

Time Series & Matlab



Professor Mehmet Adak (Ph. D. in Theoretical Economics)
İstanbul University, Transportation and Logistics Faculty
mehmet.adak@istanbul.edu.tr

Time Series & Matlab

Research Topic

Linear Time Series Models :

Autoregressive Model (Process) AR(p)

Moving-Average Model (Process) MA(q)

Autoregressive Moving Average Model (Process) ARMA(p,q)

Autoregressive Integrated Moving Average Model (Process) ARIMA(p, d, q)

Time Series § Matlab

Research Goals

- Understanding the basics of linear time series processes,
- Learning to derive time series processes with Matlab,
- Analyzing time series processes derived with Matlab,

Benefits / added value of using MATLAB and Simulink

- Matlab successfully presents graphical representation of time series.
- Matlab allows us to perform operations on a time series. (For example, the natural logarithm of the time series can be taken or the first and second lag difference of the time series can be taken)
- Matlab Econometric Modeler enables advanced econometric analysis to be performed on time series.

Time Series § Matlab

Linear Time Series Models :

Autoregressive Model (Process) AR(p)

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \dots + \alpha_p Y_{t-p} + e_t$$

Moving-Average Model (Process) MA(q)

$$Y_t = \beta_0 + \beta_1 e_{t-1} + \dots + \beta_q e_{t-q} + e_t$$

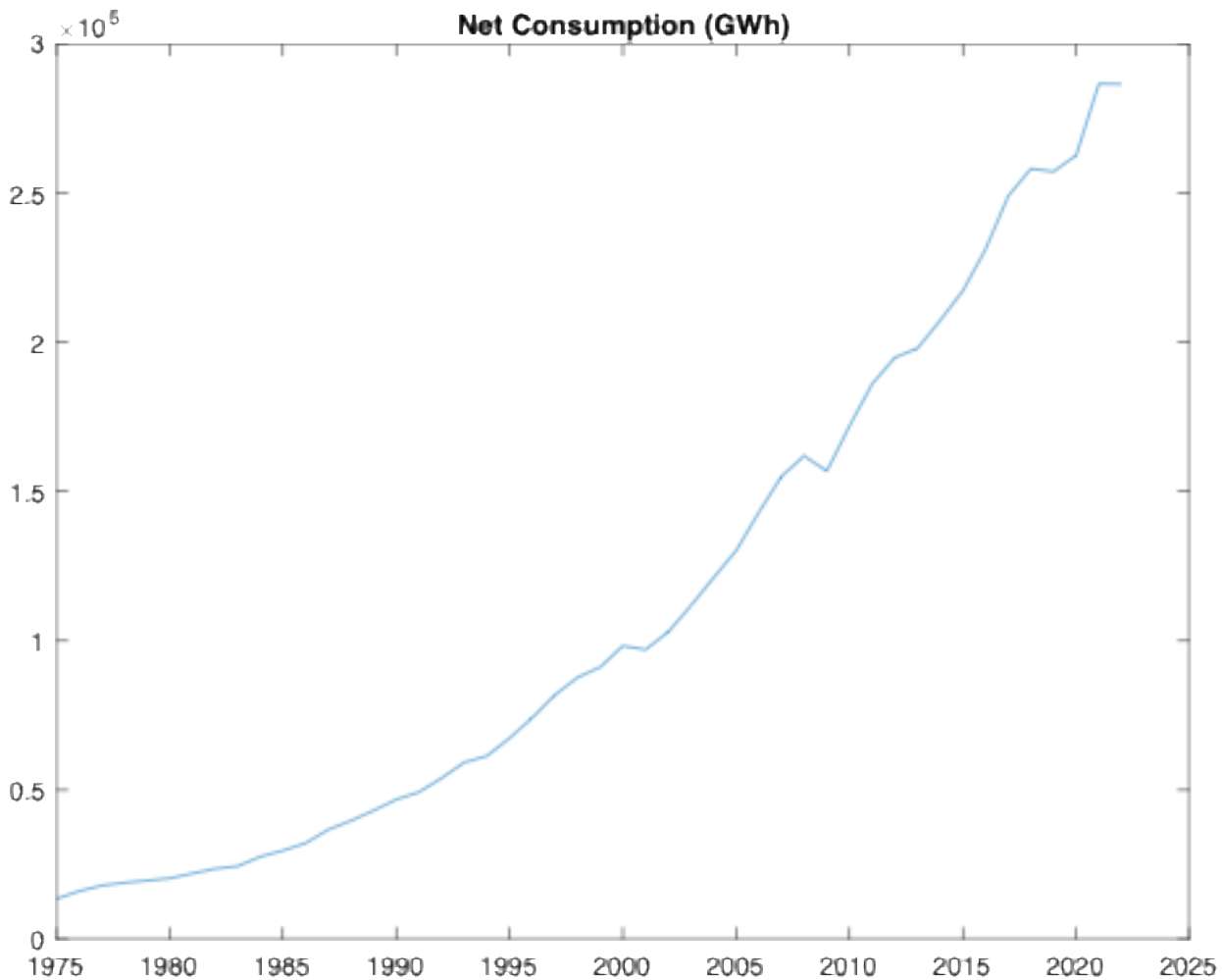
Autoregressive Moving Average Model (Process) ARMA(p,q)

$$Y_t = \gamma_0 + \alpha_1 Y_{t-1} + \dots + \alpha_p Y_{t-p} + \beta_1 e_{t-1} + \dots + \beta_q e_{t-q} + e_t$$

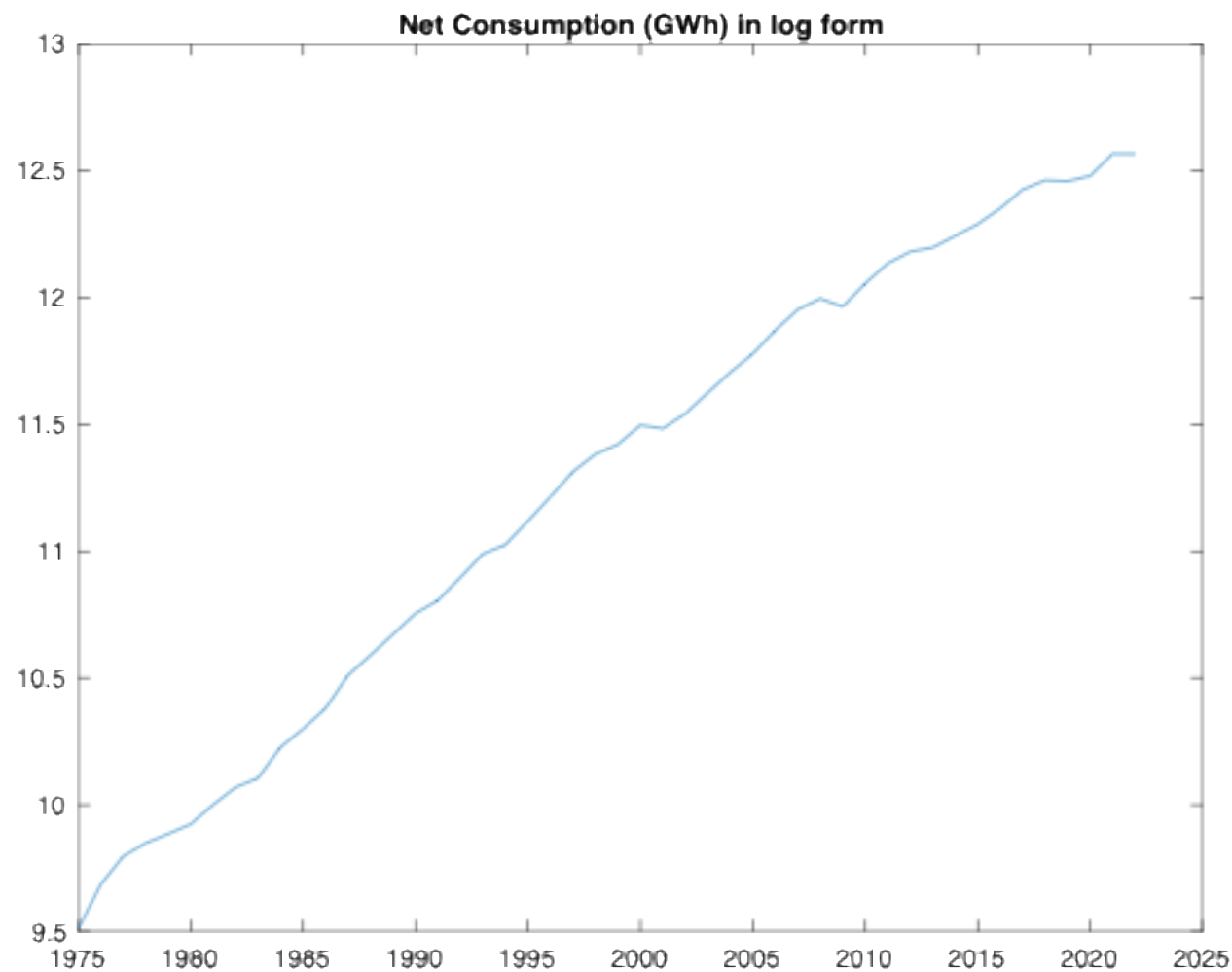
Autoregressive Integrated Moving Average Model (Process) ARIMA(p, d, q)

After differencing the time series $Y(t)$, the ARMA(p,q) process is derived.

Modeling by Coding



`plot(data.Year, data.NetConsumption)`



`plot(data.Year, log(data.NetConsumption))`

Modeling with Interface; Econometric Modeler

ECONOMETRIC MODELER PLOTS

IMPORT TESTS TRANSFORMS MODELS DIAGNOSTICS EXPORT

Time Series Plot(NetConsumption) × Time Series Plot(NetConsumptionDiff) × Time Series Plot(NetConsumptionLogDiff) ×

Time Series

NetConsumption

NetConsumptionLog

NetConsumptionLogDiff

Models

Preview

NetConsumption

=

1.0e+05 *

0.1349

0.1608

0.1797

0.1893

0.1963

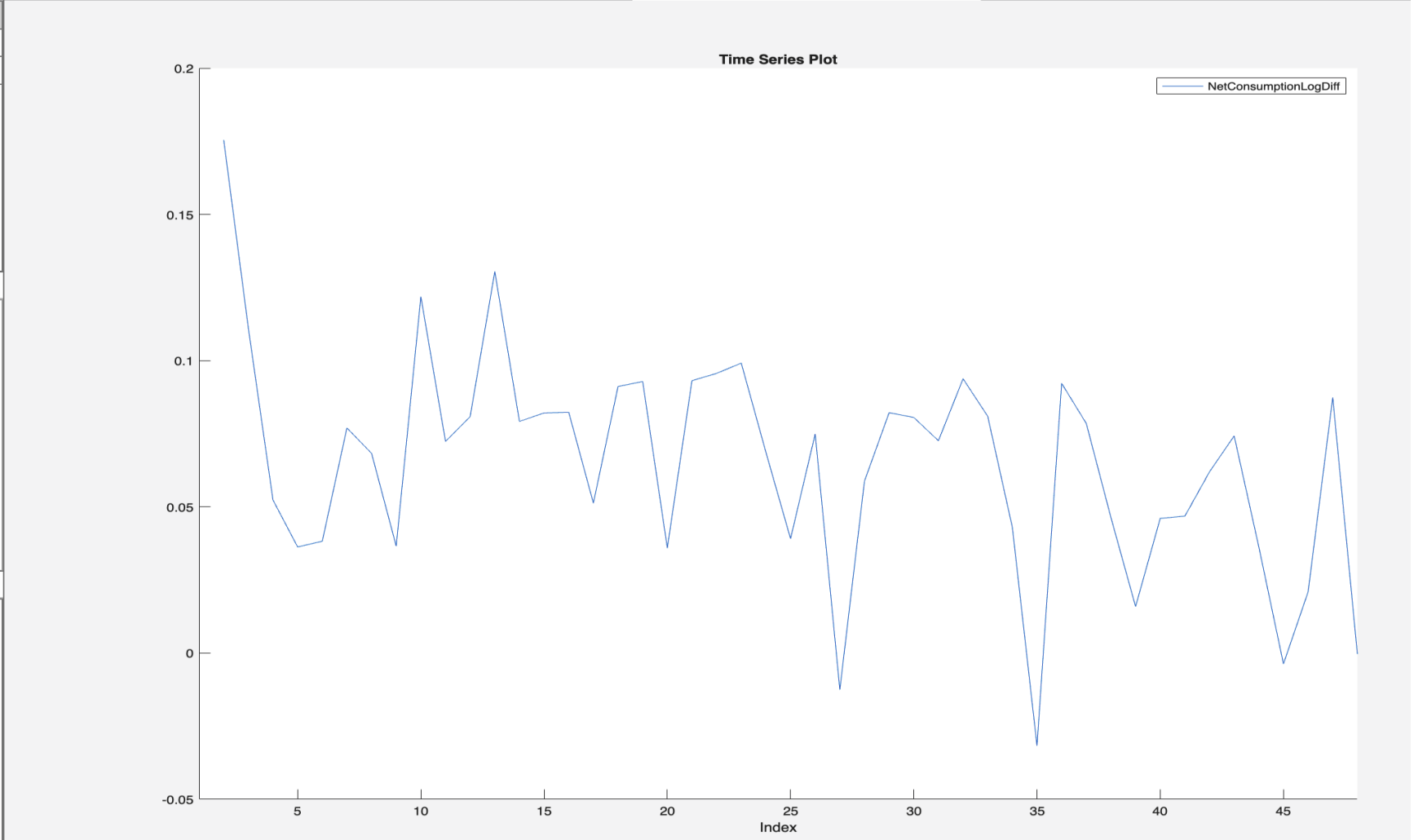
0.2040

0.2203

0.2359

0.2447

0.2764



Autoregressive Model; AR(1), $Y_t = \alpha_0 + \alpha_1 Y_{t-1} + e_t$

ECONOMETRIC MODELER PLOTS

Import
New Test
Difference
Seasonal 12
Detrend
Log

Select a time series to model
AR
MA
ARMA
ARIMA

Residual Diagnostics
Export

Time Series

- NetConsumption
- NetConsumptionLog
- NetConsumptionLogDiff

Models

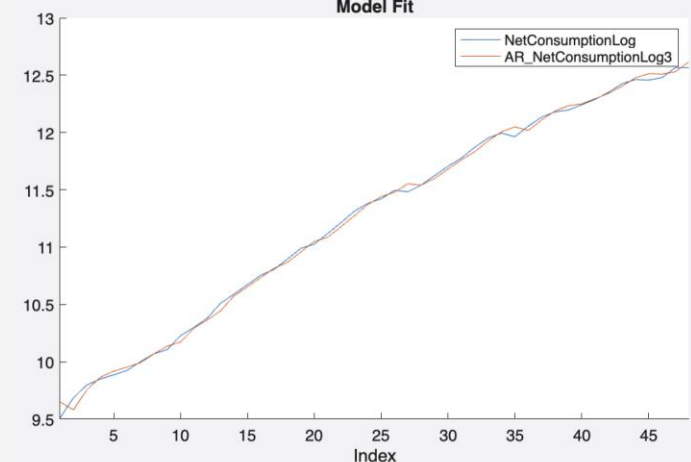
- AR_NetConsumptionLog
- AR_NetConsumptionLog2
- AR_NetConsumptionLog3
- AR_NetConsumptionLogDiff

Preview

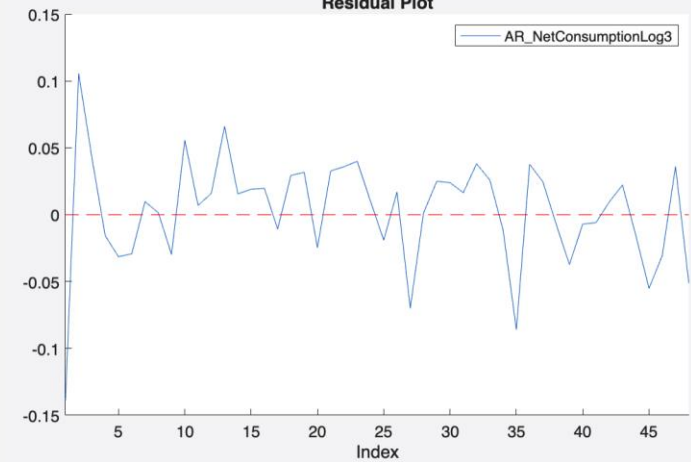
```

AR_NetConsumptionLog3
=
arma with properties:
  Description: "ARIMA(1,0,0) Model (Gaussian
  Distribution)"
  SeriesName: "Y"
  Distribution: Name = "Gaussian"
  P: 1
  D: 0
  Q: 0
  Constant: 0.129212
  AR: {0.993756} at lag [1]
  SAR: {}
  MA: {}
  SMA: {}
          
```

Model Fit



Residual Plot



Parameters

Parameter	Value	Standard Err...	t Statistic	P-Value
Constant	0.1292	0.0456	2.8341	0.0046
AR{1}	0.9938	0.0044	225.5075	0
Variance	0.0017	0.0003	5.6427	0.0000

Goodness of Fit

Measure	Value
AIC	-164.9833
BIC	-159.4329

Moving Average Model; MA(3)

$$Y_t = \beta_0 + \beta_1 e_{t-1} + \beta_2 e_{t-2} + \beta_3 e_{t-3} + e_t$$

ECONOMETRIC MODELER PLOTS

Import New Test IMPORT TESTS Difference Seasonal 12 Detrend Log TRANSFORMS

Select a time series to model AR MA ARMA ARIMA MODELS

Residual Diagnostics EXPORT DIAGNOSTICS EXPORT

Time Series

- NetConsumption
- NetConsumptionLog
- NetConsumptionLogDiff

Models

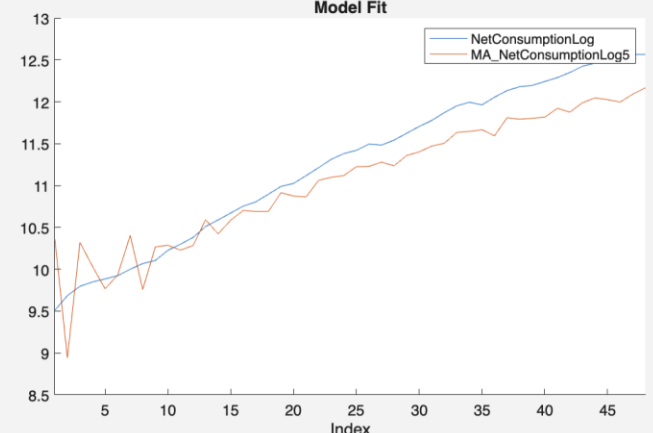
- AR_NetConsumptionLog
- AR_NetConsumptionLog2
- AR_NetConsumptionLog3
- AR_NetConsumptionLogDiff
- MA_NetConsumptionLog
- MA_NetConsumptionLog2
- MA_NetConsumptionLog3
- MA_NetConsumptionLog4
- MA_NetConsumptionLog5

Preview

```

MA_NetConsumptionLog5
=
arima with properties:
  Description: "ARIMA(0,0,3) Model (Gaussian Distribution)"
  SeriesName: "y"
  Distribution: Name = "Gaussian"
    P: 0
    D: 0
    Q: 3
  Constant: 10.3641
  AR: {}
  SAR: {}
  MA: {1.66445 1.5 0.670489} at lags
  
```

Model Fit




Parameters

Parameter	Value	Standard Err...	t Statistic	P-Value
Constant	10.3641	0.1861	55.6997	0
MA(1)	1.6645	0.1315	12.6620	0.0000
MA(2)	1.5000	0.2397	6.2574	0.0000
MA(3)	0.6705	0.1569	4.2725	0.0000
Variance	0.1148	0.0458	2.5095	0.0121

Goodness of Fit

Measure	Value
AIC	42.3293
BIC	51.6853

Residual Plot



Autoregressive Moving Average Model; ARMA(2,1)

$$Y_t = \gamma_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \beta_1 e_{t-1} + e_t$$

ECONOMETRIC MODELER PLOTS

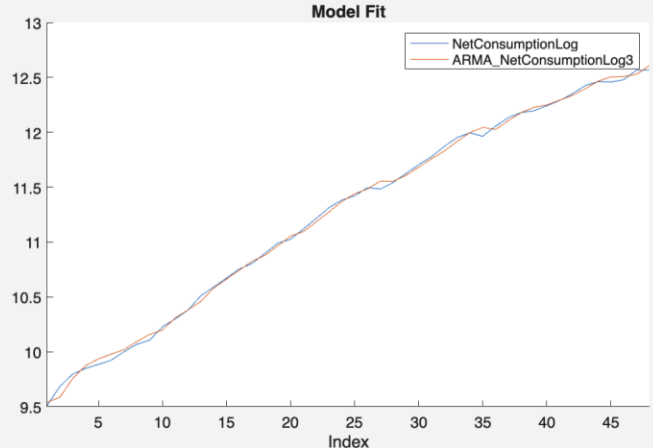
Import New Test Difference Detrend Seasonal 12 Log AR MA ARMA ARIMA Residual Diagnostics Export

Time Series: NetConsumption, NetConsumptionLog, NetConsumptionLogDiff

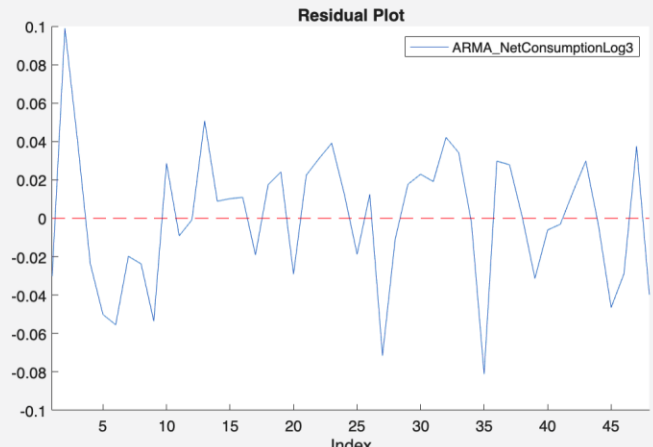
Models: ARMA_NetConsumptionLog, ARMA_NetConsumptionLog2, **ARMA_NetConsumptionLog3**, AR_NetConsumptionLog, AR_NetConsumptionLog2, AR_NetConsumptionLog3, AR_NetConsumptionLogDiff, MA_NetConsumptionLog, MA_NetConsumptionLog2, MA_NetConsumptionLog3

Preview: ARMA_NetConsumptionLog3 = arima with properties: Description: "ARIMA(2,0,1) Model (Gaussian Distribution)" SeriesName: "y" Distribution: Name = "Gaussian" P: 2 D: 0 Q: 1 Constant: 0.157819 AR: {1.36344 -0.373914} at lags [1 2] SAR: {} MA: {}

Model Fit



Residual Plot



Parameters

Parameter	Value	Standard Err...	t Statistic	P-Value
Constant	0.1578	0.0335	4.7154	0.0000
AR{1}	1.3634	0.1018	13.3885	0.0000
AR{2}	-0.3739	0.1013	-3.6908	0.0002
MA{1}	-0.5160	0.1671	-3.0884	0.0020
Variance	0.0012	0.0003	3.8997	0.0001

Goodness of Fit

Measure	Value
AIC	-176.6507
BIC	-167.5075

Stationarity Test; I(0) at level

ECONOMETRIC MODELER PLOTS ADF

Number of Lags: 0 Model: Autoregressive Run Test Clear Tests

Significance Level: 0.05 Test Statistic: Standard t statistic

PARAMETERS TESTS

Time Series: NetConsumption, NetConsumptionLog, NetConsumptionLogDiff

ADF(NetConsumptionLog) × ADF(NetConsumptionLogDiff) × Model Summary(AR_NetConsumptionLog3) × Model Summary(MA_NetConsumptionLog) × Model Summary

Augmented Dickey-Fuller Test(NetConsumptionLog)

Null Hypothesis: NetConsumptionLog contains a unit root

Results

	Select	Null Rejected	P-Value	Test Statistic	Critical Value	Lags	Model	Test Statistic	Significance Level
1	<input type="checkbox"/>	false	0.9990	10.7421	-1.9469	0	AR	t1	0.0500

Stationarity Test; I(1) at first difference

ECONOMETRIC MODELER PLOTS ADF

Number of Lags: 0 Model: Autoregressive Run Test Clear Tests

Significance Level: 0.05 Test Statistic: Standard t statistic

PARAMETERS TESTS

Time Series: NetConsumption, NetConsumptionLog, NetConsumptionLogDiff

ADF(NetConsumptionLogDiff) × Model Summary(AR_NetConsumptionLog3) × Model Summary(MA_NetConsumptionLog) × Model Summary(MA_NetConsumptionLog2) ×

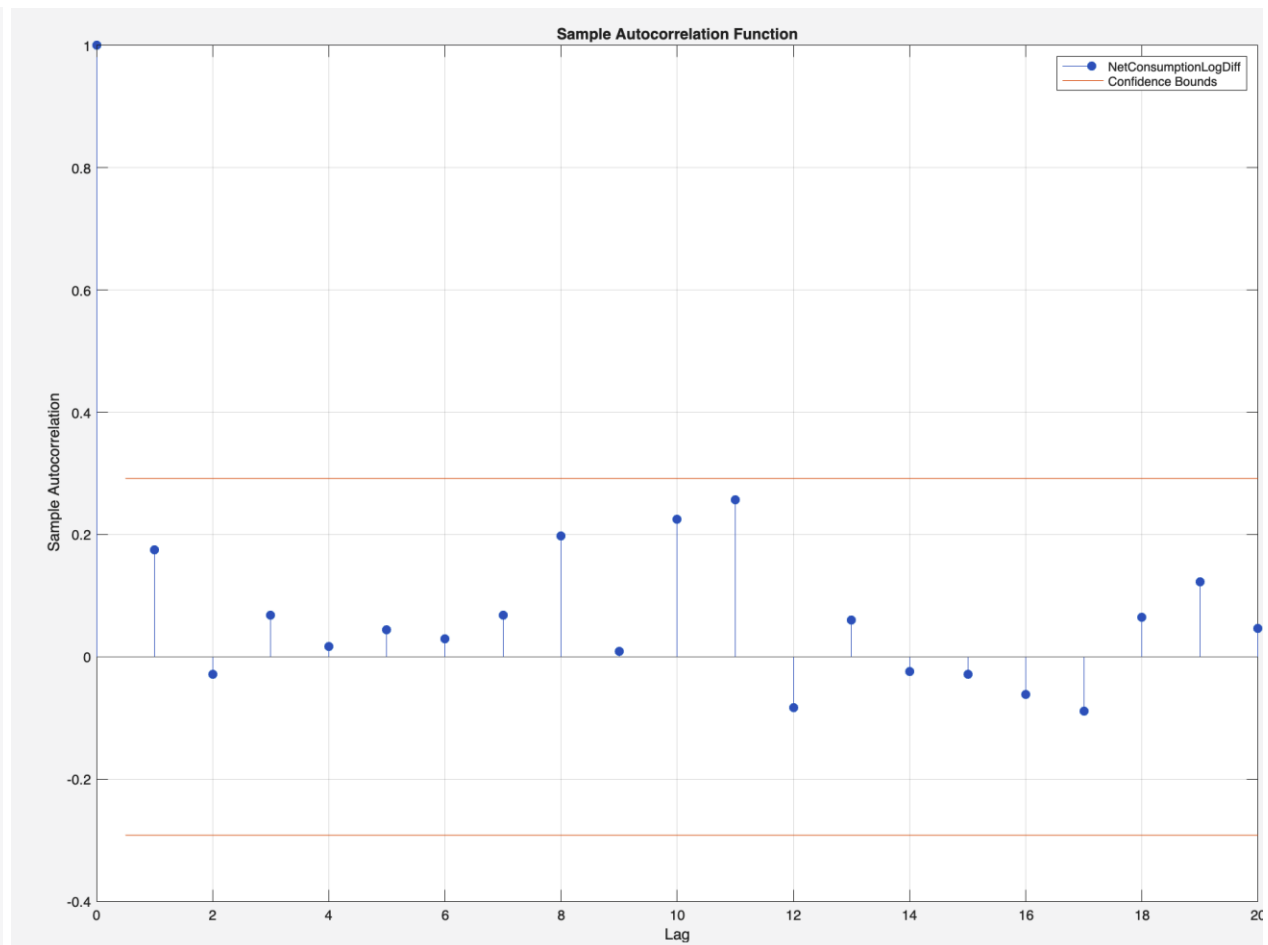
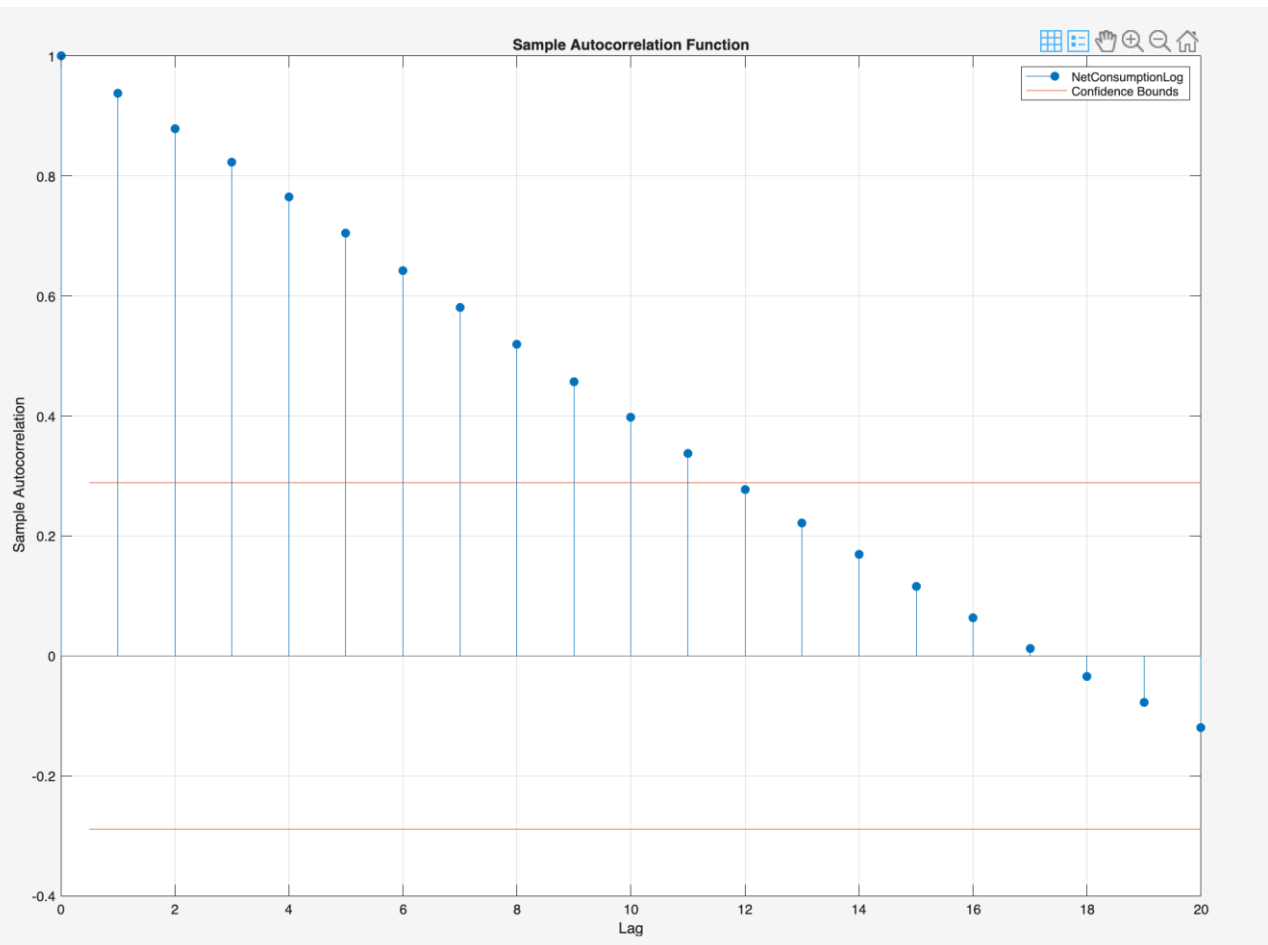
Augmented Dickey-Fuller Test(NetConsumptionLogDiff)

Null Hypothesis: NetConsumptionLogDiff contains a unit root

Results

	Select	Null Rejected	P-Value	Test Statistic	Critical Value	Lags	Model	Test Statistic	Significance Level
1	<input type="checkbox"/>	true	0.0050	-2.8796	-1.9470	0	AR	t1	0.0500

Autocorrelation Functions of non-Stationary and Stationary Series



Autoregressive Integrated Moving Average Model; ARIMA(2,1,0)

ECONOMETRIC MODELER
PLOTS

Import
New Test
Difference
Seasonal 12
Detrend
Log

$\hat{\beta}$
AR

\hat{R}
MA

\hat{R}
ARMA

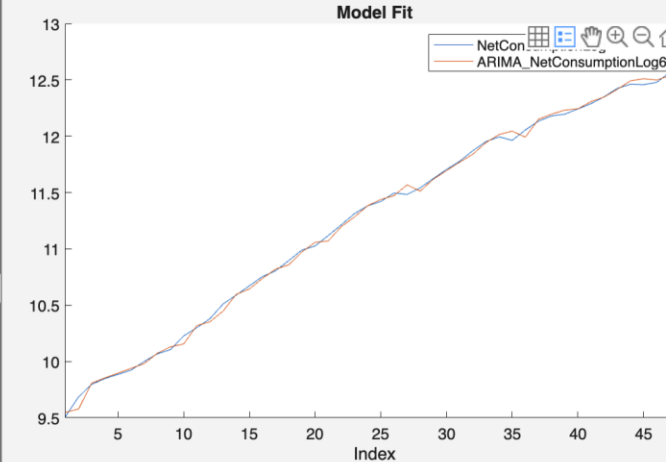
$\hat{\beta}$
ARIMA

Residual Diagnostics
Export

Time Series

- NetConsumption
- NetConsumptionLog
- NetConsumptionLogDiff

Model Fit



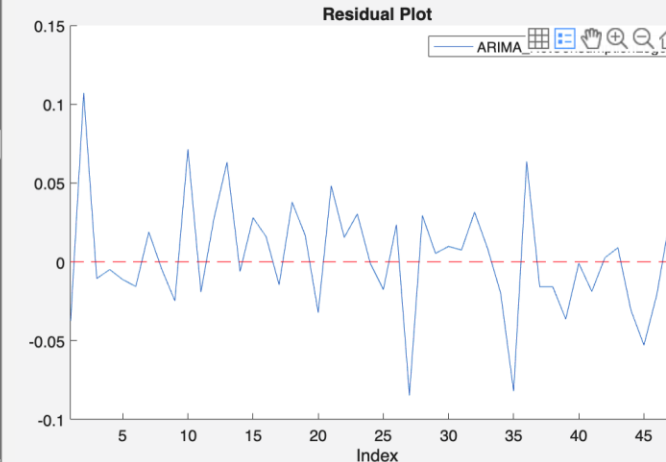
Parameters

Parameter	Value	Standard Err...	t Statistic	P-Value
Constant	0.0506	0.0072	7.0103	0.0000
AR{1}	0.3998	0.1057	3.7822	0.0002
AR{2}	-0.2156	0.0949	-2.2723	0.0231
Variance	0.0014	0.0003	5.0884	0.0000

Models

- ARIMA_NetConsumptionLog
- ARIMA_NetConsumptionLog2
- ARIMA_NetConsumptionLog3
- ARIMA_NetConsumptionLog4
- ARIMA_NetConsumptionLog5
- ARIMA_NetConsumptionLog6
- ARMA_NetConsumptionLog
- ARMA_NetConsumptionLog2
- ARMA_NetConsumptionLog3
- AR_NetConsumptionLog

Residual Plot



Goodness of Fit

Measure	Value
AIC	-171.2047
BIC	-163.9780

Preview

```

ARIMA_NetConsumptionLog6
=
arma with properties:
    Description: "ARIMA(2,1,0) Model (Gaussian Distribution)"
    SeriesName: "y"
    Distribution: Name = "Gaussian"
    P: 3
    D: 1
    Q: 0
    Constant: 0.050596
    AR: {0.399815 -0.215642} at lags
[1 2]
    SAR: {}
    MA: {}
          
```

Thank You for Your Patience

Q&A – 5min

Professor Mehmet Adak (Ph. D. in Theoretical Economics)
İstanbul University, Transportation and Logistics Faculty
mehmet.adak@istanbul.edu.tr

