TIME SERIES ANALYSIS FINAL PROJECT

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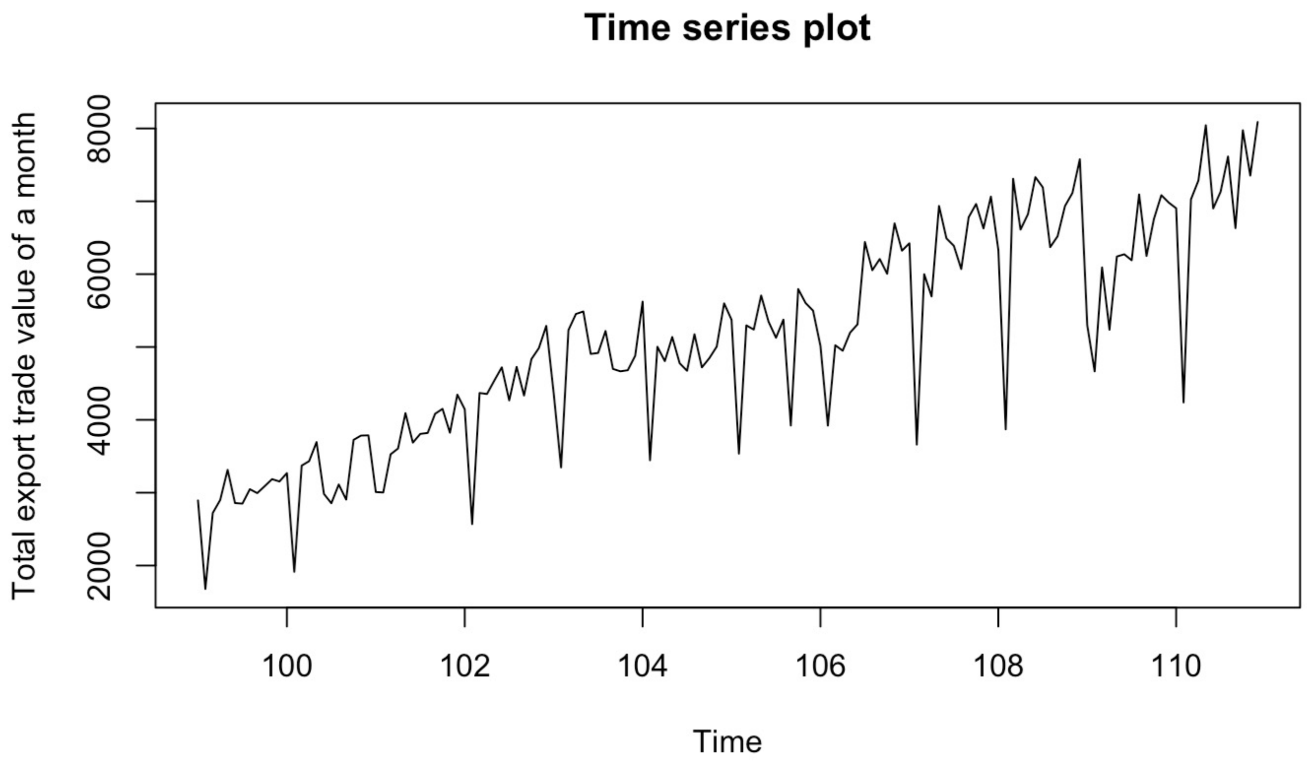
DATA

- 民國99年至112年出口貿易總額
- 資料來源：財政部統計資料庫
- Training data：民國99年1月至民國110年12月
- Testing data：民國111年1月至民國112年5月

DATA

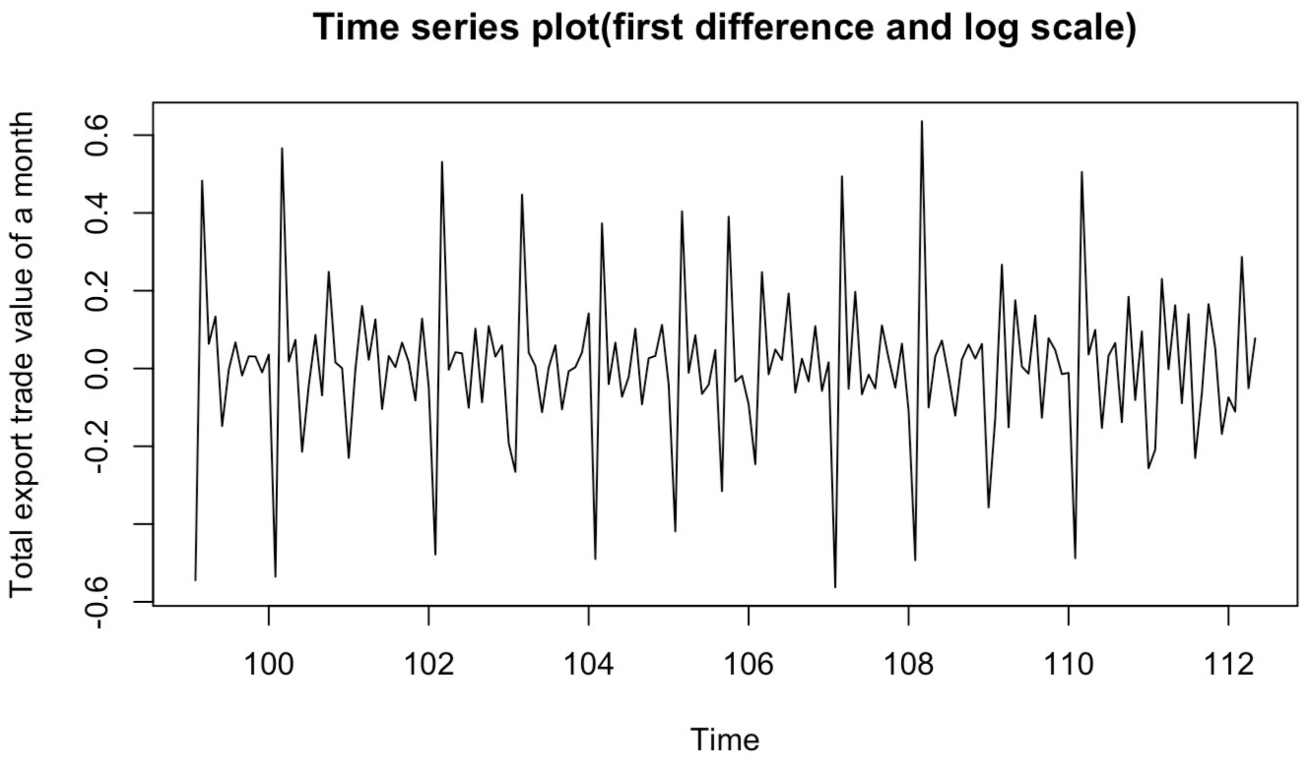
- 時間序列圖



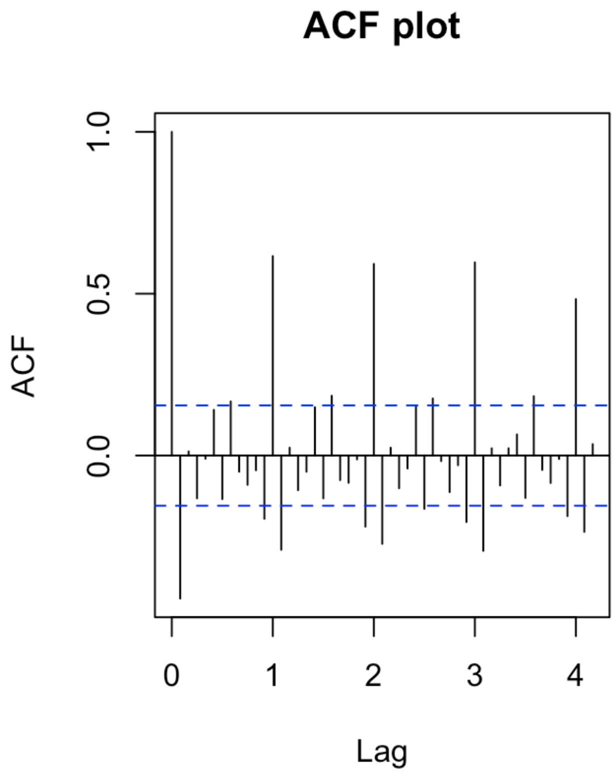
Time series plot
Total export trade value of a month
2000
4000
6000
8000
100
102
104
106
108
110
Time

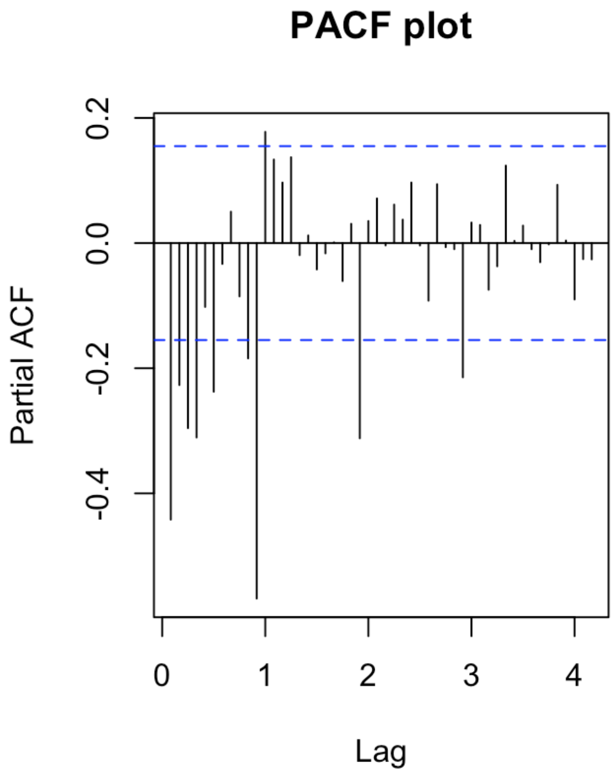
DATA

- 先進行一階差分



DATA ACF/PACF



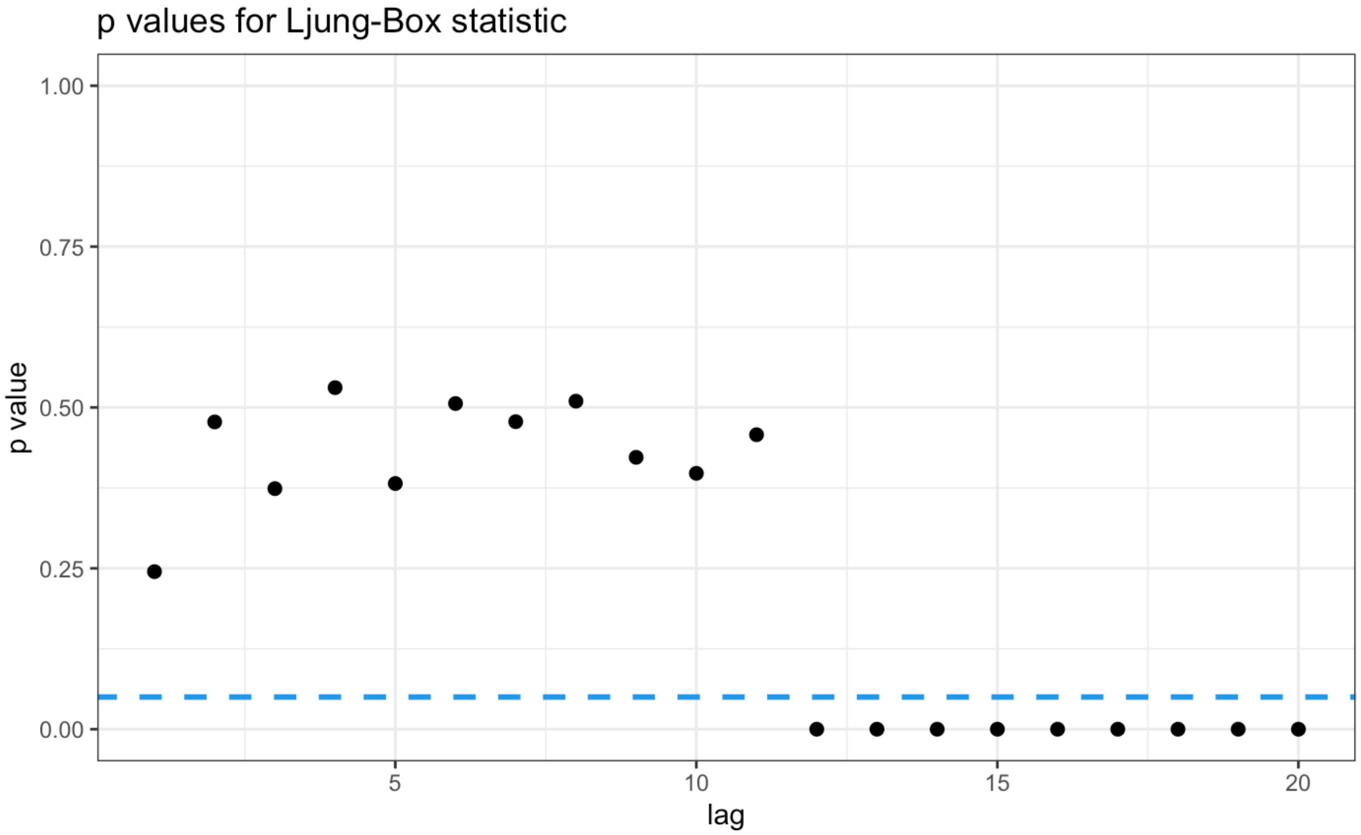


ARIMA(0,1,1)

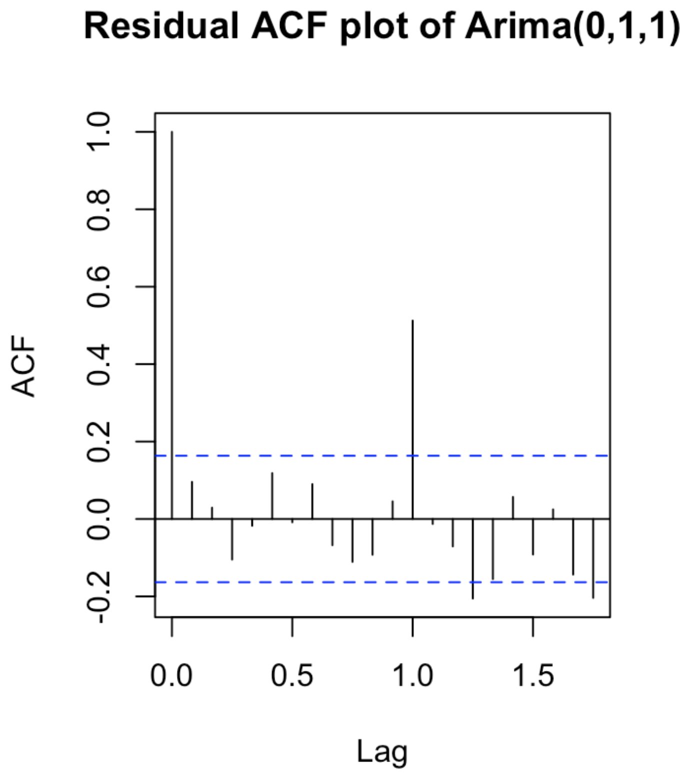
- 用AIC進行選模

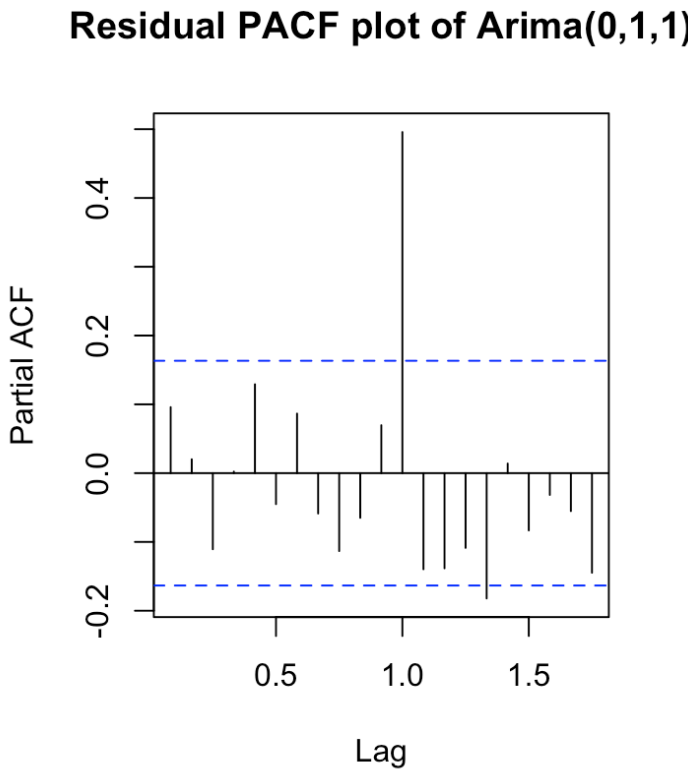
```
Series: dats_train
ARIMA(0,1,1) with drift

Coefficients:
          ma1    drift
      -0.9390  31.9924
s.e.   0.0933   4.3891

sigma^2 = 491650:  log likelihood = -1140.01
AIC=2286.03   AICc=2286.2   BIC=2294.91

Training set error measures:
                   ME     RMSE      MAE      MPE     MAPE      MASE       ACF1
Training set 7.961651 693.8349 486.5316 -1.74443 10.86456 0.8064263 0.09590838
```

ARIMA(0,1,1) LJUNG-BOX TEST

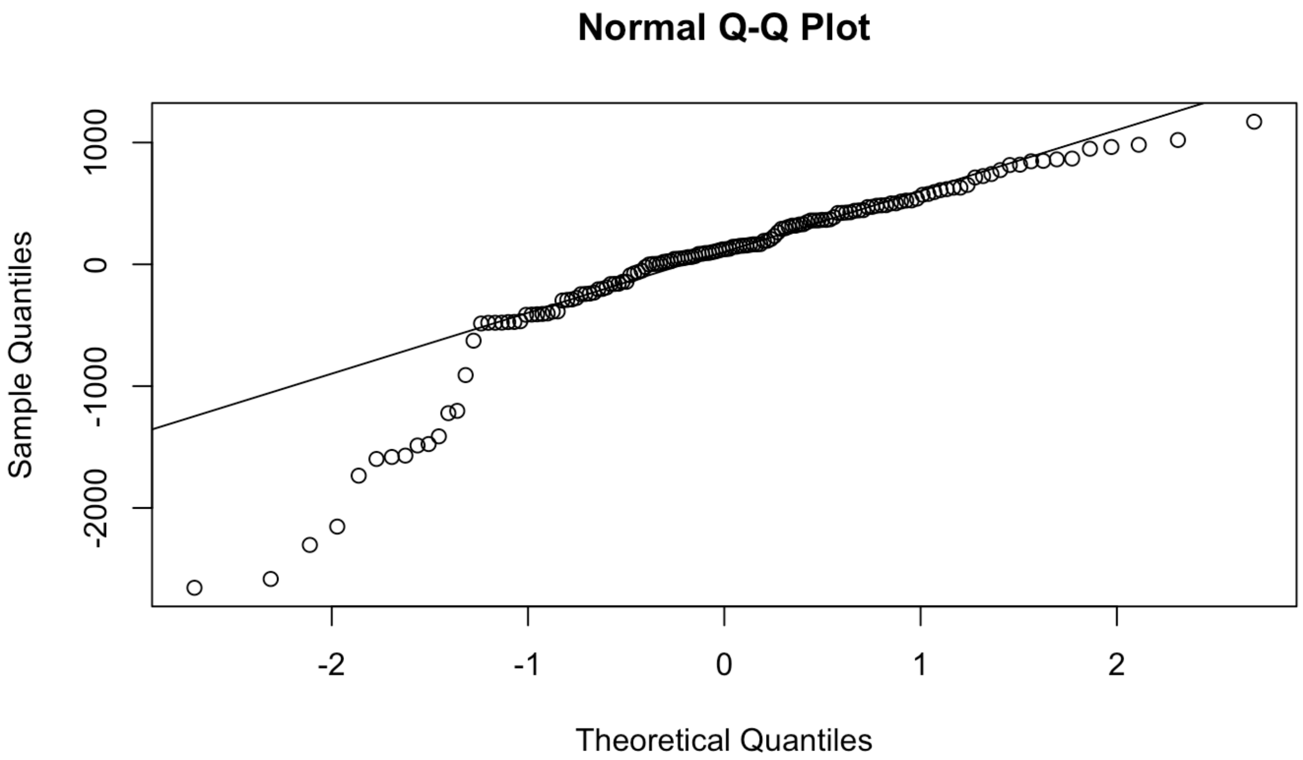


ARIMA(0,1,1) ACF/PACF



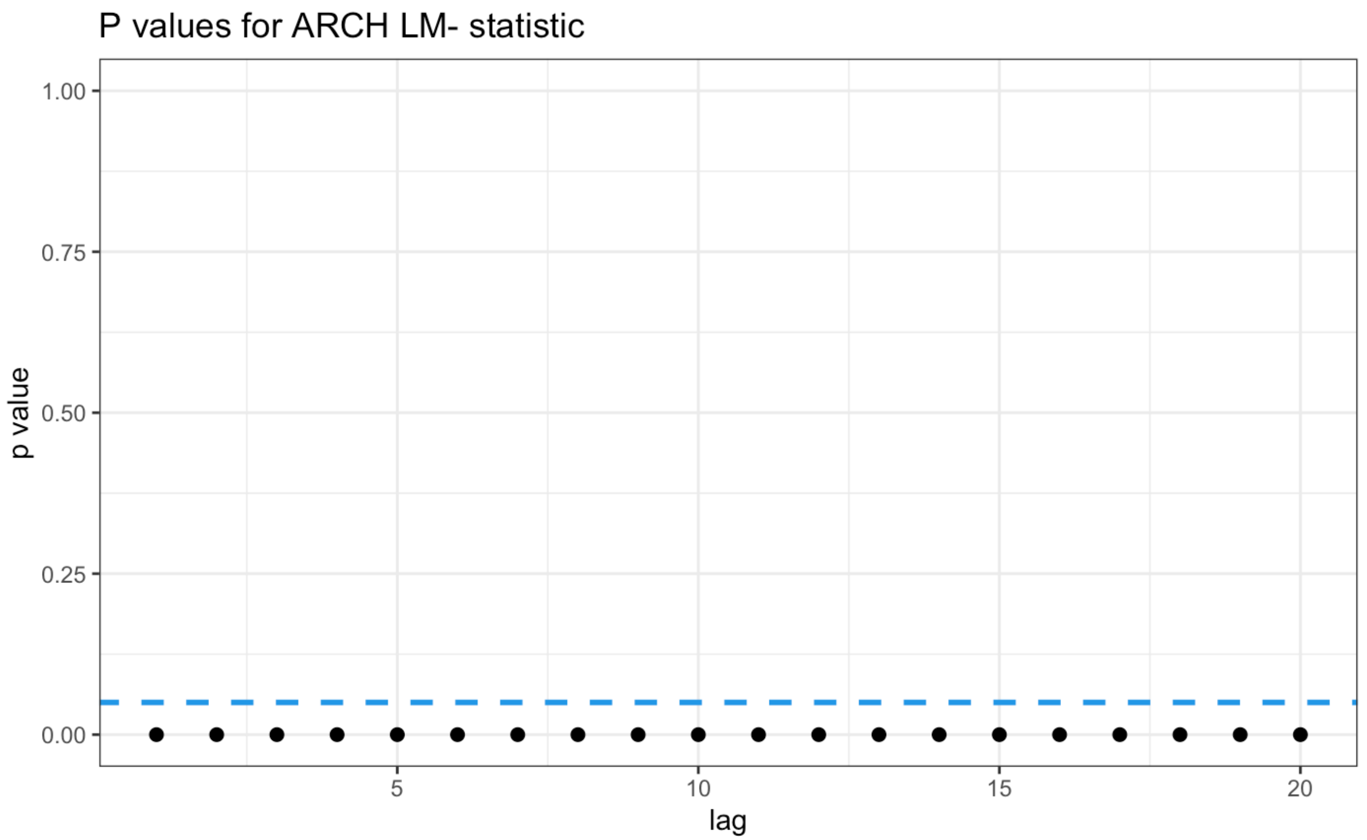


ARIMA(0,1,1) NORMAL Q-Q



ARIMA(0,1,1) ARCH LM TEST

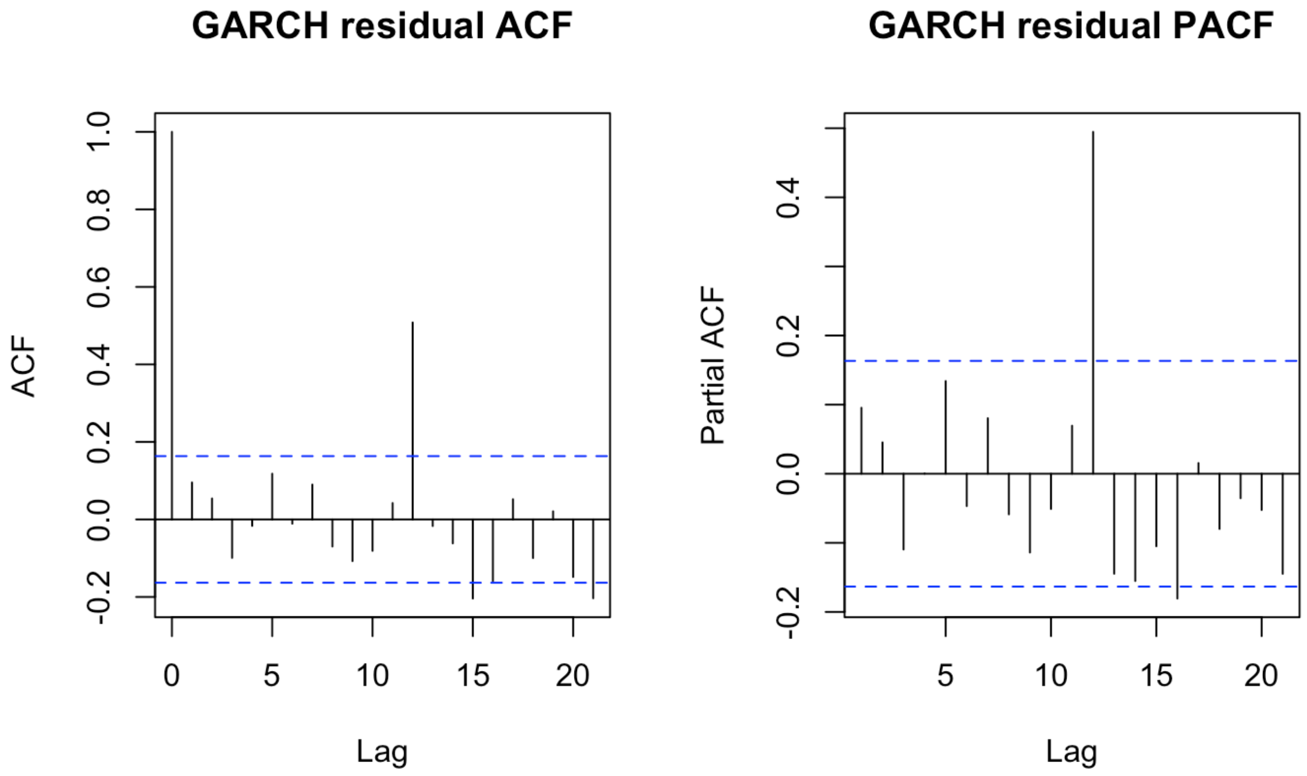
- 所有lag下的p-value都顯示有ARCH effect



ARIMA(0,1,1)+GARCH(1,1)

```
*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(0,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu    -13.852875  6.1964e+01 -0.22356 0.823098
ma1     0.080369  8.4832e-02  0.94739 0.343439
omega 489.741309  1.9191e+03  0.25520 0.798572
alpha1  0.023365  7.0930e-03  3.29431 0.000987
beta1   0.975635  1.7620e-02 55.37010 0.000000
```

ARIMA(0,1,1)+GARCH(1,1) ACF/PACF



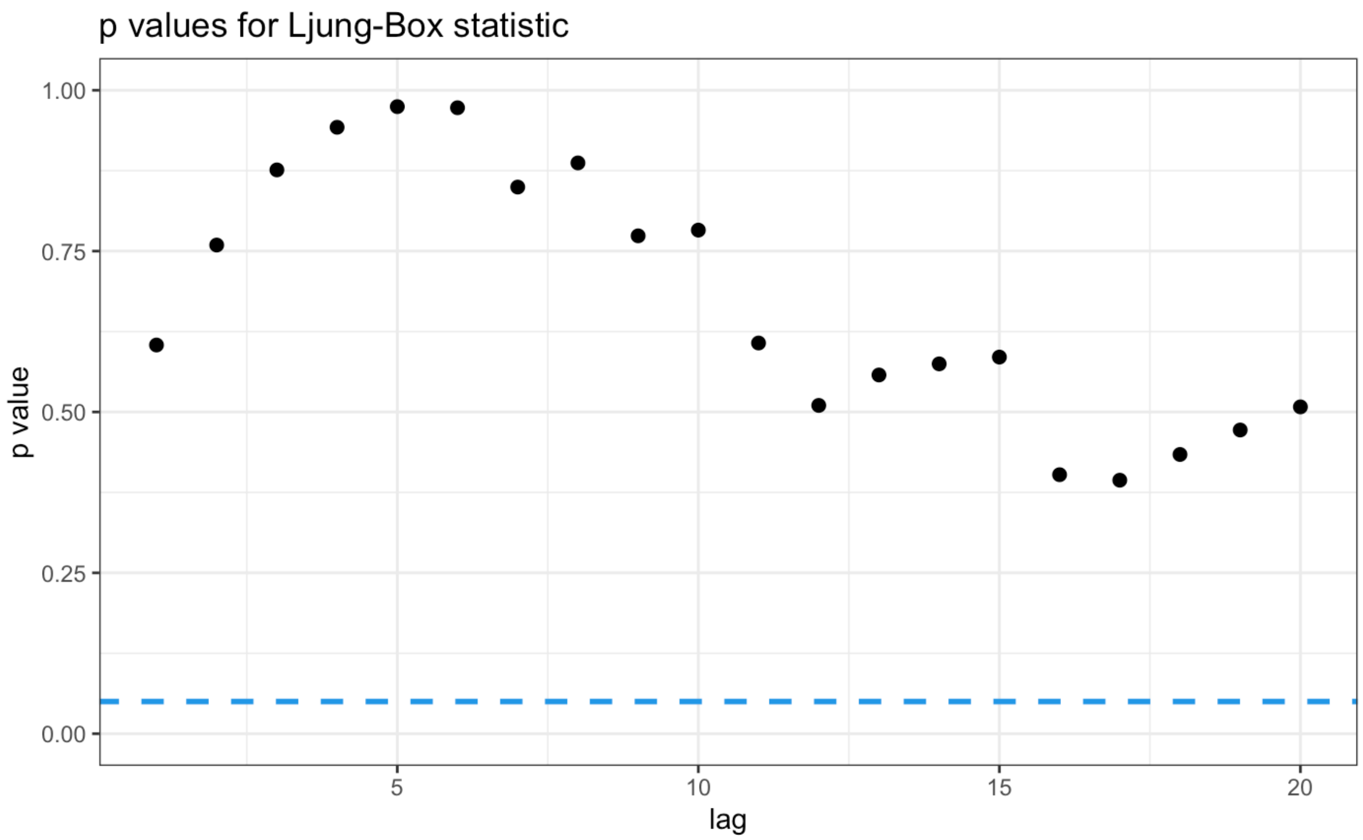
SARIMA(1,0,1)X(0,1,1)

- 用AIC進行選模

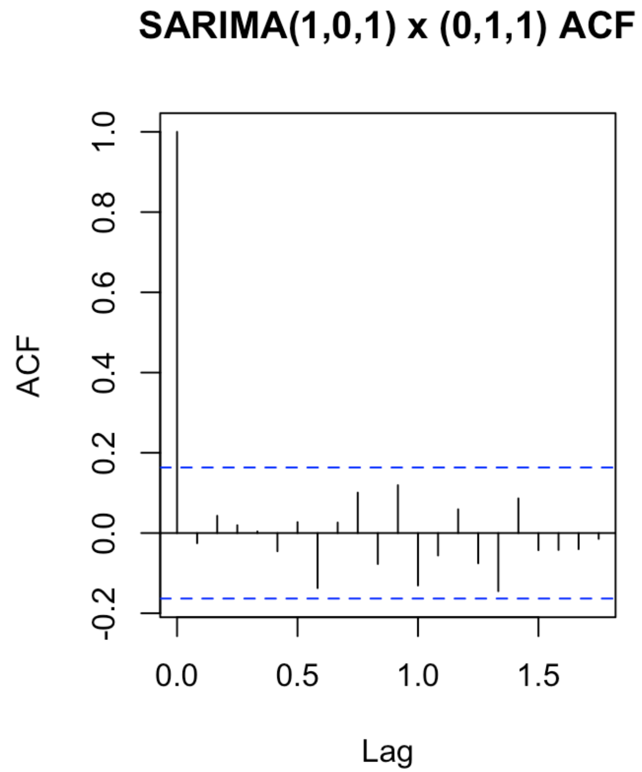
```
Call:
arima(x = dats_train, order = c(1, 0, 1), seasonal = list(order = c(0, 1, 1),
    period = 12))

Coefficients:
         ar1      ma1     sma1
      0.9975  -0.7452  -0.7752
s.e.  0.0041   0.0633   0.0768

sigma^2 estimated as 221705:  log likelihood = -1005.52,  aic = 2019.03

Training set error measures:
                   ME     RMSE      MAE         MPE     MAPE      MASE        ACF1
Training set 30.60616 450.8111 323.1846 -0.02795158 6.393399 0.5279044 -0.02532674
```

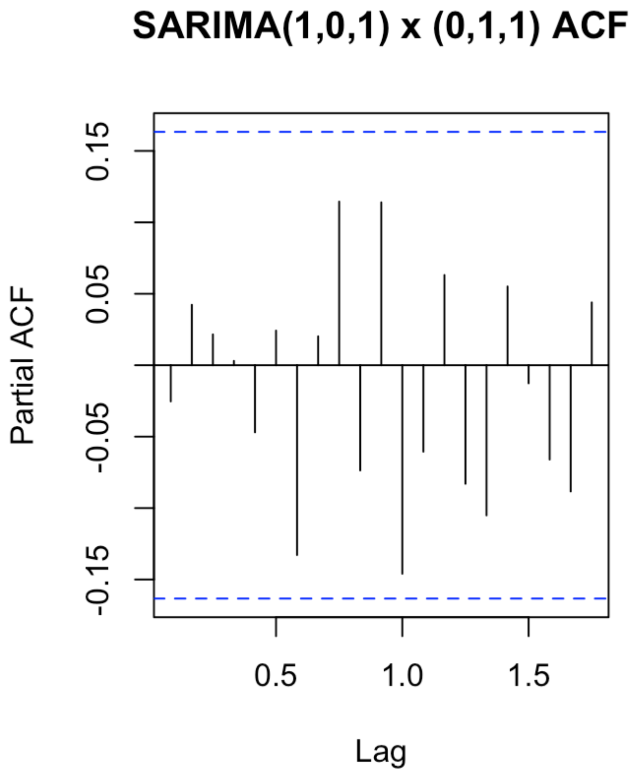
SARIMA(1,0,1)X(0,1,1) LJUNG-BOX TEST

- 所有lag下的p-value皆顯示符合white noise假設

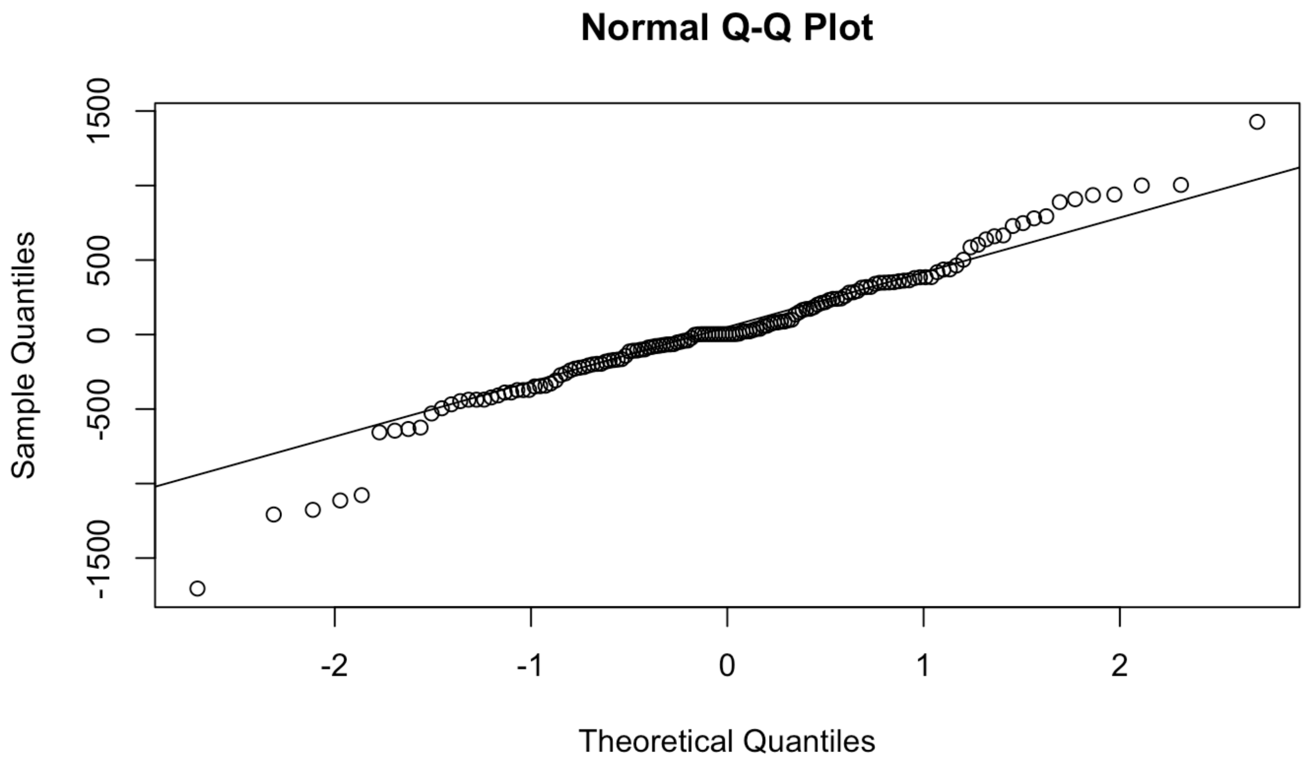


SARIMA(1,0,1)X(0,1,1) ACF/PACF



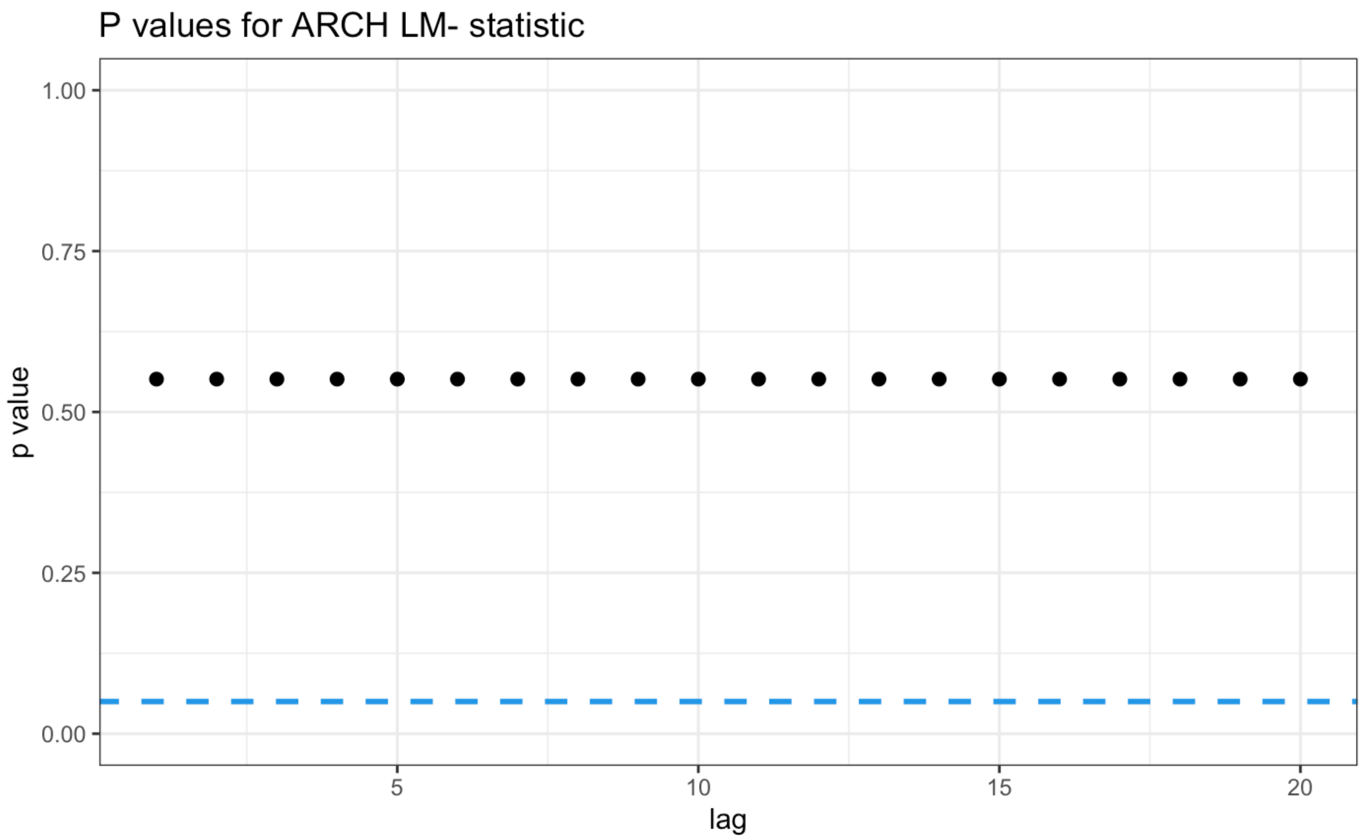


SARIMA(1,0,1)X(0,1,1) NORMAL Q-Q

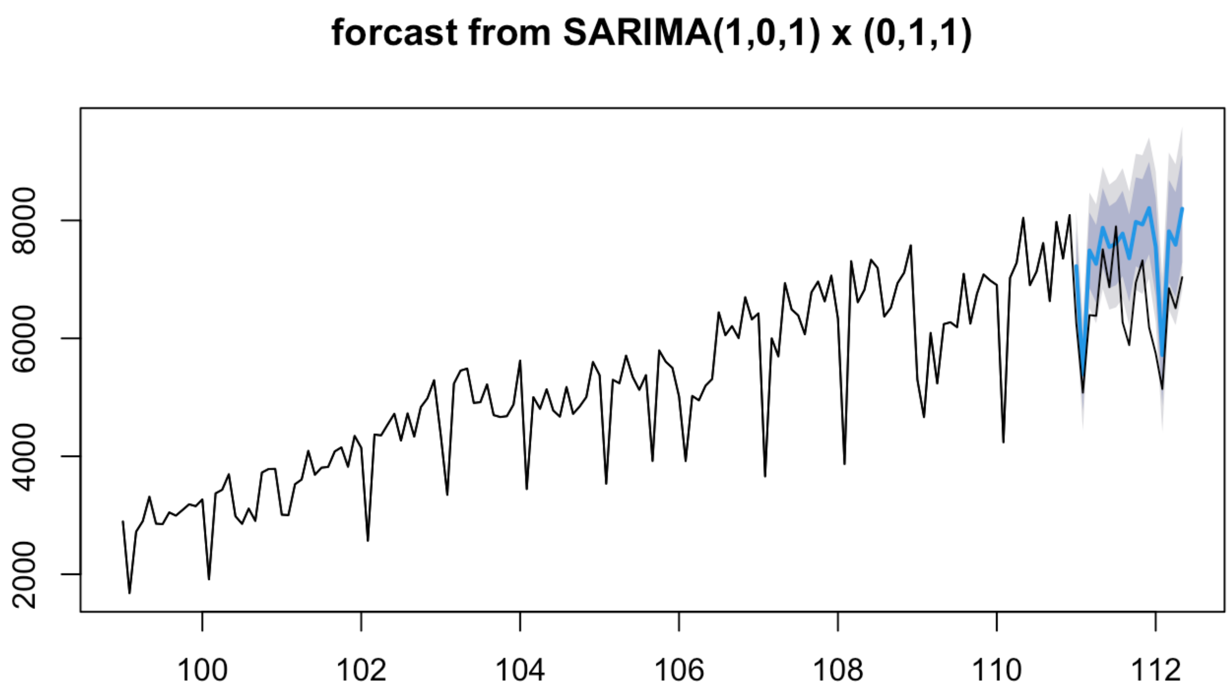


SARIMA(1,0,1)X(0,1,1) ARCH LM TEST

- 所有lag下的p-value都顯示沒有ARCH effect



SARIMA(1,0,1)X(0,1,1) PREDICTION



RMSE=1103.204

HOLT LINEAR TREND MODEL & HOLT-WINTERS SEASONAL MODEL

- 美國德州大學奧斯丁分校**Charles Holt(1957)**將指數平滑法納入趨勢方程式
- 他的學生**Peter Winters(1960)**將預測方程式改良納入季節因子，成為Holt-Winters季節趨勢模型
- **Holt Linear Trend Model :** 將時間序列分為循環變化**(level)**與趨勢變化**(trend)**，將兩者指數平滑後再做線性組合
- **Holt-Winters Seasonal Model :** 將時間序列分為循環變化**(level)**、趨勢變化**(trend)**與季節變化**(seasonality)** ，將三者指數平滑後再做線性組合

HOLT-WINTERS SEASONAL MODEL

$Z_t = \mu_t + T_t + S_t + a_t$

where $\mu_t =$ level, $T_t =$ trend, $S_t =$ seasonality

$$\bar{\mu}_t = \alpha(Z_t - \bar{S}_{t-s}) + (1-\alpha)(\bar{\mu}_{t-1} + \bar{T}_{t-1}), \qquad 0 < \alpha < 1,$$
$$\bar{T}_t = \beta(\bar{\mu}_t - \bar{\mu}_{t-1}) + (1-\beta)\bar{T}_{t-1}, \qquad 0 < \beta < 1,$$
$$\bar{S}_t = \gamma(Z_t - \bar{\mu}_t) + (1-\gamma)\bar{S}_{t-1}, \qquad 0 < \gamma < 1.$$

where α, β, γ are smoothing constants

$$\hat{Z}_t(k) = \bar{\mu}_t + k\bar{T}_t + \bar{S}_{t+k-hs}, \; h = 1 + \text{int}(k/s)$$

HOLT LINEAR TREND MODEL & HOLT-WINTERS SEASONAL MODEL

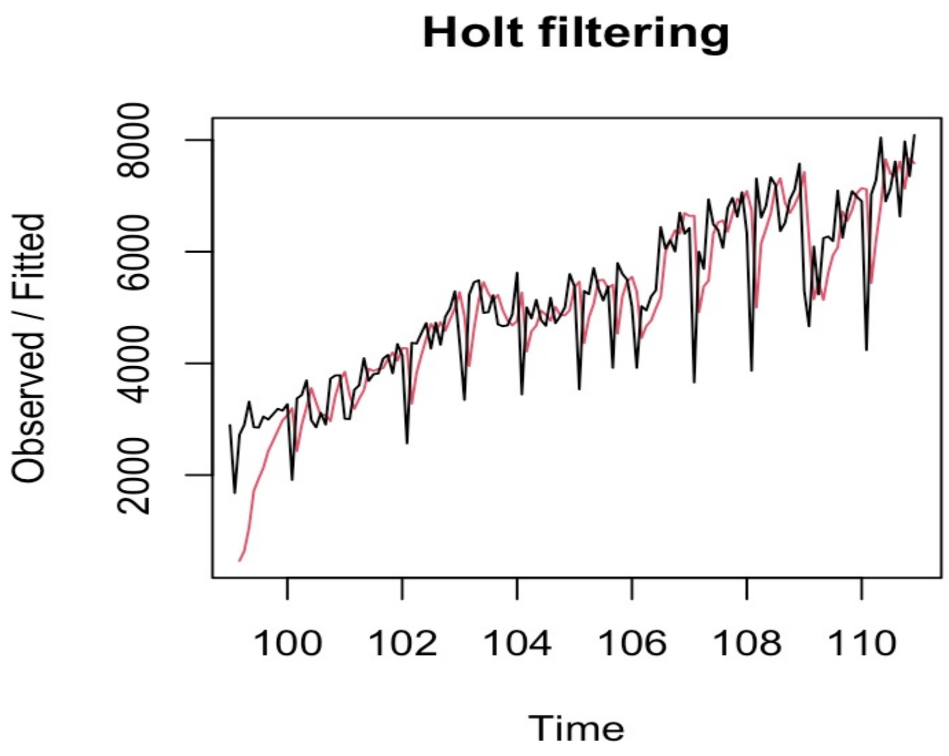
- Holt Linear Trend

```
Call:
HoltWinters(x = dat_train, gamma = FALSE)

Smoothing parameters:
 alpha: 0.5091814
 beta : 0.2107366
 gamma: FALSE

Coefficients:
       [,1]
a 7840.9744
b  129.2519
```

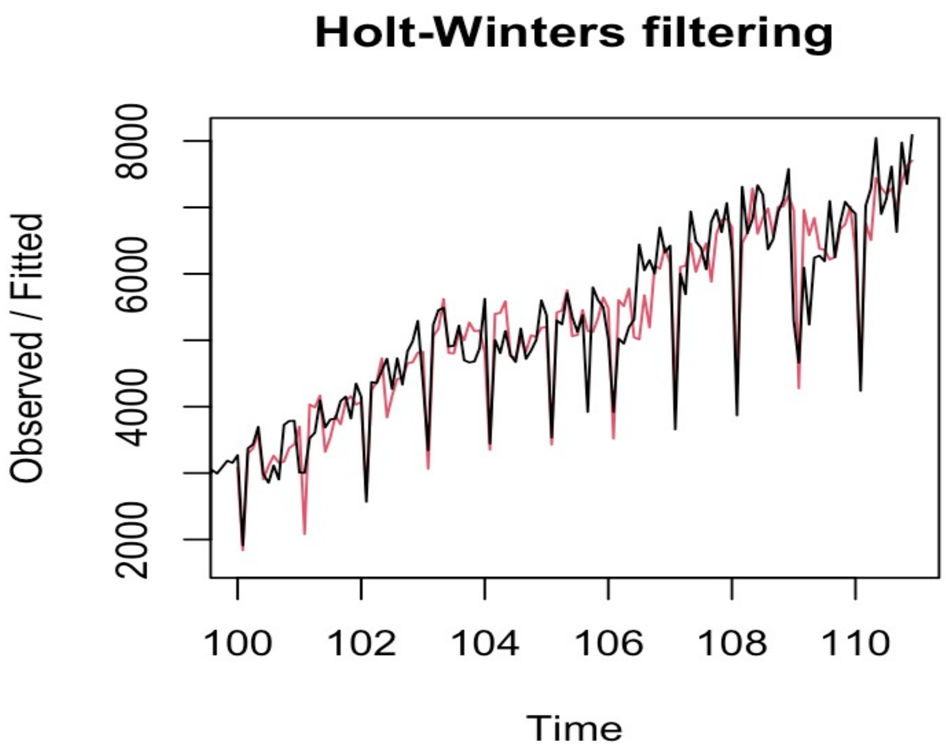
- Holt-Winters Seasonal

```
Call:
HoltWinters(x = dat_train, seasonal

Smoothing parameters:
 alpha: 0.2164627
 beta : 0
 gamma: 0.2481529

Coefficients:
            [,1]
a   7164.0203695
b     23.6976981
s1     0.9942581
s2     0.6682512
s3     1.0366536
s4     1.0009350
s5     1.1040573
s6     1.0331569
s7     1.0371040
s8     1.0589817
s9     0.9840298
s10    1.0754349
s11    1.0642417
s12    1.0973951
```

HOLT LINEAR TREND MODEL & HOLT-WINTERS SEASONAL MODEL

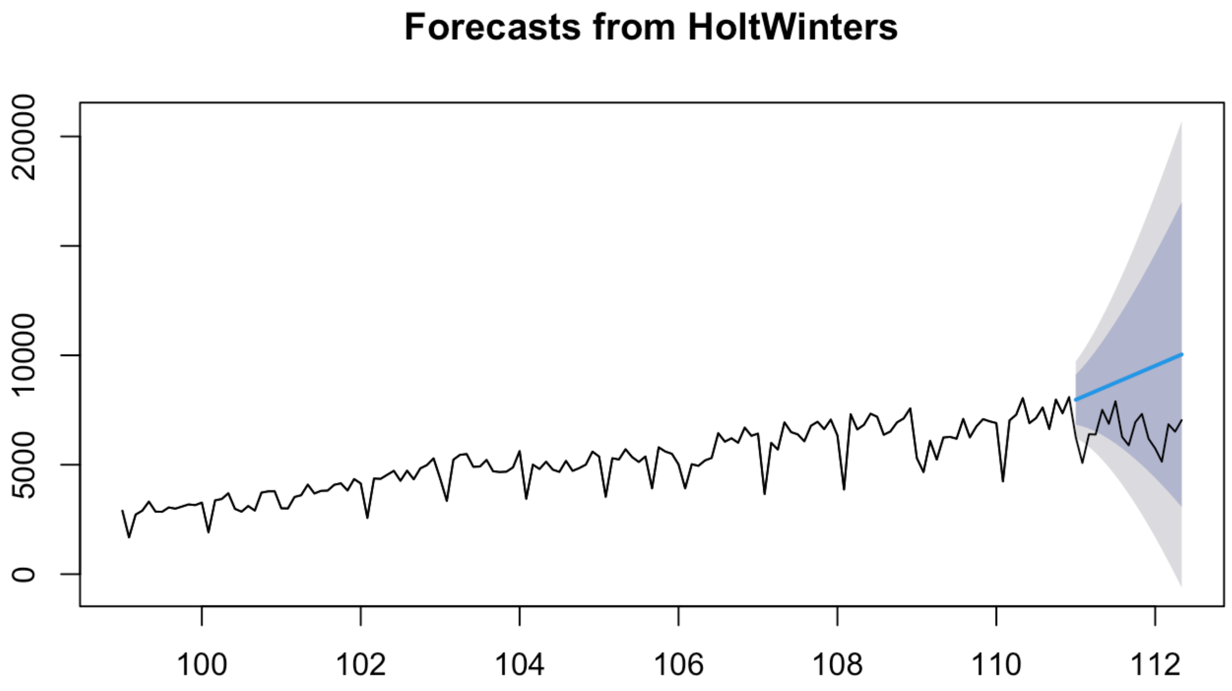


SSE=113042143



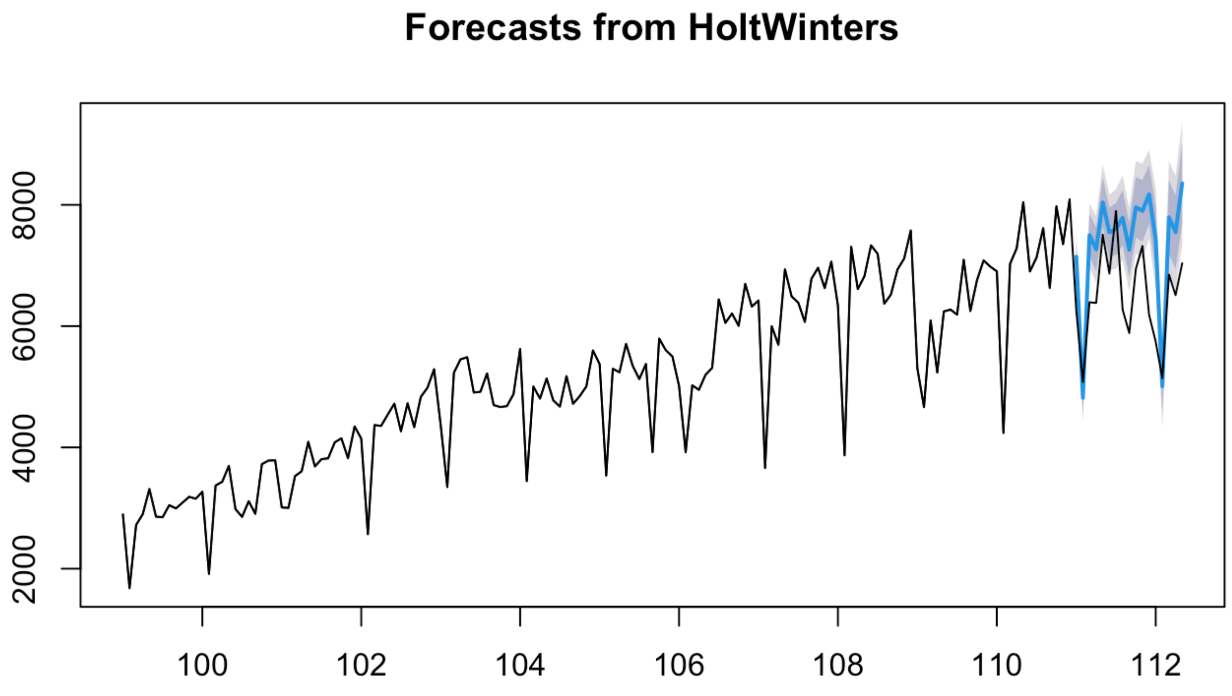
SSE=28367713

HOLT LINEAR TREND MODEL PREDICTION



RMSE=2691.283

HOLT-WINTERS SEASONAL MODEL PREDICTION



RMSE=1078.029

CONCLUSION

model	SARIMA	HOLT	HOLT-WINTERS
RMSE	1103.204	2691.283	1078.029

從模型結果可以看出季節性對此data的重要性！