412	[0.000]
7.	0.9300 ***	-0.0173	2424.9065	[0.000]
8.	0.9212 ***	-0.0075	2750.0916	[0.000]
9.	0.9130 ***	0.0169	3070.4423	[0.000]
10.	0.9055 ***	0.0129	3386.3546	[0.000]
11.	0.8978 ***	0.0000	3697.8264	[0.000]
12.	0.8896 ***	-0.0182	4004.4615	[0.000]
13.	0.8806 ***	-0.0286	4305.7677	[0.000]
14.	0.8709 ***	-0.0379	4601.2608	[0.000]
15.	0.8614 ***	-0.0084	4891.1557	[0.000]
16.	0.8532 ***	0.0298	5176.3550	[0.000]
17.	0.8458 ***	0.0237	5457.4089	[0.000]
18.	0.8379 ***	-0.0096	5734.0153	[0.000]
19.	0.8293 ***	-0.0162	6005.7500	[0.000]
20.	0.8213 ***	0.0201	6273.0422	[0.000]
21.	0.8144 ***	0.0284	6536.5679	[0.000]
22.	0.8081 ***	0.0221	6796.7817	[0.000]
23.	0.8021 ***	0.0187	7053.8929	[0.000]

24.	0.7961 ***	0.0137	7307.9109	[0.000]
25.	0.7896 ***	-0.0072	7558.5267	[0.000]



e. **Test for Normality**



Frequency distribution for residual, obs 2-373
number of bins = 19, mean = 0.00786839, sd = 2.29231

interval	midpt	frequency	rel.	cum.
< -9.4702	-10.130	1	0.27%	0.27%
-9.4702 - -8.1499	-8.8101	1	0.27%	0.54%
-8.1499 - -6.8297	-7.4898	1	0.27%	0.81%
-6.8297 - -5.5094	-6.1695	2	0.54%	1.34%
-5.5094 - -4.1891	-4.8492	2	0.54%	1.88%

-4.1891 - -2.8688	-3.5290	11	2.96%	4.84% *
-2.8688 - -1.5485	-2.2087	40	10.75%	15.59% ***
-1.5485 - -0.22825	-0.88839	126	33.87%	49.46% ************
-0.22825 - 1.0920	0.43189	109	29.30%	78.76% **********
1.0920 - 2.4123	1.7522	43	11.56%	90.32% ****
2.4123 - 3.7326	3.0725	20	5.38%	95.70% *
3.7326 - 5.0529	4.3927	5	1.34%	97.04%
5.0529 - 6.3732	5.7130	5	1.34%	98.39%
6.3732 - 7.6934	7.0333	1	0.27%	98.66%
7.6934 - 9.0137	8.3536	3	0.81%	99.46%
9.0137 - 10.334	9.6739	1	0.27%	99.73%
10.334 - 11.654	10.994	0	0.00%	99.73%
11.654 - 12.975	12.314	0	0.00%	99.73%
>= 12.975	13.635	1	0.27%	100.00%

Test for null hypothesis of normal distribution:
Chi-square(2) = 162.006 with p-value 0.00000

f. Test for ARCH of order 12

	coefficient	std. error	t-ratio	p-value
alpha(0)	3.09258	1.03414	2.990	0.0030 ***
alpha(1)	0.546547	0.0673369	8.117	8.42e-15 ***
alpha(2)	−0.0758515	0.0739672	−1.025	0.3059
alpha(3)	−0.0217513	0.0740980	−0.2935	0.7693
alpha(4)	−0.00116065	0.0740621	−0.01567	0.9875
alpha(5)	0.0853825	0.0740551	1.153	0.2497
alpha(6)	−0.0942926	0.0742239	−1.270	0.2048
alpha(7)	−0.00316287	0.0742374	−0.04260	0.9660
alpha(8)	0.0533153	0.0740680	0.7198	0.4721
alpha(9)	−0.0159760	0.0741173	−0.2156	0.8295
alpha(10)	0.0139363	0.0741957	0.1878	0.8511
alpha(11)	−0.0368434	0.0742287	−0.4964	0.6200
alpha(12)	0.00430027	0.0682084	0.06305	0.9498

Null hypothesis: no ARCH effect is present
Test statistic: LM = 63.5597, with p-value = P(Chi-square(12) > 63.5597) = 5.02728e-09

g. Belsley-Kuh-Welsch collinearity diagnostics:

variance proportions

lambda	cond	const	phi_1	phi_2	phi_3	theta_1
3.268	1.000	0.002	0.011	0.010	0.013	0.017
0.993	1.815	0.970	0.000	0.001	0.001	0.000
0.455	2.681	0.001	0.123	0.005	0.232	0.027
0.229	3.776	0.020	0.052	0.168	0.012	0.534

0.055	7.705	0.008	0.813	0.817	0.741	0.422

lambda = eigenvalues of inverse covariance matrix (smallest is 0.0550476)
cond = condition index
Note: variance proportions columns sum to 1.0.

According to BKW, cond >= 30 indicates "strong" near linear dependence, and cond between 10 and 30 "moderately strong". Parameter estimates whose variance is mostly associated with problematic cond values may themselves be considered problematic.

Count of condition indices >= 30: 0
Count of condition indices >= 10: 0

No evidence of excessive collinearity

Model estimation range: 1990:02 - 2021:01
Standard error of the regression = 2.27687

ChickenFullyDres~	Fitted	Residual	
1990:02	51.27	53.11	-1.84
1990:03	51.91	51.04	0.87
1990:04	52.82	53.08	-0.26
1990:05	54.15	53.42	0.73
1990:06	53.01	54.72	-1.71
1990:07	53.38	52.53	0.85
1990:08	54.72	54.20	0.52
1990:09	54.29	55.45	-1.16
1990:10	54.88	54.07	0.81
1990:11	55.34	55.52	-0.18
1990:12	58.63	55.66	2.97
1991:01	62.89	59.91	2.98
1991:02	62.26	63.42	-1.16
1991:03	60.71	60.50	0.21
1991:04	60.85	60.04	0.81
1991:05	60.67	61.23	-0.56
1991:06	61.06	60.56	0.50
1991:07	61.26	61.29	-0.03
1991:08	64.11	61.30	2.81
1991:09	67.25	65.09	2.16
1991:10	67.29	67.36	-0.07
1991:11	67.45	66.02	1.43
1991:12	69.18	67.08	2.10
1992:01	69.29	69.36	-0.07
1992:02	67.28	68.42	-1.14
1992:03	59.58	66.19	-6.61 *
1992:04	62.12	57.50	4.62
1992:05	65.28	65.78	-0.50

1992:06	68.68	66.26	2.42
1992:07	74.35	69.22	5.13
1992:08	74.96	75.20	-0.24
1992:09	73.95	72.98	0.97
1992:10	71.29	72.74	-1.45
1992:11	68.24	70.18	-1.94
1992:12	69.72	67.83	1.89
1993:01	68.50	71.30	-2.80
1993:02	65.56	67.92	-2.36
1993:03	63.28	65.29	-2.01
1993:04	64.34	64.04	0.30
1993:05	66.66	66.29	0.37
1993:06	65.83	68.04	-2.21
1993:07	65.95	65.59	0.36
1993:08	68.31	66.92	1.39
1993:09	69.65	69.76	-0.11
1993:10	68.93	69.92	-0.99
1993:11	66.90	68.66	-1.76
1993:12	69.10	66.84	2.26
1994:01	70.21	71.01	-0.80
1994:02	70.45	70.45	0.00
1994:03	69.56	70.57	-1.01
1994:04	68.39	69.54	-1.15
1994:05	71.17	68.70	2.47
1994:06	73.94	72.99	0.95
1994:07	71.68	74.44	-2.76
1994:08	71.97	70.26	1.71
1994:09	71.82	72.96	-1.14
1994:10	70.96	72.03	-1.07
1994:11	70.89	71.10	-0.21
1994:12	72.72	71.59	1.13
1995:01	74.11	73.87	0.24
1995:02	70.80	74.44	-3.64
1995:03	70.94	69.58	1.36
1995:04	70.46	72.46	-2.00
1995:05	70.32	70.90	-0.58
1995:06	68.32	71.10	-2.78
1995:07	71.51	68.43	3.08
1995:08	74.19	74.02	0.17
1995:09	72.35	74.83	-2.48
1995:10	69.21	71.35	-2.14
1995:11	79.20	69.18	10.02 *
1995:12	74.02	84.15	-10.13 *
1996:01	71.17	69.54	1.63
1996:02	68.92	71.96	-3.04
1996:03	68.44	69.68	-1.24
1996:04	68.63	69.90	-1.27

1996:05	69.67	69.90	-0.23
1996:06	70.26	71.01	-0.75
1996:07	71.01	71.10	-0.09
1996:08	69.17	71.93	-2.76
1996:09	68.21	69.12	-0.91
1996:10	68.80	69.32	-0.52
1996:11	68.06	70.30	-2.24
1996:12	69.74	68.65	1.09
1997:01	69.77	71.52	-1.75
1997:02	70.15	70.19	-0.04
1997:03	70.33	71.09	-0.76
1997:04	70.67	71.07	-0.40
1997:05	71.01	71.49	-0.48
1997:06	70.81	71.75	-0.94
1997:07	70.47	71.34	-0.87
1997:08	69.96	71.13	-1.17
1997:09	69.56	70.64	-1.08
1997:10	69.40	70.38	-0.98
1997:11	69.67	70.32	-0.65
1997:12	70.84	70.68	0.16
1998:01	71.49	72.00	-0.51
1998:02	71.41	72.11	-0.70
1998:03	72.10	71.85	0.25
1998:04	74.22	73.00	1.22
1998:05	81.05	75.31	5.74 *
1998:06	84.68	83.07	1.61
1998:07	80.15	83.69	-3.54
1998:08	78.92	76.96	1.96
1998:09	77.82	79.51	-1.69
1998:10	77.83	77.84	-0.01
1998:11	80.54	78.36	2.18
1998:12	85.49	81.70	3.79
1999:01	88.84	86.41	2.43
1999:02	88.49	88.13	0.36
1999:03	87.00	86.67	0.33
1999:04	84.40	85.90	-1.50
1999:05	84.74	83.51	1.23
1999:06	83.40	85.48	-2.08
1999:07	82.35	82.87	-0.52
1999:08	81.29	82.55	-1.26
1999:09	80.61	81.58	-0.97
1999:10	80.81	81.19	-0.38
1999:11	81.37	81.68	-0.31
1999:12	81.65	82.12	-0.47
2000:01	81.78	82.16	-0.38
2000:02	80.01	82.30	-2.29
2000:03	79.37	79.95	-0.58

2000:04	79.93	80.38	-0.45
2000:05	80.48	81.13	-0.65
2000:06	81.41	81.30	0.11
2000:07	80.25	82.29	-2.04
2000:08	81.35	80.25	1.10
2000:09	82.00	82.76	-0.76
2000:10	82.17	82.57	-0.40
2000:11	83.14	82.63	0.51
2000:12	86.97	83.97	3.00
2001:01	89.99	88.43	1.56
2001:02	88.33	90.03	-1.70
2001:03	87.00	86.75	0.25
2001:04	87.26	86.97	0.29
2001:05	88.13	87.88	0.25
2001:06	88.76	88.56	0.20
2001:07	88.86	88.89	-0.03
2001:08	89.17	88.85	0.32
2001:09	89.06	89.40	-0.34
2001:10	89.26	89.10	0.16
2001:11	89.49	89.57	-0.08
2001:12	89.53	89.74	-0.21
2002:01	81.02	89.73	-8.71 *
2002:02	87.21	78.53	8.68 *
2002:03	86.54	92.69	-6.15 *
2002:04	86.65	85.32	1.33
2002:05	87.16	87.50	-0.34
2002:06	87.95	87.94	0.01
2002:07	87.44	88.67	-1.23
2002:08	87.28	87.59	-0.31
2002:09	86.32	87.95	-1.63
2002:10	85.51	86.68	-1.17
2002:11	85.44	86.24	-0.80
2002:12	85.42	86.48	-1.06
2003:01	86.99	86.29	0.70
2003:02	84.01	88.36	-4.35
2003:03	83.56	83.31	0.25
2003:04	84.93	85.20	-0.27
2003:05	85.32	86.56	-1.24
2003:06	86.99	85.99	1.00
2003:07	87.82	88.27	-0.45
2003:08	88.03	88.30	-0.27
2003:09	87.81	88.43	-0.62
2003:10	89.80	88.22	1.58
2003:11	94.21	91.08	3.13
2003:12	104.25	95.49	8.76 *
2004:01	109.79	106.25	3.54
2004:02	99.72	107.77	-8.05 *

2004:03	91.54	93.25	-1.71
2004:04	97.33	90.99	6.34 *
2004:05	110.41	101.91	8.50 *
2004:06	109.31	113.15	-3.84
2004:07	104.00	104.11	-0.11
2004:08	101.18	101.29	-0.11
2004:09	100.01	101.11	-1.10
2004:10	98.58	100.28	-1.70
2004:11	98.49	98.55	-0.06
2004:12	102.19	99.18	3.01
2005:01	99.89	103.81	-3.92
2005:02	99.24	98.20	1.04
2005:03	100.88	99.92	0.96
2005:04	103.69	102.00	1.69
2005:05	105.76	104.44	1.32
2005:06	106.69	105.68	1.01
2005:07	106.30	106.23	0.07
2005:08	104.81	105.66	-0.85
2005:09	103.95	104.27	-0.32
2005:10	104.60	104.13	0.47
2005:11	103.75	105.27	-1.52
2005:12	104.95	103.51	1.44
2006:01	107.61	105.89	1.72
2006:02	107.40	108.40	-1.00
2006:03	106.21	106.61	-0.40
2006:04	104.82	105.91	-1.09
2006:05	104.59	104.89	-0.30
2006:06	104.81	105.30	-0.49
2006:07	105.36	105.42	-0.06
2006:08	106.10	105.96	0.14
2006:09	104.87	106.64	-1.77
2006:10	106.09	104.66	1.43
2006:11	109.62	107.34	2.28
2006:12	113.97	110.88	3.09
2007:01	114.05	114.51	-0.46
2007:02	110.19	112.53	-2.34
2007:03	107.83	108.54	-0.71
2007:04	107.63	108.20	-0.57
2007:05	108.53	108.66	-0.13
2007:06	109.08	109.41	-0.33
2007:07	111.60	109.48	2.12
2007:08	113.34	112.69	0.65
2007:09	113.36	113.40	-0.04
2007:10	114.33	112.90	1.43
2007:11	117.63	114.66	2.97
2007:12	123.01	118.41	4.60
2008:01	122.77	123.54	-0.77

2008:02	117.84	120.39	-2.55
2008:03	116.51	115.50	1.01
2008:04	116.95	117.22	-0.27
2008:05	118.55	117.55	1.00
2008:06	121.04	119.08	1.96
2008:07	124.13	121.42	2.71
2008:08	126.31	124.23	2.08
2008:09	124.81	125.67	-0.86
2008:10	123.82	123.04	0.78
2008:11	122.60	123.42	-0.82
2008:12	123.95	122.20	1.75
2009:01	123.47	124.66	-1.19
2009:02	123.19	122.84	0.35
2009:03	123.66	123.21	0.45
2009:04	125.12	123.96	1.16
2009:05	125.14	125.54	-0.40
2009:06	127.43	124.72	2.71
2009:07	129.25	128.17	1.08
2009:08	126.63	129.04	-2.41
2009:09	125.90	124.95	0.95
2009:10	128.08	126.35	1.73
2009:11	136.21	129.13	7.08 *
2009:12	143.32	138.24	5.08
2010:01	140.46	142.61	-2.15
2010:02	134.02	136.04	-2.02
2010:03	130.43	131.46	-1.03
2010:04	129.89	130.60	-0.71
2010:05	131.17	130.84	0.33
2010:06	132.36	132.05	0.31
2010:07	129.29	132.63	-3.34
2010:08	127.08	128.10	-1.02
2010:09	123.31	127.66	-4.35
2010:10	122.34	123.45	-1.11
2010:11	125.31	124.23	1.08
2010:12	129.14	127.86	1.28
2011:01	128.83	130.59	-1.76
2011:02	128.64	128.24	0.40
2011:03	127.70	129.19	-1.49
2011:04	128.19	128.02	0.17
2011:05	127.85	129.29	-1.44
2011:06	128.58	128.27	0.31
2011:07	128.78	129.61	-0.83
2011:08	127.73	129.28	-1.55
2011:09	126.57	127.95	-1.38
2011:10	126.92	127.21	-0.29
2011:11	127.65	128.22	-0.57
2011:12	128.49	128.64	-0.15

2012:01	127.99	129.33	-1.34
2012:02	127.91	128.27	-0.36
2012:03	128.83	128.73	0.10
2012:04	127.28	129.89	-2.61
2012:05	127.73	127.18	0.55
2012:06	128.34	129.09	-0.75
2012:07	128.26	129.20	-0.94
2012:08	128.39	128.78	-0.39
2012:09	128.39	129.17	-0.78
2012:10	128.58	129.06	-0.48
2012:11	129.41	129.35	0.06
2012:12	133.33	130.33	3.00
2013:01	133.17	135.00	-1.83
2013:02	131.31	132.28	-0.97
2013:03	130.37	130.95	-0.58
2013:04	129.49	131.00	-1.51
2013:05	129.64	130.05	-0.41
2013:06	129.62	130.64	-1.02
2013:07	129.92	130.29	-0.37
2013:08	128.75	130.74	-1.99
2013:09	128.18	128.99	-0.81
2013:10	128.25	129.13	-0.88
2013:11	130.26	129.32	0.94
2013:12	134.78	131.78	3.00
2014:01	136.19	136.38	-0.19
2014:02	135.86	135.62	0.24
2014:03	135.23	135.38	-0.15
2014:04	135.79	135.19	0.60
2014:05	134.88	136.33	-1.45
2014:06	136.29	134.62	1.67
2014:07	137.57	137.31	0.26
2014:08	141.95	137.82	4.13
2014:09	142.19	143.13	-0.94
2014:10	140.92	140.77	0.15
2014:11	140.29	140.10	0.19
2014:12	141.31	140.29	1.02
2015:01	141.12	141.82	-0.70
2015:02	139.65	140.76	-1.11
2015:03	137.96	139.26	-1.30
2015:04	134.56	138.04	-3.48
2015:05	133.83	134.39	-0.56
2015:06	134.63	135.38	-0.75
2015:07	136.78	136.08	0.70
2015:08	138.33	138.18	0.15
2015:09	138.31	138.93	-0.62
2015:10	137.78	138.37	-0.59
2015:11	138.00	138.10	-0.10

2015:12	139.04	138.77	0.27
2016:01	139.11	139.88	-0.77
2016:02	138.76	139.32	-0.56
2016:03	138.86	139.09	-0.23
2016:04	137.87	139.51	-1.64
2016:05	139.44	138.06	1.38
2016:06	140.22	140.87	-0.65
2016:07	141.55	140.57	0.98
2016:08	142.74	142.20	0.54
2016:09	140.93	143.08	-2.15
2016:10	140.63	140.22	0.41
2016:11	140.25	141.42	-1.17
2016:12	140.72	140.70	0.02
2017:01	140.63	141.53	-0.90
2017:02	143.21	141.01	2.20
2017:03	143.98	144.62	-0.64
2017:04	144.92	143.84	1.08
2017:05	145.61	145.23	0.38
2017:06	145.69	145.73	-0.04
2017:07	145.17	145.64	-0.47
2017:08	141.85	145.11	-3.26
2017:09	139.99	141.14	-1.15
2017:10	143.06	140.90	2.16
2017:11	144.86	145.43	-0.57
2017:12	148.73	145.21	3.52
2018:01	150.92	149.87	1.05
2018:02	151.14	150.56	0.58
2018:03	150.56	150.36	0.20
2018:04	150.11	150.06	0.05
2018:05	151.35	150.00	1.35
2018:06	152.01	151.87	0.14
2018:07	152.87	151.82	1.05
2018:08	155.18	152.87	2.31
2018:09	154.19	155.56	-1.37
2018:10	153.24	152.92	0.32
2018:11	152.92	153.02	-0.10
2018:12	153.01	153.07	-0.06
2019:01	149.26	153.23	-3.97
2019:02	148.50	148.17	0.33
2019:03	148.86	149.84	-0.98
2019:04	148.20	149.91	-1.71
2019:05	148.64	148.60	0.04
2019:06	152.48	149.74	2.74
2019:07	156.30	154.35	1.95
2019:08	157.44	156.85	0.59
2019:09	158.44	156.70	1.74
2019:10	162.78	158.26	4.52

2019:11	166.75	163.67	3.08
2019:12	166.62	166.23	0.39
2020:01	164.54	164.49	0.05
2020:02	161.53	162.95	-1.42
2020:03	158.98	160.50	-1.52
2020:04	155.09	158.79	-3.70
2020:05	151.12	154.72	-3.60
2020:06	153.58	151.56	2.02
2020:07	154.13	156.61	-2.48
2020:08	151.98	154.60	-2.62
2020:09	150.87	151.98	-1.11
2020:10	152.16	152.14	0.02
2020:11	153.68	154.06	-0.38
2020:12	160.94	154.87	6.07 *
2021:01	177.37	163.74	13.63 *

Note: * denotes a residual in excess of 2.5 standard errors
Forecast evaluation statistics using 372 observations

Mean Error	0.0078684
Root Mean Squared Error	2.2769
Mean Absolute Error	1.4827
Mean Percentage Error	-0.058319
Mean Absolute Percentage Error	1.5458
Theil's U2	0.92041

h. Covariance matrix of regression coefficients

const	phi_1	phi_2	phi_3	theta_1	
0.00210767	-2.85123e-04	1.48891e-04	-1.72492e-04	3.07332e-04	const
	0.00526577	-0.00434494	0.00275455	-0.00222815	phi_1
		0.00662872	-0.00404509	0.00105892	phi_2
			0.0040771	-0.00156284	phi_3
				0.00203357	theta_1