

# Séries temporais

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Rodrigo Cunha

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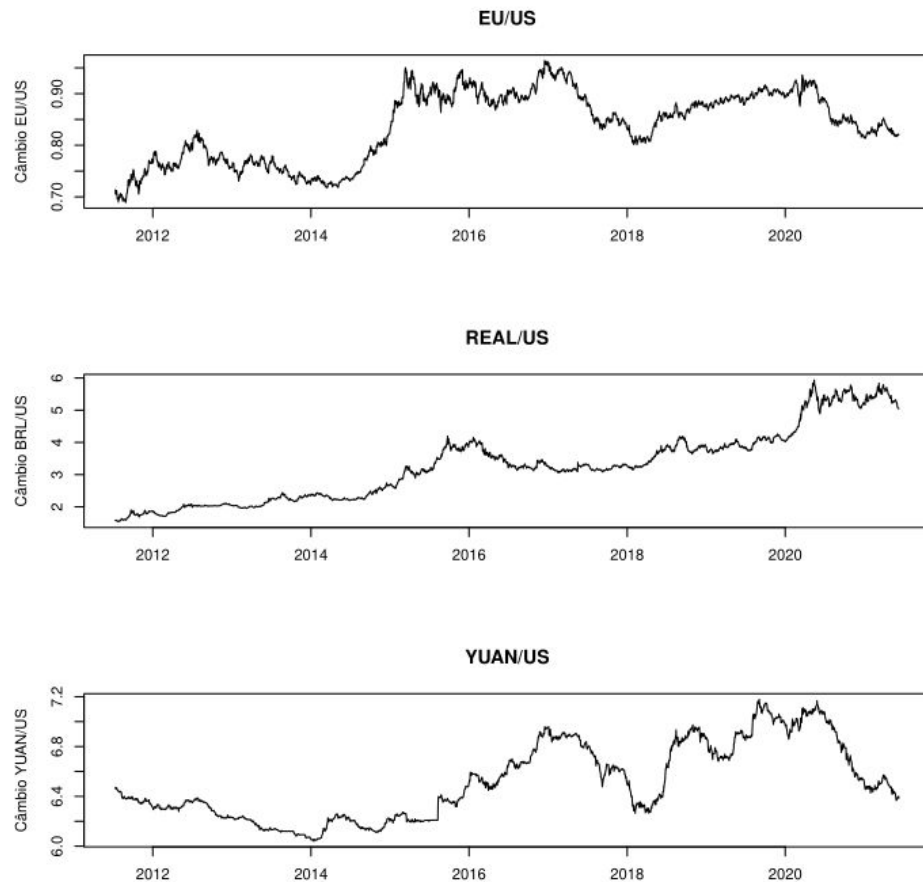
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Espectro cruzado

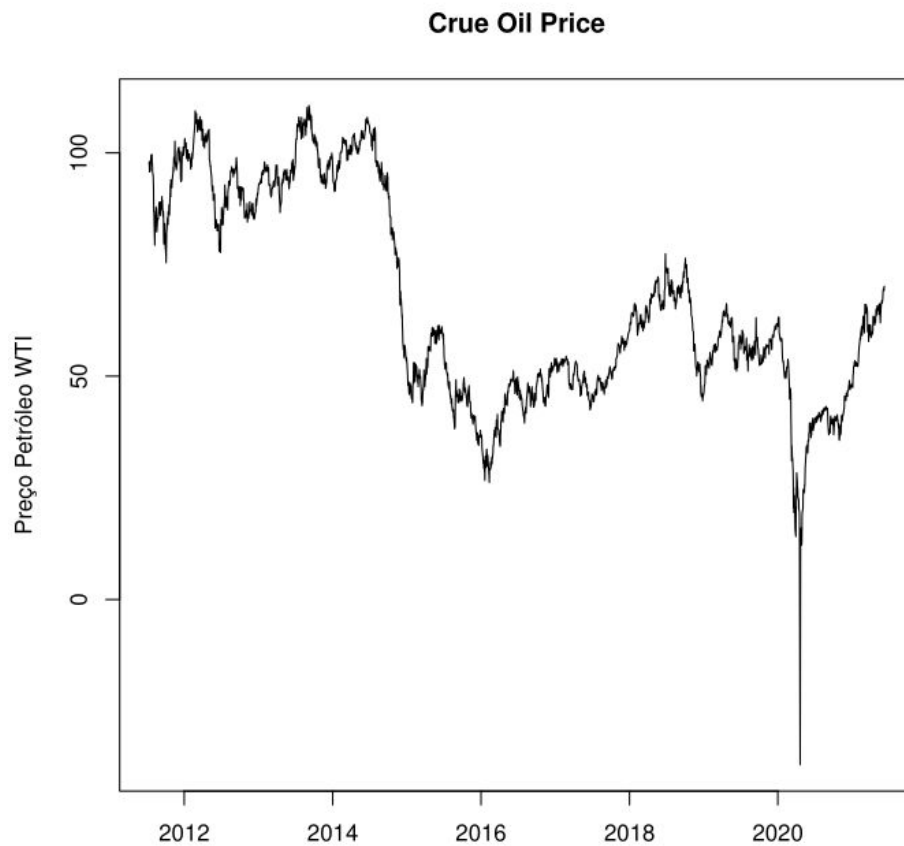
Lagged Regression

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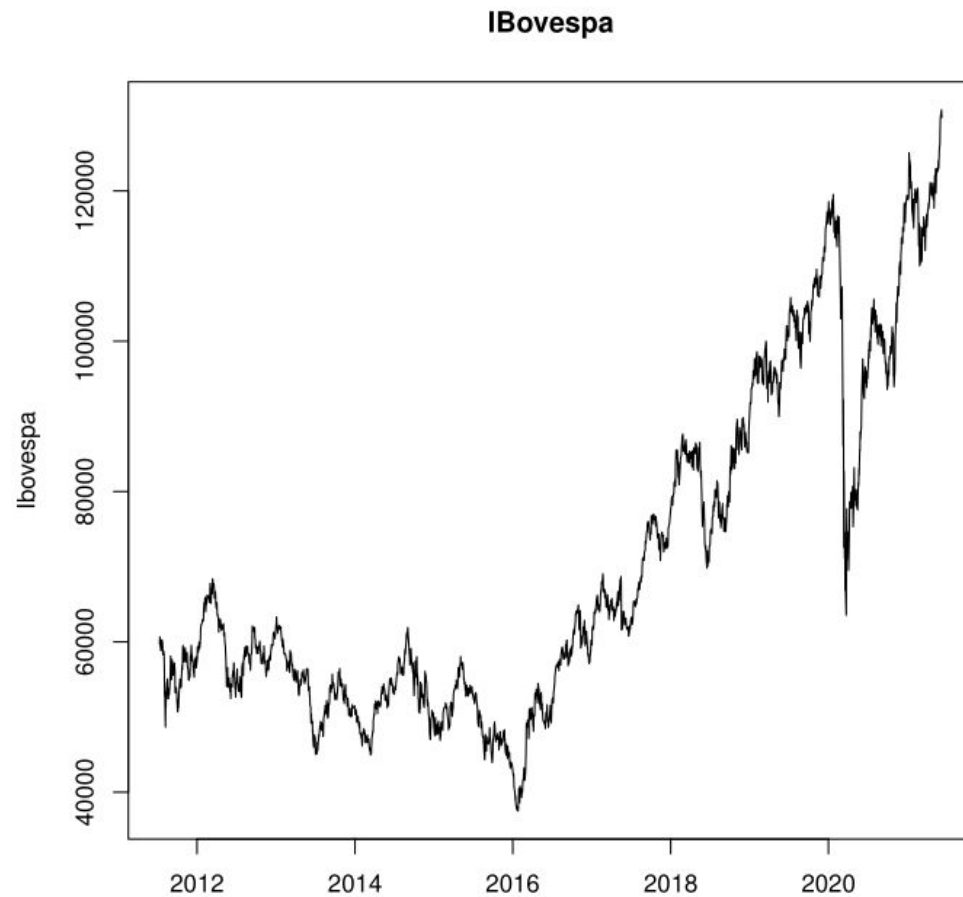
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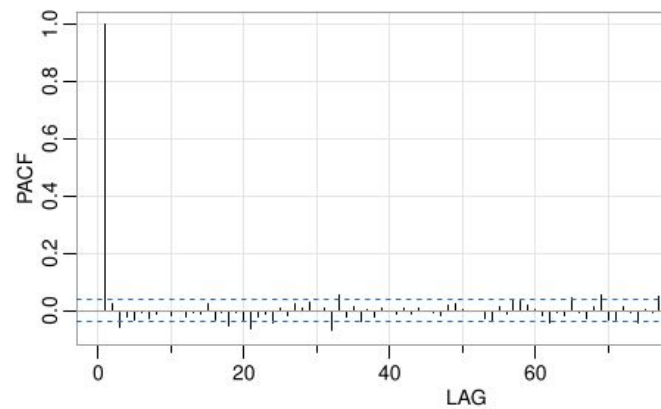
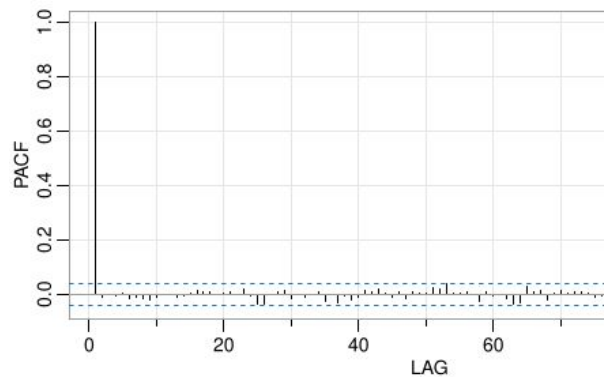
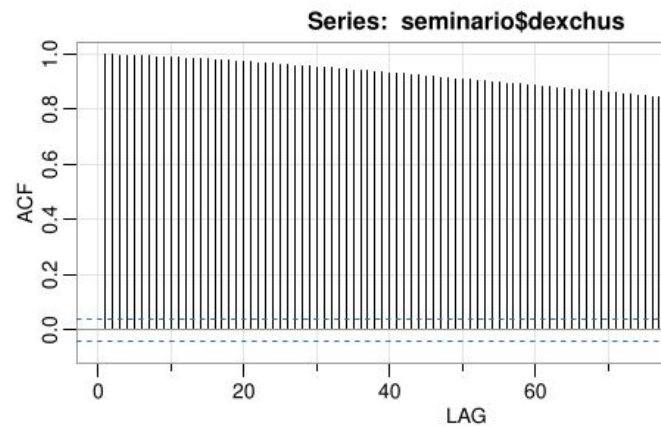
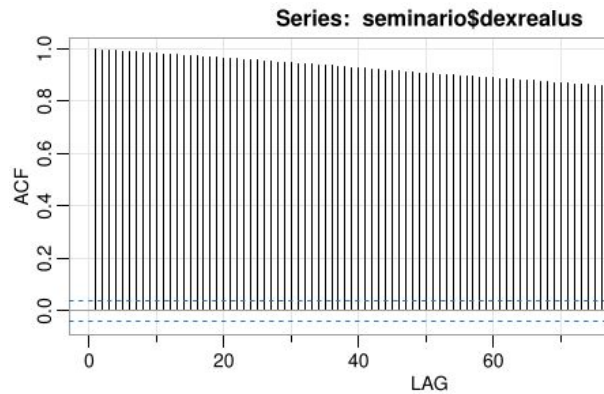
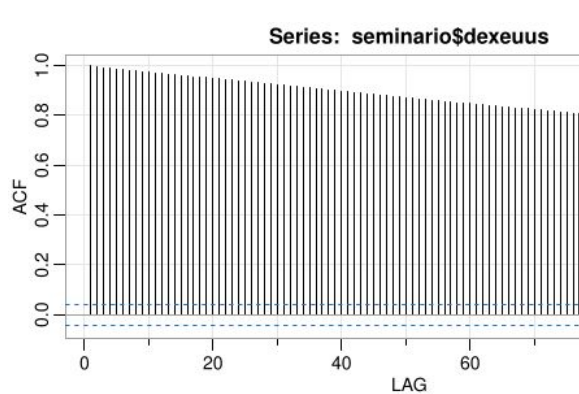
# Petróleo Cru



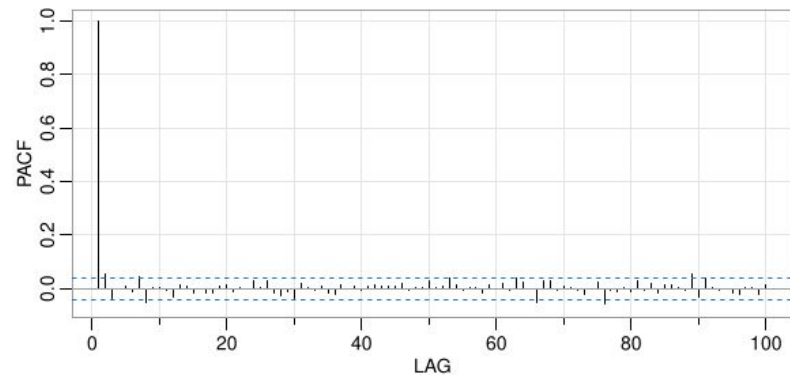
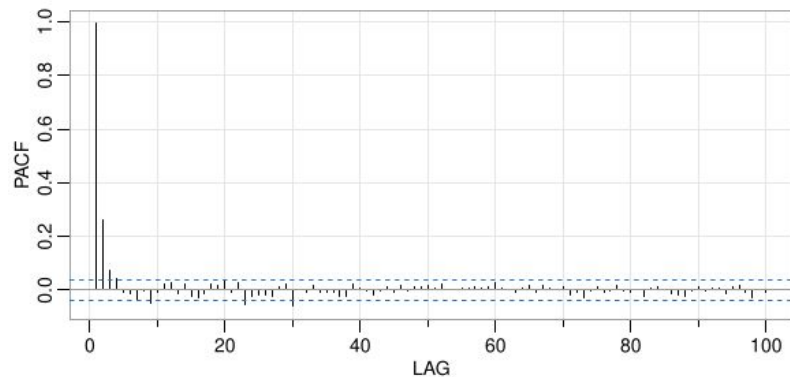
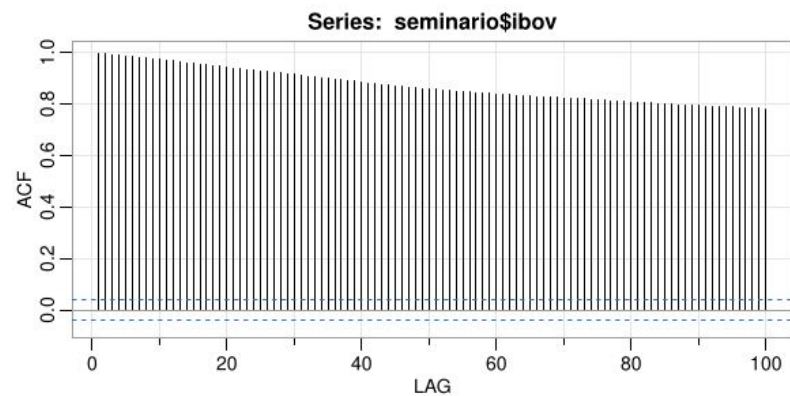
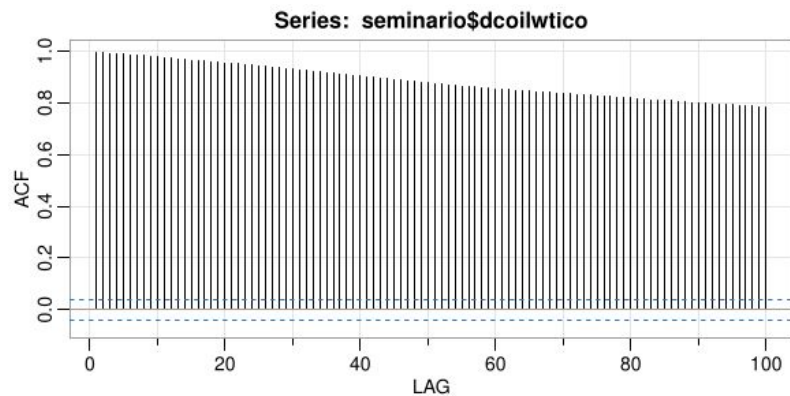
# Ibovespa



# Estacionariedade



# Estacionariedade





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# Diferenciação

$$\nabla x_t = x_t - x_{t-1}$$

- Transformar séries em estacionárias

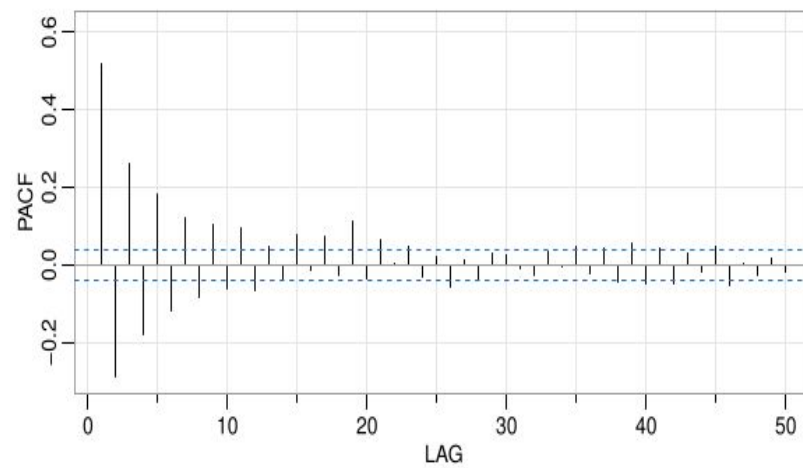
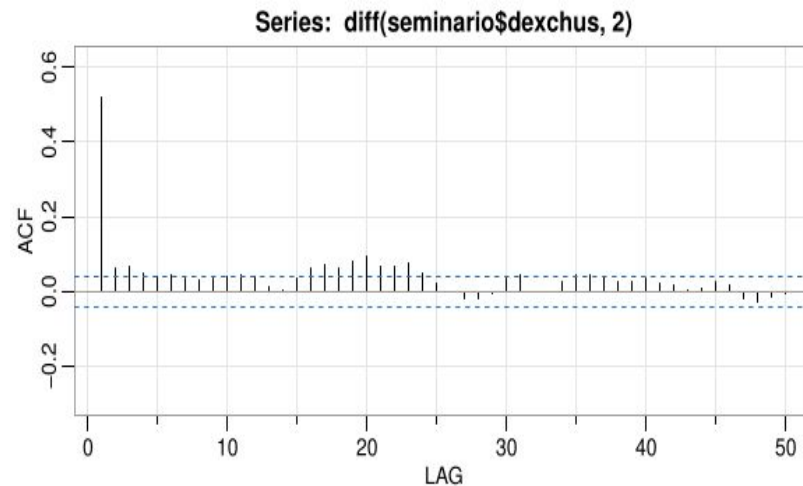
## 3.2 Difference Equations

The study of the behavior of ARMA processes and their ACFs is greatly enhanced by a basic knowledge of difference equations, simply because they are difference equations.

# ACF/PACF

Modelo proposto:

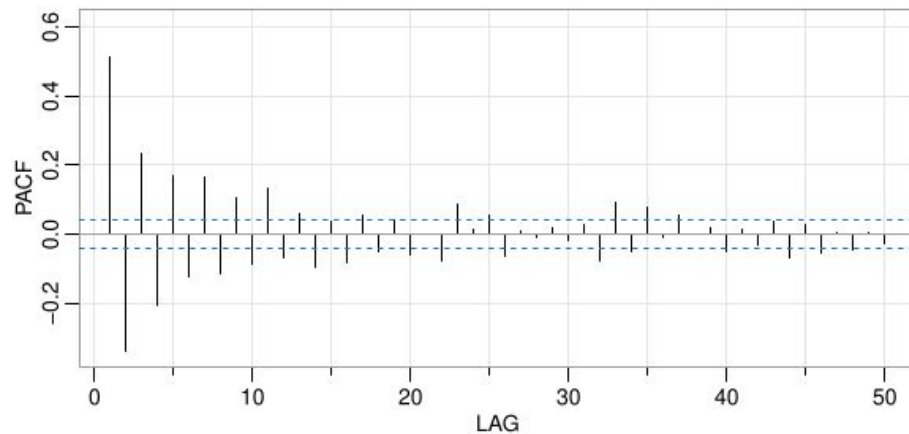
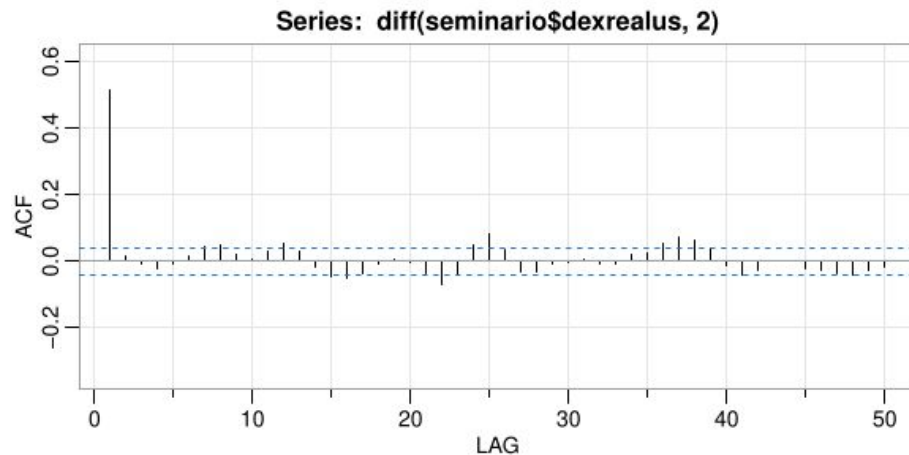
ARIMA(0,2,1)



# ACF/PACF

Modelo proposto:

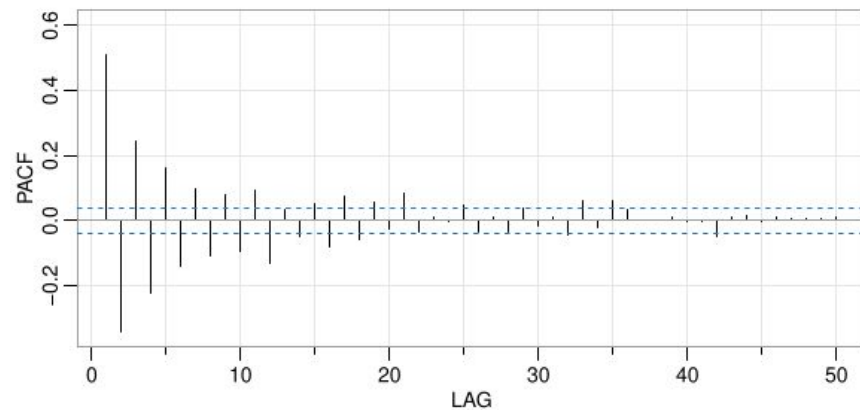
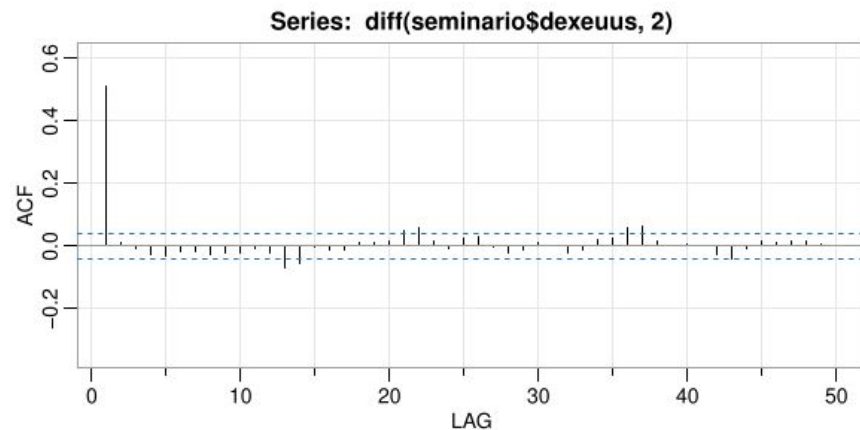
ARIMA(0,2,1)



# ACF/PACF

Modelo proposto:

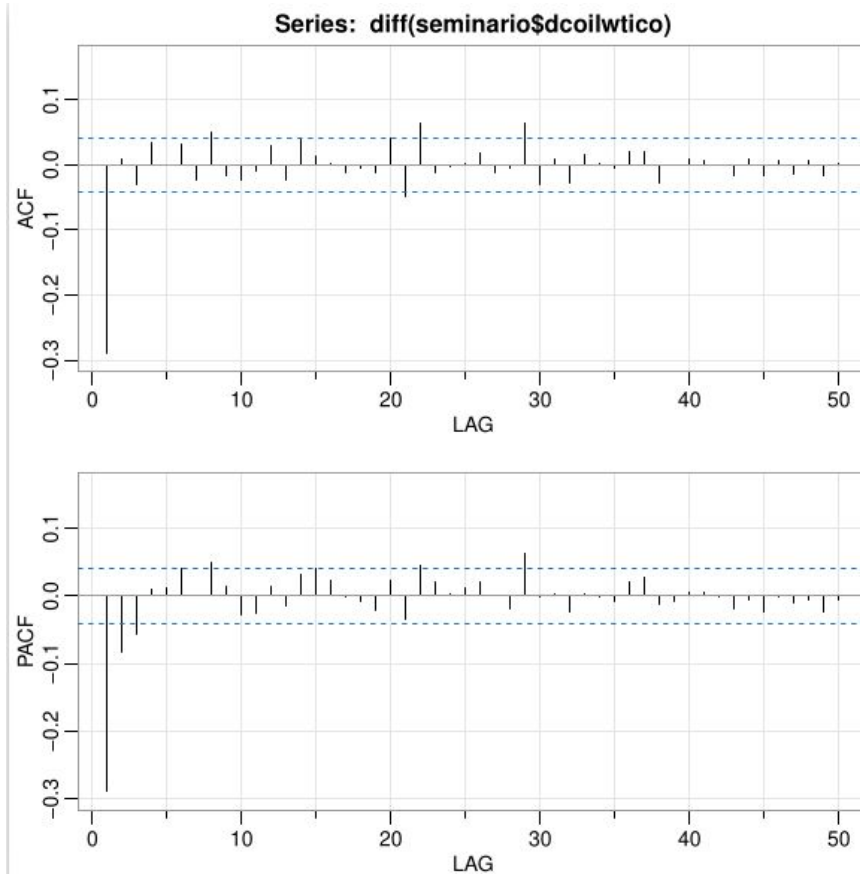
ARIMA(0,2,1)



# ACF/PACF

Modelo proposto:

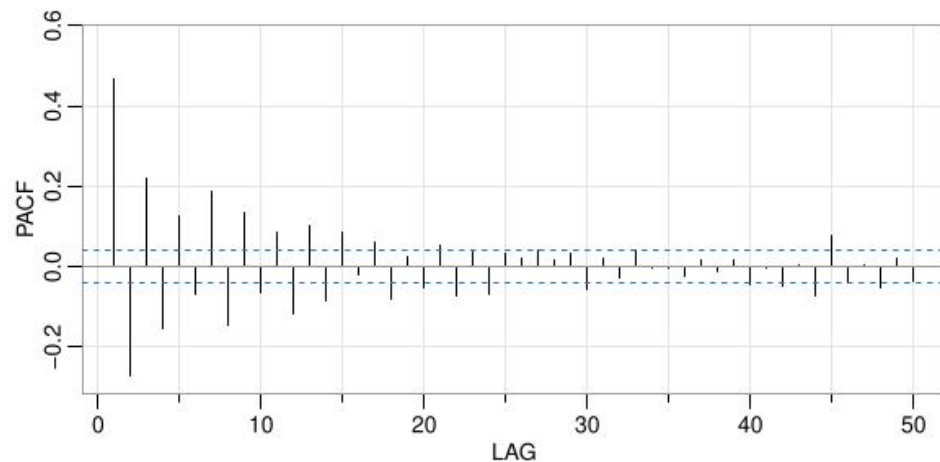
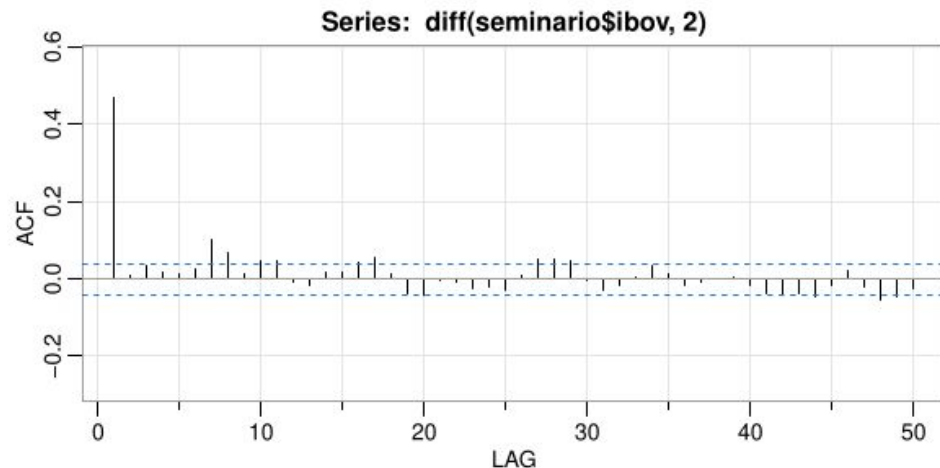
ARIMA(0,1,1)



# ACF/PACF

Modelo proposto:

ARIMA(0,2,1)



# Ordem dos modelos

Identificação

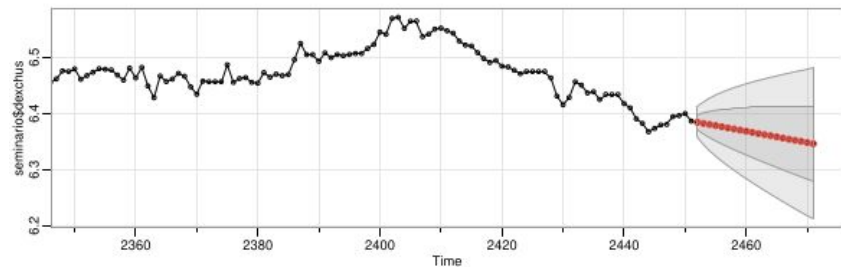
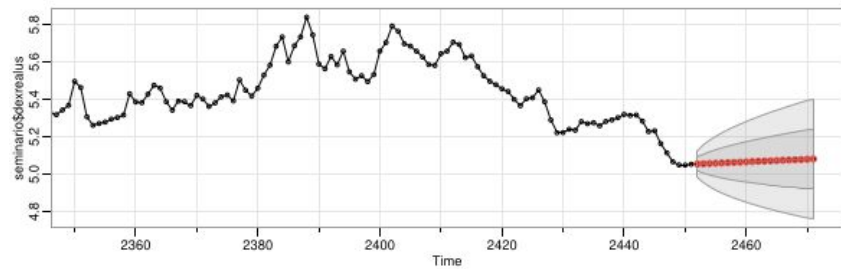
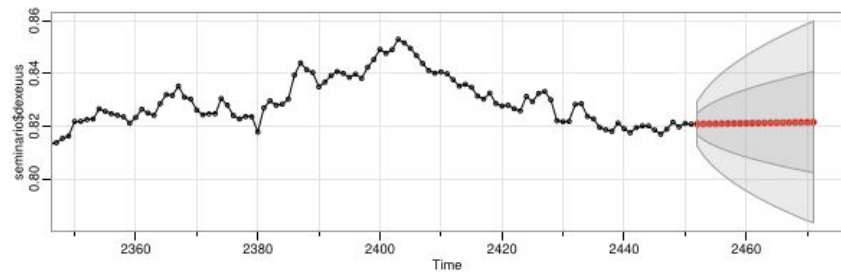
	p	d	q
Euro	0	2	1
Real	0	2	1
Yuan	0	2	1
WTI	0	1	1
Ibov	0	2	1

auto.arima()

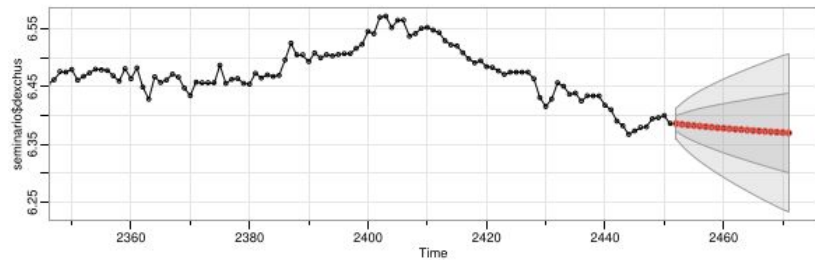
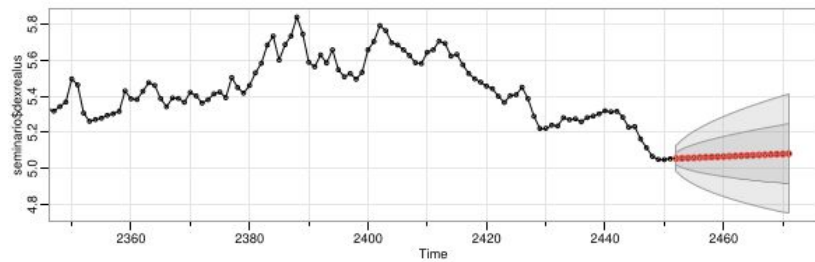
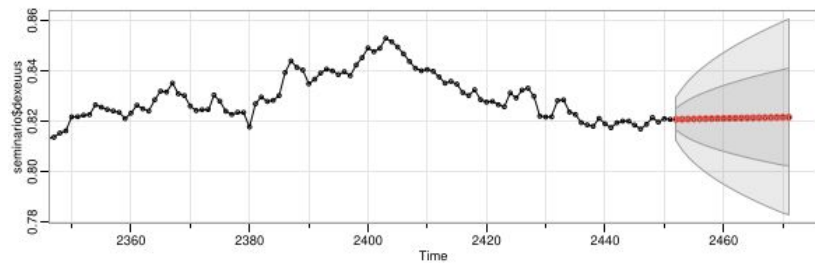
	p	d	q
Euro	1	1	0
Real	1	1	0
Yuan	1	1	3
WTI	0	1	1
Ibov	4	1	1



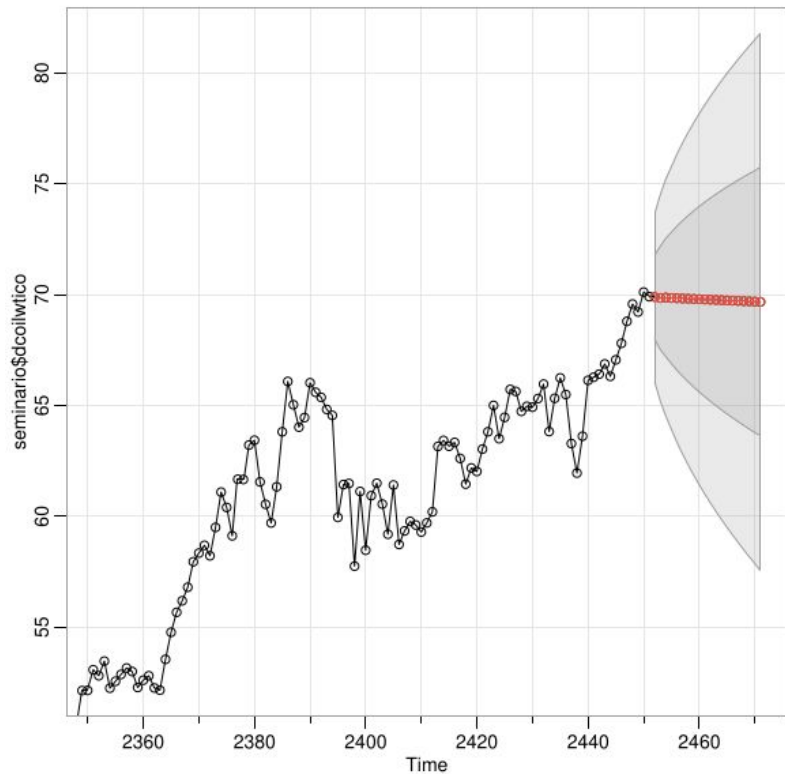
# Previsão



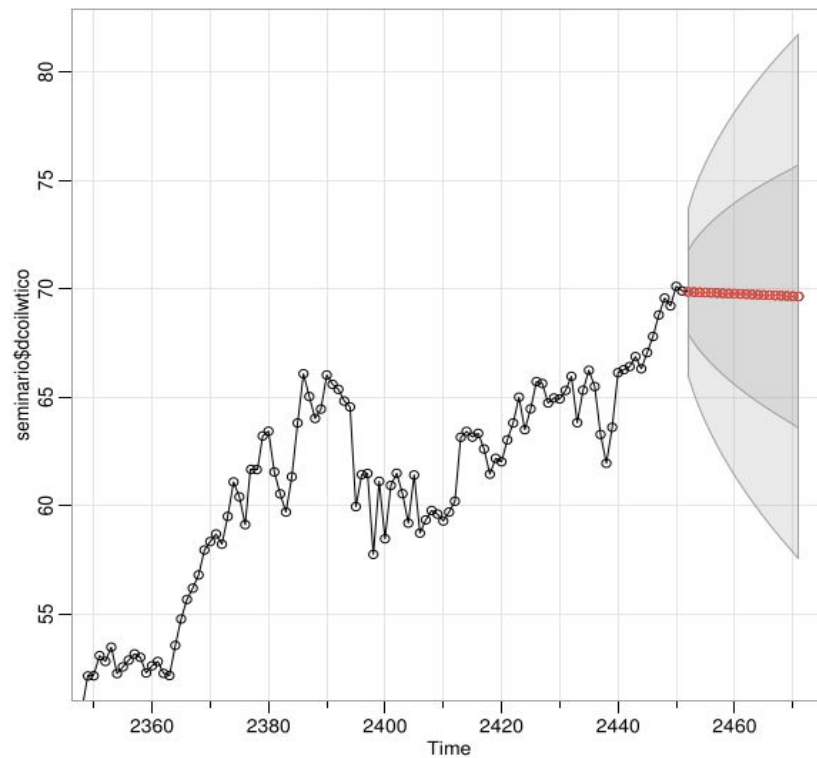
auto.arima



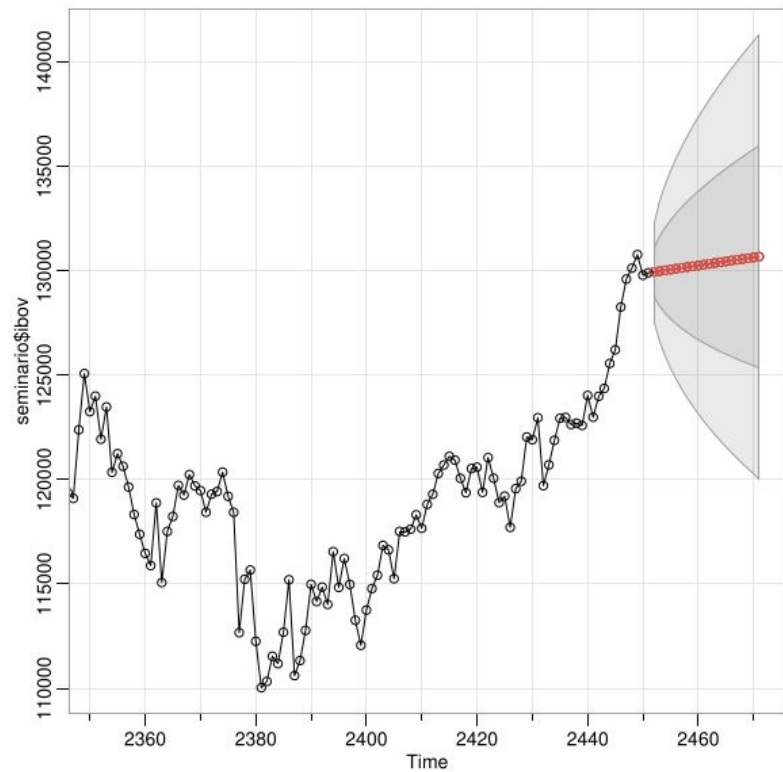
# Previsão



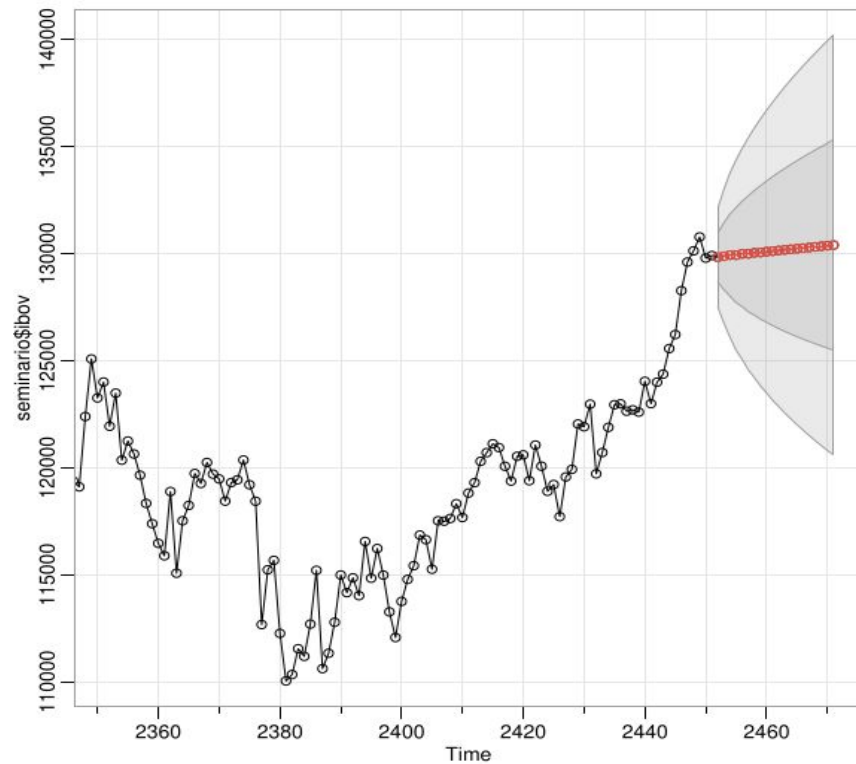
auto.arima



# Previsão



auto.arima



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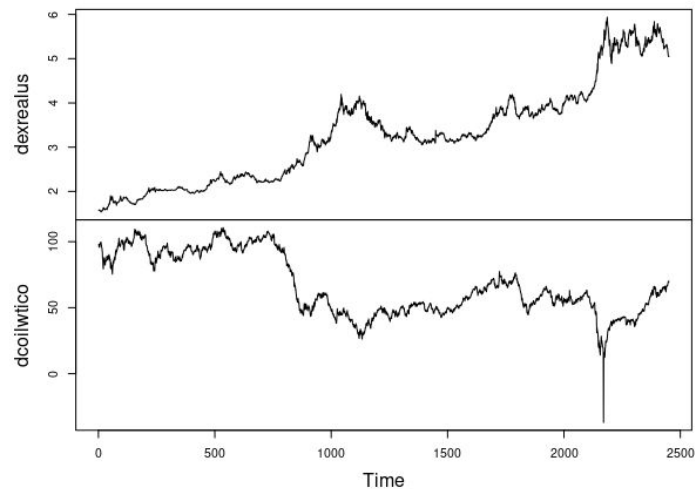
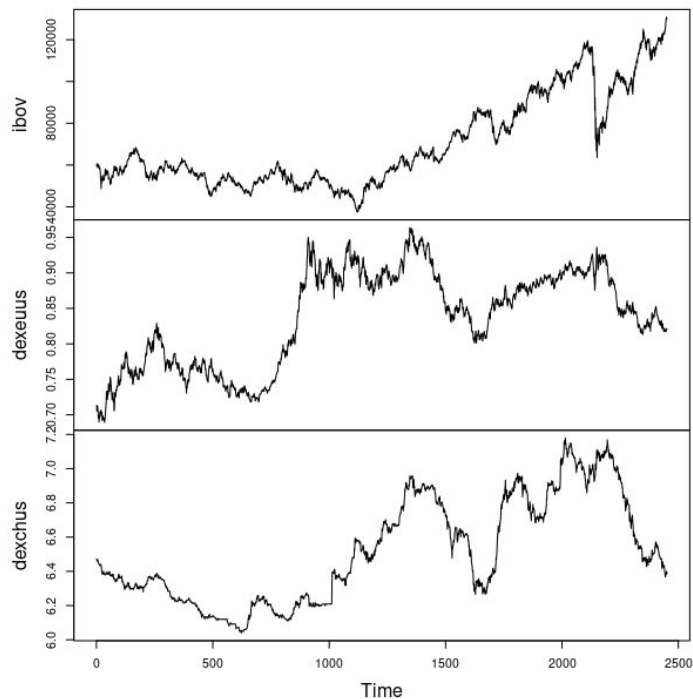
Espectro cruzado

Lagged Regression

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# Visualização dos Dados

## Análise de Séries Financeiras

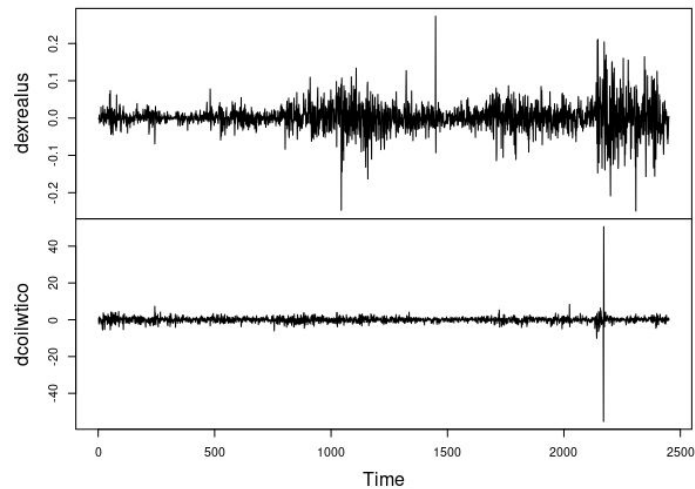
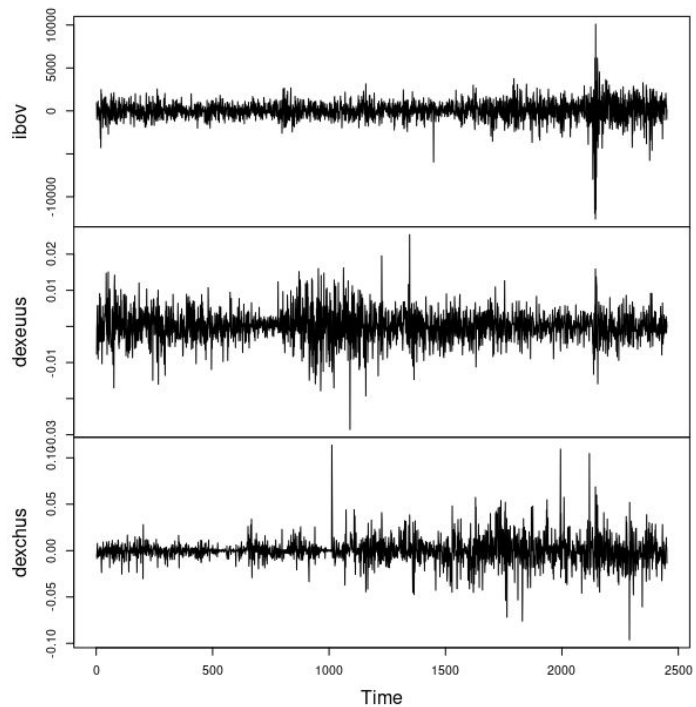


## Fontes (2011 ~ 2021)

- REAL/US: <https://www.bcb.gov.br/estatisticas/>
- Demais: [FRED \(Federal Reserve Economic Data\)](https://fred.stlouisfed.org/)

# Transformação

Séries Diferenciadas



# Parâmetros escolhidos

$N = 2451$  observações

$H = 31$  dias

$L = 401$

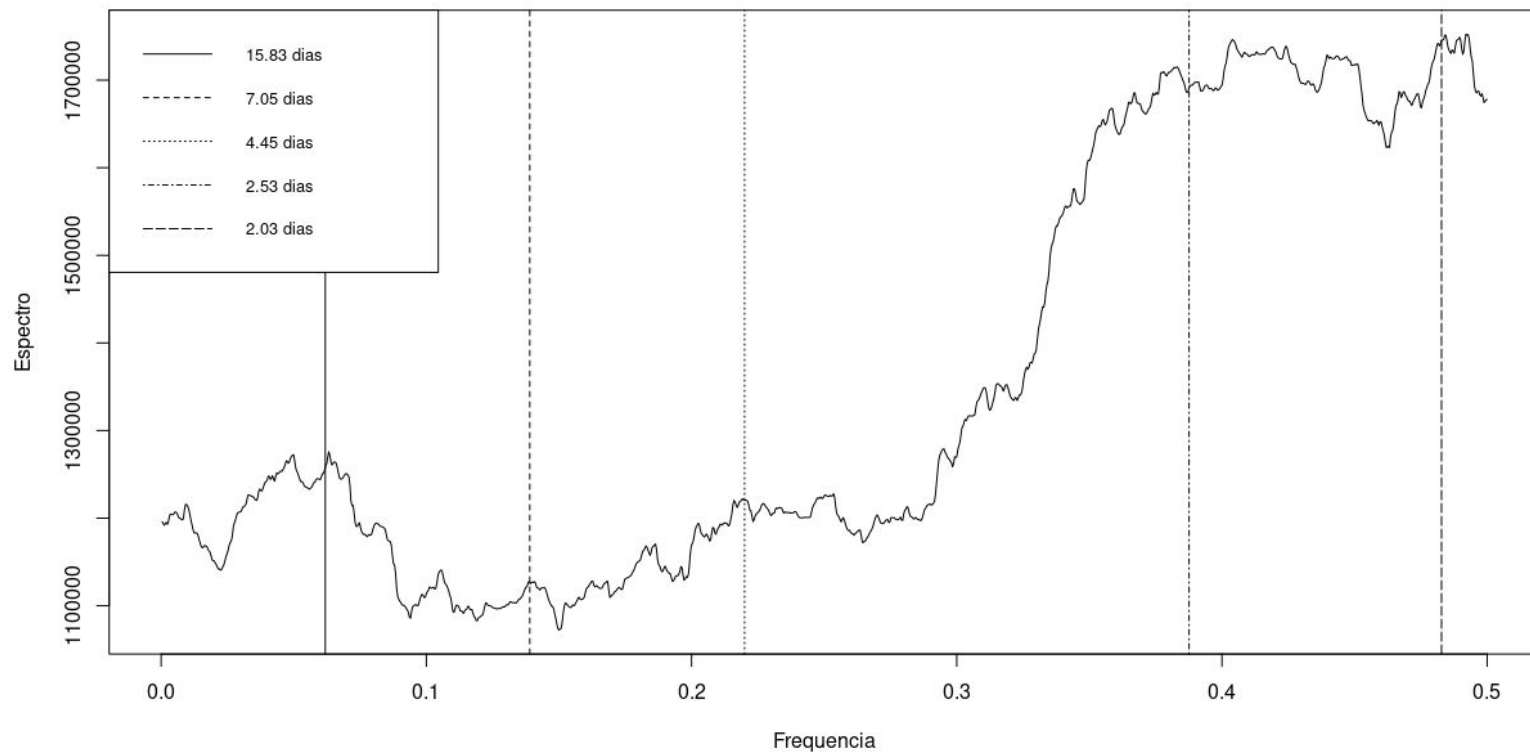
$M = 800$

Taper = 0.1

Objetivo: *prever IBovespa*

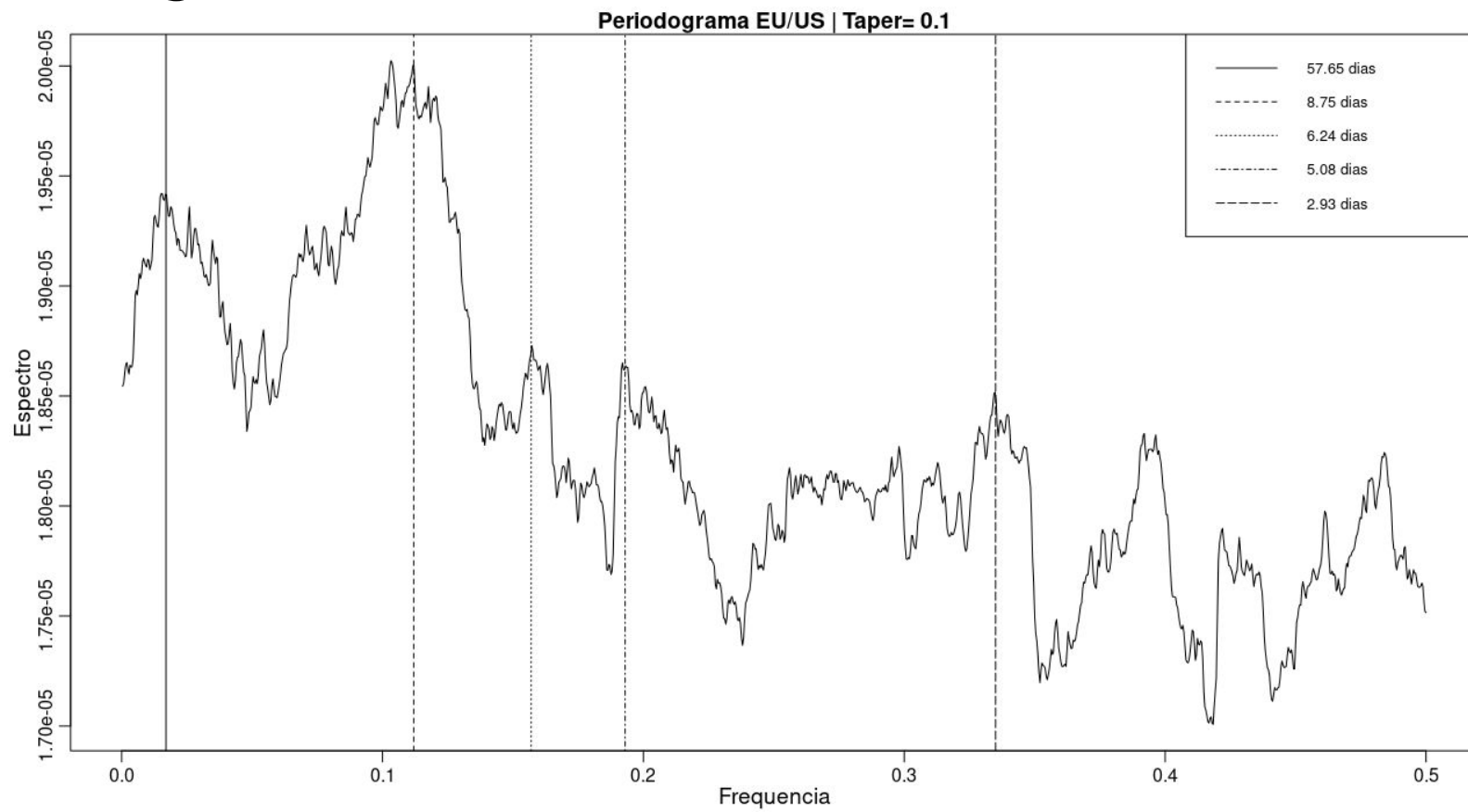
# Períodogramas

Periodograma IBovespa | Taper= 0.1

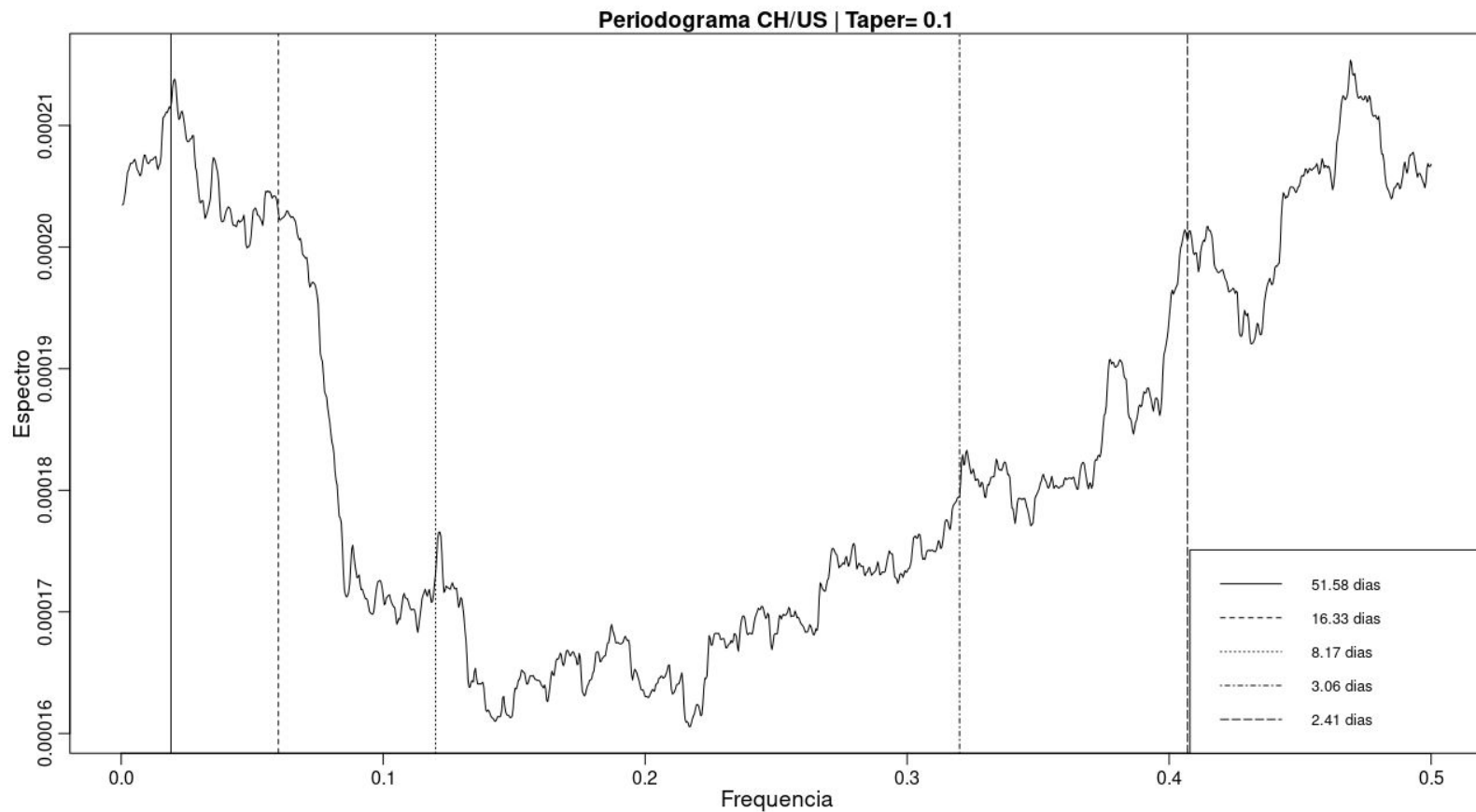




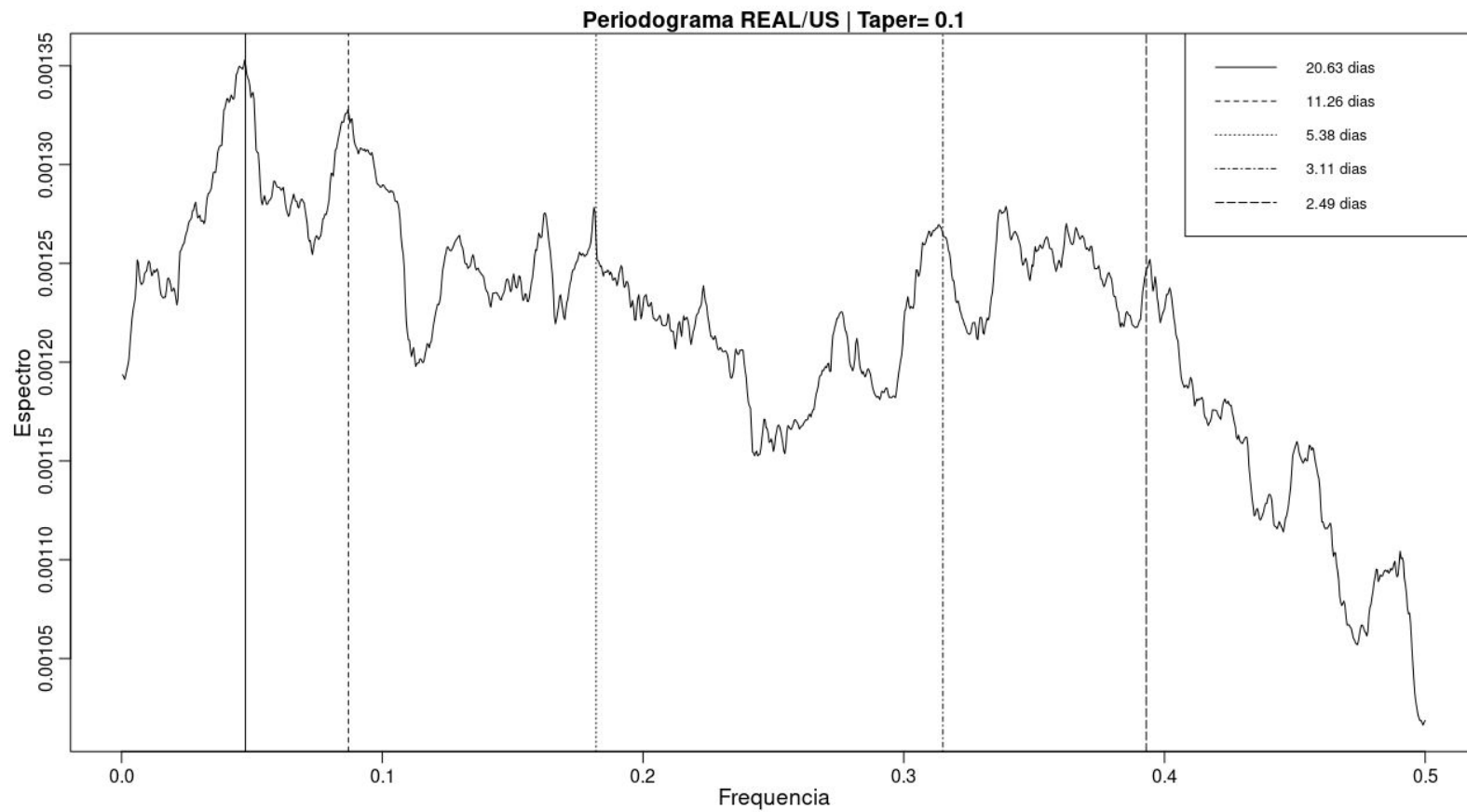
# Períodogramas



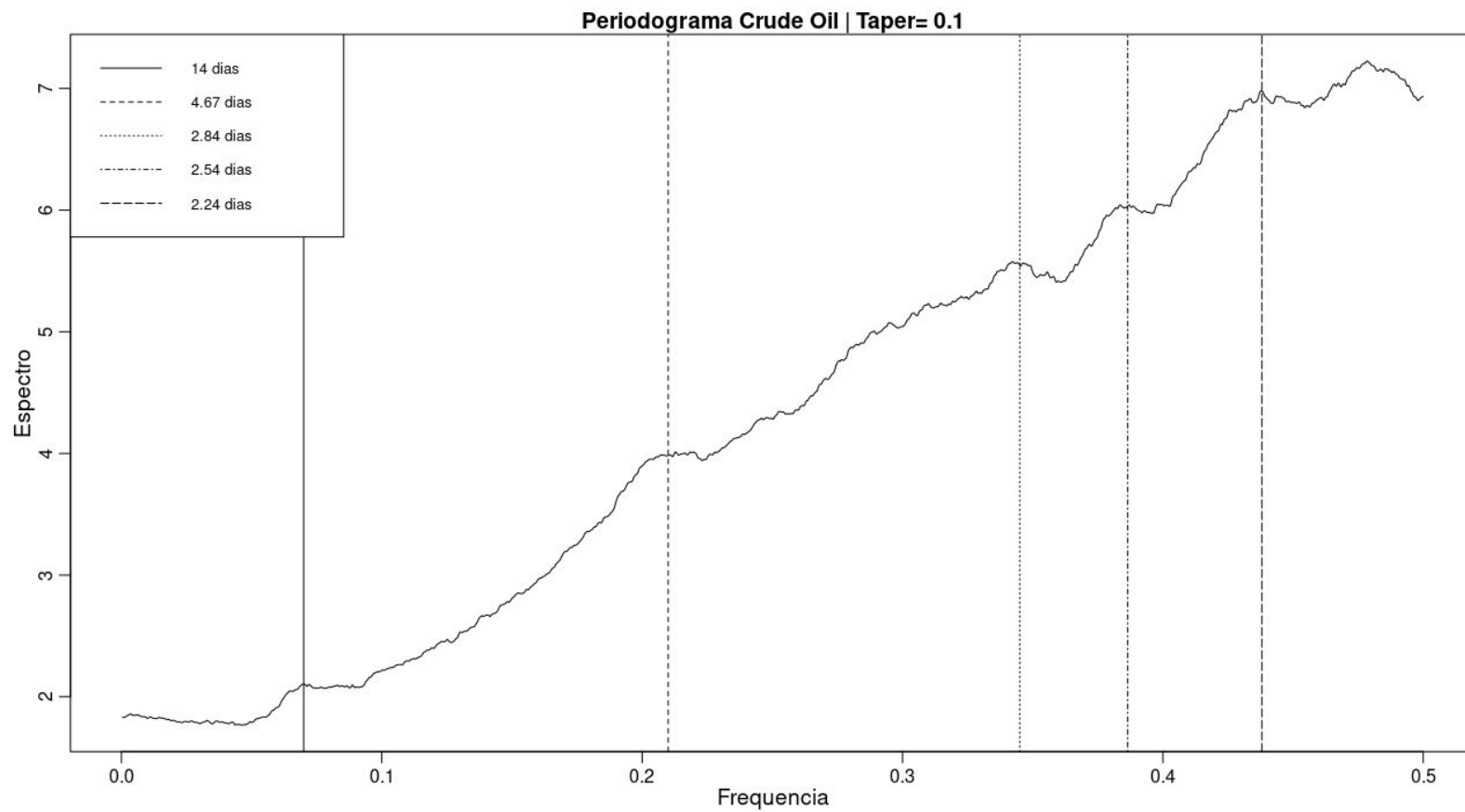
# Períodogramas



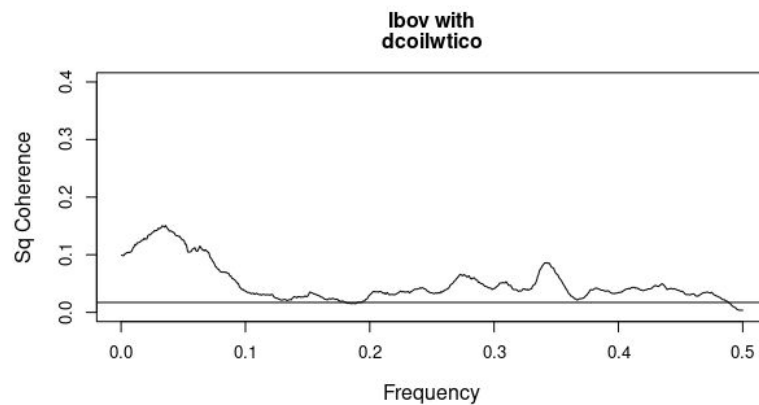
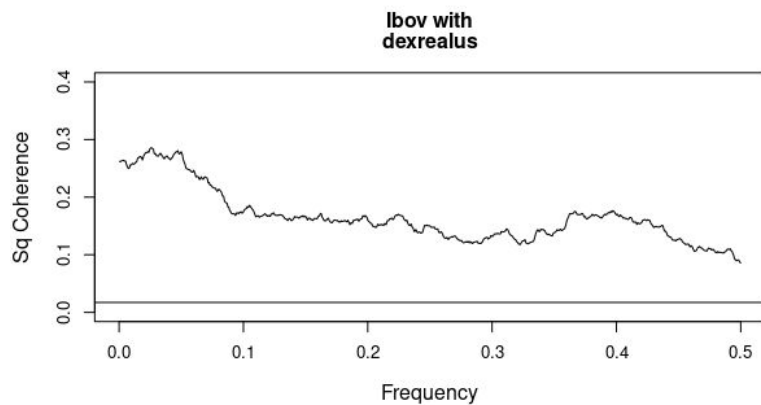
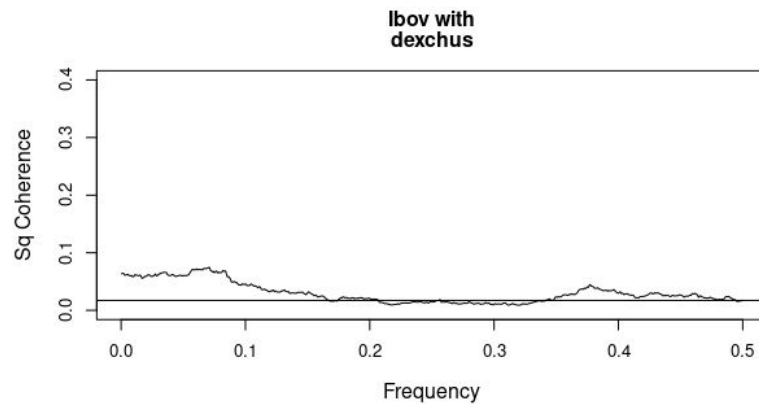
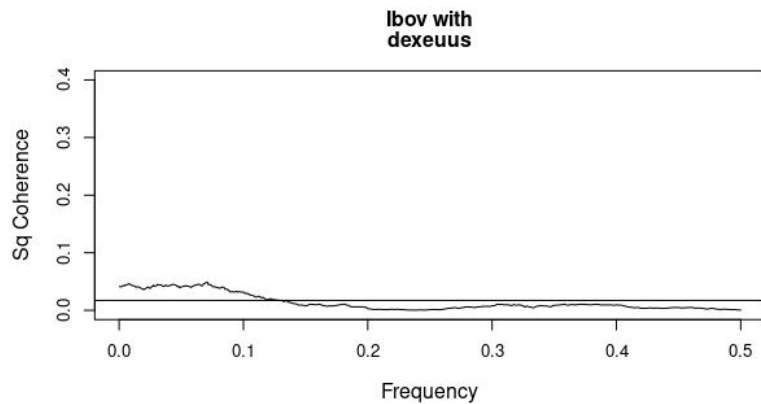
# Períodogramas



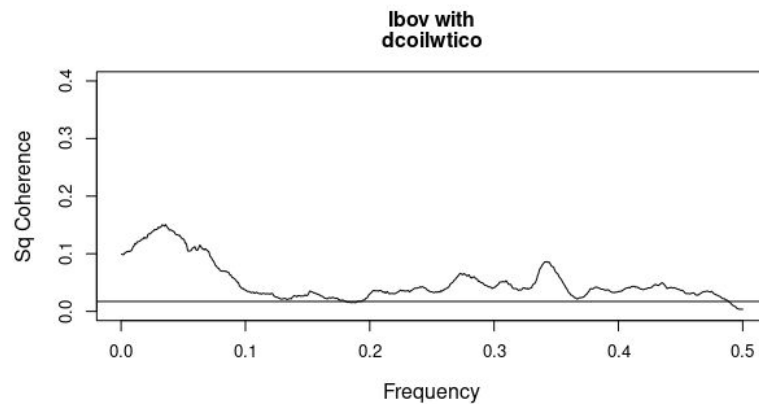
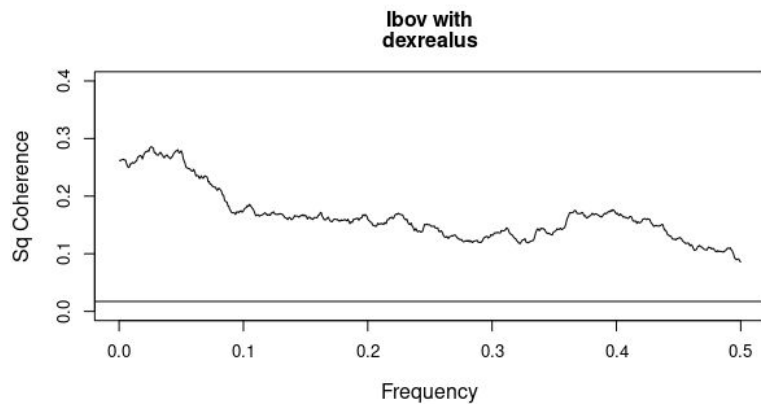
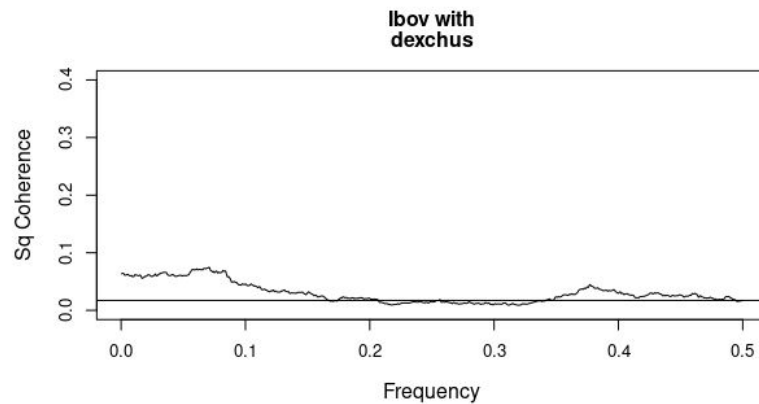
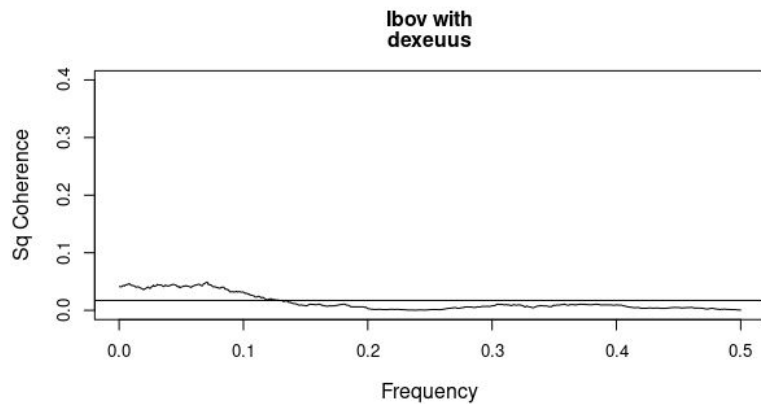
# Períodogramas



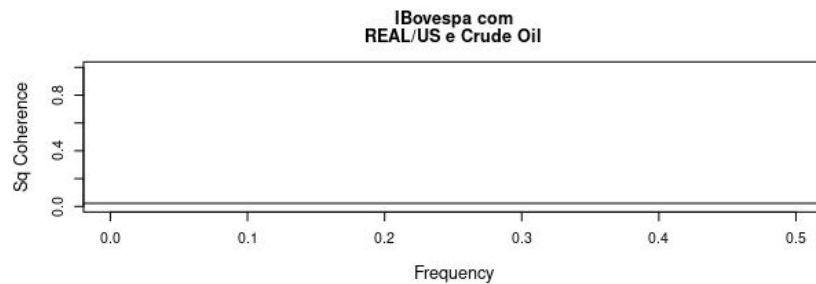
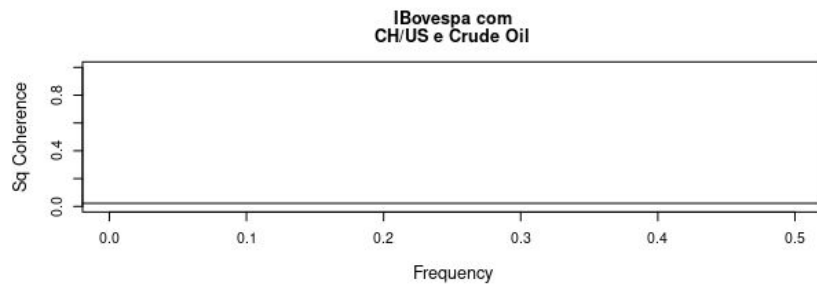
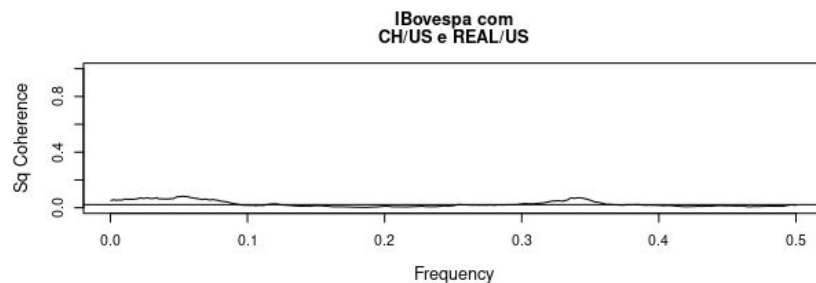
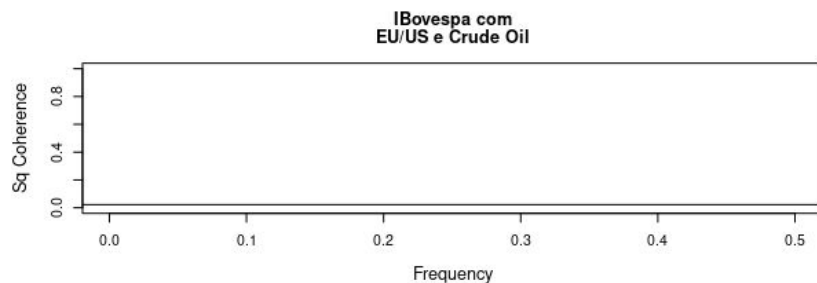
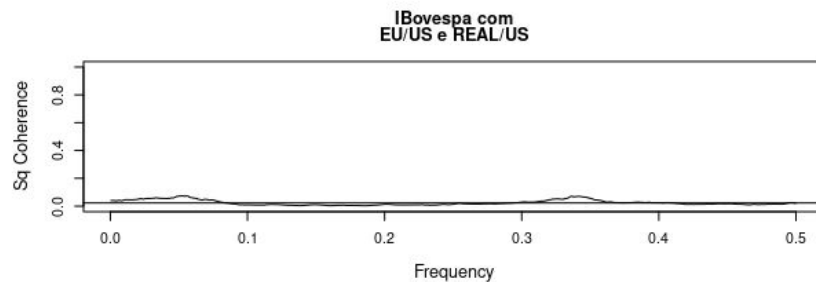
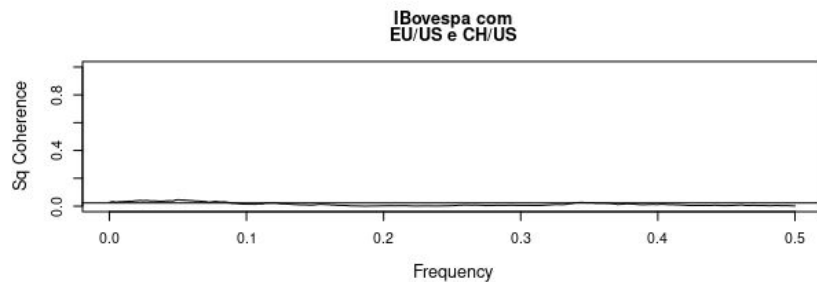
# Coerência



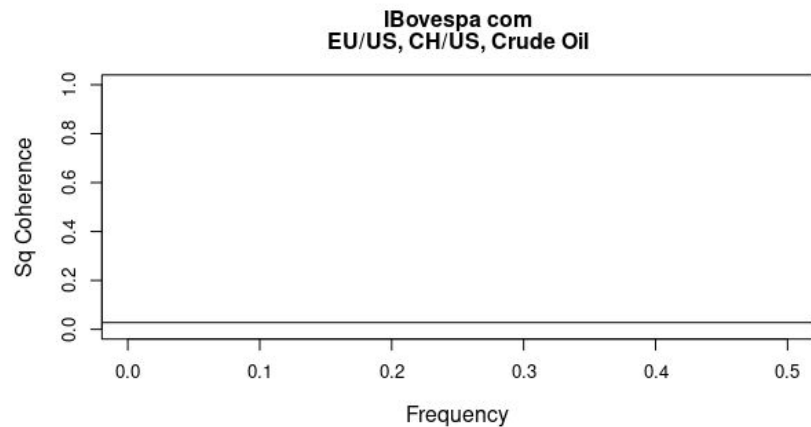
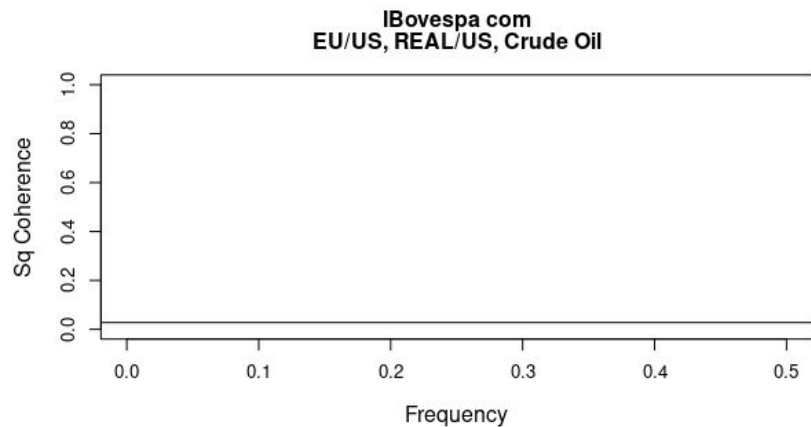
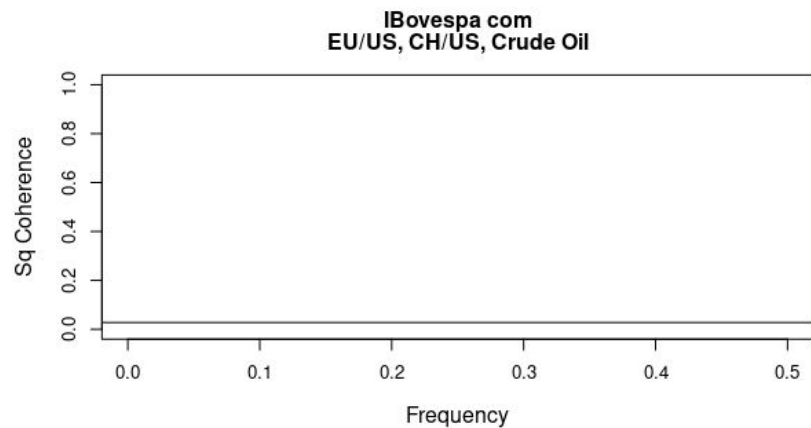
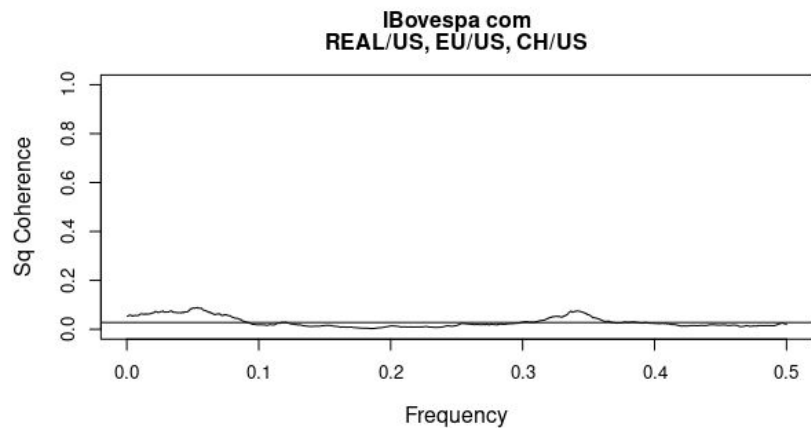
# Coerência



# Coerência cruzada

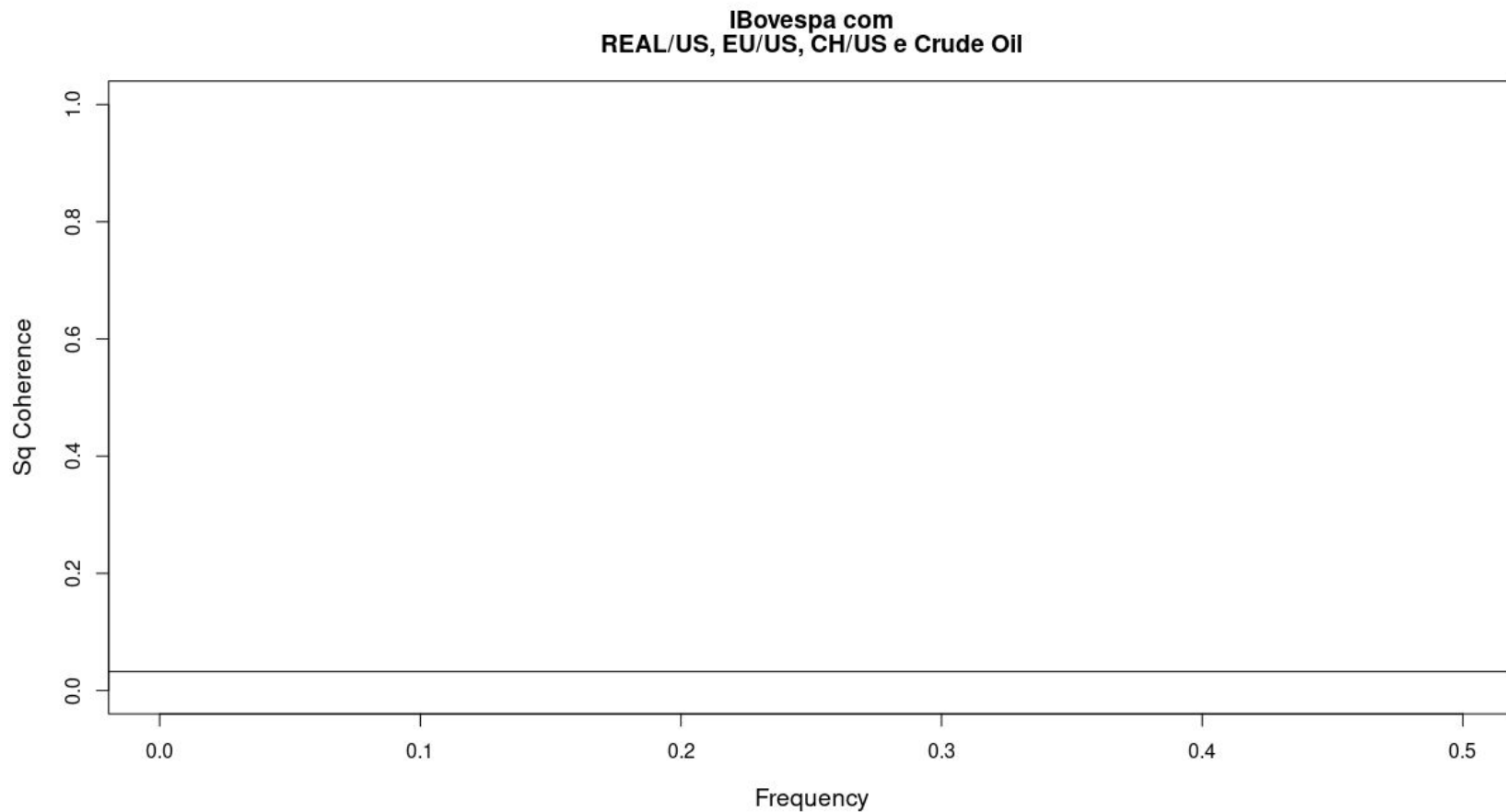


# Coerência cruzado





# Espectro cruzado

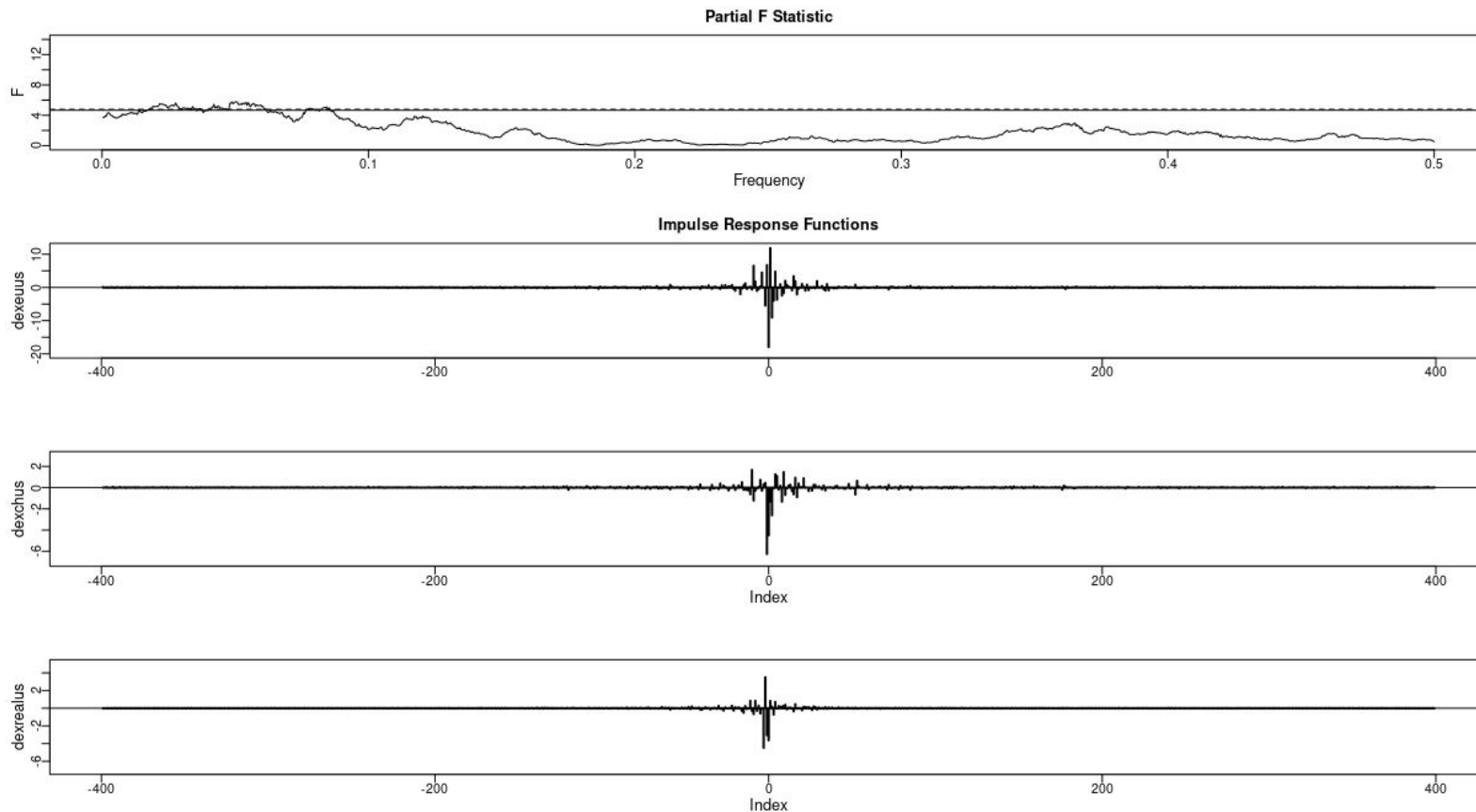


# Proposta de Modelo

Modelo 1:  $\text{IBovespa} \sim \text{EU/US} + \text{CH/US} + \text{REAL/US}$

Modelo 2:  $\text{IBovespa} \sim \text{REAL/US}$

# Modelo 1: IBovespa $\sim$ EU/US + CH/US + REAL/US



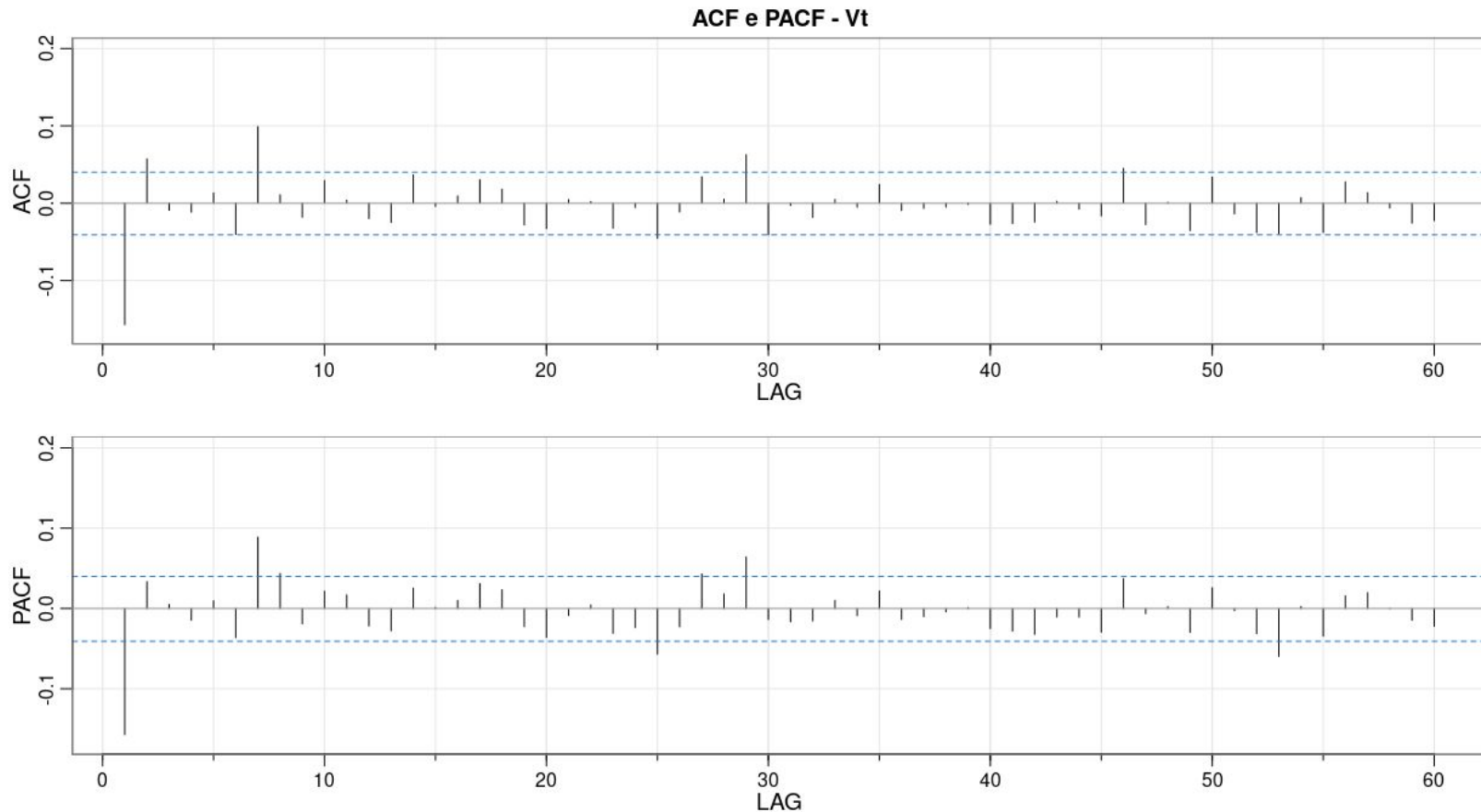
# Modelo 1: IBovespa $\sim$ EU/US + CH/US + REAL/US

Modelo 1:

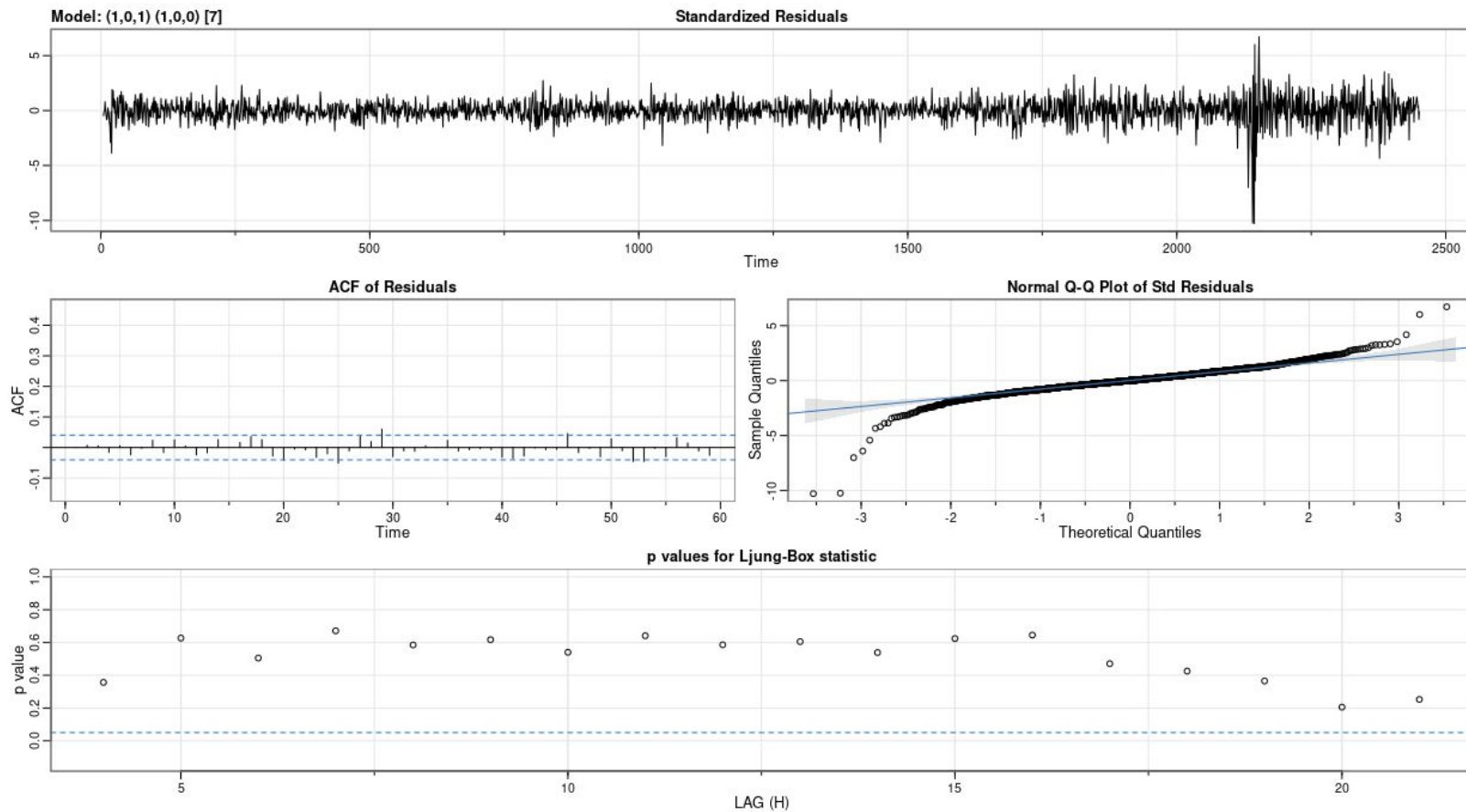
$$It = 41.15 - 5653.43 * E0 - 5409.52 * C0 - 354.94 C1 - 10820.69 * R0 + 2277.81 * R1 - 1432.8 * R2 + 1335.66 * R3 + Vt$$

- It : IBovespa
- E0 : EU/US com lag igual a 0
- C0 : CH/US com lag igual a 0
- C1 : CH/US com lag igual a -1
- R0 : REAL/US com lag igual a 0
- R1 : REAL/US com lag igual a -1
- R2 : REAL/US com lag igual a -2
- R3 : REAL/US com lag igual a -3
- Vt : sinal estacionário

# Modelo 1: IBovespa $\sim$ EU/US + CH/US + REAL/US



# Modelo 1: IBovespa $\sim$ EU/US + CH/US + REAL/US



# Modelo 1: IBovespa $\sim$ EU/US + CH/US + REAL/US

Modelo 1:

$$I_t = 42 - 7336 \cdot E_0 - 5504 \cdot C_0 - 1253 \cdot C_1 - 11158 \cdot R_0 + 2329 \cdot R_1 - 1116 \cdot R_2 + 1211 \cdot R_3 + V_t$$
$$V_t = 0.34 \cdot V_1 + .18 \cdot W_1 + 0.1 \cdot V_7 + W_t$$

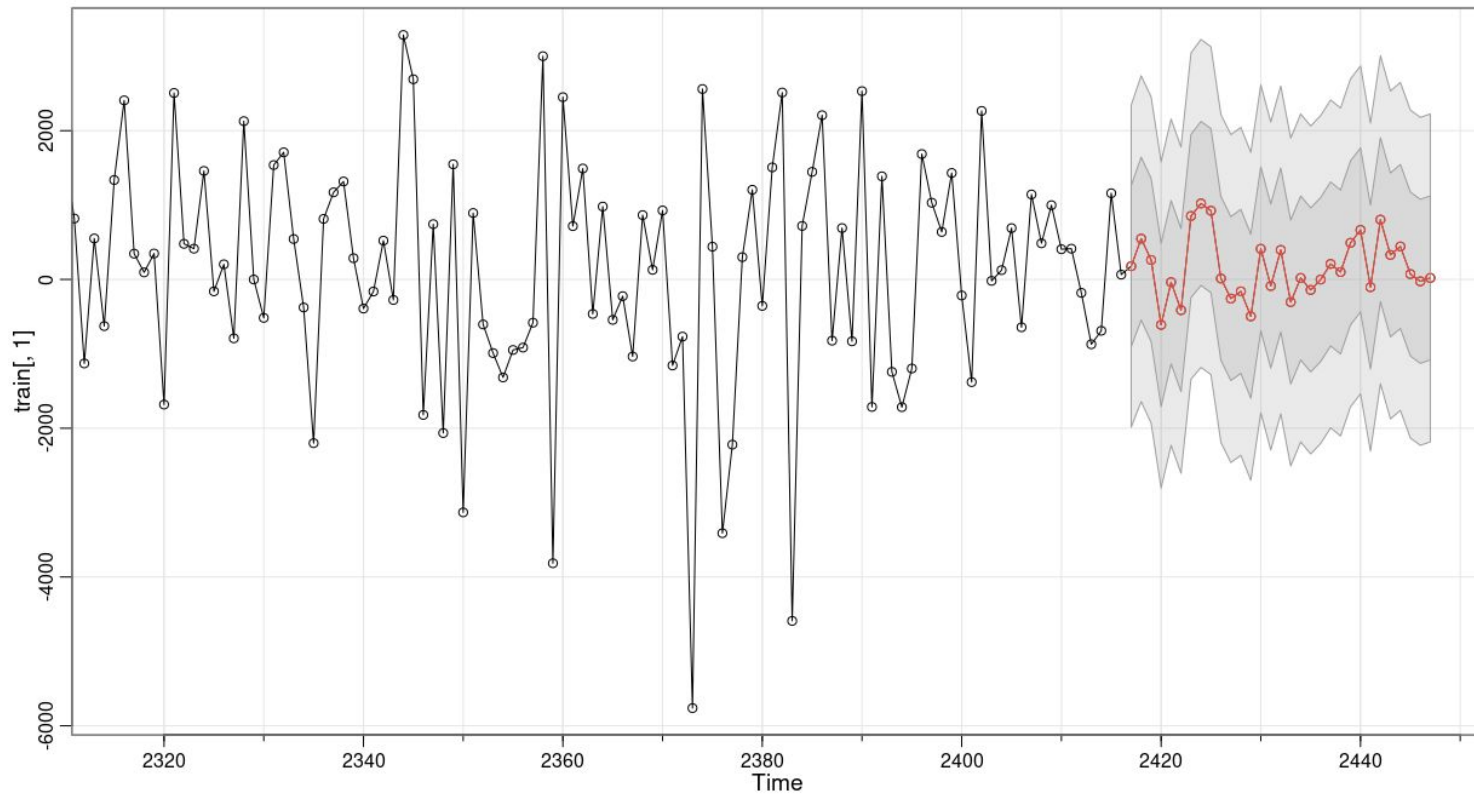
$$S^2 = 1169349$$

$$AIC = 41157.76$$

- $I_t$  : IBovespa
- $E_0$  : EU/US com lag igual a 0
- $C_0$  : CH/US com lag igual a 0
- $C_1$  : CH/US com lag igual a -1
- $R_0$  : REAL/US com lag igual a 0
- $R_1$  : REAL/US com lag igual a -1
- $R_2$  : REAL/US com lag igual a -2
- $R_3$  : REAL/US com lag igual a -3
- $V_t$  : sinal estacionário
- $V_1$ :  $V_t$  com lag igual a -1
- $V_7$ :  $V_t$  com lag igual a -7
- $W_t$ : ruído  $\sim \text{iid}(0, S^2)$
- $W_1$ :  $W_t$  com lag igual a -1

# Modelo 1: IBovespa $\sim$ EU/US + CH/US + REAL/US

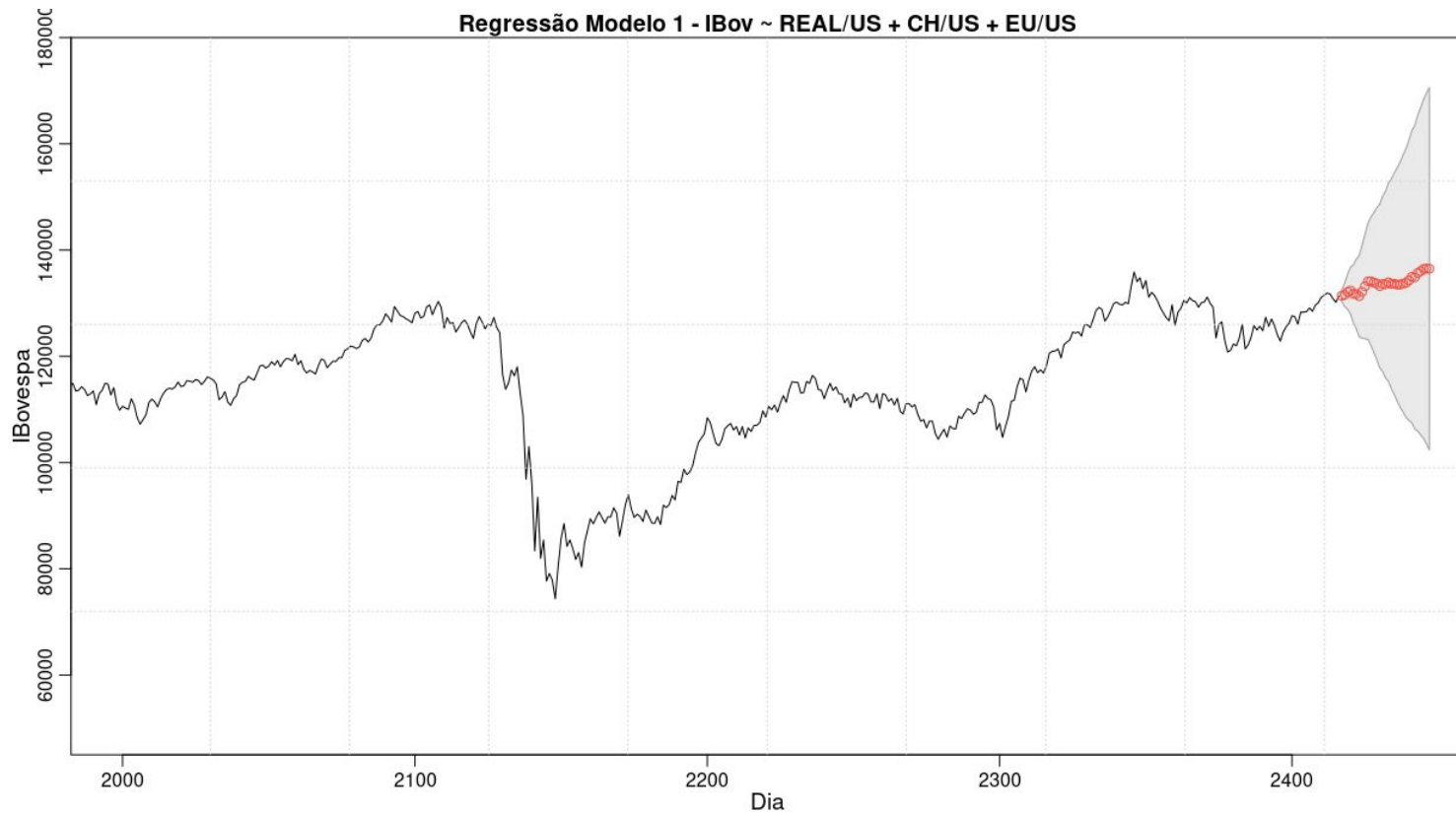
Modelo 1: previsões das diferenças





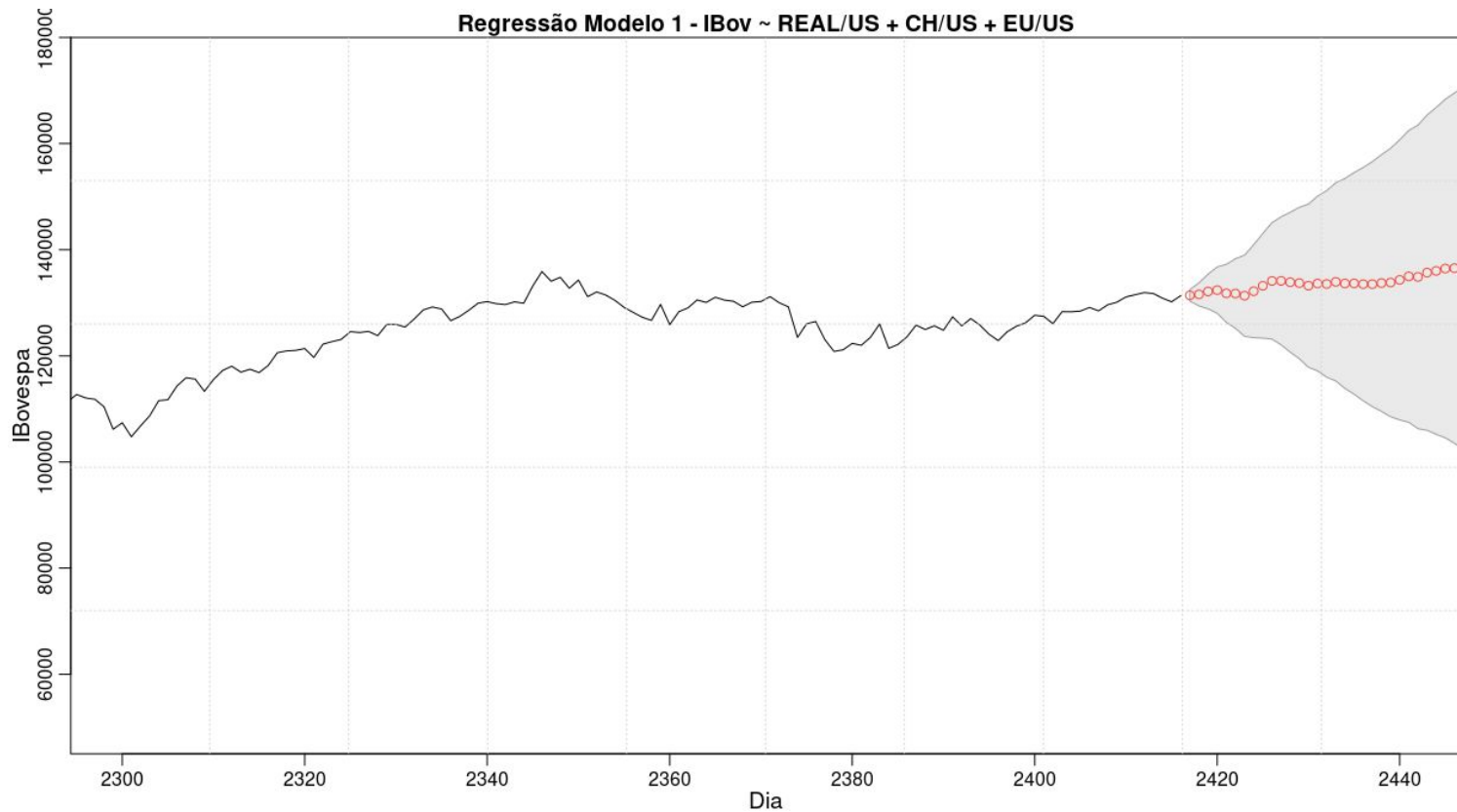
# Modelo 1: IBovespa $\sim$ EU/US + CH/US + REAL/US

Modelo 1: previsões finais

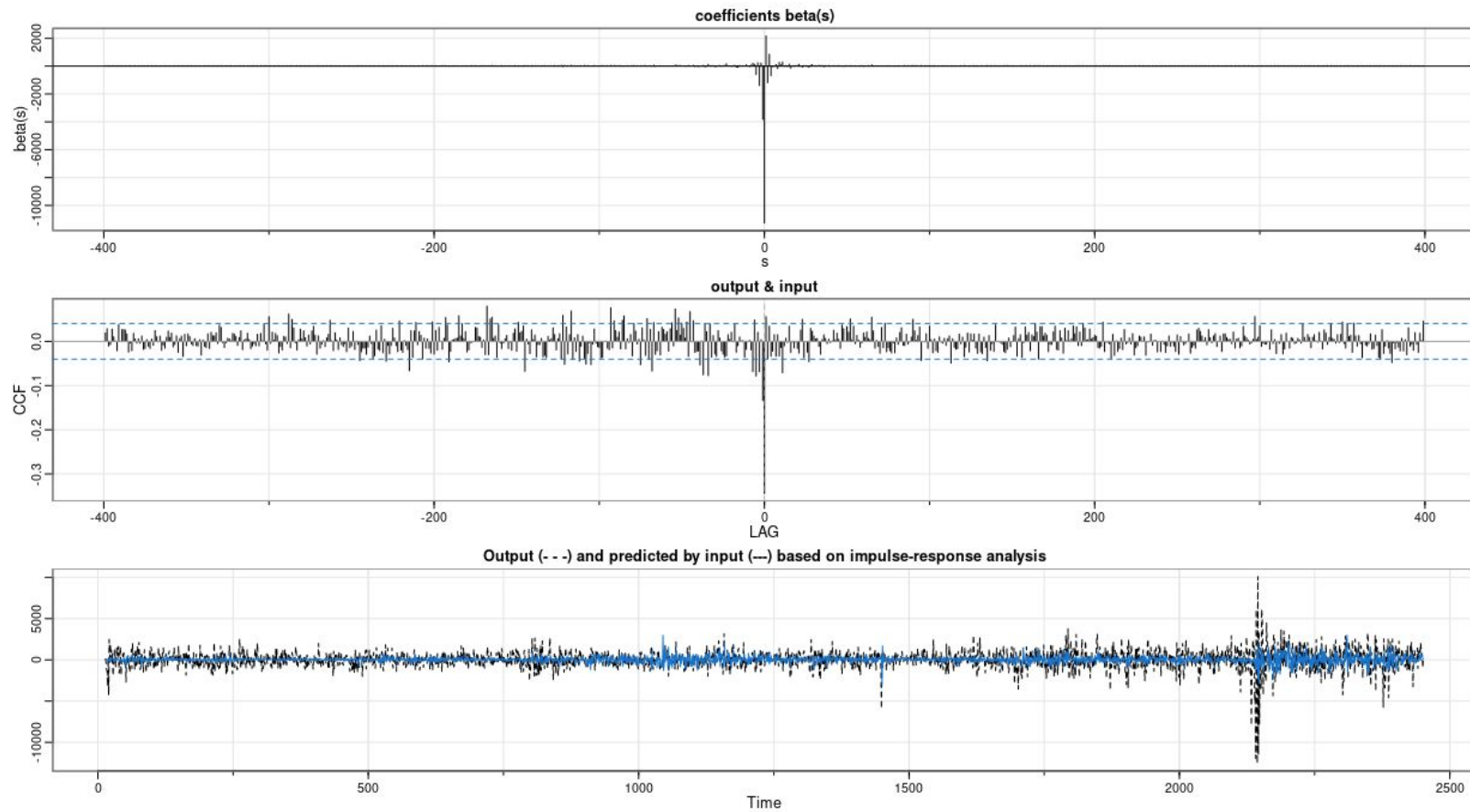


# Modelo 1: IBovespa $\sim$ EU/US + CH/US + REAL/US

Modelo 1: previsões finais (zoom)



# Modelo 2: IBovespa $\sim$ REAL/US



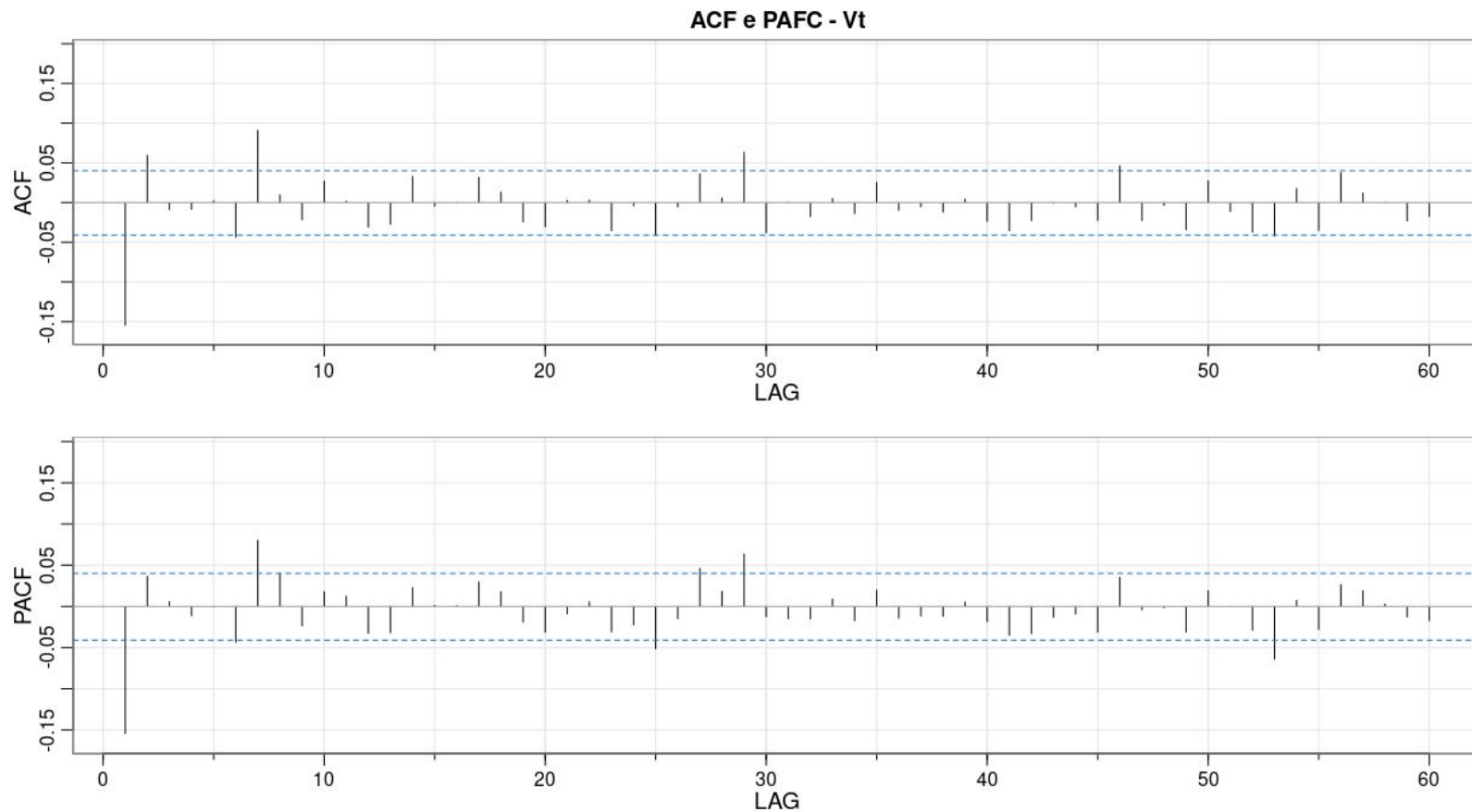
# Modelo 2: IBovespa $\sim$ REAL/US

Modelo 2:

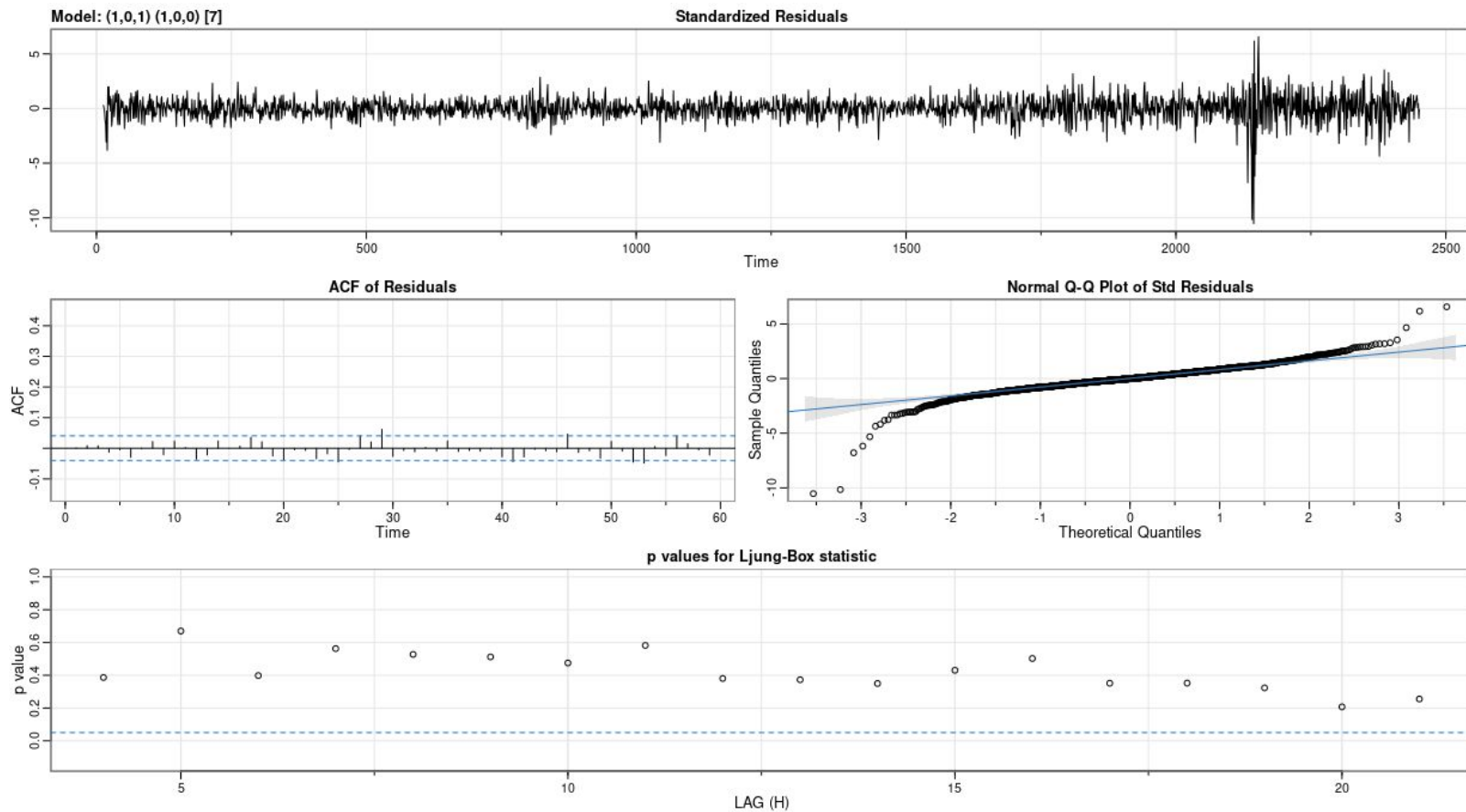
$$I_t = 49.42 - 11411.52 \cdot R_0 + 2299.41 \cdot R_1 - 1410.38 \cdot R_2 + 1362.49 \cdot R_3 - 1456.66 \cdot R_4 - 981.09 \cdot R_9 - 2180.64 \cdot R_{11} + V_t$$

- $I_t$  : IBovespa
- $R_0$  : REAL/US com lag igual a 0
- $R_1$  : REAL/US com lag igual a -1
- $R_2$  : REAL/US com lag igual a -2
- $R_3$  : REAL/US com lag igual a -3
- $R_4$  : REAL/US com lag igual a -4
- $R_9$  : REAL/US com lag igual a -9
- $R_{11}$  : REAL/US com lag igual a -11
- $V_t$  : sinal estacionário

## Modelo 2: IBovespa $\sim$ REAL/US



# Modelo 2: IBovespa $\sim$ REAL/US



# Modelo 2: IBovespa $\sim$ REAL/US

Modelo 2:

$$I_t = 49 - 17791 \cdot R_0 + 2354 \cdot R_1 - 1275 \cdot R_2 + 1463 \cdot R_3 - 1403 \cdot R_4 - 823 \cdot R_9 - 2170 \cdot R_{11} + V_t$$
$$V_t = -0.36 \cdot V_1 + .21 \cdot W_1 + 0.1 \cdot V_7 + W_t$$

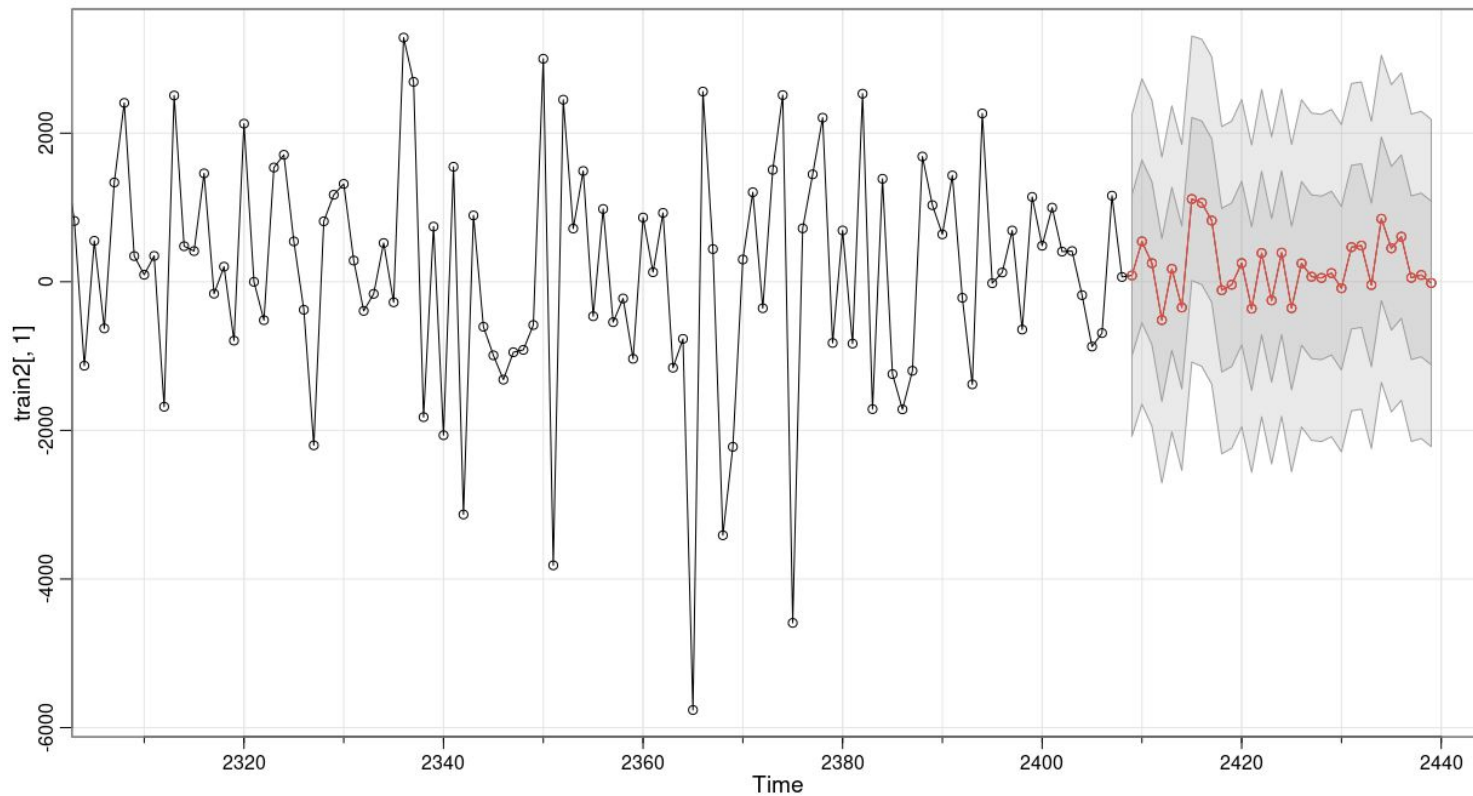
$$S^2 = 1171076$$

$$AIC = 41026.87$$

- $I_t$  : IBovespa
- $R_0$  : REAL/US com lag igual a 0
- $R_1$  : REAL/US com lag igual a -1
- $R_2$  : REAL/US com lag igual a -2
- $R_3$  : REAL/US com lag igual a -3
- $R_4$  : REAL/US com lag igual a -4
- $R_9$  : REAL/US com lag igual a -9
- $R_{11}$  : REAL/US com lag igual a -11
- $V_t$  : sinal estacionário
- $V_1$ :  $V_t$  com lag igual a -1
- $V_7$ :  $V_t$  com lag igual a -7
- $W_t$ : ruído  $\sim \text{iid}(0, S^2)$
- $W_1$ :  $W_t$  com lag igual a -1

# Modelo 2: IBovespa $\sim$ REAL/US

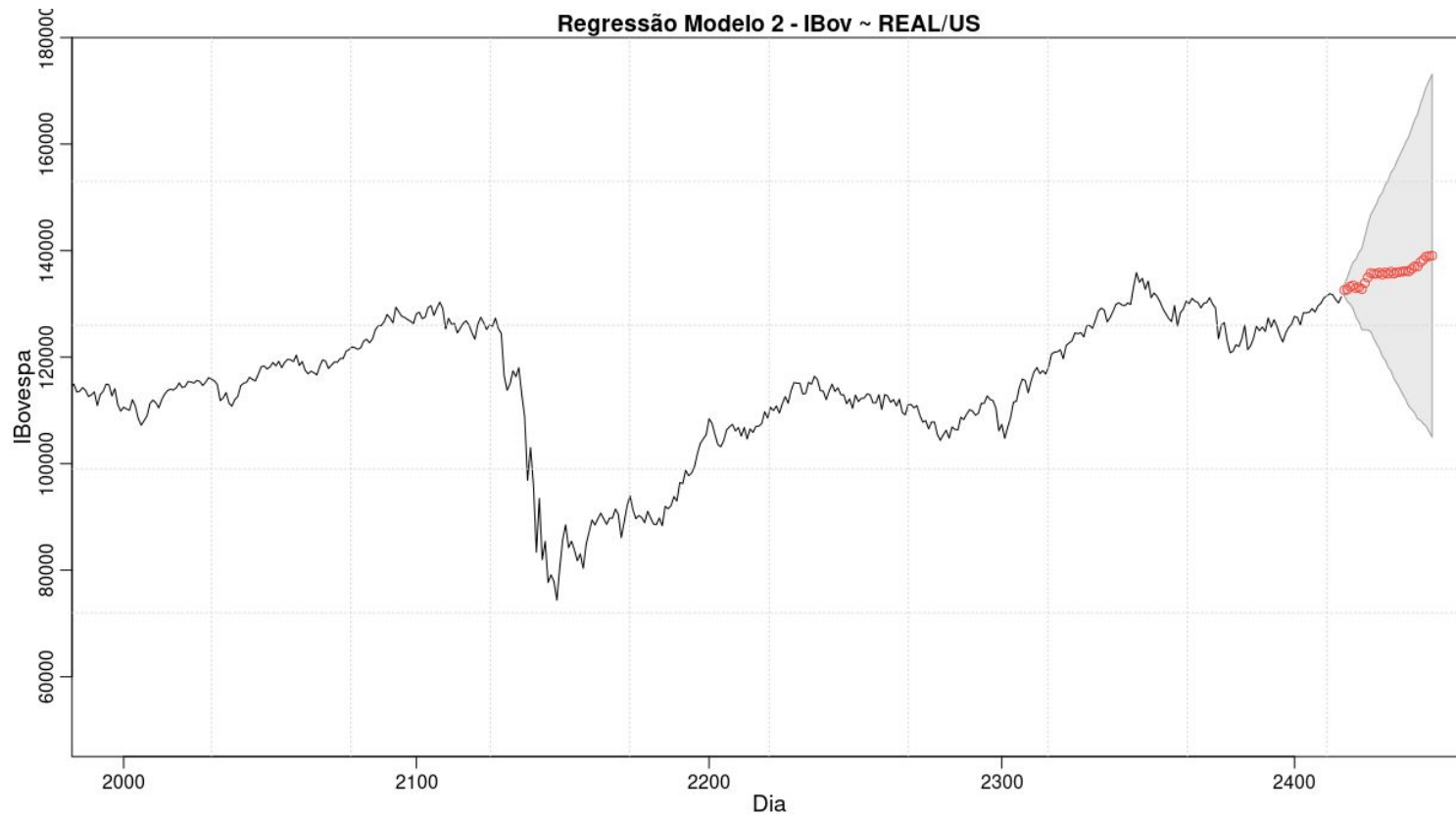
Modelo 2: previsões das diferenças





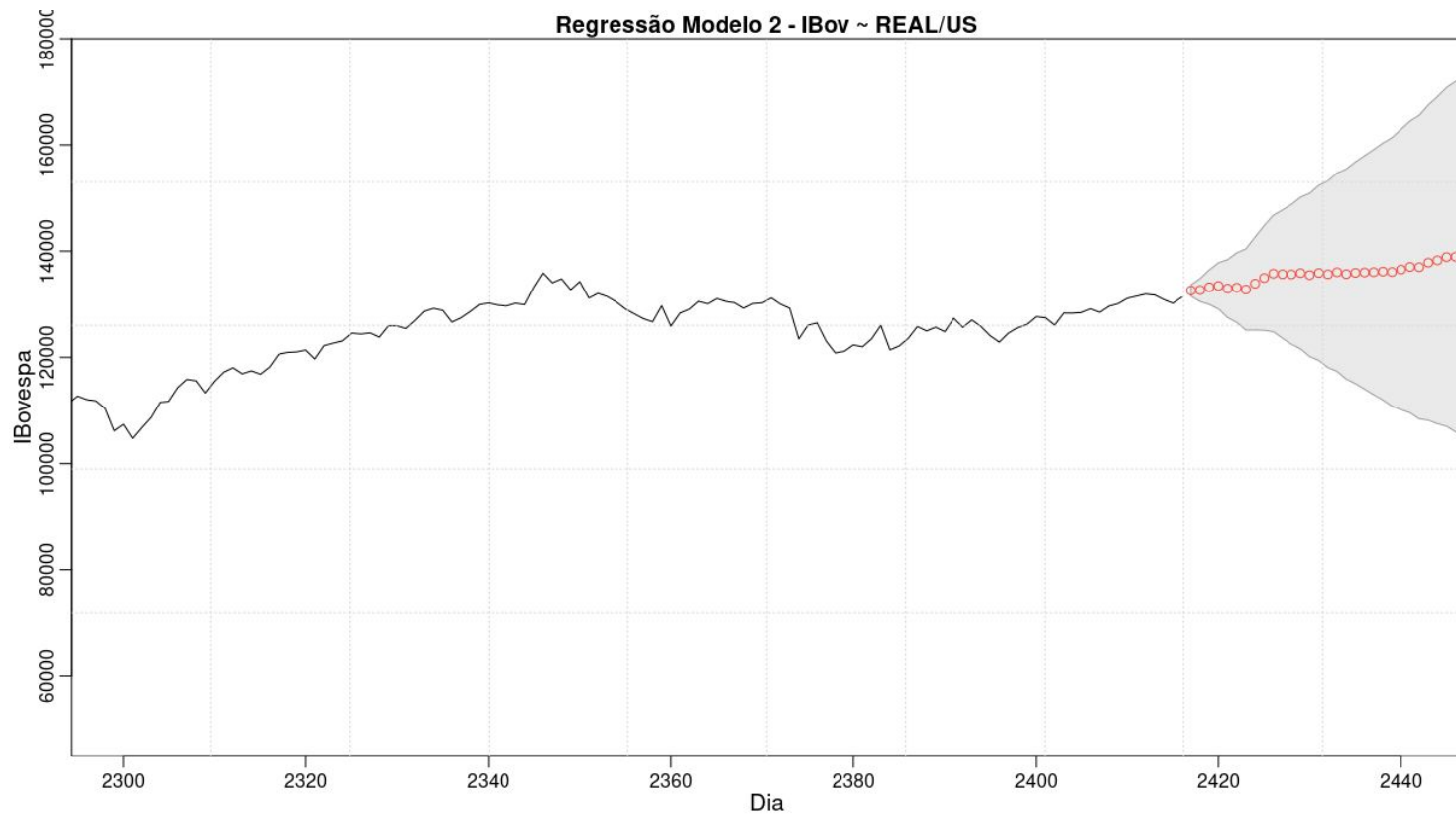
# Modelo 2: IBovespa $\sim$ REAL/US

Modelo 2: previsões finais



# Modelo 2: IBovespa $\sim$ REAL/US

Modelo 2: previsões finais (zoom)



# Modelo 1 vs Modelo 2

