# EEX Electricity Spot Prices and TAR Model

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# Outline

- Motivation
- Data
- The Proposal Model
- Data Analysis
- Conclusion
- Future Work

# Motivations

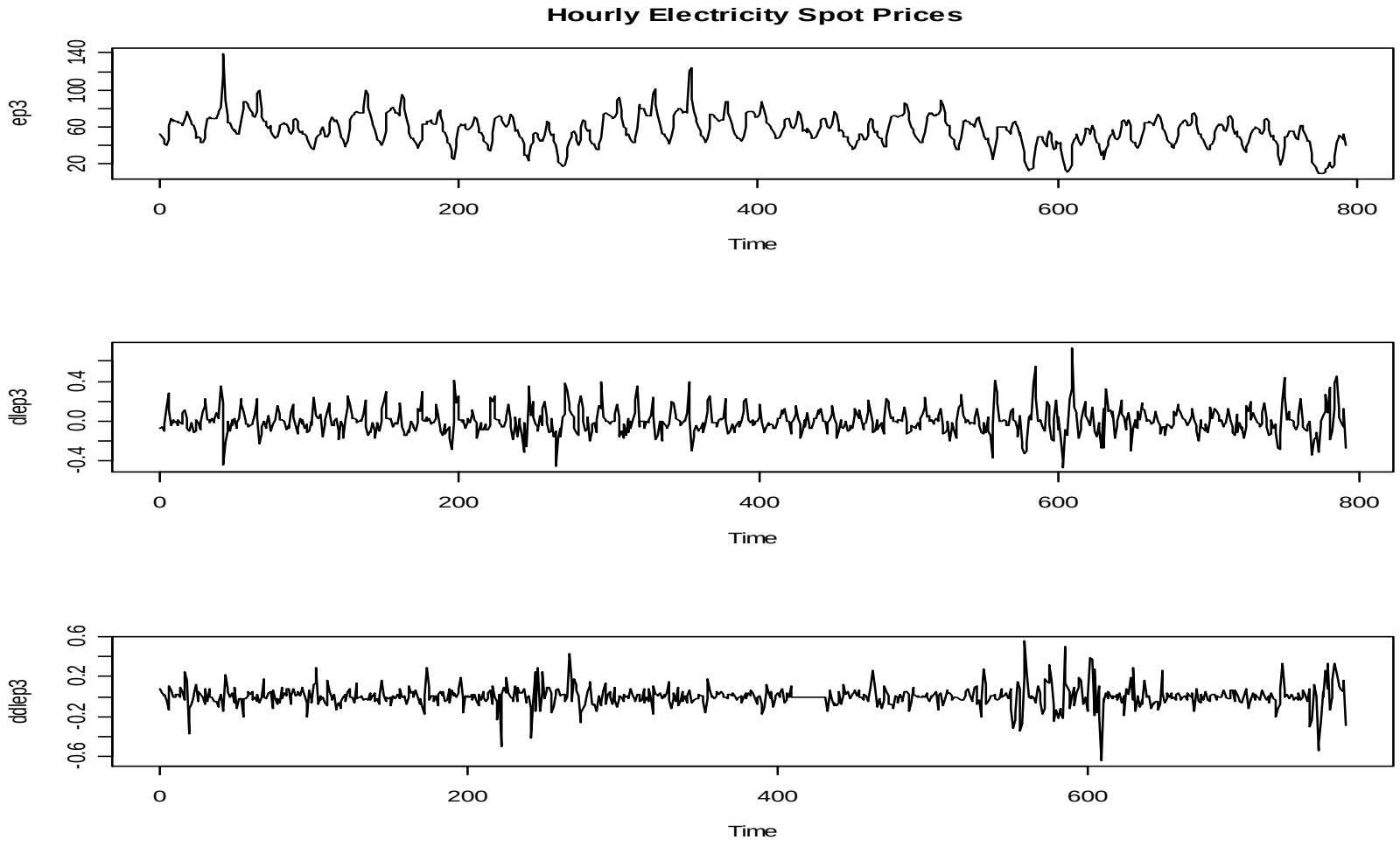
- To test the adequacy of various models for the Electricity spot prices

- To check whether the TAR model is better than AR model

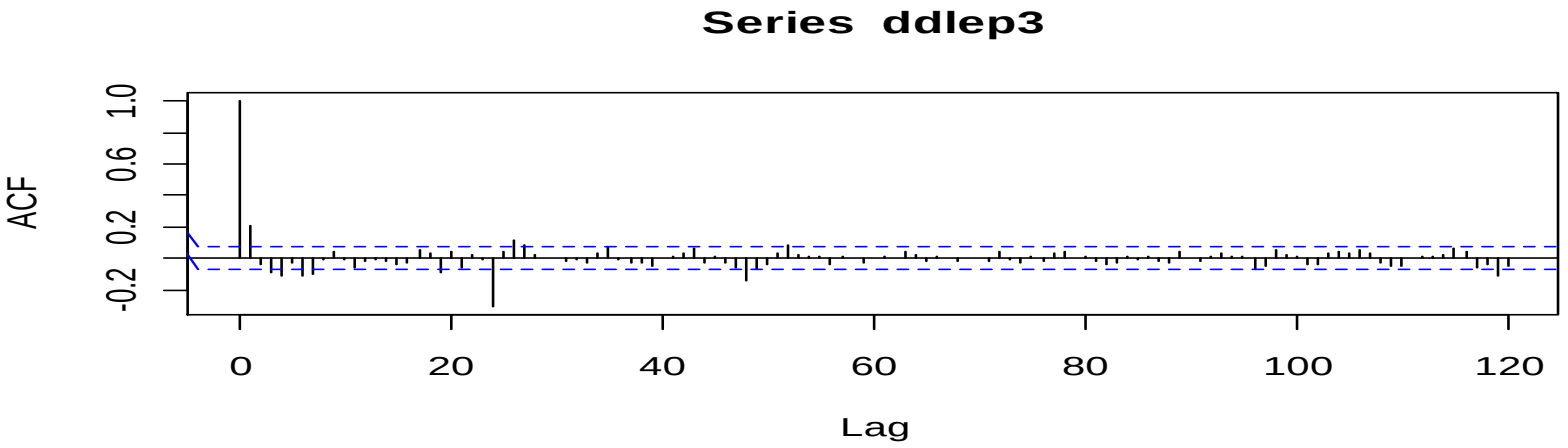
# Data(1/3)

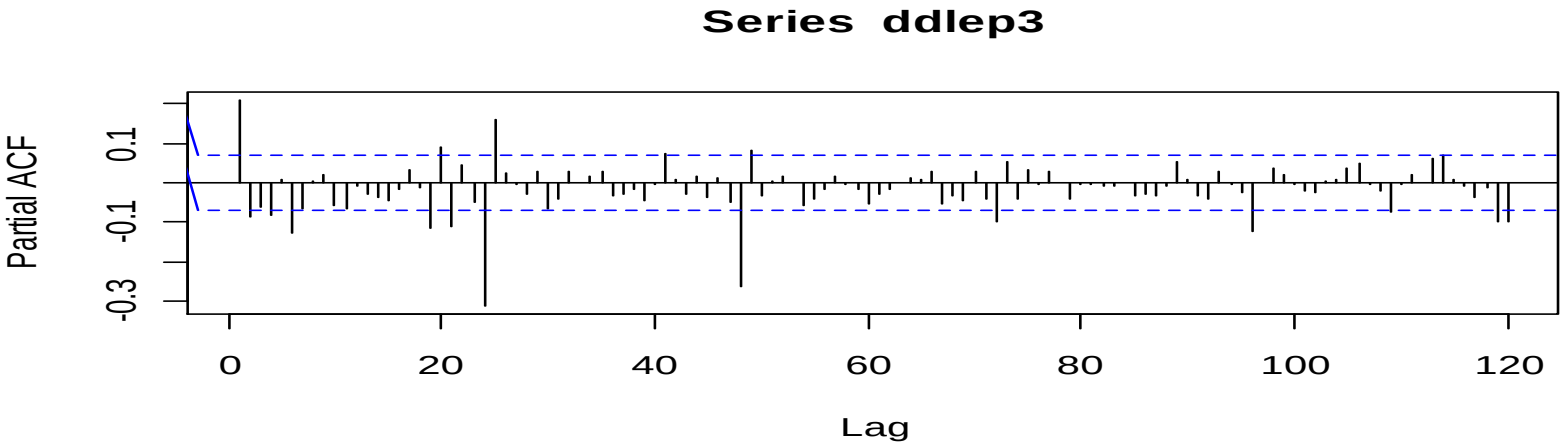
- European Energy Exchange (EEX)
- Electricity spot prices
- The spot is an hourly contract
- The 24 hourly spot prices are determined in a daily auction
- From Dec. 1, 2010 to Jan. 2, 2011
- €/MWh
- Sample size: 792

# Data(2/3)


Hourly Electricity Spot Prices
ep3
20
60
100
140
0
200
400
600
800
Time
dlep3
-0.4
0.0
0.4
0
200
400
600
800
Time
ddlep3
-0.6
-0.2
0.2
0.6
0
200
400
600
Time

# Data(3/3)


Series ddlep3
ACF
1.0
0.6
0.2
-0.2
0
20
40
60
80
100
120
Lag


Series ddlep3
Partial ACF
0.1
-0.1
-0.3
0
20
40
60
80
100
120
Lag

# The Proposal Model(1/2)

- AR(m) model

$$x_t = \phi + \phi_0 x_t + \phi_1 x_{t-1} + \cdots + \phi_m x_{t-m} + \omega_t$$

- Threshold Autoregressive (TAR) model

$$x_t = \phi_0^{(j)} + \phi_1^{(j)} x_{t-1} + \cdots + \phi_p^{(j)} x_{t-p} + \omega_t^{(j)}, \text{if } \gamma_{j-1} < x_{t-d} < \gamma_j$$

# The Proposal Model(2/2)

A time series $x_t$ is said to follow a k-regime self-exciting TAR (SETAR) model with threshold variable $x_{t-d}$ if It satisfies $x_t = \phi_0^{(j)} + \phi_1^{(j)} x_{t-1} + \cdots + \phi_p^{(j)} x_{t-p} + \omega_t^{(j)}$, if $\gamma_{j-1} < x_{t-d} < \gamma_j$ , where k and d are positive integer, j=1…k, $\gamma_j$ are real numbers

- The parameter d is the delay parameter and $\gamma_j$ are the thresholds
- A SETAR model is a piecewise linear AR models in the threshold space

# Data Analysis(1/8)

- AR(m) model

| m | AIC |
|---|---|
| 1 | -3290.671 |
| 2 | -3554.26 |
| 3 | -3552.532 |
| 4 | -3553.168 |

Based the AIC value, choose m=2

# Data Analysis(2/8)

Non linear autoregressive model

AR model

Coefficients:

| const | phi.1 | phi.2 |
|---|---|---|
| 0.3719748 | 1.4415611 | -0.5350362 |

- The fitted model:

$$\hat{x}_t = 0.372 + 1.442x_{t-1} - 0.535x_{t-2}$$

# Data Analysis(3/8)

- TAR model: The one threshold model case

$$X_t = \begin{cases} \Phi_1 + \Phi_{10} X_{t-d} + \cdots + \Phi_{1L} X_{t-(L-1)d} + \omega_t , z_t \leq th \\ \Phi_2 + \Phi_{20} X_{t-d} + \cdots + \Phi_{2H} X_{t-(H-1)d} + \omega_t , z_t > th \end{cases}$$

Need to set d(thDelay), L(mL), H(mH)

:TAR(d,L,H)

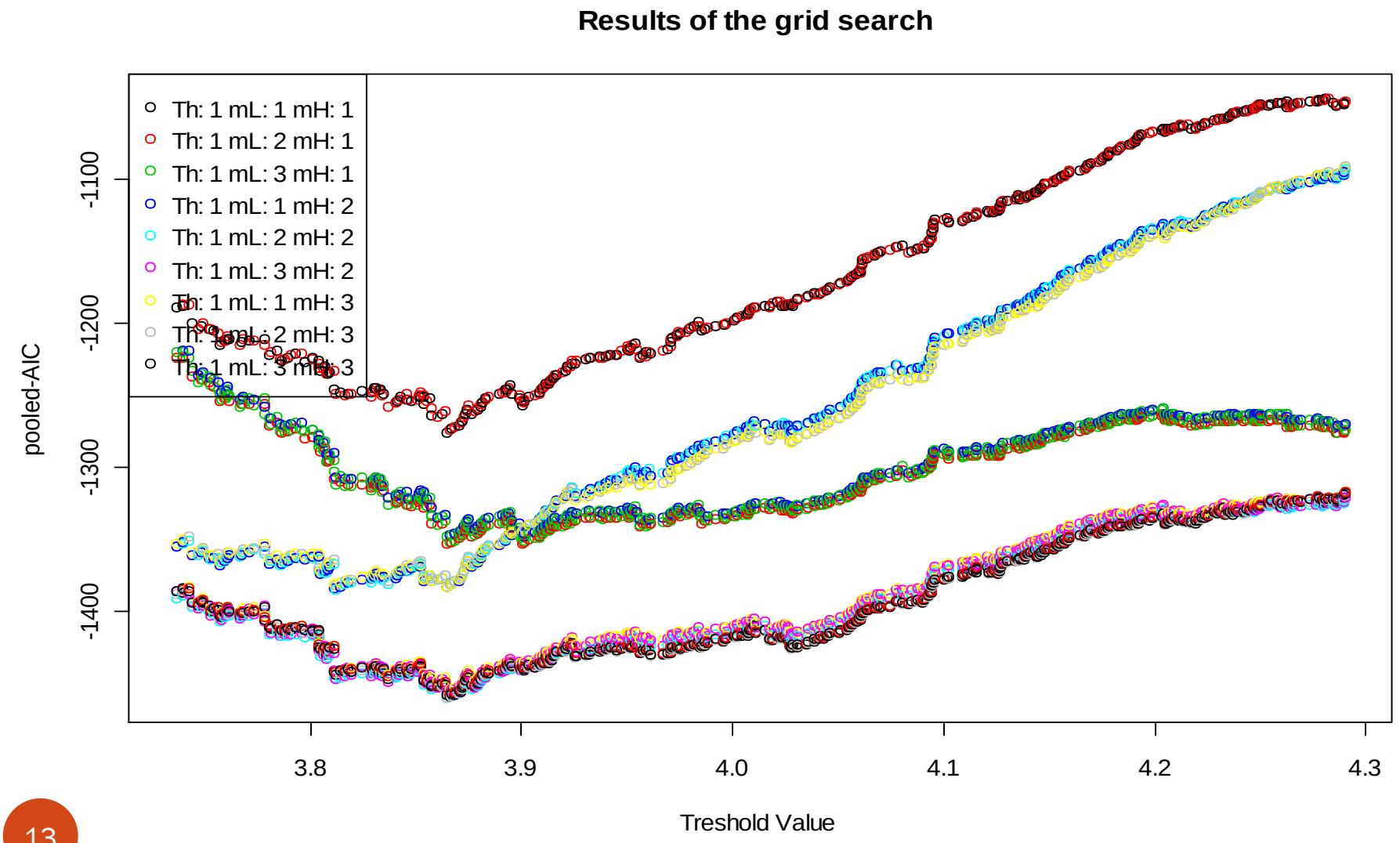
# Data Analysis(4/8)

Results of the grid search for 1 threshold

| | thDelay | mL | mH | th | Pooled-AIC |
|---|---|---|---|---|---|
| 1 | 1 | 2 | 2 | 3.864512 | -1460.304 |
| 2 | 1 | 2 | 3 | 3.864512 | -1460.277 |
| 3 | 1 | 2 | 2 | 3.866816 | -1459.181 |
| 4 | 1 | 2 | 3 | 3.866816 | -1459.043 |
| 5 | 1 | 2 | 2 | 3.866188 | -1459.036 |
| 6 | 1 | 2 | 3 | 3.866188 | -1459.031 |
| 7 | 1 | 3 | 3 | 3.864512 | -1458.593 |
| 8 | 1 | 2 | 2 | 3.868280 | -1458.393 |
| 9 | 1 | 2 | 3 | 3.868280 | -1458.159 |
| 10 | 1 | 3 | 3 | 3.866816 | -1457.350 |

Pooled-AIC=AIC(lowregimemodel) +AIC(highregimemodel)

# Data Analysis(5/8)



# Data Analysis(6/8)

Non linear autoregressive model

SETAR model ( 2 regimes)

Coefficients:

Low regime:

| phiL.1 | phiL.2 | const L |
|---|---|---|
| 1.5126190 | -0.5911899 | 0.3244976 |

High regime:

| phiH.1 | phiH.2 | const H |
|---|---|---|
| 1.3446171 | -0.4110457 | 0.2560902 |

# Data Analysis(7/8)

Threshold:

-Variable: Z(t) = + (0) X(t)+ (1)X(t-1)

-Value: 3.865 (fixed)

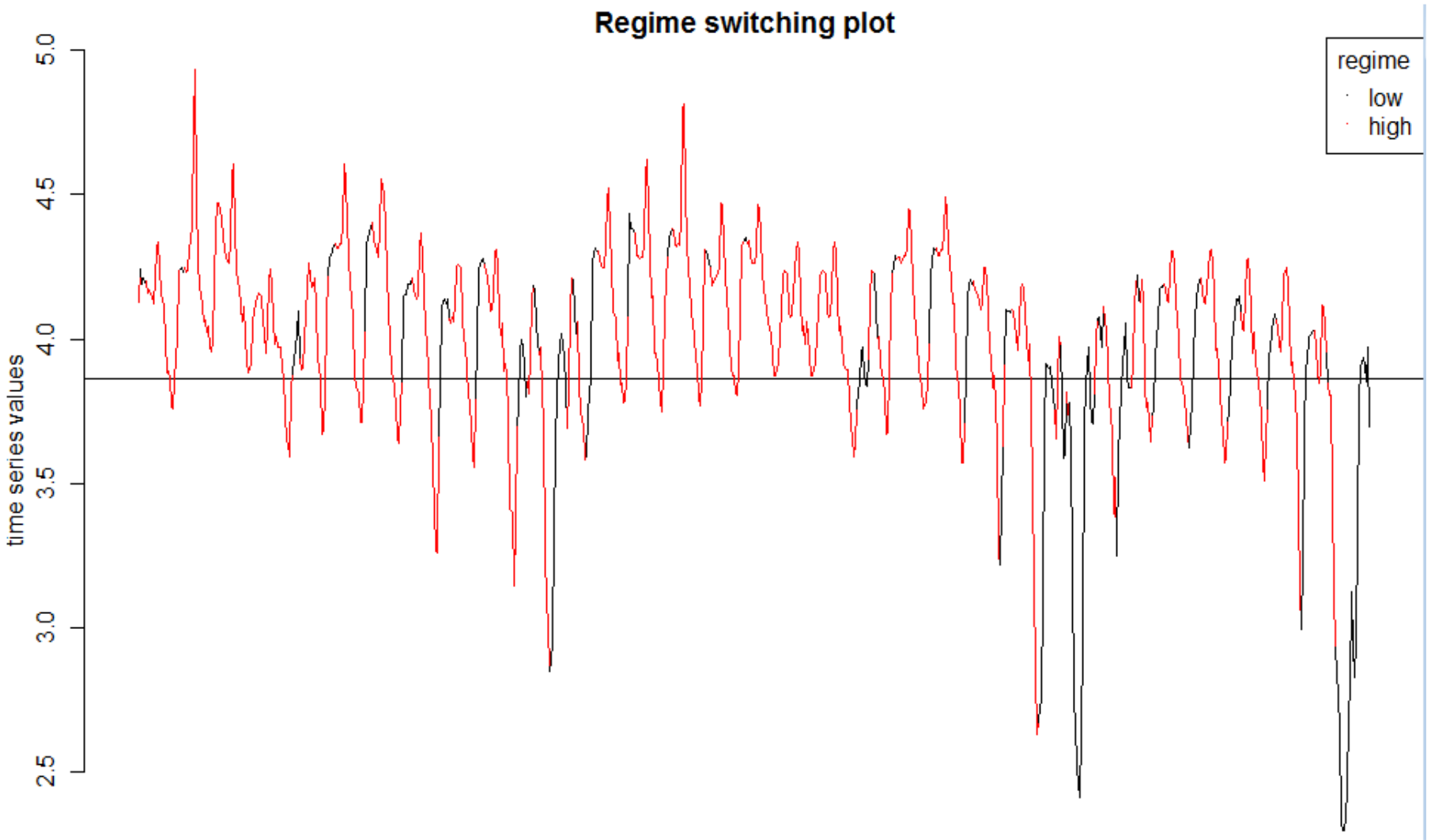
Proportion of points in Low regime: 27.72%

High regime: 72.28%

- The fitted model:

$$\hat{x}_t = \begin{cases} 0.324 + 1.513x_{t-1} - 0.591x_{t-2}, & x_{t-1} \leq 3.865 \\ 0.256 + 1.345x_{t-1} - 0.411x_{t-2}, & x_{t-1} > 3.865 \end{cases}$$

# Data Analysis(8/8)



# Conclusion

- Compare the AIC of AR(2) and TAR(1,2,2)

| | AIC |
|---|---|
| AR(2) | -3554.26 |
| TAR(1,2,2) | -3559.549 |

Based on the above AIC values, TAR model is an improvement to the AR model

We conclude to choose TAR model

# Future Work

- Use TAR models with more than 2 thresholds to fit data

- Try other nonlinear models like LSTAR model, Neutral Network model, Additive Autoregressive(AAR) model… to fit the data. To see if there exists any improvement.

# Reference

- www.eex.com/en
- www.r-project.org (To search the needed package)

Thanks for your listening!