Impacto de la Crisis Sanitaria por COVID-19 sobre los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero

Sergio Cubero-Soto, Estadística, Universidad de Costa Rica

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Resumen

por definir

1. Introducción

La crisis sanitaria por el COVID 19 ha impactado la conducta de los diferentes agentes económicos las cuales son importantes identificar ya que podrían profundizar aún más la crisis económica que se desarrolla actualmente. Este cambio en las conductas se observa desde el primer caso de COVID - 19 en Costa Rica y aún persiste en el 2021, en gran parte debido a la incertidumbre sobre el futuro de la pandemia, en términos de duración y profundidad.

Países como Costa Rica se han visto severamente afectados por esta crisis sanitaria y económica ya que poseen una apertura comercial internacional bastante alta y los expone a choques en la economía internacional, de acuerdo con el BCCR, gran medida de estos choque de las economías externas se deben a las medidas sanitarias impuestas por las grande economías mundiales como medida para evitar la propagación del virus, ocasionando la interrupción de la producción y distribución global, así como el cierre de fronteras, esta última con severas consecuencias en el sector turístico de Costa Rica (Banco Central de Costa Rica 2021a).

Aunado a esto, las familias se vieron severamente impactadas por esta interrupción provocando una disminución en sus ingresos debido al impacto negativo que tiene la crisis en el mercado laboral, debido a lo anterior los hogares mostraron una reducción en el consumo de bienes y servicios (Banco Central de Costa Rica 2021a).

Los bancos centrales del mundo, como medida de re-activación de la economía, especialmente, por la vía del otorgamiento del crédito para consumo o productivo, establecieron una reducción en las tasas de interés,

tomando una posición de política monetaria expansiva y contra cíclico; Costa Rica es uno de los países que siguió esta vía para atenuar el decaimiento de la actividad económica.

Con respecto a los mercados financieros internacionales, la incertidumbre de la pandemia a provocado un gran volatilidad, ya que los agentes económicos buscan refugiarse en activos líquidos, que de acuerdo con el Banco Central de Costa Rica (Banco Central de Costa Rica 2021a) :

> *esto trae como consecuencia aumento de la prima por riesgo sobre la deuda de mercados emergentes, que ha contrarrestado para esos países la caída en las tasas de interés en las economías avanzadas.*

Conforme la pandemia por COVID-19 evoluciona, las medidas sanitarias se flexibilizan para mitigar la crisis económica ocasionada. De acuerdo con el BCCR en la revisión del Programa Macroeconómico 2021-2022 (Banco Central de Costa Rica 2021b), el desempeño de la economía Costarricense muestra mejoras con respecto al año 2020 en aspectos como el desempleo, exportaciones y la recaudación fiscal, sin embargo, se mantiene la incertidumbre de la duración de la pandemia y su rumbo en términos sanitarios, ya que como afirman muchos especialistas el país el aumento en los casos puede ocasionar una tercera ola (Rosero-Bixby, n.d.).

En Costa Rica, dada la crisis económica y sanitaria, los agentes económicos, como es de esperarse en tiempos de crisis e incertidumbre, optan por tomar una posición de refugiarse en activos líquidos y menos en ahorros de depósito a plazo (Banco Central de Costa Rica 2021b) . Esta conducta está fundamentada ya que los agentes desean tener el dinero disponible inmediatamente para hacer frente a cualquier situación inesperada provocada por la crisis sanitaria y económica. De acuerdo a los datos de la SUGEVAL en el informe del mercado de valores de Costa Rica I Trimestre 2021 (Superintendencia General de Valores 2021) :

> La industria de fondos de inversión reportó al primer trimestre del año 2021 un crecimiento del 22 por ciento en el activo neto administrado con respecto al mismo periodo del año 2020, donde los fondos de inversión del mercado de dinero son los que reportan el mayor crecimiento (38 por ciento).

Los activos líquidos se pueden distinguir entre ahorros a la vista en cuentas de ahorros y/o corrientes (administrados por el sistema bancario) y las inversiones en fondos de inversión, estos últimos se desarrollan en el mercado de valores para lo cual el inversionista debe recurrir a las Sociedades de Administración de Fondos de Inversión, que como su nombre lo expresa, su función es administrar fondos de inversión.

Como se mencionó anteriormente, los agentes económicos en épocas de crisis económica buscan refugiarse en activos líquidos, especialmente, los que muestran tasas mayores rendimientos, por lo cual, el presente documento brinda detalle exclusivamente sobre los fondos de inversión financieros a la vista de corto plazo (compra de títulos valores), en los cuales se diferencian por la facilidad que tiene el inversionista para retirar

el dinero cuando lo desea, en otras palabras, no está limitado a un plazo (Banco Nacional de Costa Rica, n.d.) .

Los fondos de inversión financieros a la vista de corto plazo se puede evaluar por medio de activo neto de inversión, el cual representa el dinero total invertido (participación) por las personas y que están respaldados por títulos valores (Banco Nacional de Costa Rica, n.d.) .

El rendimiento del fondo se define a partir de los títulos valores que componen y que se negocian en el mercado. Los títulos valores se negocian en el mercado de valores y tienen un precio el cual se establece de acuerdo a las expectativas de los agentes que los venden y su contraparte, el comprador, y a partir de este precio se calculan los rendimientos, y el conjunto de estos rendimientos definen las rentabilidades de las participaciones en el fondo.

Es importante resaltar que cada título que se negocia en el mercado de valores tiene una tasa, la cual varía de acuerdo al mercado y se ve influencia en cierto grado (no de forma directa ni unitaria) por la tasa de política monetaria que dicta el BCCR.

El BCCR en el 2021 tomó la decisión de realizar una política monetaria expansiva aún más profunda (Banco Central de Costa Rica 2021b):

> ... Esta política busca contribuir en el proceso de recuperación de la actividad económica y garantizar la estabilidad del sistema financiero. Así, el Banco Central ha reducido su Tasa de Política Monetaria en 450 puntos base (p.b.) entre marzo de 2019 y julio de 2021.

Dado lo anterior, existe un riesgo materializable de una reducción en el saldo activo neto administrado ocasionado por una salida de inversionista producto de la crisis sanitaria y económica provocada por el COVID-19. Este evento podría producir una profundización de la crisis económica incidiendo en las políticas macroprudenciales del sistema financiero.

Este trabajo tiene como objetivo estimar el efecto de una potencial caída abrupta de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones y dólares en Costa Rica para diciembre 2021 a partir de los pronósticos obtenidos de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones y dólares en Costa Rica. Esto con el fin que los entes reguladores tomen medidas preventivas ante este escenario.

2. Metodología

2.1. Datos

Para implementar el modelo de estimación de los volúmenes mensuales[1] del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en millones colones y dolares en Costa Rica para el periodo

[1]Los valores mensuales se obtuvieron a partir del último día habil del mes.

de febrero-2001 a julio-2021 (246 observaciones)[2].

2.2. Series de Tiempo: Modelos de Pronostico

El análisis de la serie comprende la descripción de la serie temporal donde se indica su comportamiento, identificación de valores extremos sus componentes (estacional, tendencia-ciclo y irregular), linealidad de la serie cronológica y identificación si la serie es estacionaria.

El estudio utiliza diferentes metodologías de pronostico como modelos lineales, no lineales y de minería de datos, los cuales se detallaran en los siguientes apartados. Una vez estimados se seleccionó el mejor de cada uno para posteriormente realizar un ensamble de modelos.

Para seleccionar el mejor modelo dentro de cada uno de los grupos de modelos (lineales, no lineales y de minería de datos) se utilizó las medidas de bondad de ajuste Porcentaje de Error Absoluto Medio (MAPE) y la Raíz del Error Cuadrático Medio (RMSE).

2.2.1. Modelo Lineal

Un serie estocástica x_t es lineal si se puede expresar como:

$$x_t = \mu + \sum_{t=0}^{\infty} \psi_t a_{t-i}$$

Donde μ es una constante ψ_t es un número real con $\psi_0 = 1$ y a_t es una secuencia de variables aleatorias idénticamente distribuidas e independientes.

Para probar y seleccionar los mejores modelos lineales se seleccionó una muestra de la serie de tiempo considerando los periodos de ene-2011 a julio 2021. A partir de esta muestra a se realiza la separación de la series en un set de datos de entrenamiento, el cual comprende el 90 % del periodo; y un set de datos de prueba, el cual comprende el 10 % de los periodos más recientes de la serie, con el objetivo de generar un análisis robusto de las estimaciones producidas por los modelos empleados . (G. Hyndman Rob & Athanasopoulos 2018)

2.2.1.1. Modelo de suavizamiento exponencial Holt-Winter El modelo de suavizamiento exponencial Holt-Winter es una modificación al método Holt, ya que este no solo considerar la tendencia, sino la estacionalidad. Esto metodo tiene dos variantes en la que considera la tendencia de forma multiplicativa o aditiva.

Este modelo estima los parámetros α , β y γ, y se estiman minimizando la suma de cuadrados del error de pronóstico (Hernández-Rodrıéguez 2001; G. Hyndman Rob & Athanasopoulos 2018).

Este método esta basado en 4 ecuaciones las cuales se detallan a continuación (Hernández-Rodrıéguez 2001):

[2]Los datos fueron obtenidos a partir de la información publicada en la Superintendencia General de Valores de Costa Rica publicada en : https://aplicaciones.sugeval.fi.cr/InformesEstadisticas/InformesDiarios

- Ecuación 1: Estimación del nivel promedio de la serie en el tiempo t para el caso multiplicativo:

$$a_t = \alpha \frac{Z_t}{S_{t-s}} + (1-\alpha)(a_{t-1} + b_{t-1})$$

  Para el caso aditivo es:

$$a_t = \alpha(Z_t - S_{t-s}) + (1-\alpha)(a_{t-1} + b_{t-1})$$

  Como se observa en la ecuación anterior a la serie original Z_t se le resta el componente estacional S_{t-s}, principal diferencia respecto al modelo de Holt.

- Ecuación 2: Estimación de la pendiente en el tiempo t

$$b_t = \beta(a_t - a_{t-1}) + (1-\beta)b_{t-1}$$

- Ecuación 3: Estimación de la estacionalidad. Para el caso multiplicativo es:

$$S_t = \gamma \frac{Z_t}{a_t} + (1-\gamma)S_{t-s}$$

  Para el caso aditivo es:

$$S_t = \gamma(Z_t - a_t) + (1-\gamma)S_{t-s}$$

- Ecuación 4: Pronostico de la serie, donde m es la cantidad de periodos a pronosticar. Para el caso multiplicativo es:

$$P_{t+m} = (a_t + b_t m)S_{t-s+m}$$

  Para el caso aditivo es

$$P_{t+m} = a_t + b_t m + S_{t-s+m}$$

Los modelos ARIMA fueron estimados en el programa estadístico R con el paquete *forecast* (R. J. Hyndman and Khandakar 2008)

2.2.1.2. Modelos univariantes autorregresivos integrados de media movil (ARIMA) Los modelos univariantes autorregresivos integrados de media móvil (ARIMA), utilizados por el enfoque Box-

Jenkins, son una representación teórica de las posibles observaciones de una serie cronológica definida mediante una ecuación que incorpora elementos probabilísticos.

Esta metodología es adecuada para series temporales estacionarias, en otras palabras, que su media sea constante en el tiempo y que su varianza no este relaciona con el tiempo, ademas de que la correlación entre valores de la serie separados por k periodos dependa solo de k y es constante para todo t

Cada uno de estos procesos están relacionados con una función de autocorrelación teórica y una función de autocorrelación parcial teórica que lo caracteriza. Bajo el enfoque de Box-Jenkins, se debe comparar la funciones de autocorrelación muestral y la función de autocorrelación parcial, con sus respectivas funciones teóricas con el propósito de identificar el proceso probabilístico ARIMA que representa a la serie de tiempo.(Hernández-Rodrıéguez 2001)

Posterior a la identificación se procede a estimar los parámetros que lo definen y seguidamente se realiza un diagnostico evaluando los residuos en aspectos como normalidad y la autocorrelación de los residuos. Para el caso de la normalidad se utilizan los histogramas y la prueba Jarque-Bera, por otro lado para analizar la autocorrelación de los residuos se utiliza la prueba de Ljung-Box.

Para este estudio se utiliza el modelo ARIMA no estacional, la cual tiene como forma abreviada:

$$ARIMA(p, d, q)$$

donde p es el proceso Autoregresivo, d es la Diferenciación no estacional y q es el proceso de Medias Móviles. Este modelo se puede escribir mediante el operador de rezagos B como:

$$\varphi(B) \bigtriangledown^d \widetilde{Z}_t = \theta(B) a_t$$

Donde los componentes:

$$AR(p) = \varphi(B) = 1 - \varphi_1 B .... - \varphi_p B^p$$

$$MA(p) = \theta(B) = 1 - \theta_1 B .... - \theta_p B^p$$

Los modelos ARIMA fueron estimados en R con el paquete *Seasonal* por medio de *X-13ARIMA-SEATS* (Sax and Eddelbuettel 2018)

2.2.2. Modelo No Lineal

Se considera que una serie es no lineal cuando es generadas por procesos no lineales, como por ejemplo ecuaciones dinámicas no lineales, las cuales no puede ser modeladas por modelos no lineales como los ARIMA.

Considere una serie de tiempo univariada x_t, se dice que un proceso es puramente estocástico si se puede representar por (Tsay 2010) :

$$x_t = \mu + \sum_{i=0}^{\infty} \psi_i a_{t-i}$$

Donde μ es una constante ψ_i es un número real y a_{t-i} es una secuencia de variables aleatorias independientes y idénticamente distribuidas (i.i.d), por lo tanto, según (Tsay 2010) cualquier proceso estocástico que no satisfaga la ecuación anterior es no lineal.

Para modelar las series no lineales existe una extensa variedad de modelos no lineales que se pueden aplicar, sin embargo, para considerar el mejor debe entenderse el tipo de serie que se va modelar y en que área se esa trabajando. Para el caso particular de este estudio, se utlizaron los modelos de cambio de régimen, ya que cuando se modelan series económicas como el Saldo del Activo Neto del Mercado de Dinero, este tipo de modelos no lineales son utilizados debido a que este tipo de series cronológica tienen a definirse en diferentes estados o regimientes los cuales son dinámicos[3] (Franses and Dijk 2000).

En esta sección se explicara los modelos: Umbral autorregresivo (TAR), Autorregresivo de umbral de autoexcitación (SETAR) , Autorregresivo logístico de transición suave (LSTAR), los cuales fueron estimados en R con los paquetes: tsDyn-Nonlinear Time Series Models with Regime Switching (Narzo et al. 2020) y TSA- Time Series Analysis (Chan and Ripley 2020)

2.2.2.1. TAR: Umbral autorregresivo Los modelos TAR fueron propuestos Tong en 1978 y 1990 y Tong y Lim en 1980, estos modelos permiten modelar las asimetrías de la serie de tiempo que proveniente de los proceso crecientes o decrecientes, que los modelos lineales en ocasiones no logran modelar. TAR utiliza dos más ecuaciones lineales para obtener una aproximación de la ecuación de la media condicional; cada una de estas ecuaciones están determinados por el valor de un umbral (Franses and Dijk 2000; Tsay 2010) .

Los modelos TAR(p) de dos regímenes se pueden representar por (Franses and Dijk 2000) :

$$x_t = \begin{cases} \phi_{0,1} + \phi_{1,1} x_{t-1} + \ldots + \phi_{p,1} x_{t-p} + \varepsilon_{1,t} & x_{t-1} \leq c \\ \phi_{0,2} + \phi_{1,2} x_{t-1} + \ldots + \phi_{2,p} x_{t-p} + \varepsilon_{2,t} & x_{t-1} > c \end{cases}$$

Donde c es el valor umbral que define en que régimen se encuentra la serie en el tiempo t, ε_t se asume que es ruido blanco (i.i.d) condicionada a la historia de la serie.

2.2.2.2. SETAR: Autorregresivo de umbral de autoexcitación Los modelos SETAR son un caso especial de los modelos TAR, ya que la variable umbral se toma como un valor rezagado (d) de la propia serie, en otras palabras, $q_t = x_{t-d}$ para un $d > 0$, por lo tanto la ecuación anterior se representa como (Franses and Dijk 2000):

[3]De acuerdo con (Franses and Dijk 2000) se entiende "comportamiento dinámico dependiente del estado" como:

una serie de tiempo que tiene ciertas propiedades , como que su media, varianza y / o autocorrelación sean diferentes en los diferentes regímenes

$$x_t = \begin{cases} \phi_{0,1} + \phi_{1,1}x_{t-1} + \ldots + \phi_{p,1}x_{t-p} + \varepsilon_{1,t} & x_{t-1} \leq c \\ \phi_{0,2} + \phi_{1,2}x_{t-1} + \ldots + \phi_{2,p}x_{t-p} + \varepsilon_{2,t} & x_{t-1} > c \end{cases}$$

Donde c es el valor umbral que define en que régimen se encuentra la serie en el tiempo t, ε_t se asume que es ruido blanco (i.i.d) condicionada a la historia de la serie.

Los modelos TAR y SETAR pueden ser alternativamente representados como:

$$x_t = (\phi_{0,2}+\phi_{1,2}x_{t-1}+\ldots+\phi_{2,p}x_{t-p}+\varepsilon_{2,t})(1-I\left[y_{t-d} > c\right])+\phi_{0,2}+\phi_{1,2}x_{t-1}+\ldots+\phi_{2,p}x_{t-p}+\varepsilon_{2,t}(I\left[y_{t-d} > c\right])$$

2.2.3. Modelo Machine Learning

2.2.3.1. PROPHET W/ XGBOOST ERRORS

2.2.3.2. Validación Cruzada

2.2.4. Métricas de Rendimiento

Para la comparación de los modelos se plantean métricas de rendimiento y criterios de información para la selección del mejor modelo. Entre las medidas de rendimiento están:

Error Absoluto Medio (MAE)

$$MAE = \frac{\sum_{t=1}^{T} |y_t - \hat{y_t}|}{T}$$

Raíz del Error Cuadrático Medio (RMSE)

$$RMSE = \sqrt{\frac{\sum_{t=1}^{T}(y_t - \hat{y}_t)^2}{T}}$$

2.3. Prueba de tensión

Las pruebas de tensión o estrés es una herramienta muy utilizada en el sector financiero, ya que permiten a las entidades financieras evaluar la capacidad que estas tienen para enfrentar escenarios económicos y/o financieros extremos (baja probabilidad de ocurrencia pero factibles) a través de modelos estadísticos o simulaciones (BCCR 2019) .

Para el caso en particular, se realiza una prueba de tensión con el fin de modelar el efecto que existe de que se haga efectiva una salida extrema de capital de los fondos de inversión (corrida) .

Como método estadístico para modelar el escenario adverso de una salida de inusual del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones y dolares se utiliza la **Teoría**

de Valor Extremo (EVT, conocida por sus siglas en ingles) la cual se centra el modelamiento del comportamiento de la cola de una distribución *(para este caso nos interesa la cola inferior o izquierda por ser una salida en el activo neto),* para lo cual se utiliza solo los valores extremos en lugar de todo el set de datos (Danıéelsson 2011).

De acuerdo con la **Teoría de Valor Extremo,** establece que las colas de cualquier distribución caen en tres categorías bajo el supuesto que la distribución no cambie con el tiempo. Estas tres distribuciones de las colas son (Danıéelsson 2011):

1. **Weibull** Se caracteriza ser delgada con un final finito
2. **Gumbel** disminuyen exponencialmente
3. **Fréchet** Se conocen por colas gordas ya que declina por la regla de potencia

Existen diferentes enfoque para implementar la **Teoría de Valor Extremo,** sin embargo, para esta investigación se seleccionó el enfoque de extremos (picos) sobre un umbral (Peaks Over Thresholds, POT), el cual se basa en modelar las observaciones que superen un umbral, en el caso particular se seleccionaron las observaciones que superaron el percentil 95. Para el caso del enfoque POT se utiliza la distribución generalizada de Pareto (GDP) (Danıéelsson 2011)

3. Resultados

El presente apartado esta dividido en dos secciones las cuales muestran los resultados obtenidos que buscan respaldar el objetivo planteado. La primera sección se compara y selecciona el mejor modelo de pronostico de serie de tiempo según el tipo de modelo: lineales, no lineales y de minería de datos, para posteriormente, realizar un ensamble con los mejores tres métodos. La segunda sección presenta una prueba de tensión en el cual se plantearán diferentes escenarios para estimar el potencial impacto de una caída abrupta de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones y dólares en Costa Rica para diciembre 2021.

3.1. Análisis Exploratorio

En la figura 1 se muestran los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones y dolares para febrero-2001 a julio-2021 y de la cual se genera el análisis para identificar las siguientes características: tendencias o ciclos, existencia de estabilidad en las observaciones, variancia de las observaciones (constante o variable en el tiempo), existencia de observaciones inusuales y de puntos extremos, cambios en la estructura de la serie, entre otras.

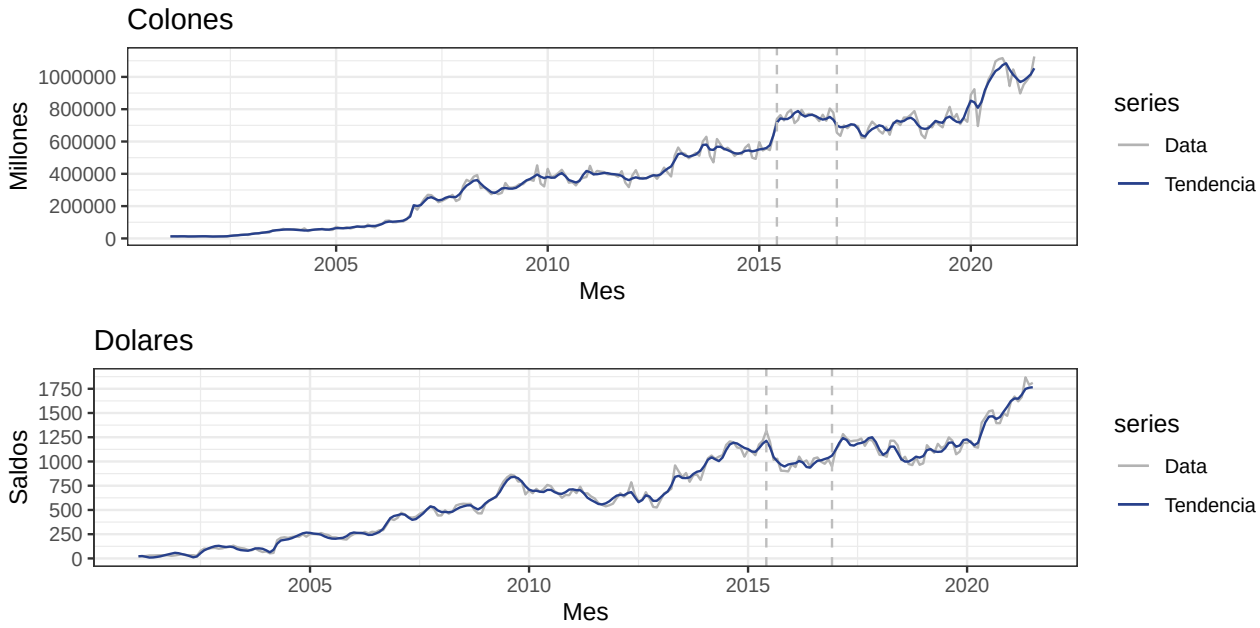
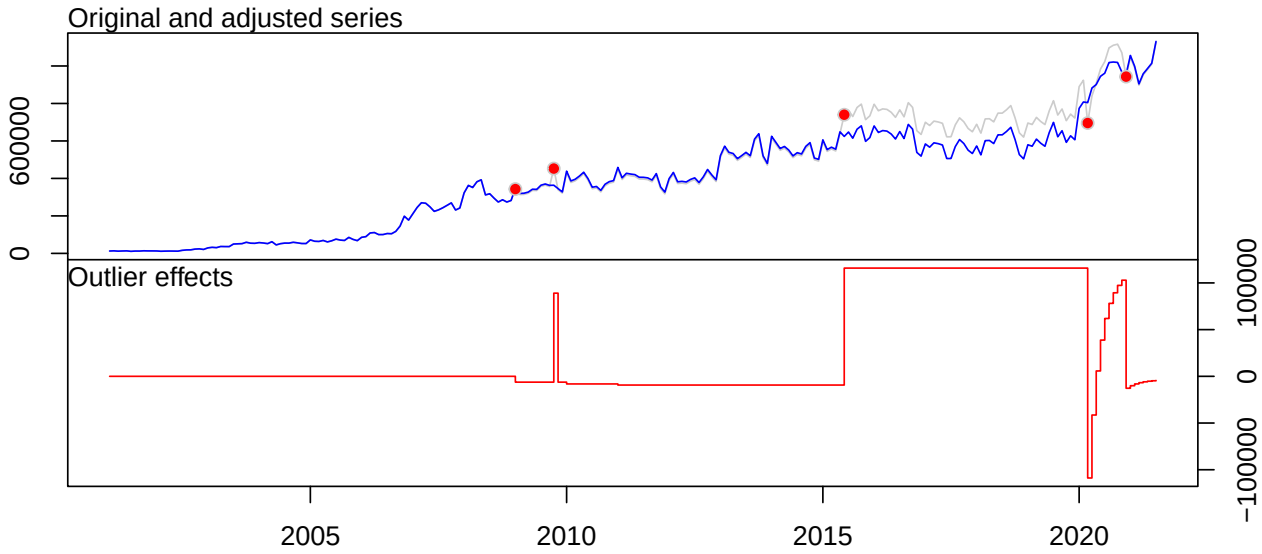


Figura 1: Costa Rica:Evolución de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones y dolares, febrero-2001 a julio-2021



A partir del análisis de la serie se identificaron las siguientes característica:

- Para ambas series del activo neto , colones y dolares, se observa una tendencia creciente desde febrero 2001, así como un aumento de la variabilidad conforme aumenta los meses.

- Para el periodo de mayo 2015 a octubre 2016 (lineas punteadas gris) hay un cambio de nivel (Valor extremo LS[ˆ4]) en el volumen mensual del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero tanto en colones como en dolares, sin embargo, es inverso en ambas series, lo cual sugiere que posiblemente los participantes trasladaron sus inversiones de dolares a colones, esto se explica por:

- La adopción del régimen de tipo de cambio de flotación administrada por parte del Banco Central de Costa Rica (BCCR) y el incremento en el superávit de divisas del sector privado incidió en la apreciación del colón (disminución del tipo de cambio) (Banco Central de Costa Rica 2015).
- La reducción de la tasa de interés de política monetaria por parte del BCCR en 300 puntos base en el 2015, con el objetivo de estimular la economía, promoviendo el crecimiento en el crédito nacional y para reducir el costo de la deuda para el gobierno (Mercado de Valores Multifondos 2015b, 2015a).
- En el último trimestre del 2015, la industria tuvo una contracción de la liquidez en dolares, explicado por la salida de los participantes hacia el mercado internacional (Mercado de Valores Multifondos 2015a).

- Para el activo neto en colones se observa que en abril 2020 el activo neto en colones creció en 19.5 por ciento respecto al mismo periodo del año pasado, este comportamiento creciente y acelerado se mantuvo hasta diciembre de ese mismo año. Lo cual coincide con el efecto de la crisis sanitaria por COVID-19 que inicio en Costa Rica en marzo 2020, esta fecha es identificada como un valor extremo de cambio temporal [ˆ4]. Esta situación sanitaria provocó un aumento de la incertidumbre en la economía mundial incidiendo en que los agentes económicos buscaran refugiarse en activos líquidos (Banco Central de Costa Rica 2021a). Un comportamiento similar ocurre para el activo neto en dolares.
- Respecto a la estacionalidad de las series, se observa en la figura 2 que para el caso de colones los saldos del activo neto tienden a ser mayores en enero y octubre, y presentar valores relativamente bajos al finalizar el año noviembre y diciembre, esto es de esperar debido a la época navideña y que diciembre comúnmente se labora 3 de las 4 semana del mes. Para el caso de dolares se observa que los meses con mayores saldos del activo neto se dan de mayo a agosto, y al igual que el caso de colones, se observa que los dos últimos meses del año los mismos se reduce.

Por otro lado, respecto al componente irregular para la serie en colones (ver en el 5, la figura **??**) ,se comporta de hasta el año 2012 de forma aditiva, en otras, palabras la variancia de la serie no fluctua con el nivel de la serie, sin embargo, a partir de 2012 hacia delante se observa que la variación aumenta con el nivel de la serie, por lo cual se podría argumentar que la serie tiene un comportamiento mixto (aditivo y multiplicativo). En contra parte, para la serie en dolares no se observa una variación similar en todo el periodo y que no varía con respecto al nivel de la serie.

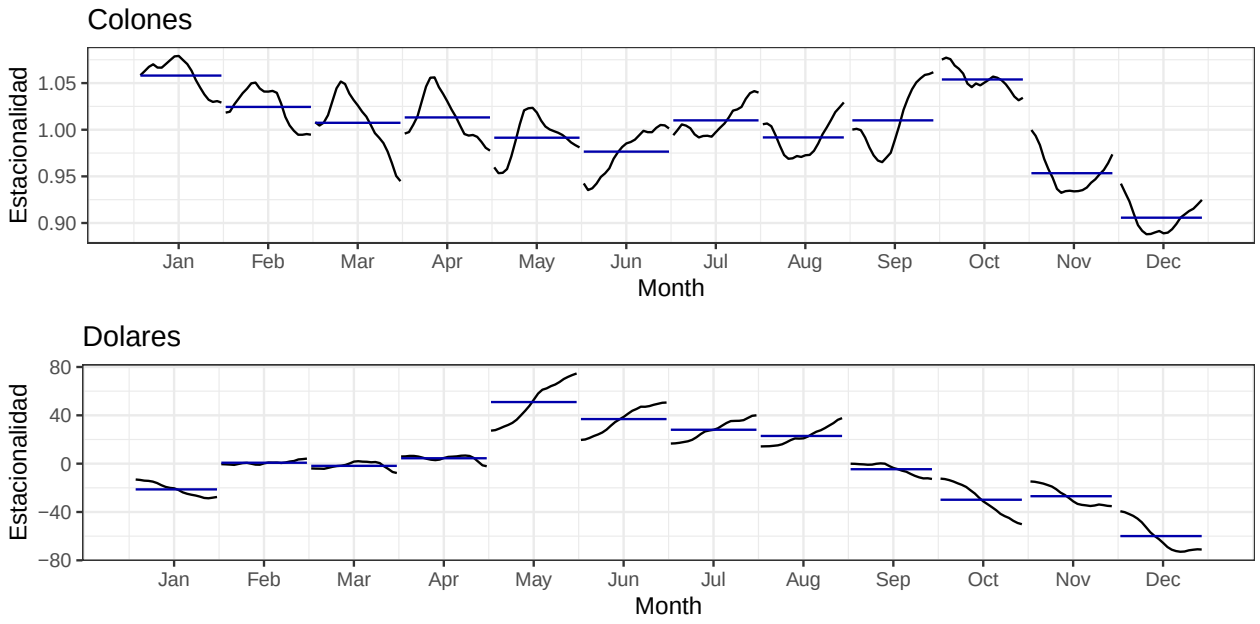
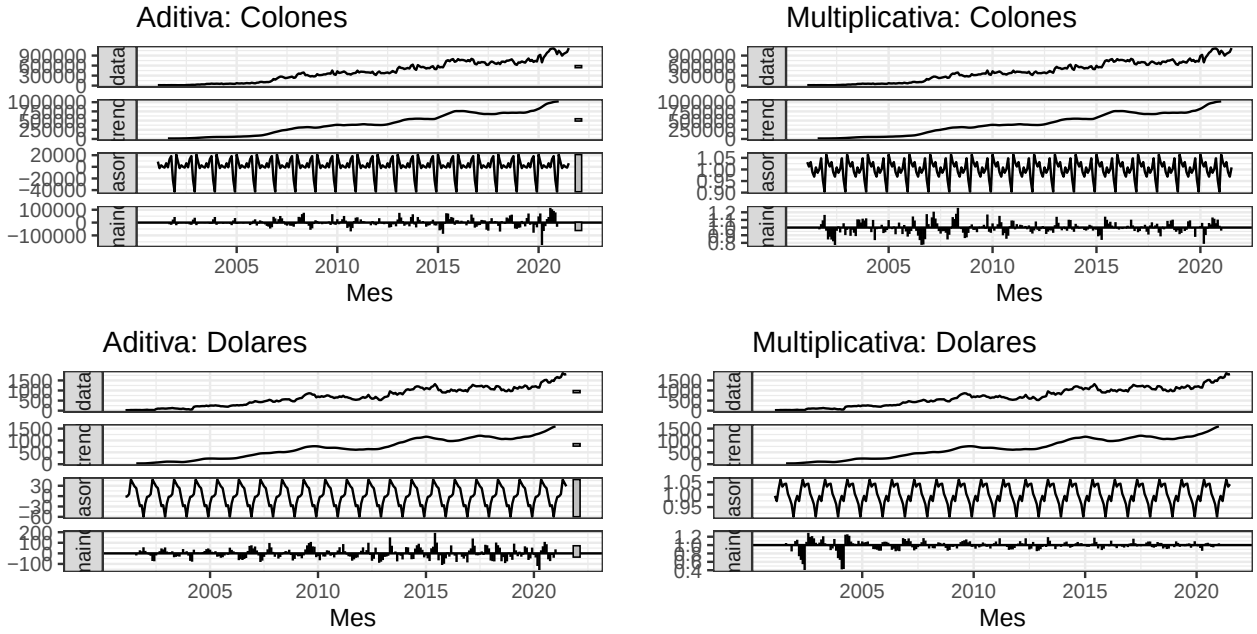


Figura 2: Costa Rica:Indice Estacional de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones y dolares, febrero-2001 a julio-2021



Para confirmar cual modelo (aditivo o multiplicativo) se ajusta mejor a cada serie se procedió a evaluar si el componente irregular identificando se ajusta a una distribución normal, para lo cual se realizaron la pruebas de hipótesis de normalidad *Shapiro-Wilk* y *Jarque-Bera,* así como una inspección gráfica por medio de Cuantil- Cuantil (qqplot). En la figura 3 se puede identificar que para el caso de la serie en colones, el mejor modelo es el multiplicativo mientras que para la serie en dolares es el aditivo.

En relación a la estacionariedad[ˆ5] de las series, ambas no cumplen con dicha condición ya que presentan tendencia creciente y por ende no tienen media constante en el tiempo. Para confirmar esto realiza la prueba

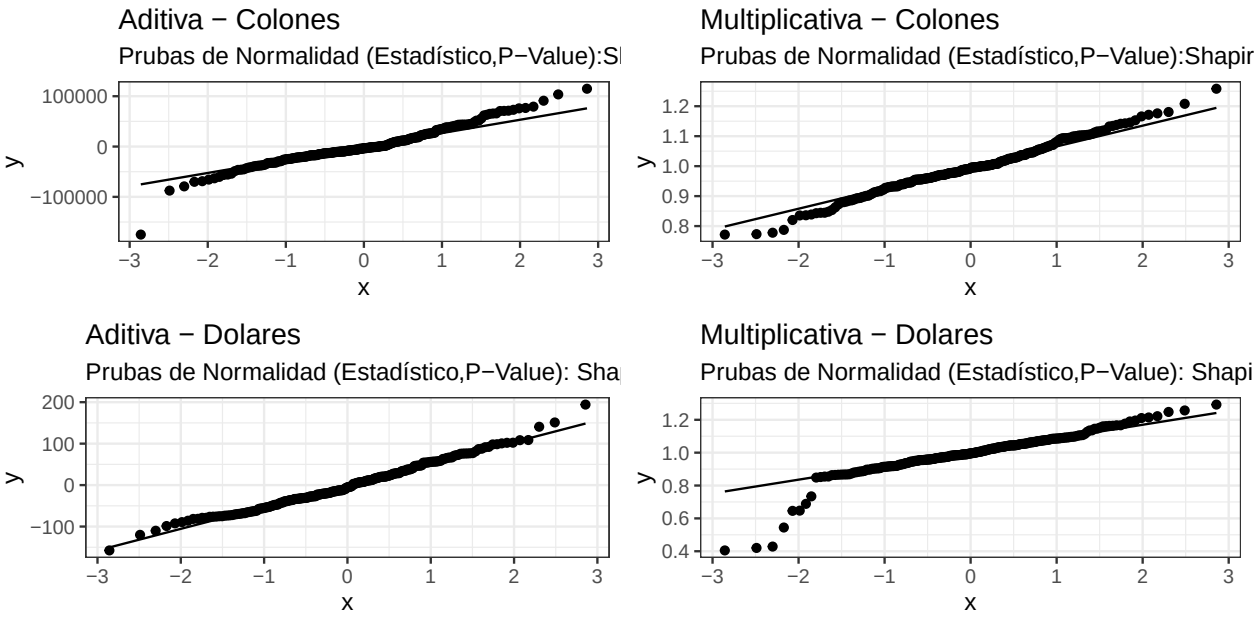


Figura 3: Costa Rica: QQPlot de los residuos de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones y dolares por tipo de descomposición, febrero-2001 a julio-2021

de hipótesis de Dickey-Fuller aumentada donde lo hipótesis nula es que la serie tiene raíz unitaria (proceso no estacionario), en ambos casos no se rechaza la hipótesis nula (Serie Colones: estadístico: -3.0082767 y valor-p: 0.1515055 y la Serie Dolares: estadístico: -2.7303393 y valor-p: 0.2684702), y se puede observar que la Función de Autocorrelación Simple Muestral (ACF) decae lentamente a 0 (Figuras 4 y 5), esto sugiere que para realizar estacionaria las series se podrían transformar a logaritmo y diferenciar.

Lo que respecta a la linealidad de las series, se observa que las mismas cumplen con la linealidad en la media lo que es confirmado con la prueba de hipótesis de *Teraesvirta*, de la cual se concluye que no hay suficiente evidencia estadística para rechazar la hipótesis nula que la serie cronológica es lineal en la media, tanto para colones como dolares (Colones: Estadístico 0.4947052 , Valor P 0.7808653 ; Estadístico 1.4958362 , Valor P 0.473351)

En la figura **??** se observa para el caso de colones una variabilidad estable a lo largo del periodo de análisis, por otro lado, los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en dolares se observa una variabilidad importante antes del año 2005, sin embargo, posterior a ese año tiende a estabilizarse.

3.2. Modelos

3.2.1. Modelo Lineal

A partir del análisis exploratorio realizado de las series y considerando sus características se procedió a estimar 5 modelos de pronóstico lineales por cada serie:

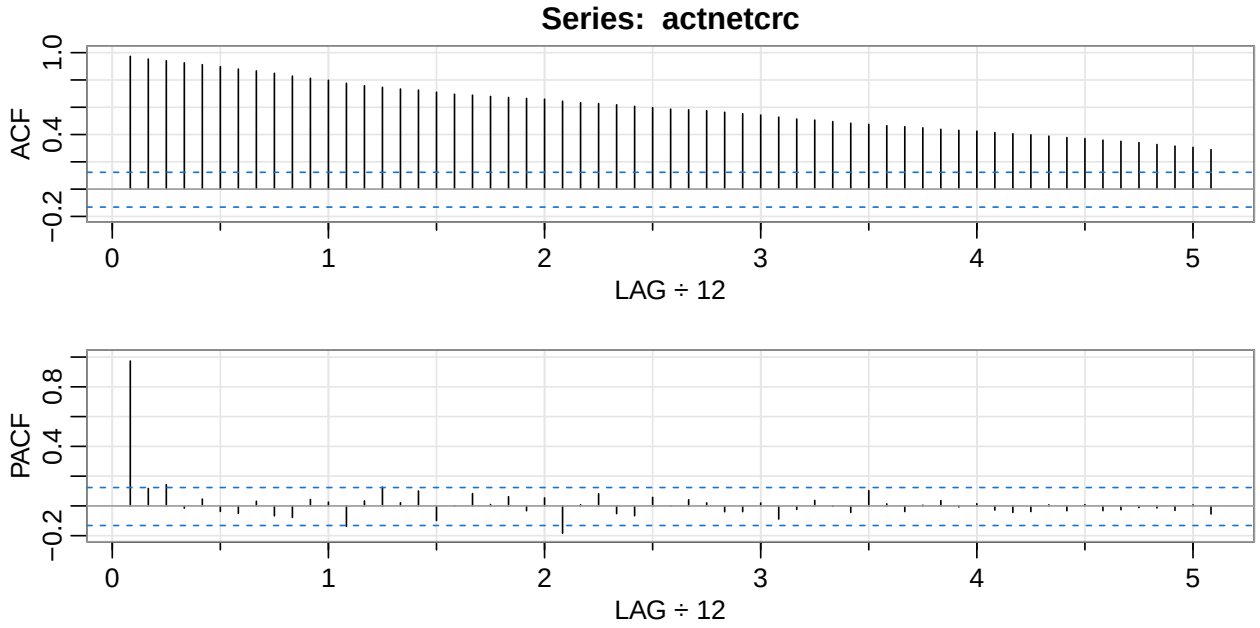


Figura 4: Función de autocorrelación y autocorrelación parcial estimadas de la serie de cronológica de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en colones, febrero 2001 a diciembre-2020

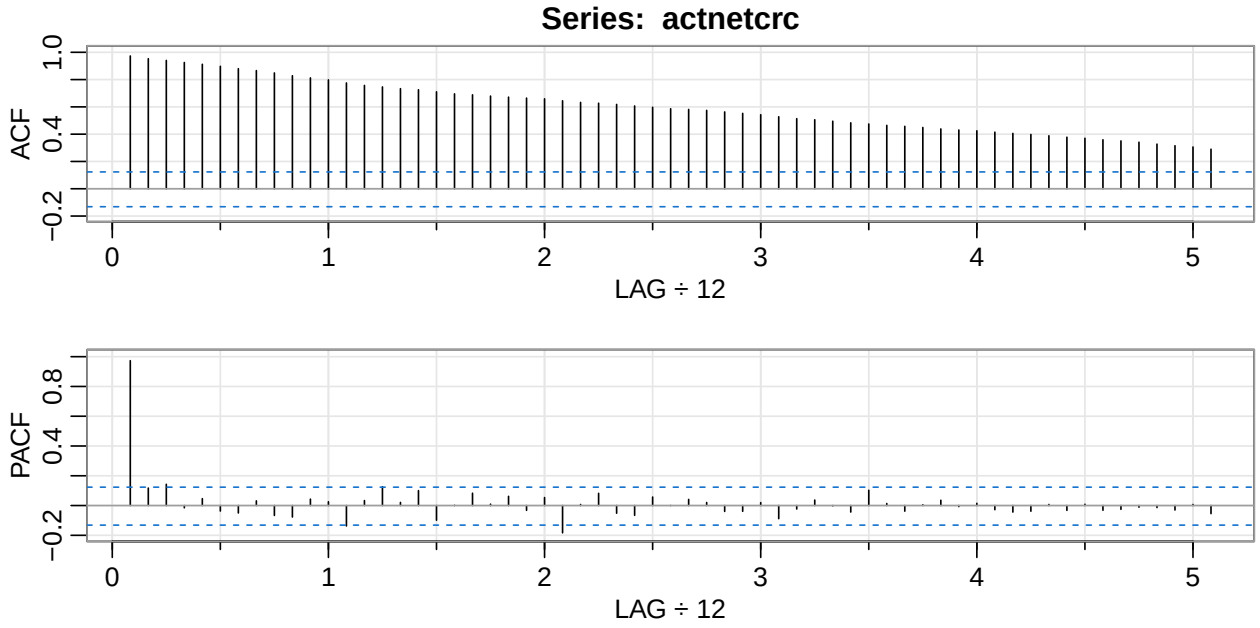


Figura 5: Función de autocorrelación y autocorrelación parcial estimadas de la serie de cronológica de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en dolares, febrero 2001 a diciembre-2020

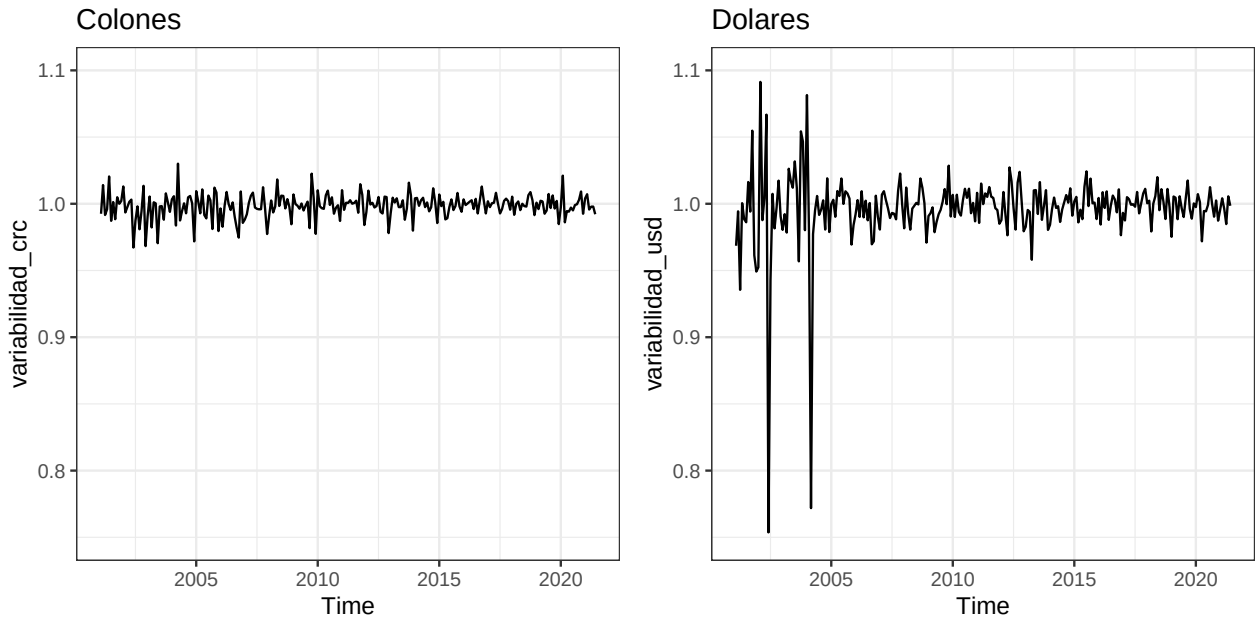


Figura 6: (#fig:variabilidadseries)Evolución de la variabilidad de la serie cronológica de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en dolares, febrero 2001 a diciembre-2020

- Modelo de Suavizamiento Exponencial Holt-Winter Aditivo
- Modelo de Suavizamiento Exponencial Holt-Winter Multiplicativo
- 3 Modelos univariantes autorregresivos integrados de media movil (ARIMA)

3.2.1.1. Serie en Colones Para el caso de la serie de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en **colones**, se estimó un modelo autoregresivo de medias moviles (ARIMA) con transformación logarítmica, la cual tiene la siguiente forma:

En el gráfico xxx se puede apreciar el pronostico sobre los últimos 5 meses reservado para probar el modelo, es importante resaltar que los meses pronosticados se acercan en gran medida a los valores reales y los intervalos de confianza son amplios pero contienen los valores reales, para mas detalles sobre las metricas de rendimientos de los modelos dirigirse al anexo xxx.

Es importante resaltar que el modelo ARIMA()() cumple con los supuestos:

3.2.1.1.1. ARIMA

```
##
## Call:
## seas(x = sactnetcrc_train, transform.function = "log", regression.aictest = NULL,
##     outlier = NULL, regression.variables = "ao2020.Mar", arima.model = "(0 1 0)(1 0 1)")
```

```
##
## Coefficients:
##                Estimate Std. Error z value             Pr(>|z|)
## AO2020.Mar     -0.26213    0.04651  -5.636   0.0000000173759851 ***
## AR-Seasonal-12  0.93237    0.03143  29.664 < 0.0000000000000002 ***
## MA-Seasonal-12  0.62705    0.08332   7.526   0.0000000000000523 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## SEATS adj.  ARIMA: (0 1 0)(1 0 1)  Obs.: 122  Transform: log
## AICc:  2930, BIC:  2941  QS (no seasonality in final):    0
## Box-Ljung (no autocorr.): 25.52   Shapiro (normality): 0.9725 **

##
## Call:
## seas(x = sactnetcrc_train, transform.function = "none", regression.aictest = NULL,
##     outlier = NULL, regression.variables = "ao2020.Mar", arima.model = "(0 1 0)(0 1 1)")
##
## Coefficients:
##                      Estimate    Std. Error z value             Pr(>|z|)
## AO2020.Mar     -200519.71119   29678.44417  -6.756      0.0000000000141 ***
## MA-Seasonal-12       0.78410       0.07922   9.898 < 0.0000000000000002 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## SEATS adj.  ARIMA: (0 1 0)(0 1 1)  Obs.: 122  Transform: none
## AICc:  2647, BIC:  2655  QS (no seasonality in final):    0
## Box-Ljung (no autocorr.): 27.41   Shapiro (normality): 0.9743 *

##
## Call:
## seas(x = sactnetcrc_train, transform.function = "log", regression.aictest = NULL,
##     outlier = NULL, regression.variables = c("ls2015.May", "ao2020.Mar"),
##     arima.model = "(2 1 0)(1 0 0)")
##
## Coefficients:
##                   Estimate Std. Error z value         Pr(>|z|)
```

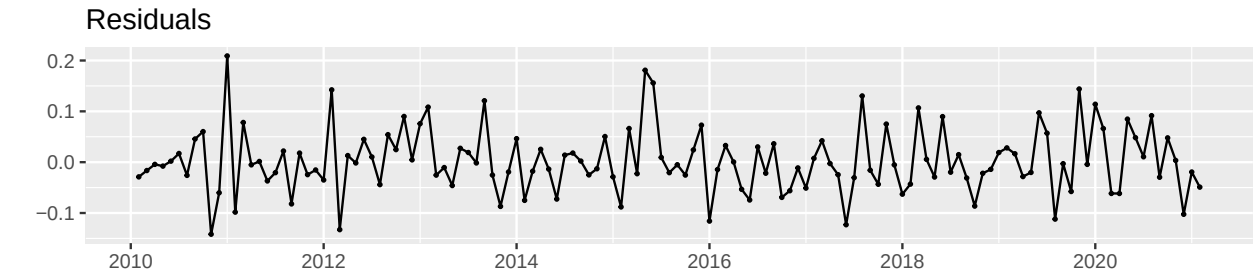
```
## LS2015.May          0.21302    0.05516   3.861         0.000113 ***
## AO2020.Mar         -0.24242    0.04827  -5.023 0.00000051001064 ***
## AR-Nonseasonal-01 -0.13474    0.08772  -1.536         0.124556
## AR-Nonseasonal-02 -0.23542    0.08922  -2.639         0.008325 **
## AR-Seasonal-12     0.54195    0.07683   7.054 0.00000000000173 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## SEATS adj.  ARIMA: (2 1 0)(1 0 0)  Obs.: 122  Transform: log
## AICc:  2926, BIC:  2942  QS (no seasonality in final):    0
## Box-Ljung (no autocorr.): 19.38   Shapiro (normality): 0.9827
```

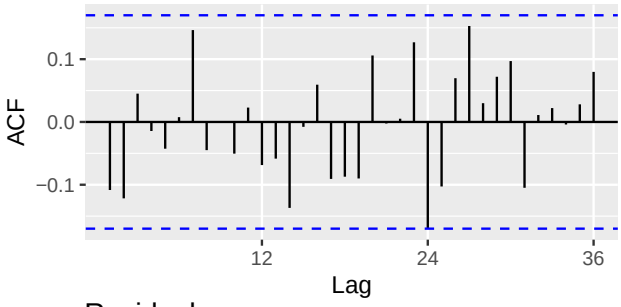
Análisis de Supuestos

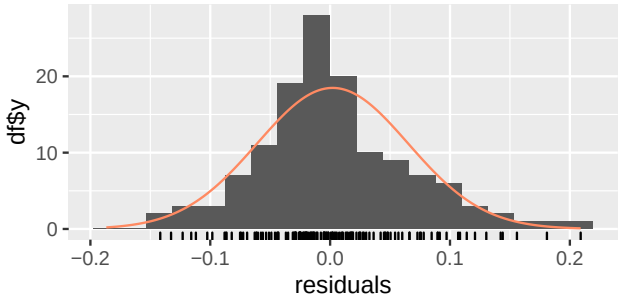
```
##
##  Augmented Dickey-Fuller Test
##
## data:  resseas1
## Dickey-Fuller = -4.8317, Lag order = 5, p-value = 0.01
## alternative hypothesis: stationary

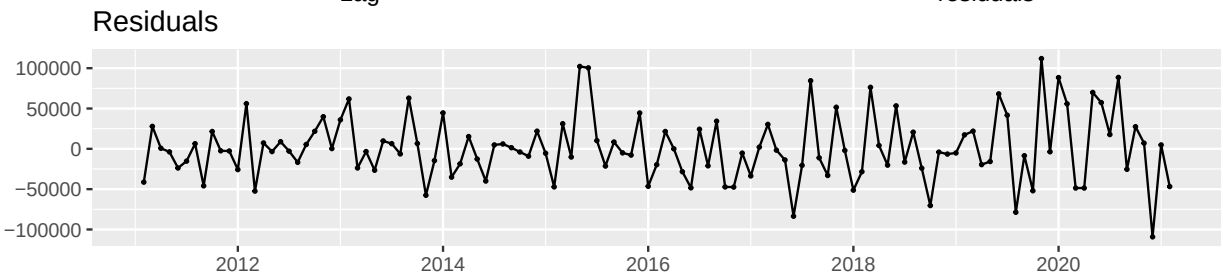
##
##  Augmented Dickey-Fuller Test
##
## data:  resseas2
## Dickey-Fuller = -5.1753, Lag order = 4, p-value = 0.01
## alternative hypothesis: stationary

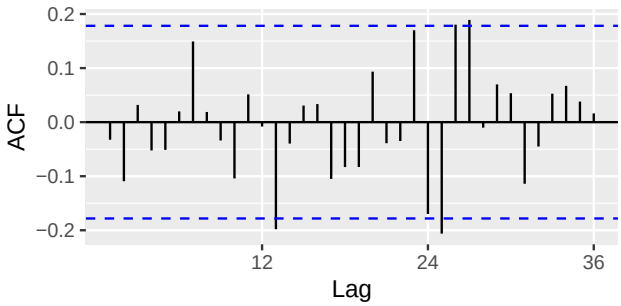
##
##  Augmented Dickey-Fuller Test
##
## data:  resseas3
## Dickey-Fuller = -4.4897, Lag order = 4, p-value = 0.01
## alternative hypothesis: stationary
```

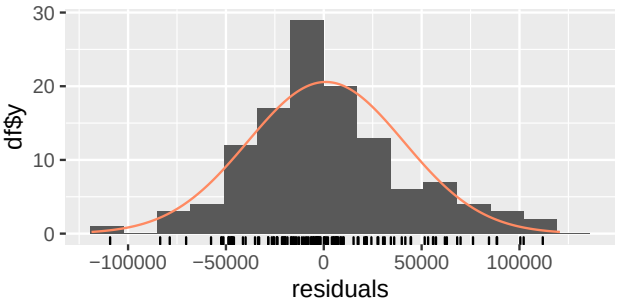

Residuals
0.2
0.1
0.0
−0.1
2010
2012
2014
2016
2018
2020

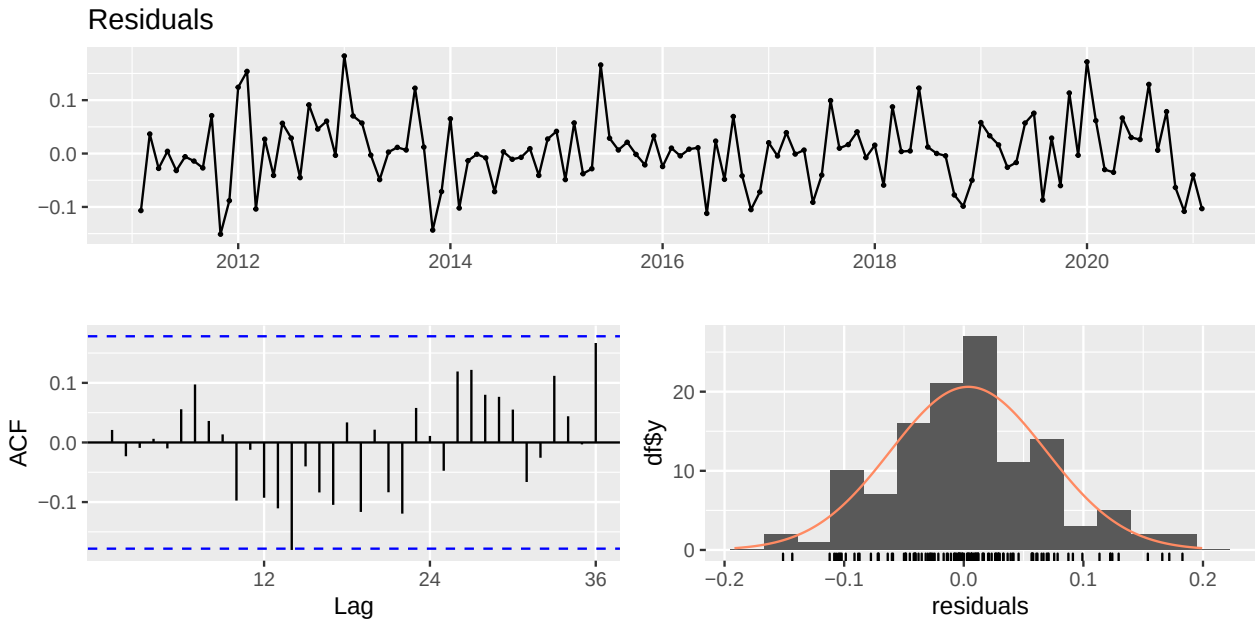

ACF
0.1
0.0
−0.1
12
24
36
Lag


df$y
20
10
0
−0.2
−0.1
0.0
0.1
0.2
residuals


Residuals
100000
50000
0
−50000
−100000
2012
2014
2016
2018
2020


ACF
0.2
0.1
0.0
−0.1
−0.2
12
24
36
Lag


df$y
30
20
10
0
−100000
−50000
0
50000
100000
residuals




```
##
##  Box-Ljung test
##
## data:  resseas1
## X-squared = 1.5978, df = 1, p-value = 0.2062

##
##  Box-Ljung test
##
## data:  resseas2
## X-squared = 0.13088, df = 1, p-value = 0.7175

##
##  Box-Ljung test
##
## data:  resseas3
## X-squared = 0.054739, df = 1, p-value = 0.815

##
##  Box-Ljung test
##
## data:  resseas1
## X-squared = 8.691, df = 12, p-value = 0.7291

##
```

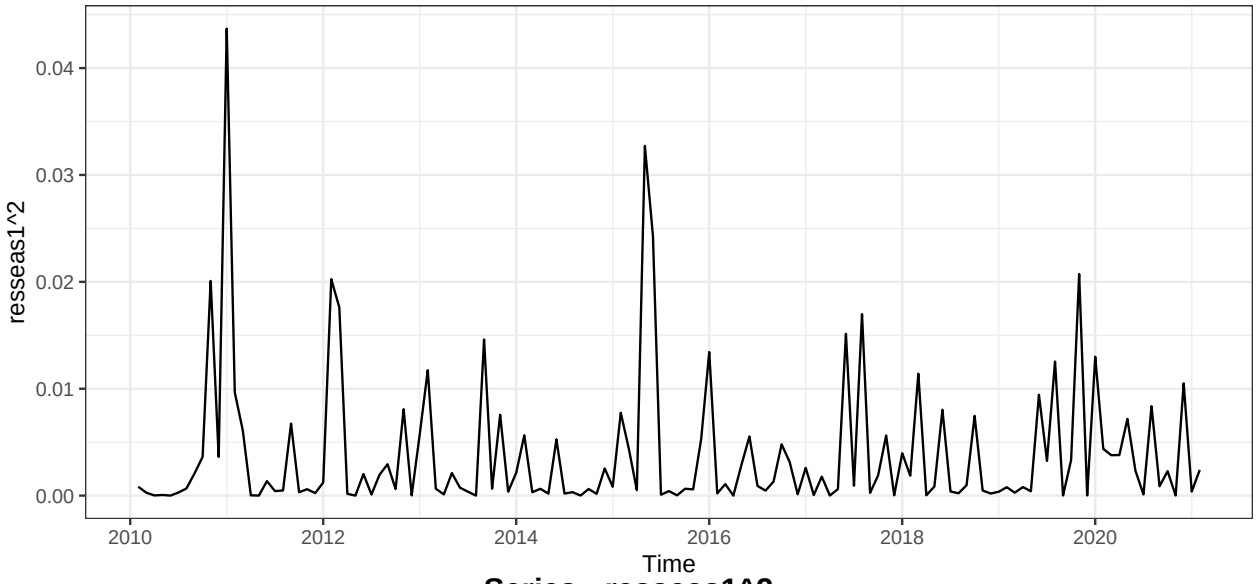
```
##  Box-Ljung test
##
## data:  resseas2
## X-squared = 7.4138, df = 12, p-value = 0.8291

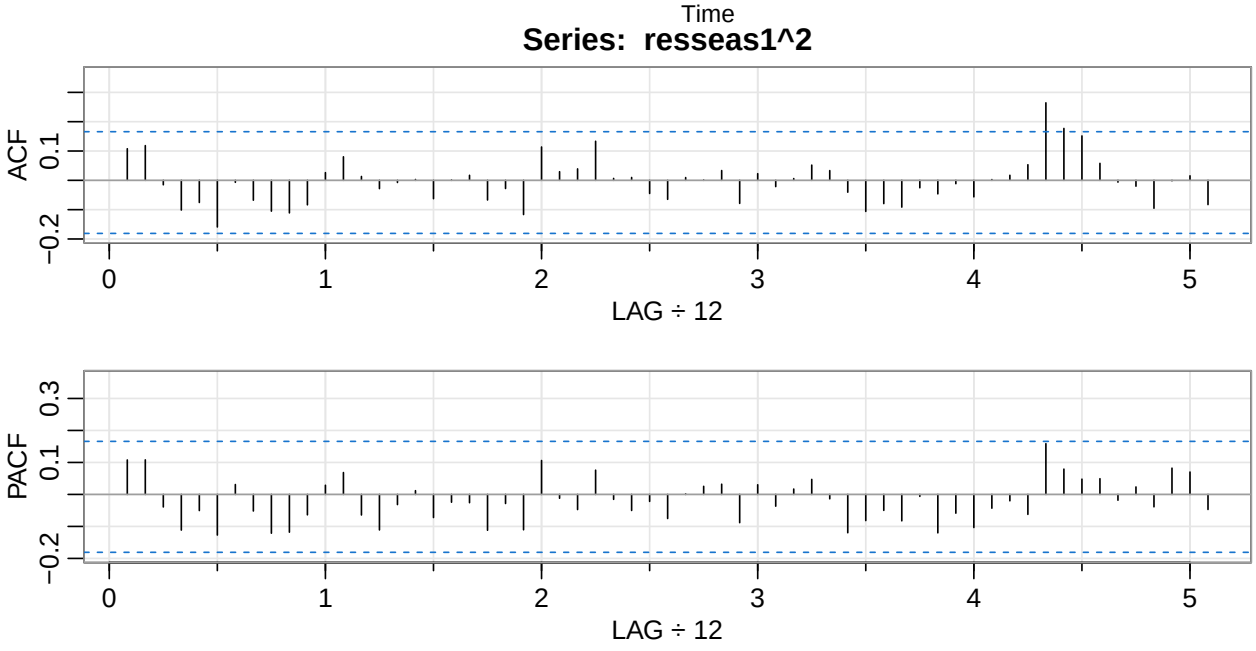
##
##  Box-Ljung test
##
## data:  resseas3
## X-squared = 4.4531, df = 12, p-value = 0.9738

##
##  ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  resseas1
## Chi-squared = 9.7695, df = 12, p-value = 0.6362

##
##  ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  resseas2
## Chi-squared = 12.286, df = 12, p-value = 0.423

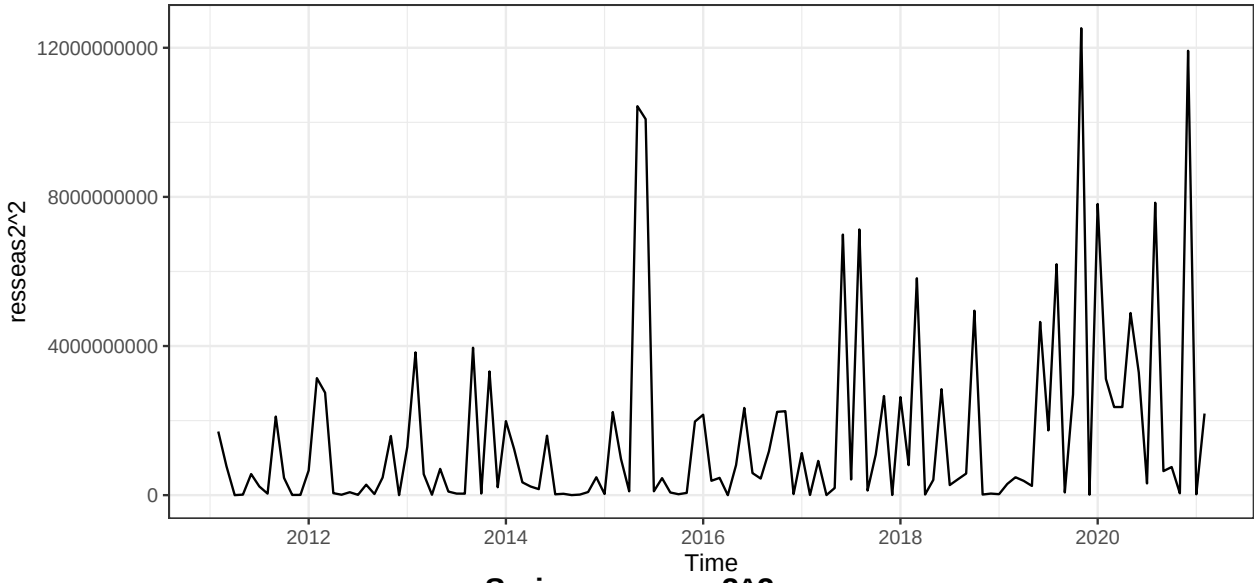
##
##  ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  resseas3
## Chi-squared = 10.948, df = 12, p-value = 0.5334
```

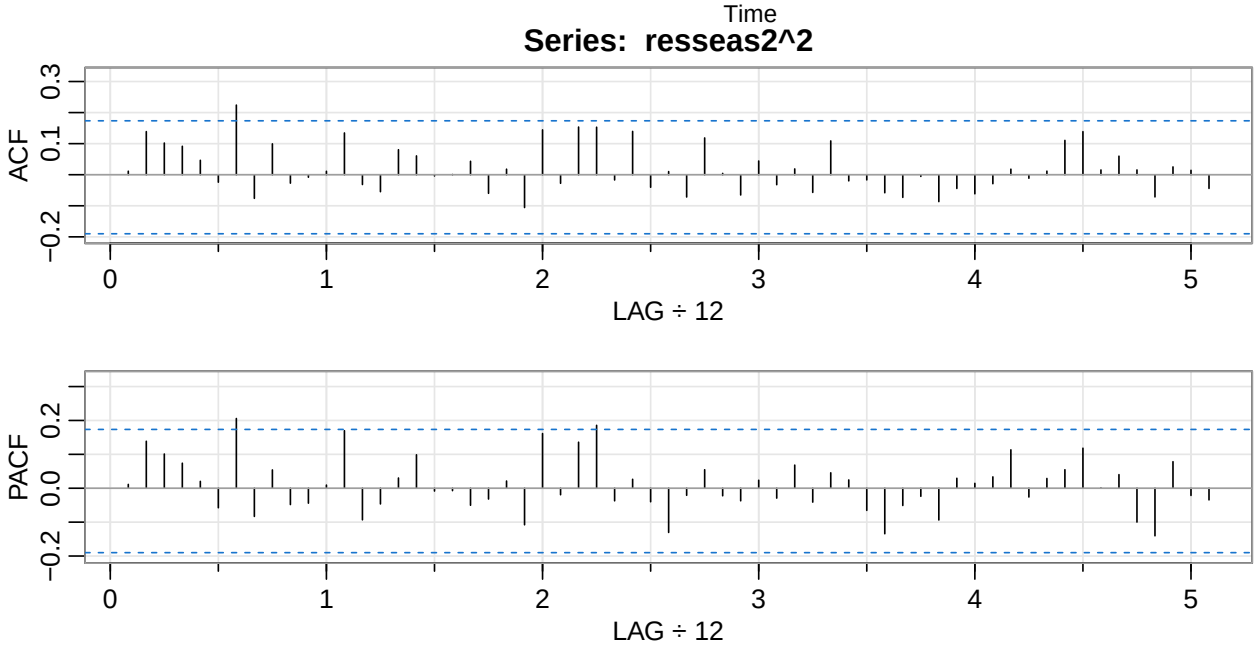





```
##      [,1] [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12]
## ACF  0.11 0.12 -0.02 -0.10 -0.08 -0.16 -0.01 -0.07 -0.11 -0.11 -0.08  0.03
## PACF 0.11 0.11 -0.04 -0.11 -0.05 -0.13  0.03 -0.05 -0.12 -0.12 -0.06  0.03
##      [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24]
## ACF   0.08  0.01 -0.03 -0.01  0.00 -0.06  0.00  0.02 -0.07 -0.03 -0.12  0.11
## PACF  0.07 -0.06 -0.11 -0.03  0.01 -0.07 -0.02 -0.03 -0.11 -0.03 -0.11  0.11
##      [,25] [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36]
## ACF   0.03  0.04  0.13  0.01  0.01 -0.04 -0.06  0.01  0.00  0.03 -0.08  0.02
## PACF -0.01 -0.05  0.08 -0.02 -0.05 -0.02 -0.08  0.00  0.03  0.03 -0.09  0.03
##      [,37] [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48]
```

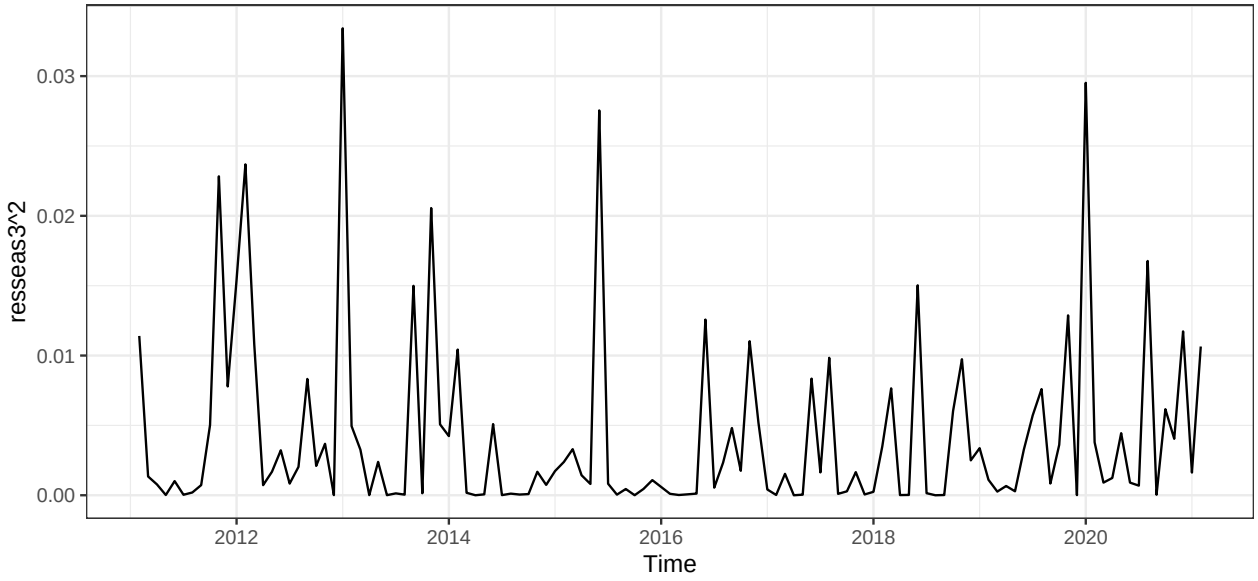
```
## ACF  -0.02  0.01  0.05  0.03 -0.04 -0.11 -0.08 -0.09 -0.03 -0.05 -0.01 -0.06
## PACF -0.04  0.02  0.05 -0.01 -0.12 -0.08 -0.05 -0.08 -0.01 -0.12 -0.06 -0.10
##      [,49] [,50] [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60]
## ACF   0.00  0.02  0.05  0.26  0.18  0.15  0.06 -0.01 -0.02 -0.10  0.00  0.02
## PACF -0.04 -0.02 -0.06  0.16  0.08  0.05  0.05 -0.02  0.02 -0.04  0.08  0.07
##      [,61]
## ACF  -0.08
## PACF -0.05
```

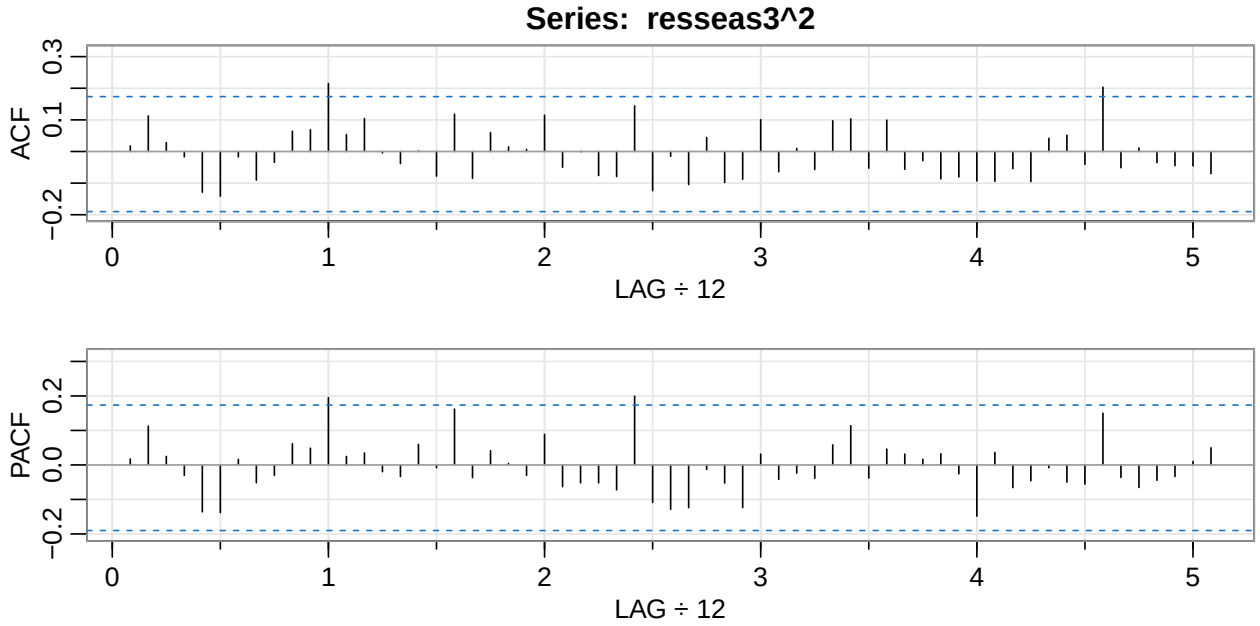





```
##      [,1] [,2] [,3] [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  0.01 0.14  0.1 0.09 0.05 -0.02 0.22 -0.08 0.10 -0.03 -0.01  0.01  0.13
```

```
## PACF 0.01 0.14  0.1 0.07 0.02 -0.06 0.21 -0.08 0.05 -0.05 -0.04  0.01  0.17
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF  -0.03 -0.05  0.08  0.06  0.00  0.00  0.04 -0.06  0.02 -0.11  0.14 -0.03
## PACF -0.09 -0.05  0.03  0.10 -0.01 -0.01 -0.05 -0.03  0.02 -0.11  0.16 -0.02
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF   0.15  0.15 -0.02  0.14 -0.04  0.01 -0.07  0.12  0.00 -0.07  0.04 -0.03
## PACF  0.14  0.19 -0.04  0.03 -0.04 -0.13 -0.02  0.05 -0.02 -0.04  0.02 -0.03
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.02 -0.06  0.11 -0.02 -0.02 -0.06 -0.07 -0.01 -0.09 -0.04 -0.06 -0.03
## PACF  0.07 -0.04  0.05  0.02 -0.07 -0.13 -0.05 -0.02 -0.09  0.03  0.01  0.03
##      [,50] [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60] [,61]
## ACF   0.02 -0.01  0.01  0.11  0.14  0.02  0.06  0.02 -0.07  0.03  0.01 -0.04
## PACF  0.11 -0.03  0.03  0.05  0.12  0.00  0.04 -0.10 -0.14  0.08 -0.02 -0.03
```






```
##      [,1] [,2] [,3]  [,4]  [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12] [,13]
## ACF  0.02 0.11 0.03 -0.02 -0.13 -0.14 -0.02 -0.09 -0.03  0.06  0.07  0.21  0.05
## PACF 0.02 0.11 0.02 -0.03 -0.14 -0.14  0.02 -0.05 -0.03  0.06  0.05  0.20  0.02
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF   0.10  0.00 -0.04  0.00 -0.08  0.12 -0.08  0.06  0.01  0.01  0.11 -0.05
## PACF  0.03 -0.02 -0.03  0.06 -0.01  0.16 -0.04  0.04  0.00 -0.03  0.09 -0.06
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF   0.00 -0.08 -0.08  0.14 -0.12 -0.02 -0.10  0.04 -0.10 -0.09  0.10 -0.06
## PACF -0.05 -0.05 -0.07  0.20 -0.11 -0.13 -0.12 -0.01 -0.05 -0.12  0.03 -0.04
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.01 -0.06  0.10  0.10 -0.05  0.10 -0.06 -0.03 -0.09 -0.08 -0.09 -0.09
## PACF -0.02 -0.04  0.06  0.11 -0.04  0.05  0.03  0.02  0.03 -0.03 -0.15  0.04
##      [,50] [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60] [,61]
## ACF  -0.05 -0.10  0.04  0.05 -0.04  0.20 -0.05  0.01 -0.04 -0.04 -0.05 -0.07
## PACF -0.07 -0.05 -0.01 -0.05 -0.06  0.15 -0.04 -0.07 -0.04 -0.03  0.01  0.05

##
##  Jarque Bera Test
##
## data:  resseas1
## X-squared = 9.9942, df = 2, p-value = 0.006758

##
##  Jarque Bera Test
```

Cuadro 1: Medidas de Ajuste: ARIMA Entrenamiento

Models	AIC	BIC
2. ARIMA (0 1 0)(0 1 1) Niveles	2646.710	2654.784
3. ARIMA (2 1 0)(1 0 0) Log	2925.722	2942.497
1. ARIMA (0 1 0)(1 0 1) Log	2929.554	2940.737

```
##
## data:  resseas2
## X-squared = 4.636, df = 2, p-value = 0.09847

##
##  Jarque Bera Test
##
## data:  resseas3
## X-squared = 1.8213, df = 2, p-value = 0.4023

##
##  Shapiro-Wilk normality test
##
## data:  resseas1
## W = 0.97246, p-value = 0.008379

##
##  Shapiro-Wilk normality test
##
## data:  resseas2
## W = 0.97432, p-value = 0.02051

##
##  Shapiro-Wilk normality test
##
## data:  resseas3
## W = 0.98269, p-value = 0.1232
```

Cuadro 2: (#tab:metricas de rendimiento lineales generales)Metricas de Rendimiento sobre la muestra de prueba

Modelo	Dataset	MAE	RSS	MSE	RMSE
1. ARIMA (0 1 0)(1 0 1) Log	Entrenamiento	21165.00	99913636070	818964230	28617.55
2. ARIMA (0 1 0)(0 1 1) Niveles	Entrenamiento	21829.20	103361143650	847222489	29107.09
3. ARIMA (2 1 0)(1 0 0) Log	Entrenamiento	28923.01	165071131447	1353042061	36783.72
Holt Winter Aditivia	Entrenamiento	32997.01	230557903869	1889818884	43472.05
Holt Winter Multiplicativa	Entrenamiento	35508.68	248809460176	2039421805	45159.96
3. ARIMA (2 1 0)(1 0 0) Log	Prueba	42671.15	12081978350	2416395670	49156.85
2. ARIMA (0 1 0)(0 1 1) Niveles	Prueba	47704.12	17563051551	3512610310	59267.28
1. ARIMA (0 1 0)(1 0 1) Log	Prueba	47783.00	17050515820	3410103164	58396.09
Holt Winter Aditivia	Prueba	47797.04	16671689420	3334337884	57743.73
Holt Winter Multiplicativa	Prueba	53117.50	18279523374	3655904675	60464.08

Modelo	Dataset	MAE	RSS	MSE	RMSE
1. ARIMA (0 1 0)(1 0 1) Log	Entrenamiento	21165.00	99913636070	818964230	28617.55
2. ARIMA (0 1 0)(0 1 1) Niveles	Entrenamiento	21829.20	103361143650	847222489	29107.09
3. ARIMA (2 1 0)(1 0 0) Log	Entrenamiento	28923.01	165071131447	1353042061	36783.72
1. ARIMA (0 1 0)(1 0 1) Log	Prueba	47783.00	17050515820	3410103164	58396.09
2. ARIMA (0 1 0)(0 1 1) Niveles	Prueba	47704.12	17563051551	3512610310	59267.28
3. ARIMA (2 1 0)(1 0 0) Log	Prueba	42671.15	12081978350	2416395670	49156.85

Métricas de Rendimiento Modelos Lineales

3.2.1.2. Serie en Dolares Por otro lado para la serie de los saldos del Activo Neto Administrado de los Fondos de Inversión del Mercado de Dinero en **dolares**, se estimó un modelo autoregresivo de medias moviles (ARIMA) con transformación logarítmica, la cual tiene la siguiente forma:

En el gráfico xxx se puede apreciar el pronostico sobre los últimos 5 meses reservado para probar el modelo, es importante resaltar que los meses pronosticados se acercan en gran medida a los valores reales y los intervalos de confianza son amplios pero contienen los valores reales, para mas detalles sobre las metricas de rendimientos de los modelos dirigirse al anexo xxx.

Es importante resaltar que el modelo ARIMA()() cumple con los supuestos:

ARIMA

```
##
## Call:
## seas(x = sactnetcrc_train, transform.function = "log", regression.aictest = NULL,
##     outlier = NULL, regression.variables = "ao2020.Mar", arima.model = "(0 1 0)(1 0 1)")
##
## Coefficients:
##                Estimate Std. Error z value             Pr(>|z|)
```

```
## AO2020.Mar     -0.26213    0.04651  -5.636   0.0000000173759851 ***
## AR-Seasonal-12  0.93237    0.03143  29.664 < 0.0000000000000002 ***
## MA-Seasonal-12  0.62705    0.08332   7.526   0.0000000000000523 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## SEATS adj.  ARIMA: (0 1 0)(1 0 1)  Obs.: 122  Transform: log
## AICc:  2930, BIC:  2941  QS (no seasonality in final):    0
## Box-Ljung (no autocorr.): 25.52   Shapiro (normality): 0.9725 **
##
## Call:
## seas(x = sactnetcrc_train, transform.function = "none", regression.aictest = NULL,
##     outlier = NULL, regression.variables = "ao2020.Mar", arima.model = "(0 1 0)(0 1 1)")
##
## Coefficients:
##                     Estimate    Std. Error z value             Pr(>|z|)
## AO2020.Mar     -200519.71119   29678.44417  -6.756      0.0000000000141 ***
## MA-Seasonal-12       0.78410       0.07922   9.898 < 0.0000000000000002 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## SEATS adj.  ARIMA: (0 1 0)(0 1 1)  Obs.: 122  Transform: none
## AICc:  2647, BIC:  2655  QS (no seasonality in final):    0
## Box-Ljung (no autocorr.): 27.41   Shapiro (normality): 0.9743 *
##
## Call:
## seas(x = sactnetcrc_train, transform.function = "log", regression.aictest = NULL,
##     outlier = NULL, regression.variables = c("ls2015.May", "ao2020.Mar"),
##     arima.model = "(2 1 0)(1 0 0)")
##
## Coefficients:
##                   Estimate Std. Error z value         Pr(>|z|)
## LS2015.May         0.21302    0.05516   3.861         0.000113 ***
## AO2020.Mar        -0.24242    0.04827  -5.023 0.00000051001064 ***
## AR-Nonseasonal-01 -0.13474    0.08772  -1.536         0.124556
## AR-Nonseasonal-02 -0.23542    0.08922  -2.639         0.008325 **
```

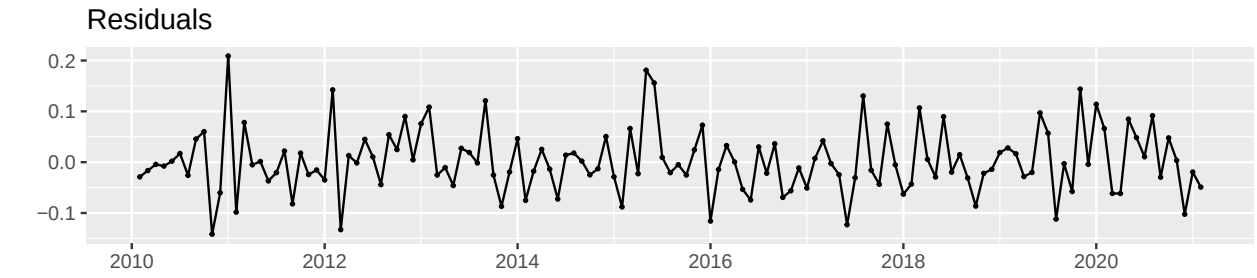
```
## AR-Seasonal-12     0.54195    0.07683   7.054 0.00000000000173 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## SEATS adj.  ARIMA: (2 1 0)(1 0 0)  Obs.: 122  Transform: log
## AICc:  2926, BIC:  2942  QS (no seasonality in final):    0
## Box-Ljung (no autocorr.): 19.38   Shapiro (normality): 0.9827
```

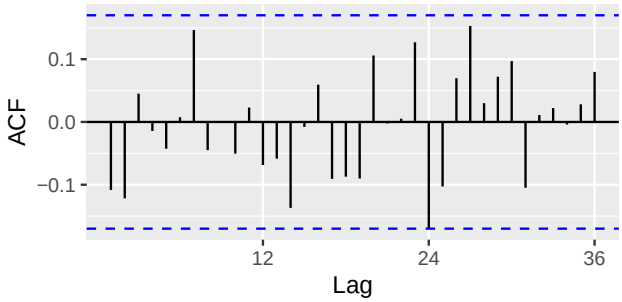
Análisis de Supuestos

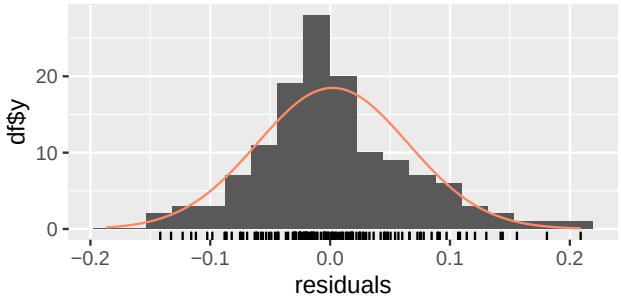
```
##
##  Augmented Dickey-Fuller Test
##
## data:  resseas1_usd
## Dickey-Fuller = -4.8317, Lag order = 5, p-value = 0.01
## alternative hypothesis: stationary

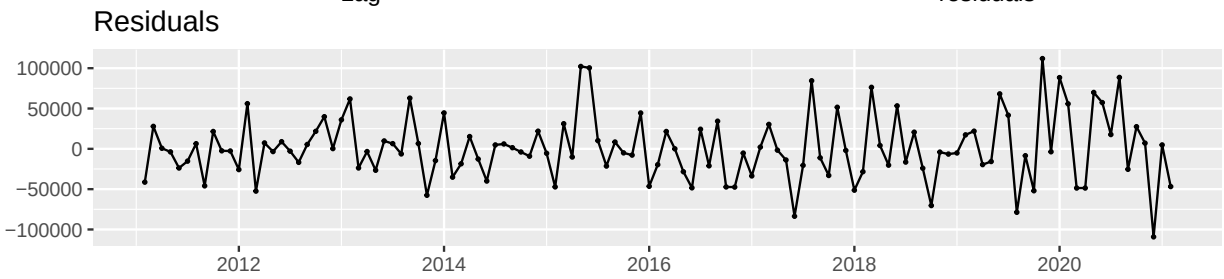
##
##  Augmented Dickey-Fuller Test
##
## data:  resseas2_usd
## Dickey-Fuller = -5.1753, Lag order = 4, p-value = 0.01
## alternative hypothesis: stationary

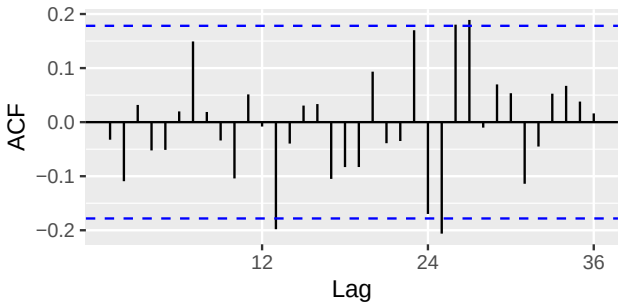
##
##  Augmented Dickey-Fuller Test
##
## data:  resseas3_usd
## Dickey-Fuller = -5.34, Lag order = 4, p-value = 0.01
## alternative hypothesis: stationary
```

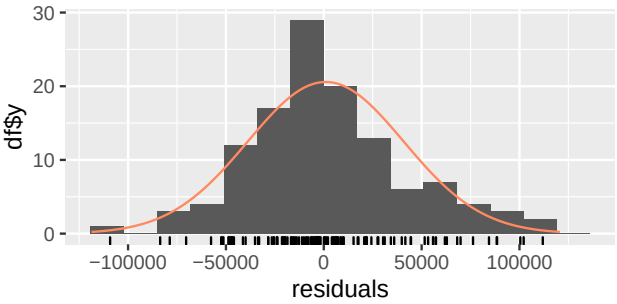

Residuals
0.2
0.1
0.0
−0.1
2010
2012
2014
2016
2018
2020

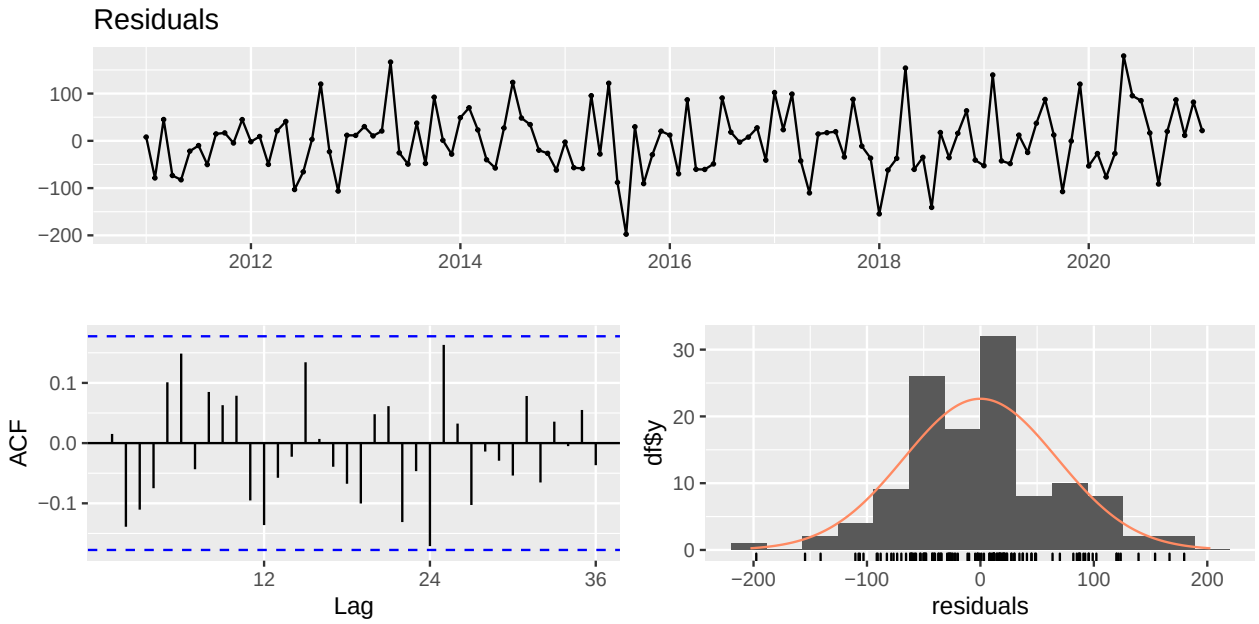

ACF
0.1
0.0
−0.1
12
24
36
Lag


df$y
20
10
0
−0.2
−0.1
0.0
0.1
0.2
residuals


Residuals
100000
50000
0
−50000
−100000
2012
2014
2016
2018
2020


ACF
0.2
0.1
0.0
−0.1
−0.2
12
24
36
Lag


df$y
30
20
10
0
−100000
−50000
0
50000
100000
residuals




```
##
##  Box-Ljung test
##
## data:  resseas1_usd
## X-squared = 1.5978, df = 1, p-value = 0.2062

##
##  Box-Ljung test
##
## data:  resseas2_usd
## X-squared = 0.13088, df = 1, p-value = 0.7175

##
##  Box-Ljung test
##
## data:  resseas3_usd
## X-squared = 0.029115, df = 1, p-value = 0.8645

##
##  Box-Ljung test
##
## data:  resseas1_usd
## X-squared = 8.691, df = 12, p-value = 0.7291

##
```

```
##  Box-Ljung test
##
## data:  resseas2_usd
## X-squared = 7.4138, df = 12, p-value = 0.8291

##
##  Box-Ljung test
##
## data:  resseas3_usd
## X-squared = 15.287, df = 12, p-value = 0.2261

##
##  Jarque Bera Test
##
## data:  resseas1_usd
## X-squared = 9.9942, df = 2, p-value = 0.006758

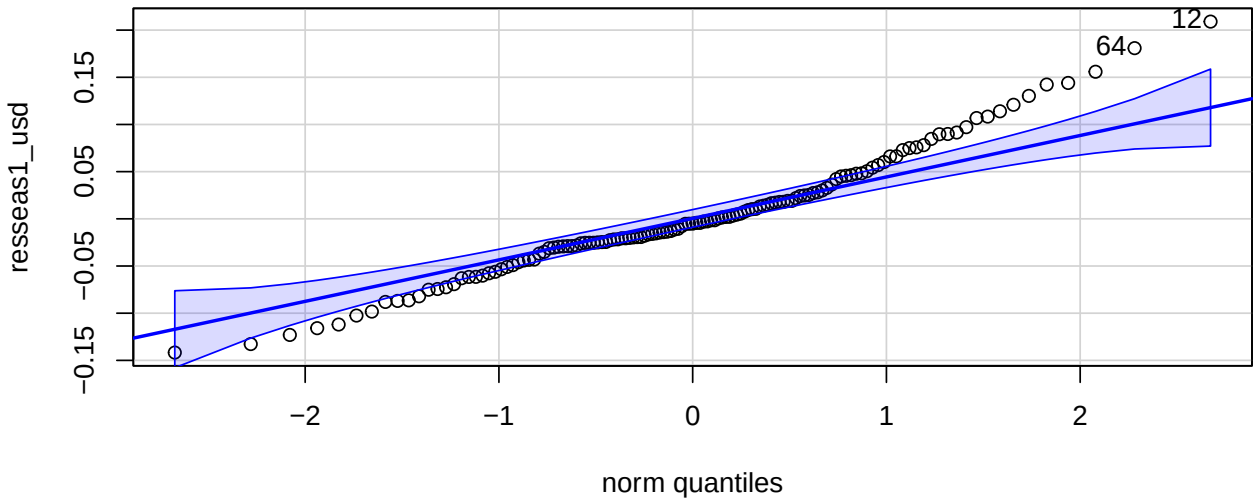
##
##  Jarque Bera Test
##
## data:  resseas2_usd
## X-squared = 4.636, df = 2, p-value = 0.09847

##
##  Jarque Bera Test
##
## data:  resseas3_usd
## X-squared = 1.0719, df = 2, p-value = 0.5851

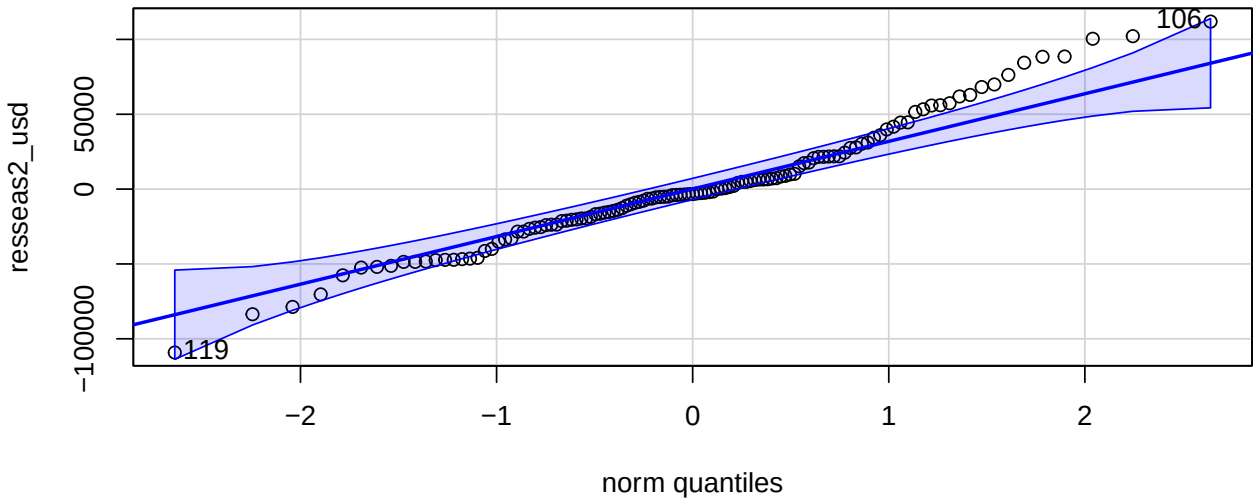
##
##  Shapiro-Wilk normality test
##
## data:  resseas1_usd
## W = 0.97246, p-value = 0.008379

##
##  Shapiro-Wilk normality test
##
## data:  resseas2_usd
## W = 0.97432, p-value = 0.02051
```

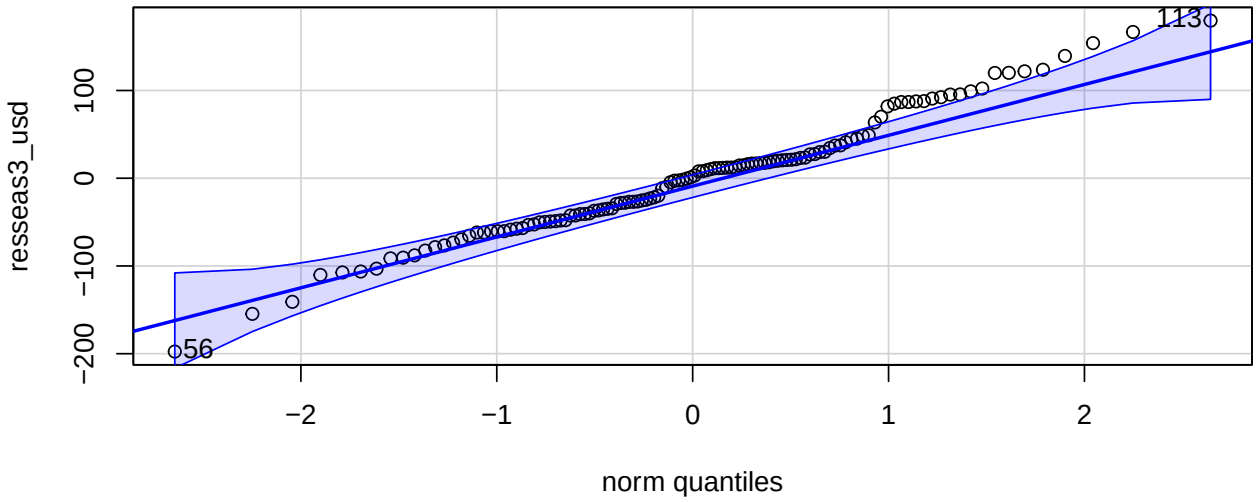
```
##
##  Shapiro-Wilk normality test
##
## data:  resseas3_usd
## W = 0.98456, p-value = 0.1791
```




```
## [1] 12 64
```




```
## [1] 106 119
```

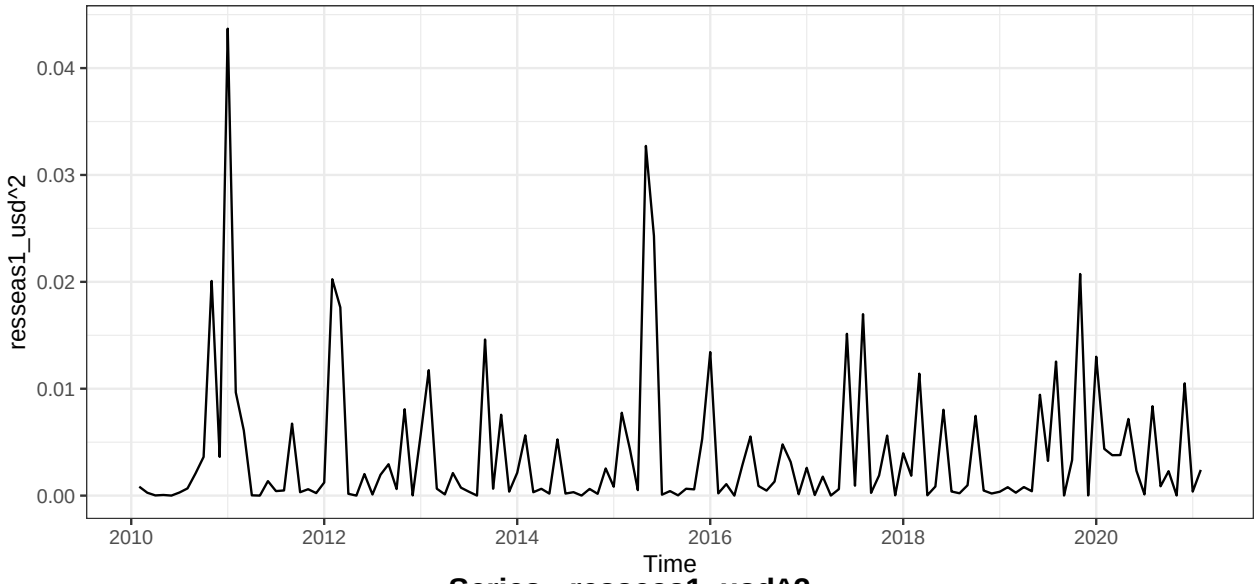


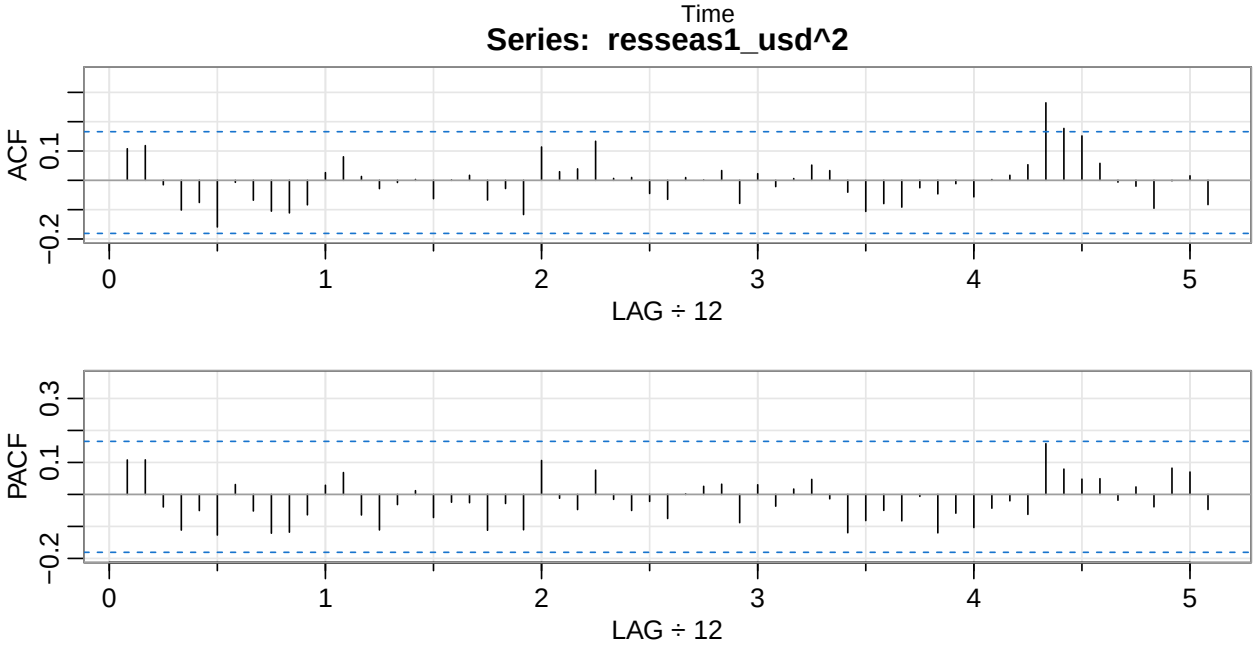

```
## [1]  56 113

##
##  ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  resseas1_usd
## Chi-squared = 9.7695, df = 12, p-value = 0.6362

##
##  ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  resseas2_usd
## Chi-squared = 12.286, df = 12, p-value = 0.423

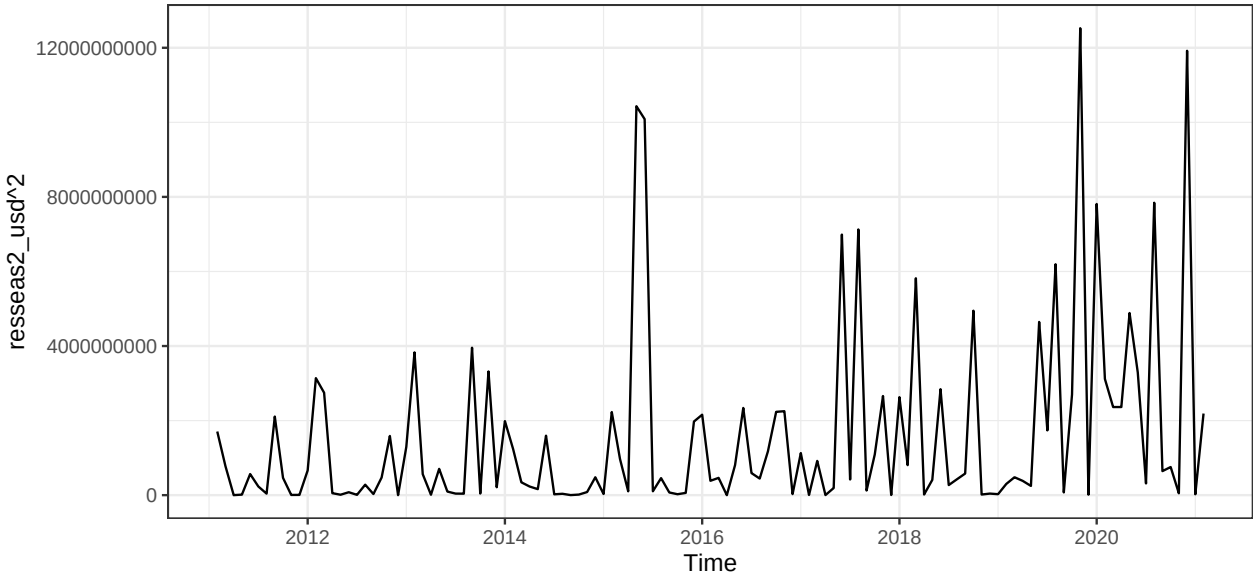
##
##  ARCH LM-test; Null hypothesis: no ARCH effects
##
## data:  resseas3_usd
## Chi-squared = 7.3322, df = 12, p-value = 0.8349
```

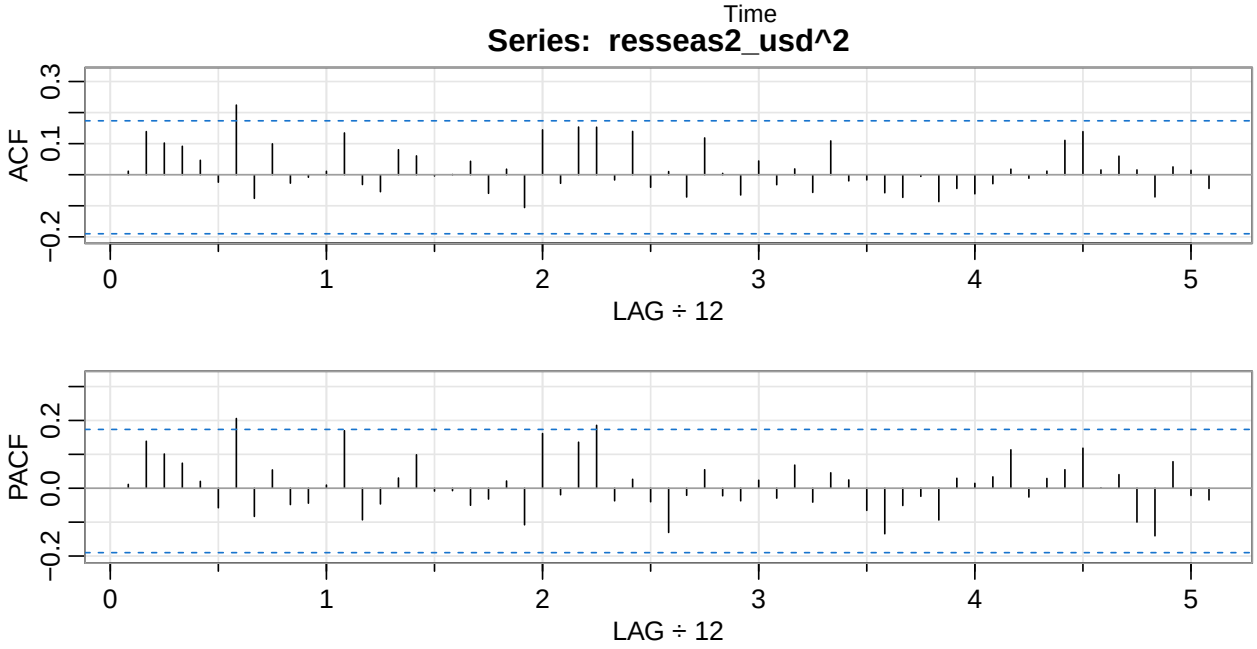





```
##       [,1] [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12]
## ACF   0.11 0.12 -0.02 -0.10 -0.08 -0.16 -0.01 -0.07 -0.11 -0.11 -0.08  0.03
## PACF 0.11 0.11 -0.04 -0.11 -0.05 -0.13  0.03 -0.05 -0.12 -0.12 -0.06  0.03
##       [,13] [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24]
## ACF    0.08  0.01 -0.03 -0.01  0.00 -0.06  0.00  0.02 -0.07 -0.03 -0.12  0.11
## PACF  0.07 -0.06 -0.11 -0.03  0.01 -0.07 -0.02 -0.03 -0.11 -0.03 -0.11  0.11
##       [,25] [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36]
## ACF    0.03  0.04  0.13  0.01  0.01 -0.04 -0.06  0.01  0.00  0.03 -0.08  0.02
## PACF -0.01 -0.05  0.08 -0.02 -0.05 -0.02 -0.08  0.00  0.03  0.03 -0.09  0.03
##       [,37] [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48]
```

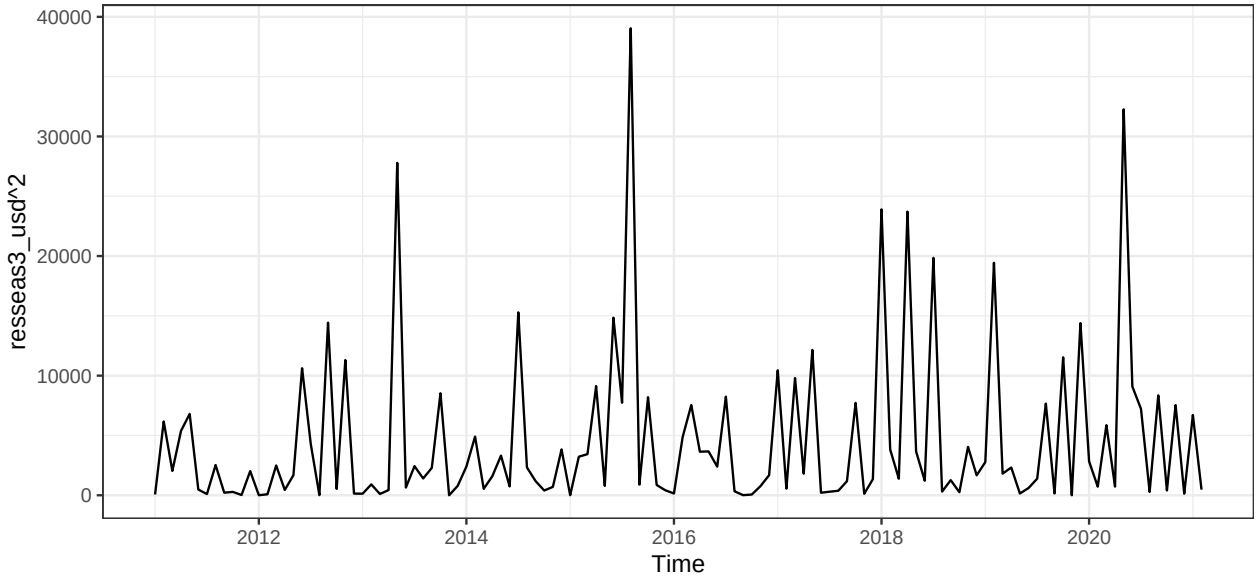
```
## ACF  -0.02  0.01  0.05  0.03 -0.04 -0.11 -0.08 -0.09 -0.03 -0.05 -0.01 -0.06
## PACF -0.04  0.02  0.05 -0.01 -0.12 -0.08 -0.05 -0.08 -0.01 -0.12 -0.06 -0.10
##      [,49] [,50] [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60]
## ACF   0.00  0.02  0.05  0.26  0.18  0.15  0.06 -0.01 -0.02 -0.10  0.00  0.02
## PACF -0.04 -0.02 -0.06  0.16  0.08  0.05  0.05 -0.02  0.02 -0.04  0.08  0.07
##      [,61]
## ACF  -0.08
## PACF -0.05
```





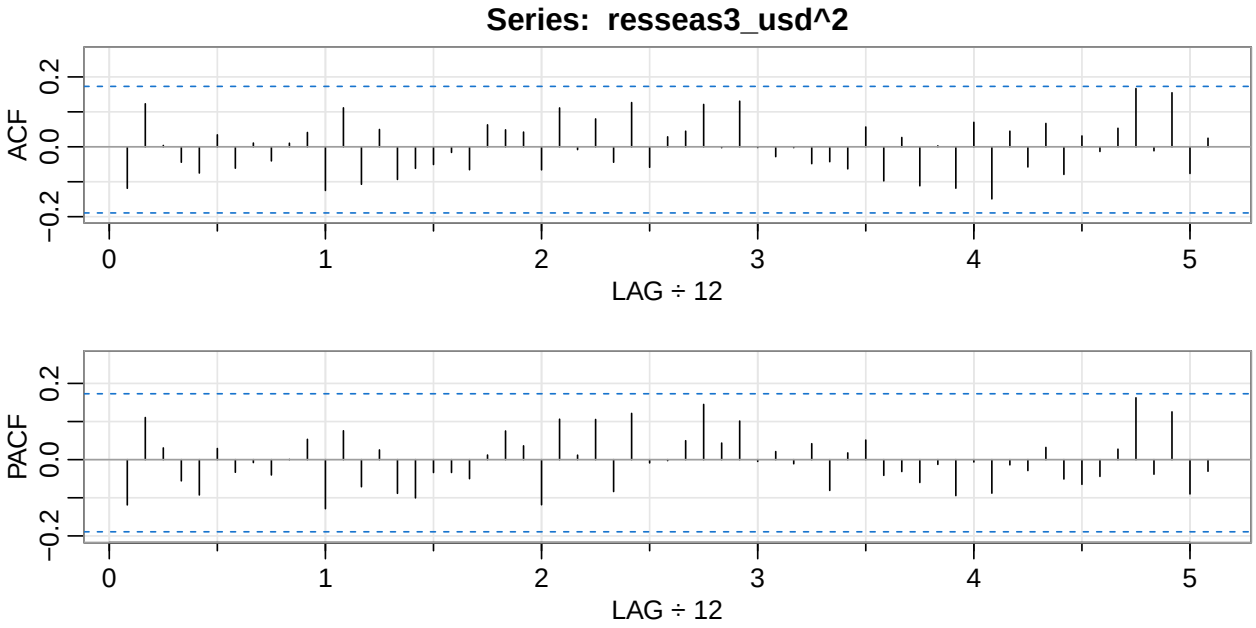

```
##      [,1] [,2] [,3] [,4] [,5]  [,6] [,7]  [,8] [,9] [,10] [,11] [,12] [,13]
## ACF  0.01 0.14  0.1 0.09 0.05 -0.02 0.22 -0.08 0.10 -0.03 -0.01  0.01  0.13
```

```
## PACF 0.01 0.14  0.1 0.07 0.02 -0.06 0.21 -0.08 0.05 -0.05 -0.04  0.01  0.17
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF  -0.03 -0.05  0.08  0.06  0.00  0.00  0.04 -0.06  0.02 -0.11  0.14 -0.03
## PACF -0.09 -0.05  0.03  0.10 -0.01 -0.01 -0.05 -0.03  0.02 -0.11  0.16 -0.02
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF   0.15  0.15 -0.02  0.14 -0.04  0.01 -0.07  0.12  0.00 -0.07  0.04 -0.03
## PACF  0.14  0.19 -0.04  0.03 -0.04 -0.13 -0.02  0.05 -0.02 -0.04  0.02 -0.03
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.02 -0.06  0.11 -0.02 -0.02 -0.06 -0.07 -0.01 -0.09 -0.04 -0.06 -0.03
## PACF  0.07 -0.04  0.05  0.02 -0.07 -0.13 -0.05 -0.02 -0.09  0.03  0.01  0.03
##      [,50] [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60] [,61]
## ACF   0.02 -0.01  0.01  0.11  0.14  0.02  0.06  0.02 -0.07  0.03  0.01 -0.04
## PACF  0.11 -0.03  0.03  0.05  0.12  0.00  0.04 -0.10 -0.14  0.08 -0.02 -0.03
```



Cuadro 3: Medidas de Ajuste: ARIMA Entrenamiento

Models	AIC	BIC
3. ARIMA (2 1 0)(1 0 0) Log	1272.902	1280.976
2. ARIMA (0 1 0)(0 1 1) Niveles	2646.710	2654.784
1. ARIMA (0 1 0)(1 0 1) Log	2929.554	2940.737



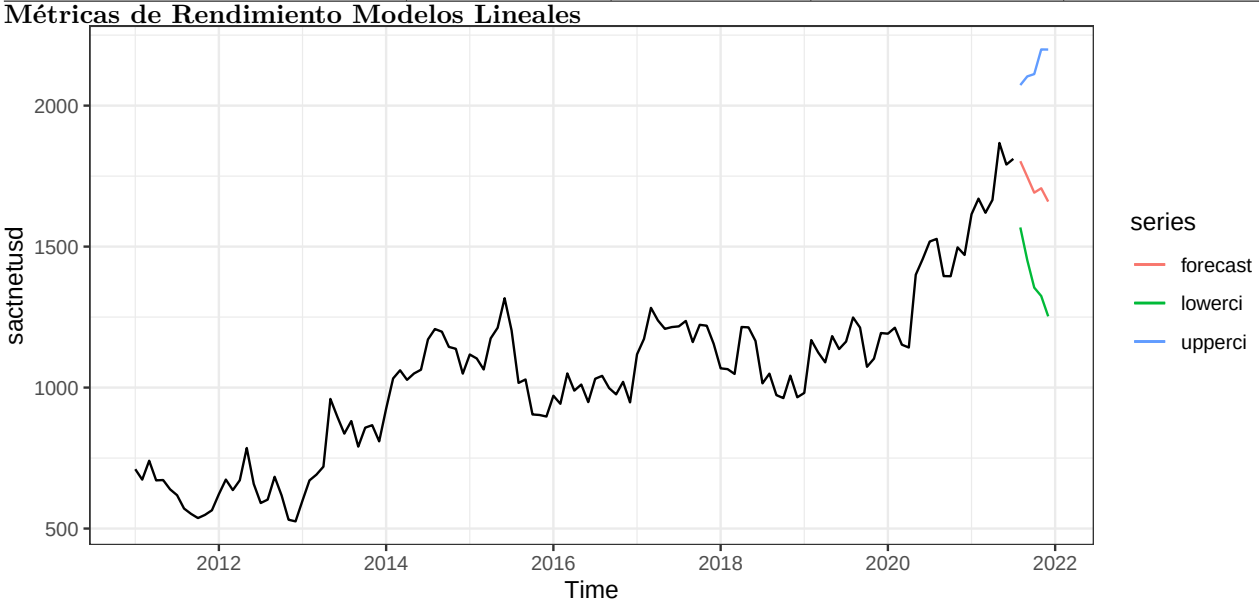

```
##       [,1] [,2] [,3]  [,4]  [,5] [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12] [,13]
## ACF  -0.12 0.12 0.00 -0.04 -0.08 0.03 -0.06  0.01 -0.04  0.01  0.04 -0.12  0.11
## PACF -0.12 0.11 0.03 -0.06 -0.09 0.03 -0.03 -0.01 -0.04  0.00  0.05 -0.13  0.08
##      [,14] [,15] [,16] [,17] [,18] [,19] [,20] [,21] [,22] [,23] [,24] [,25]
## ACF  -0.11  0.05 -0.09 -0.06 -0.05 -0.02 -0.07  0.06  0.05  0.04 -0.07  0.11
## PACF -0.07  0.03 -0.09 -0.10 -0.03 -0.03 -0.05  0.01  0.08  0.04 -0.12  0.11
##      [,26] [,27] [,28] [,29] [,30] [,31] [,32] [,33] [,34] [,35] [,36] [,37]
## ACF  -0.01  0.08 -0.04  0.13 -0.06  0.03  0.04  0.12  0.00  0.13     0 -0.03
## PACF  0.01  0.11 -0.08  0.12 -0.01  0.00  0.05  0.14  0.04  0.10     0  0.02
##      [,38] [,39] [,40] [,41] [,42] [,43] [,44] [,45] [,46] [,47] [,48] [,49]
## ACF   0.00 -0.05 -0.04 -0.06  0.06 -0.10  0.03 -0.11  0.00 -0.12  0.07 -0.15
## PACF -0.01  0.04 -0.08  0.02  0.05 -0.04 -0.03 -0.06 -0.01 -0.09 -0.01 -0.09
##      [,50] [,51] [,52] [,53] [,54] [,55] [,56] [,57] [,58] [,59] [,60] [,61]
## ACF   0.04 -0.06  0.07 -0.08  0.03 -0.01  0.05  0.17 -0.01  0.15 -0.08  0.02
## PACF -0.01 -0.03  0.03 -0.05 -0.06 -0.04  0.03  0.16 -0.04  0.13 -0.09 -0.03
```

Cuadro 4: Metricas de Rendimiento sobre la muestra de prueba

Modelo	Dataset	MAE	RSS	MSE	R
3.ARIMA (0 1 1)(0 1 1) Niveles	Entrenamiento	38.43133	255606.93	2095.139	45.7
Holt Winter Aditivia	Entrenamiento	53.54778	563335.58	4617.505	67.9
Holt Winter Multiplicativa	Entrenamiento	54.89003	598013.39	4901.749	70.0
2.ARIMA (0 1 1)(0 1 1) Log	Entrenamiento	642303.60890	54237406974815.20	444568909629.633	666760.0
1.ARIMA (0 1 1)(1 1 0) Niveles	Entrenamiento	642544.04698	54263807533192.29	444785307649.117	666922.2
Holt Winter Aditivia	Prueba	53.12659	16432.39	3286.479	57.3
Holt Winter Multiplicativa	Prueba	54.05022	18804.05	3760.810	61.3
3.ARIMA (0 1 1)(0 1 1) Niveles	Prueba	62.33028	22993.34	4598.669	67.8
2.ARIMA (0 1 1)(0 1 1) Log	Prueba	1009565.39211	5099159757987.84	1019831951597.568	1009867.2
1.ARIMA (0 1 1)(1 1 0) Niveles	Prueba	1018903.39138	5196674889398.60	1039334977879.719	1019477.7

Modelo	Dataset	MAE	RSS	MSE	
1.ARIMA (0 1 1)(1 1 0) Niveles	Entrenamiento	642544.04698	54263807533192.29	444785307649.117	6669
2.ARIMA (0 1 1)(0 1 1) Log	Entrenamiento	642303.60890	54237406974815.20	444568909629.633	6667
3.ARIMA (0 1 1)(0 1 1) Niveles	Entrenamiento	38.43133	255606.93	2095.139	
1.ARIMA (0 1 1)(1 1 0) Niveles	Prueba	1018903.39138	5196674889398.60	1039334977879.719	10194
2.ARIMA (0 1 1)(0 1 1) Log	Prueba	1009565.39211	5099159757987.84	1019831951597.568	10098
3.ARIMA (0 1 1)(0 1 1) Niveles	Prueba	62.33028	22993.34	4598.669	

Métricas de Rendimiento Modelos Lineales



3.2.2. Modelo No Lineal

3.2.2.1. Serie en Colones

3.2.2.1.1. TAR Definir Parametros modelo TAR

```
## [1] "0-3-1"
```

```
## [1] "3-1-1"
## [1] "3-3-1"
## [1] "3-1-2"
## [1] "3-2-2"
```

Ordene-delay	1
3-2-2	2924
3-1-2	2925
3-3-1	2929
3-1-1	2930
1-3-1	2936

Los tres mejores modelos

```
##
## 634783.1

##
## 733818.8

##
## 511224.5

## intercept-sactnetcrc_train      lag1-sactnetcrc_train
##              21868.4352666                  0.7499834
##      lag2-sactnetcrc_train      lag3-sactnetcrc_train
##                  -0.3430847                  0.5609114

## intercept-sactnetcrc_train      lag1-sactnetcrc_train
##              15867.9606105                  0.8874530
##      lag2-sactnetcrc_train      lag3-sactnetcrc_train
##                  -0.2851389                  0.3824949

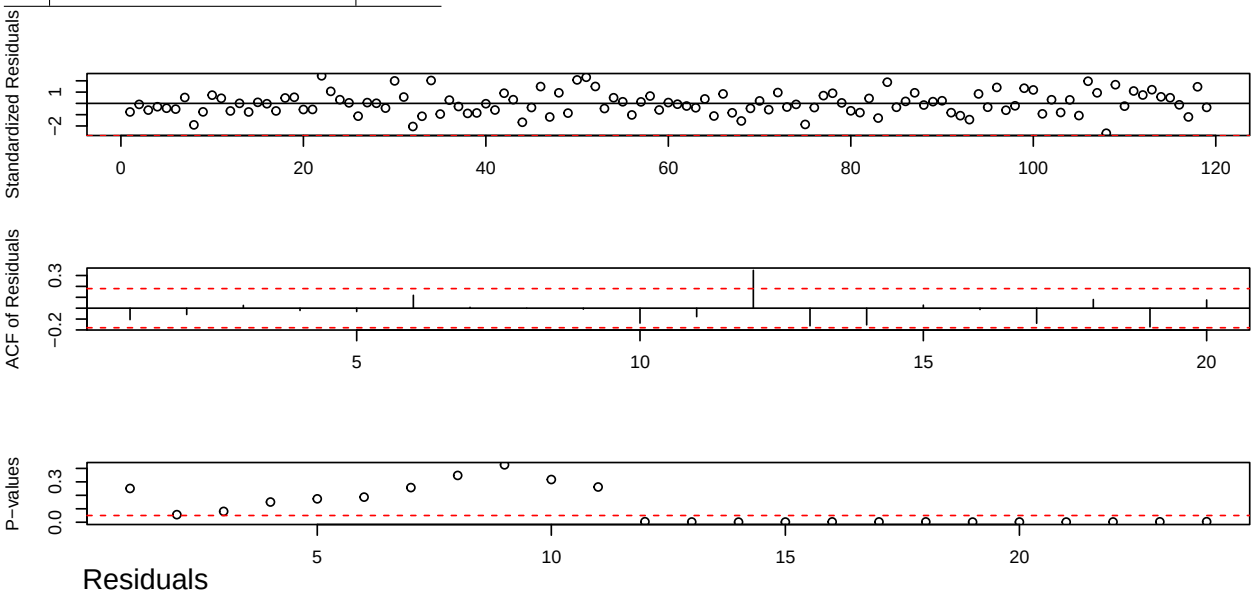
## intercept-sactnetcrc_train      lag1-sactnetcrc_train
##              38543.7938885                  0.6614203
##      lag2-sactnetcrc_train      lag3-sactnetcrc_train
##                  -0.7022195                  0.9513138

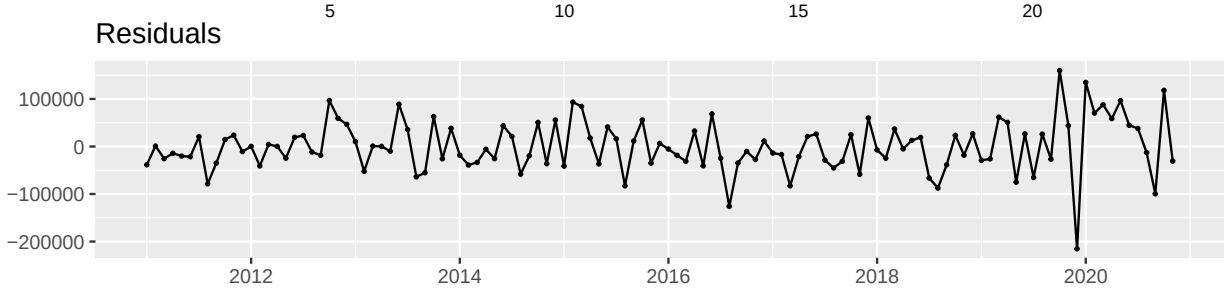
## intercept-sactnetcrc_train      lag1-sactnetcrc_train
##               81703.567757                   0.897547

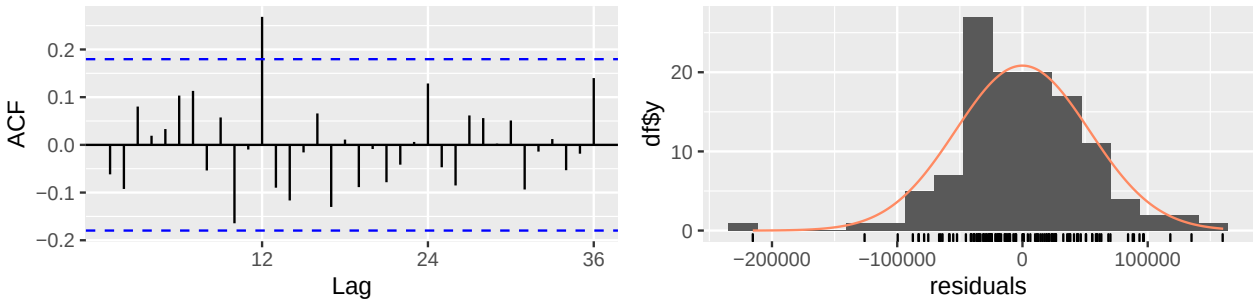
## intercept-sactnetcrc_train      lag1-sactnetcrc_train
##              88446.1214206                  0.8892529
```

```
## intercept-sactnetcrc_train      lag1-sactnetcrc_train
##                34728.59159827                 0.78818409
##      lag2-sactnetcrc_train      lag3-sactnetcrc_train
##                  -0.05905747                 0.23115235
```

	Modelo	AIC
1	1.TAR p1=3,p2=2,d=1	2930
1	2.TAR p1=3,p2=1,d=2	2925
1	3.TAR p1=3,p2=3,d=1	2929

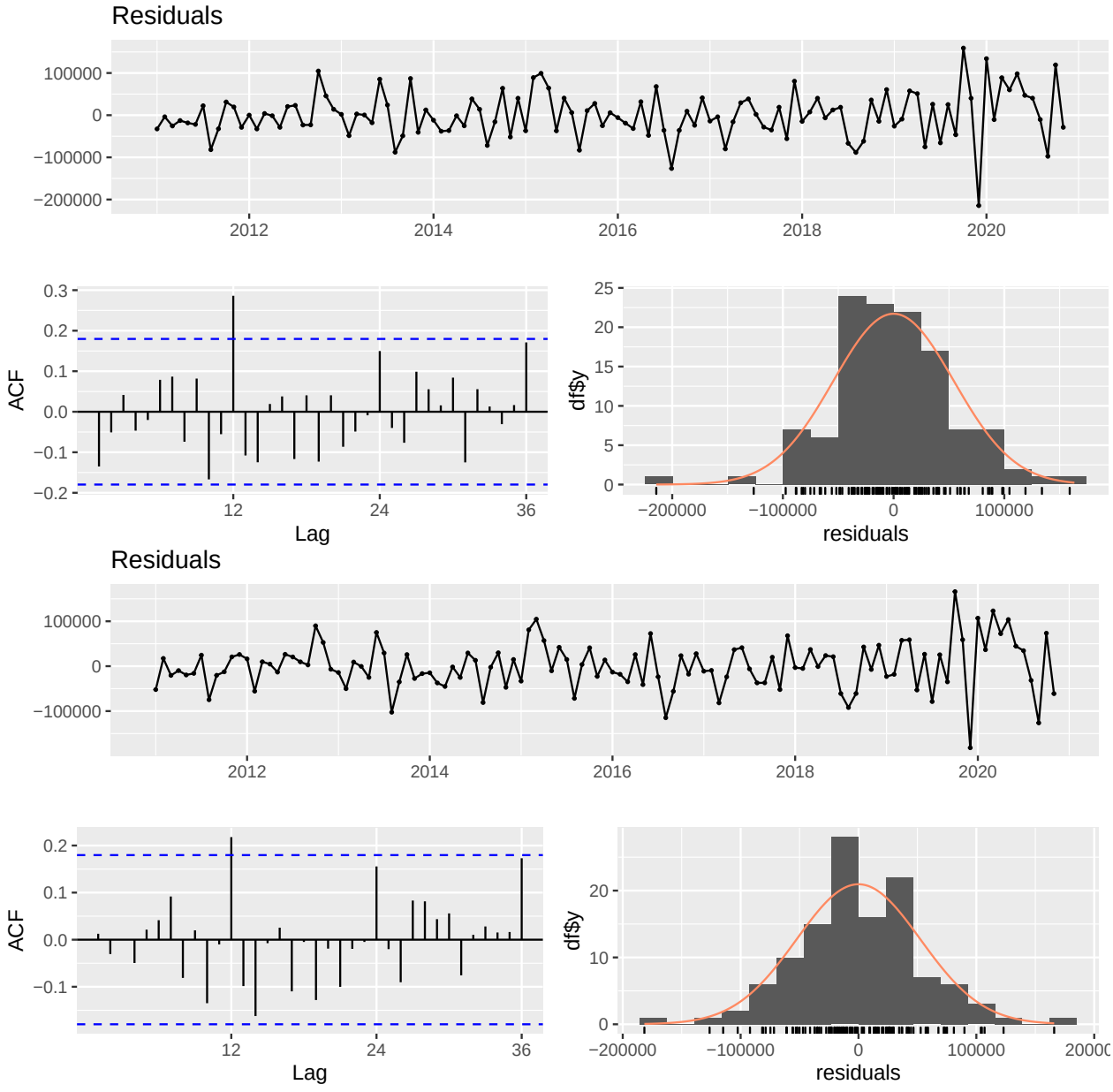


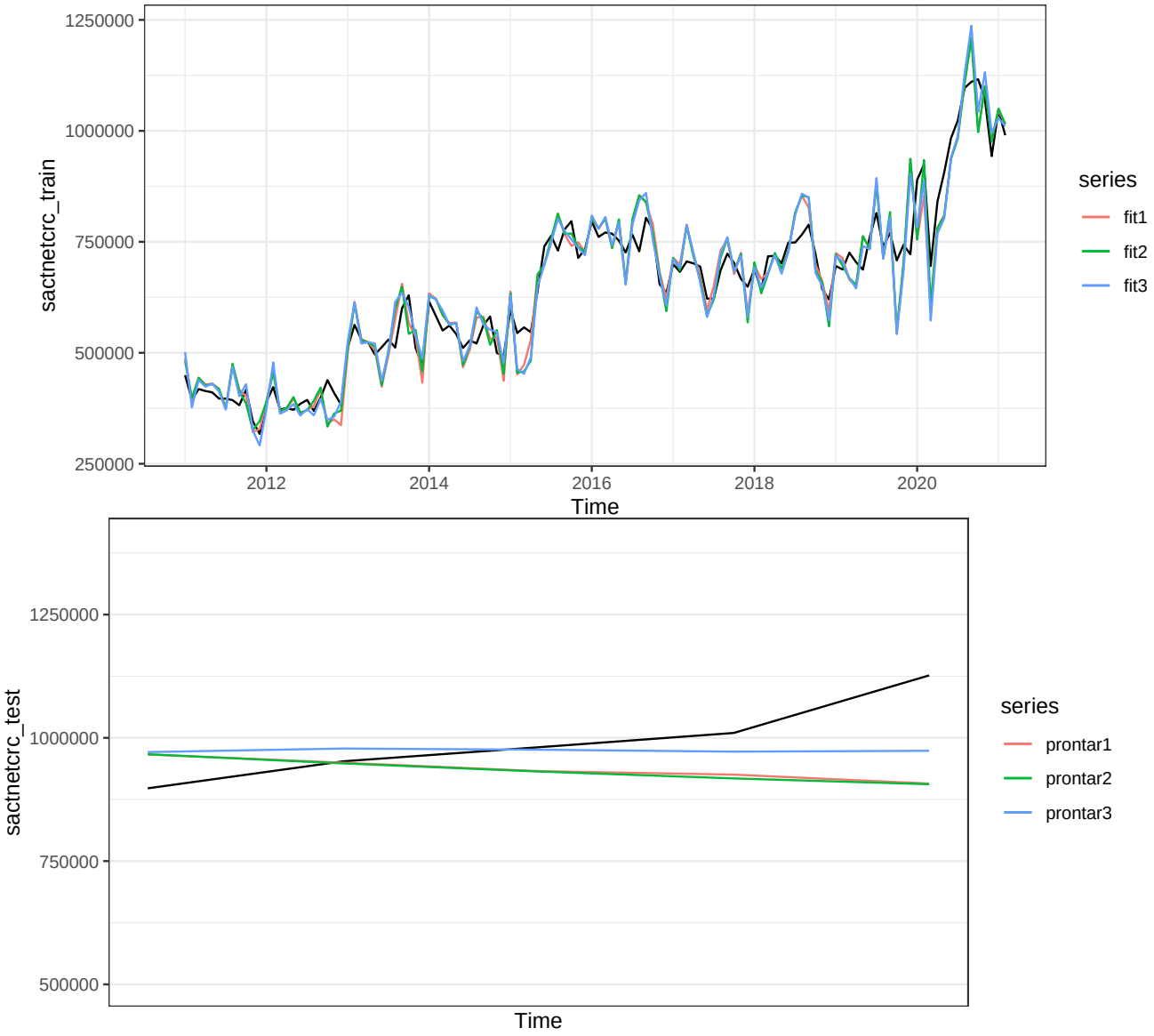




Cuadro 5: Metricas de Rendimiento Modelos TAR

Modelo	DataSet	MAE	RSS	MSE	RMSE
3.TAR p1=3,p2=3,d=1	Entrenamiento	39772.97	328942351055	2696248779	51925.42
1.TAR p1=3,p2=2,d=1	Entrenamiento	40308.12	338913405336	2777978732	52706.53
2.TAR p1=3,p2=1,d=2	Entrenamiento	40514.30	351547834112	2881539624	53679.97
3.TAR p1=3,p2=3,d=1	Prueba	59009.97	30898688005	6179737601	78611.31
1.TAR p1=3,p2=2,d=1	Prueba	84725.95	62293400375	12458680075	111618.46
2.TAR p1=3,p2=1,d=2	Prueba	87059.11	64393263703	12878652741	113484.15





3.2.2.1.2. SETAR Thus the threshold delay, the number of lags in each regime and the threshold value are computed.

```
## Using maximum autoregressive order for low regime: mL = 3
## Using maximum autoregressive order for high regime: mH = 3
## Using maximum autoregressive order for middle regime: mM = 3
## Searching on 83 possible threshold values within regimes with sufficient ( 15% ) number of observati
## Searching on  1494  combinations of thresholds ( 83 ), thDelay ( 2 ), mL ( 3 ) and MM ( 3 )
##
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
```

```
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5Result of the one threshold search:
##  -Thresh:  778351.5  -Delay:  2  -mL: 3  -mH: 1  - AIC 2664.942
##
## Trim not respected:  0.1680672 0.697479 0.1344538 from 416644.8 778351.5
## Trim not respected:  0.1764706 0.6890756 0.1344538 from 418187.9 778351.5
## Trim not respected:  0.1848739 0.6806723 0.1344538 from 422751.8 778351.5
## Trim not respected:  0.1932773 0.6722689 0.1344538 from 438446.4 778351.5
## Trim not respected:  0.210084 0.6554622 0.1344538 from 470793.3 778351.5
## Trim not respected:  0.2184874 0.6470588 0.1344538 from 492453.3 778351.5
## Trim not respected:  0.2268908 0.6386555 0.1344538 from 496086.7 778351.5
## Trim not respected:  0.2352941 0.6302521 0.1344538 from 499552.3 778351.5
## Trim not respected:  0.2436975 0.6218487 0.1344538 from 510928.7 778351.5
## Trim not respected:  0.2521008 0.6134454 0.1344538 from 511224.5 778351.5
## Trim not respected:  0.2605042 0.605042 0.1344538 from 511791.8 778351.5
## Trim not respected:  0.2689076 0.5966387 0.1344538 from 511895.9 778351.5
## Trim not respected:  0.2773109 0.5882353 0.1344538 from 512476.7 778351.5
## Trim not respected:  0.2857143 0.5798319 0.1344538 from 521049.7 778351.5
## Trim not respected:  0.2941176 0.5714286 0.1344538 from 523480.9 778351.5
## Trim not respected:  0.302521 0.5630252 0.1344538 from 528105.4 778351.5
## Trim not respected:  0.3109244 0.5546218 0.1344538 from 529852.4 778351.5
## Trim not respected:  0.3193277 0.5462185 0.1344538 from 530010.3 778351.5
## Trim not respected:  0.3277311 0.5378151 0.1344538 from 542167.5 778351.5
```

```
## Trim not respected:  0.3361345 0.5294118 0.1344538 from 544430 778351.5
## Trim not respected:  0.3445378 0.5210084 0.1344538 from 546553.9 778351.5
## Trim not respected:  0.3529412 0.512605 0.1344538 from 550118.6 778351.5
## Trim not respected:  0.3613445 0.5042017 0.1344538 from 557325.5 778351.5
## Trim not respected:  0.3697479 0.4957983 0.1344538 from 561437.7 778351.5
## Trim not respected:  0.3781513 0.487395 0.1344538 from 561724.3 778351.5
## Trim not respected:  0.3865546 0.4789916 0.1344538 from 562865.8 778351.5
## Trim not respected:  0.394958 0.4705882 0.1344538 from 581770.8 778351.5
## Trim not respected:  0.4033613 0.4621849 0.1344538 from 582916.3 778351.5
## Trim not respected:  0.4117647 0.4537815 0.1344538 from 596791 778351.5
## Trim not respected:  0.4201681 0.4453782 0.1344538 from 600365 778351.5
## Trim not respected:  0.4285714 0.4369748 0.1344538 from 615605.6 778351.5
## Trim not respected:  0.4369748 0.4285714 0.1344538 from 620337.8 778351.5
## Trim not respected:  0.4453782 0.4201681 0.1344538 from 621904.5 778351.5
## Trim not respected:  0.4537815 0.4117647 0.1344538 from 622250.1 778351.5
## Trim not respected:  0.4621849 0.4033613 0.1344538 from 629474.1 778351.5
## Trim not respected:  0.4705882 0.394958 0.1344538 from 634783.1 778351.5
## Trim not respected:  0.4789916 0.3865546 0.1344538 from 639380.1 778351.5
## Trim not respected:  0.487395 0.3781513 0.1344538 from 641543.7 778351.5
## Trim not respected:  0.4957983 0.3697479 0.1344538 from 643093.6 778351.5
## Trim not respected:  0.5042017 0.3613445 0.1344538 from 648906.5 778351.5
## Trim not respected:  0.512605 0.3529412 0.1344538 from 654757 778351.5
## Trim not respected:  0.5210084 0.3445378 0.1344538 from 666744 778351.5
## Trim not respected:  0.5294118 0.3361345 0.1344538 from 682393.1 778351.5
## Trim not respected:  0.5378151 0.3277311 0.1344538 from 685707.6 778351.5
## Trim not respected:  0.5462185 0.3193277 0.1344538 from 687379.9 778351.5
## Trim not respected:  0.5546218 0.3109244 0.1344538 from 687628.7 778351.5
## Trim not respected:  0.5630252 0.302521 0.1344538 from 689025.3 778351.5
## Trim not respected:  0.5714286 0.2941176 0.1344538 from 694178.9 778351.5
## Trim not respected:  0.5798319 0.2857143 0.1344538 from 695528 778351.5
## Trim not respected:  0.5882353 0.2773109 0.1344538 from 695643.6 778351.5
## Trim not respected:  0.5966387 0.2689076 0.1344538 from 699826.5 778351.5
## Trim not respected:  0.605042 0.2605042 0.1344538 from 701399.4 778351.5
## Trim not respected:  0.6134454 0.2521008 0.1344538 from 701843.8 778351.5
## Trim not respected:  0.6218487 0.2436975 0.1344538 from 702153.4 778351.5
## Trim not respected:  0.6302521 0.2352941 0.1344538 from 703858 778351.5
```

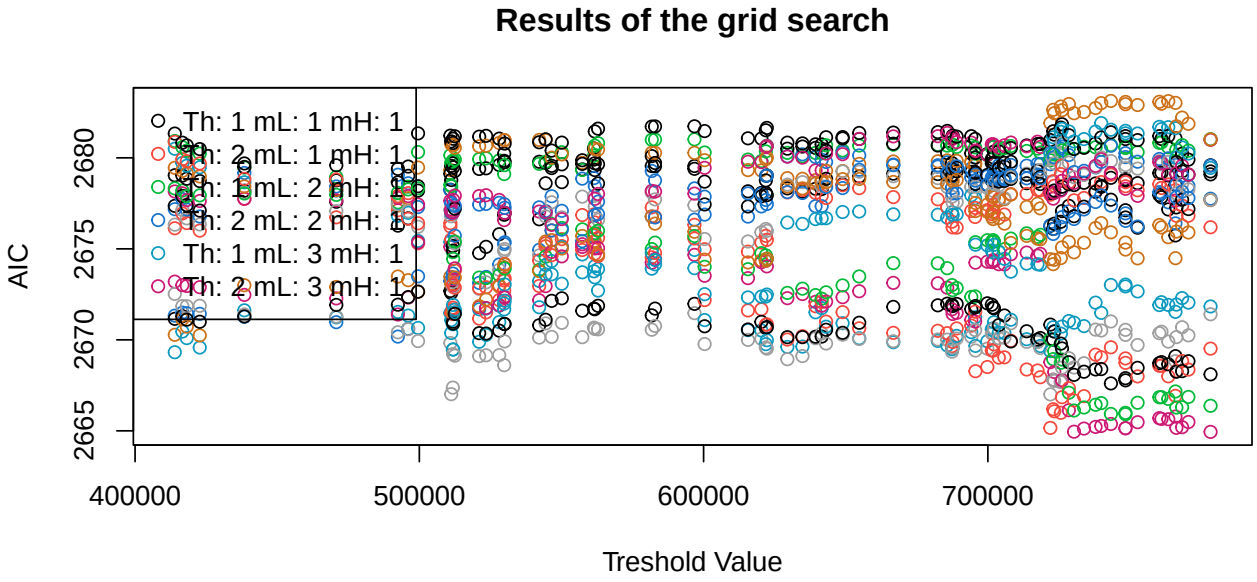
```
## Trim not respected:  0.6386555 0.2268908 0.1344538 from 705830 778351.5
## Trim not respected:  0.6470588 0.2184874 0.1344538 from 708095.7 778351.5
## Trim not respected:  0.6554622 0.210084 0.1344538 from 713654.1 778351.5
## Trim not respected:  0.6638655 0.2016807 0.1344538 from 717484.9 778351.5
## Trim not respected:  0.6722689 0.1932773 0.1344538 from 718458 778351.5
## Trim not respected:  0.6806723 0.1848739 0.1344538 from 721993.2 778351.5
## Trim not respected:  0.6890756 0.1764706 0.1344538 from 722997.2 778351.5
## Trim not respected:  0.697479 0.1680672 0.1344538 from 723361.2 778351.5
## Trim not respected:  0.7058824 0.1596639 0.1344538 from 725680.7 778351.5
## Trim not respected:  0.7142857 0.1512605 0.1344538 from 726081.6 778351.5Second best: 705830 (conditi
##
## Trim not respected:  0.6386555 0.2268908 0.1344538 from 705830 778351.5Second best: 778351.5 (conditi
##
## Trim not respected:  0.1680672 0.697479 0.1344538 from 416644.8 778351.5
## Trim not respected:  0.1764706 0.6890756 0.1344538 from 418187.9 778351.5
## Trim not respected:  0.1848739 0.6806723 0.1344538 from 422751.8 778351.5
## Trim not respected:  0.1932773 0.6722689 0.1344538 from 438446.4 778351.5
## Trim not respected:  0.210084 0.6554622 0.1344538 from 470793.3 778351.5
## Trim not respected:  0.2184874 0.6470588 0.1344538 from 492453.3 778351.5
## Trim not respected:  0.2268908 0.6386555 0.1344538 from 496086.7 778351.5
## Trim not respected:  0.2352941 0.6302521 0.1344538 from 499552.3 778351.5
## Trim not respected:  0.2436975 0.6218487 0.1344538 from 510928.7 778351.5
## Trim not respected:  0.2521008 0.6134454 0.1344538 from 511224.5 778351.5
## Trim not respected:  0.2605042 0.605042 0.1344538 from 511791.8 778351.5
## Trim not respected:  0.2689076 0.5966387 0.1344538 from 511895.9 778351.5
## Trim not respected:  0.2773109 0.5882353 0.1344538 from 512476.7 778351.5
## Trim not respected:  0.2857143 0.5798319 0.1344538 from 521049.7 778351.5
## Trim not respected:  0.2941176 0.5714286 0.1344538 from 523480.9 778351.5
## Trim not respected:  0.302521 0.5630252 0.1344538 from 528105.4 778351.5
## Trim not respected:  0.3109244 0.5546218 0.1344538 from 529852.4 778351.5
## Trim not respected:  0.3193277 0.5462185 0.1344538 from 530010.3 778351.5
## Trim not respected:  0.3277311 0.5378151 0.1344538 from 542167.5 778351.5
## Trim not respected:  0.3361345 0.5294118 0.1344538 from 544430 778351.5
## Trim not respected:  0.3445378 0.5210084 0.1344538 from 546553.9 778351.5
## Trim not respected:  0.3529412 0.512605 0.1344538 from 550118.6 778351.5
## Trim not respected:  0.3613445 0.5042017 0.1344538 from 557325.5 778351.5
```

```
## Trim not respected:  0.3697479 0.4957983 0.1344538 from 561437.7 778351.5
## Trim not respected:  0.3781513 0.487395 0.1344538 from 561724.3 778351.5
## Trim not respected:  0.3865546 0.4789916 0.1344538 from 562865.8 778351.5
## Trim not respected:  0.394958 0.4705882 0.1344538 from 581770.8 778351.5
## Trim not respected:  0.4033613 0.4621849 0.1344538 from 582916.3 778351.5
## Trim not respected:  0.4117647 0.4537815 0.1344538 from 596791 778351.5
## Trim not respected:  0.4201681 0.4453782 0.1344538 from 600365 778351.5
## Trim not respected:  0.4285714 0.4369748 0.1344538 from 615605.6 778351.5
## Trim not respected:  0.4369748 0.4285714 0.1344538 from 620337.8 778351.5
## Trim not respected:  0.4453782 0.4201681 0.1344538 from 621904.5 778351.5
## Trim not respected:  0.4537815 0.4117647 0.1344538 from 622250.1 778351.5
## Trim not respected:  0.4621849 0.4033613 0.1344538 from 629474.1 778351.5
## Trim not respected:  0.4705882 0.394958 0.1344538 from 634783.1 778351.5
## Trim not respected:  0.4789916 0.3865546 0.1344538 from 639380.1 778351.5
## Trim not respected:  0.487395 0.3781513 0.1344538 from 641543.7 778351.5
## Trim not respected:  0.4957983 0.3697479 0.1344538 from 643093.6 778351.5
## Trim not respected:  0.5042017 0.3613445 0.1344538 from 648906.5 778351.5
## Trim not respected:  0.512605 0.3529412 0.1344538 from 654757 778351.5
## Trim not respected:  0.5210084 0.3445378 0.1344538 from 666744 778351.5
## Trim not respected:  0.5294118 0.3361345 0.1344538 from 682393.1 778351.5
## Trim not respected:  0.5378151 0.3277311 0.1344538 from 685707.6 778351.5
## Trim not respected:  0.5462185 0.3193277 0.1344538 from 687379.9 778351.5
## Trim not respected:  0.5546218 0.3109244 0.1344538 from 687628.7 778351.5
## Trim not respected:  0.5630252 0.302521 0.1344538 from 689025.3 778351.5
## Trim not respected:  0.5714286 0.2941176 0.1344538 from 694178.9 778351.5
## Trim not respected:  0.5798319 0.2857143 0.1344538 from 695528 778351.5
## Trim not respected:  0.5882353 0.2773109 0.1344538 from 695643.6 778351.5
## Trim not respected:  0.5966387 0.2689076 0.1344538 from 699826.5 778351.5
## Trim not respected:  0.605042 0.2605042 0.1344538 from 701399.4 778351.5
## Trim not respected:  0.6134454 0.2521008 0.1344538 from 701843.8 778351.5
## Trim not respected:  0.6218487 0.2436975 0.1344538 from 702153.4 778351.5
## Trim not respected:  0.6302521 0.2352941 0.1344538 from 703858 778351.5
## Trim not respected:  0.6386555 0.2268908 0.1344538 from 705830 778351.5
## Trim not respected:  0.6470588 0.2184874 0.1344538 from 708095.7 778351.5
## Trim not respected:  0.6554622 0.210084 0.1344538 from 713654.1 778351.5
## Trim not respected:  0.6638655 0.2016807 0.1344538 from 717484.9 778351.5
```

```
## Trim not respected:  0.6722689 0.1932773 0.1344538 from 718458 778351.5
## Trim not respected:  0.6806723 0.1848739 0.1344538 from 721993.2 778351.5
## Trim not respected:  0.6890756 0.1764706 0.1344538 from 722997.2 778351.5
## Trim not respected:  0.697479 0.1680672 0.1344538 from 723361.2 778351.5
## Trim not respected:  0.7058824 0.1596639 0.1344538 from 725680.7 778351.5
## Trim not respected:  0.7142857 0.1512605 0.1344538 from 726081.6 778351.5Second best: 705830 (conditi
##
## Trim not respected:  0.6386555 0.2268908 0.1344538 from 705830 778351.5Second best: 771089.2 (conditi
##
## Trim not respected:  0.1680672 0.697479 0.1344538 from 416644.8 778351.5
## Trim not respected:  0.1764706 0.6890756 0.1344538 from 418187.9 778351.5
## Trim not respected:  0.1848739 0.6806723 0.1344538 from 422751.8 778351.5
## Trim not respected:  0.1932773 0.6722689 0.1344538 from 438446.4 778351.5
## Trim not respected:  0.210084 0.6554622 0.1344538 from 470793.3 778351.5
## Trim not respected:  0.2184874 0.6470588 0.1344538 from 492453.3 778351.5
## Trim not respected:  0.2268908 0.6386555 0.1344538 from 496086.7 778351.5
## Trim not respected:  0.2352941 0.6302521 0.1344538 from 499552.3 778351.5
## Trim not respected:  0.2436975 0.6218487 0.1344538 from 510928.7 778351.5
## Trim not respected:  0.2521008 0.6134454 0.1344538 from 511224.5 778351.5
## Trim not respected:  0.2605042 0.605042 0.1344538 from 511791.8 778351.5
## Trim not respected:  0.2689076 0.5966387 0.1344538 from 511895.9 778351.5
## Trim not respected:  0.2773109 0.5882353 0.1344538 from 512476.7 778351.5
## Trim not respected:  0.2857143 0.5798319 0.1344538 from 521049.7 778351.5
## Trim not respected:  0.2941176 0.5714286 0.1344538 from 523480.9 778351.5
## Trim not respected:  0.302521 0.5630252 0.1344538 from 528105.4 778351.5
## Trim not respected:  0.3109244 0.5546218 0.1344538 from 529852.4 778351.5
## Trim not respected:  0.3193277 0.5462185 0.1344538 from 530010.3 778351.5
## Trim not respected:  0.3277311 0.5378151 0.1344538 from 542167.5 778351.5
## Trim not respected:  0.3361345 0.5294118 0.1344538 from 544430 778351.5
## Trim not respected:  0.3445378 0.5210084 0.1344538 from 546553.9 778351.5
## Trim not respected:  0.3529412 0.512605 0.1344538 from 550118.6 778351.5
## Trim not respected:  0.3613445 0.5042017 0.1344538 from 557325.5 778351.5
## Trim not respected:  0.3697479 0.4957983 0.1344538 from 561437.7 778351.5
## Trim not respected:  0.3781513 0.487395 0.1344538 from 561724.3 778351.5
## Trim not respected:  0.3865546 0.4789916 0.1344538 from 562865.8 778351.5
## Trim not respected:  0.394958 0.4705882 0.1344538 from 581770.8 778351.5
```

```
## Trim not respected:  0.4033613 0.4621849 0.1344538 from 582916.3 778351.5
## Trim not respected:  0.4117647 0.4537815 0.1344538 from 596791 778351.5
## Trim not respected:  0.4201681 0.4453782 0.1344538 from 600365 778351.5
## Trim not respected:  0.4285714 0.4369748 0.1344538 from 615605.6 778351.5
## Trim not respected:  0.4369748 0.4285714 0.1344538 from 620337.8 778351.5
## Trim not respected:  0.4453782 0.4201681 0.1344538 from 621904.5 778351.5
## Trim not respected:  0.4537815 0.4117647 0.1344538 from 622250.1 778351.5
## Trim not respected:  0.4621849 0.4033613 0.1344538 from 629474.1 778351.5
## Trim not respected:  0.4705882 0.394958 0.1344538 from 634783.1 778351.5
## Trim not respected:  0.4789916 0.3865546 0.1344538 from 639380.1 778351.5
## Trim not respected:  0.487395 0.3781513 0.1344538 from 641543.7 778351.5
## Trim not respected:  0.4957983 0.3697479 0.1344538 from 643093.6 778351.5
## Trim not respected:  0.5042017 0.3613445 0.1344538 from 648906.5 778351.5
## Trim not respected:  0.512605 0.3529412 0.1344538 from 654757 778351.5
## Trim not respected:  0.5210084 0.3445378 0.1344538 from 666744 778351.5
## Trim not respected:  0.5294118 0.3361345 0.1344538 from 682393.1 778351.5
## Trim not respected:  0.5378151 0.3277311 0.1344538 from 685707.6 778351.5
## Trim not respected:  0.5462185 0.3193277 0.1344538 from 687379.9 778351.5
## Trim not respected:  0.5546218 0.3109244 0.1344538 from 687628.7 778351.5
## Trim not respected:  0.5630252 0.302521 0.1344538 from 689025.3 778351.5
## Trim not respected:  0.5714286 0.2941176 0.1344538 from 694178.9 778351.5
## Trim not respected:  0.5798319 0.2857143 0.1344538 from 695528 778351.5
## Trim not respected:  0.5882353 0.2773109 0.1344538 from 695643.6 778351.5
## Trim not respected:  0.5966387 0.2689076 0.1344538 from 699826.5 778351.5
## Trim not respected:  0.605042 0.2605042 0.1344538 from 701399.4 778351.5
## Trim not respected:  0.6134454 0.2521008 0.1344538 from 701843.8 778351.5
## Trim not respected:  0.6218487 0.2436975 0.1344538 from 702153.4 778351.5
## Trim not respected:  0.6302521 0.2352941 0.1344538 from 703858 778351.5
## Trim not respected:  0.6386555 0.2268908 0.1344538 from 705830 778351.5
## Trim not respected:  0.6470588 0.2184874 0.1344538 from 708095.7 778351.5
## Trim not respected:  0.6554622 0.210084 0.1344538 from 713654.1 778351.5
## Trim not respected:  0.6638655 0.2016807 0.1344538 from 717484.9 778351.5
## Trim not respected:  0.6722689 0.1932773 0.1344538 from 718458 778351.5
## Trim not respected:  0.6806723 0.1848739 0.1344538 from 721993.2 778351.5
## Trim not respected:  0.6890756 0.1764706 0.1344538 from 722997.2 778351.5
## Trim not respected:  0.697479 0.1680672 0.1344538 from 723361.2 778351.5
```

```
## Trim not respected:  0.7058824 0.1596639 0.1344538 from 725680.7 778351.5
## Trim not respected:  0.7142857 0.1512605 0.1344538 from 726081.6 778351.5Second best: 705830 (conditi
##
## Trim not respected:  0.6386555 0.2268908 0.1344538 from 705830 778351.5Second best: 771089.2 (conditi
```




```
## Using maximum autoregressive order for low regime: mL = 3
## Using maximum autoregressive order for high regime: mH = 3
## Using maximum autoregressive order for middle regime: mM = 3
## Searching on 80 possible threshold values within regimes with sufficient ( 15% ) number of observatio
## Searching on  1440  combinations of thresholds ( 80 ), thDelay ( 2 ), mL ( 3 ) and MM ( 3 )
##
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
```

```
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2Result of the one threshold search:
##  -Thresh:  771089.2  -Delay:  2  -mL: 2  -mH: 1  - AIC 2714.372
##
## Trim not respected:  0.1896552 0.6896552 0.1206897 from 422751.8 771089.2
## Trim not respected:  0.1982759 0.6810345 0.1206897 from 438446.4 771089.2
## Trim not respected:  0.2155172 0.6637931 0.1206897 from 470793.3 771089.2
## Trim not respected:  0.2241379 0.6551724 0.1206897 from 492453.3 771089.2
## Trim not respected:  0.2327586 0.6465517 0.1206897 from 496086.7 771089.2
## Trim not respected:  0.2413793 0.637931 0.1206897 from 499552.3 771089.2
## Trim not respected:  0.25 0.6293103 0.1206897 from 510928.7 771089.2
## Trim not respected:  0.2586207 0.6206897 0.1206897 from 511224.5 771089.2
## Trim not respected:  0.2672414 0.612069 0.1206897 from 511791.8 771089.2
## Trim not respected:  0.2758621 0.6034483 0.1206897 from 511895.9 771089.2
## Trim not respected:  0.2844828 0.5948276 0.1206897 from 512476.7 771089.2
```

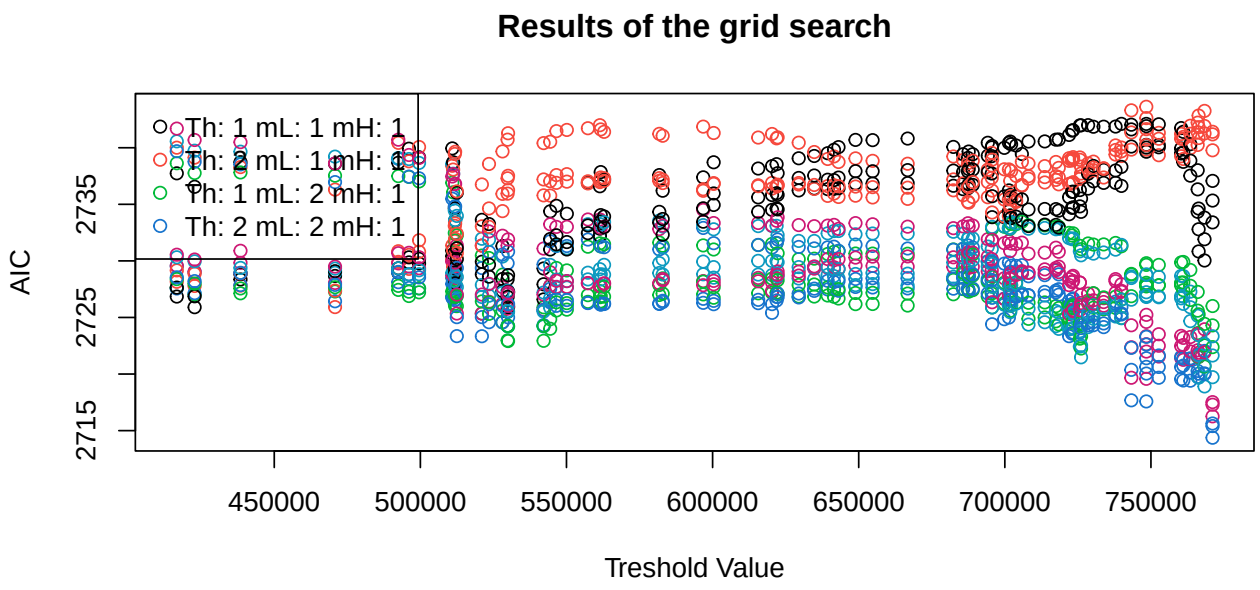
```
## Trim not respected:  0.2931034 0.5862069 0.1206897 from 521049.7 771089.2
## Trim not respected:  0.3017241 0.5775862 0.1206897 from 523480.9 771089.2
## Trim not respected:  0.3103448 0.5689655 0.1206897 from 528105.4 771089.2
## Trim not respected:  0.3189655 0.5603448 0.1206897 from 529852.4 771089.2
## Trim not respected:  0.3275862 0.5517241 0.1206897 from 530010.3 771089.2
## Trim not respected:  0.3362069 0.5431034 0.1206897 from 542167.5 771089.2
## Trim not respected:  0.3448276 0.5344828 0.1206897 from 544430 771089.2
## Trim not respected:  0.3534483 0.5258621 0.1206897 from 546553.9 771089.2
## Trim not respected:  0.362069 0.5172414 0.1206897 from 550118.6 771089.2
## Trim not respected:  0.3706897 0.5086207 0.1206897 from 557325.5 771089.2
## Trim not respected:  0.3793103 0.5 0.1206897 from 561437.7 771089.2
## Trim not respected:  0.387931 0.4913793 0.1206897 from 561724.3 771089.2
## Trim not respected:  0.3965517 0.4827586 0.1206897 from 562865.8 771089.2
## Trim not respected:  0.4051724 0.4741379 0.1206897 from 581770.8 771089.2
## Trim not respected:  0.4137931 0.4655172 0.1206897 from 582916.3 771089.2
## Trim not respected:  0.4224138 0.4568966 0.1206897 from 596791 771089.2
## Trim not respected:  0.4310345 0.4482759 0.1206897 from 600365 771089.2
## Trim not respected:  0.4396552 0.4396552 0.1206897 from 615605.6 771089.2
## Trim not respected:  0.4482759 0.4310345 0.1206897 from 620337.8 771089.2
## Trim not respected:  0.4568966 0.4224138 0.1206897 from 621904.5 771089.2
## Trim not respected:  0.4655172 0.4137931 0.1206897 from 622250.1 771089.2
## Trim not respected:  0.4741379 0.4051724 0.1206897 from 629474.1 771089.2
## Trim not respected:  0.4827586 0.3965517 0.1206897 from 634783.1 771089.2
## Trim not respected:  0.4913793 0.387931 0.1206897 from 639380.1 771089.2
## Trim not respected:  0.5 0.3793103 0.1206897 from 641543.7 771089.2
## Trim not respected:  0.5086207 0.3706897 0.1206897 from 643093.6 771089.2
## Trim not respected:  0.5172414 0.362069 0.1206897 from 648906.5 771089.2
## Trim not respected:  0.5258621 0.3534483 0.1206897 from 654757 771089.2
## Trim not respected:  0.5344828 0.3448276 0.1206897 from 666744 771089.2
## Trim not respected:  0.5431034 0.3362069 0.1206897 from 682393.1 771089.2
## Trim not respected:  0.5517241 0.3275862 0.1206897 from 685707.6 771089.2
## Trim not respected:  0.5603448 0.3189655 0.1206897 from 687379.9 771089.2
## Trim not respected:  0.5689655 0.3103448 0.1206897 from 687628.7 771089.2
## Trim not respected:  0.5775862 0.3017241 0.1206897 from 689025.3 771089.2
## Trim not respected:  0.5862069 0.2931034 0.1206897 from 694178.9 771089.2
## Trim not respected:  0.5948276 0.2844828 0.1206897 from 695528 771089.2
```

```
## Trim not respected:  0.6034483 0.2758621 0.1206897 from 695643.6 771089.2
## Trim not respected:  0.612069 0.2672414 0.1206897 from 699826.5 771089.2
## Trim not respected:  0.6206897 0.2586207 0.1206897 from 701399.4 771089.2
## Trim not respected:  0.6293103 0.25 0.1206897 from 701843.8 771089.2
## Trim not respected:  0.637931 0.2413793 0.1206897 from 702153.4 771089.2
## Trim not respected:  0.6465517 0.2327586 0.1206897 from 703858 771089.2
## Trim not respected:  0.6551724 0.2241379 0.1206897 from 705830 771089.2
## Trim not respected:  0.6637931 0.2155172 0.1206897 from 708095.7 771089.2
## Trim not respected:  0.6724138 0.2068966 0.1206897 from 713654.1 771089.2
## Trim not respected:  0.6810345 0.1982759 0.1206897 from 717484.9 771089.2
## Trim not respected:  0.6896552 0.1896552 0.1206897 from 718458 771089.2
## Trim not respected:  0.6982759 0.1810345 0.1206897 from 721993.2 771089.2
## Trim not respected:  0.7068966 0.1724138 0.1206897 from 722997.2 771089.2
## Trim not respected:  0.7155172 0.1637931 0.1206897 from 723361.2 771089.2
## Trim not respected:  0.7241379 0.1551724 0.1206897 from 725680.7 771089.2Second best: 725680.7 (condi
## Second best: 529852.4 (conditionnal on th= 725680.7 and Delay= 2 )    SSR/AIC: 2732.59
##
## Trim not respected:  0.1896552 0.6896552 0.1206897 from 422751.8 771089.2
## Trim not respected:  0.1982759 0.6810345 0.1206897 from 438446.4 771089.2
## Trim not respected:  0.2155172 0.6637931 0.1206897 from 470793.3 771089.2
## Trim not respected:  0.2241379 0.6551724 0.1206897 from 492453.3 771089.2
## Trim not respected:  0.2327586 0.6465517 0.1206897 from 496086.7 771089.2
## Trim not respected:  0.2413793 0.637931 0.1206897 from 499552.3 771089.2
## Trim not respected:  0.25 0.6293103 0.1206897 from 510928.7 771089.2
## Trim not respected:  0.2586207 0.6206897 0.1206897 from 511224.5 771089.2
## Trim not respected:  0.2672414 0.612069 0.1206897 from 511791.8 771089.2
## Trim not respected:  0.2758621 0.6034483 0.1206897 from 511895.9 771089.2
## Trim not respected:  0.2844828 0.5948276 0.1206897 from 512476.7 771089.2
## Trim not respected:  0.2931034 0.5862069 0.1206897 from 521049.7 771089.2
## Trim not respected:  0.3017241 0.5775862 0.1206897 from 523480.9 771089.2
## Trim not respected:  0.3103448 0.5689655 0.1206897 from 528105.4 771089.2
## Trim not respected:  0.3189655 0.5603448 0.1206897 from 529852.4 771089.2
## Trim not respected:  0.3275862 0.5517241 0.1206897 from 530010.3 771089.2
## Trim not respected:  0.3362069 0.5431034 0.1206897 from 542167.5 771089.2
## Trim not respected:  0.3448276 0.5344828 0.1206897 from 544430 771089.2
## Trim not respected:  0.3534483 0.5258621 0.1206897 from 546553.9 771089.2
```

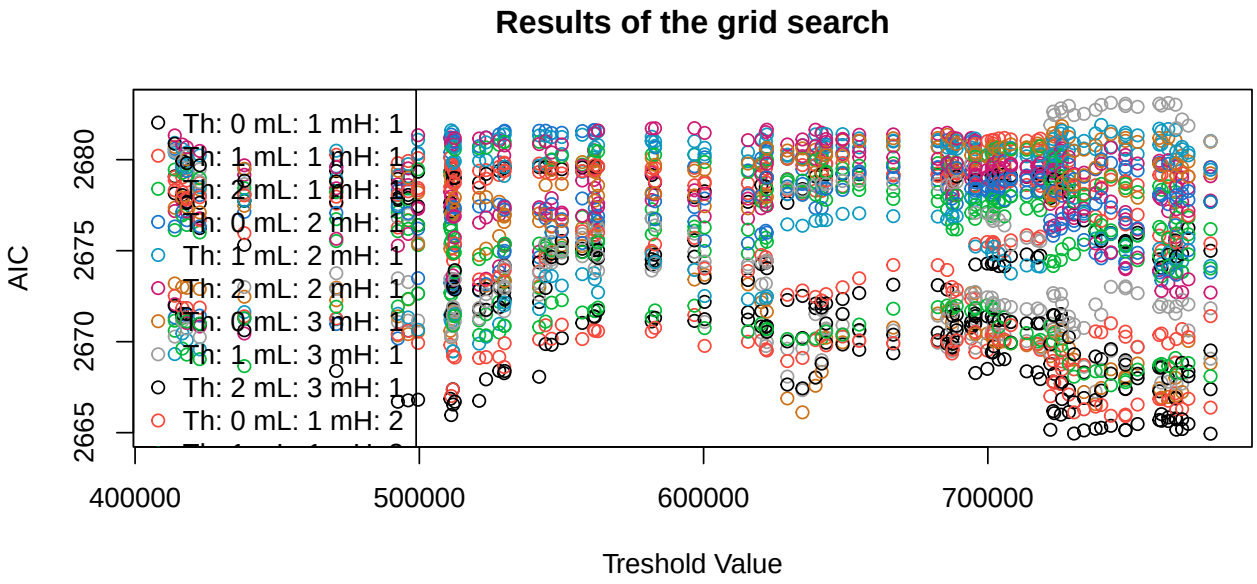
```
## Trim not respected:  0.362069 0.5172414 0.1206897 from 550118.6 771089.2
## Trim not respected:  0.3706897 0.5086207 0.1206897 from 557325.5 771089.2
## Trim not respected:  0.3793103 0.5 0.1206897 from 561437.7 771089.2
## Trim not respected:  0.387931 0.4913793 0.1206897 from 561724.3 771089.2
## Trim not respected:  0.3965517 0.4827586 0.1206897 from 562865.8 771089.2
## Trim not respected:  0.4051724 0.4741379 0.1206897 from 581770.8 771089.2
## Trim not respected:  0.4137931 0.4655172 0.1206897 from 582916.3 771089.2
## Trim not respected:  0.4224138 0.4568966 0.1206897 from 596791 771089.2
## Trim not respected:  0.4310345 0.4482759 0.1206897 from 600365 771089.2
## Trim not respected:  0.4396552 0.4396552 0.1206897 from 615605.6 771089.2
## Trim not respected:  0.4482759 0.4310345 0.1206897 from 620337.8 771089.2
## Trim not respected:  0.4568966 0.4224138 0.1206897 from 621904.5 771089.2
## Trim not respected:  0.4655172 0.4137931 0.1206897 from 622250.1 771089.2
## Trim not respected:  0.4741379 0.4051724 0.1206897 from 629474.1 771089.2
## Trim not respected:  0.4827586 0.3965517 0.1206897 from 634783.1 771089.2
## Trim not respected:  0.4913793 0.387931 0.1206897 from 639380.1 771089.2
## Trim not respected:  0.5 0.3793103 0.1206897 from 641543.7 771089.2
## Trim not respected:  0.5086207 0.3706897 0.1206897 from 643093.6 771089.2
## Trim not respected:  0.5172414 0.362069 0.1206897 from 648906.5 771089.2
## Trim not respected:  0.5258621 0.3534483 0.1206897 from 654757 771089.2
## Trim not respected:  0.5344828 0.3448276 0.1206897 from 666744 771089.2
## Trim not respected:  0.5431034 0.3362069 0.1206897 from 682393.1 771089.2
## Trim not respected:  0.5517241 0.3275862 0.1206897 from 685707.6 771089.2
## Trim not respected:  0.5603448 0.3189655 0.1206897 from 687379.9 771089.2
## Trim not respected:  0.5689655 0.3103448 0.1206897 from 687628.7 771089.2
## Trim not respected:  0.5775862 0.3017241 0.1206897 from 689025.3 771089.2
## Trim not respected:  0.5862069 0.2931034 0.1206897 from 694178.9 771089.2
## Trim not respected:  0.5948276 0.2844828 0.1206897 from 695528 771089.2
## Trim not respected:  0.6034483 0.2758621 0.1206897 from 695643.6 771089.2
## Trim not respected:  0.612069 0.2672414 0.1206897 from 699826.5 771089.2
## Trim not respected:  0.6206897 0.2586207 0.1206897 from 701399.4 771089.2
## Trim not respected:  0.6293103 0.25 0.1206897 from 701843.8 771089.2
## Trim not respected:  0.637931 0.2413793 0.1206897 from 702153.4 771089.2
## Trim not respected:  0.6465517 0.2327586 0.1206897 from 703858 771089.2
## Trim not respected:  0.6551724 0.2241379 0.1206897 from 705830 771089.2
## Trim not respected:  0.6637931 0.2155172 0.1206897 from 708095.7 771089.2
```

```
## Trim not respected:  0.6724138 0.2068966 0.1206897 from 713654.1 771089.2
## Trim not respected:  0.6810345 0.1982759 0.1206897 from 717484.9 771089.2
## Trim not respected:  0.6896552 0.1896552 0.1206897 from 718458 771089.2
## Trim not respected:  0.6982759 0.1810345 0.1206897 from 721993.2 771089.2
## Trim not respected:  0.7068966 0.1724138 0.1206897 from 722997.2 771089.2
## Trim not respected:  0.7155172 0.1637931 0.1206897 from 723361.2 771089.2
## Trim not respected:  0.7241379 0.1551724 0.1206897 from 725680.7 771089.2Second best: 725680.7 (condi
## Second best: 521049.7 (conditionnal on th= 725680.7 and Delay= 2 )    SSR/AIC: 2730.675
##
## Trim not respected:  0.1896552 0.6896552 0.1206897 from 422751.8 771089.2
## Trim not respected:  0.1982759 0.6810345 0.1206897 from 438446.4 771089.2
## Trim not respected:  0.2155172 0.6637931 0.1206897 from 470793.3 771089.2
## Trim not respected:  0.2241379 0.6551724 0.1206897 from 492453.3 771089.2
## Trim not respected:  0.2327586 0.6465517 0.1206897 from 496086.7 771089.2
## Trim not respected:  0.2413793 0.637931 0.1206897 from 499552.3 771089.2
## Trim not respected:  0.25 0.6293103 0.1206897 from 510928.7 771089.2
## Trim not respected:  0.2586207 0.6206897 0.1206897 from 511224.5 771089.2
## Trim not respected:  0.2672414 0.612069 0.1206897 from 511791.8 771089.2
## Trim not respected:  0.2758621 0.6034483 0.1206897 from 511895.9 771089.2
## Trim not respected:  0.2844828 0.5948276 0.1206897 from 512476.7 771089.2
## Trim not respected:  0.2931034 0.5862069 0.1206897 from 521049.7 771089.2
## Trim not respected:  0.3017241 0.5775862 0.1206897 from 523480.9 771089.2
## Trim not respected:  0.3103448 0.5689655 0.1206897 from 528105.4 771089.2
## Trim not respected:  0.3189655 0.5603448 0.1206897 from 529852.4 771089.2
## Trim not respected:  0.3275862 0.5517241 0.1206897 from 530010.3 771089.2
## Trim not respected:  0.3362069 0.5431034 0.1206897 from 542167.5 771089.2
## Trim not respected:  0.3448276 0.5344828 0.1206897 from 544430 771089.2
## Trim not respected:  0.3534483 0.5258621 0.1206897 from 546553.9 771089.2
## Trim not respected:  0.362069 0.5172414 0.1206897 from 550118.6 771089.2
## Trim not respected:  0.3706897 0.5086207 0.1206897 from 557325.5 771089.2
## Trim not respected:  0.3793103 0.5 0.1206897 from 561437.7 771089.2
## Trim not respected:  0.387931 0.4913793 0.1206897 from 561724.3 771089.2
## Trim not respected:  0.3965517 0.4827586 0.1206897 from 562865.8 771089.2
## Trim not respected:  0.4051724 0.4741379 0.1206897 from 581770.8 771089.2
## Trim not respected:  0.4137931 0.4655172 0.1206897 from 582916.3 771089.2
## Trim not respected:  0.4224138 0.4568966 0.1206897 from 596791 771089.2
```

```
## Trim not respected:  0.4310345 0.4482759 0.1206897 from 600365 771089.2
## Trim not respected:  0.4396552 0.4396552 0.1206897 from 615605.6 771089.2
## Trim not respected:  0.4482759 0.4310345 0.1206897 from 620337.8 771089.2
## Trim not respected:  0.4568966 0.4224138 0.1206897 from 621904.5 771089.2
## Trim not respected:  0.4655172 0.4137931 0.1206897 from 622250.1 771089.2
## Trim not respected:  0.4741379 0.4051724 0.1206897 from 629474.1 771089.2
## Trim not respected:  0.4827586 0.3965517 0.1206897 from 634783.1 771089.2
## Trim not respected:  0.4913793 0.387931 0.1206897 from 639380.1 771089.2
## Trim not respected:  0.5 0.3793103 0.1206897 from 641543.7 771089.2
## Trim not respected:  0.5086207 0.3706897 0.1206897 from 643093.6 771089.2
## Trim not respected:  0.5172414 0.362069 0.1206897 from 648906.5 771089.2
## Trim not respected:  0.5258621 0.3534483 0.1206897 from 654757 771089.2
## Trim not respected:  0.5344828 0.3448276 0.1206897 from 666744 771089.2
## Trim not respected:  0.5431034 0.3362069 0.1206897 from 682393.1 771089.2
## Trim not respected:  0.5517241 0.3275862 0.1206897 from 685707.6 771089.2
## Trim not respected:  0.5603448 0.3189655 0.1206897 from 687379.9 771089.2
## Trim not respected:  0.5689655 0.3103448 0.1206897 from 687628.7 771089.2
## Trim not respected:  0.5775862 0.3017241 0.1206897 from 689025.3 771089.2
## Trim not respected:  0.5862069 0.2931034 0.1206897 from 694178.9 771089.2
## Trim not respected:  0.5948276 0.2844828 0.1206897 from 695528 771089.2
## Trim not respected:  0.6034483 0.2758621 0.1206897 from 695643.6 771089.2
## Trim not respected:  0.612069 0.2672414 0.1206897 from 699826.5 771089.2
## Trim not respected:  0.6206897 0.2586207 0.1206897 from 701399.4 771089.2
## Trim not respected:  0.6293103 0.25 0.1206897 from 701843.8 771089.2
## Trim not respected:  0.637931 0.2413793 0.1206897 from 702153.4 771089.2
## Trim not respected:  0.6465517 0.2327586 0.1206897 from 703858 771089.2
## Trim not respected:  0.6551724 0.2241379 0.1206897 from 705830 771089.2
## Trim not respected:  0.6637931 0.2155172 0.1206897 from 708095.7 771089.2
## Trim not respected:  0.6724138 0.2068966 0.1206897 from 713654.1 771089.2
## Trim not respected:  0.6810345 0.1982759 0.1206897 from 717484.9 771089.2
## Trim not respected:  0.6896552 0.1896552 0.1206897 from 718458 771089.2
## Trim not respected:  0.6982759 0.1810345 0.1206897 from 721993.2 771089.2
## Trim not respected:  0.7068966 0.1724138 0.1206897 from 722997.2 771089.2
## Trim not respected:  0.7155172 0.1637931 0.1206897 from 723361.2 771089.2
## Trim not respected:  0.7241379 0.1551724 0.1206897 from 725680.7 771089.2Second best: 725680.7 (condi
## Second best: 521049.7 (conditionnal on th= 725680.7 and Delay= 2 )    SSR/AIC: 2731.29
```

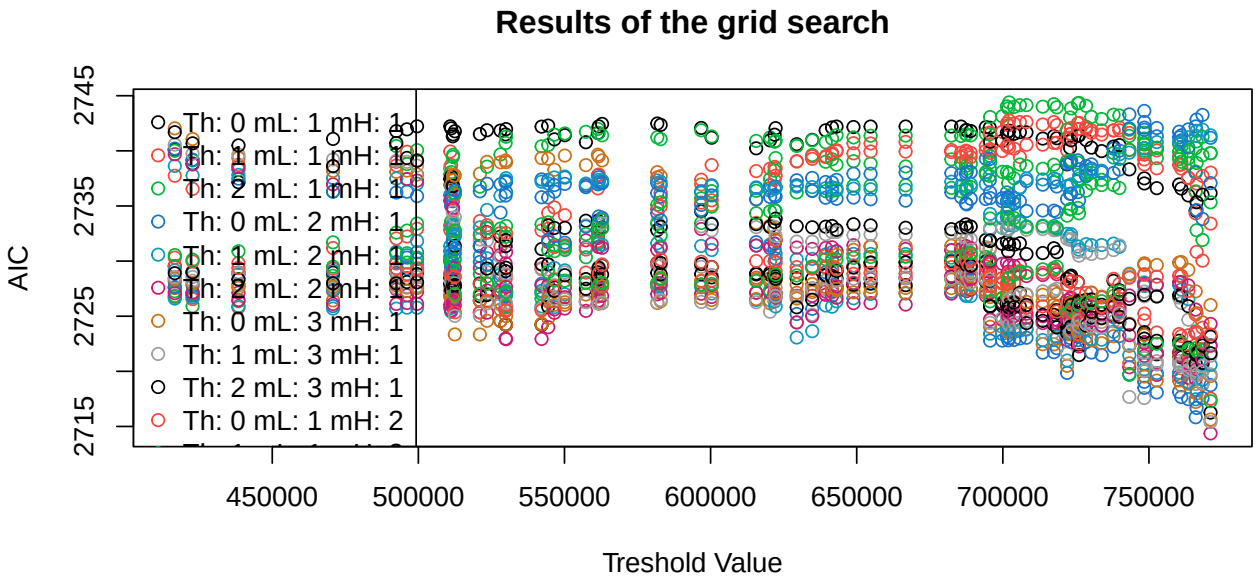



```
## Using maximum autoregressive order for low regime: mL = 3
## Using maximum autoregressive order for high regime: mH = 3
## Searching on 83 possible threshold values within regimes with sufficient ( 15% ) number of observati
## Searching on  2241  combinations of thresholds ( 83 ), thDelay ( 3 ), mL ( 3 ) and MM ( 3 )
##
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8571429 0.1428571 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
```




```
## Using maximum autoregressive order for low regime: mL = 3
## Using maximum autoregressive order for high regime: mH = 3
## Searching on 80 possible threshold values within regimes with sufficient ( 15% ) number of observatio
## Searching on  2160  combinations of thresholds ( 80 ), thDelay ( 3 ), mL ( 3 ) and MM ( 3 )
##
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
```

```
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.862069 0.137931 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
```




```
##   thDelay mL mH       th      AIC
## 1       2  3  1 778351.5 2664.942
## 2       2  3  1 730317.6 2664.952
## 3       2  3  1 733818.8 2665.123
## 4       2  3  1 748435.4 2665.137
```

```
## 5       2  3  1 748409.3 2665.149
```

```
##   thDelay mL mH       th      AIC
## 1       2  2  1 771089.2 2714.372
## 2       2  2  3 771089.2 2715.404
## 3       2  2  2 771089.2 2715.629
## 4       2  3  1 771089.2 2716.262
## 5       2  3  3 771089.2 2717.291
```

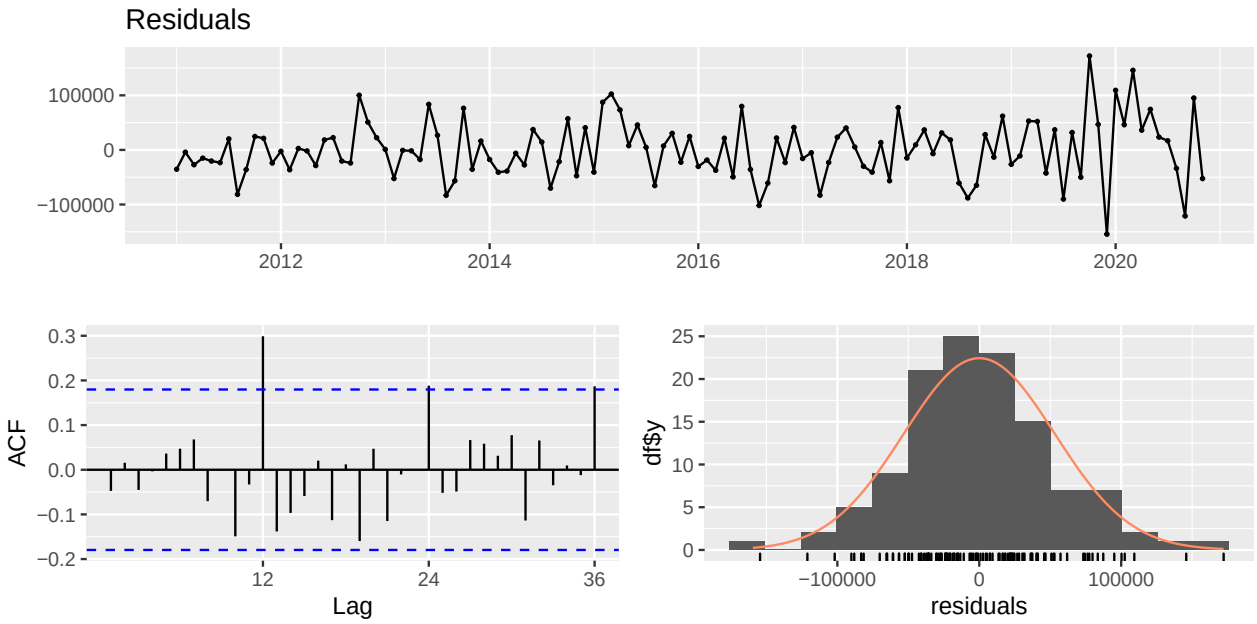
```
##   thDelay mL mH       th      AIC
## 1       2  3  1 778351.5 2664.942
## 2       2  3  1 730317.6 2664.952
## 3       2  3  1 733818.8 2665.123
## 4       2  3  1 748435.4 2665.137
## 5       2  3  1 748409.3 2665.149
```

```
##   thDelay mL mH       th      AIC
## 1       2  2  1 771089.2 2714.372
## 2       2  2  3 771089.2 2715.404
## 3       2  2  2 771089.2 2715.629
## 4       0  2  1 765999.6 2715.832
## 5       2  3  1 771089.2 2716.262
```

```
##
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 778351.5
```

```
##
## Non linear autoregressive model
##
## SETAR model ( 2 regimes)
## Coefficients:
## Low regime:
##       const.L        phiL.1        phiL.2        phiL.3
## 15609.1159299     0.8269447    -0.2758435     0.4374676
##
## High regime:
##        const.H         phiH.1
## 115310.2619648      0.8862372
```

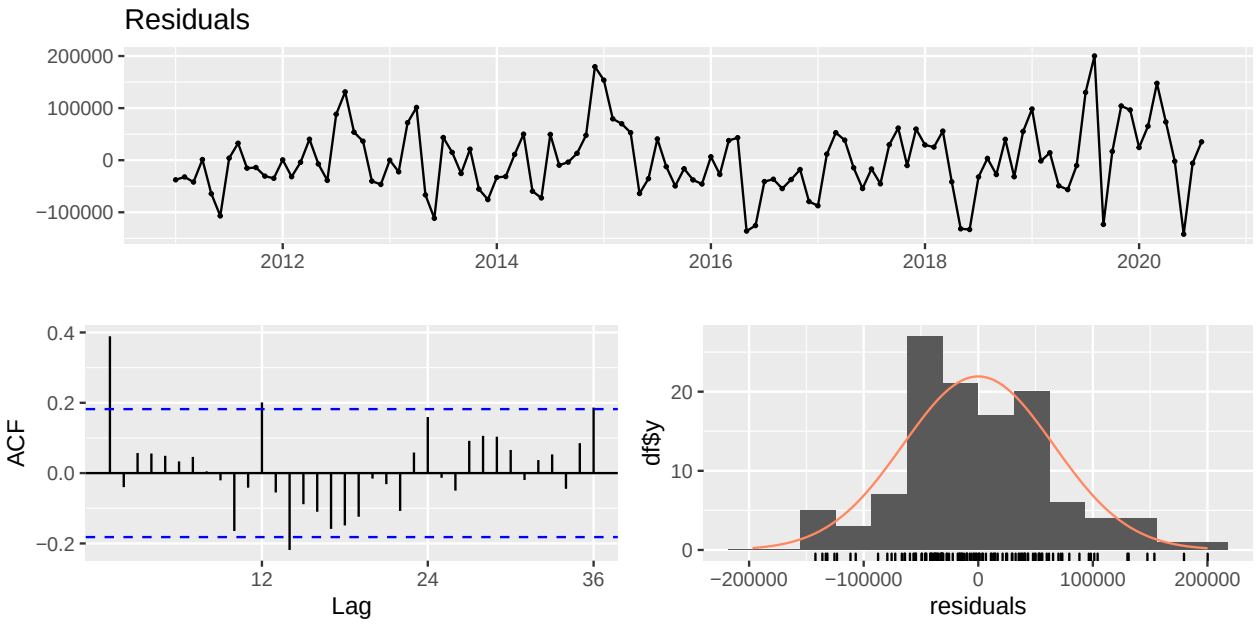
```
##
## Threshold:
## -Variable: Z(t) = + (0) X(t)+ (0)X(t-1)+ (1)X(t-2)
## -Value: 778351
## Proportion of points in low regime: 86.55%    High regime: 13.45%
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -154452.7  -35472.8   -2474.2   30816.0  172187.3
##
## Fit:
## residuals variance = 2734001726,  AIC = 2665, MAPE = 6.472%
##
## Coefficient(s):
##
##              Estimate    Std. Error  t value              Pr(>|t|)
## const.L  15609.115930  23870.032713   0.6539             0.5144570
## phiL.1       0.826945      0.107621   7.6838     0.000000000005423 ***
## phiL.2      -0.275843      0.142709  -1.9329             0.0556856 .
## phiL.3       0.437468      0.113051   3.8696             0.0001805 ***
## const.H 115310.261965  68150.181595   1.6920             0.0933301 .
## phiH.1       0.886237      0.075633  11.7175 < 0.00000000000000022 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold
## Variable: Z(t) = + (0) X(t) + (0) X(t-1)+ (1) X(t-2)
##
## Value: 778351
```




```
##
##  1 T: Trim not respected:  0.8534483 0.1465517 from th: 766323.9
##  1 T: Trim not respected:  0.862069 0.137931 from th: 768336.6
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2
##  1 T: Trim not respected:  0.8793103 0.1206897 from th: 771089.2

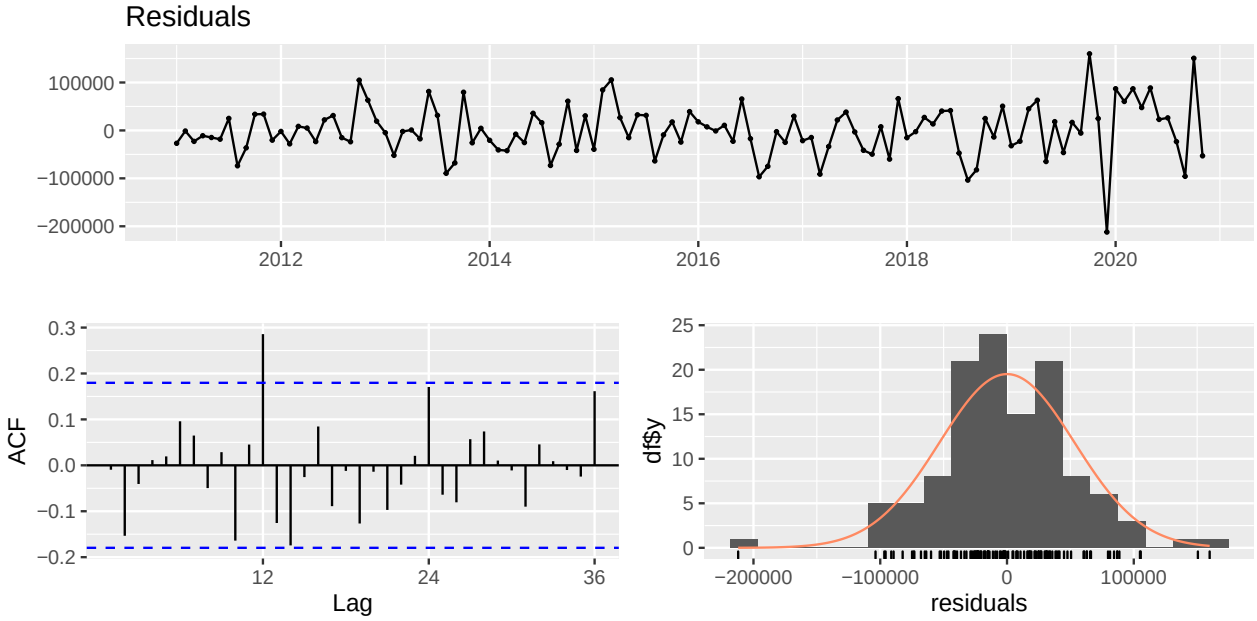
##
## Non linear autoregressive model
##
## SETAR model ( 2 regimes)
## Coefficients:
## Low regime:
##       const.L        phiL.1        phiL.2
## 34071.1080807     0.4627114     0.5021382
##
## High regime:
##        const.H         phiH.1         phiH.2         phiH.3
## -77861.2418850      1.0319769     -0.4420645      0.5041543
##
## Threshold:
## -Variable: Z(t) = + (0) X(t)+ (0)X(t-1)+ (1)X(t-2)
## -Value: 771089
## Proportion of points in low regime: 87.93%    High regime: 12.07%
```

```
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -142122.0  -39133.9   -6568.6   40446.3  200204.4
##
## Fit:
## residuals variance = 4067367517,  AIC = 2715, MAPE = 7.964%
##
## Coefficient(s):
##
##              Estimate    Std. Error  t value     Pr(>|t|)
## const.L  34071.108081  28347.172029   1.2019       0.2319
## phiL.1       0.462711      0.091475   5.0583 0.0000016165 ***
## phiL.2       0.502138      0.092180   5.4474 0.0000002944 ***
## const.H -77861.241885 197462.308180  -0.3943       0.6941
## phiH.1       1.031977      0.220265   4.6852 0.0000077304 ***
## phiH.2      -0.442065      0.273944  -1.6137       0.1093
## phiH.3       0.504154      0.346506   1.4550       0.1484
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold
## Variable: Z(t) = + (0) X(t) + (0) X(t-1)+ (1) X(t-2)
##
## Value: 771089
```




```
##
## Non linear autoregressive model
##
## SETAR model ( 2 regimes)
## Coefficients:
## Low regime:
##       const.L        phiL.1        phiL.2        phiL.3
## -6554.1376992     0.7843393    -0.1477890     0.3951947
##
## High regime:
##        const.H         phiH.1         phiH.2
## -21230.4436532      1.1909899     -0.1927039
##
## Threshold:
## -Variable: Z(t) = + (1) X(t)+ (0)X(t-1)+ (0)X(t-2)
## -Value: 737895
## Proportion of points in low regime: 73.11%    High regime: 26.89%
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -212069.7  -26359.4   -2570.8   30755.0  159863.0
##
## Fit:
```

```
## residuals variance = 2741163981,  AIC = 2667, MAPE = 6.291%
##
## Coefficient(s):
##
##             Estimate   Std. Error  t value       Pr(>|t|)
## const.L  -6554.13770  27001.52675  -0.2427       0.808645
## phiL.1       0.78434      0.11867   6.6093 0.000000001262 ***
## phiL.2      -0.14779      0.15100  -0.9788       0.329752
## phiL.3       0.39519      0.12353   3.1993       0.001781 **
## const.H -21230.44365  67109.96245  -0.3164       0.752308
## phiH.1       1.19099      0.18970   6.2782 0.000000006271 ***
## phiH.2      -0.19270      0.17324  -1.1123       0.268311
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold
## Variable: Z(t) = + (1) X(t) + (0) X(t-1)+ (0) X(t-2)
##
## Value: 737895
```

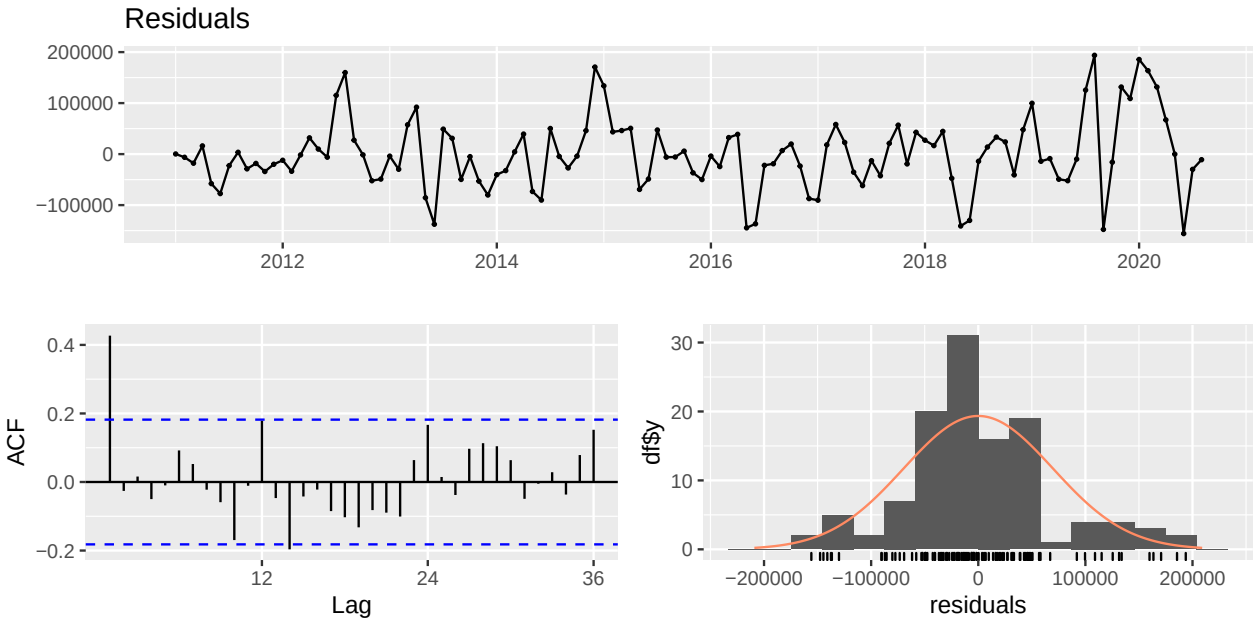



```
##
## Non linear autoregressive model
##
## SETAR model ( 2 regimes)
```

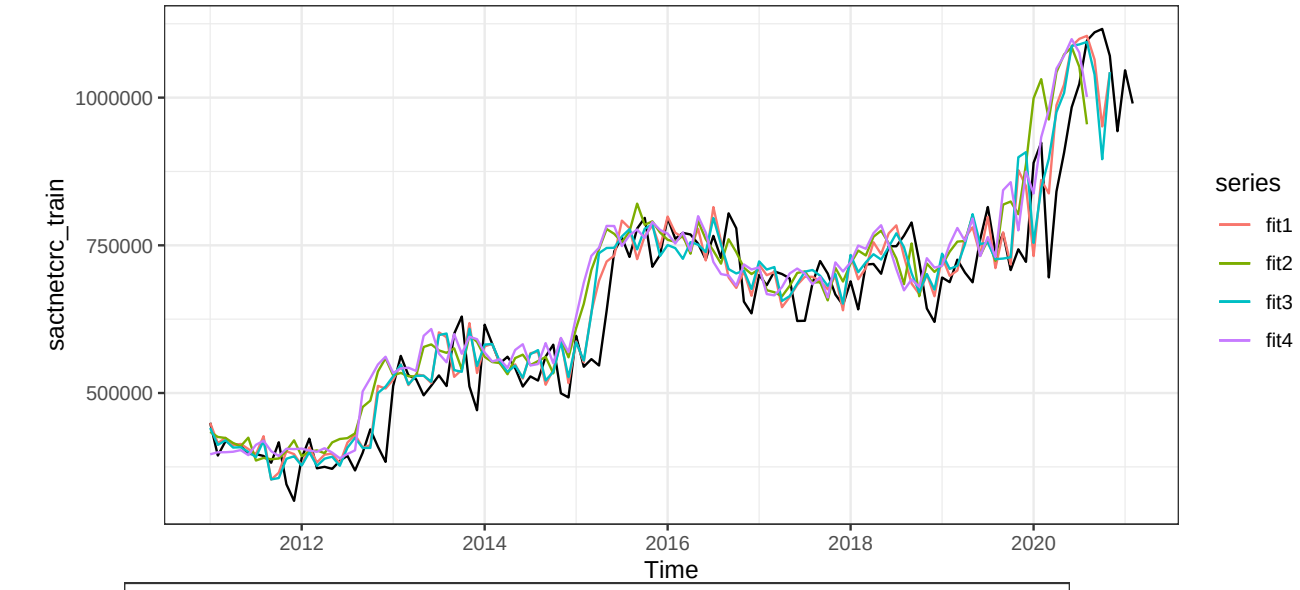
```
## Coefficients:
## Low regime:
##       const.L        phiL.1
## 497047.101814     -0.245272
##
## High regime:
##       const.H        phiH.1        phiH.2
## 55962.5321562     0.6042356     0.3360949
##
## Threshold:
## -Variable: Z(t) = + (1) X(t)+ (0)X(t-1)+ (0)X(t-2)
## -Value: 438446
## Proportion of points in low regime: 17.24%    High regime: 82.76%
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -155836.0  -37647.5   -5849.8   34675.6  193708.0
##
## Fit:
## residuals variance = 4576252319,  AIC = 2726, MAPE = 7.827%
##
## Coefficient(s):
##
##              Estimate    Std. Error  t value        Pr(>|t|)
## const.L 497047.101814 229225.967759   2.1684       0.0321548 *
## phiL.1      -0.245272      0.588794  -0.4166       0.6777585
## const.H  55962.532156  36809.220638   1.5203       0.1311234
## phiH.1       0.604236      0.090559   6.6723 0.0000000008819 ***
## phiH.2       0.336095      0.091306   3.6810       0.0003529 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold
## Variable: Z(t) = + (1) X(t) + (0) X(t-1)+ (0) X(t-2)
##
## Value: 438446
```

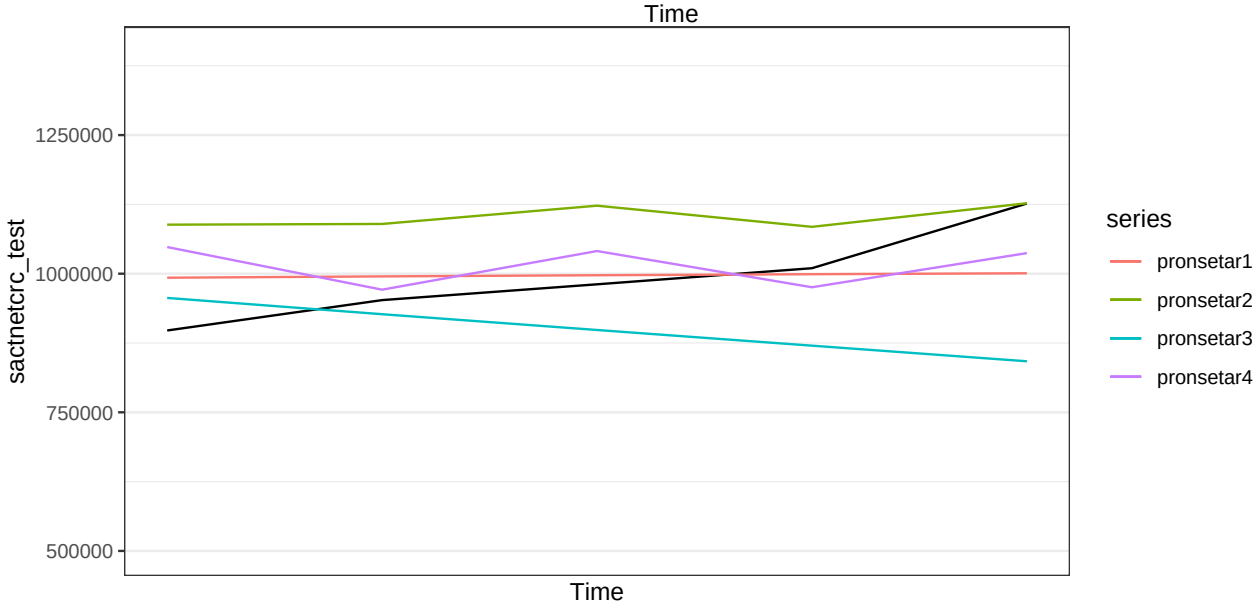
Cuadro 6: Metricas de Rendimiento Modelos SETAR

Modelo	DataSet	MAE	RSS	
1.SETAR m = 3,mL = 3, mH = 1, d=1,nthresh = 1,thDelay = 2	Entrenamiento	42575.25	411939644750	337655
3.SETAR m = 3,mL = 3, mH = 2, d=1,nthresh = 1,thDelay = 0	Entrenamiento	43976.89	479773603905	393257
2.SETAR m = 3,mL = 2, mH = 3, d=2,nthresh = 1,thDelay = 2	Entrenamiento	51081.82	607319064278	497802
4.SETAR m = 3,mL = 1, mH = 2, d=2,nthresh = 1,thDelay = 0	Entrenamiento	53854.21	669984437781	549167
1.SETAR m = 3,mL = 3, mH = 1, d=1,nthresh = 1,thDelay = 2	Prueba	58177.95	27099683662	541993
4.SETAR m = 3,mL = 1, mH = 2, d=2,nthresh = 1,thDelay = 0	Prueba	70611.86	35773255567	715465
2.SETAR m = 3,mL = 2, mH = 3, d=2,nthresh = 1,thDelay = 2	Prueba	109019.00	80955890516	1619117
3.SETAR m = 3,mL = 3, mH = 2, d=1,nthresh = 1,thDelay = 0	Prueba	118153.55	111351647786	2227032



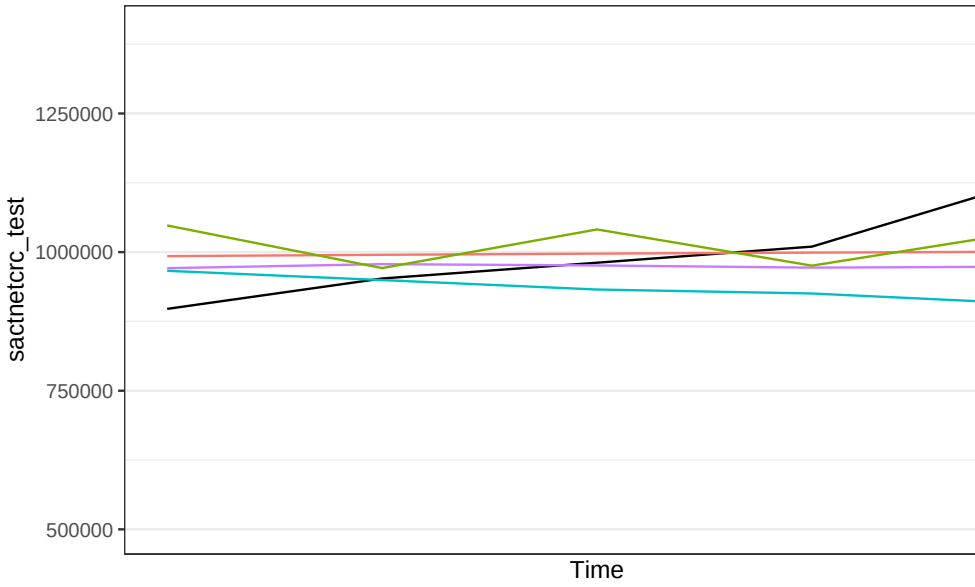
Modelo	AIC	BIC
1.SETAR m = 3,mL = 3, mH = 1, d=1,nthresh = 1,thDelay = 2	2664.94192921197	2684.57007652511
2.SETAR m = 3,mL = 2, mH = 3, d=2,nthresh = 1,thDelay = 2	2715.40394269942	2737.83611105729
3.SETAR m = 3,mL = 3, mH = 2, d=1,nthresh = 1,thDelay = 0	2667.26111427235	2689.69328263021
4.SETAR m = 3,mL = 1, mH = 2, d=2,nthresh = 1,thDelay = 0	2725.78583996026	2742.60996622866


sactnetcrc_train
1000000
750000
500000
2012
2014
2016
2018
2020
Time
series
fit1
fit2
fit3
fit4


sactnetcrc_test
1250000
1000000
750000
500000
Time
series
pronsetar1
pronsetar2
pronsetar3
pronsetar4

Cuadro 7: Metricas de Rendimiento Modelos No Lineales Colones

Modelo	DataSet	MAE	RSS	
3.TAR p1=3,p2=3,d=1	Entrenamiento	39772.97	328942351055	269624
1.TAR p1=3,p2=2,d=1	Entrenamiento	40308.12	338913405336	277797
2.TAR p1=3,p2=1,d=2	Entrenamiento	40514.30	351547834112	288153
1.SETAR m = 3,mL = 3, mH = 1, d=1,nthresh = 1,thDelay = 2	Entrenamiento	42575.25	411939644750	337655
3.SETAR m = 3,mL = 3, mH = 2, d=1,nthresh = 1,thDelay = 0	Entrenamiento	43976.89	479773603905	393257
2.SETAR m = 3,mL = 2, mH = 3, d=2,nthresh = 1,thDelay = 2	Entrenamiento	51081.82	607319064278	497802
4.SETAR m = 3,mL = 1, mH = 2, d=2,nthresh = 1,thDelay = 0	Entrenamiento	53854.21	669984437781	549167
1.SETAR m = 3,mL = 3, mH = 1, d=1,nthresh = 1,thDelay = 2	Prueba	58177.95	27099683662	541993
3.TAR p1=3,p2=3,d=1	Prueba	59009.97	30898688005	617973
4.SETAR m = 3,mL = 1, mH = 2, d=2,nthresh = 1,thDelay = 0	Prueba	70611.86	35773255567	715465
1.TAR p1=3,p2=2,d=1	Prueba	84725.95	62293400375	1245868
2.TAR p1=3,p2=1,d=2	Prueba	87059.11	64393263703	1287865
2.SETAR m = 3,mL = 2, mH = 3, d=2,nthresh = 1,thDelay = 2	Prueba	109019.00	80955890516	1619117
3.SETAR m = 3,mL = 3, mH = 2, d=1,nthresh = 1,thDelay = 0	Prueba	118153.55	111351647786	2227032



3.2.2.1.3. Metricas Generales

3.2.2.2. Serie en Dolares

3.2.2.2.1. TAR

```
## [1] "Modelo:-1-1-1"
## [1] "0-1-1"
## [1] "Modelo:-1-2-1"
## [1] "0-1-1"
## [1] "Modelo:-1-3-1"
## [1] "0-1-1"
## [1] "Modelo:-1-4-1"
```

```
## [1] "0-1-1"
## [1] "Modelo:-2-1-1"
## [1] "Modelo:-2-2-1"
## [1] "Modelo:-2-3-1"
## [1] "Modelo:-2-4-1"
## [1] "2-1-1"
## [1] "Modelo:-3-1-1"
## [1] "Modelo:-3-2-1"
## [1] "Modelo:-3-3-1"
## [1] "Modelo:-3-4-1"
## [1] "3-1-1"
## [1] "Modelo:-4-1-1"
## [1] "Modelo:-4-2-1"
## [1] "Modelo:-4-3-1"
## [1] "Modelo:-4-4-1"
## [1] "Modelo:-1-1-2"
## [1] "Modelo:-1-2-2"
## [1] "Modelo:-1-3-2"
## [1] "Modelo:-1-4-2"
## [1] "Modelo:-2-1-2"
## [1] "Modelo:-2-2-2"
## [1] "Modelo:-2-3-2"
## [1] "Modelo:-2-4-2"
## [1] "Modelo:-3-1-2"
## [1] "Modelo:-3-2-2"
## [1] "Modelo:-3-3-2"
## [1] "Modelo:-3-4-2"
## [1] "Modelo:-4-1-2"
## [1] "Modelo:-4-2-2"
## [1] "Modelo:-4-3-2"
## [1] "Modelo:-4-4-2"
## [1] "Modelo:-1-1-3"
## [1] "Modelo:-1-2-3"
## [1] "Modelo:-1-3-3"
## [1] "Modelo:-1-4-3"
## [1] "Modelo:-2-1-3"
```

```
## [1] "Modelo:-2-2-3"
## [1] "Modelo:-2-3-3"
## [1] "Modelo:-2-4-3"
## [1] "Modelo:-3-1-3"
## [1] "Modelo:-3-2-3"
## [1] "Modelo:-3-3-3"
## [1] "Modelo:-3-4-3"
## [1] "Modelo:-4-1-3"
## [1] "Modelo:-4-2-3"
## [1] "Modelo:-4-3-3"
## [1] "Modelo:-4-4-3"
## [1] "Modelo:-1-1-4"
## [1] "Modelo:-1-2-4"
## [1] "Modelo:-1-3-4"
## [1] "Modelo:-1-4-4"
## [1] "Modelo:-2-1-4"
## [1] "Modelo:-2-2-4"
## [1] "Modelo:-2-3-4"
## [1] "Modelo:-2-4-4"
## [1] "Modelo:-3-1-4"
## [1] "Modelo:-3-2-4"
## [1] "Modelo:-3-3-4"
## [1] "Modelo:-3-4-4"
## [1] "Modelo:-4-1-4"
## [1] "Modelo:-4-2-4"
## [1] "Modelo:-4-3-4"
## [1] "Modelo:-4-4-4"
```

Ordene-delay	1
3-4-1	1349
2-4-1	1350
1-4-1	1360
1-3-1	1372
1-2-1	1382
1-1-1	1394

```
##
## 622.0209
```

```
##
## 590.6428

##
## 590.6428

## intercept-sactnetusd_train      lag1-sactnetusd_train
##                  181.4332347                  1.6151098
##      lag2-sactnetusd_train      lag3-sactnetusd_train
##                   -1.3676001                  0.4599062

## intercept-sactnetusd_train
##                    569.0528

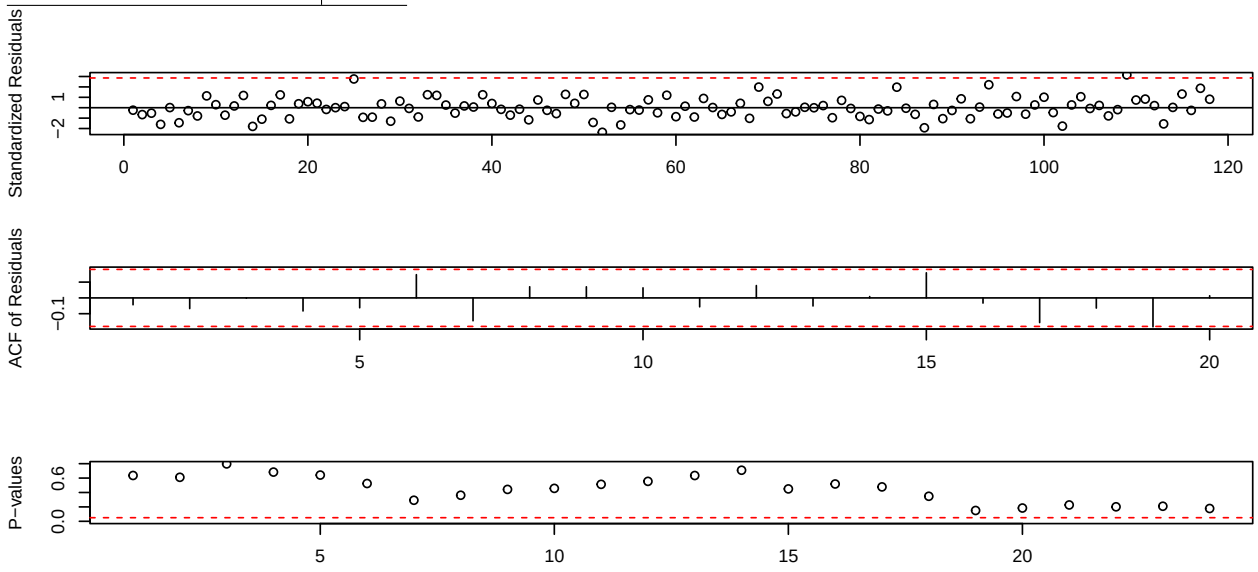
## intercept-sactnetusd_train
##                    569.0528

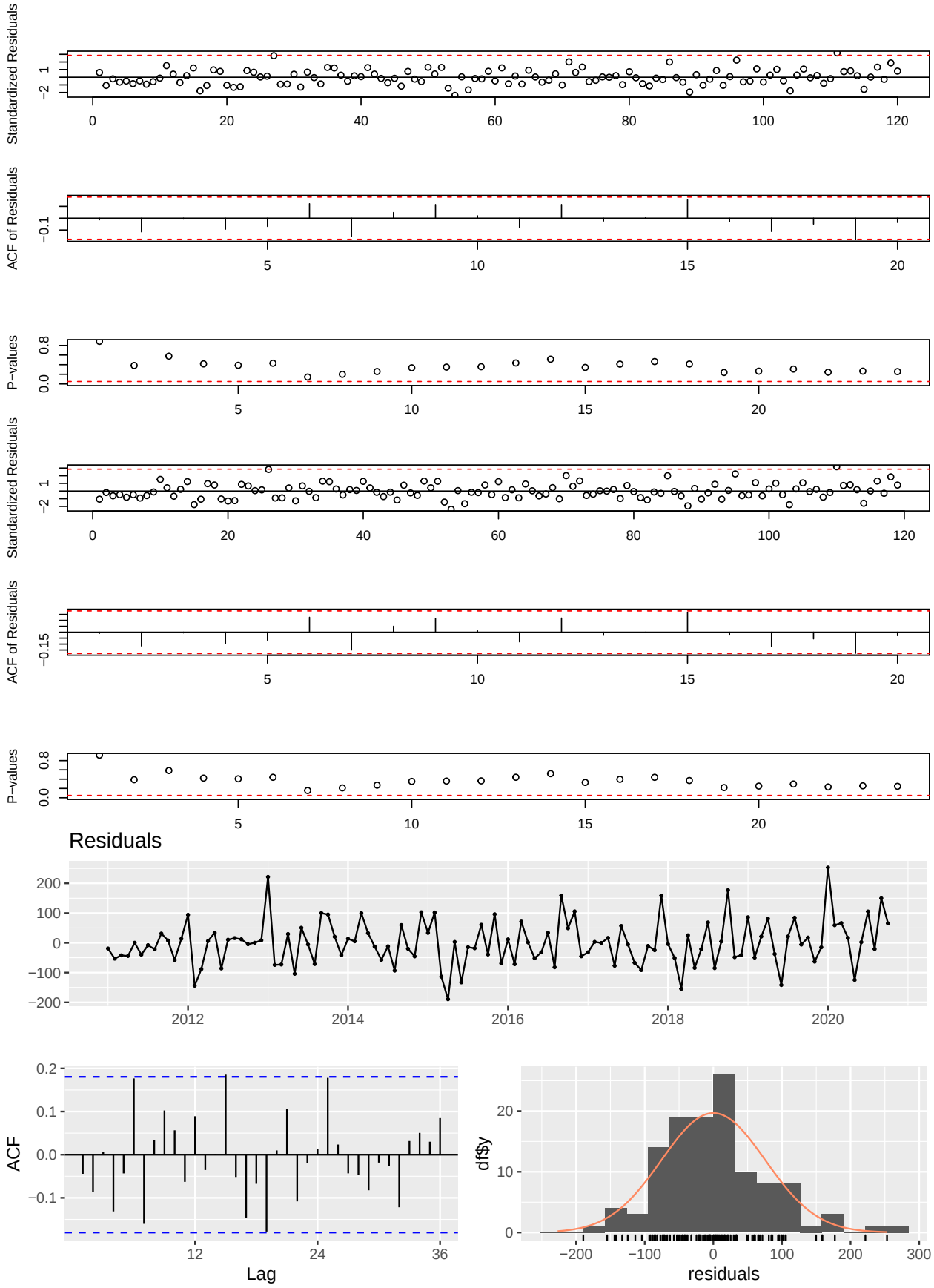
## intercept-sactnetusd_train      lag1-sactnetusd_train
##                   41.7045508                  0.9679892

## intercept-sactnetusd_train      lag1-sactnetusd_train
##                   36.6212186                  0.9721871

## intercept-sactnetusd_train      lag1-sactnetusd_train
##                   32.8396744                  0.9753914
```

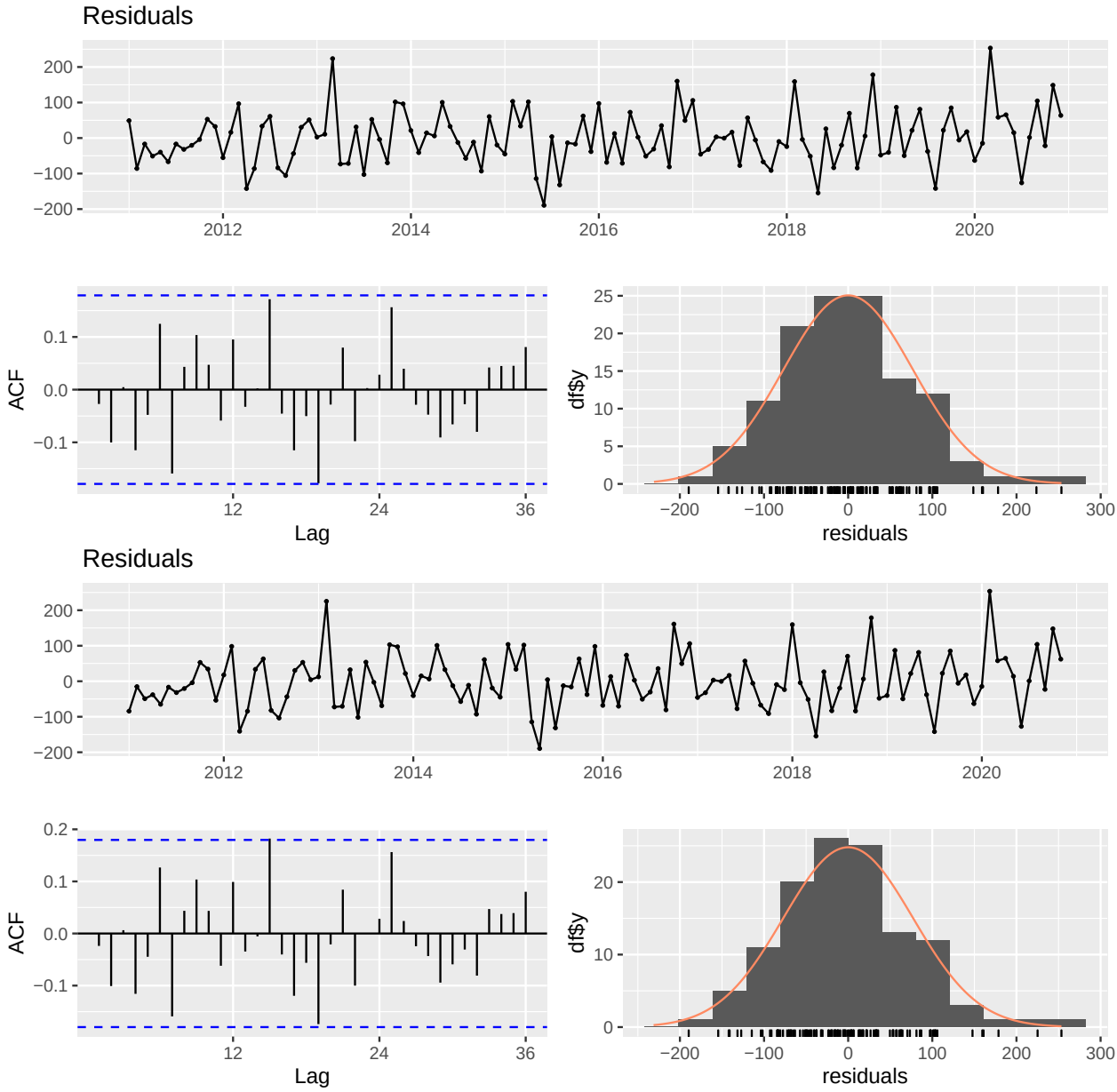
Modelo	AIC
1. TAR p1=3,p2=4,d=1	1349
3. TAR p1=1,p2=3,d=1	1372
2. TAR p1=1,p2=2,d=1	1382

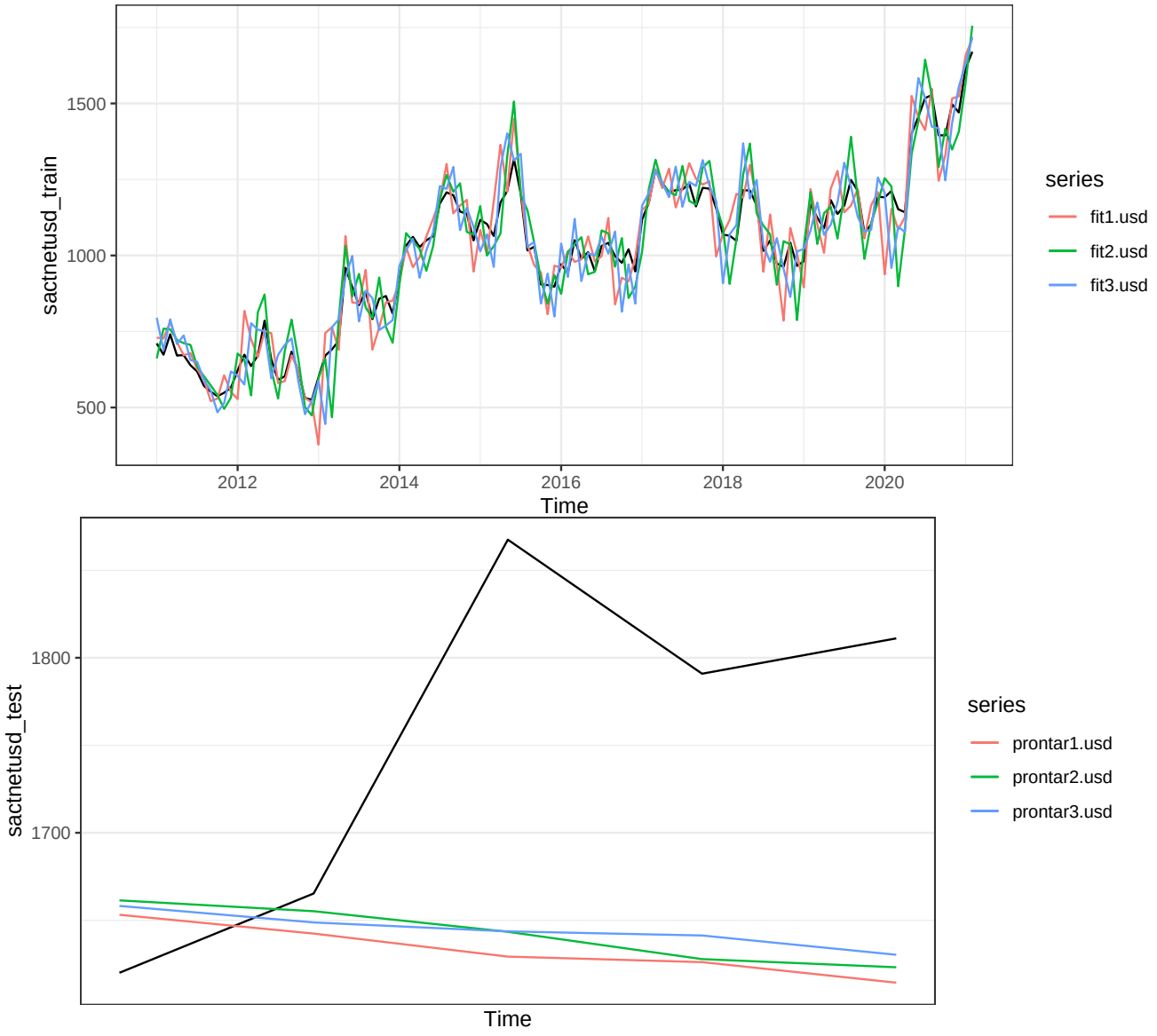



Standardized Residuals
ACF of Residuals
P−values
Standardized Residuals
ACF of Residuals
P−values
Residuals
ACF
Lag
df$y
residuals

Cuadro 8: Metricas de Rendimiento Modelos TAR USD

Modelo	DataSet	MAE	RSS	MSE	RMSE
1. TAR p1=3,p2=4,d=1	Entrenamiento	55.96542	676293.4	5543.389	74.45394
3. TAR p1=1,p2=3,d=1	Entrenamiento	59.12611	711230.7	5829.760	76.35286
2. TAR p1=1,p2=2,d=1	Entrenamiento	59.42877	713711.6	5850.095	76.48592
3. TAR p1=1,p2=3,d=1	Prueba	121.80264	106912.6	21382.522	146.22764
2. TAR p1=1,p2=2,d=1	Prueba	125.33080	113962.3	22792.469	150.97175
1. TAR p1=3,p2=4,d=1	Prueba	131.18617	124281.3	24856.252	157.65866



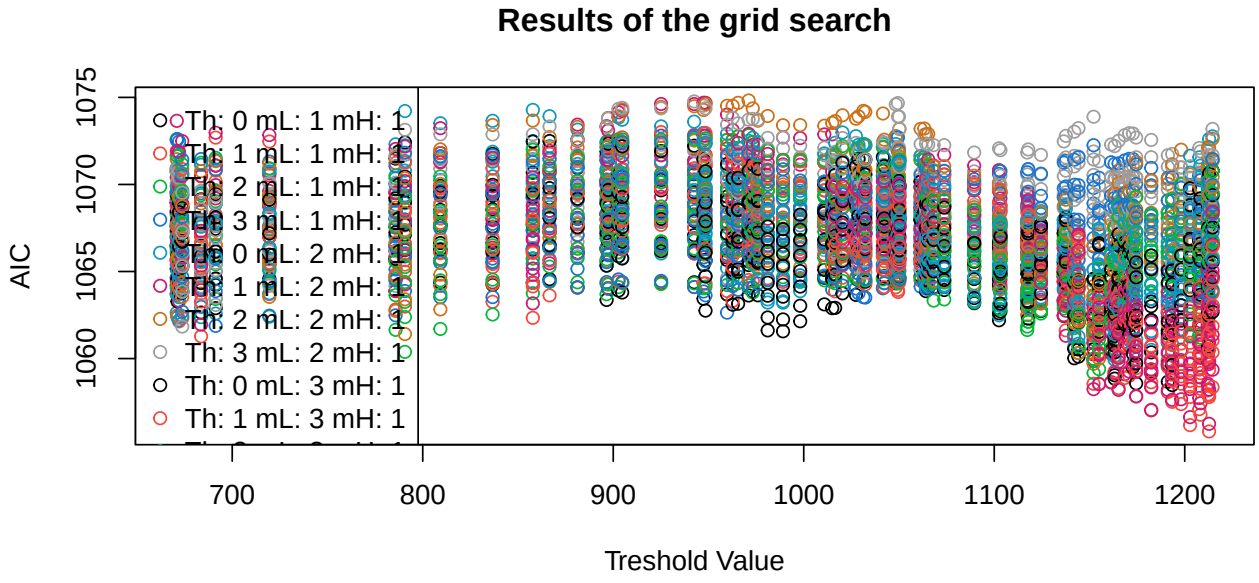


3.2.2.2.2. SETAR Thus the threshold delay, the number of lags in each regime and the threshold value are computed.

```
## Using maximum autoregressive order for low regime: mL = 4
## Using maximum autoregressive order for high regime: mH = 4
## Searching on 82 possible threshold values within regimes with sufficient ( 15% ) number of observatio
## Searching on  5248  combinations of thresholds ( 82 ), thDelay ( 4 ), mL ( 4 ) and MM ( 4 )
##
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
```

```
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
```

```
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
```



```
## Using maximum autoregressive order for low regime: mL = 4
## Using maximum autoregressive order for high regime: mH = 4
## Searching on 78 possible threshold values within regimes with sufficient ( 15% ) number of observati
## Searching on  4992  combinations of thresholds ( 78 ), thDelay ( 4 ), mL ( 4 ) and MM ( 4 )
##
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
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##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
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##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
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##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
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##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
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##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
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##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
```

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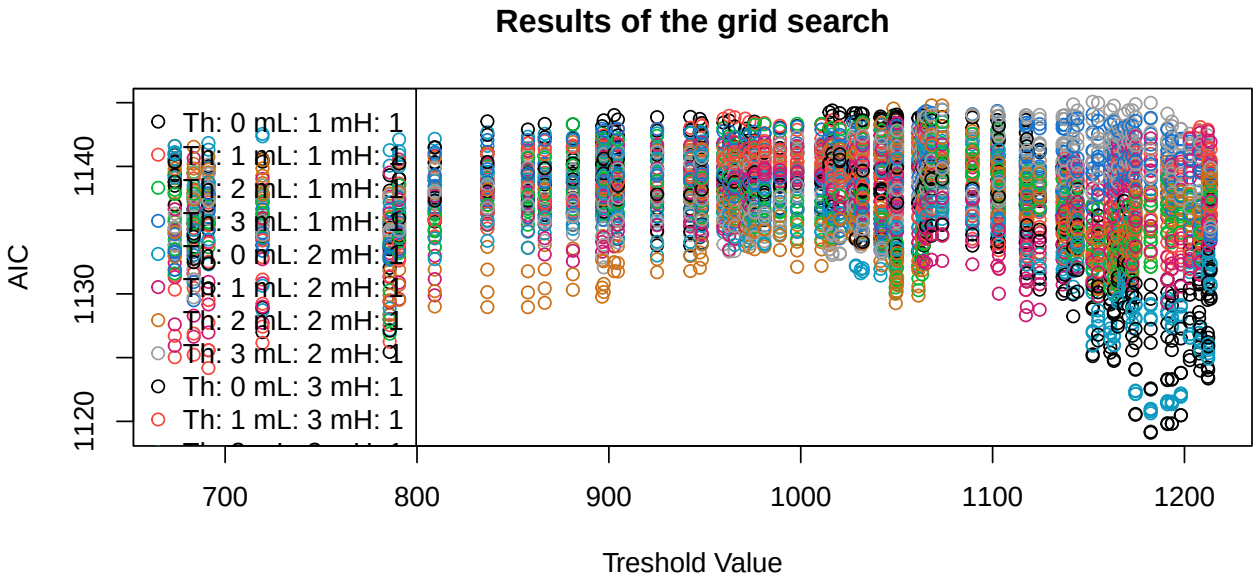
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
```

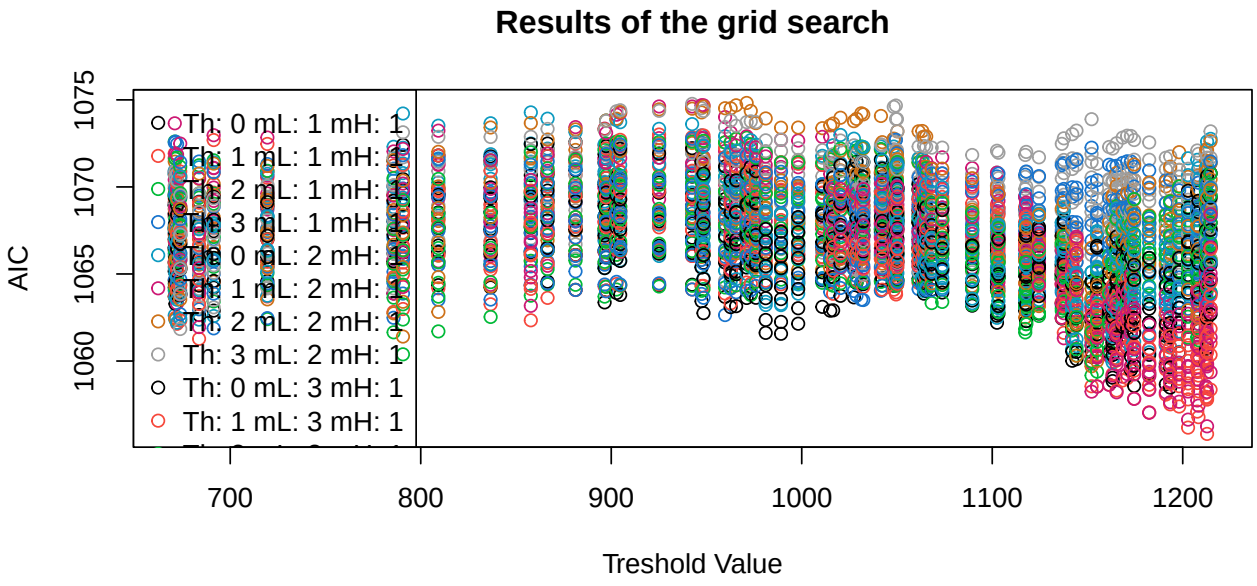
```
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
```




```
## Using maximum autoregressive order for low regime: mL = 4
## Using maximum autoregressive order for high regime: mH = 4
## Searching on 82 possible threshold values within regimes with sufficient ( 15% ) number of observati
## Searching on  5248  combinations of thresholds ( 82 ), thDelay ( 4 ), mL ( 4 ) and MM ( 4 )
##
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
```

```
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1212.776
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
```

```
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
##  1 T: Trim not respected:  0.8559322 0.1440678 from th: 1214.61
##  1 T: Trim not respected:  0.8644068 0.1355932 from th: 1214.61
##  1 T: Trim not respected:  0.8728814 0.1271186 from th: 1214.61
```




```
## Using maximum autoregressive order for low regime: mL = 4
## Using maximum autoregressive order for high regime: mH = 4
## Searching on 78 possible threshold values within regimes with sufficient ( 15% ) number of observatio
## Searching on  4992  combinations of thresholds ( 78 ), thDelay ( 4 ), mL ( 4 ) and MM ( 4 )
##
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
```

```
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1207.644
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
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##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1208.27
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
```

```
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8508772 0.1491228 from th: 1212.131
##  1 T: Trim not respected:  0.8684211 0.1315789 from th: 1212.131
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
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##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
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##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
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##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
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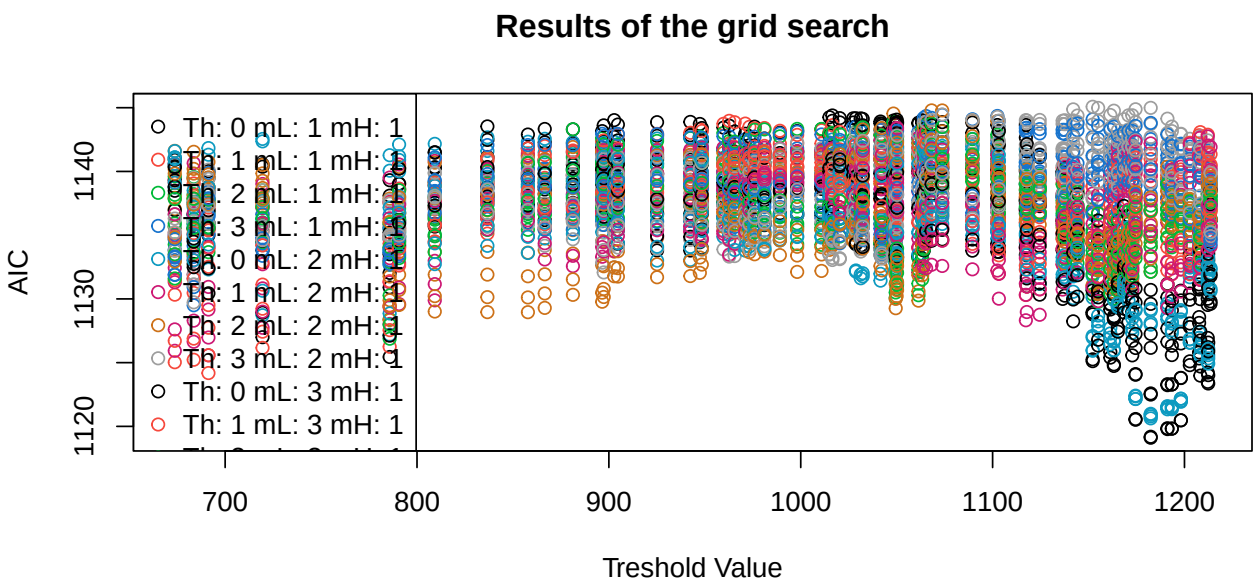
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1212.381
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1212.381
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
```

```
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
##  1 T: Trim not respected:  0.8596491 0.1403509 from th: 1213.601
##  1 T: Trim not respected:  0.877193 0.122807 from th: 1213.601
##  1 T: Trim not respected:  0.8947368 0.1052632 from th: 1213.601
```




```
##   thDelay mL mH       th      AIC
## 1       1  1  1 1212.776 1055.814
## 2       1  1  1 1202.790 1056.177
## 3       1  2  1 1212.776 1056.251
## 4       1  2  1 1202.790 1056.635
## 5       1  1  1 1208.270 1056.776

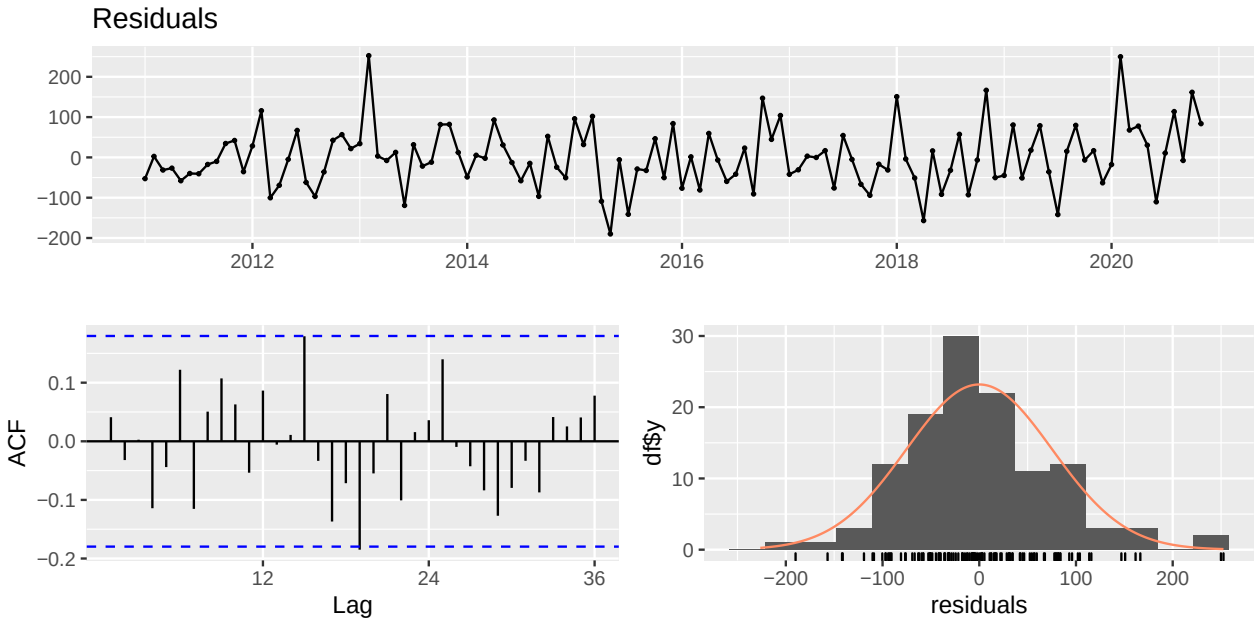
##   thDelay mL mH       th      AIC
## 1       0  1  4 1182.401 1119.110
## 2       0  1  3 1182.401 1119.187
## 3       0  1  4 1191.128 1119.788
## 4       0  1  4 1193.428 1119.823
## 5       0  1  3 1193.428 1119.826

##   thDelay mL mH       th      AIC
## 1       1  1  1 1212.776 1055.814
## 2       1  1  1 1202.790 1056.177
## 3       1  2  1 1212.776 1056.251
## 4       1  2  1 1202.790 1056.635
## 5       1  1  1 1208.270 1056.776

##   thDelay mL mH       th      AIC
## 1       0  1  4 1182.401 1119.110
## 2       0  1  3 1182.401 1119.187
## 3       0  1  4 1191.128 1119.788
```

```
## 4       0  1  4 1193.428 1119.823
## 5       0  1  3 1193.428 1119.826
##
##  1 T: Trim not respected:  0.8655462 0.1344538 from th: 1214.61
##
## Non linear autoregressive model
##
## SETAR model ( 2 regimes)
## Coefficients:
## Low regime:
##     const.L      phiL.1
## 149.9768322   0.7745225
##
## High regime:
##    const.H     phiH.1
## 97.1339609  0.9222561
##
## Threshold:
## -Variable: Z(t) = + (0) X(t)+ (0)X(t-1)+ (1)X(t-2)
## -Value: 790.7
## Proportion of points in low regime: 24.37%    High regime: 75.63%
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -189.9204  -49.4084   -6.5524   42.2501  252.5032
##
## Fit:
## residuals variance = 5509,  AIC = 1061, MAPE = 5.783%
##
## Coefficient(s):
##
##           Estimate  Std. Error  t value              Pr(>|t|)
## const.L 149.976832   88.379070   1.6970               0.09234 .
## phiL.1    0.774522    0.132371   5.8512         0.00000004466 ***
## const.H  97.133961   55.118809   1.7623               0.08061 .
## phiH.1    0.922256    0.048606  18.9740 < 0.00000000000000022 ***
```

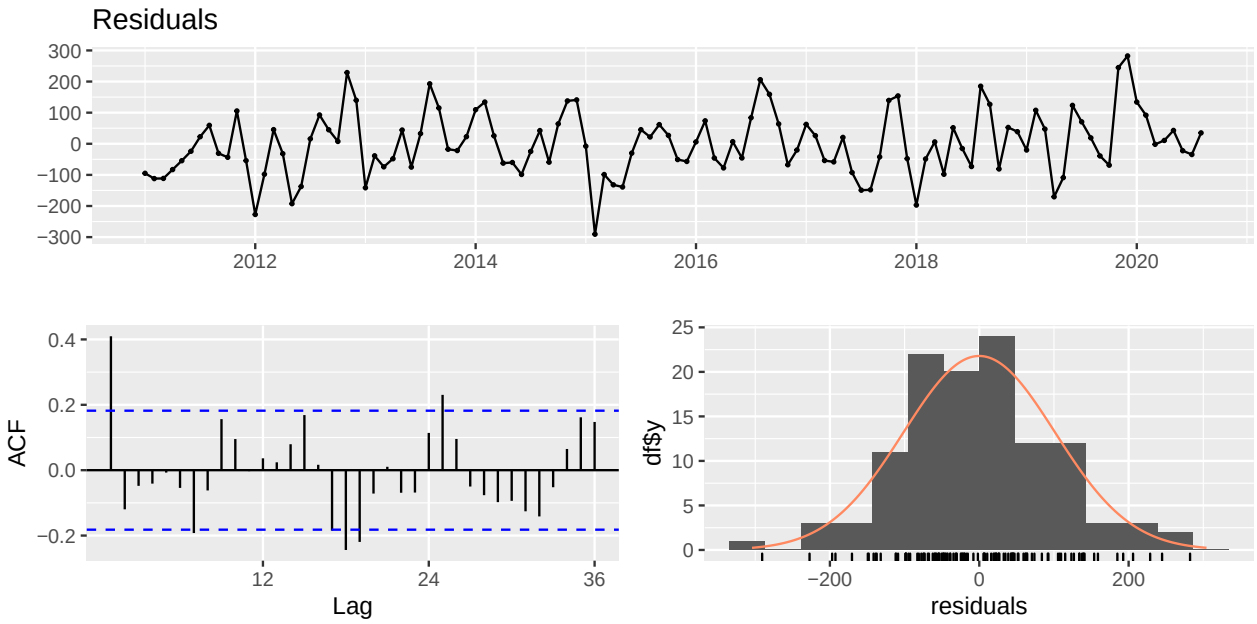
```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold
## Variable: Z(t) = + (0) X(t) + (0) X(t-1)+ (1) X(t-2)
##
## Value: 790.7
```




```
##
##  1 T: Trim not respected:  0.862069 0.137931 from th: 1213.601

##
## Non linear autoregressive model
##
## SETAR model ( 2 regimes)
## Coefficients:
## Low regime:
##    const.L     phiL.1
## 94.1527345  0.9211025
##
## High regime:
##      const.H       phiH.1       phiH.2       phiH.3
## -318.4527806    0.7902831   -0.2328454    0.7309027
##
```

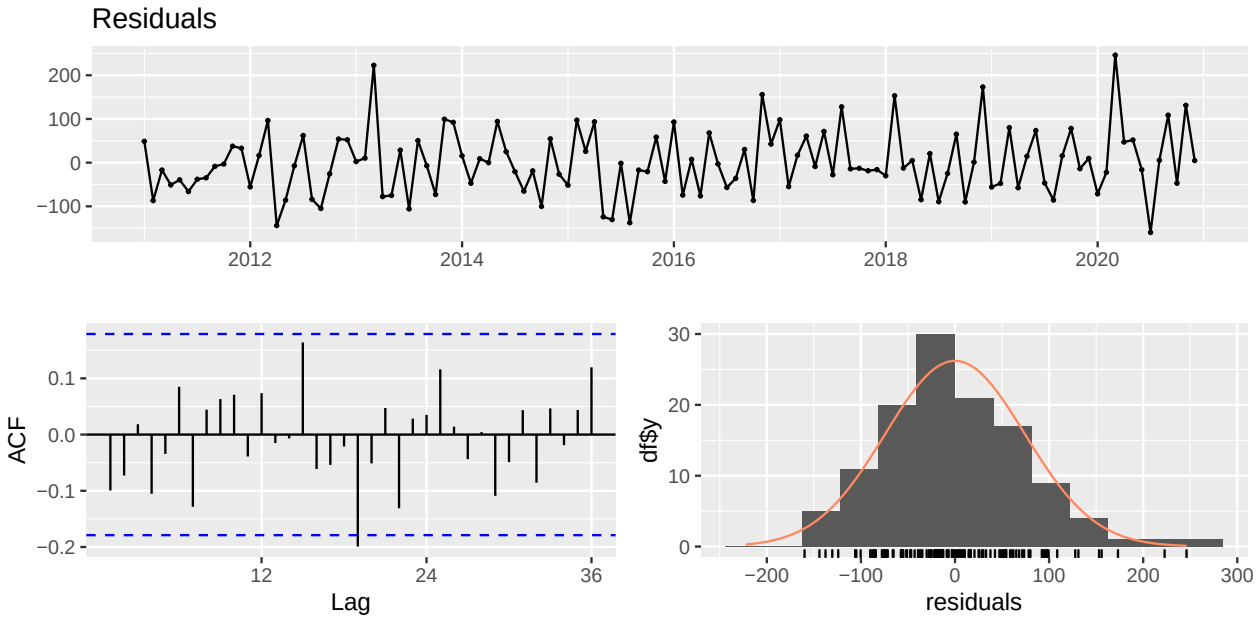
```
## Threshold:
## -Variable: Z(t) = + (0) X(t)+ (1)X(t-1)+ (0)X(t-2)
## -Value: 1208
## Proportion of points in low regime: 82.76%    High regime: 17.24%
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -290.709  -60.694  -11.602   59.844  282.297
##
## Fit:
## residuals variance = 9698,  AIC = 1134, MAPE = 8.4%
##
## Coefficient(s):
##
##            Estimate  Std. Error  t value              Pr(>|t|)
## const.L   94.152734   44.346631   2.1231             0.0358703 *
## phiL.1     0.921103    0.044864  20.5309 < 0.00000000000000022 ***
## const.H -318.452781  287.963339  -1.1059             0.2710669
## phiH.1     0.790283    0.226575   3.4880             0.0006886 ***
## phiH.2    -0.232845    0.363553  -0.6405             0.5231297
## phiH.3     0.730903    0.216327   3.3787             0.0009924 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold
## Variable: Z(t) = + (0) X(t) + (1) X(t-1)+ (0) X(t-2)
##
## Value: 1208
```




```
##
##  1 T: Trim not respected:  0.8583333 0.1416667 from th: 1214.61

##
## Non linear autoregressive model
##
## SETAR model ( 2 regimes)
## Coefficients:
## Low regime:
##    const.L     phiL.1
## 26.5631680  0.9873869
##
## High regime:
##     const.H      phiH.1
## -366.770565    1.258479
##
## Threshold:
## -Variable: Z(t) = + (0) X(t)+ (1)X(t-1)
## -Value: 1213
## Proportion of points in low regime: 84.17%    High regime: 15.83%
##
## Residuals:
##       Min        1Q    Median        3Q       Max
```

```
## -159.9134  -51.1907   -7.7945   49.2934  246.0615
##
## Fit:
## residuals variance = 5365,  AIC = 1058, MAPE = 5.927%
##
## Coefficient(s):
##
##            Estimate  Std. Error  t value             Pr(>|t|)
## const.L   26.563168   32.728557   0.8116              0.41864
## phiL.1     0.987387    0.033652  29.3408 < 0.0000000000000002 ***
## const.H -366.770565  154.135328  -2.3795              0.01894 *
## phiH.1     1.258479    0.115936  10.8549 < 0.0000000000000002 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold
## Variable: Z(t) = + (0) X(t) + (1) X(t-1)
##
## Value: 1213
```



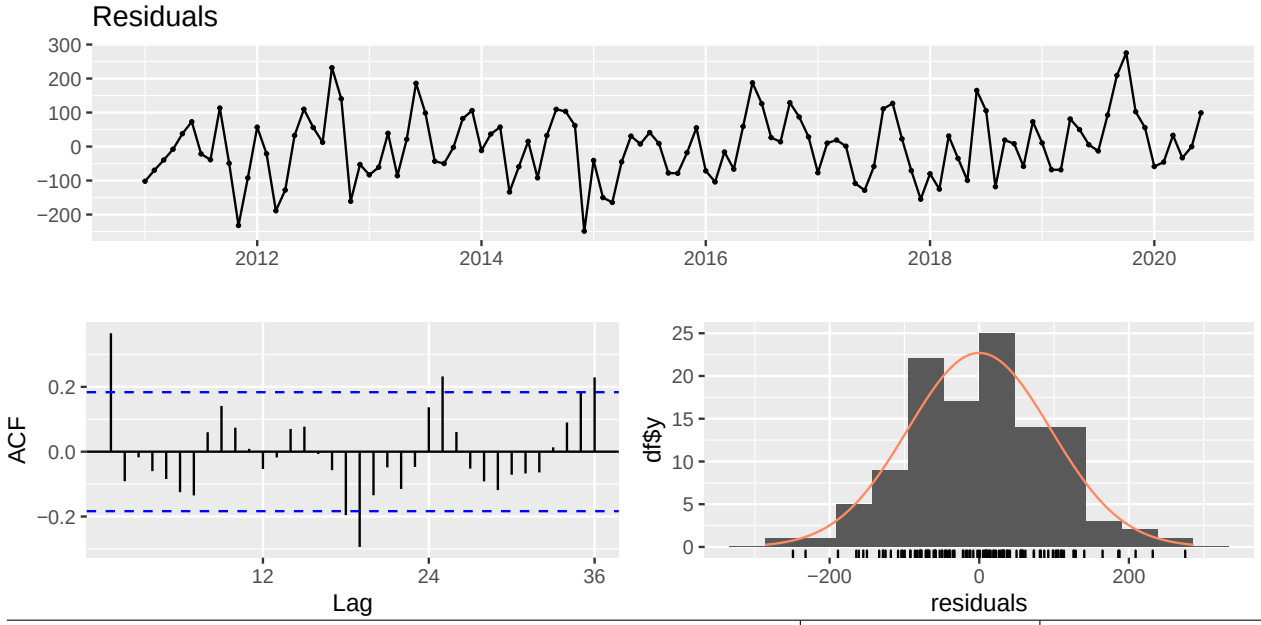

```
##
## Non linear autoregressive model
##
## SETAR model ( 2 regimes)
```

```
## Coefficients:
## Low regime:
##   const.L    phiL.1
## 32.723268  1.005528
##
## High regime:
##      const.H       phiH.1       phiH.2       phiH.3       phiH.4
## -533.2039159    1.2228038   -0.2014876    0.6895297   -0.3198967
##
## Threshold:
## -Variable: Z(t) = + (1) X(t)+ (0)X(t-1)+ (0)X(t-2)+ (0)X(t-3)
## -Value: 1182
## Proportion of points in low regime: 75.44%    High regime: 24.56%
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -249.0256  -67.8389    6.3576   57.1181  275.2895
##
## Fit:
## residuals variance = 8450,  AIC = 1119, MAPE = 7.924%
##
## Coefficient(s):
##
##            Estimate  Std. Error  t value              Pr(>|t|)
## const.L   32.723268   48.127028   0.6799             0.4979119
## phiL.1     1.005528    0.050783  19.8003 < 0.00000000000000022 ***
## const.H -533.203916  232.449479  -2.2938             0.0236151 *
## phiH.1     1.222804    0.240614   5.0820            0.00000146 ***
## phiH.2    -0.201488    0.216292  -0.9316             0.3535187
## phiH.3     0.689530    0.203927   3.3813             0.0009865 ***
## phiH.4    -0.319897    0.227650  -1.4052             0.1626545
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Threshold
## Variable: Z(t) = + (1) X(t) + (0) X(t-1)+ (0) X(t-2)+ (0) X(t-3)
```

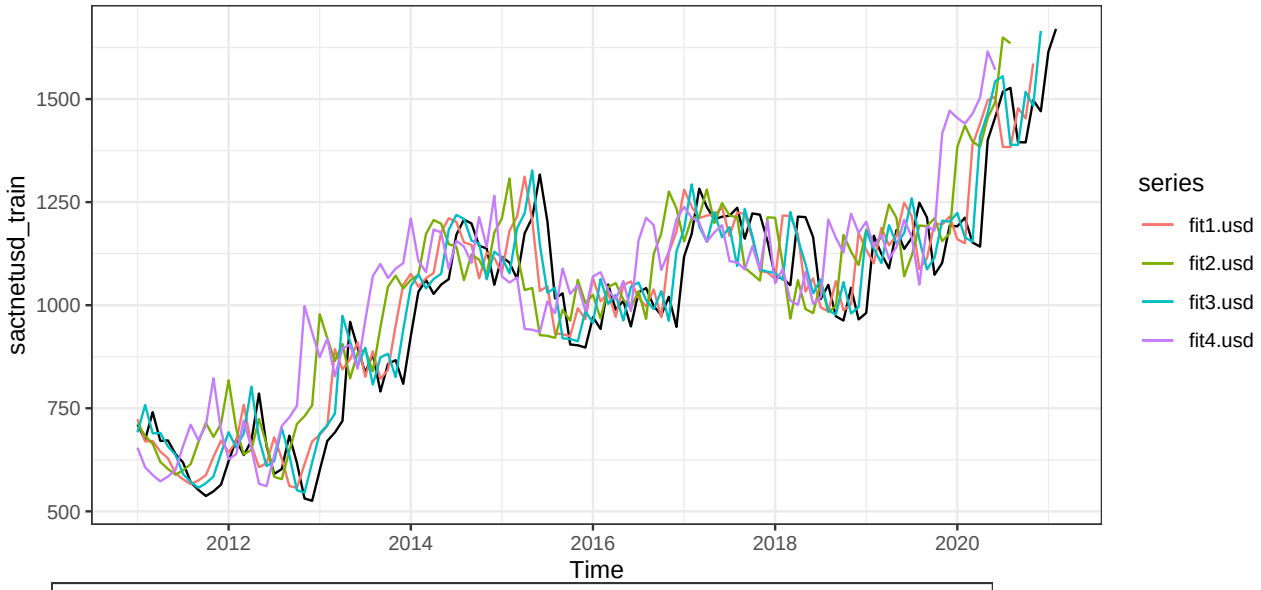
Cuadro 9: Metricas de Rendimiento Modelos SETAR

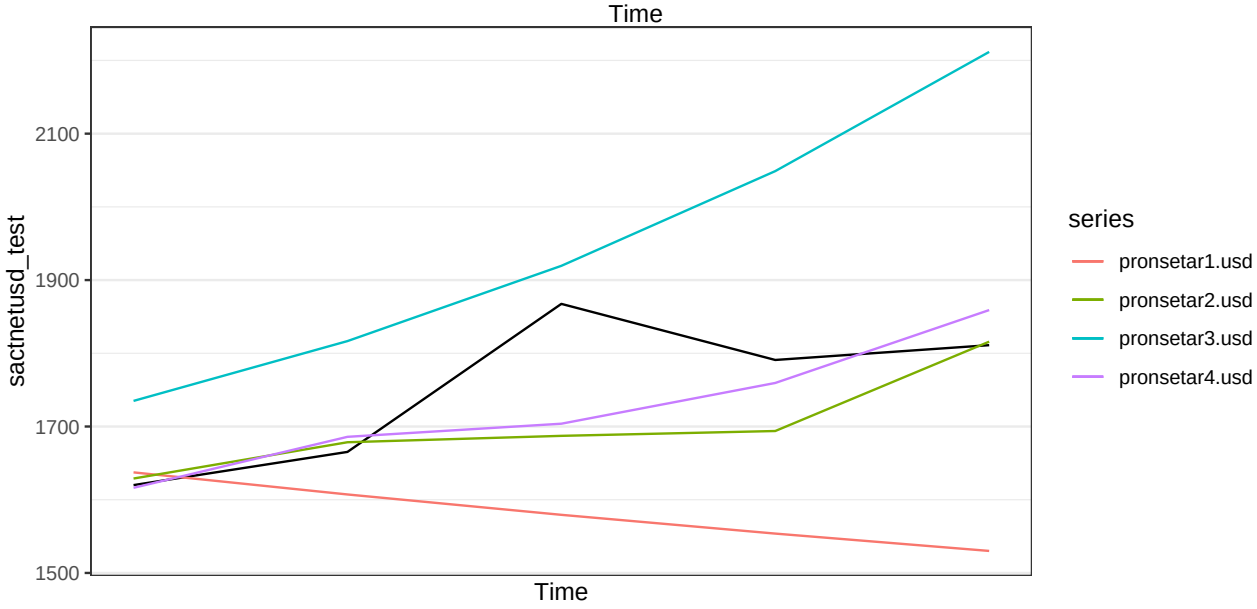
Modelo	DataSet	MAE	RSS	MSE
3.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 1	Entrenamiento	65.24851	867891.56	7113.865
1.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 2	Entrenamiento	76.03300	1190732.79	9760.105
2.SETAR m = 4,mL = 1, mH = 3, d=2,nthresh = 1,thDelay = 2	Entrenamiento	98.93892	2057277.74	16862.932
4.SETAR m = 4,mL = 1, mH = 4, d=2,nthresh = 1,thDelay = 0	Entrenamiento	120.78529	3019923.18	24753.469
4.SETAR m = 4,mL = 1, mH = 4, d=2,nthresh = 1,thDelay = 0	Prueba	53.47200	30513.91	6102.783
2.SETAR m = 4,mL = 1, mH = 3, d=2,nthresh = 1,thDelay = 2	Prueba	60.85853	42188.91	8437.782
1.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 2	Prueba	176.35296	221897.62	44379.524
3.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 1	Prueba	195.36421	265812.38	53162.477

```
##
## Value: 1182
```



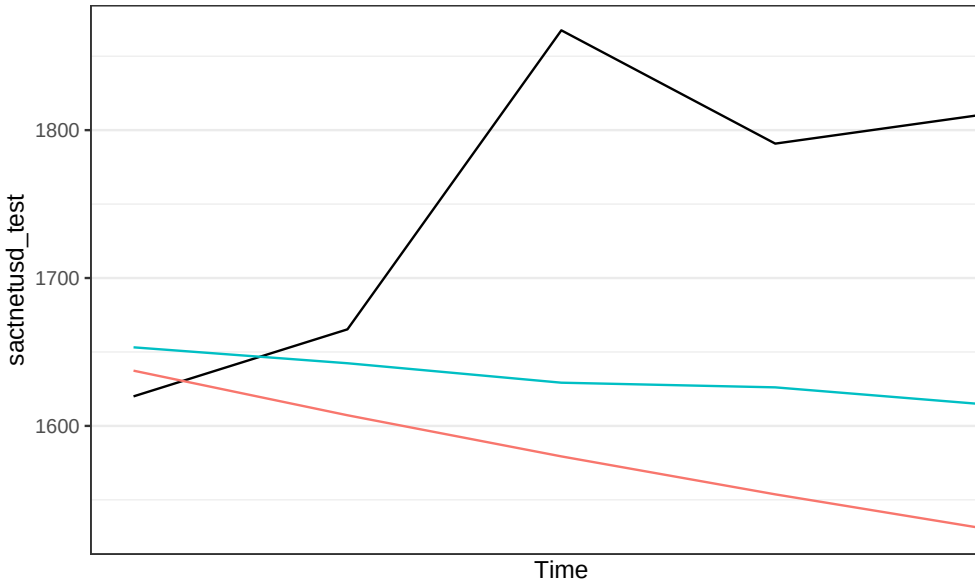
Modelo	AIC	BIC
1.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 2	2664.94192921197	2684.57007652511
2.SETAR m = 4,mL = 1, mH = 3, d=2,nthresh = 1,thDelay = 2	2715.40394269942	2737.83611105729
3.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 1	2667.26111427235	2689.69328263021
4.SETAR m = 4,mL = 1, mH = 4, d=2,nthresh = 1,thDelay = 0	2725.78583996026	2742.60996622866


sactnetusd_train
1500
1250
1000
750
500
2012
2014
2016
2018
2020
Time
series
fit1.usd
fit2.usd
fit3.usd
fit4.usd


sactnetusd_test
2100
1900
1700
1500
Time
series
pronsetar1.usd
pronsetar2.usd
pronsetar3.usd
pronsetar4.usd

Cuadro 10: Metricas de Rendimiento Modelos No Lineales Dolares

Modelo	DataSet	MAE	RSS	MSE
1. TAR p1=3,p2=4,d=1	Entrenamiento	55.96542	676293.45	5543.389
3. TAR p1=1,p2=3,d=1	Entrenamiento	59.12611	711230.72	5829.760
2. TAR p1=1,p2=2,d=1	Entrenamiento	59.42877	713711.62	5850.095
3.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 1	Entrenamiento	65.24851	867891.56	7113.865
1.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 2	Entrenamiento	76.03300	1190732.79	9760.105
2.SETAR m = 4,mL = 1, mH = 3, d=2,nthresh = 1,thDelay = 2	Entrenamiento	98.93892	2057277.74	16862.932
4.SETAR m = 4,mL = 1, mH = 4, d=2,nthresh = 1,thDelay = 0	Entrenamiento	120.78529	3019923.18	24753.469
4.SETAR m = 4,mL = 1, mH = 4, d=2,nthresh = 1,thDelay = 0	Prueba	53.47200	30513.91	6102.783
2.SETAR m = 4,mL = 1, mH = 3, d=2,nthresh = 1,thDelay = 2	Prueba	60.85853	42188.91	8437.782
3. TAR p1=1,p2=3,d=1	Prueba	121.80264	106912.61	21382.522
2. TAR p1=1,p2=2,d=1	Prueba	125.33080	113962.34	22792.469
1. TAR p1=3,p2=4,d=1	Prueba	131.18617	124281.26	24856.252
1.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 2	Prueba	176.35296	221897.62	44379.524
3.SETAR m = 4,mL = 1, mH = 1, d=1,nthresh = 1,thDelay = 1	Prueba	195.36421	265812.38	53162.477



3.2.2.2.3. Metricas Generales

3.2.3. Modelo Machine Learning

3.2.3.1. Serie en Colones

3.2.3.1.1. MODELS XGBOOST

Random Forest

SVM

prophet_boost

```
## # Modeltime Table
## # A tibble: 4 x 3
```

```
##   .model_id .model     .model_desc
##       <int> <list>     <chr>
## 1         1 <workflow> PROPHET W/ XGBOOST ERRORS
## 2         2 <workflow> XGBOOST
## 3         3 <workflow> RANDOMFOREST
## 4         4 <workflow> KERNLAB
```

.model_id	.model_desc	.type	mae	mape	mase	smape	rm
1	PROPHET W/ XGBOOST ERRORS	Fitted	8358.066	4.664870	0.2878886	5.034977	12284
2	XGBOOST	Test	9057.424	2.410889	0.3119775	2.426319	13862
3	RANDOMFOREST	Test	22228.350	27.626853	0.7656422	17.175190	28609
4	KERNLAB	Test	51133.042	27.917171	1.7612471	25.196393	74180

.model_id	.model_desc	.type	mae	mape	mase	smape	rm
1	PROPHET W/ XGBOOST ERRORS	Test	52131.10	5.268918	0.9106689	5.210271	64435
2	XGBOOST	Test	46463.83	4.473893	0.8116684	4.667059	66341
3	RANDOMFOREST	Test	60557.75	5.825055	1.0578725	6.073960	74428
4	KERNLAB	Test	199407.40	19.831176	3.4834126	22.083500	205148

Validación cruzada

https://cran.r-project.org/web/packages/modeltime.resample/vignettes/getting-started.html

```
## # Time Series Cross Validation Plan
## # A tibble: 5 x 2
##   splits         id
##   <list>         <chr>
## 1 <split [36/5]> Slice1
## 2 <split [36/5]> Slice2
## 3 <split [36/5]> Slice3
## 4 <split [36/5]> Slice4
## 5 <split [36/5]> Slice5
```

3.2.3.1.2. ENSEMBLE Ensamble Media y Meta-Learner

.model_id	.model_desc	.type	mae	mape	mase	s
4	PROPHET W/ XGBOOST ERRORS	Fitted	8358.066	4.664870	0.2878886	5.0
5	XGBOOST	Test	9057.424	2.410889	0.3119775	2.4
1	ENSEMBLE (MEAN): 4 MODELS	Test	20188.732	11.921483	0.6953888	10.3
6	RANDOMFOREST	Test	22228.350	27.626853	0.7656422	17.1
7	KERNLAB	Test	51133.042	27.917171	1.7612471	25.1
2	ENSEMBLE (GLMNET STACK): 4 MODELS	Test	88266.294	101.030467	3.0402798	42.7
3	ENSEMBLE (XGBOOST STACK): 4 MODELS	Test	355159.469	746.670336	12.2332558	78.7

.model_id	.model_desc	.type	mae	mape	mase	smap
2	ENSEMBLE (GLMNET STACK): 4 MODELS	Test	39532.79	3.868887	0.6905913	3.85370
4	PROPHET W/ XGBOOST ERRORS	Test	52131.10	5.268918	0.9106689	5.21027
5	XGBOOST	Test	46463.83	4.473893	0.8116684	4.66705
6	RANDOMFOREST	Test	60557.75	5.825055	1.0578725	6.07396
1	ENSEMBLE (MEAN): 4 MODELS	Test	71950.03	6.937332	1.2568823	7.28272
3	ENSEMBLE (XGBOOST STACK): 4 MODELS	Test	88613.23	8.942972	1.5479688	8.81057
7	KERNLAB	Test	199407.40	19.831176	3.4834126	22.08350

3.2.3.2. Serie en Dolares

3.2.3.2.1. **MODELS** prophet

XGBOOST

Random Forest

SVM

prophet_boost

.model_id	.model_desc	.type	mae	mape	mase	smape	r
2	PROPHET W/ XGBOOST ERRORS	Fitted	14.72961	5.048915	0.3616871	4.883939	20.37
3	XGBOOST	Test	13.15145	2.141262	0.3229353	2.158493	20.71
4	RANDOMFOREST	Test	36.96544	19.784290	0.9076900	13.176725	47.40
1	PROPHET W/ REGRESSORS	Fitted	84.72176	24.775372	2.0803512	23.088997	109.54
5	KERNLAB	Test	85.53778	23.042314	2.1003887	18.335571	114.97

.model_id	.model_desc	.type	mae	mape	mase	smape	rmse
2	PROPHET W/ XGBOOST ERRORS	Test	118.0343	6.525348	1.371201	6.833269	141.1785
3	XGBOOST	Test	168.0157	9.335913	1.951834	9.930132	192.0582
4	RANDOMFOREST	Test	310.7488	17.555510	3.609960	19.331450	320.6782
1	PROPHET W/ REGRESSORS	Test	353.9586	20.075326	4.111928	22.363135	359.7840
5	KERNLAB	Test	436.0666	24.813671	5.065774	28.356871	439.5200

Validación cruzada

https://cran.r-project.org/web/packages/modeltime.resample/vignettes/getting-started.html

```
## # Time Series Cross Validation Plan
## # A tibble: 5 x 2
##   splits         id
##   <list>         <chr>
## 1 <split [36/5]> Slice1
## 2 <split [36/5]> Slice2
## 3 <split [36/5]> Slice3
## 4 <split [36/5]> Slice4
## 5 <split [36/5]> Slice5

## # Modeltime Table
## # A tibble: 5 x 4
##   .model_id .model     .model_desc                .resample_results
##       <int> <list>     <chr>                      <list>
## 1         1 <workflow> PROPHET W/ REGRESSORS      <rsmp[+]>
## 2         2 <workflow> PROPHET W/ XGBOOST ERRORS  <rsmp[+]>
## 3         3 <workflow> XGBOOST                    <rsmp[+]>
## 4         4 <workflow> RANDOMFOREST               <rsmp[+]>
## 5         5 <workflow> KERNLAB                    <rsmp[+]>
```

3.2.3.2.2. ENSEMBLE Ensamble Media y Meta-Learner

.model_id	.model_desc	.type	mae	mape	mase	sm
5	PROPHET W/ XGBOOST ERRORS	Fitted	14.72961	5.048915	0.3616871	4.88
6	XGBOOST	Test	13.15145	2.141262	0.3229353	2.15
7	RANDOMFOREST	Test	36.96544	19.784290	0.9076900	13.17
1	ENSEMBLE (MEAN): 5 MODELS	Test	42.26934	10.988917	1.0379279	9.50
4	PROPHET W/ REGRESSORS	Fitted	84.72176	24.775372	2.0803512	23.08
8	KERNLAB	Test	85.53778	23.042314	2.1003887	18.33
2	ENSEMBLE (GLMNET STACK): 5 MODELS	Test	384.58760	339.894415	9.4435869	94.29
3	ENSEMBLE (XGBOOST STACK): 5 MODELS	Test	485.24104	418.765819	11.9151422	68.22

.model_id	.model_desc	.type	mae	mape	mase	smape
2	ENSEMBLE (GLMNET STACK): 5 MODELS	Test	57.38698	3.393666	0.666663	3.309372
3	ENSEMBLE (XGBOOST STACK): 5 MODELS	Test	103.55834	5.736585	1.203034	5.963642
5	PROPHET W/ XGBOOST ERRORS	Test	118.03429	6.525348	1.371201	6.833269
6	XGBOOST	Test	168.01570	9.335913	1.951834	9.930132
1	ENSEMBLE (MEAN): 5 MODELS	Test	275.30170	15.533800	3.198172	16.922376
7	RANDOMFOREST	Test	310.74877	17.555510	3.609960	19.331450
4	PROPHET W/ REGRESSORS	Test	353.95864	20.075326	4.111928	22.363135
8	KERNLAB	Test	436.06661	24.813671	5.065774	28.356871

3.2.4. Resumen de Modelo

3.2.5. Pronóstico

4. Prueba de Tensión

5. Conclusiones

Anexos

Banco Central de Costa Rica. 2015. “Memoria Anual 2015.” Banco Central de Costa Rica.

———. 2021a. “Coyuntura macroeconómica ante la pandemia y revisión de proyecciones 2020-2021.” Banco Central de Costa Rica.

———. 2021b. “REVISIÓN PROGRAMA MACROECONÓMICO 2021 / 2022.” Banco Central de Costa Rica.

Banco Nacional de Costa Rica. n.d. “Conceptos básicos de los fondos de inversión.” Banco Nacional de Costa Rica; Banco Nacional de Costa Rica.

BCCR. 2019. “Informe Anual de Estabilidad Financiera 2019.” BCCR. 2019.

Chan, Kung-Sik, and Brian Ripley. 2020. *TSA: Time Series Analysis*. https://CRAN.R-project.org/package=TSA.

Danıéelsson, Jón. 2011. *Financial Risk Forecasting*. Edited by WileyFinance. WileyFinance.

Franses, Philip Hans, and Dick van Dijk. 2000. *Non-Linear Time Series Models in Empirical Finance*. Cambridge University Press. https://doi.org/10.1017/CBO9780511754067.

Hernández-Rodrıéguez, Oscar. 2001. *Introducción a Las Series Cronológicas*. Edited by Editorial UCR. 1st ed. UCR.

Hyndman, George, Rob & Athanasopoulos. 2018. *Forecasting: Principles and Practice*. Edited by OTexts. 2nd ed. OTexts. OTexts.com/fpp2.

Hyndman, Rob J, and Yeasmin Khandakar. 2008. “Automatic Time Series Forecasting: The Forecast Package for R.” *Journal of Statistical Software* 26 (3): 1–22. https://www.jstatsoft.org/article/view/v027i03.

Mercado de Valores Multifondos. 2015a. “Informe Trimestra de Fondos de Inversión del 01 de octubre al 31 de diciembre del 2015.” Mercado de Valores Multifondos.

———. 2015b. “Informe Trimestral de Fondos de Inversión del 01 de abril al 30 de junio del 2015.” Mercado de Valores Multifondos.

Narzo, Antonio Fabio Di, Jose Luis Aznarte, Matthieu Stigler, and Ho Tsung-wu. 2020. *tsDyn: Nonlinear Time Series Models with Regime Switching*. https://CRAN.R-project.org/package=tsDyn.

Rosero-Bixby, Luis. n.d. “Situación de Covid-19 en Costa Rica al viernes 20 de agosto de 2021, con énfasis en la tasa R.” Centro Centroamericano de Población.

Sax, Christoph, and Dirk Eddelbuettel. 2018. “Seasonal Adjustment by X-13arima-SEATS in R.” *Journal of Statistical Software* 87 (11): 1–17. https://doi.org/10.18637/jss.v087.i11.

Superintendencia General de Valores. 2021. “Informe del mercado de valores de Costa Rica I Trimestre 2021.” Superintendencia General de Valores.

Tsay, Ruey S. 2010. *Analysis of Financial Time Series*. 3rd ed. John Wiley & Sons, Inc.