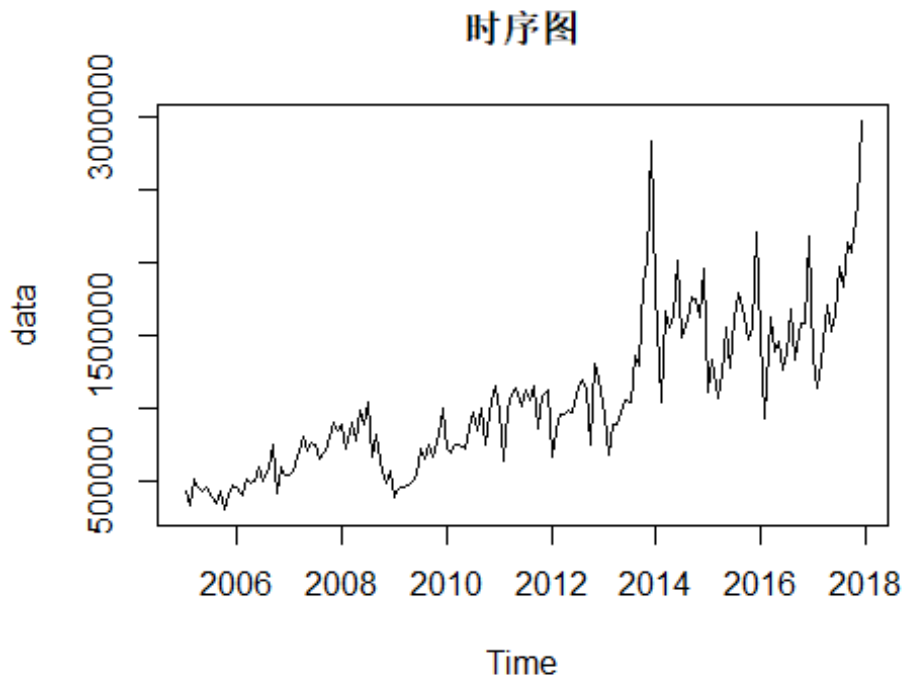


```

library(dplyr)
library(urca)
library(uroot)
library(TSA)
library(forecast)
library(modelsummary)
library(ggplot2)
library(tsoutliers)
library(patchwork)

all_data <- read.csv("D:/预删除文件夹/大三下/时间序列/云南省进出口贸易值.csv") %>%
  .$进出口值 %>%
  ts(start = c(2005,01),frequency = 12)
data <- window(all_data,end=c(2017,12))
plot(data,main="时序图")

```



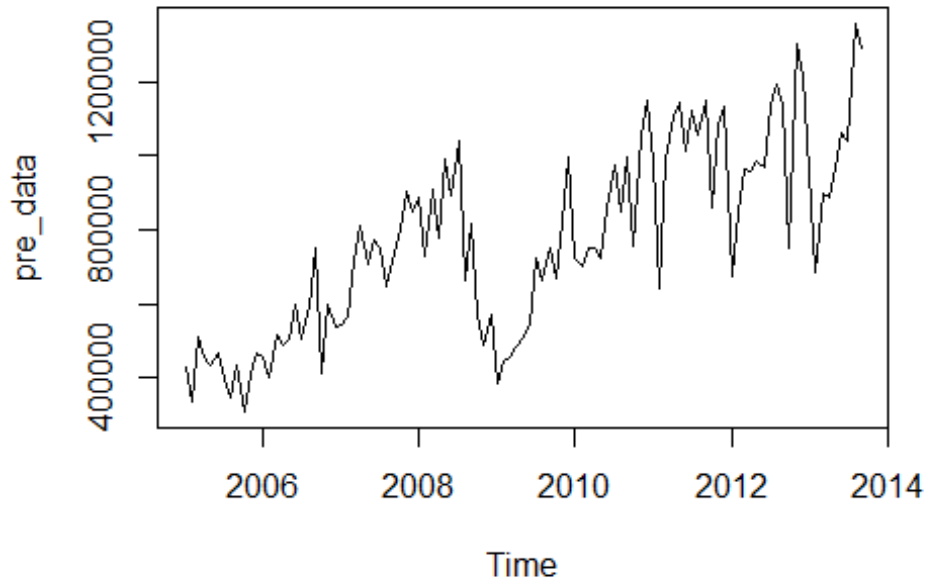
从时序图可以注意到进出口值明显地分为两段，考虑历史背景，2013 年 9 月我国提出一带一路方案，以此作为节点进行干预分析。下面首先对事件发生前的序列拟合一个模型

```

pre_data <- window(data,end=c(2013,9))
plot(pre_data,main="干预前时序图")

```

干预前时序图



```
ur.df(pre_data,type = "trend",lags = 12) %>% summary()

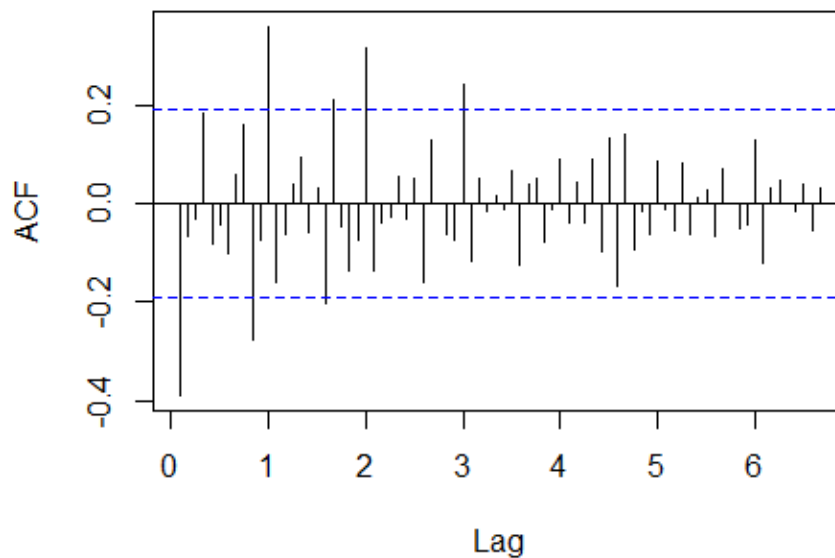
##
## #####
## # Augmented Dickey-Fuller Test Unit Root Test #
## #####
##
## Test regression trend
##
##
## Call:
## lm(formula = z.diff ~ z.lag.1 + 1 + tt + z.diff.lag)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -347718  -57518    6308   79755  264750
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  1.819e+05  7.411e+04   2.455  0.01635 *
## z.lag.1      -4.066e-01  1.670e-01  -2.435  0.01723 *
## tt           2.601e+03  1.194e+03   2.179  0.03237 *
## z.diff.lag1  -1.394e-01  1.795e-01  -0.776  0.43991
## z.diff.lag2   6.719e-02  1.710e-01   0.393  0.69551
## z.diff.lag3   6.402e-02  1.589e-01   0.403  0.68811
## z.diff.lag4   2.644e-01  1.572e-01   1.682  0.09658 .
## z.diff.lag5   1.453e-01  1.547e-01   0.939  0.35050
```

```
## z.diff.lag6    8.414e-02  1.499e-01   0.561  0.57617
## z.diff.lag7    9.813e-03  1.466e-01   0.067  0.94681
## z.diff.lag8   -1.760e-02  1.471e-01  -0.120  0.90511
## z.diff.lag9    1.239e-01  1.494e-01   0.830  0.40937
## z.diff.lag10  -1.802e-01  1.457e-01  -1.237  0.21995
## z.diff.lag11  -1.228e-01  1.437e-01  -0.854  0.39567
## z.diff.lag12   3.416e-01  1.243e-01   2.747  0.00748 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 132100 on 77 degrees of freedom
## Multiple R-squared:  0.4887, Adjusted R-squared:  0.3958
## F-statistic: 5.258 on 14 and 77 DF, p-value: 7.411e-07
##
##
## Value of test-statistic is: -2.4345 2.7147 2.9635
##
## Critical values for test statistics:
##      1pct  5pct 10pct
## tau3 -3.99 -3.43 -3.13
## phi2  6.22  4.75  4.07
## phi3  8.43  6.49  5.47
```

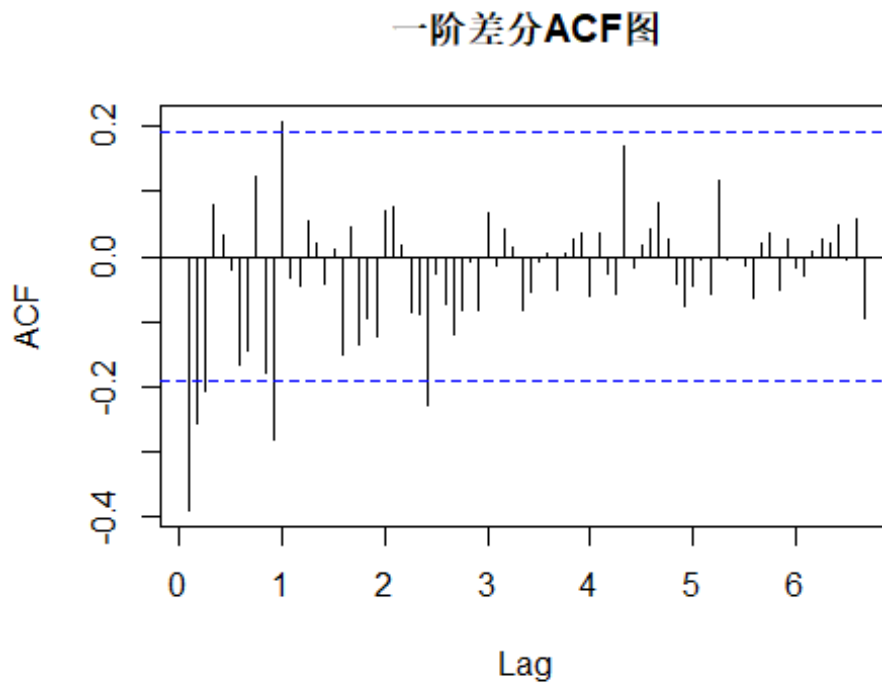
从 ADF 检验的结果来看，事件发生前的序列不存在单位根，且存在截距项和趋势项，结合时序图来看，其存在一定的线性上升趋势，下面作一阶差分尝试

```
d1_pre_data <- diff(pre_data)
acf(d1_pre_data,lag.max = 80,main="一阶差分 ACF 图")
```

一阶差分ACF图



```
acf(d1_pre_data,type = "partial",lag.max = 80,main="一阶差分 ACF 图")
```



```
hegy.test(d1_pre_data,maxlag = 12)
```

```
##
##  HEGY test for unit roots
##
## data:  d1_pre_data
##
##          statistic p-value
## t_1      -2.4649  0.0779 .
## t_2      -0.6288  0.3372
## F_3:4      1.8292  0.1232
## F_5:6      0.7753  0.4141
## F_7:8       0.122  0.8727
## F_9:10     0.8291  0.3891
## F_11:12    1.498  0.1799
## F_2:12     1.0835  0.3751
## F_1:12     1.5214  0.2515
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Deterministic terms: constant
## Lag selection criterion and order: fixed, 12
## P-values: based on response surface regressions
```

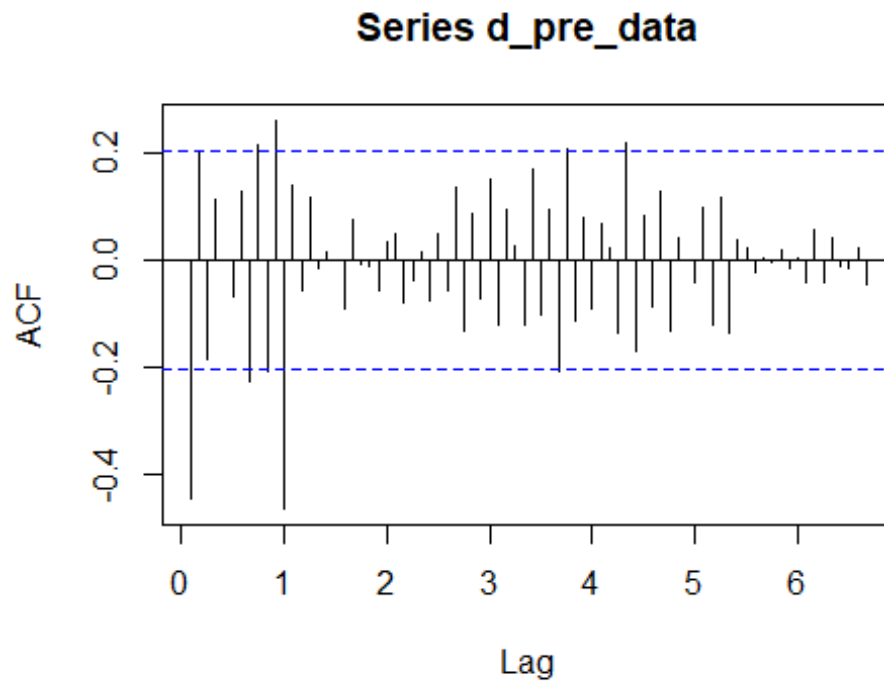
从 ACF 图和 PACF 图来看，一阶差分后的序列表现出了明显的季节性特征，估计周期为 12，对季节单位根作 HEGY 检验，可以看到不能拒绝季节单位根的存在，下面作 12 步差分尝试

```
d_pre_data <- diff(d1_pre_data, lag = 12)
hegy.test(d_pre_data, maxlag = 12)

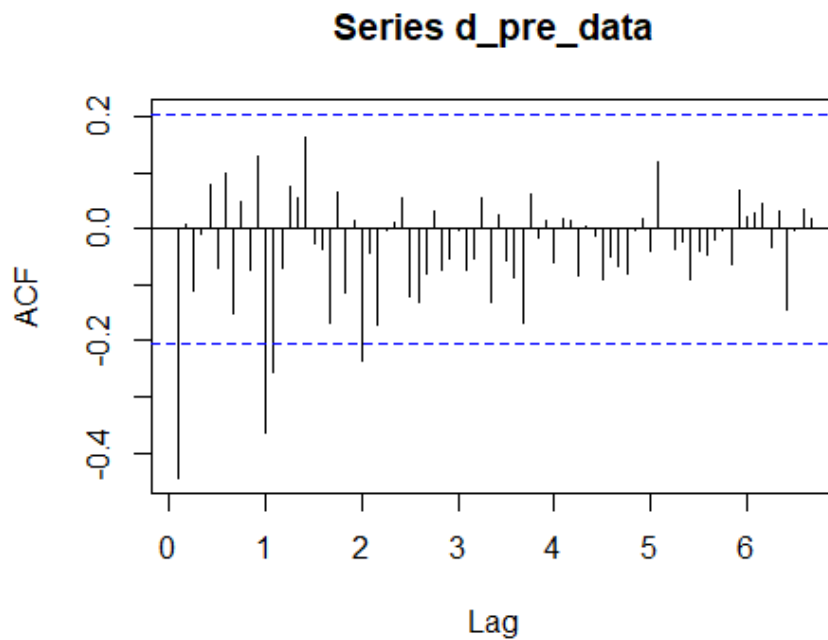
##
## HEGY test for unit roots
##
## data: d_pre_data
##
##          statistic p-value
## t_1          -2.7418  0.039 *
## t_2          -2.922  0.0017 **
## F_3:4         5.6267  0.0022 **
## F_5:6         4.8741  0.0044 **
## F_7:8         2.3914  0.0617 .
## F_9:10        2.8708  0.0361 *
## F_11:12       3.4013  0.0202 *
## F_2:12        6.7519      0 ***
## F_1:12        7.256      0 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Deterministic terms: constant
## Lag selection criterion and order: fixed, 12
## P-values: based on response surface regressions
```

可以看到 12 步差分后，显著地拒绝了季节单位根存在的假设，下面识别季节项的 P 和 Q 以及非季节项的 p 和 q

```
acf(d_pre_data, lag.max = 80)
```



```
acf(d_pre_data,lag.max = 80,type = "partial")
```



可以认为在一个周期长度上 ACF 一阶截尾，PACF 拖尾，故取 $P=0$ ， $Q=1$ ，而在一个周期内 PACF 均不显著，ACF 在一阶滞后处显著，可以尝试取 $p=11, q=0$

```
pre_model <- Arima(pre_data,c(1,1,0),c(0,1,1))
modelsummary(pre_model,stars = T,gof_map = c("rmse","bic"))
```

干预前模型

ar1	-0.430*** (0.094)
sma1	-0.560*** (0.100)
RMSE	119688.87
BIC	2443.0

• p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

```
Box.test(pre_model$residuals,lag = 12)
```

```
##
## Box-Pierce test
##
## data: pre_model$residuals
## X-squared = 11.69, df = 12, p-value = 0.4709
```

可以看到模型的系数均显著，残差也通过了纯随机性检验，不过模型的 RMSE 较大，这是因为序列本身就是大数值，总的来说可以认为模型较好地提取了未经干预的序列信息，下面考察一带一路建设的影响机制

```
e <- pre_model %>%
  forecast(51) %>%
  .$mean %>%
  `~` (data[56:106])
tso(data)

## Series: data
## Regression with ARIMA(0,1,1)(0,0,2)[12] errors
##
## Coefficients:
##          ma1      sma1      sma2      LS106      A0108      A0110      A01
14
##      -0.4330   0.1421   0.2457  753531.7   913496.5  -696966.6  491221.
5
## s.e.    0.0723   0.0928   0.0988  138325.2  130652.1   128548.3  125181.
0
##          A0120      A0132      A0134      A0144      A0156
##      504585.0  677533.7  -566738.8  742589.7  732680.4
## s.e.  130169.8  133831.1  132171.6  132876.4  158808.2
##
## sigma^2 = 2.473e+10: log likelihood = -2069.29
## AIC=4164.58  AICc=4167.16  BIC=4204.15
##
## Outliers:
```

```
##   type ind   time coefhat  tstat
## 1  LS 106 2013:10 753532  5.448
## 2  AO 108 2013:12 913496  6.992
## 3  AO 110 2014:02 -696967 -5.422
## 4  AO 114 2014:06 491221  3.924
## 5  AO 120 2014:12 504585  3.876
## 6  AO 132 2015:12 677534  5.063
## 7  AO 134 2016:02 -566739 -4.288
## 8  AO 144 2016:12 742590  5.589
## 9  AO 156 2017:12 732680  4.614
```

```
e %>%
  autoplot() +
  labs(title = "事件发生后无干预模型预测值与实际值差值") +
  theme_bw()
```



从上图可以推测，一带一路的建设产生了一个长期的影响，并且影响没有衰减，结合对异常值的检验来看，可以认为一带一路的建设使得进出口值的均值发生了偏移，下面对此进行建模

```
x <- ts(c(rep(0,105),rep(1,51)),frequency = 12)
model <- Arima(data,c(1,1,0),c(0,1,1),xreg = x,include.mean = T)
modelsummary(model,stars = T,gof_map = c("bic","rmse"))
```

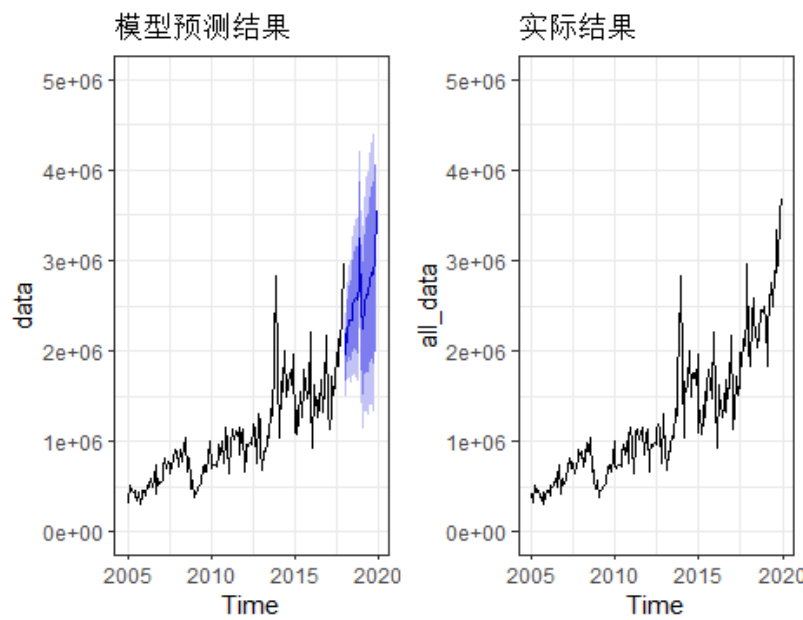

带干预效应模型

ar1	-0.482 (0.073)
sma1	-0.633 (0.061)
xreg	668968.523 (166203.490)
BIC	3927.8
RMSE	194698.38

- $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

可以看到一带一路使得进出口值平均增加了 668968 万元，而原来的均值仅为 768803.8 万元，近乎翻了一倍

```
p1 <- forecast(model,xreg = rep(1,24)) %>%
  autoplot() +
  ylim(0,5e+06) +
  labs(title = "模型预测结果") +
  theme_bw()
p2 <- autoplot(all_data) +
  ylim(0,5e+06) +
  labs(title = "实际结果") +
  theme_bw()
p1|p2
```



带有干预效应的模型预测结果如上所示