

Fuel Price Prediction in Italy

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Models and Methods



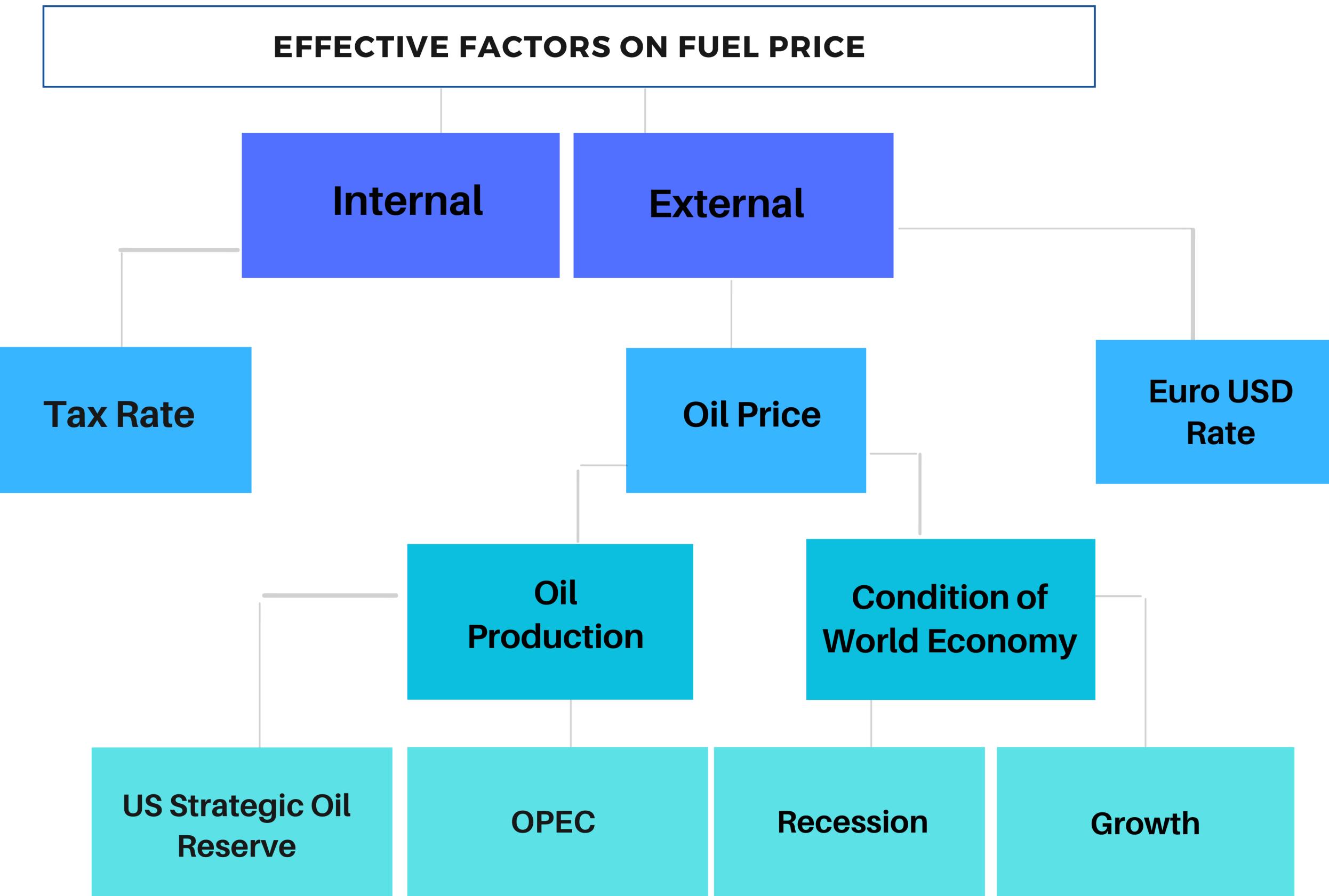
- 1 Linear Regression Model
- 2 Exponential smoothing method
- 3 Holt's Method
- 4 ARIMA Model

Identification Questions

WHO	Local Energy Company in Italy and Italian Government
WHAT	Time series data related to fuel prices, including various factors influencing pricing dynamics.
WHERE	Italy
WHEN	From 2005 to 2023
WHY	To analyze and forecast time series sales, providing insights into future fuel prices and aiding in strategic decision-making.

EFFECTIVE FACTORS ON FUEL PRICE







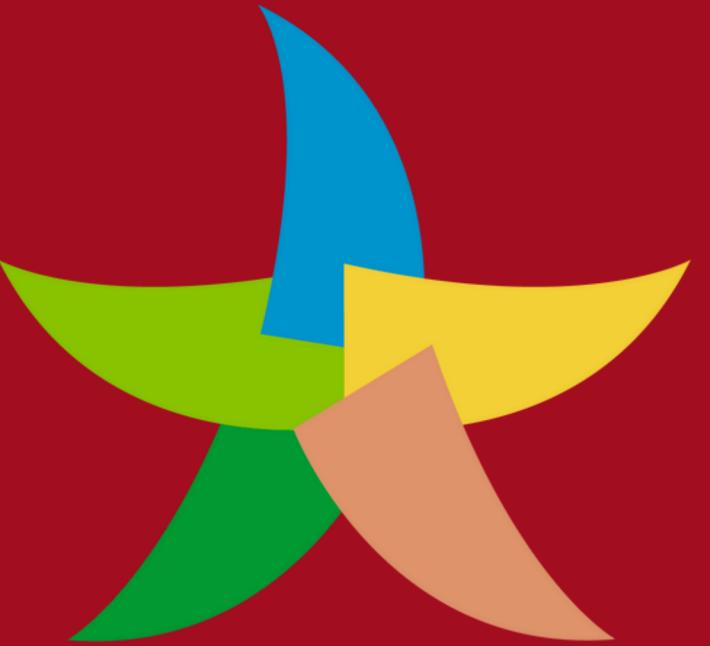
Project Overview

- ▶ Weekly Prediction, 12 Weeks in Advance
- ▶ Price of Two Different Fuels Per Litre.

DATA OVERVIEW

- Ministry of Environment and Energy Security - General Directorate for Infrastructure and Security.
- Date from 2005-01-03 To 2023-12-25
- Types of fuels:
 - Automotive gas oil
 - LPG

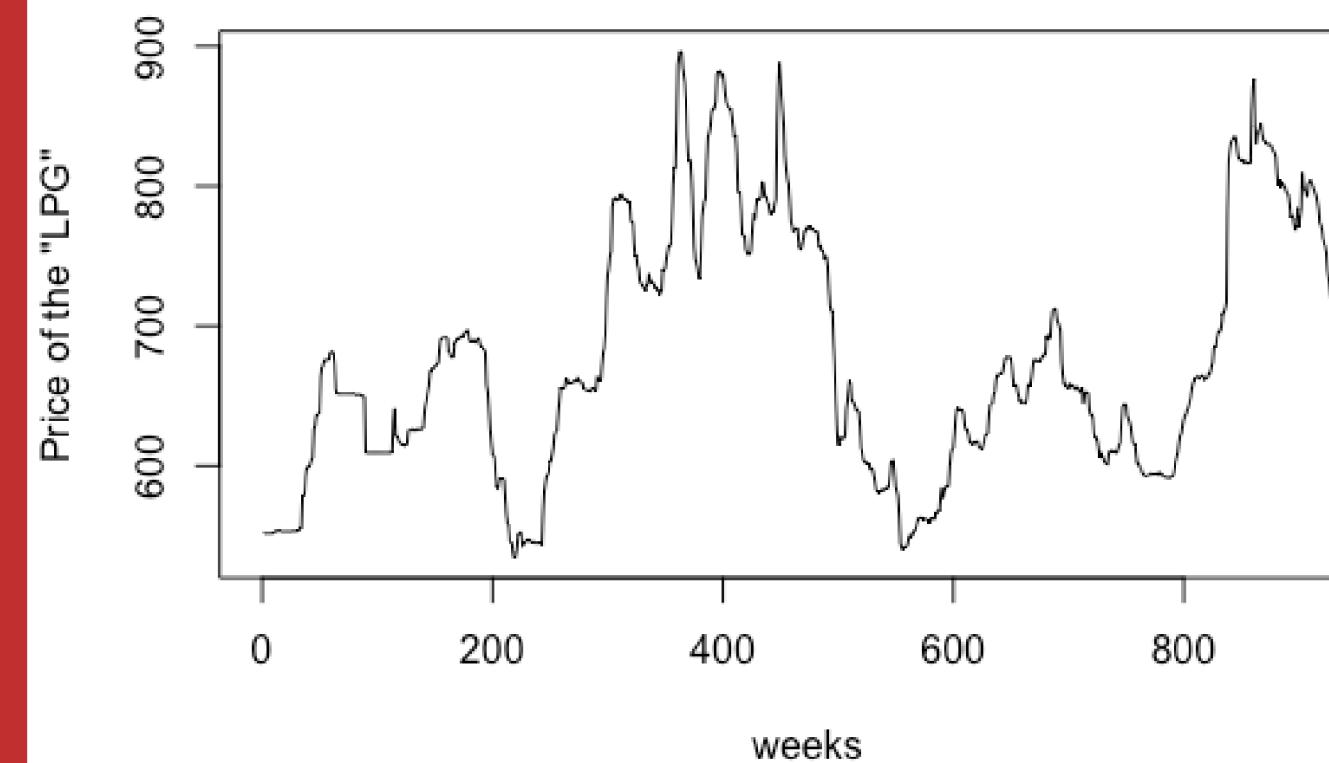
READ MORE: [HTTPS://DGIAE.MISE.GOV.IT](https://dgiae.mise.gov.it)



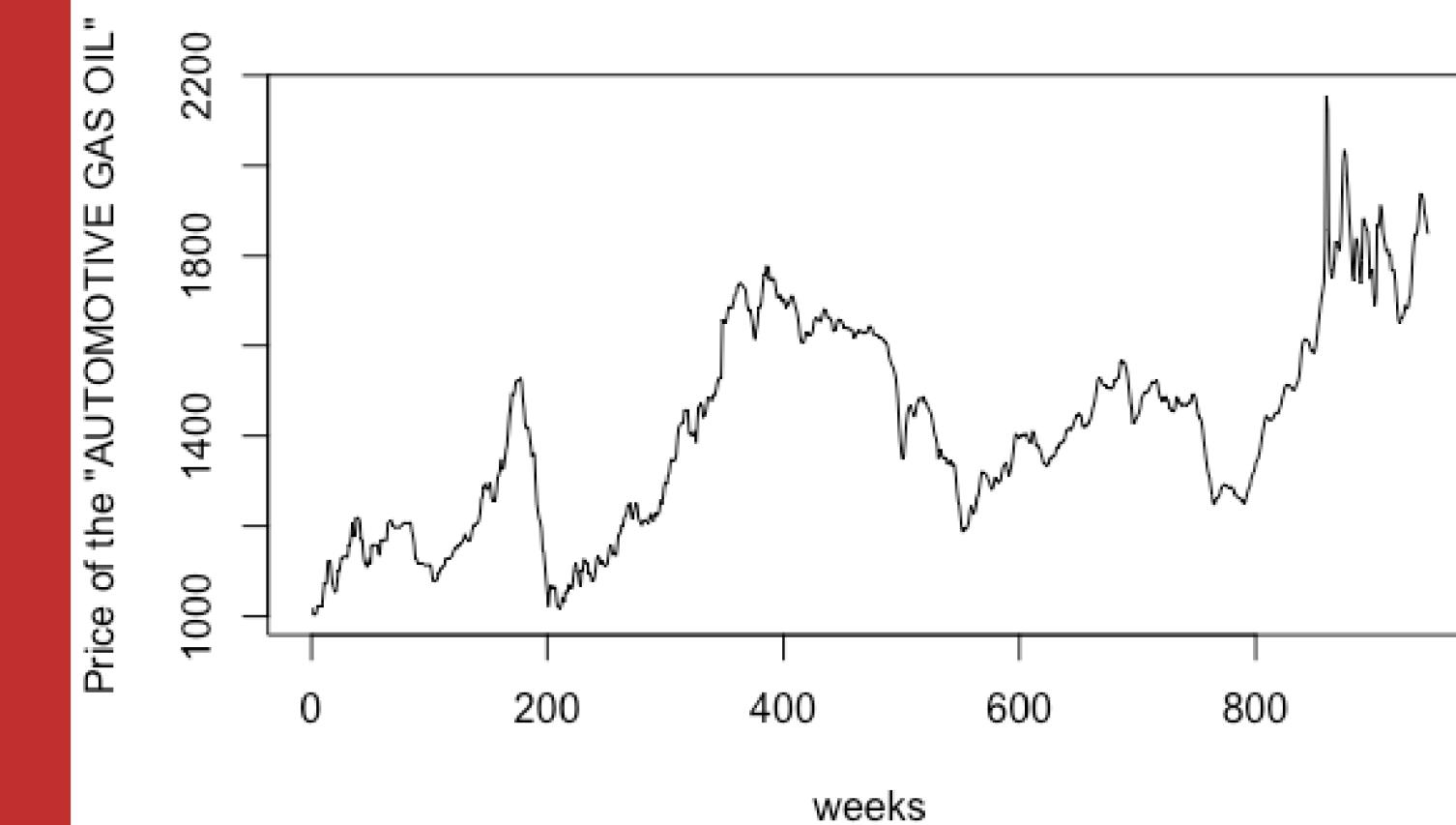
Ministry of Environment
and Energy Security

EXPLORATORY DATA ANALYSIS

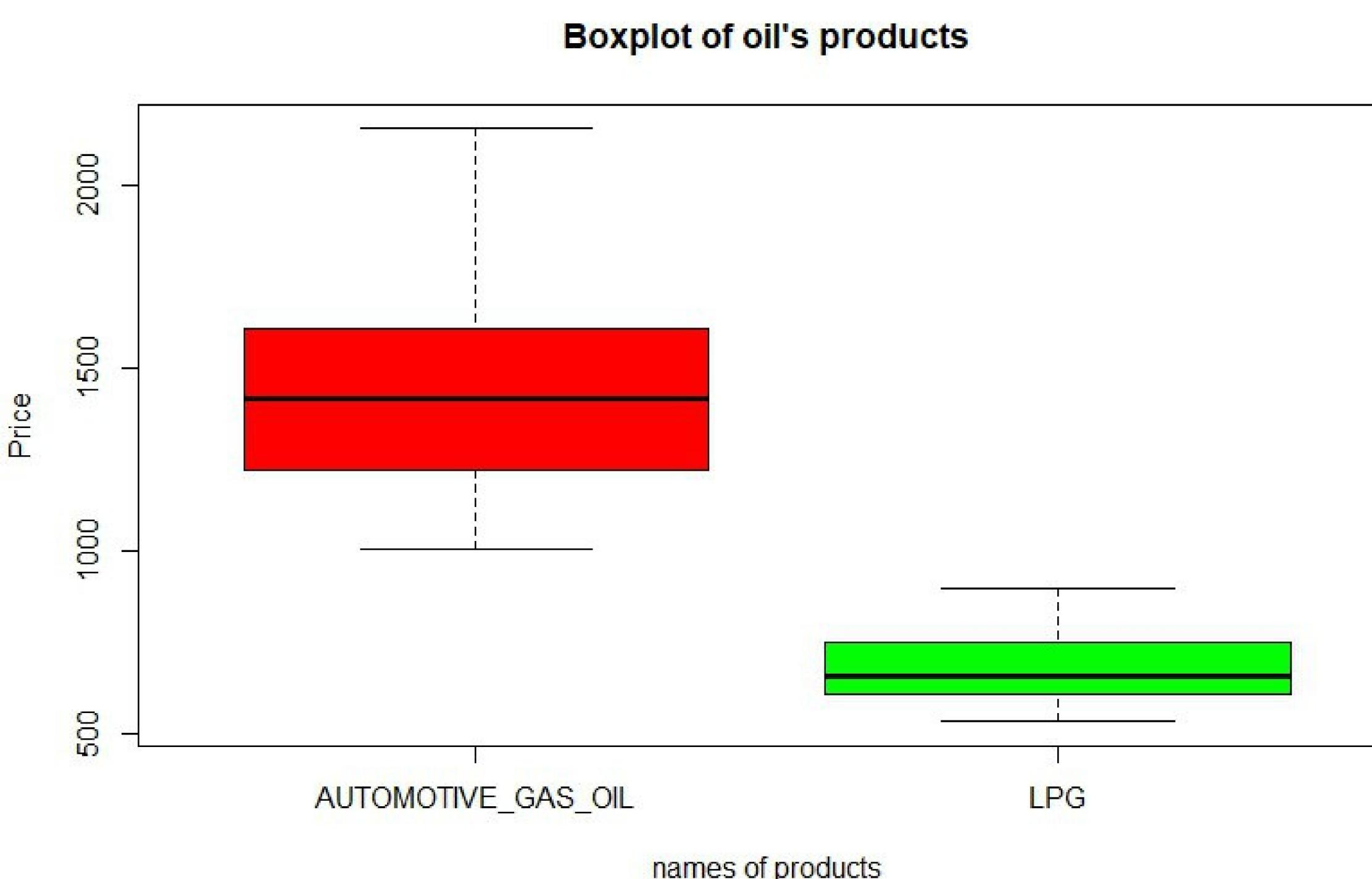
LPG



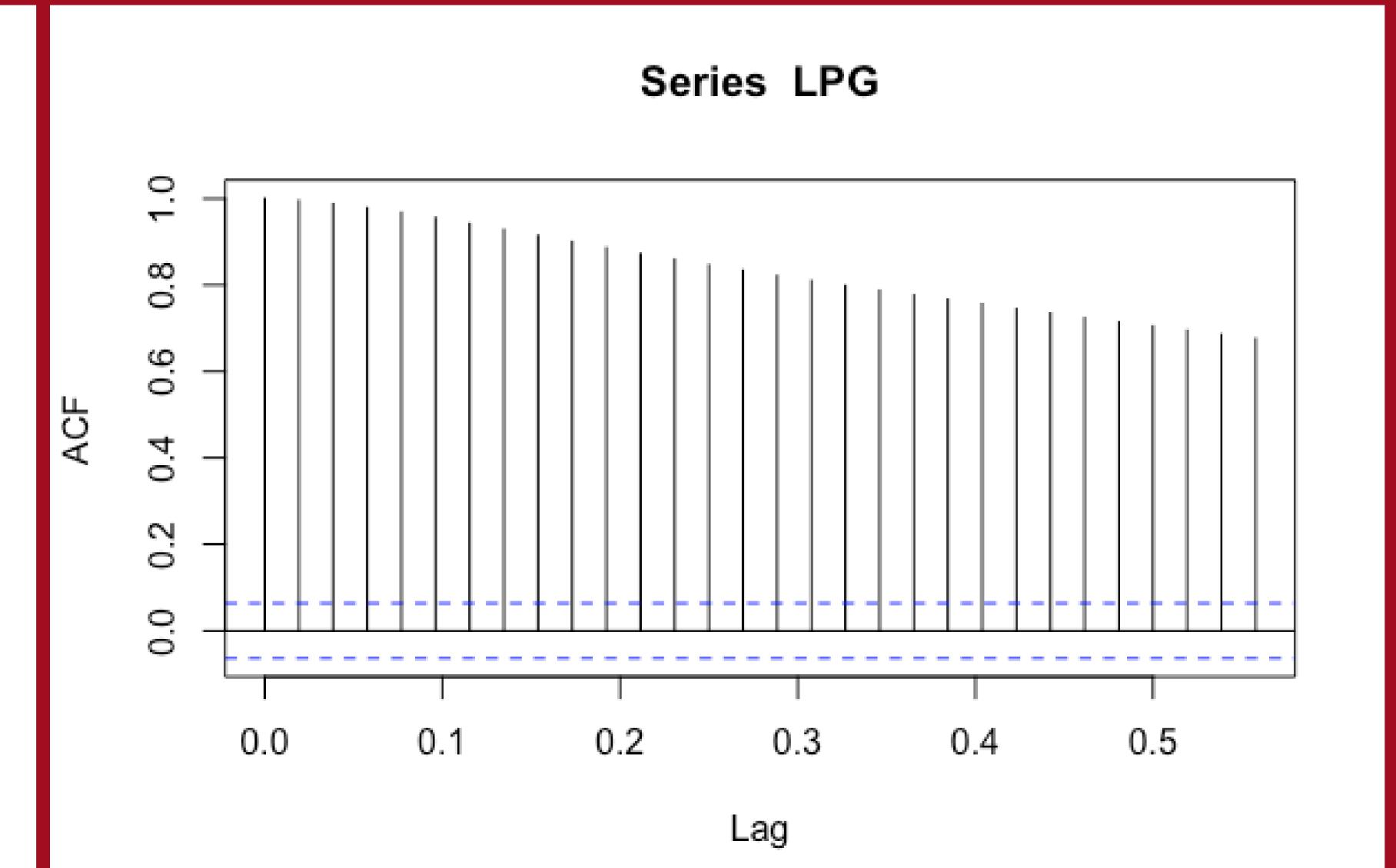
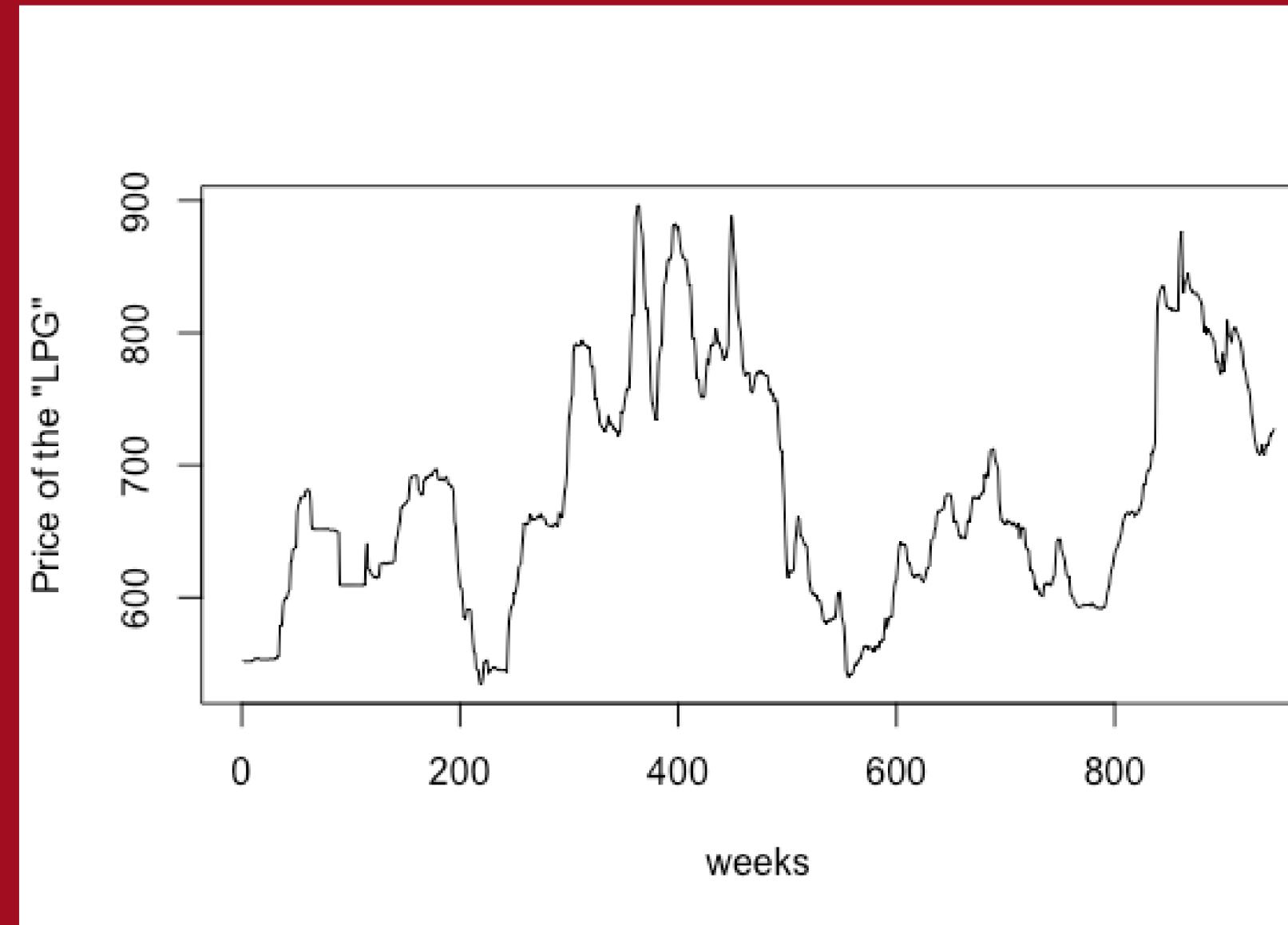
Automotive Gas Oil



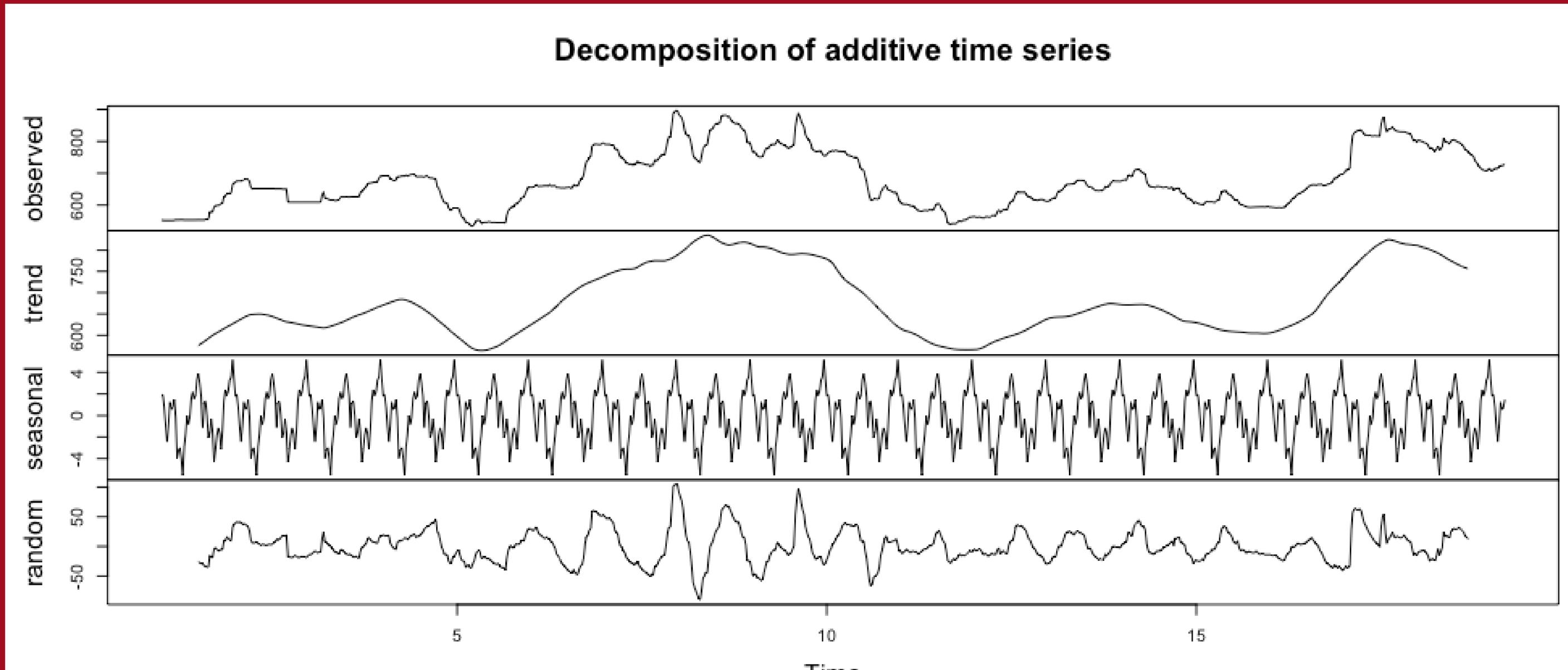
BOX PLOT



LPG



DECOMPOSITION



LINEAR MODEL

$$LPG = 637.77941 + 0.08477 \times tt$$

Intercept Estimate: 637.77941

Slope Estimate (tt): 0.08477

Min	1Q	Median	3Q	Max
-144.94	-70.53	-14.79	70.53	227.63

$Pr(|t|) < 2e-16$ * coefficient is statistically significant.

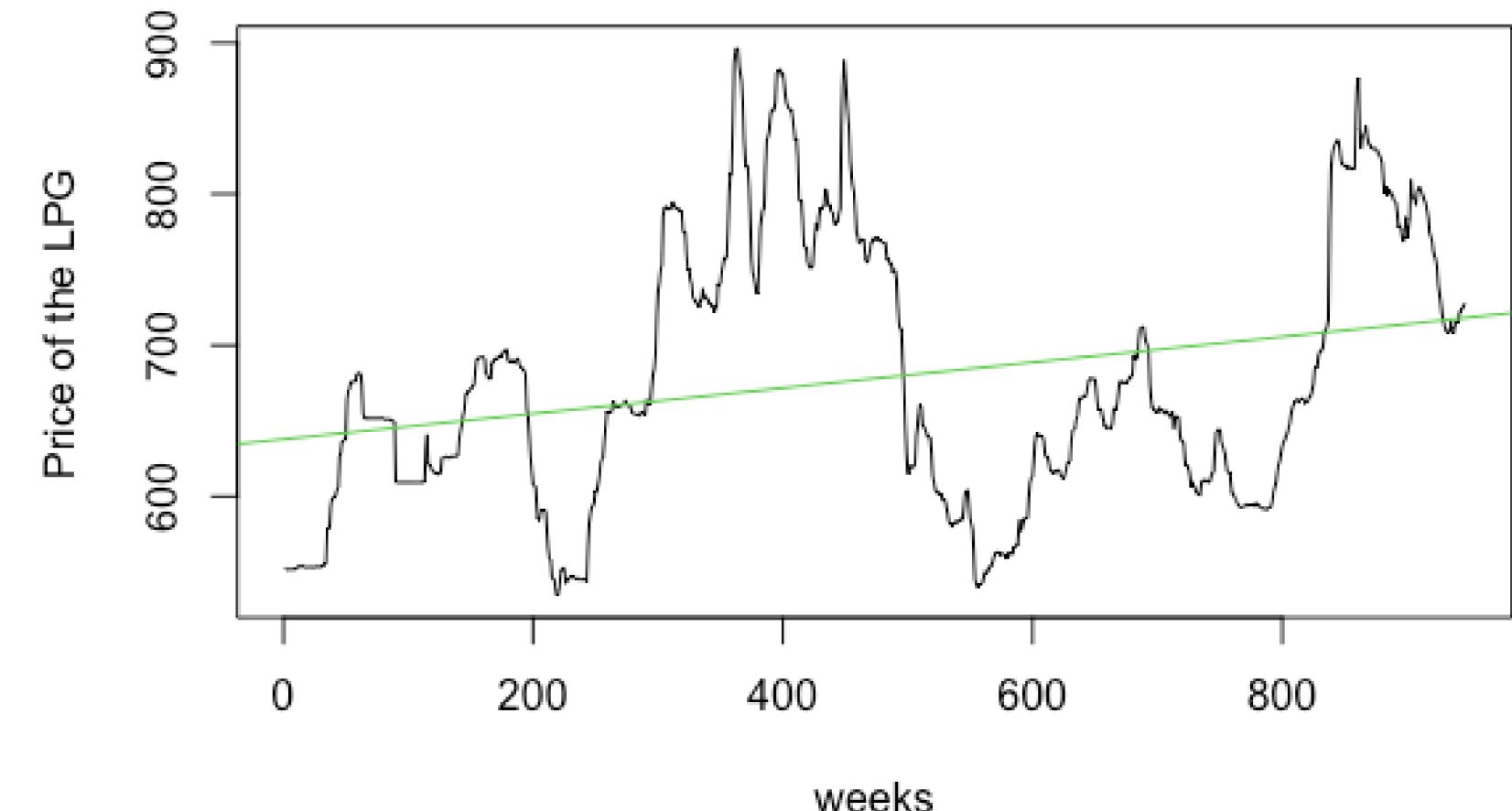
Residual Standard Error: 85.57 * size of the residuals

R-squared: 0.06833 * of the variability in the response

variable can be explained by the linear relationship with
the predictor variable (tt).

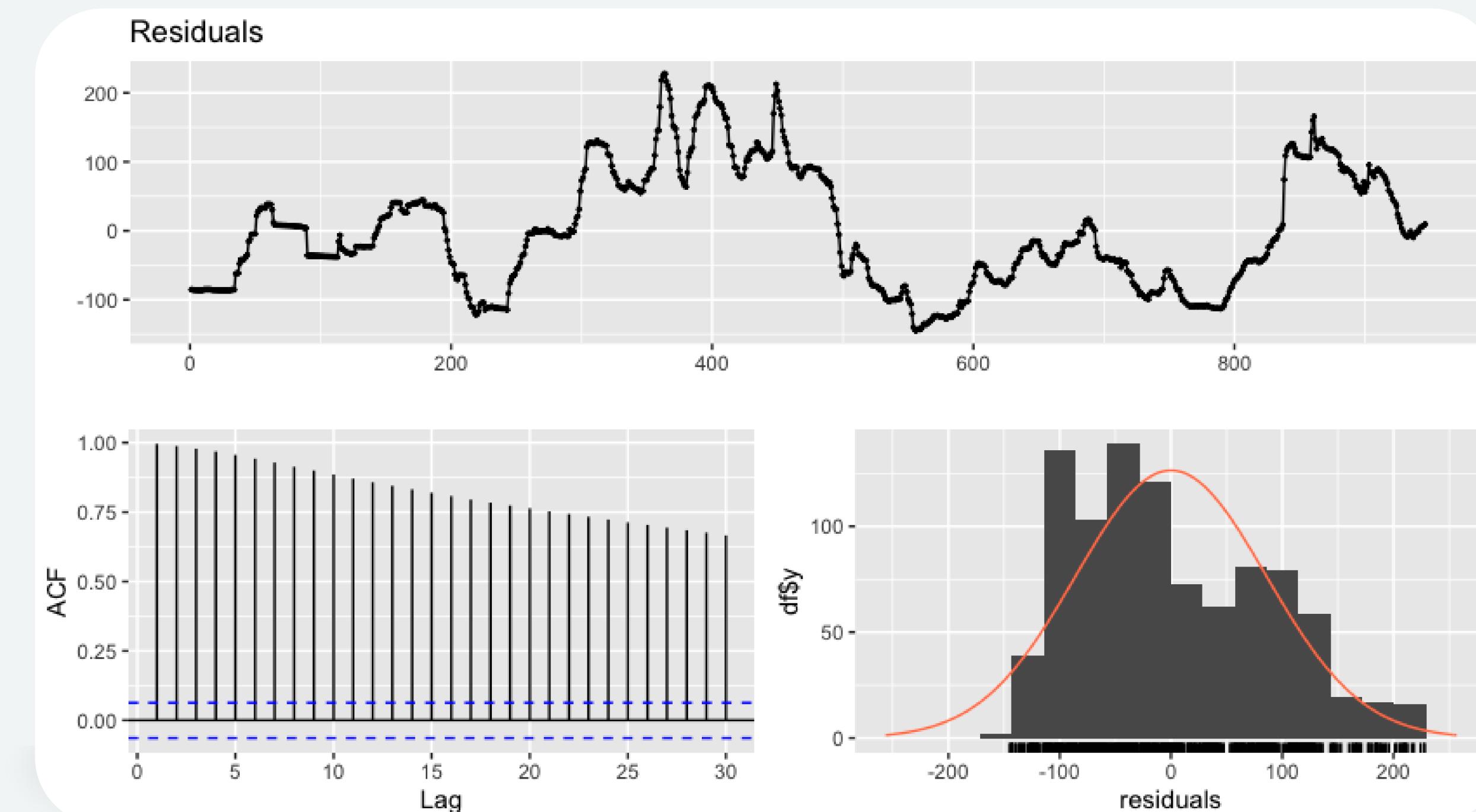
F-statistic: 69.24 * overall significance of the model

p-value: 3.037e-16 * the overall model is significant



- DW = 0.0073603
- RMSE: 85.48

RESIDUAL



EXPONENTIAL SMOOTHING

Smoothing Parameter (α): 0.9999 *high emphasis on recent data

ME (Mean Error): 0.1853292

RMSE (Root Mean Squared Error): 7.335588

MAE (Mean Absolute Error): 3.901348

MPE (Mean Percentage Error): 0.02394518

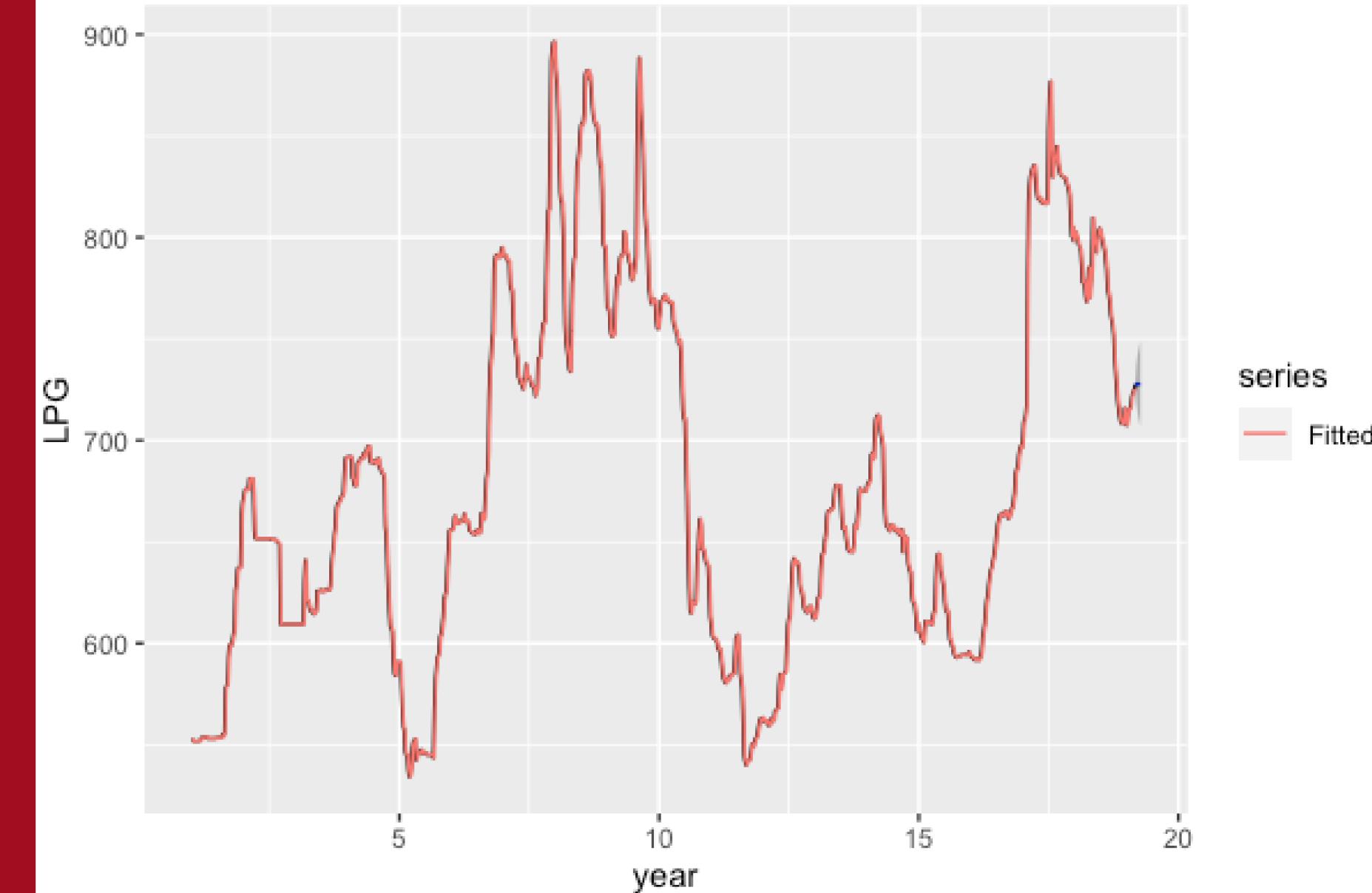
MAPE (Mean Absolute Percentage Error): 0.5563942

MASE (Mean Absolute Scaled Error): 0.05070153

ACF1 (Autocorrelation of Residuals at Lag 1): 0.4680077

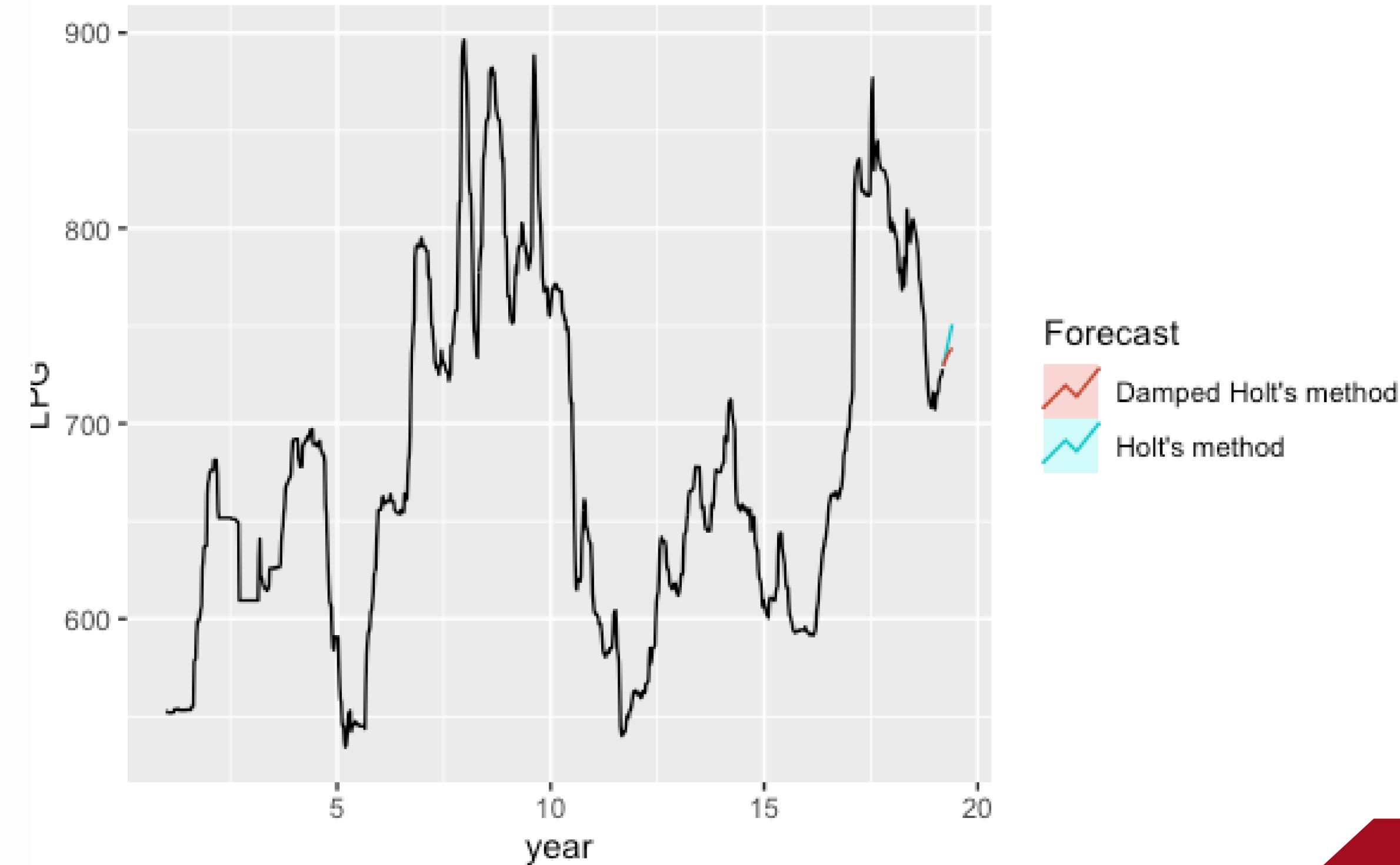
Forecasts:

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
19.19231	727.7998	718.3889	737.2106	713.4070	742.1925
19.21154	727.7998	714.4914	741.1081	707.4464	748.1531
.					
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RMSE: 7.335588

Forecasts from Holt's method



HOLT'S METHOD

- Alpha: 0.9999
- Beta = 0.366
- ME (Mean Error): 0.007137823
- RMSE (Root Mean Squared Error): 6.866139
- MAE (Mean Absolute Error): 3.959496
- MPE (Mean Percentage Error): 0.009147784
- MAPE (Mean Absolute Percentage Error): 0.5653141
- MASE (Mean Absolute Scaled Error): 0.05145721

Forecasts:

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
19.19231	729.7082	720.8902	738.5262	716.2223	743.1941
19.21154	731.6165	716.7334	746.4995	708.8548	754.3781

RMSE: 6.866139

DAMPED HOLT'S METHOD

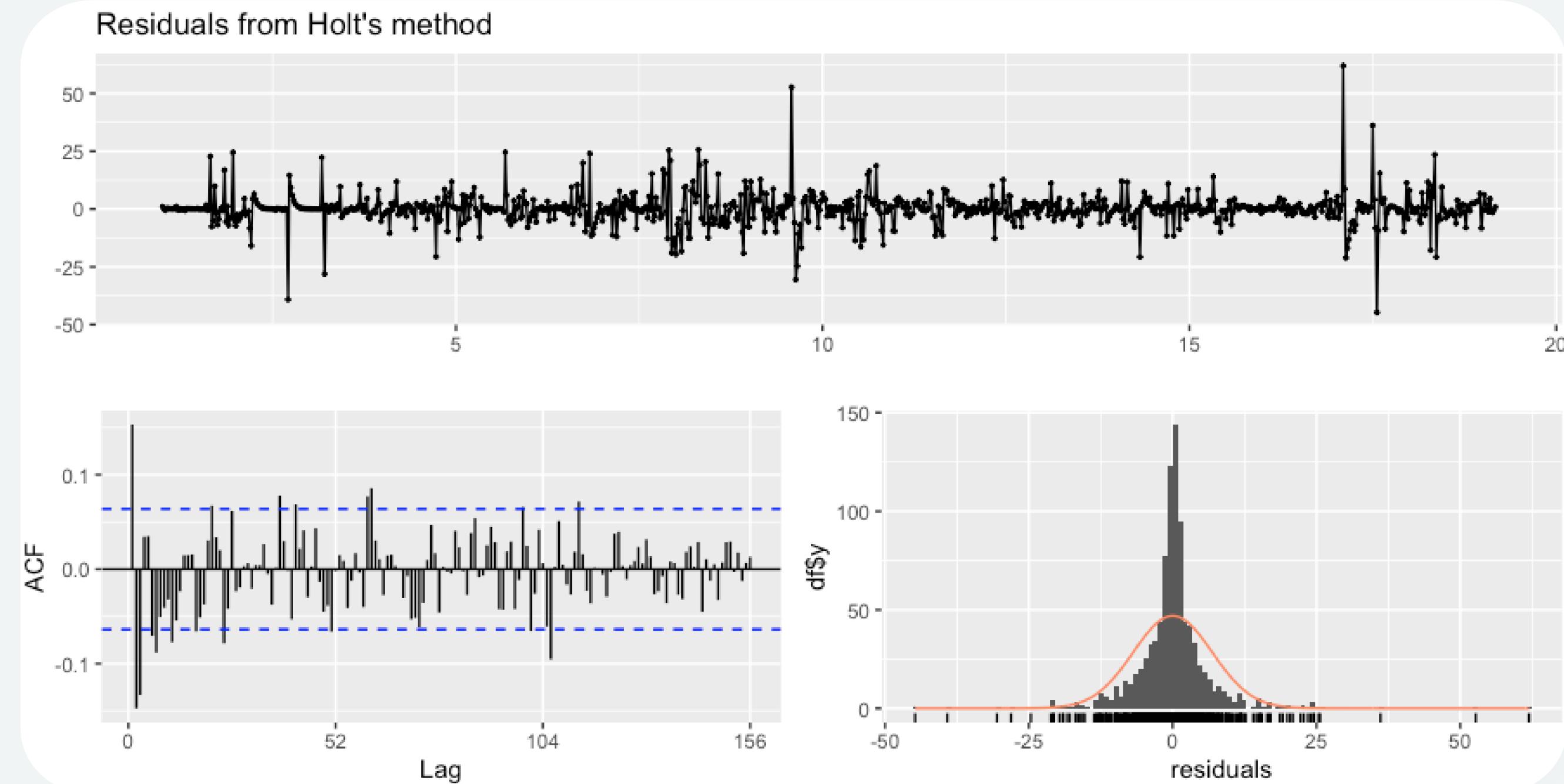
- Alpha: 0.9999
- Beta = 0.3598
- ME (Mean Error): 0.04803562
- RMSE (Root Mean Squared Error): 6.636492
- MAE (Mean Absolute Error): 3.65968
- MPE (Mean Percentage Error): 0.01198819
- MAPE (Mean Absolute Percentage Error): 0.5223886
- MASE (Mean Absolute Scaled Error): 0.04756083

Forecasts:

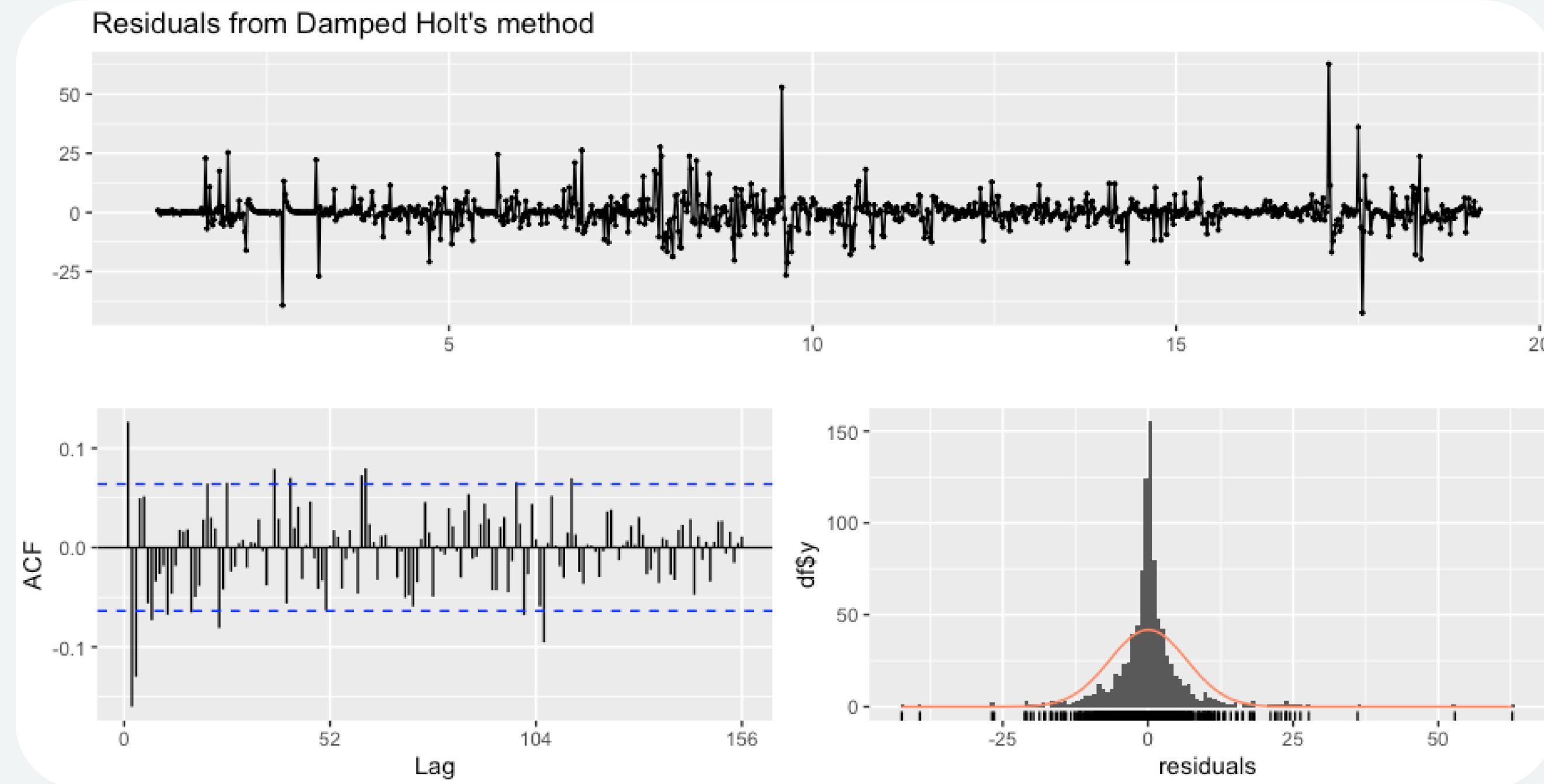
	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
19.19231	729.2920	720.7645	737.8196	716.2502	742.3338
19.21154	730.6350	716.4497	744.8202	708.9405	752.3295

RMSE: 6.636492

HOLT'S RESIDUAL



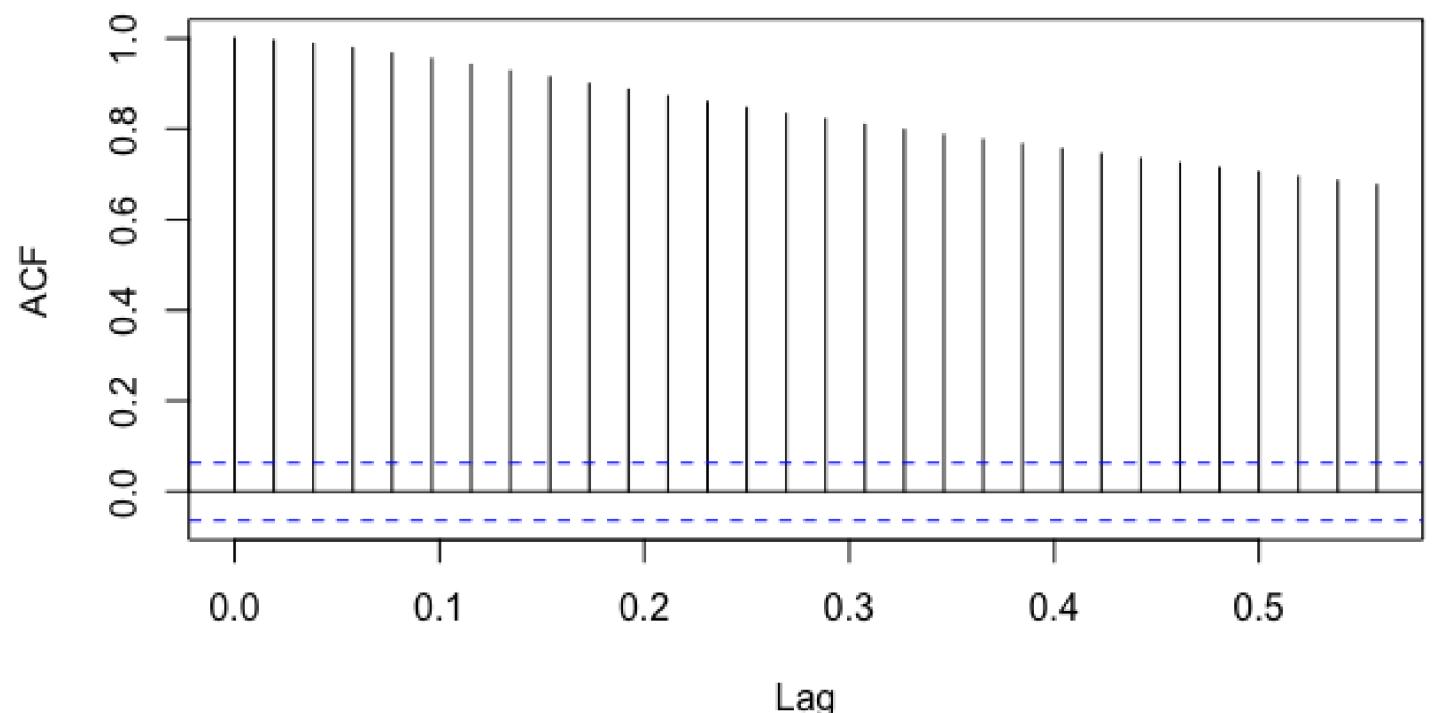
DAMPED HOLT'S RESIDUAL



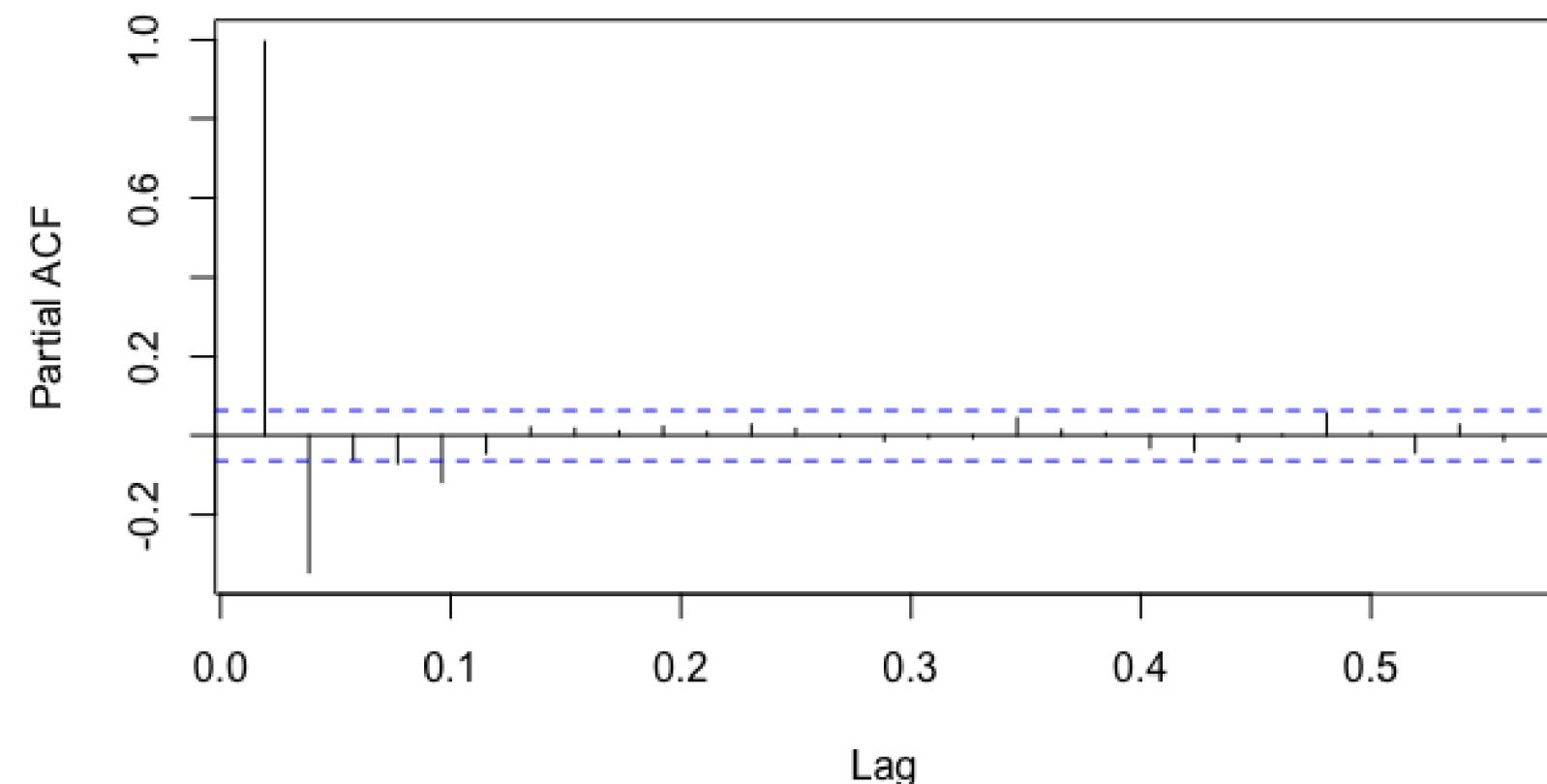
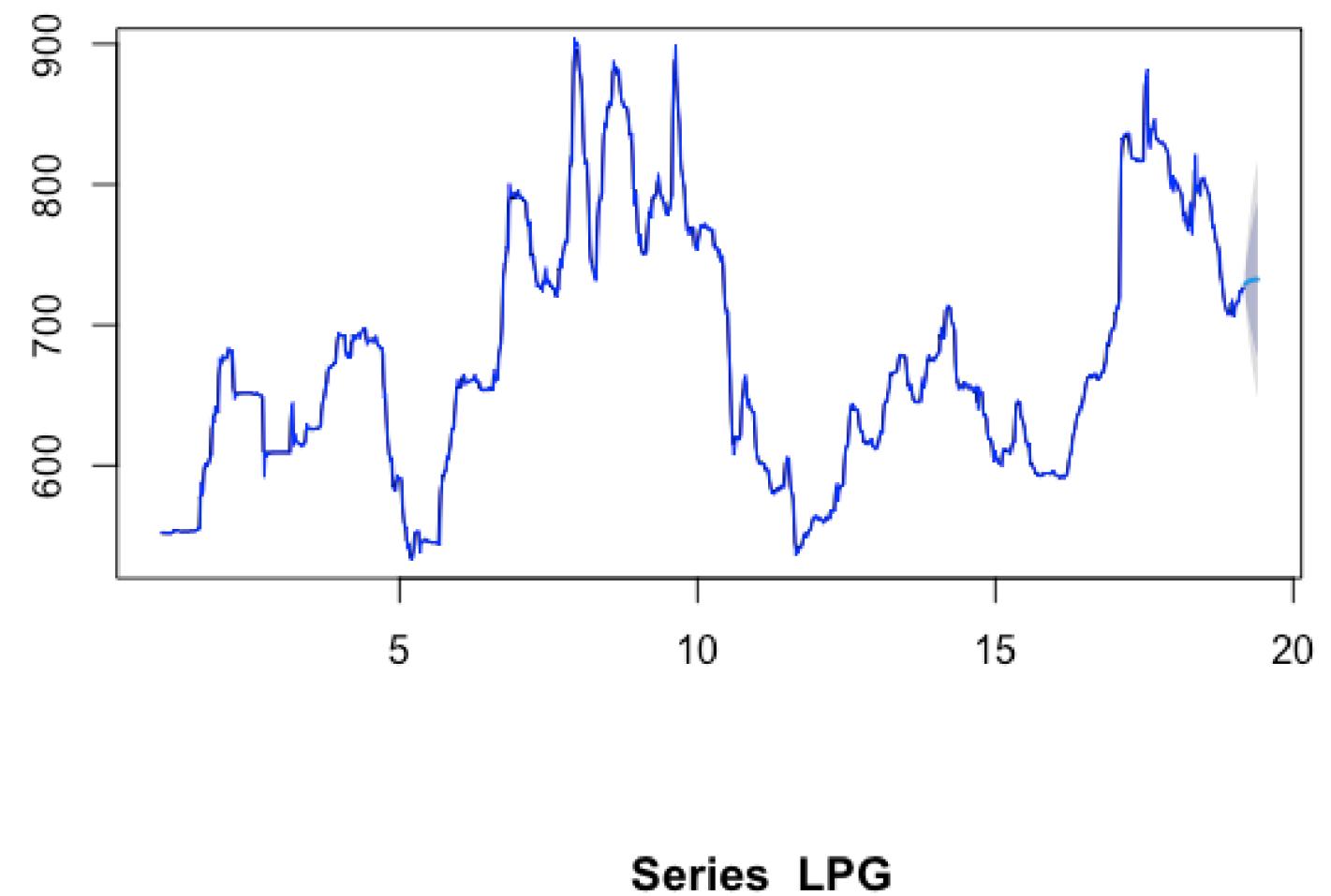
ARIMA MODEL

ARIMA(1,1,2)
AR(1): 0.7863
MA(1): -0.3365
MA(2): -0.1647
ME (Mean Error): 0.08218799
RMSE: 6.439696
MAE: 3.376541
MPE: 0.01418297
MAPE: 0.4840519
MASE: 0.04388119

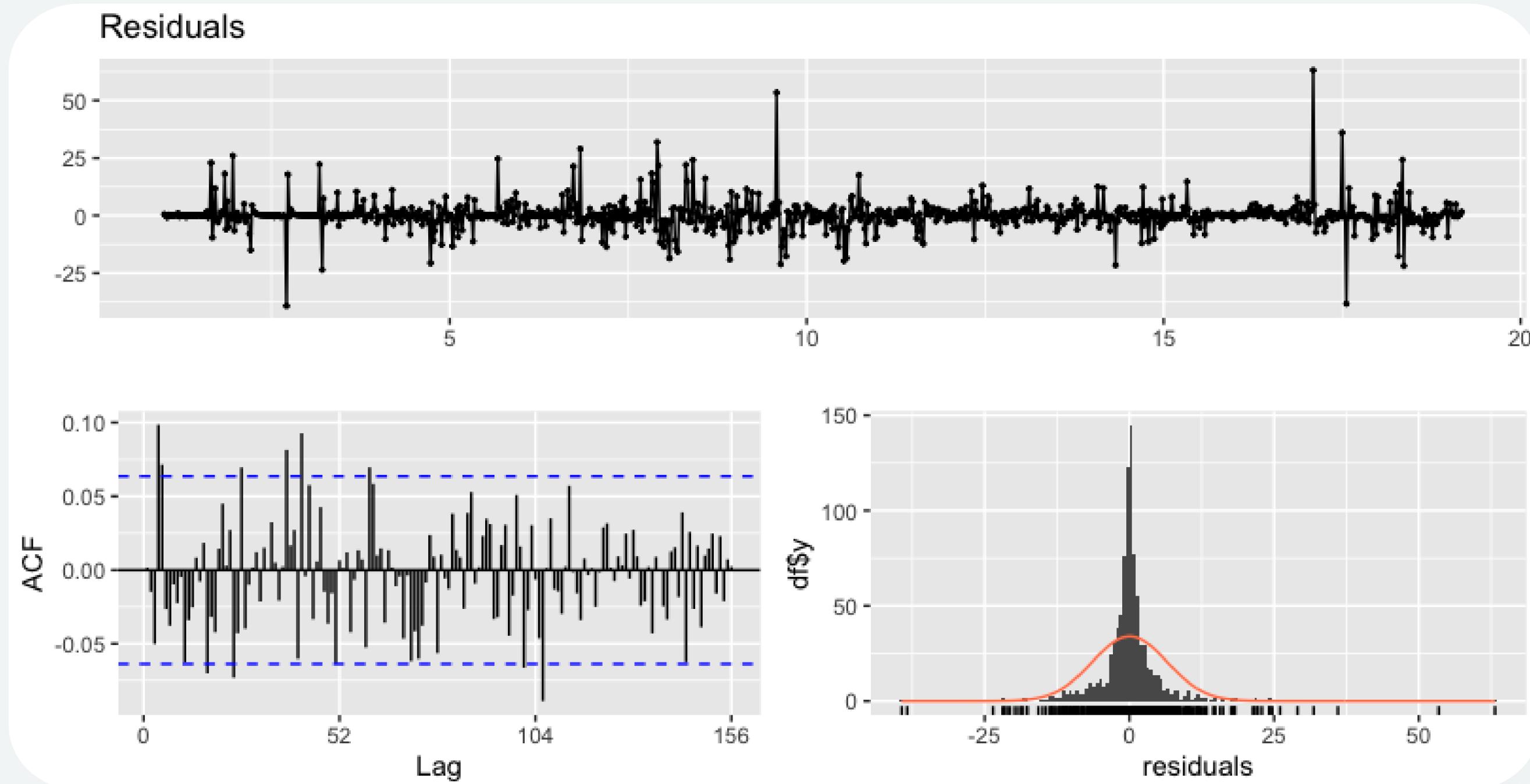
Series LPG



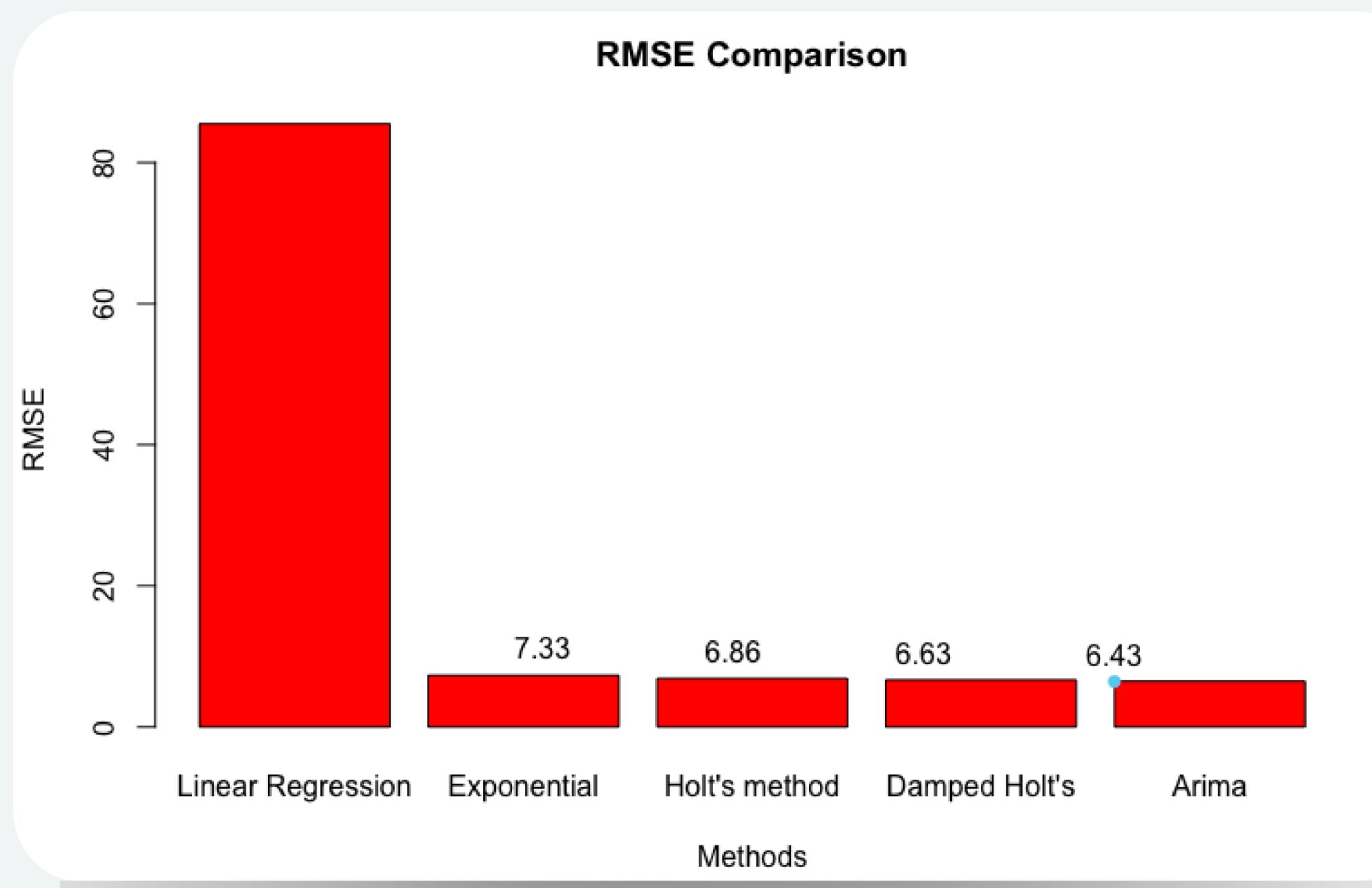
Forecasting price of the LPG ARIMA(1,1,2)



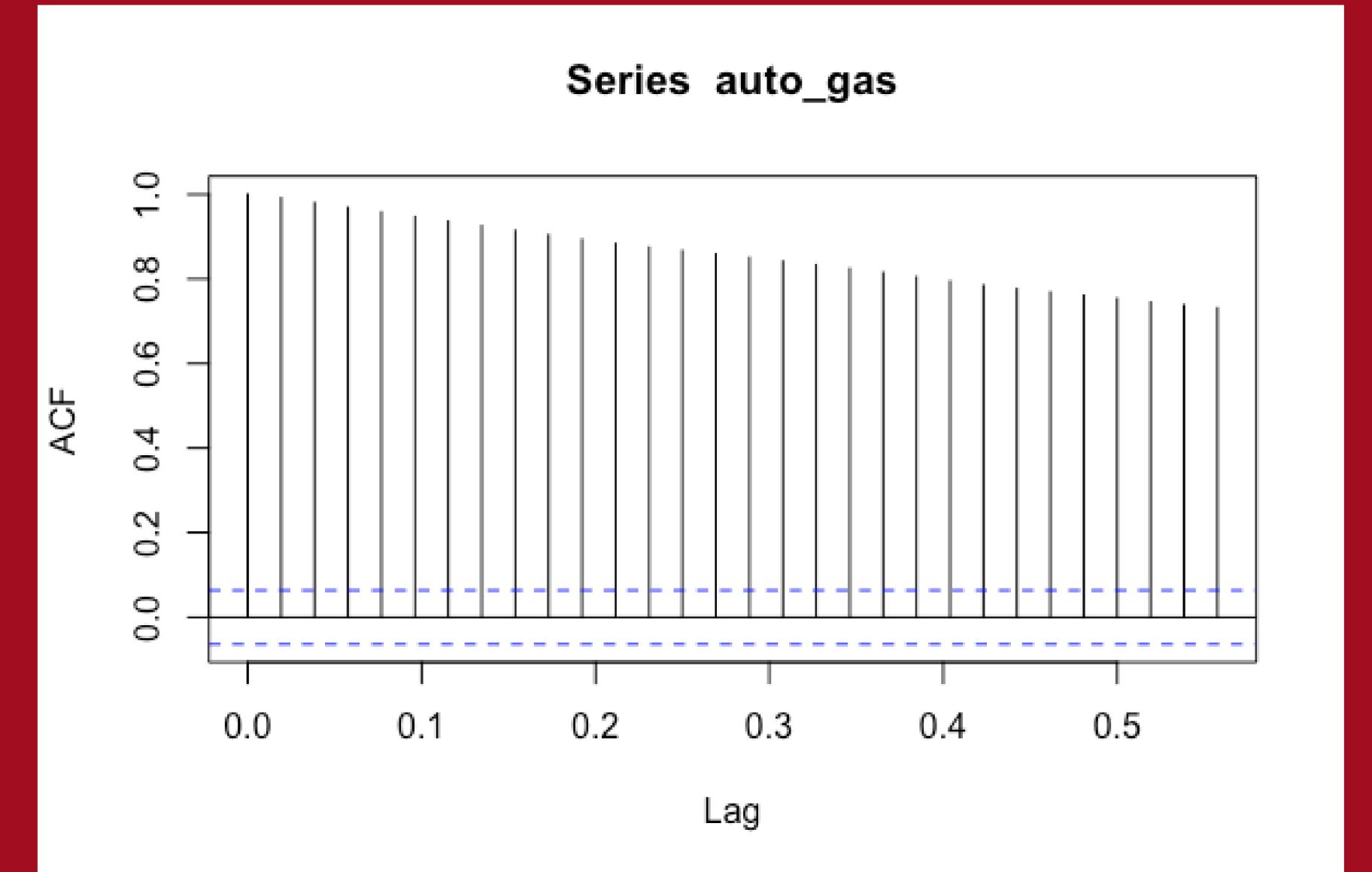
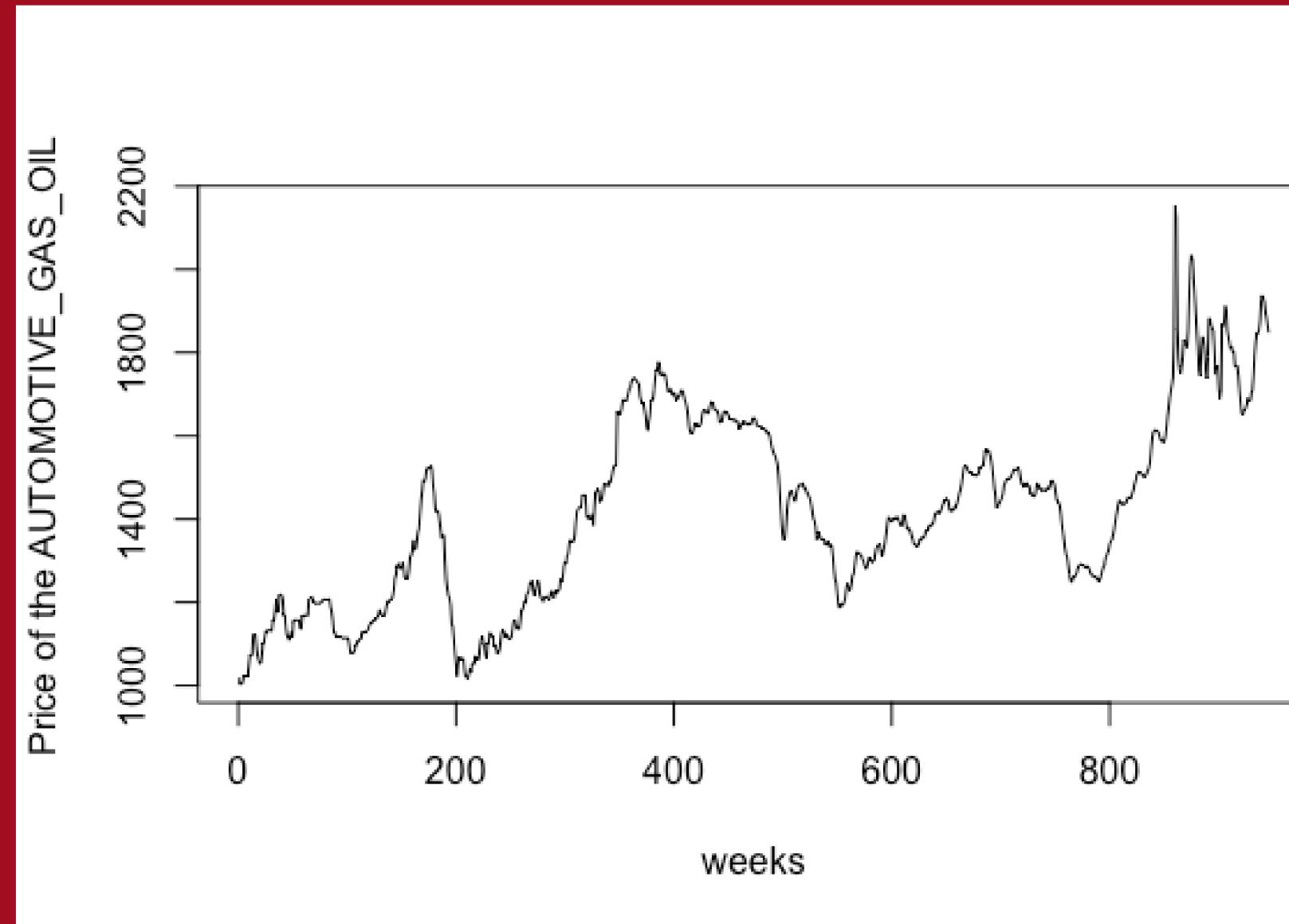
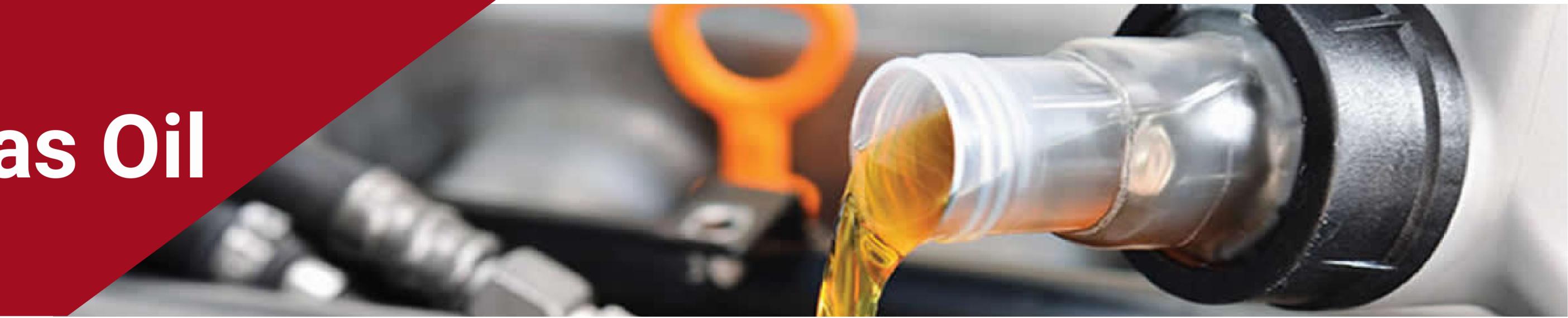
ARIMA RESIDUAL



RMSE COMPARISION



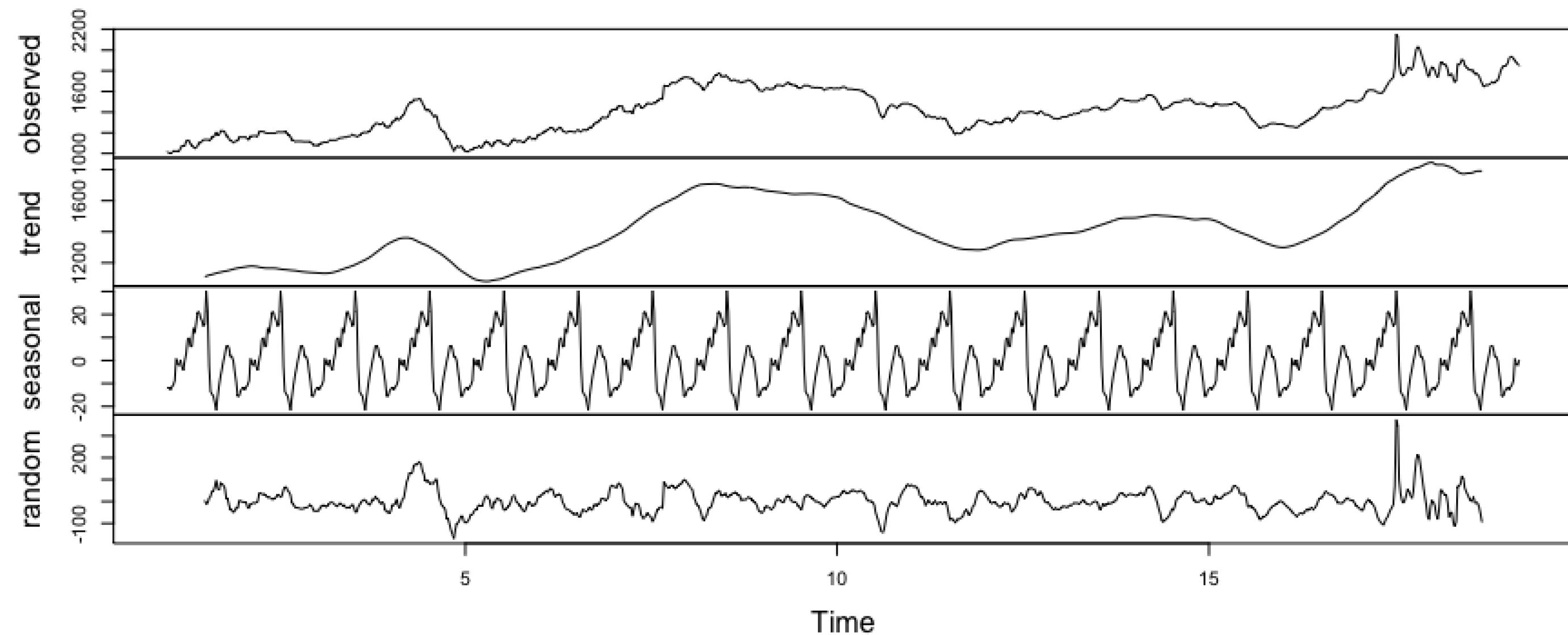
Automotive Gas Oil



DECOMPOSITION



Decomposition of additive time series



LINEAR MODEL

Automotive Gas Oil= $1.163e+03 + 5.349e-01 \times tt$

Intercept Estimate: $1.163e+03$

Slope Estimate (tt): $5.349e-01$

Min	1Q	Median	3Q	Max
-337.19	-113.92	-42.91	127.38	531.28

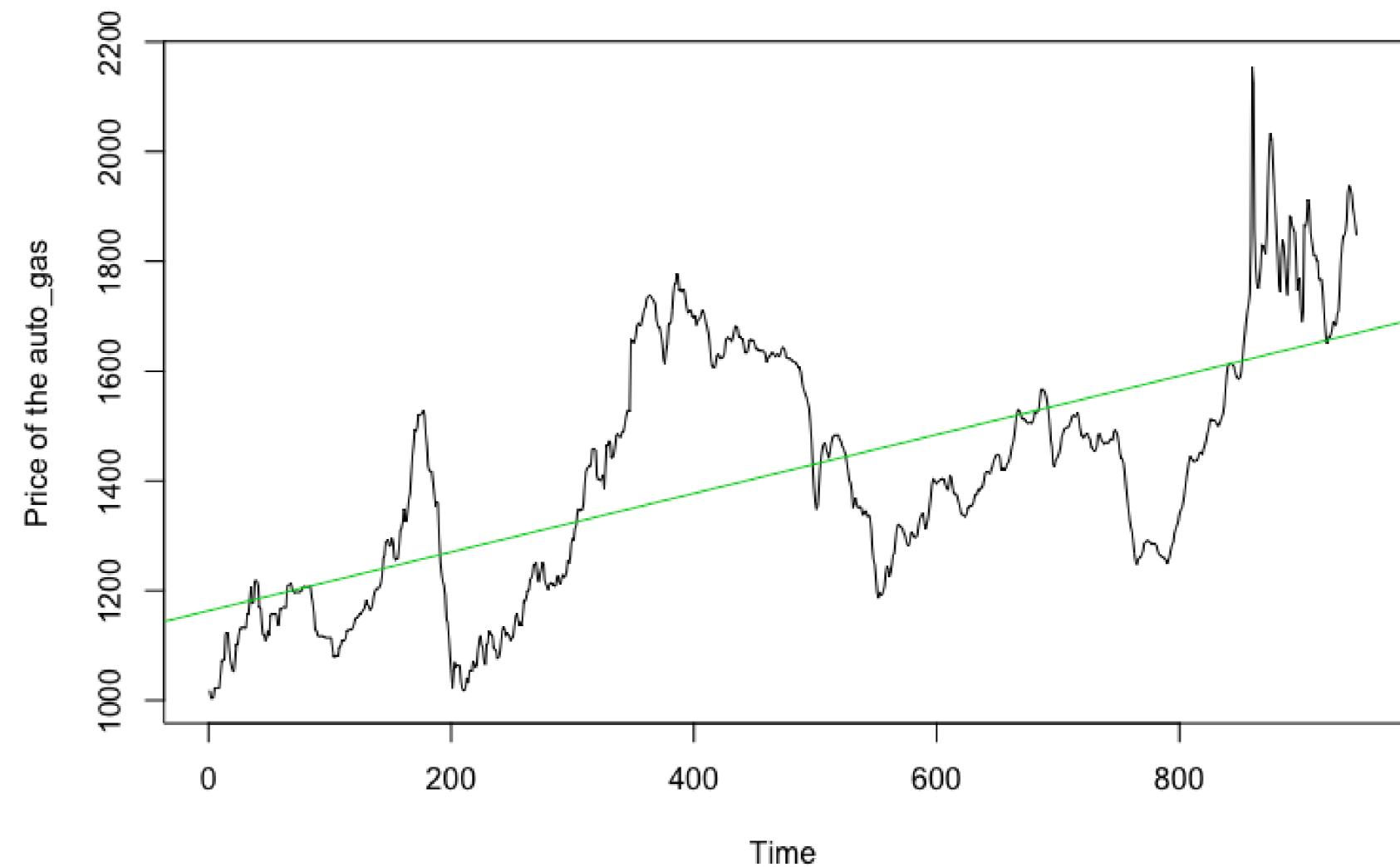
$Pr(>|t|) < 2e-16$ * coefficient is statistically significant.

Residual Standard Error: 173.8 * size of the residuals

R-squared: 0.4146 * of the variability in the response variable can be explained by the linear relationship with the predictor variable (tt).

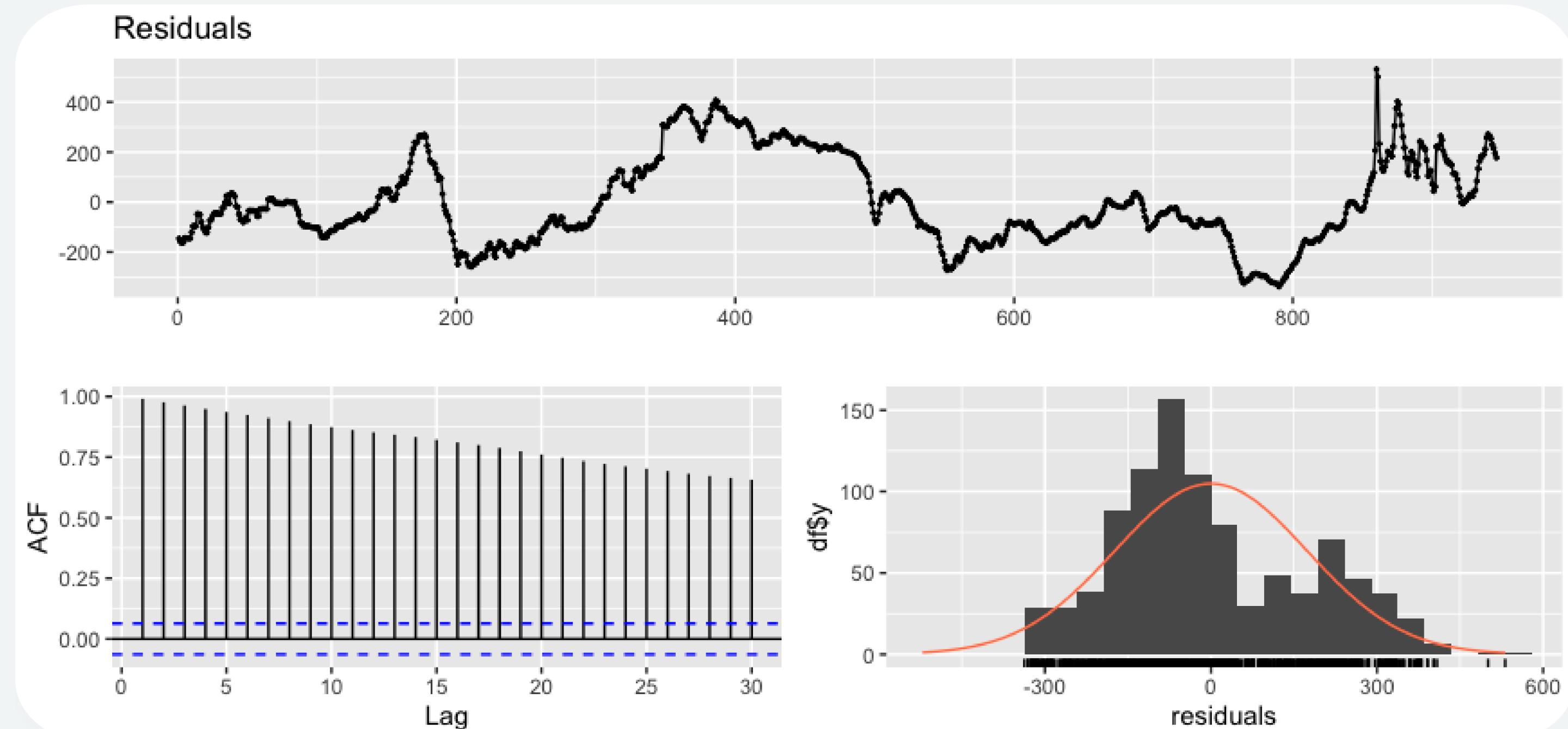
F-statistic: 668.7 * overall significance of the model

p-value: $< 2.2e-16$ * the overall model is significant



- DW = 0.01586
- RMSE: 173.57

RESIDUAL OF LINEAR MODEL



EXPONENTIAL SMOOTHING

Smoothing Parameter (α): 0.9999 *high emphasis on recent data

ME (Mean Error): 0.8766883

RMSE (Root Mean Squared Error): 21.87494

MAE (Mean Absolute Error): 11.24681

MPE (Mean Percentage Error): 0.05406044

MAPE (Mean Absolute Percentage Error): 0.7752278

MASE (Mean Absolute Scaled Error): 0.06990843

ACF1 (Autocorrelation of Residuals at Lag 1): 0.3604208

Forecasts:

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
19.19231	1847.712	1819.648	1875.775	1804.792	1890.631
19.21154	1847.712	1808.026	1887.398	1787.017	1908.406
.					
.					
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HOLT'S METHOD

- Alpha: 0.9993
- Beta = 1e-04
- ME (Mean Error): -0.04195725
- RMSE (Root Mean Squared Error): 21.87337
- MAE (Mean Absolute Error): 11.33017
- MPE (Mean Percentage Error): -0.01182722
- MAPE (Mean Absolute Percentage Error): 0.7818299
- MASE (Mean Absolute Scaled Error): 0.07042658

Forecasts:

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
19.19231	1848.663	1820.572	1876.754	1805.701	1891.625
19.21154	1849.604	1809.888	1889.319	1788.864	1910.343

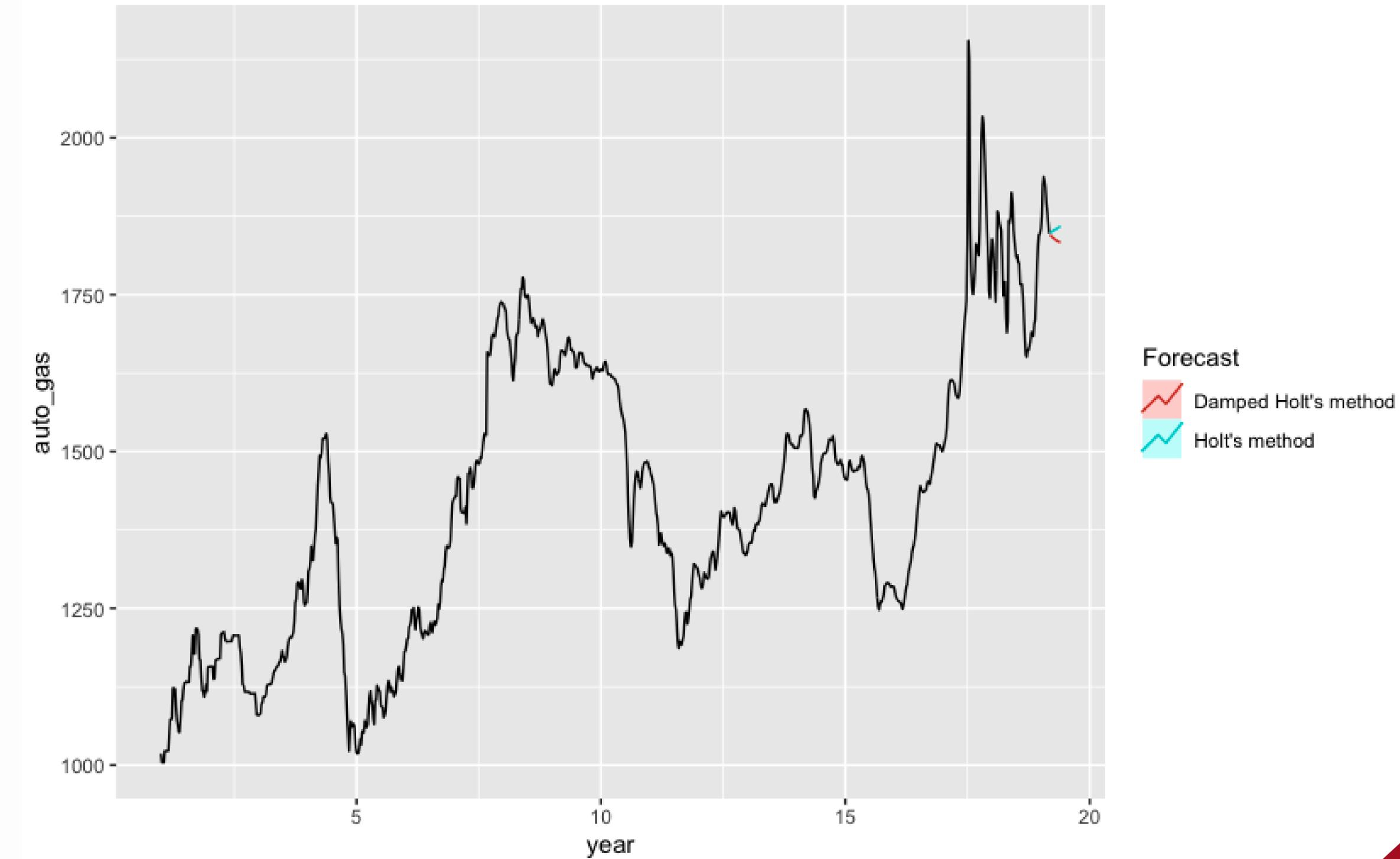
DAMPED HOLT'S METHOD

- Alpha: 0.9999
- Beta = 0.084
- ME (Mean Error): 0.4527155
- RMSE (Root Mean Squared Error): 21.73348
- MAE (Mean Absolute Error): 10.99141
- MPE (Mean Percentage Error): 0.03019387
- MAPE (Mean Absolute Percentage Error): 0.7567199
- MASE (Mean Absolute Scaled Error): 0.06832087

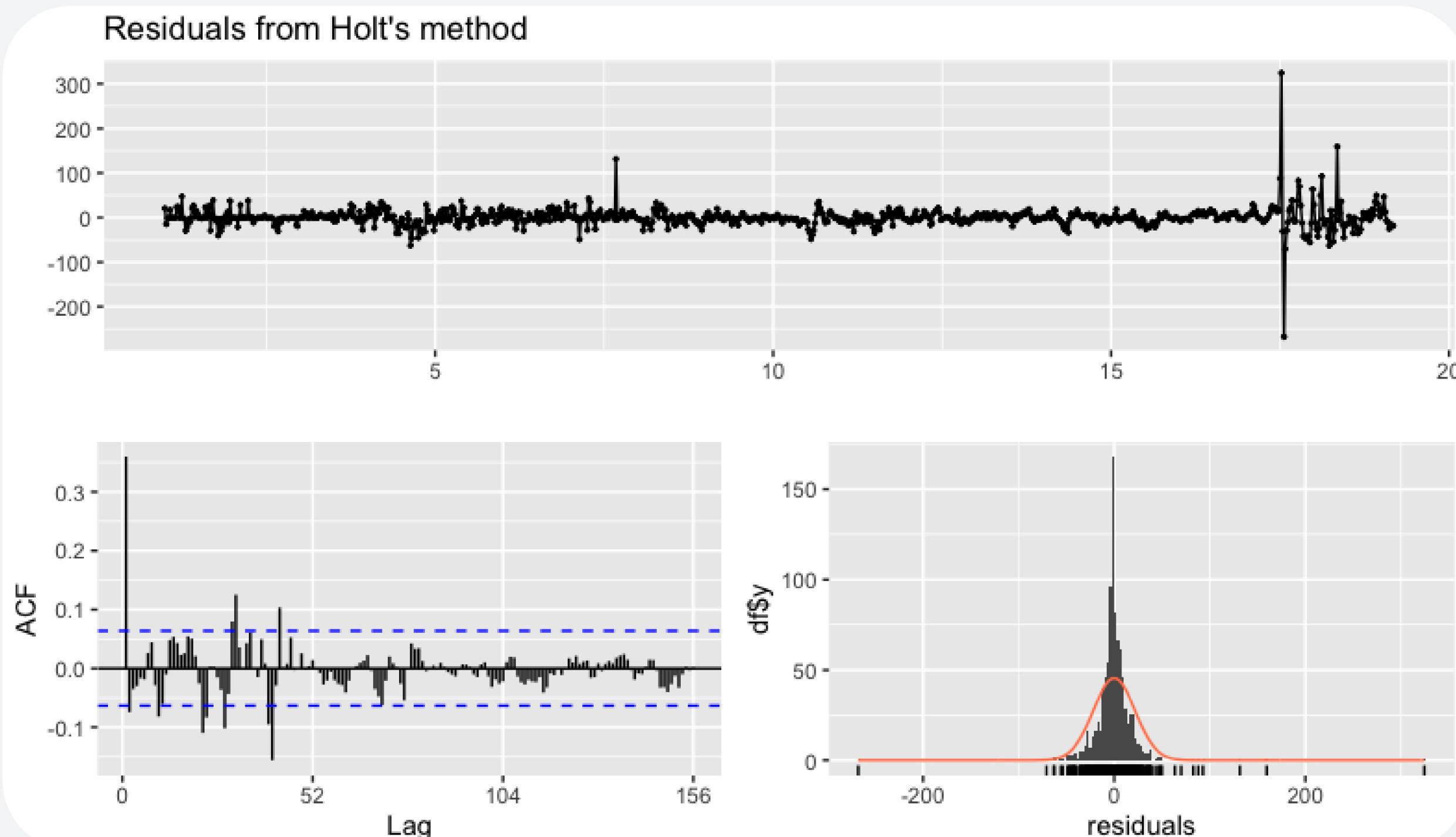
Forecasts:

	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
19.19231	1845.653	1817.726	1873.579	1802.943	1888.362
19.21154	1843.799	1802.787	1884.812	1781.076	1906.523

Forecasts from Holt's method



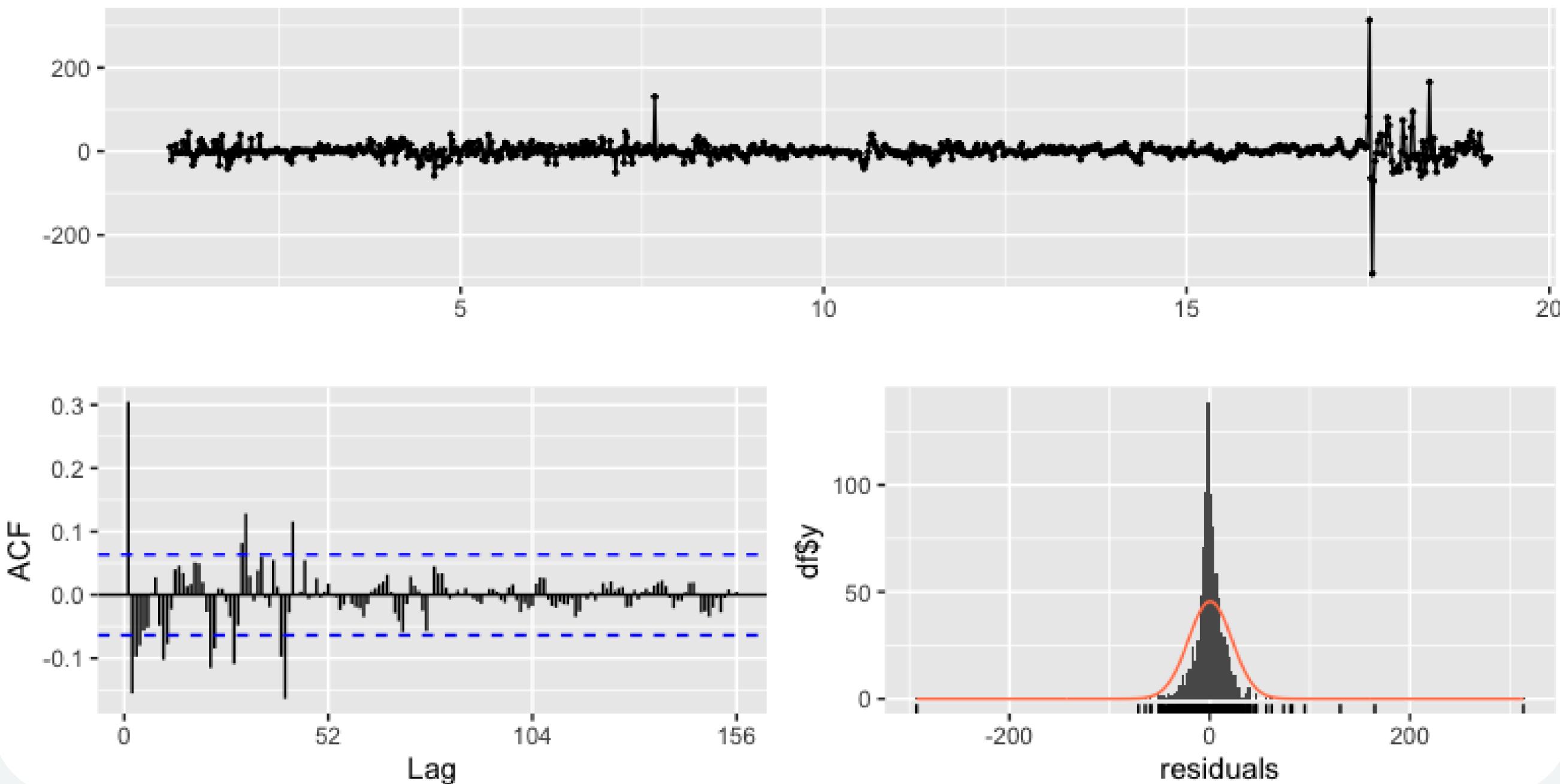
HOLT'S RESIDUAL



DAMPED HOLT'S RESIDUAL



Residuals from Damped Holt's method



ARIMA MODEL

ARIMA(0,1,2)

MA(1): 0.4863

MA(2): -0.0793

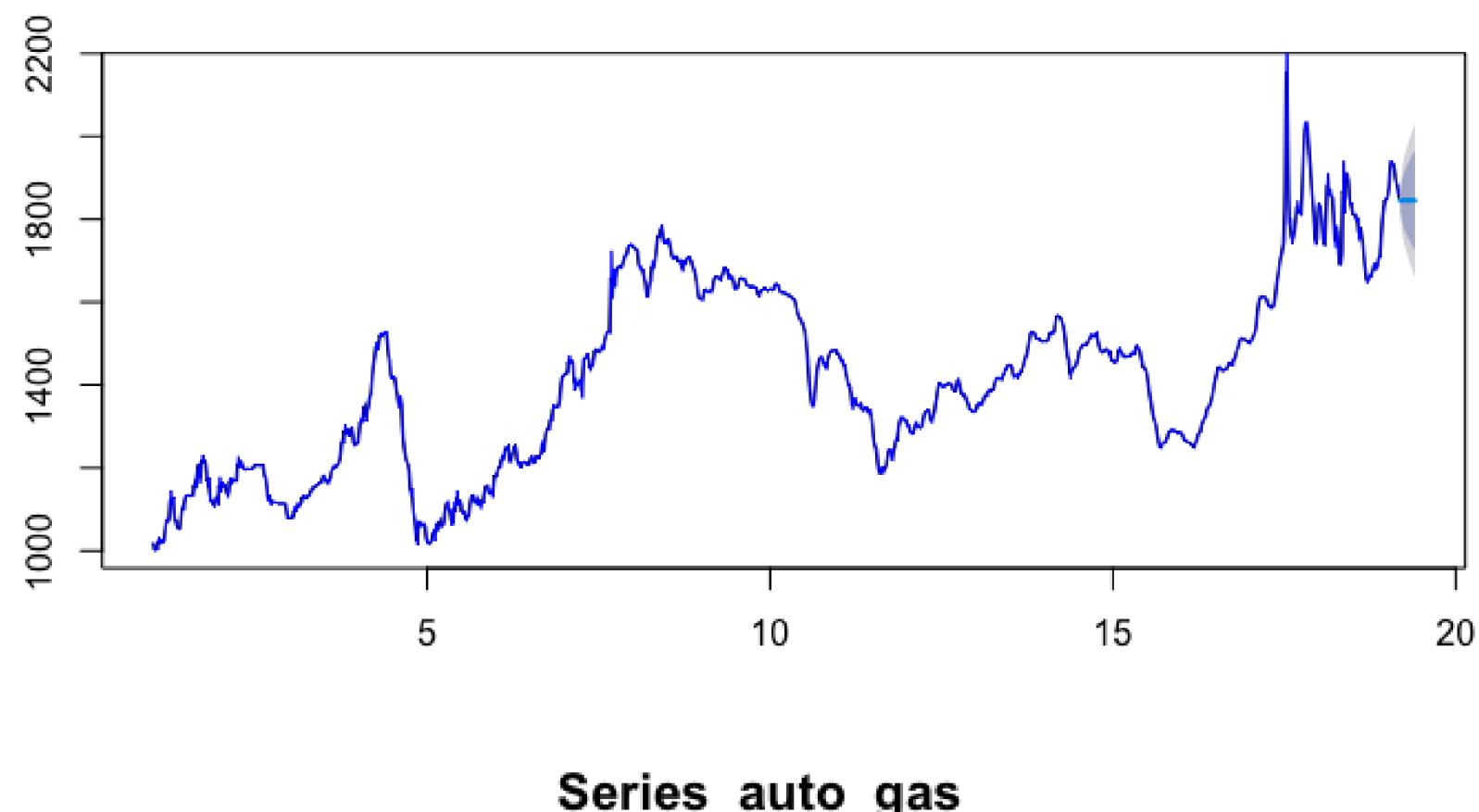
ME (Mean Error): 0.6227

RMSE: 19.61248

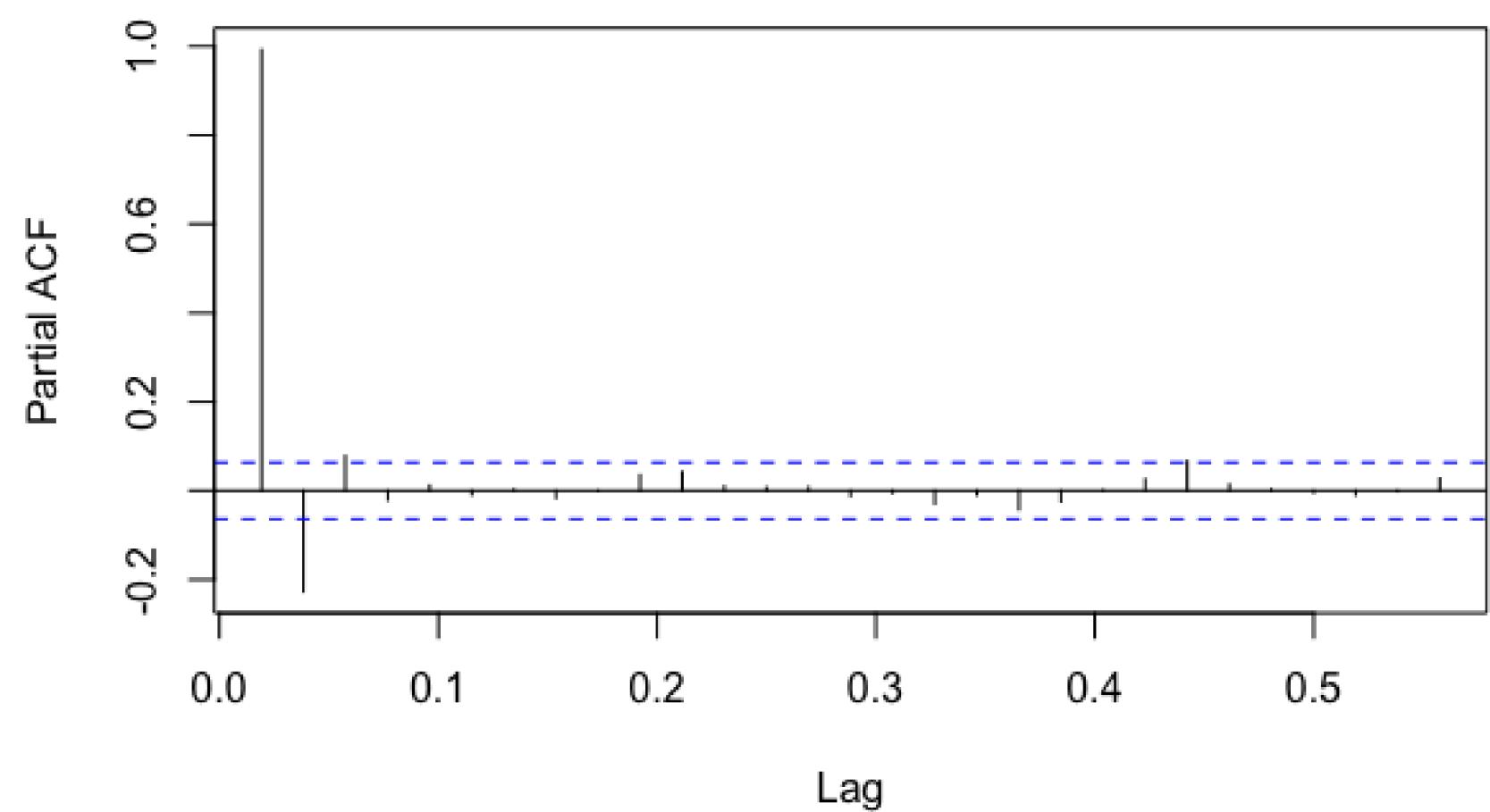
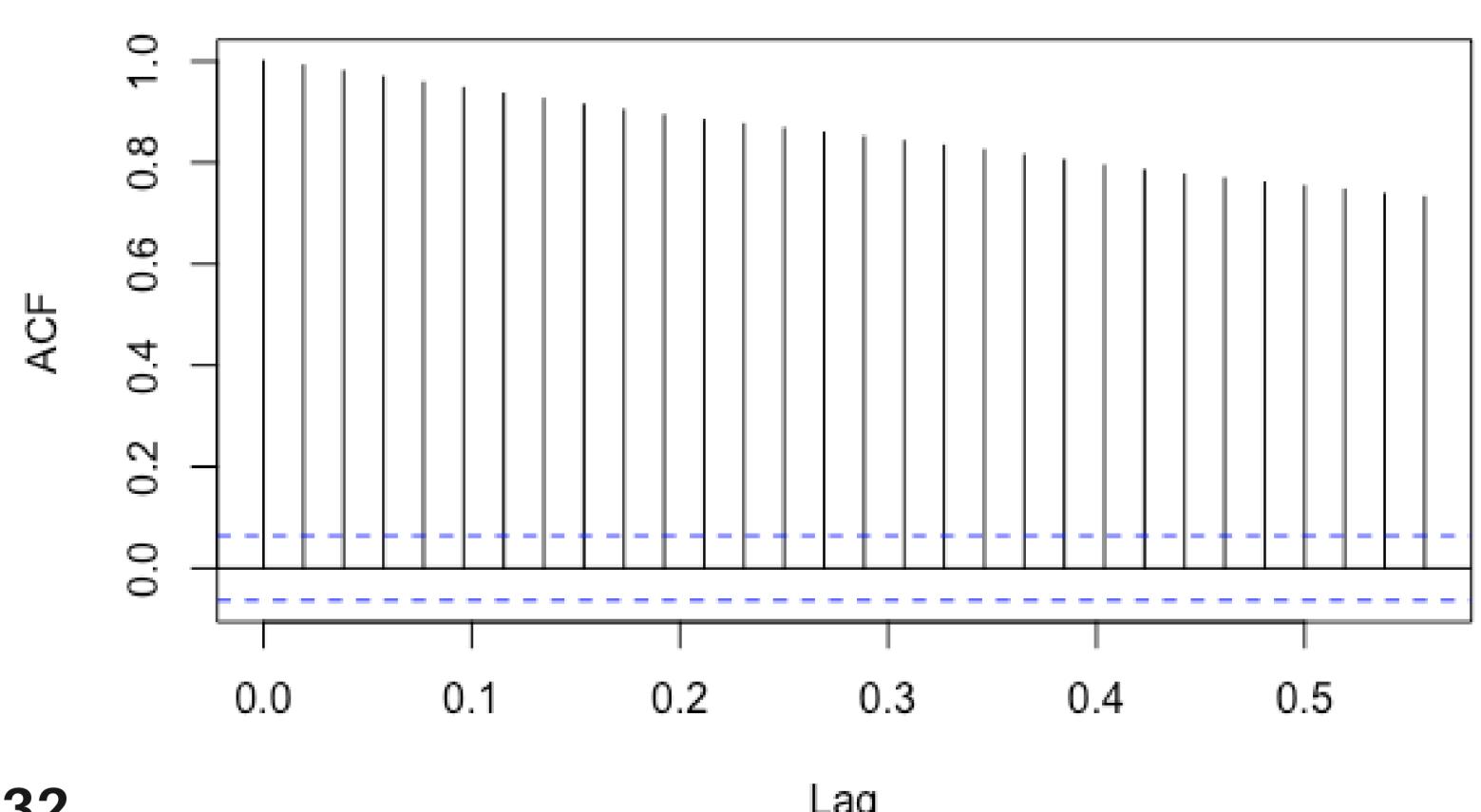
MAE: 10.28629

MPE: 0.04047079

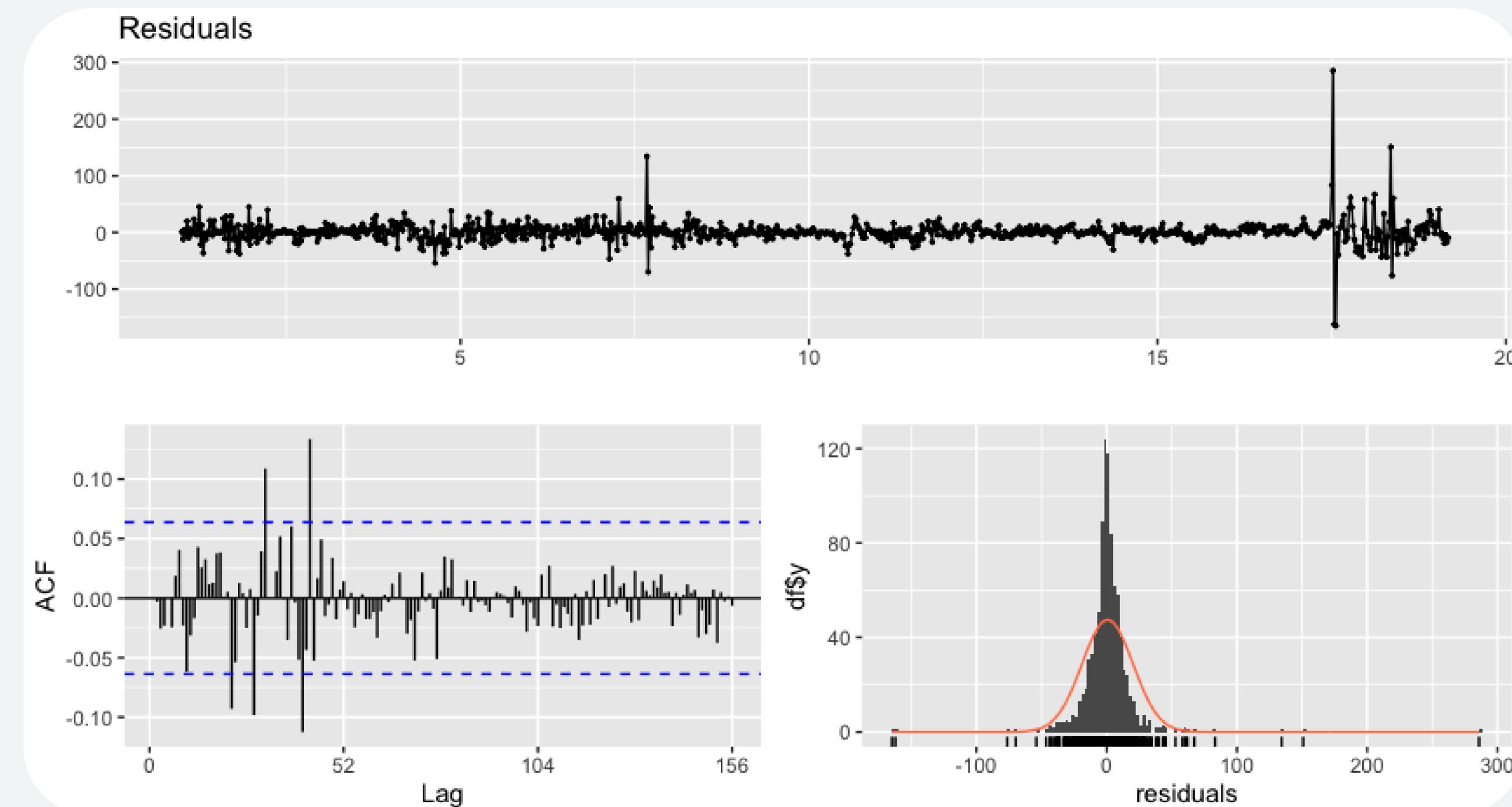
Forecasting price of the auto gas ARIMA(0,1,2)



Series auto_gas



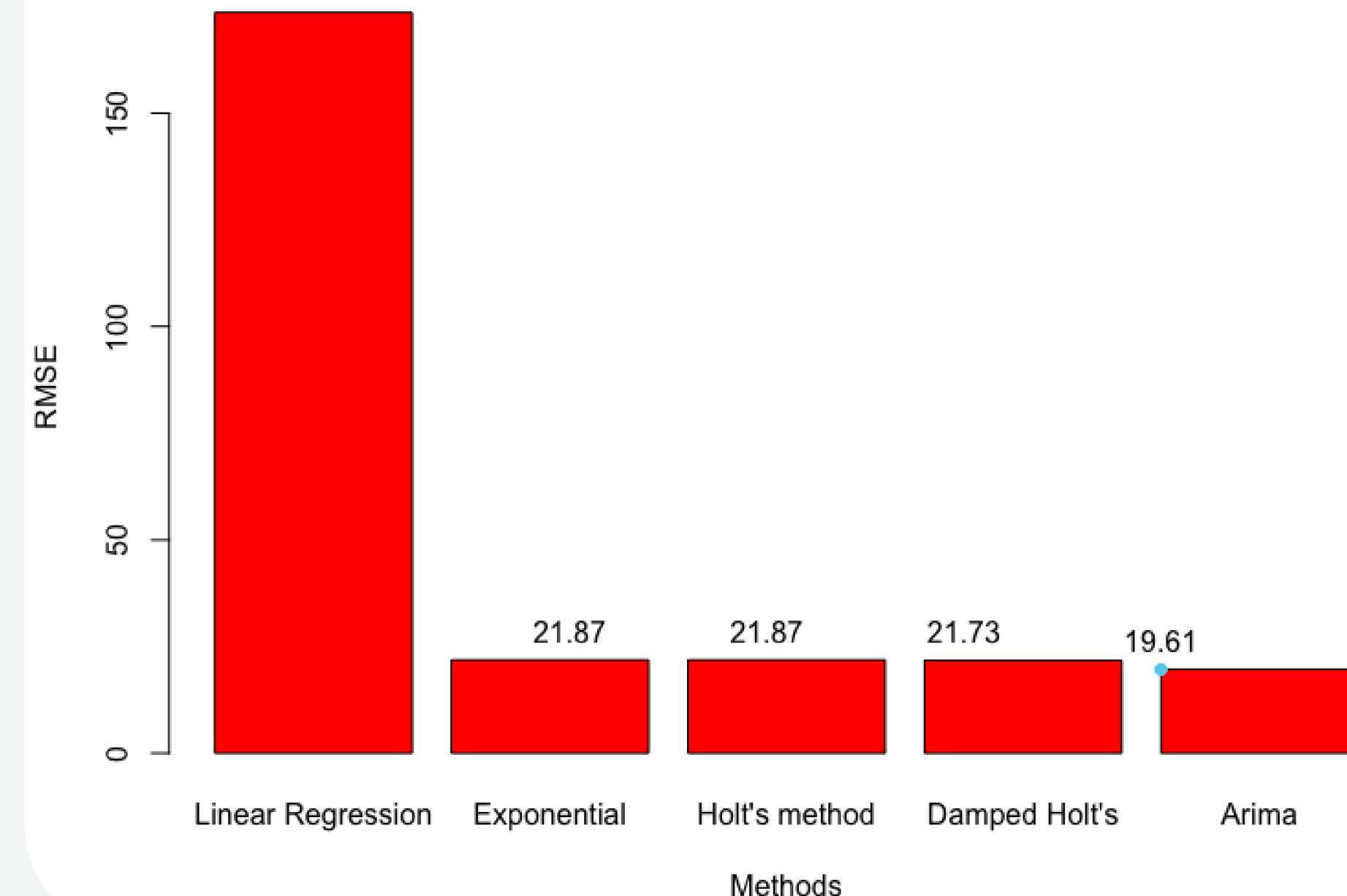
ARIMA RESIDUAL



RMSE COMPARISON



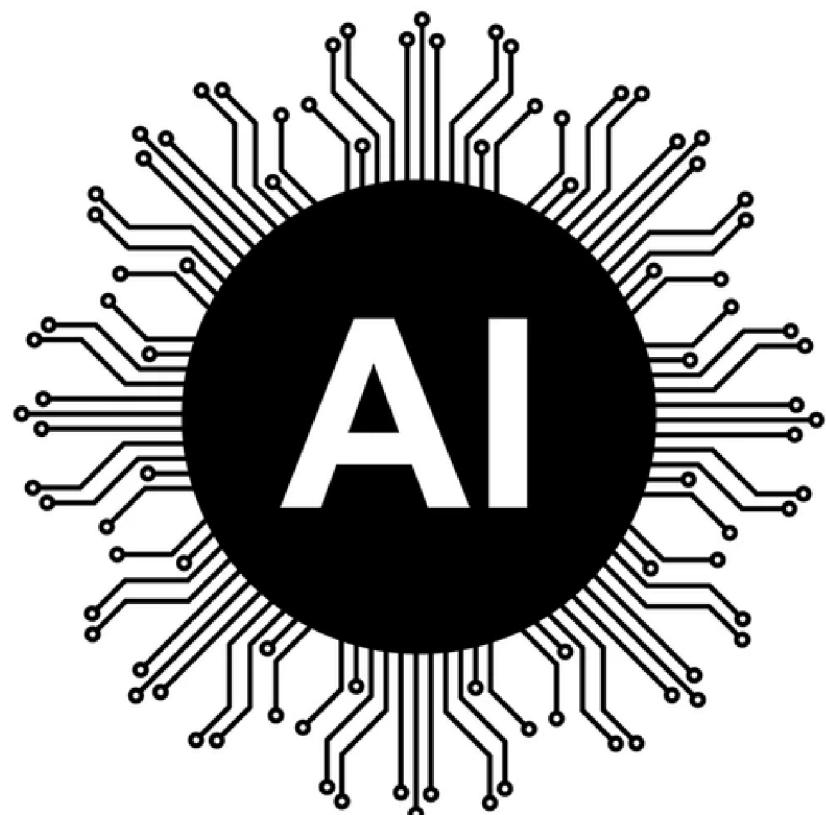
RMSE Comparison





Next Steps :

- Sentiment Analysis
- Using State of the Art
‘Transformers’



Resources

1

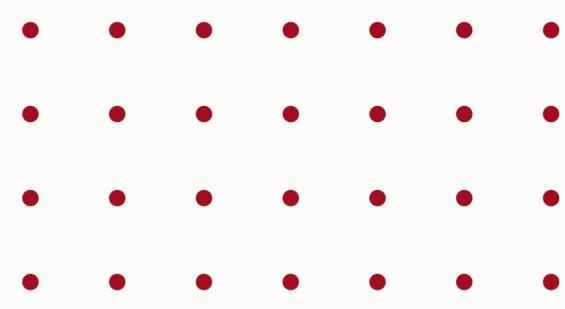
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2

Guidolin, Mariangela. Business, Economic and Financial data. Department of Statistical Sciences, University of Padua, a.y. 2023-24.

3

Hyndman, Rob J., and George Athanasopoulos. Forecasting: Principles and Practice. 2nd ed. Monash University, Australia, Year of Publication.



THANK YOU

